AGROECOLOGY FOR WEEDS

DELIVERABLE 1.3: Needs, barriers, and opportunities for AWM practices in organic, mixed and conventional systems

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1.0	**Writers**: María Rosa Mosquera-Losada Ana Couso-Viana Diego Vázquez Miramontes Nuria Ferreiro Domínguez FJ Rodríguez Rigueiro Alexandros Tataridas	

Summary

GOOD project aims to co-create systemic and sustainable Agroecological Weed Management (AWM) solutions via the establishment of Living Labs (LLs), encouraging multi-actor approaches that ensure long-term and large-scale transition to sustainable weed management. The present deliverable intends to categorize needs, barriers and opportunities for AWM practices in various farming systems, as well as gaps towards non-chemical weed management. To do so, questionnaires (n=532) and surveys (n=241) were held in eight European countries (Spain, Italy, Greece, Serbia, Portugal, Latvia, The Netherlands, and Cyprus), in different arable (rice, triticale, wheat, maize, cowpea, soybean, rye-pea, and onion) and permanent (olives, cherry, apple, grapes, citrus) crops as well as and LL board meetings.

The analysis of the collected data revealed that most stakeholders, in line with established European policies, considered that agriculture without herbicides is possible and preferable, acknowledging detrimental effects of herbicides on overall environmental and human health. Transition to more sustainable approaches, especially AWM implementation, was considered as a knowledge intense by most actors across LLs. Stakeholders across countries and crops consider that it is needed to be a redefinition in policies, instating more financial tools to support farmers and including AWM practices as eco-schemes or as part of the agri-environment measures. Expense and lack of funds were appointed as the most relevant barrier to AWM implementation by stakeholders. Lastly, most of the respondents considered ecosystem services provision as the most important opportunity that derives from AWM implementation.

The report is presented in 780 pages followed by a set of annexes where individual country results are detailed. Annex I shows the set of questionnaires and surveys and Annexes II and III deploys the main results for arable and permanent crops, respectively, disaggregated per country, crop and type of stakeholder.

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1 Introduction

The overall objective of the GOOD project is to co-create innovative, systemic and sustainable agroecological weed management (AWM) solutions through the deployment of living labs (LLs) and to encourage a long-term and large-scale transition to sustainable biodiversity based agri-food systems through the development of the AWM network. Therefore, to identify existing needs, barriers and opportunities affecting farmers decision-making to favour novel and innovative AWM solutions adoption is a core activity of the GOOD project which affect the needed agroecological transition of agricultural systems. The D1.3 is linked to T1.2 associated with the development of 15 interviews to identify needs, barriers and opportunities of AWM for each farming systems as well as the gaps towards non-chemical weed management but also to analyse behavioral, social, business and economic factors influencing the adoption of AWM solutions as a result of the questionnaires, as well as a literature review to further understand the results from both the SWOT analysis of AWM and the gaps they have as well as the factors influencing the AWM adoption. The objective of deliverable 1.3 "Needs, barriers and opportunities for AWM practices in organic, mixed and conventional systems" is to identify needs, barriers and opportunities for AWM practices for each LL farming system, as well as gaps towards non-chemical weed management and the factors preventing the adoption of farmers of those AWM solutions. Moreover, the outputs of this deliverable will feed all R&I WPs (WP2, 3, 4, 5) through a list of weed management innovations and strategies based on the combinations of preventive, cultural, biological, digital and mechanical non-chemical weed control method.

2 Methodology

The methodology developed in D1.3 was based on a deep knowledge about the situation of the different sectors in the 16 living labs (LL).

(i) Literature review was conducted to benchmark our results with former studies

(ii) contextualize the crop growth at LL scale and the potential it has to represent the sector in Europe through the development of workshops within the living lab sessions. In particular, the types of weeds to fight against and the type of weeding technology is used were analysed

(iii) SWOT analysis a set of interviews in each Living Lab were carried out to generally understand the main opportunities, strengths, threats and weaknesses that herbicide and AWM use have for the LL context by developing a SWOT analysis.

(iv) An analysis of the main opportunities, needs, gaps and barriers of each of the AWM practices and Herbicides were carried out by developing a survey to 6 types of stakeholders (advisors, consumers, farmers, industry, policy maker and researchers).

The type of weeding technologies analysed are detailed in Table .

Table A. Types of weeding management technique presented to LL in the different LLs.

Weed control method group		Acronym	Weed control method	Description
Chemical		H	Herbicide	Application of synthetic substances to control weed populations
		SSS	Site specific spraying	Optimized site-specific herbicide application based on weed infestations
		BH	Biobased herbicides	Application of naturally occurring substances or microorganisms to control weed populations with minimal environmental impact
Physical		MW	Mechanical weeding	Use of mechanical tools and equipment, such as cultivators and weeders, to physically remove or destroy weeds
		MO	Mowing	Regular cutting of weeds to reduce seed production and limit their spread in agricultural fields
		TW	Thermal weeding	Application of heat to burn weeds causing a knockdown effect (flaming) and precise application of hot water with organic foam that kills or damages weeds (Hot foam)
		MU	Mulching	Application of preferably organic or synthetic materials on soil surfaces to suppress weed germination and growth while conserving soil moisture
Nature Based Solutions	Temporal use of biodiversity	CC	Cover crops	Utilization of specific plant species, grown between cash crop cycles, to suppress weed growth and enhance soil health
		CCI	Inoculated cover crops	Enhancement of (cover) crop competitive ability against weeds and nutrient uptake with seed inoculation with arbuscular mycorrhizal fungi
		FS	False seed	Creation of a false seedbed by preparing the soil and then managing emerging weeds before planting the main crop
	Spatial use of biodiversity	I	Inter cropping	Simultaneous cultivation of multiple crops in the same field to naturally reduce weed pressure and enhance resource utilization
		G	Grazing	Use of animals to manage weeds
		NE	Natural enemies	Introduction of natural enemies, such as insects or pathogens, to target specific weed species and reduce their abundance
Digital		AWC	Automated weed control	Precise weed removal and management with automatic robots
		UAV	Unmaned aerial vehicle	Rapid weed detection or aerial spraying of herbicides with drones

2.1 Living Lab board meetings

Co-creation activities are important for the GOOD project to engage and empower people in adopting agroecological practices and AWM. At the LL level, three annual virtual, in-person or hybrid meetings will be conducted to monitor and assess the LLs' output and annually adjust next year's activities, as well as ensure establishing a common protocol on the LLs. In this context, LL boards have been established, consisting of different members representing the several types of stakeholders (GOOD partners, farmers, advisors, researchers, consumers and policymakers) animated by a facilitator. The 1st meeting of the LL boards was aiming at informing the participants about the GOOD project and its activities and research plan, describing agroecological principles and practices and delving deeper into AWM. During these meetings, discussions with pre-defined questions (Annex I) were held to facilitate data collection and encourage knowledge sharing about the current stage of the sector that the LL tackled with regard to the AWN implementation. The LL boards were able to adjust/add/remove questions according to local needs, experience and relevance. The Living lab board meeting minutes and results were taken and written by each LL leader and reported to USC. Transcripts for each LL board meeting are available in Annex II.

2.2 Interviews

Knowledge-Base surveys (interviews) were designed in a structured format to identify opportunities, strengths and gaps of AWM, as well as gaps towards non-chemical weed management, through interviews with farmers, researchers and advisors at the LL level. Each LL was responsible to carry out in total 15 interviews (5 farmers, 5 researchers, 5 advisors). In principle, the SWOT analysis was followed to systematically categorize strengths, weaknesses, opportunities, and threats for AWM and threats and weaknesses towards non-chemical weed management. Moreover, there were identified and are presented below opportunities, strengths, threats and weaknesses for the use of herbicides. The steps that were taken were the following: (i) identification of research questions (Table B), (ii) identification and engagement of respondents, (iii) interview undertake, (iv) transcription coded by the same person ensuring uniformity in the coding, (v) analysis with qualitative coding, and final (vii) summary. Each interview started by collecting preliminary information from the respondent on the type of farm (for farmers), nationality, gender and year of birth. Then, an introduction to AWM was made by the interviewer. Question 1 was in multiple choice format, while the remaining questions were open to respondents to express their opinion. Qualitative coding was deployed to systematically categorize excerpts from the qualitative data aiming at finding topics and patterns. A ground-up approach was followed to derive the codes from the data without using predetermined codes (inductive coding). In vivo codes (=using the participant's own words) and descriptive codes (=a summary of the content of text into a description) were appointed to each answer at the first-round pass at coding the qualitative data. Then, the codes were grouped into categories. A second-round pass was done to find any opportunity, strength, threat, and weakness that was answered in another question (e.g., an opportunity for AWM that was mentioned in the question of weaknesses for non-chemical weed management). This was followed by refining again the coding to categorize codes and identify themes. Keyword frequency refers to at least one mention of a keyword in an answer. It was calculated as the percentage of responses containing this keyword in the answers of interviewees belonging to a specific stakeholder group (farmers, advisors, researchers) to the total number of answers.

Table B: Questions of the Knowledge-Base interview

Question 1	What types of weed management practices are mostly used in your region? *Multiple choice (cover crops, intercropping, grazing, mowing, natural enemies, mulching, mechanical control, false seedbed, bio-based herbicides, thermal weeding, automated weed control, Unmanned Aerial Vehicles, cover crop inoculation to increase competitiveness, herbicides, site-specific weed management)*
Question 2	What are the main opportunities of the weed management practices you are aware of?
Question 3	What are the main strengths of the weed management practices you are aware of?
Question 4	What are the main external (threats) and internal (weaknesses) gaps for weed management practices you are aware of?
Question 5	What are the main external (threats) and internal (weaknesses) gaps towards non-chemical weed management practices you are aware of?

Overall, a hybrid analysis method was followed including elements of the *thematic analysis (TA)* to focus on the overarching themes in the data and how those themes relate to one another (=comparisons among stakeholder groups at LL level and comparisons between different LLs, therefore country and crops) and the *qualitative content analysis (CA)* to count instances of coded concepts and keywords of textual data from the answers. TA was mainly used for questions 2-5 and CA for question 1. The summaries of SWOT are presented at the LL level in the Results section, while the whole country report can be seen in Annex II.

Results were based on the elaboration of four graphs presenting the average number of opportunities for AWM, strengths of AWM, weaknesses of non-chemical weed management, and weaknesses tied to herbicides, identified by stakeholders. The basic criterion to include a LL in those graphs was the collection of at least four responses per stakeholder group. Therefore, questions that were answered only by a few interviewees were not considered enough to extract valuable information, hence are not presented.

In addition, several lists of TOP-10 or TOP-5 opportunities, strengths, threats and weaknesses tied either to AWM, non-chemical weed management or herbicides are included. Percentage of responses means the actual number of total responses (summed for all LLs) divided by the total number of responses per question.

2.3 Questionnaires

Knowledge-Base questionnaires were designed to gain insight with regard to stakeholders' assessment of relevant AWM practices for each established LL. As promised in the Grant Agreement, respondents were categorized by stakeholder type (Advisor, Consumer, Farmer, Policy Maker, Industry or Researcher), who select the most relevant weed management practices for a particular crop. Afterwards, participants were challenged with a set of assertions with regard to the selected practices disadvantages, needs, opportunities, and barriers. They selected whether they consider if the assertion was "highly relevant", "low relevant" or "irrelevant" for the crop. Questions associated with the questionnaires can be seen in Table C.

Table C.Questions of the Knowledge-based questionnaires

Question	Possible choices
Interviewee type	Policy maker, Industry, Researcher, Farmer, Advisor, Consumer
What types of weed management practices are mostly used in your region?	1. Cover crop 2. Intercroping 3. Grazing 4. Mowing 5. Mulching 6. Mechanical control 7. False seedbed 8. Biobased herbicides 9. Automated weed control 10. UAV 11. Cover crop inoculation to increase competitiveness 12. Herbicides 13. Site-specific spraying 14. Natural enemies 15. Thermal weeding 16. Other 17. If you select other, please specify
What are the main disadvantages of the weed management	1. No significant disadvantages 2. time-consuming 3. Complicated 4. Expensive

practices you are aware of? **(For all the practices previously selected) The relevance will be scored from 1 to 3 (1: irrelevant 2: low relevant; 3: high relevant)**	5. Low efficacy 6. Harmful to the environment and human 7. High carbon foot print 8. Public against the use of control methods 9. Customer demand the reduction of the use of the control methods 10. No barriers 11. Other reason 12. If you select other, please specify:
What are the main needs for weed management practices you are aware of? **(For all the practices previously selected) The relevance will be scored from 1 to 3 (1: irrelevant 2: low relevant; 3: high relevant)**	1. Timing reduction 2. Cost reduction 3. Reduction of maintenance 4. Training 5. Management Expertise 6. Practicing Knowledge skills 7. Lack of advisors 8. Low efficiency of the method 9. Regulation change 10. Ecosystem services impact knowledges 11. No needs 12. Other reason, please specify:
What are the main opportunities for agroecological weed management you foreseen? **(For all the practices previously selected) The relevance will be scored from 1 to 3 (1: irrelevant 2: low relevant; 3: high relevant)**	1. AWM will reduce my reliance on herbicides 2. AWM will increase my income 3. AWM will stabilize the crop yields 4. The profit of my business will be increased 5. AWM will become an important scientific discipline in the future 6. AWM will increase soil health…. 7. AWM will increase biodiversity 8. AWM will increase water quality 9. AWM will increase water availability 10. AWM will foster integrated pest management strategies 11. Others: please specify:
What are the main barriers for agroecological weed management you foreseen? **(For all the practices previously selected) The relevance will be scored from 1 to 3 (1: irrelevant 2: low relevant; 3: high relevant)**	1. No significant barriers 2. Expensive 3. Regulation 4. Lack of funds 5. Training... 6. Time consuming 7. Complicated 8. Low efficiency 9. Harmful to the environment and human 10. High carbon footprint 11. Others: please specify:

Partners were responsible to gather at least 30 respondents for each LL (480 responses). After performing the questionnaires, 532 unique responses were gathered (Table D). Only those respondents that finished the questionnaire were considered for the analysis, while those questions with at least 3 respondents were considered for the analysis. The data were analysed using Rstudio, we separated the responses from the LL (country and crop), practice and stakeholder. The specific results of the LL can be seen in Annexes II and III.

Questionnaires were used to construct bar plots with a Likert-scale with the levels mentioned above (country, crop, practice and stakeholder) to describe the stakeholder type perception of each practice, the overall stakeholder perception as percentage. Differences among stakeholders were described in the conclusion section for each LL and practice. In those crops that were considered as relevant by more than one LL, an extra section was added in order to compare stakeholders' perceptions in each region for the specific type of practice.

Table D. Number of respondents of Knowledge-Base questionnaires for each LL. (AIAB, Italian Asociation for Organic Agriculture; AUA, Agricultural University of Athens; DELPHY; CICYTEX, Extremadura Scientific and Technological Research Centre; CNR ISPAAM, Institute for Animal Production System in Mediterranean Environment, National Research Council; CUT, Cyprus University of Technology; LLKC Latvian Rural Advisory and Training Centre; LSSV, Living Seeds Sementes Vivas; MRIZP,Maize Research Institute Zemun Polje;USC, University of Santiago de Compostela).

Crop type	Crop	Country	Lead participant	Number of respondents
Arable crops	Rice	Spain	CICYTEX	18
	Triticale	Italy	CNR ISPAAM	39
	Wheat	Greece	AUA	34
	Maize	Serbia	MRIZP	31
	Cowpea	Portugal	LSSV	28
	Soybean	Serbia	MRIZP	38
	Rye-pea	Latvia	LLKC	29
	Onions	The Netherlands	DELPHY	29
Permanent crops	Olives	Portugal	LSSV	28
		Cyprus	CUT	56
	Cherry	Spain	CICYTEX	17
	Apple	Spain	USC	49
	Grapes	Spain	USC	41
		Italy	AIAB	28
		Greece	AUA	29
	Citrus	Italy	AIAB	28
				532

3 Results

The results from the stakeholders' perceptions will be divided by annual crops (cereals, legumes, mixed cereals and legumes and horticultural crops) and permanent crops (olive (with two countries), cherry, apple, grapes (3 countries) and citrus).

3.1 Annual crops: Cereals

3.1.1 Cereal global analysis

3.1.1.1 Contextualization

The cereal section includes the analysis of four types of cereals in different countries of Europe, that are highly relevant for all Europe such as rice (Spain), Triticale (Italy), wheat (Greece) and maize (Serbia). Wheat and maize are very extended grown crops in Europe while the other two crops are specifically grown in few locations across the EU (rice and triticale) as shown in Eurostat (Eurostat, 2024). None of the cereal stakeholder considered economic aspects related to circular economy or new markets, prices and products, technical topics linked to synergies or social aspects associated with education (peer to peer knowledge) of health (product quality) as an opportunity for AWM.

The LL context showed that cereals have a large number of challenges to overcome with regard to weeds. Crops like triticale have a large amount of weeds while rice or maize have a small number due to the water and height of cropping, respectively. All stakeholders trust herbicides and understand that if they are used with low doses then herbicides do not cause environment or health problems, in spite of recognizing the link between herbicides use and environmental/human health challenges. All stakeholders declare concerns because the herbicide use. The type of weeds to fight against are monocots and dicots being the most cited *Amaranthus* spp, *Galium* spp or *Papaver rohea* for the not irrigated crops. However, in general, there are more types of weeds than those declared by the LLs at European level as shown by Weber and Gut (2005), Jensen et al (2011), Krehmer et al (2017) because weeds are locally adapted and these studies were conducted at EU level for the same crop.

3.1.1.2 Weeding needs, barriers, gaps and opportunities

All cereal stakeholders found regulatory changes, policy concerns, education and technical aspects as relevant needs to fight against weeds in their crops, being the cost and the lack of funds highlighted as one of the main barriers. All cereal stakeholders declared as gaps to overcome the weed challenges the herbicide resistance, the lack of new chemicals and their cost. Finally, cereal stakeholders see opportunities to find techniques that allows to reduce the herbicide reliance while fostering the IPM methodologies. Weeding is a very important problem for stakeholders due to the herbicides resistance that are limited by the lack of effective methods which are economically feasible available. Cereal actors perceived as an oppourtunity the combination of AWM options as part of the IPM can favour the herbicide reliance to control weeds.

3.1.1.3 Weeding techniques SWOT analysis

3.1.1.3.1 Herbicides

The SWOT analysis of the cereals showed that selectivity and efficacy are relevant opportunities for the less extended crops studied in Europe (rice and triticale), but no opportunities were provided by the most used crops (maize and wheat). Herbicide efficacy is the common strength for all the crops evaluated. On the other hand, the withdrawal of herbicides associated with policy is perceived as a common concern for all cereals. Finally, the herbicide resistance is seen as the most important weakness for all cereals. **The analysis reveals the trust of cereal actors on herbicides due to their selectivity and efficacy and are very worried about legislation.**

3.1.1.3.2 Agroecological Weed Management techniques

The SWOT analysis of the agroecology weed management techniques revealed training-education as an opportunity, being the same aspect highlighted by rice and triticale stakeholders but not by the maize of wheat stakeholders. Combination of strategies was perceived as a strength by all stakeholders excepting those dealing with maize. Changes in weed flora was declared as a threat by rice and triticale stakeholders but none threats are mentioned by maize and wheat. Finally, effectiveness and cost of application are perceived as a weaknesses by all stakeholders excepting maize, that did not mention any weaknesses to crop corn. **The analysis revealed that cereal actors do not trust AWM techniques, as they declare no weaknesses or threats for maize while for the rest of crops aspects like effectiveness and cost of application are seen as a weakness. AWM techniques are more appreciated in rice and triticale than in maize or wheat as they recognize that training is needed, but stakeholders consider that AWM can be part of combined strategies to fight against weeds**.

3.1.1.4 Weeding techniques evaluation

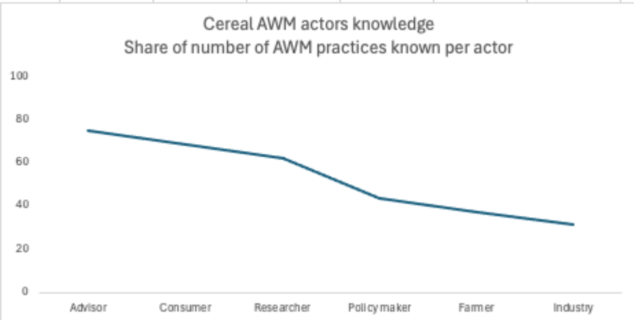
In cereals the initial perception gathered in the **questionnaires** are associated with the lack of knowledge of some of the techniques proposed to the stakeholders as shown in **Figure 1**. Cereal questionnaire were answered by around the 23% of the whole interviewees. From those consumers (28%) were those with the higher share of answer followed by researchers (21%), being the rest below the 20%, with only 11% of farmers.

The first aspect to adopt a AWM is to know the practices that are available, among all type of stakeholders the advisors are those with a higher number of techniques known, followed by consumers, researchers, policy makers and farmers, while industry in the last position is focused on the type of weed technologies they are working with. Within each technique grazing, herbicides, mowing, mechanical weeding, site specific spraying and unmaned aerial vehicle are known by all type of actors. On the opposite side, the role of the natural enemies are not knowledgeable as happens with the thermal wedding. Specifically, farmers are not aware of the temporal use of the biodiversity such as the use of cover crop with or without inoculum, this prevents from the extension of the use of biodiversity as a form to foster weeding (**Table 1**).

Table 1. Actors vs practices matrix awareness in cereal weed management. Cells highlighted in light green correspond to practices considered as relevant across all crop types, whereas rows highlighted in red correspond to practices considered irrelevant across all crop types. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle.

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
AWC	0	1	0	1	0	2
BH	0	2	1	1	0	1
CCI	2	0	0	0	2	1
CC	4	2	0	0	1	7
FS	5	1	1	0	0	2
Gr	11	12	9	5	5	9
H	19	15	12	7	4	13
I	6	7	2	1	0	5
MW	12	18	11	2	4	13
MO	10	11	9	4	2	5
MU	6	3	1	0	1	3
NE	0	0	0	0	0	0
Other	2	2	0	1	1	0
SSS	8	3	5	1	3	1
TW	0	0	0	1	0	0
UAV	8	11	1	7	3	10

Figure 1 shows the degree of knowledge on the cereal crops of the different type of actors as a matrix. Herbicide is the most knowledgeable form of weeding, followed by mowing, that is not of interest for farmers. Natural enemies are not acknowledged by any stakeholder while industry is the only one mentioning thermal weeding.



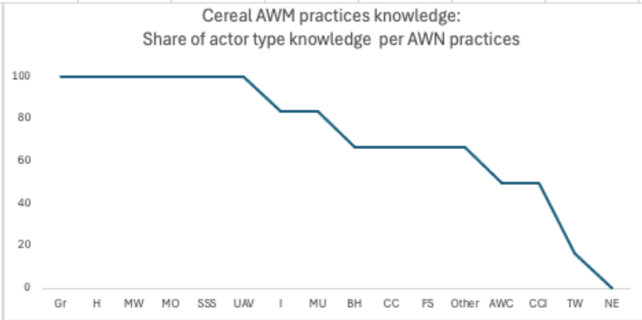


Figure 1. Cereal ASW practices by the whole set of interviewed actors as percentage of the number of actors answering with regard to those interviewed. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H:Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle.

The specific cereal knowledge on AWM shows specificities by the different types of crops, while most of the techniques are unknown in the case of rice, they are recognized by the triticale stakeholders with an intermediate behavior for wheat and maize. Cereal results show that advisors following by consumers are researchers are more aware about the different AWM than farmers, industries and policy makers, which limits the potential of the transition from herbicides use in conventional farming systems towards a more sustainable farming systems. **Chemical weeding is known by all cereal actors, as well as physical weeding (mowing and mechanical weeding), and also happens for nature-based (grazing) and digital (UAV) solutions**. **However, none actor was referred to natural enemies as an option to weed.**

3.1.1.5 Conclusions

The global cereal analysis reveals the trust of cereal actors on herbicides due to their selectivity and efficacy and are very worried about legislation. AWM techniques are not fully trustable, as they declare no weaknesses or threats for maize while for the rest of crops aspects like effectiveness and cost of application are seen as a weakness. Training and the use of AWM as part of the IPM strategies are perceived as positive due to the recognition of weeds resistance. Chemical weeding is known by all cereal actors, as well as traditional physical weeding (mowing and mechanical weeding), with a lower knowledge of weeding nature-based (grazing) and digital (UAV) solutions. Moreover, none actor was referred to natural enemies as an option to weed.

3.1.2 Rice

3.1.2.1 Contextualization

The description provided by the **Rice LLs** (Annex II) shows that the rice LL has a cultivated area of around 8,000 hectares reduced up to 1,000 hectares due to water restrictions, but in good years it could reach 28,000 hectares. Rice crop is mostly grown in Italy and Spain that comprised around 75% of the total European rice surface areas (around half a million hectares) as highlighted Kraehmer et al. (2017). In the Spanish region of Extremadura, rice crop is not further processed but some bioeconomy models have been promoted without success (i.e. levulinic acid, biomass use). Rice is produced as non-organic. Weed management have a lot of concerns and full herbicide use is proposed as the main solution in the area. Main weeds listed by the LL are *Echinochloa* spp and *Leptochloas* spp. Being the *Echinochloa* already cited by Kraehmer et al (2017) that only mention *Cyperus* or *Heteranthera* species as prevalent weeds in Europe, but these authors do not cite *Leptochloas* as such. A long list of herbicides is used by weed control. Actors perceive that adequate dose of herbicides inputs makes no environment damage at all, with a short soil retention time of the herbicides principles. The main drivers for the adoption of AWM is field testing and reducing prices from non-EU countries (i.e. Camboya). **The rice stakeholders have an important weed challenge to overcome associated with relevant weeds that are linked to a long herbicides. Rice international market is also seen as a concern. The stakeholders limit the power of herbicides to harm environment if low doses are applied, without recognizing long term effect.**

3.1.2.2 Weeding needs, barriers, gaps and opportunities

Table 2 shows the most relevant needs, barriers, gaps and opportunities found for the rice. Rice weeding **needs** are linked to regulatory changes, policy concerns, education, technical, treatment organization and combination of strategies and the development of new herbicides, while the recognized **barriers** were educational, policy (regulatory challenges, lack of funds for AWM), cost, social (environment and human harm and public opposition) and technical (herbicide resistance). The **gaps** were associated with the economic (cost of AWM), technical (technical assistance, lower AWM efficiency than herbicides, lack of technology) and policy (lack of drivers for farmer habits change). Rice stakeholders found as **opportunity** aspects linked to technology (lower AWM efficacy and selectivity than herbicides, reduction of herbicide reliance) and environmental (IPM fostering and ecosystem services provision). Therefore the **interviews** (Annex II) revealed that the use herbicides is the most common technique for weed management in the area of study. The use of AWM alternative technique to herbicides is negatively affected by external threats such as lack of subsidies, effectiveness of machinery or equipment availability or research knowledge, no-product added value in the market, but they recognize that AWM alternative techniques to herbicides provides external opportunities such as water quality. From an internal perspective, the cost of alternative AWM techniques is perceived as a weakness. Moreover, the resistance of weeds to current herbicides is perceived as a major concern. **Rice stakeholders recognizes the need of weeding by using herbicides linked to the harm they cause and the resistance which makes them having technical, policy, educational and social problems to overcome weeding issues.**

Table 2. Rice LL main needs, barriers, gaps and opportunities.

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Rice LL (Spain)	1. **Regulatory changes- Policy concerns.** Rice is highly dependent on herbicides. Stakeholders consider that severe policies hinder transition to AWM. 2. **Improvements in educational related aspects**. Including farmers training, management expertise and practicing knowledge skills. 3. **Enhancement in technical aspects**, including reductions of maintenance and cost. 4. **Treatment optimization** and increases in the design of **combination strategies**. 5. Development of new herbicides.	1. **Educational aspects** they consider lack of training as the most relevant barrier. 2. **Expense** and farmers **lack of funds** to implement AWM practices. 3. EU policies-**regulatory challenges**. Stakeholders consider that no transition will take place if requirements continue to be instated and demand taxation and increased customer information on produce imports. 4. Farmers reported instances of **herbicide resistance** which are increasingly concerning in the recent years. 5. **Environmental** or **human** health **harm** and **Public's opposition** to herbicides**.** Stakeholders consider that herbicides have a negative impact on the environment and on sales.	1. **Cost of application** of AWM practices compared to herbicides. **Transition** does not imply an **economic benefit**. 2. **Herbicide resistance** and **lack of** development of **new chemicals** due to regulation. 3. Technical **assistance** as well as lack of advisors. **Low efficiency** of AWM practices compared to herbicide application. 4. **Lack of technology** and other **technical aspects** in the region. That may hinder the adoption of AWM practices. 5. Lack of drivers for **change in farmers habits**. As they are pessimistic about the adoption of AWM. Education and increases in knowledge and the adoption of multi-actor approaches might crucial.	1. **IPM fostering**. They consider that the combination of sustainable practices has beneficial social impact as well as improvements in their produce. 2. **Ecosystem services provision,** including increased water quality and availability, improvements in biodiversity as well as an amelioration on soil health. 3. High **efficacy** and selectivity of herbicides compared to AWM. 4. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.** 5. **Reduction of herbicide reliance**. As a result of the adoption of combination strategies.

3.1.2.3 Weeding techniques SWOT analysis

3.1.2.3.1 Herbicides

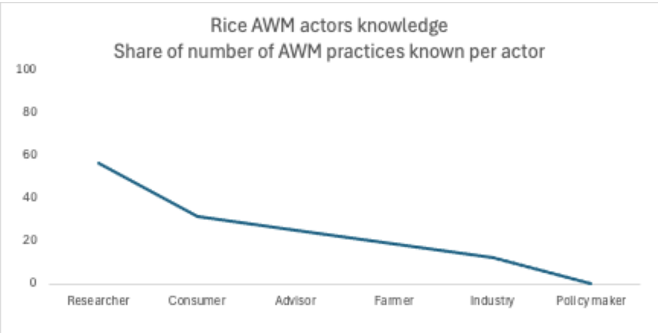
Regarding the SWOT analysis of **herbicides**, there is a low mentioning on opportunities, strengths and threats regarding its use in rice. All these three SWOT sections are aware of technical aspects linked to the selectivity, efficacy but also to the future of the herbicides (availability, withdrawal, lack of new (due to herbicide resistance.) or market herbicides). There were not mention to environment, economic or social aspects**. In summary, herbicides is seen as not harmful for the environment if appropriate doses are used due to the short retention time in the soil.**

3.1.2.3.2 Agroecological Weed Management techniques

The real adoption in the field of rice AWM should take into account the SWOT analysis of advisors and farmers as a first step while researchers should be considered as a technology and technology impact economic, environment and social impact analysis. As a AWM rice **opportunity**, technical aspects are seen by farmers (machinery and equipment availability) and advisors (new technologies and machinery, combination of strategies, and consultancy), while both advisors and farmers are aware of social-funding (subsidies, incentives and funding). Researchers see the ones mentioned by Advisors and farmers with the exception of the machinery and equipment availability and the social training and education. Regarding the **strengths**, technical aspects are acknowledged by all types of stakeholders associated with research needs and farmers linked to combination of strategies, but also environment aspects (water management resources). Researchers see strengths linked to the knowledge of weeds and ecology while social aspects linked to farmers access are also recognized by this type of stakeholders. Regarding the main **threats**, they are mostly linked to environment (changes in flora) and social aspects (policy). Finaly with regard to the main **weaknesses**, topics associated with technical aspects linked to the main crop (damage), herbicide effectiveness (short term effect, replacement), economic aspects (cost of operations and purchasing equipment) were highlighted. In summary, **technical aspects, therefore the know-how is the most relevant topic with regard to the rice AWM implementation, with some awareness about education and policy and finally with a minor role of the environment aspects.** The AWM use is limited by the effectiveness, cheaper prices in Cambodia.

3.1.2.4 Weeding techniques evaluation

The rice **questionnaire** was answered by 18 actors, after the criteria check (Annex II). As can be seen in the picture consumers and advisors are the type of stakeholders that know a large number of technologies to weed rice, however, in any case they know more than the 30% of the possibilities of weeding. Policy makers are the ones with a lower amount of rice weeding methodologies knowledge (**Figure 2** left). The most knowledgeable Rice AWM is associated with the use of herbicides or mechanical wedding as around the 80% of stakeholders declare to k now it, followed far away (33%) by the false seed, grazing, site specific spraying (**Figure 2** right). The matrix actors x AWM practices can be seen in the Annex II as well as a deeper analysis of the different actors knowledge about the different types of AMW techniques. Techniques linked to inoculated cover crops, intercropping, natural enemies, Thermal weeding or unmaned aerial vehicle are not known by any of the stakeholders asked.



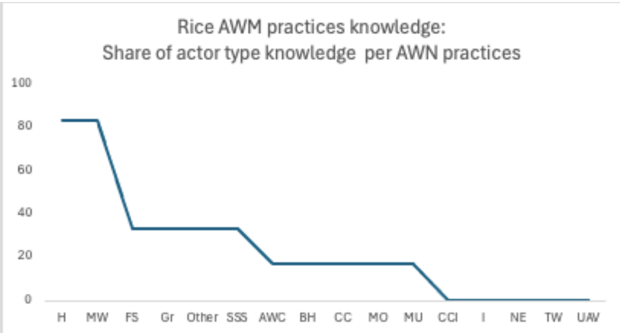


Figure 2. Rice AWM practices (left) and actors knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH:Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr:Grazing; FS:False seed, H:Herbicide, I: Intercropping, MO:Mowing; MU:Mulching, MW: Mechanical weeding, Ne:Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV:Unmaned aerial vehicle.

The description of the rice results from the **questionnaires** classified by type of actors are shown in the Annex II where a deep stakeholder analysis (researcher, consumer and advisors but not farmers, industry or policy makers) for the herbicides and mechanical weeding is shown. With regard to the ***herbicide use*** the adoption is prevented from economic factors such as the costs but business adoption is also negatively affected by inadequate regulations as advisors described. In any case, researchers understands that herbicides resistance, lack of new substances, and low efficacy as important factors that converge on the importance of addressing customer demands for reducing herbicide use and further adoption of this technique. The consumer are aware of the health and soil damage of the use of herbicides. However, ***mechanical weeding***, is perceived as a AWM technique for rice with a huge potential as it is associated with the huge potential of fostering IPM and therefore ecosystem services delivery, but the complexity and expensiveness are considered the main factors reducing the adoption of this technology in rice.

3.1.2.5 Conclusions

Few alternatives are nowadays available for farmers to crop rice without the use of herbicides, and they are worried about the availability of this tool, in spite of the soil and health concerns highlighted by consumers, which are not perceived by farmers. Farmers are not happy with the use of herbicides but threats like economic (costs, market competition (i.e. Asian countries)), technical aspects (effectiveness, infrastructure availability) prevents them for using it. More research and education, and adequate advisory systems are needed to foster AWM in rice in the area, as farmers at the end does not perceive AWM as a realistic tool as they do for herbicides. Moreover, the herbicides use is perceived as not harmful for the environment if appropriate doses are used due to the short retention time in the soil. The AWM use is limited by the effectiveness, cheaper prices in Camboya. They declare to see herbicide resistance.

3.1.3 Triticale

3.1.3.1 Contextualization

The Triticale is a well-known crop in the **Italian LL** (Annex II), occupies over 350 hectares not all officially recognized. and it is used to deliver several products: grain, grazing, biogas, bread and silage replacing maize produced with some labels. Differently from rice, the Triticale is cropped using crop rotation and legumes fostered by RDP measures. Is a crop very well adapted to the area. AWM practices are well known. Main detailed weeds are mainly monocot (*Avena*, *Hordeum Agrostis* and *Bromus*) and dicots (mainly thistle but also *Fumaria*, *Chrysanthemum*, mustard, horseradish, inula, *Gallium*, *Veronica*, poppy and *Amaranthus*) that uses 2-4 D, HRAC A(inhibiting ACCase), HRAC B (inhibiting ALS), HRAC C1 and C2 (inhibiting photosynthesis), HRAC G (inhibint EPSP synthase), Granstar, Tribenuron, Metasulfuron and Sulfonylureas depending on mono or dicots treatment which are exclusively used in pre-emergence phase. Other tools like grazing are used but they are happy due to the triticale adaptation to the area which is a weed crop resistance. For them, herbicides are no harmful at all for environment (soil, water and biodversity) because they use "little amounts". Cropping is not possible without herbicides but some of the stakeholders are optimistic. They described herbicide resistance. Triticale actors declare that triticale has weed concerns with many monocots and dicots weeds and with a large number of herbicides to combat those weeds. **As happened with the rice, triticale stakeholders are not aware nor of the possibility to grow triticale with AWM neither of the long-term damage and the cumulative effects of herbicides, which is a major issue for farming systems transition towards agroecological practices.**

3.1.3.2 Weeding needs, barries, gaps and opportunities

Table 3 shows the most relevant needs, barriers, gaps and opportunities found for the Triticale. The weeding needs described by triticale stakeholders are linked to regulatory changes, policy concerns, educational, technical, need of scientific knowledge and the need of developing AWM able to be adapted to climate change.

Table 3. Triticale main needs, barriers, gaps and opportunities

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Triticale LL (Italy)	1. **Improvements in educational related aspects**. Including farmers training and practicing knowledge skills. 2. **Increases in scientific knowledge** related to practices impact on ecosystem services. 3. **Enhancement in technical aspects**, including reductions of maintenance, cost, and application time. 4. **Regulatory changes- Policy concerns.** Farmers would prefer less severe policies on herbicide reduction, thought they only use herbicides in extreme situations. 5. **Climate change and weather** vastly affect weed behavior in this region. More extreme climate scenarios may lead to increase in chemical weeding use, need to **adapt AWM strategies**.	1. **Expense and time consumption** in agroecological weed management strategies 2. **Educational aspects** they demand increased training about weed management strategies. 3. **Changes in the flora** and particularly in the presence of **invasive species**, as stakeholders shared concerns about poppy distribution in the island 4. EU policies, **regulatory challenges,** and the European system of incentives, particularly those related to CAP payments. 5. **Climate change** and high **carbon footprint** of certain AWM practices.	1. **Time consumption** in AWM strategies as well as non-chemical weed management approaches. 2. **Cost of application**. The isolation of the region hinders the importation of machinery and limits the export of the produce. 3. **Environmental impact** of weed management strategies. 4. Technical **assistance** as well as lack of advisors. 5. **Herbicide resistance,** human health and environmental concerns were voiced for the use of chemical weeding.	1**. Ecosystem services provision,** including increased water quality and availability, improvements in biodiversity as well as an amelioration on soil health. 2. **IPM fostering**. The socio-economic environment in the island promotes the adoption of combination strategies to successfully manage weeds. 3**. Reduction of herbicide reliance**. As a result of the adoption of combination strategies. 4. **Source of food for livestock.** 5. **Economical-business aspects,** such as crop yield stabilization and income increase

As barriers aspects linked to education, costs (expensiveness, lacks of funds), policy (regulatory challenges and environment (change of flora, climate change and carbon foot print are highlighted). The main gaps are associated with education (technical assistance and lack of drivers), economic (costs, time consumption), technical (herbicide resistance and lack of new products) and environmental impact. The most relevant opportunities are linked to technical (IPM fostering, reduction of herbicide reliance), economic (business development and food source for livestock) and environment (ecosystem services provision).**The uptake for AWM with regard to triticale is limited due to the need of training of famers and advisors, the need of machinery, the knowledge about the impact, time of application and precise technologies associated with the AWM. Some stakeholders link grazing are perceived as an opportunity as a forag**e.

3.1.3.3 Weeding techniques SWOT analysis

3.1.3.3.1 Herbicides

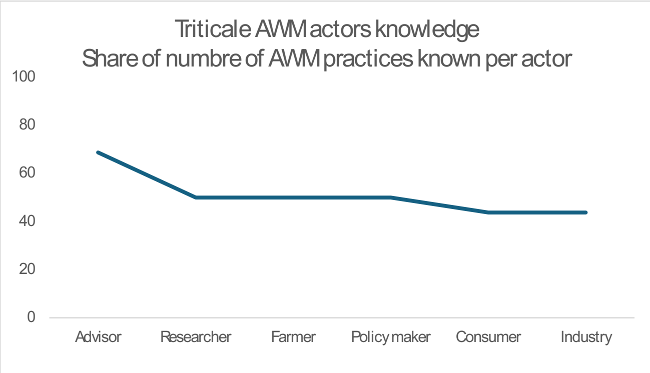
From the SWOT analysis for **herbicides** there are acknowledge **opportunities** mostly linked to technical aspects (effectivity (F), selectivity (A), quick results (A), fast operation (R), efficacy (R), Available equipment (R), selectivity (R), low cost (R)) and **strengths** also associated with technical aspects (simplicity (R), selectivity (R), low cost (A), optimized treatment (A), available equipment (A). With regard to the **threats** social aspects linked to the possibility of losing the capacity of use herbicides is sees as a concern (market (A, F, R), how herbicides are sold/distributed (A, F, R), pressure for herbicide reduction (R)). Finally with regard to **weaknessess** negative environmental aspects are highlighted by the whole set of stakeholders (Risks to human health, Environmental impact, pollutants) but also from a technical (herbicide resistance) perspective. Farmers also point out other economic (expensive), environmental (biodiversity decline) and social (lack of awareness), while the advisors are also worried about educational social (lack of training) or technical (residues) aspects. **Triticale herbicides SWOT analysis show that there is a higher awareness of the negative environmental impact compared to rice. Similarly to rice, the lack of possibility of the herbicides potential long-term use is seeing as a major concern.**

3.1.3.3.2 Agroecological weed management techniques

The SWOT analysis of AWM was largely answered by researchers with regard to the economic, technical, environmental and social concerns, which demonstrates that there is a strong work done in Triticale in the area from a research perspective. However, the answers from farmers and advisors were less intense. With regard to **opportunities**, farmers give relevance to reduced tillage, combination of strategies from a technical perspective, while the economic benefit is seen as an economic opportunity to use. Environment is considered when they declare that the use of AWM may reduce human health challenges and the fact that the environmental balance is needed to safeguard biodiversity, while the social aspects is directed to education (consultancy) and policy (subsidies) as main aspects. Advisors perceive economy (economic benefit), technical (feed resource, less inputs, new technologies and machinery, effectiveness), environment (soil health) and social (education) as the main AWM opportunities. The main **strengths** seen by farmers are understood as economic (economic benefit, reduction of fuel costs, reduction of labour, reduction of herbicide inputs) while advisors perceived the main strengths linked to technological aspects of the use of AWM (simple to use, speed quick, results, reduction of weed seed production, available machinery and equipment, farmers access) while both highlight environment (low environment impact) and education aspects (knowledge of weeds biology and ecology, consultancy). Therefore, both types of stakeholders see opportunities and strengths from internal (technical and economic by farmers, respectively) and external (all of them but mostly in environment and social by advisors) perspectives. With regard to **threats**, both forest and farmers perceive social (EU policy) and environment (Climate change) as relevant, while the technical aspect (lack of active compounds) is perceived as a threat by advisors. Finally, the **weaknesses** are shown as technical (effective crop production, effectiveness, complexity, no viable alternatives to herbicides), environmental (impact), and social linked to education (lack of extension services lack of technical assistance) or policy (more commitment). Advisors are also aware of technical aspects (lack of herbicides, non selectivity) environment (soil pollution, environmental impact), social (lack of experience knowledge, lack of training, lack of extension services, more cmommitments, limited knowledge of weeds), economic (cost of purchasing equipment). All stakeholders are concerned about economic issues (cost of applications). **In summary, Triticale AWM use was noticed with a lot of questions associated with the replacement of herbicides by AWM, but both farmers and advisors find more positive (opportunities and strengths) that negative aspects (threats and weaknesses) that should be overcome. Adoption should be based on demonstration pillars.**

3.1.3.4 Weeding techniques evaluation

The **triticale questionnaire** (Annex II) was responded by 41 actors in total answering about cover crops, false seedbed, grazing, herbicides, intercropping, mechanical wedding, mowing, mulching, site specific spraying. Differently from what happens in rice most of the triticale actors are aware of at least 40% of the techniques shown by the questionnaire (Figure 3). Grazing and mowing are the most knowledgeable techniques to weed triticale, that again has a low share of knowledge on digital tools (automated weed control, unmaned aerial vehicle), recent techniques (thermal weeding) or nature-based solutions (natural enemies).



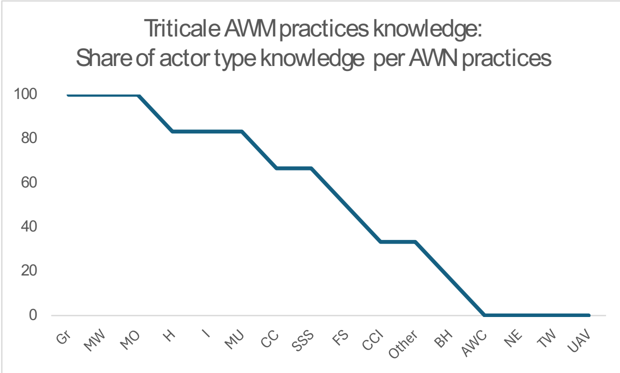


Figure 3. Triticale AWM practices (left) and actors knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle.

The **questionnaires** associated with triticale included answers for **chemical weed control** linked to the use of herbicides (advisors, consumers, farmers and researchers) and site specific spraying (advisor and farmer), **physical weed control** such as mechanical weeding (advisors, consumers, farmers and researchers), mowing (advisors, consumers, farmers, industry and researchers), mulching (advisors and consumers) and **nature based solutions** weed control such as cover crops (advisors and researchers), false seed (advisors, consumers, farmers and researchers), intercopping (advisors) and grazing (advisors, consumers, farmers and researchers). The deep summary of the questionnaires can be found in Annex II.

Chemical control is perceived as a good technique to implement AWM, that needs more training to use herbicides as part of the IPM as a type of intervention that are economically and ecologically justified to deliver ecosystem services, water quality, biodiversity and soil health. This is especially relevant when the surveyed actors are talking about the SSS as a catalyst for IPM strategies that should be supported by adequate regulations, being farmers expecting an improvement of waster security, biodiversity, soil health while reducing reliance and costs associated with herbicides. Stakeholders also noted external that prevent from the use of chemical control (herbicides and SSS) in a responsible form as part of the IPM such as education, training, regulations and costs or herbicide prices. They highlight the fact that bad used herbicide causes to health and environment and emphasized the importance of addressing societal concerns and ensuring transparency in herbicide practices that can be linked to other aspects such as carbon footprint. This shared recognition underscores the importance of balancing the benefits of herbicide use with addressing environmental, health, and economic considerations for a sustainable and responsible AWM approach.

Physical weed management control such as **mechanical weeding, mowing and mulching** was considered by stakeholders as a practice rich in opportunities and that probably reduce the herbicide reliance as it is a technique that promotes IPM and as a provider of ecosystem services. For various stakeholders is important to reduce the costs and the importance of management expertise and ecosystem service impact knowledge. With regard to adoption, the time consumption was recognized as the primary internal weakness by all stakeholders, followed by expenses (farmers, researchers), lack of funds for education (advisors), and training (consumers). Maintenance concerns were especially mentioned for mulching.

With regard to the **nature based solutions weed control methods** linked to the temporal (cover crops, false seed) and spatial (intercropping and grazing) use of the biodiversity, stakeholders perception associated with the ecosystem services provision is positive as part of the IPM technology. **Cover crops and false seedbed** are recognized as major players to improve water quality, increase biodiversity and promote soil health for researchers and advisors. However, some external threats prevents from cover crop adoption in triticale grams such as the lack of advisors, training, the cost, maintenance, complexity and the time consumption and from false seed linked to training, management expertise. Maintenance is seen less important in the case of false-seed Aspects including knowledge about ecosystem service impacts, practicing knowledge skills, management expertise, and training are needed. Moreover, there is a need for increasing knowledge about the carbon footprint associated with cover crops. **Intercropping** is perceived as an improver of water quality, soil health, farmers' income, and a reduction in herbicide reliance and linked to IPM technology enhancing biodiversity, business profitability, and stabilizing crop yields but the real impact on the ecosystem services is not known. However, the mechanical weeding use is also associated with the intercropping. Education associated with the importance of management expertise is a primary need. Main aspects that prevent from intercropping adoption as an AWM is time consumption, followed by expenses, lack of funds for education and training. **Grazing** is one of the most complex nature-based solution that makes stakeholders to see the benefits of this AWM tool from different perspectives, for advisors and consumers is a tool that enhances soil health, water quality and reduces her reliance recognizing opportunities in IPM to provide ecosystem services. Farmers see grazing as AWM tool that generate economic benefits. Key needs, such as addressing the lack of advisors and training, with training identified as a primary barrier. However, the perspective of farmers and advisors recognizes the customer demands for a reduction in grazing, while researchers perceive this a tool to provide ecosystem services, if adequate management is promoted.

3.1.3.5 Conclusions

We can conclude that the long experience in cropping Triticale in the Italian LL made them very aware to different AWM alternatives to herbicides perceived as a good alternative. Farmers indicated that herbicides are not harmful for the environment because of the low doses they have and most believe that growing triticale without herbicides is not possible, in spite of some of them being optimistic about this fact. They also found that some weeds are becoming more resistant to herbicides.

3.1.4 Wheat

3.1.4.1 Contextualization

The **wheat LL** represents more than 1000 farmers growing wheat in Thessaly. It is cropped as monocrop that sometimes is rotated with cotton (irrigated) or winter legumes (no-irrigated). The main products derived are flour, bread, pasta. Weeds are used controlled by around 15 active ingredients applied as post-emergence. They recognize that herbicides pollute soil and water, reduces biodiversity and are harmful to humans and animals, considering that if dose and number of applications are under control damages are minimum. Stakeholders understand the potential of AWM implementation, but real field research experiments are needed. Weed infestation with weeds are the main way to spread weed seeds. The major weeds are *Sinapis arvensis*, *Avena sterilis* but also *Galium aparine*, *Convolvulus arvensis*, *Lolium rigidum* and poppy. *Papaver rhoeas, Avena sterilis* and *Galium aparine* have shown herbicide resistance. **There are many challenges associated with weed resistance. However, stakeholders are aware of the risk, but if adequate doses and application number are adequately applied then minimum damage is expected. This is especially relevant for wheat, that is one of the most important crops in the world and in the EU and the flour one of the most consumed cereal in Europe.**

3.1.4.2 Weeding needs, barriers, gaps and Opportunities

The main needs, barriers, gaps and opportunities described by the stakeholders can be seen in Table 4. Wheat stakeholders declared as **needs**, the regulatory changes and the policy concerns but also education linked to the lack of advisors and technical aspects. As **barriers** they fund policy (expensiveness and lack of funds for AWM), environment (environment and human harm, climate change and carbon footprint of some AWM), social (public opposition) aspects as relevant. As **gaps** for weeding wheat stakeholders mentioned aspects related to education (technical assistance and lack of advisors), economy (cost of AWM, time consumption) technical (herbicide resistance and lack of new chemicals) and environment (impact). As happened with all cereals, the integration of IPM in AWM as well as the farmers professionalization on AWM, education and training as well as economic and business aspects are perceived as opportunities.

Table 4. Wheat main needs, barriers, gaps and opportunities

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Wheat LL **(Greece)**	1. Enhancement in **technical aspects**, especially those related to decreased maintenance, costs, and timing. 2. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studied. They emphasize the importance of communication among stakeholders. 3. **Regulatory changes- Policy concerns.** Herbicides are the main weed management practice in the region, respondents acknowledge the problems with herbicides. In contrast with other LL, Greek participants consider AWM practices as reasonable weed management solution, they consider that labor an other costs will increase, there needs to be a political solution, for example with increased payments. 4. **Improvements in educational related aspects**. They emphasized practicing knowledge skills as a key need. 5. **Lack of advisors** and reliable knowledge related to AWM practices (UAV).	1. **Environmental or human health harm.** Stakeholders recognize herbicides and site-specific spraying as potentially dangerous (soil pollution…), however, they consider that proper manage reduces risks. 2. Need for **certifications** for the application of certain practices. 3. EU policies, **regulatory challenges** related to restrictions in herbicide use. They considered that eco-schemes should integrate AWM. 4. **Expense and lack of fund** in certain agroecological weed management strategies 5. **High carbon footprint** of mechanical weeding.	1. **Cost of application** in AWM practices compared to herbicides. 2. Development of a sustainable system for **organic farming**. 3. **Low efficiency** of AWM practices compared to herbicide application 4. Stakeholders shared concerns with regard to some method's **high carbon footprint**. 5. **Herbicide resistance,** human health and environmental concerns were voiced for the use of herbicides.	1. **Economical-business aspects,** were recognized by industry, policy makers and researchers. 2. **IPM fostering**. They consider that the combination of sustainable practices has beneficial social impact as well as improvements in their produce. 3**. Reduction of herbicide reliance**. As a result of the adoption of combination strategies, especially after mechanical weeding. 4. **The availability of machinery and equipment**, contributes to cost effectiveness of AWM. 5. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.**

As beforementioned, wheat is one of the most important crops in the EU. **Wheat weeding is mainly linked to herbicides and farmers see major needs, barriers and gaps aspects linked to technical, educational, environmental and economic issues to support AWM. This is a major concern for human and environment perspective due to the large area of fertile soils occupied by wheat, that may be reducing the soil health.**

3.1.4.3 Weeding techniques SWOT analysis

3.1.4.3.1 Herbicides

The **herbicides SWOT** showed no **opportunities** but highlighted efficacy, low cost, quick results, simplicity, cost-effectiveness, optimized treatment, no intensive labour demand as **strengths**. Agricultural policy is seen as a **threat**. Many weaknesses are highlighted, for example cost (farmer), residues (farmer), environment (A, F) and human (F) risk, herbicide resistance (A, F) and pollutant (A) generation. **The SWOT analysis shows the main strengths of herbicides and the main concern towards the future that may prevent to use them**

3.1.4.3.2 Agroecological weed management techniques

The **AMW SWOT** analysis revealed that stakeholders and advisors think that there are **opportunities** for machinery and equipment availability, social impact and employment and for training and education. The cost effectiveness, the potential of combining strategies are seen as **strengths**, while no **threats** are mentioned. Finally, risk for human health, soil-pollution disturbance, lack of certificates and cost of applications are seen as a **weaknesses** by advisors, with farmers concerned about their effectiveness. **AMW use in wheat are seen very positively without threats mentioned, that may be hinder by the future use.**

3.1.4.4 Weeding techniques evaluation

The wheat **questionnaire** was answered by 34 actors in total answering about herbicides, mechanical weeding, site specific spraying and UAV. Figure 4 shows the knowledge of the 16 AWM techniques known by type of stakeholder and the stakeholder type knowledge about the 16 AWM techniques. Farmers and consumer are more aware of AWM techniques than policy makers, researchers or industry, while grazing, mechanical weeding, mowing, herbicides, intercropping, mulching cover crop, site specific spraying are techniques known by the 50% of the surveyed stakeholders. Again, digital tools (automated weed control, unmaned aerial vehicle), recent techniques (thermal weeding) or nature-based solutions (natural enemies) are mostly unknown for wheat weed control by stakeholders.

The **wheat questionnaire** (Annex II) was responded by 34 actors in total answering about biobased herbicides, cover crops, false seeds, grazing, herbicides, mechanical wedding, mowing, site specific spraying and unmanned aerial vehicle. Differently from what happens in rice and similar with what happened in triticale farmers and consumers are aware of at least 40% of the techniques shown by the questionnaire (Figure a3), however policy makers and researchers are below 30% and industry is just around 10% aware of the AWM techniques. As happened with triticale, mowing is the most knowledgeable techniques to weed wheat after herbicides and mechanical wedding. However, digital technics such as unmanned aerial vehicle are also extensively used but automated weed control is not used. Recent techniques (thermal weeding) or nature-based solutions (natural enemies, cover crop inoculated) together with mulching is not used to weed wheat.

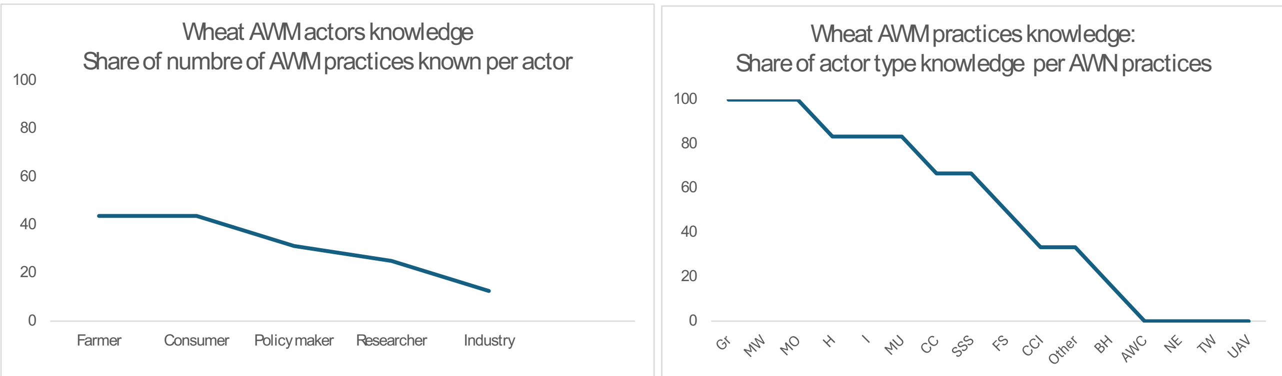


Figure 4. Wheat AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH:Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr:Grazing; FS:False seed, H:Herbicide, I: Intercropping, MO:Mowing; MU:Mulching, MW: Mechanical weeding, Ne:Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV:Unmaned aerial vehicle.

The **questionnaires** associated with wheat included answers for **chemical weed control** linked to the use of herbicides (advisors, consumers, farmers, industry, policy maker and researchers) and site specific spraying (advisors, consumers, farmers, and policy maker), **physical weed control** such as mechanical weeding (advisors, consumers, farmers, policy makers and researchers) and **digital solutions** (unmanned aerial vehicle), but not **nature based solutions**. The deep summary of the questionnaires can be found in Annex II.

Chemical weed control linked to the use of herbicides and site specific spraying. There is a clear difference between the perspective of using ***herbicides*** as a chemical weed control. On one hand, farmers, advisors, and consumers collectively share a pessimistic view on herbicide-related opportunities and on the other hand, stakeholders linked to industry, policy makers, and researchers hold a more optimistic perspective, partially considering the practice to increase business profitability and stabilize crop yields, foster IPM, and potentially evolve into an important scientific discipline. All stakeholders consistently express, in varying proportions, that cost reduction and regulatory changes are highly relevant needs for herbicide use. Additionally, over half of advisors, consumers, industry representatives, and policy makers emphasize the necessity of ecosystem services impact knowledge. Regarding main barriers, advisors, consumers, farmers, industry representatives, and researchers unanimously identify environmental and human harm as the most relevant factor. Regulation and high carbon footprint are also cited by most stakeholders as significant impediments to use herbicide use in the case of the wheat. However, half of surveyed policy-makers do not perceive environmental and human harm as a highly relevant challenge. Almost all stakeholders agree that herbicides harm to the environment and humans, customer demands to either eliminate or reduce herbicides, and high carbon footprint are relevant impediments to herbicide use, with at least 50% agreement in each group. With regard to ***Specific Site spraying***, consumers have a pessimistic perspective about this technology. Key needs included by advisors were timing, and maintenance reduction. As happened with the herbicides, environmental and human harm was unanimously identified as the primary barrier, followed by a high carbon footprint and expensiveness. Training, lack of funds, and regulation are additional impediments. Main disadvantages include public demand for reduced use, high carbon footprint, and potential harm to the environment and human.

Physical weeding included mechanical wedding. Consumers and advisors identified that the implementation of ***mechanical weeding*** will reduce herbicide reliance and agreed with farmers and policy makers on its potential to promote IPM strategies. Advisors identified practicing knowledge skills as the most relevant need, which was also deemed as relevant by 40% of consumers. Around 40% of the consumers also declared ecosystem services impact knowledge as highly relevant, being also considered crucial by half of the farmers and advisors plus one third of the policy makers. Reduction of maintenance, cost, and timing were also stated as relevant necessities by all researchers and half of the farmers and one third of the policy makers. Advisors, consumers, and researchers identified high carbon footprint as the main barrier for mechanical weeding. Expensiveness was deemed as highly relevant by advisors and as the main impediment by farmers, in line with what policy makers expressed as they view lack of funds as the most important barrier. Concerns over customer demand for mechanical weeding reduction are shared among advisors, consumers, and researchers. Besides, a high carbon footprint was considered by a relevant proportion of advisors, farmers, policy makers, and researchers. Lastly, concerns with regards to expense were expressed by consumers and farmers.

Digital weeding was linked to ***Unmaned Automated Vehicle*** (UAV) only nuanced by advisors view on UAV opportunities, with one-third recognizing its potential. Key needs include ecosystem impact knowledge and regulatory changes, while barriers and disadvantages, such as environmental harm and expense, align with the distributed nature of opportunities. This suggests a cautious yet informed stance among advisors on UAV integration in agriculture.

The knowledge of AWM for wheat weeding is limited to herbicide (but not SSS), mechanical weeding and mowing and digital (AWC), which is a major concern due to the large land use and consumption of wheat in Europe.

3.1.4.5 Conclusions

Stakeholders highlighted that herbicides use is the most successful tool to overcome wheat weeds while major needs, barriers and gaps aspects linked to technical, educational, environmental and economic issues to support AWM. AMW use in wheat are seen very positively without threats mentioned, that may be hinder by the future use. Even though, stakeholders are aware of the risk, they consider that if adequate doses and application number are adequately applied then minimum damage is expected for environment and health. This is especially relevant for wheat, that is one of the most important crops in the world and in the EU, the flour one of the most consumed cereal in Europe and there is a large area of fertile soils occupied by wheat, that may be reducing the soil health. Moreover, the knowledge of AWM for wheat weeding is limited t herbicide (but not SSS), mechanical weeding and mowing and digital (AWC), which is a major concern due to the large land use and consumption of wheat in Europe.

3.1.5 Maize

3.1.5.1 Contextualization

The maize LL represent 100 farmers. Around 10% of the farmers does not rotate maize with other crop, while 60-70% rotates maize with winter wheat and the rest mix maize with wheat and soybean or sunflowers. Maize is mainly used as a forage and other sell in the market. The most relevant weeds are Johnsongrass, Goosefoot and Amaranth or pigweed. Farmers mostly uses herbicides from more than 15 active ingredients of 6 MOAs used as per-emergence and post-emergence. Around 25% of the farmers mix herbicides with mechanical control. **Resistance is declared. Maize stakeholders do think that growing maize without herbicides is not viable.**

3.1.5.2 Weeding needs, barriers, gaps and opportunities

The main needs, barriers, gaps and opportunities described by the stakeholders can be seen in Table 5. Maize weeding needs are linked to policy (regulatory changes, policy concerns), technical (treatment organization and combination of strategies), educational and environment (AWM adaptation to climate change).

Table 5. Maize main needs, barriers, gaps and opportunities

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Maize LL **(Serbia)**	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. 2. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 3. **Regulatory changes- Policy concerns.** They consider that there needs to be a redefinition in policies, increasing subsides to implement sustainable practices. Stakeholders, especially farmers are skeptical about nonchemical methods. 4. Enhancement in **technical aspects**, especially those related to decreased maintenance, costs and timing. Stakeholders also emphasize the need for increased efficiency in non-chemical weed management. 5. **Treatment optimization** and increases in the design of **combination strategies**.	1. **Expense** emerges as the most relevant barrier. Farmers consider that the use of herbicides as the sole weed management practice is not viable. 2. **Environmental or human health harm.** Stakeholders consider that herbicides have a negative impact on the environment. 3. **Educational aspects** they demand increased training about AWM and combination of strategies 4. **Lack of technology** and other **technical aspects** in the region. That may hinder the adoption of AWM practices. 5. Some farmers reported instances of **herbicide resistance** which are increasingly concerning in the recent years.	1. **Lack of technology** and other **technical aspects** in the region. That may hinder the adoption of AWM practices. 2. **Cost of application** of AWM practices compared to herbicides. 3. **Herbicide resistance,** human health and environmental concerns were voiced for the use of herbicides. Besides, stakeholders considered **treatment optimization** as a relevant gap. 4. Create **market for organic produce**. 5. Lack of drivers for **change in farmers habits**. As they are pessimistic about the adoption of AWM. Education and increases in knowledge and the adoption of multi-actor approaches might crucial.	1. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. 2. **IPM fostering**. They consider that AWM increases IPM strategies adoption. 3. **Ecosystem services provision,** including increased water quality and availability, improvements in biodiversity as well as an amelioration on soil health. 4. **Reduction of herbicide reliance**. As a result of the implementation of mechanical weeding, mowing or automated weed management. 5. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.**

With regard to barriers they are linked to education, technology (lack of technology, herbicides resistance, policy (expensive and lack of funds for AWM) and environment (human and environment harm) and social (public opposition). As happened with wheat**, maize weeding is mainly linked to herbicides and farmers see major needs, barriers and gaps aspects linked to technical, educational, environmental and economic issues to support AWM. This is a major concern for human and environment perspective due to the large area of fertile soils occupied by wheat, that may be reducing the soil health.**

3.1.5.3 Weeding techniques SWOT analysis

3.1.5.3.1 Herbicides

The **herbicides SWOT** analysis for maize highlighted no **opportunities** but researchers found efficacy (R), low cost (R), simplicity and economic benefits as **strengths**. Agricultural policy is seen as a **threat** and agricultural policy (A) as a **threat.** Many **weaknesses** are highlighted for the herbicides such as new equipment (A, F) and herbicide resistance.

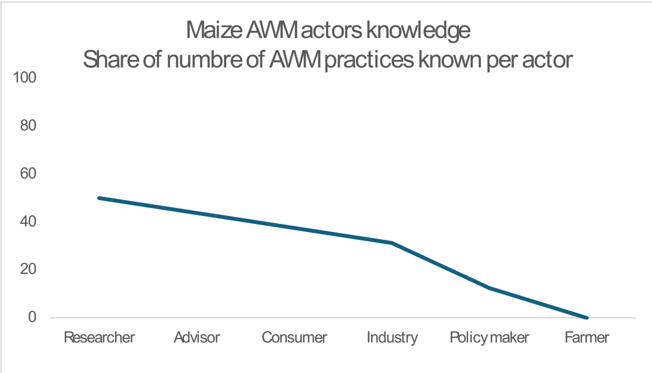
3.1.5.3.2 Agroecological weed management techniques

The **AMW SWOT analysis** revealed that stakeholders and advisors think that there are **opportunities** for new technologies and machinery and training and education for farmers, researchers and advisors while effectiveness only by farmers. No **strengths, threats or weaknesses** are mentioned.

The SWOT analysis shows as happened with the wheat, the main strengths of herbicides and the main concern towards the future that may prevent to use them and the crop resistance. AMW use in maize are seen very positively without threats mentioned, that may be hinder by the future use.

3.1.5.4 Weeding techniques evaluation

The **maize questionnaire** (Annex II) was answered by 41 actors in total answering about automated weed control, biobased herbicides, cover crops, false seeds, herbicides, intercropping, mechanical wedding, mowing, mulching, site specific spraying and unmaned aerial vehicle. For maize the most knowledgeable stakeholders about AWM are researchers followed by advisors and consumers above 35%, being industry, farmers and policy maker not aware of most of the AWM (Figure 5). As happened with wheat a digital tool is the most used AWM practice (automated weed control) after herbicides but unmaned aerial vehicle is not so much used. However, digital technics such as unmaned aerial vehicle are also extensively used but automated weed control is not used. Recent techniques (thermal weeding) or nature-based solutions (natural enemies, cover crop inoculated or grazing) is not used to weed maize.



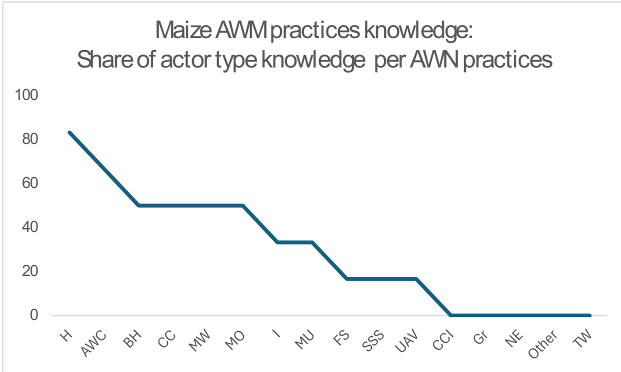


Figure 5. Maize AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle.

The **questionnaires** associated with maize included answers for **chemical weed control** linked to the use of herbicides (advisors, consumers, industry, policy maker and researchers but not farmers), **physical weed control** such as mechanical weeding (advisors, consumers and researchers) and mowing (advisors, consumers, and researchers) and **digital solutions** (automated weed control), but not **nature based solutions** as happened in wheat. The deep summary of the questionnaires can be found in Annex II.

The maize **chemical weed control** highlights only the **herbicide**, recognizing all surveyed actors unanimously the potential of herbicide use in addressing critical agricultural needs, such as crop yield stabilization, income increase, and ecosystem service provision. Moreover, despite differing views, stakeholders unanimously acknowledge the drawbacks of herbicide use, particularly environmental and human harm, expense, and customer demands for reduction. Advisors emphasize opportunities like crop yield stabilization, income increase, and the potential for fostering IPM strategies and providing ecosystem services. Consumers also highlight the negative effect of herbicides on ecosystem service provision and crop yield stabilization, with business profitability as a relevant opportunity. Researchers underscore ecosystem service provision, biodiversity increase, and soil health improvement, seeing potential for herbicides to evolve into a vital scientific discipline. Key necessities identified across stakeholders include regulatory changes, management expertise, training, and cost reduction, with researchers emphasizing ecosystem services impact knowledge. However, there is notable disparity in perceptions of herbicide barriers, with advisors downplaying significant obstacles despite acknowledging environmental and human harm, while consumers and researchers identify various challenges from training and regulatory issues to environmental concerns and expense. **Overall, the diversity in perspectives underscores the complexity of herbicide use and the importance of considering a range of factors, from regulatory frameworks to environmental impact on decision-making processes within the agricultural sector.**

The **physical weed control** in maize was linked to mechanical weeding and mowing. Stakeholders recognize the vast opportunities presented by **mechanical weeding**, as they all consider the potential reduction of herbicide reliance, fostering IPM strategies, providing ecosystem services, and its possible evolution into an important scientific discipline as highly relevant. There is a range of perspectives on the associated necessities, barriers, and drawbacks. Regarding primary needs, advisors and researchers emphasize improvements in efficiency, while consumers prioritize management expertise. Additionally, a considerable proportion of all stakeholder categories consider timing reduction as an important need for mechanical weeding. As for the main barriers, advisors unanimously cite expensiveness, while researchers consider a plethora of topics relevant, including low efficiency, complexity, time consumption, training, lack of funds, and regulatory issues, alongside expense. In contrast, consumers consider few barriers as relevant for mechanical weeding.. With regard to **mowing**, consumers recognize the opportunities this technique has, including its potential to enhance water quality, biodiversity, and soil health. While they emphasize the need for knowledge and skills development, concerns about time consumption and lack of funds are prominent. **Notably, while advisors highlight customer demands to reduce mechanical weeding, expense, and time consumption as the main disadvantages, consumers only consider expense, and researchers point to low efficacy, expense, and complexity as the most relevant drawbacks. Interestingly, few disadvantages were deemed highly relevant by respondents, indicating a generally positive outlook on mowing as an agricultural practice.**

The **digital weed control** was linked to **Automated Weed Control** (AWC) but not to UAV as happened with the wheat. Perceptions surrounding AWC among advisors, consumers, and researchers converge on a perspective filled with opportunities, yet they acknowledge substantial needs, barriers, and drawbacks. Advisors uniformly anticipate its potential to stabilize crop yields, promote IPM strategies, and serve as an ecosystem services provider, simultaneously foreseeing economic benefits. Consumers, in alignment, accentuate its role in improving water quality and stabilizing crop yields. Advisors and consumers identify ecosystem services impact knowledge, regulatory changes, management expertise, training, and cost reduction as imperative needs, and emphasize training as the primary barrier. Meanwhile, researchers, affirming the optimistic outlook, underscore the potential for increased business profitability, crop yield stabilization, and evolution into a scientific discipline. Critical needs articulated by advisors encompass, enhancing knowledge skills, training, and mitigating costs, maintenance, and timing concerns. Noteworthy needs for researchers encompass regulatory changes, knowledge skills enhancement, and reduction of costs and maintenance. The unanimity in identifying training as a primary barrier across all stakeholders is noteworthy, as is the shared concern about environment and human harm. The varied perspectives on drawbacks, ranging from customer demands to reduce automated weed control, to time consumption, underscore the multifaceted nature of challenges associated with the adoption of automated weed control. **In synthesis, while the stakeholders unanimously acknowledge the promising aspects of automated weed control, the divergent emphasis on specific needs, barriers, and drawbacks emphasizes the importance of nuanced considerations in its implementation and integration within agricultural practices.**

Most of maize direct stakeholders such as farmers or industry are not aware of AWM. Herbicides are positively described in spite of the recognition of the health and environmental damage it can cause.

3.1.5.5 Conclusions

Maize stakeholders do think that growing maize without herbicides is not viable in spite of recognizing problems associated with the resistance. Maize weeding is mainly linked to herbicides and farmers see major needs, barriers and gaps aspects linked to technical, educational, environmental and economic issues to support AWM. This is a major concern for human and environment perspective due to the large area of fertile soils occupied by wheat, that may be reducing the soil health. Moreover, the herbicide SWOT analysis shows as happened with the wheat, the main strengths of herbicides and the main concern towards the future that may prevent to use them and the crop resistance. AWM use in maize is seen very positively without threats mentioned, that may be hinder by the future use. Overall, the diversity in perspectives underscores the complexity of herbicide use and the importance of considering a range of factors, from regulatory frameworks to environmental impact on decision-making processes within the agricultural sector. The main AWM alternatives are hindered by a set of challenges, for example for mechanical weeding, expensiveness and time consumption are perceived as the main disadvantages, consumers only consider expense, and researchers point to low efficacy, expensiveness, and complexity as the most relevant drawbacks. For mowing, few disadvantages were deemed highly relevant by respondents, indicating a generally positive outlook as an agricultural practice. Finally, stakeholders unanimously acknowledge the promising aspects of automated weed control (AWC) however they diverge on specific needs, barriers, and drawbacks AWC has, which emphasizes the importance of nuanced considerations in its implementation and integration within agricultural practices.

3.2 Annual crops: Legumes

3.2.1 Legumes global analysis

3.2.1.1 Contextualization

The legume section tackles the analysis of two types of legumes: cowpea (Portugal) and Soybean (Serbia). The cropping management strategies differ. Soybean production system is more inversive, whereas cowpea is organically produced. Both legumes are a part of a rotation system, consisting of two elements in the case of cowpea and of three elements in the soybean cropping system.

The organic management in cowpea ensures that no herbicides are used, therefore, no problems regarding resistance are reported. Soybean relies heavily on herbicides, which are typically sprayed twice per season. Interestingly, while cowpea LL attendants considered that dosage influenced herbicides impact on environment, soybean stakeholders recognized their detrimental effects.

Both regions and cropping systems face a lack of technical resources in their area and considered the creation of a regional market for more sustainable produce as key to foster AWM. Attendants to both LL identified a change in policies as a need, however, while cowpea LL stakeholders considered goal-oriented subsidies, soybean stakeholders failed to express their preferred policies to increase AWM adoption.

Cowpea LL attendants considered agriculture without herbicides as possible, whereas soybean LL participants do not consider this option as viable. An increase in farmers funding and educational activities, enhancing extension services may be pivotal to ensure AWM transition.

3.2.1.2 Weeding needs, barriers, gaps and opportunities

All legume stakeholders found education and improvement in educational aspects, scientific knowledge and regulatory-policy chances as relevant **needs** related to weeding, being the cost, the weather (especially climate change) and also problems for environmental and human health problems related with herbicides as the main barriers. They declared **gaps** to overcome the weed challenges, including the lack of extension services and technology/technical advances added to the cost of some services, practices and products (AWM practices were emphasized) to achieve the goal of market demands. Finally, legume stakeholders see opportunities on find techniques stabilizes crop yields and increases business profitability, like AWM, that can provide more ecosystem services provision and improve economical and business aspects.

3.2.1.3 Weeding techniques SWOT analysis

3.2.1.3.1 Herbicides

Herbicides usage differs when comparing weed management strategies in Cowpea *vs.* Soybean. Overall, both SWOT analysis recognized environmental harm as a weakness, with its use being considered as more detrimental to biodiversity by cowpea stakeholders. Additionally, stakeholders from both LL considered herbicide efficiency as an important strength, with resistance events recognized only in soybean. Moreover, interviews from soybean emphasized the lack of technology as a relevant threat related to herbicide efficiency.

3.2.1.3.2 Agroecological Weed Management techniques

Legumes SWOT analysis revealed that AWM strategies are being implemented to an extent in cowpea cropping, as more than 10 weeding practices and combination were acknowledged by respondents. On the other hand, and despite soybean is more intensively managed, both crops are a part of a crop rotation system, leading to bettering soil health among other benefits. Globally, legumes analysis considered training and education as relevant for fostering AWM practices in both cropping systems. Besides, cowpea stakeholder emphasized the establishment of peer-to-peer knowledge dynamics as relevant for the transition, whereas evolution of the soybean cropping system to more sustainable alternatives, needs for new machinery and equipment.

3.2.1.4 Weeding techniques evaluation

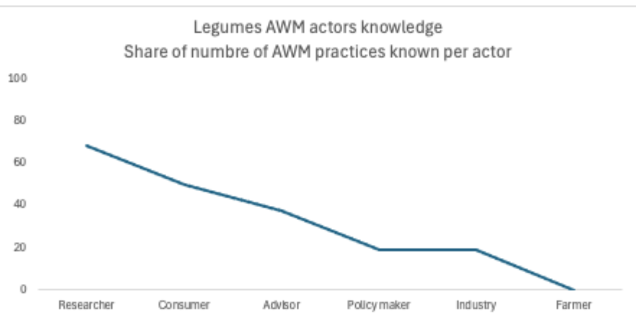
In legumes the initial perception gathered in the **questionnaires** were that most of technique were know as shown in Figure 6. The unique unknown technique for stakeholders was the use of natural enemies (NE). Cereal questionnaire were answered by around the 12,5 % of the whole interviewees. From those consumers and researchers (26%) were those with the higher share of answer followed by advisors (14%), being the rest below the 15%, with only 9% of farmers.

The most important thing to implement good AWN practices is to know all the techniques in order to be able to combine them and use them according to the needs of the crops and the characteristics of the territory. In the questionnaires some techniques such as CCI, TW or UAV were completely unknown for all stakeholders and some were only recognised by specific groups such as researchers. It is also relevant the low technical knowledge of farmers about the number of existing AWC techniques (Table 6).

Table 6. Actors vs practices matrix awareness in cereal weed management. Cells highlighted in light green correspond to practices considered as relevant across all crop types, whereas rows highlighted in red correspond to practices considered irrelevant across all crop types. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle.

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
AWC	1	2	0	2	2	2
BH	1	3	0	1	1	3
CCI	0	0	0	0	0	0
CC	2	2	0	1	0	3
FS	0	0	0	0	0	3
Gr	2	1	0	0	0	5
H	5	10	0	7	4	3
I	2	2	0	1	1	2
MW	4	9	1	6	3	8
MO	2	9	0	0	0	7
MU	1	3	1	1	0	2
NE	0	1	1	0	0	1
Other	1	1	0	0	1	0
SSS	1	1	0	0	1	3
TW	0	0	0	0	0	0
UAV	0	0	0	0	0	0

Figure 6 shows the degree of knowledge on the legumes crops of the different type of actors as a matrix. Mechanical wedding is the most knowledgeable form of weeding, followed by herbicides, that is not of interest for farmers.



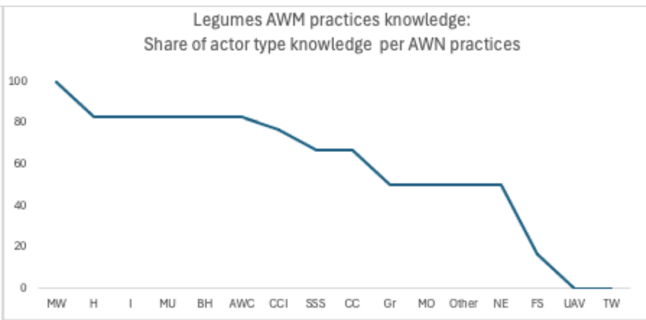


Figure 6 Legumes AWM practices by the whole set of interviewed actors as percentage of the number of actors answering with regard to those interviewed. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H:Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle.

3.2.1.5 Conclusions

Both legumes (cowpea and soybean) are part of a rotation system. However, weeding strategies and therefore overall weeding techniques perception differs. Cowpea weeding consist of a mixture of more than 10 practices and their combination, as it is typically organically managed no to little herbicides are used to ensure yield. The produce is used as as human food and its considered valuable by markets and administration, which are promoting its cultivation. On the other hand, soybean production relies heavily on herbicides, as most farmers spray at least twice per season. Herbicide resistance events were reported and the region suffers from a lack of technologies. Soybean is mainly produced to become forage, and therefore increasing the value of the produce results harder.

3.2.2 Cowpea

3.2.2.1 Contextualization

Cowpea cropping in Portugal is associated with cereal crops, being mostly organically managed. *Vigna unguiculata* (cowpea) is a legume cultivated mainly in Southern European Countries. Consumer demand for this crop is rising due to its nutritional content. In addition, its short biological cycle makes this crop ideal for partaking in crop rotation systems, as it presents high rates of nitrogen fixation, phosporus use efficiency and regrowth capacity (Lazaridi and Bebeli, 2023).

Portuguese Cowpea LL revealed a low share of farmers cultivating cowpea for production, as most of them use the crop as part of a crop rotation system, encouraged by public subsidies. Farmers are aware of the lack of definition of “agroecological management” and consider that its promotion without instating a clear definition before may be problematic, as it may induce “greenwashing” of certain types of unsustainable cropping management. Stakeholders emphasized the lack of technologies, funds and machinery in the region.

The increase in demand described by Lazaridi and Bebeli (2023), was also acknowledged by stakeholders participating in the LL. The increased consumer interest is driving up prices, boosting its cropping in the region.

Weeding management practices differ according to the irrigation system (rainfed or irrigated) in cowpea crops. Sowing, pruning, terrain preparation and weeding were listed as weeding practices in the cropping system. Cowpea is always organically managed, and therefore crop rotation is mandatory. Organic management also impedes the usage of herbicides as a mean for weed management. Thus, production of the crop without herbicides is already instated in cowpea.

Stakeholders shared several suggestions for boosting the agroecological transition, including educational activities, the creation of more producers unions as well as the description of species-specific cropping protocols that enhance uptake. Described barriers included lack of funds and machinery, as well as human resources. Stakeholders suggested measuring environmental impact of AWM vs. herbicides to encourage farmers to switch their weeding practices. It is worth mentioning that LL participants considered certain dosages of herbicides as innocuous to the environment.

3.2.2.2 Weeding needs, barriers, gaps and opportunities

Table 7 shows the most relevant needs, barriers, gaps and opportunities found for cowpea. Cowpea weeding **needs** are linked to improvements in educational aspects as well as in scientific knowledge, as expressed in the LL board meeting organized in Portugal. Additionally, enhancement in technical aspects, especially those related to decreased maintenance, costs and timing. Additionally, stakeholders recognized a need for a redefinition of policies, aiming subsidies to specific and measurable goals and especial cases. Most relevant **barriers** included expense, as farmers acknowledged the costs of AWM as an important spending. Herbicides are not sufficient as the sole control practice in cowpea weeding. Climate change is recognized as a key barrier, especially for rainfed cowpea. The **gaps** were associated to lack of extension services, hindering the adoption of more sustainable and cost-effective approaches, and the realization of the lack of practical knowledge in advisory services. Stakeholders recognized a lack of drivers for change in farmers habits as a relevant gap. Cowpea stakeholders considered IPM fostering as a result of the implementation of AWM as a key **opportunity**. Besides, the acknowledgement of ecosystem services provision and the creation of synergies within and beyond the farm were also emphasized. **Cowpea stakeholders recognized the importance of educational and scientific aspects to improve AWM uptake. Additionally, the expense barriers and the lack of technology in the area may hinder the adoption of greener weeding practices. Climate change in rainfed cropping was also raised as a relevant concern. Recognized gaps were related to a lack of extension services, leading to a decrease amount of drivers for change among farmers. Cowpea stakeholders considered AWM as an opportunity to foster IPM, while emphasizing ecosystem services provision as synergies creation as other relevant outcomes of AWM.**

Table 7. Cowpea main needs, barriers, gaps and opportunities.

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Cowpea LL (Portugal)	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. They emphasize the importance of site-specific practices. 2. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 3. Enhancement in **technical aspects**, especially those related to decreased maintenance, costs and timing. 4. **Lack of advisors** and **few extension services** hinder cowpea AWM practices. 5. **Regulatory changes- Policy concerns.** Stakeholders consider that there needs to be a redefinition of policies, aiming subsidies to specific and measurable goals and especial cases. Additionally, they consider that AWM practices should have a certification to be easily identified by consume	1. **Expense** emerges as the most relevant barrier. Farmers acknowledge the costs of AWM in this crop. They acknowledge that herbicide use as the sole control practice is not a possibility in cowpea. 2. Cowpea fields are rainfed, therefore **weather** and especially **climate change** are considered as key barriers. 3. **Environmental or human health harm** as well as **high carbon footprint** of some practices**.** Stakeholders consider that herbicides, site-specific spraying and mowing as practices that may be detrimental to environment and human health. 4. Emergence of **invasive species**. 5. **Public's opposition** to the application of certain approaches (specially chemical management) as well as **customer demand** to **reduce** their use.	1. **Lack of extension services**, which hinder adoption of greener practices. Farmers consider that **advisory services** are often far from field reality. 2. Lack of drivers for **change in farmers habits**. As they are pessimistic about the adoption of AWM, and shared concerns regarding the conflict with organic producers. 3. Absence of **market recognition** of crops produced using greener approaches. 4. Increase in e**nergy prices** and other energetic inputs, as well as **lack of technology** in the region. 5. **High timing of application** of AWM practices compared to chemical weeding.	1. **IPM fostering**. They consider that AWM increases IPM strategies adoption. 2. **Ecosystem services provision,** including increased water quality and availability, improvements in biodiversity as well as an amelioration on soil health. 3. **Creation of synergies** as a result of the adoption of AWM approaches and their combinations. 4. Harmony with new **European policies** (Fork2Farm) as well as consumer sentiments. 5. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.**

3.2.2.3 Weeding techniques SWOT analysis

3.2.2.3.1 Herbicides

From the SWOT analysis revealed that no **opportunities** or **strengths** were identified for herbicides. Main **threat** pointed from all the groups of stakeholders was the pressure on reducing the use of herbicides in cowpea weeding. Additionally, market pressure was identified as a threat for researchers and advisors Lastly, **weaknesses** related with environmental issues were highlighted from all stakeholders (environmental impact and biodiversity decline and pollutants. Additionally, farmers emphasized economic aspects related to the prices of products and human health risks and researchers were concerned of residues, lack of knowledge and certificates. **Cowpea herbicides SWOT analysis included few threats and weaknesses, being mainly related to environmental impacts, human health risks and problems associated knowledge, prices and pressure to reduce the use from the EU.**

3.2.2.3.2 Agroecological Weed Management techniques

The SWOT analysis of AWM revealed opportunities and strengths, with few weaknesses and threats related with climate for farmers. With regard to **opportunities**, all actors considered training as the main one of the list. Subsidies and synergies between stakeholders were also pointed as remarkable opportunities (R, A). Efficacy (F), Environmental sustainability (A), Less inputs and feed source for animals was noted as important for farms. For advisors, opportunities regarding peer to peer knowledge, new markets prices and products were highlighted. Identified **strengths** related with environmental and social aspects were remarked by all groups (improve soil health and training). Research associated and efficacy is remarked by farmers and advisors. Other strengths like less soil disturbance, cultural aspects, reduction of costs and accessibility to farmers were also marked for al least one of the groups. **Weakness** related to AWM were the lack of extension services and timing of application for farmers. **As a summary, AWM main opportunities and strengths are related with environmental and social aspects.**

3.2.2.4 Weeding techniques evaluation

The Cowpea **questionnaires** were answered by 28 actors (Annex II). Researchers and consumers are the actors harboring more knowledge on techniques and practices used on cowpea production (Figure 7). Farmers reported the use of grazing and rotational techniques, especially combined with cereals. Grazing and mowing are the most knowledgeable techniques to weed cowpea. A low share of knowledge of digital tools (automated weed control, unmaned aerial vehicle), recent techniques (thermal weeding) or nature-based solutions (natural enemies) was identified.

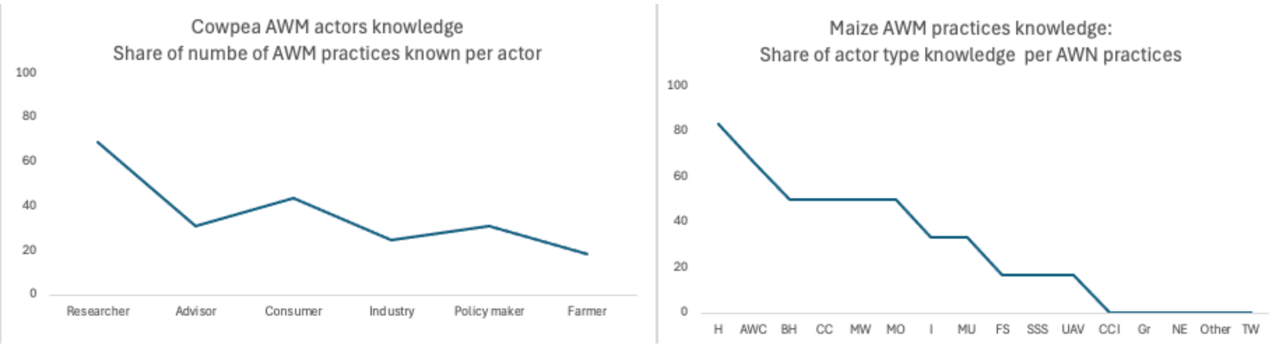


Figure 7 Cowpea AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle.

The description of cowpea results from questionnaires classified by type of actors are shown in Annex II, were a deep stakeholder analysis (including perspectives of researchers, consumers, advisors, farmers, industry representatives and policy makers) for biobased herbicides, cover crops, grazing, herbicides, mechanical weeding, mowing and site-specific spraying is performed. With regard to ***herbicide use***, consumers, industry representatives, and researchers perceive herbicides as offering numerous opportunities, as stakeholders anticipate the role of herbicides in providing ecosystem services, while also foreseeing their evolution into an important scientific discipline. Significant needs, barriers, and some disadvantages were recognized, including ecosystem services impact knowledge, regulatory changes, lack of advisors and training among others. Interestingly, advisors and farmers did not considered chemical weed management of importance for cowpea production. Biobased herbicides and site-specific spraying emerged as relevant **chemical weeding** techniques being recognized by researchers. Biobased herbicides were considered as promising but requiring significant attention to needs and barriers. On the other hand, site-specific spraying was seen as beneficial for IPM strategies and ecosystem services. They emphasize the need for knowledge enhancement and training while identifying environmental and human harm, training, and regulation as key barriers. With regard to **nature-based solutions,** temporal (cover crops) or spatial (grazing) use of biodiversity was emphasized by researchers. Both practices are recognized as beneficial for soil health and as fosterers of IPM strategies. Cost reduction was emphasized as the main need in grazing, whereas training was a key need in intercropping. Expense was acknowledged as a relevant barrier in both weeding systems. **Physical weeding** practices included mechanical weeding and mowing. Mechanical weeding was considered as a practice with abundant opportunities, as noted by advisors, consumers, industry representatives, and researchers, recognizing its potential to increase profitability, stabilize crop yields, reduce herbicide reliance, foster IPM strategies and provide ecosystem services. The main disadvantages identified across all groups were environmental and human harm, expense, and low efficacy, with other factors receiving varying levels of emphasis. On the other hand, mowing was recognized as a relevant technique by researchers, considering provision of ecosystem services, crop yield stabilization and reduction in herbicide usage as its main opportunities.

3.2.2.4.1 Conclusions

Traditional weed control methods in cowpea cultivation face important challenges, such as environmental impact, risks to human health and high costs, combined with an increasing pressure to reduce their use. On the other hand, AWM techniques offer clear advantages in sustainability, improve soil health, reduce costs and promote knowledge among farmers. The main challenges are climate and lack of extension services. It is mandatory the use of AWM through subsidies, training and research support to improve its application and effectiveness, while creating market incentives to support this sustainable transition.

3.2.3 Soybean

3.2.3.1 Contextualization

Soybean production at a EU level declined sharply (about 7,6%), due to adverse weather conditions, despite the expansion in harvested area, being increased an estimate 16.5% (Eurostat, 2024). The Soybean LL is located in Serbia. The cropping system consists of a three-crop rotation based on maize/winter wheat/soybean. Most farmers considered that agroecological management needs to be promoted in the market, while recognizing that the region suffers from a lack of technology. The regional value chain is considered to be sustainable. Soybean is mainly used in livestock feeding.

Weeding management is considered challenging in soybean cropping. Stakeholders identified a set of problematic weeds, including Johnsongrass, Amaranth species or ragweed. Herbicides represent the most relevant weeding control method. A minority of farmers combine chemical management with mechanical control.

There are 10 active ingredients and 4 modes of action. Farmers spray twice per season, with a pre-emergence and post-emergence application. Herbicides are widely used and efficient against grasses, while the broad-leaves control represents a challenge. LL attendants recognized that other weeding strategies may be as efficient as herbicides, however they consider expense as the main barrier for transitioning to other practices. Herbicides are recognized as harmful for the environment, yet stakeholders considered agriculture without herbicides as inviable.

The increase in AWM implementation necessitates for subsidies from the government. Besides, linked to the promotion of agroecology, soybean LL participants considered the creation of a market for these products as important. Main barriers for AWM are lack of knowledge and equipment, being related to the lack of technology in the region. Stakeholders considered a redefinition of policies as important to allow transition, no specific changes in current policies were suggested. Farmers have low confidence with regard to the adoption of AWM, advisors considered as a very complicated task, consumers support the transitions and researchers showed interest with regard to cover crops use.

The lack of confidence of farmers and their pessimistic perception of agroecological implementation confronts with the perceived main drivers of weed dispersal, as they considered the chemical industry as the main driver for weed dispersal to sell their expensive products. Most relevant weeds are Johnsongrass, common ragweed, Chenopodium and Amaranth species. Johnsongrass and Redroot pigweed are resistant to some herbicides. Stakeholders were mostly interested in the economic analyses of each alternate weed control measure very important because it might influence on the total price.

3.2.3.2 Weeding needs, barriers, gaps and opportunities

Table 8 shows the main needs, barriers, gaps and opportunities for soybean cultivation. Soybean weeding **needs** are associated with improving educational aspects, including training farmers in technical, economic aspects and redefinition in policies. The development of a market for agroecologically produced soybean, is considered as the most important need. Most relevant **barriers** included expense, as AWM practices are equally effective but less cost-effective. Herbicides are regarded as having a negative impact on the environment. Educational aspects and a lack of technology are also regarded as important challenges. **Gaps** regarding weeding control, include the lack of technology in the region as well as other technical difficulties that emerge in the region. The cost of application in AWM practices compared to herbicides is repeatedly considered as a problem regarding adoption. Herbicide resistance and treatment optimization are recognized as important gaps. **Opportunities** include economical-business related aspects, stakeholders recognize AWM role in stabilizing crop yields and increasing business profitability. Ecosystem services provision and IPM fostering were recognized as additional opportunities for AWM adoption. **Soybean stakeholders remain reluctant to implement AWM, as these practices are considered to be more expensive compared to herbicides. The lack of technology in the region and the absence of a market for the produce hinder AWM adoption.**

Table 8. Soybean main needs, barriers, gaps and opportunities

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Soybean LL (Serbia)	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. They emphasize the importance of increasing the knowledge related to cost structure and economical analysis. 2. Enhancement in **technical aspects**, especially those related to decreased maintenance, costs and timing. 3. **Regulatory changes- Policy concerns.** Stakeholders adopt a positive stance toward non-chemical weed management. They consider that there needs to be a redefinition of policies, aiming to an increase the government subsidies. 4. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 5. **Lack** of **funding and labour** for the implementation of AWM practices in soybean.	1. **Expense** emerges as the most relevant barrier. Farmers consider that the use of non-chemical weed management is equally efficient yet not economically viable. 2. **Environmental or human health harm.** Stakeholders consider that herbicides have a negative impact on the environment. 3. **Educational aspects** they demand increased training about AWM and combination of strategies 4. **Lack of technology** and other **technical aspects** in the region. That may hinder the adoption of AWM practices. 5. Some farmers reported instances of **herbicide resistance** which are increasingly concerning in the recent years.	1. **Lack of technology and equipment** and other **technical aspects** in the region, that may hinder the adoption of AWM practices. 2. **Cost of application** in AWM practices compared to herbicides. 3. **Herbicide resistance,** human health and environmental concerns were voiced for the use of herbicides. Stakeholders considered **treatment optimization**, to decrease potential environmental harm as a relevant gap. 4. Create **market for organic produce**, which may result difficult as soybean is mainly used in livestock nutrition. 5. Drivers for **change in farmers habits**. As they are pessimistic about the adoption of AWM, they do not envision agriculture without herbicides as possible.	1. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. 2. **IPM fostering**. They consider that AWM increases IPM strategies adoption. 3. **Ecosystem services provision,** including increased water quality and availability, improvements in biodiversity as well as an amelioration on soil health. **4. Reduction of herbicide reliance**. As a result of the implementation of mechanical weeding, mowing or automated weed management. 5. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.**

3.2.3.3 Weeding techniques SWOT analysis

3.2.3.3.1 Herbicides

From the SWOT analysis revealed that NO **opportunities** were identified for herbicides. **Strengths** were associated with technical, efficacy, and economic aspects affordability (F, A, R). Quick results and economic benefits (F, A) were also considered as relevant strengths for herbicides. Stabilizing yields and the simplicity in the use was noted as important by farmers. Lack of new herbicides was marked as an important **threat** for all stakeholder groups (F, A, R). For advisors is also remarkable the pressure of markets and additionally the withdrawal of herbicides. Lastly, identified **weaknesses** include technical aspects as herbicide resistance and the lack of renewal equipment (F, A, R). Additionally, farmers and advisors emphasized social aspects related to lack of knowledge and training. **Soybean herbicides SWOT analysis didn't include opportunities for herbicides. Main strengths were related efficacy and economic aspects like low prices of the products. Herbicide resistance, lack of new herbicides and educational aspects were considered as important threats and weaknesses of herbicide use.**

3.2.3.3.2 Agroecological Weed Management techniques

The SWOT analysis of AWM included several opportunities but no strengths, threats or weaknesses to its implementation. Regarding **opportunities**, all actors considered social (training, subsidies and consultancy) benefits, as well as technical aspects related with new technologies. Additionally, advisors emphasized the importance of soil heath. **In summary, AWM was perceived by stakeholders as an option full of opportunities but with a lot of work to be done for it´s implementation as there are no strenthgs or threats identified for none of the stakeholders**

3.2.3.4 Weeding techniques evaluation

The soybean **questionnaires** were answered by 38 actors (Annex II), including consumers, advisors, researchers, industry representatives and policy makers.

The most important practices, as recognized by interviewed stakeholders included herbicides, mechanical weeding, mowing and mowing. (Figure 8 right). This part of the figure is also remarkable because it reflects the lack of technological advances associated with more modern AWM techniques or precision agriculture techniques associated with practices that have been completely unknown in the questionnaires such as False seed, Unmaned aerial vehicle or Inoculated cover croops. It is also interesting point that some practices as Grazing or Natural enemies wa

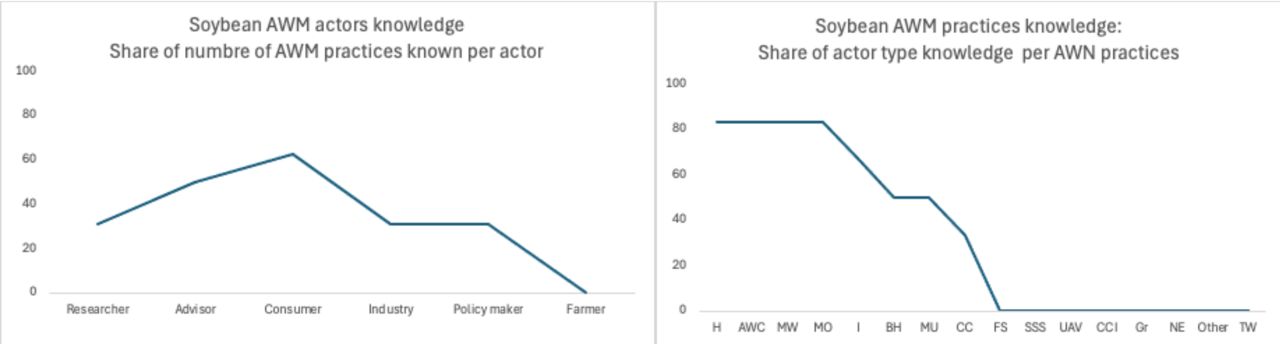


Figure 8. Soybeam AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle.

The description of Soybean results from questionnaires classified by type of actors are shown in Annex II, were a deep stakeholder analysis (including perspectives of researchers, consumers, advisors, industry representatives and policy makers) for herbicides, mechanical weeding, mowing, mulching. With regard to ***herbicide use***, advisors, consumers and industry representatives considered herbicides as an opportunity to foster IPM strategies and provide ecosystem services. Ecosystem services impact knowledge was considered as a key necessity for herbicides. Besides chemical weed management, soybean weeds are usually controlled through ***physical control*** means, including mechanical weeding, mowing and mulching. All of these control methods were considered as fosterers for IPM and providers of ecosystem services, however, technical aspects such as time consumption were considered as important challenges related to physical control methods. Customer demand to reduce both herbicides and physical control means were recognized across all the relevant weeding methods in soybean.

3.2.3.4.1 Conclusions

We can conclude that for herbicides, no opportunities were identified, although strengths related to technical and economic efficiency were highlighted. However, the main threats and weaknesses include herbicide resistance, lack of new products, and lack of training and equipment upgrades. In contrast, the SWOT analysis of agroecological weed management showed numerous opportunities, especially in social areas such as training, subsidies and advice, as well as technological advances and improved soil health. Despite these opportunities, no strengths or threats were identified, suggesting that although AWM has great potential, it still needs to be developed for effective implementation.

3.3 Annual crops: Cereal and legume mixes

3.3.1 Rye-pea analysis

3.3.1.1 Contextualization

Rye-pea cropping is a rotation system, where rye (*Secale cereale*), a cereal, are cropped during winter, whereas peas (*Pisum sativum*), a legume, are sown in spring. Rye experienced a sharp reduction in harvested area across EU in 2022, the production was 7.8 million tonnes. Interestingly, due to instability on global markets as well as the reduction in cereal production in EU, is increasing prices, with an increase in over 50% of rye prices considering changes from 2021 to 2022. Pea production accounted for 2 million tonnes (2010-2014), being mainly imported from third countries (Eurostat, 2024).

LL board meeting explained how rye production area is being reduced in recent years, as demand for consumption is virtually non-existent at the moment. Therefore, despite EU-level tendencies in price, value of rye yield is low in the region. Quantitative data regarding pea production was not included in the LL board meeting. However, attendants recognized pea nutritional value, the appearance of well-marketed products, such as yellow peas, or the production of grey peas, which are consumed traditionally in the region might be interesting to increase profitability in coming years.

The rotation system including rye and peas are not very common in the region. LL attendants emphasized rye's ability to suppress weeds through its allelopathic properties. In peas, row spacing and thickness of the crop are the main agronomic practices used. Weed management is mainly performed using harrowing (Mechanical weeding).

LL attendants knowledge on weeding differ, as each participant had a different level of expertise. Interestingly, most farmers ignore the active ingredients present in herbicides. According to advisors experience, there are about 10 active ingredients used in the region, being used specifically according to the weeds present in each field. Soil herbicides are mainly used in peas, being applied several times per season consisting of a combination of different active ingredients. Stakeholders highlighted glyphosate as the main ingredient applied before sowing rye. Efficiency of herbicides in the region was not shared by LL board members, which emphasized their detrimental impact on environment, focusing in contamination and resistance. Agriculture without herbicides was considered as viable, however, stakeholders shared concerns related to decreased productivity.

There is a lack on scientific evidence to confidently describe main drivers of weed dispersal in Latvia. Main weed in the region are Couch grass (*Elymus repens*), Thistle (*Carduoideae* spp.) and soft dandelion (*Taraxacum officinale*), other annual weeds were also emphasized as problematic in the region. Participants reported resistance events on *Poa annua* and *Stellaria media*. *Heracleum* spp. were identified as invasive species in the region. Besides, other potentially-invasive species were shared as concerning, including *Impatiens grandulifera*, *Solidago chinensis*

Market stabilization, leading to an increase in income levels for farmers, were considered as the main source to boost agroecological practices uptake. Recognized barriers included knowledge for farmers, consisting of effectivity of the alternative methods as well as customer demand of more sustainable produce. Stakeholders perceive that there is a lack of tools to achieve sustainable goals included in the Green Deal. Therefore, herbicides are regarded as the "easy way out" as they are perceived to be more convenient and cheaper compared to other practices. Besides, changes regarding subsidies distribution are important to ensure sustainable transition. Provision of practical evidence to farmers was perceived as the main driver for transition to AWM.

3.3.1.2 Weeding needs, barriers, gaps and opportunities

Table 9 shows the most relevant needs, barriers, gaps and opportunities found for rye-pea. Improvements in farmers education, as well as enhancement in technical aspects and dissemination of scientific research finding were emphasized as the most important **needs** for rye-pea cropping system. Besides, policy concerns and the need for regulatory changes were also considered as important to foster AWM transition. Most relevant **barriers** included expense as well as the public opposition to herbicides. Changes in flora related to intensive cropping systems, particularly the acknowledgement of the appearance of invasive species, as well as increases in farmers education were also regarded as important barriers. Identified **gaps** were in line with needs and barriers, as lack of knowledge and practical experience were emphasized as important. Potential risks to human health and environmental impact of herbicides, increases in bureaucracy and policy related challenges were voiced as important gaps to overcome in future years. Increasing multi-actor and holistic approaches to education and to research were also considered as lacking in the region. **Opportunities** of up-taking AWM were related to reduction of herbicide reliance, ideally reducing costs and providing ecosystem services. The increase in training programs, will enhance farmers professionalization and ease the integration of new practices in local agricultural systems. **Rye-pea stakeholders recognized the importance of educational and scientific aspects to enhance sustainable transition. Interestingly, they consider these aspects as a need, gap and as an opportunity to increase farmers professionalization and overall knowledge, encouraging producers. Policy related issues, including subsidies redefinition (need), herbicide prohibition (barrier) and excessive bureaucracy (gap). Creation of synergies and bettering usage of alternative practices were emphasized as relevant opportunities.**

Table 9. Rye-pea main needs, barriers, gaps and opportunities

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Rye-pea (Latvia)	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. 2. Enhancement in **technical aspects**, especially those related to decreased maintenance, costs and timing. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration and active dissemination of the results. 4. **Regulatory changes- Policy concerns.** They consider that there needs to be a redefinition in policies, they consider that there needs to be more subsides to implement more sustainable practices. Stakeholders, especially farmers are skeptical about nonchemical methods. 5. **Treatment optimization** and design of **combination strategies**.	1. **Expense** emerges as the most relevant barrier, emphasizing farmers **lack of funds** as important. 2. **Public's opposition** to the application of certain chemical weed management as well as **customer demand** to **reduce** their use. 3. **Changes in the flora** and particularly in the presence of **invasive species**. 4. **Educational aspects** they demand increased training about AWM and combination of strategies. 5. EU policies, **regulatory challenges** related to restrictions in herbicide use and CAP payments.	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. Risks for **human health** and **environmental impact**, including biodiversity decline were voiced for the use of herbicides. 3. **EU policy** and increases in **bureaucracy**. Stakeholders consider that EU policy does not articulate sufficient **tools** to implement AWM practices. 4. Enhance **multi-actor and holistic approaches** to implement peer to peer to ensure **changes in farmers habits**. 5. **Low** market **prices** and instability.	1. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 2. **Ecosystem services provision,** including increased water quality, improvements in biodiversity as well as an amelioration on soil health. 3. **Creation of synergies** as a result of the adoption of AWM approaches and their combinations. 4. Farmers professionalization. **Increase in training** programs, especially **peer to peer knowledge**. 5. **Ease to use** and integration of the practice in **organic agriculture**.

3.3.1.3 Weeding techniques SWOT analysis

3.3.1.3.1 Herbicides

From the SWOT analysis for **herbicides**, acknowledge **opportunities** were linked to technical aspects (efficacy (A, R), optimized treatment (R, A), Selectivity (A), quick results (R), fast operation (F), available equipment (A), among others). **Strengths** were also associated with technical issues (economic benefit (A, F, R), efficacy (A, F, R), simplicity (A, F, R), expense (F, A) and other aspects emphasized by farmers). Regarding to the **threats** social aspects linked to bans imposed on herbicides were regarded as a problem (widthdrawal of herbicides (F), market (F), agricultural policy (A, F, R), pressure to reduce herbicides (F, R)) as well as challenges related to environmental issues (A). Finally, with regard to **weaknesses** negative environmental aspects are highlighted by the whole set of stakeholders (Pollutant capacity and environmental impact), but also from a technical stance (herbicide resistance). Researchers and advisors considered other environmental (risks to human health, biodiversity decline) as well as other technical aspects, including treatment optimization. Researchers emphasized other management aspects, including herbicide mixtures, residues, while sharing concerns regarding social (lack of training) and economic (expense) aspects related to herbicides use. Advisors, emphasized social aspects as main concerns related to herbicides, including accessibility, lack of knowledge, certificates and lack of awareness. **Rye-pea herbicides SWOT analysis shows an acknowledgement of the negative impact oh herbicides in the environment. However, stakeholders emphasized ease of use and effectiveness as opportunities, highlighting also concerns linked to future bans on herbicide use, while recognizing a lack of knowledge and awareness related to herbicide application in rye-pre crops.**

3.3.1.3.2 Agroecological Weed Management techniques

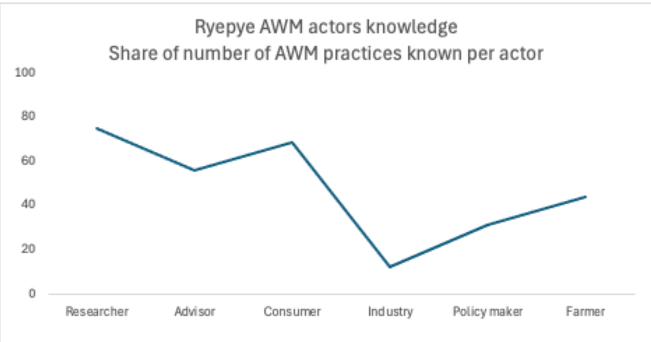
The SWOT analysis of AWM was largely answered by researchers and advisors, regarding economic, technical, environmental and social concerns, demonstrating that there is a strong work done in Rye-pea from research perspective. Answers from farmers were less intense. With regard to **opportunities**, all actors considered soil health, environmental sustainability (environmental) and peer-to-peer knowledge as relevant (social). Additionally, both advisors and researchers emphasized social (training) and technical aspects (combination of strategies and efficiency) as relevant. Advisors stressed the importance of economic opportunities, including economic benefit and subsidies. Researchers focused on various issues, including social (pushed by European Community) and technical issues (simplicity, site-specific weed management and new technologies) as well as economic sustainability (new markets and circular economy). The main **strengths** acknowledged across all stakeholders were related to technical aspects (efficacy, simplicity, availability of equipment and integration with organic agriculture) and environmental aspects (improvement of soil health). Farmers and researchers emphasized long-term beneficial effects and ground cover (environmental) and speed-quick results (technical) as strengths tied to AWM. Advisors and farmers considered the possibility of designing combination strategies (technical) as a strength. On the other hand, researchers and advisors considered low environmental impact of AWM strategies. Farmers emphasized increased research and reduction of herbicide inputs, whereas advisors consider reduction of costs and accessibility. Researchers emphasized lack of residues and repeated applications as important. Regarding **threats**, both researchers and farmers perceived social (Agricultural policy) as relevant. Farmers considered social (EU policies, bureaucracy, uncertainty and inaccurate long-term planning) aspects as their main concern. Environmental aspects were solely perceived as relevant threats by researchers. Advisors did not consider any of the queried threats as relevant in Latvian rye-pea cropping context. Finally, few **weaknesses** related to AWM were identified. While researchers did not acknowledge any of them as relevant, advisors considered the lack of a viable alternative to herbicides as to sole and technical and overall weakness. Farmers did identify several aspects regarding social (lack of experience-knowledge, accessibility to said knowledge and shortage of labour) weakness related to AWM implementation. **In summary, rye-pea AWM was positively perceived by stakeholders, as a number of strengths and opportunities were identified, encompassing environmental, economic and social aspects, while few threats and weaknesses were identified.**

3.3.1.4 Weeding techniques evaluation

Rye-pea questionnaire was answered by 29 stakeholders in total (Annex II) (Table 10), including Consumers, advisors, researchers, policy makers and consumers. Most important practices, as recognized by stakeholders included cover crops, false seed bed, herbicides, site-specific spraying, mechanical weeding, mowing and mulching (Figure 9). Researchers were the group with major knowledge on AWM practices. Remarkably, farmers and advisors share also a strong knowledge regarding AWM, showing a balance in knowledge by practitioners and facilitators.

Table 10 . Actors vs practices matrix awareness in Rye-Pea weed management. Cells highlighted in light green correspond to practices considered as relevant across all crop types, whereas rows highlighted in red correspond to practices considered irrelevant across all crop types. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle.

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
AWC	0	0	0	0	0	1
BH	0	1	0	0	0	0
CCI	0	1	0	0	0	1
CC	1	3	1	0	2	2
FS	3	0	1	0	2	3
Gr	2	2	1	0	1	1
H	3	3	4	1	4	3
I	0	0	1	0	0	1
MW	3	4	5	1	4	5
MO	2	1	2	0	3	2
MU	1	1	0	0	3	2
NE	1	1	0	0	0	0
Other	0	0	0	0	0	0
SSS	3	2	0	0	3	1
TW	0	1	0	0	0	1
UAV	0	0	0	0	0	0



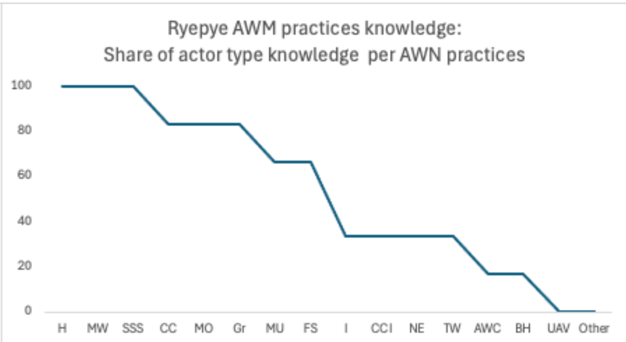


Figure 9 Rye-Pea AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle

The **questionnaires** associated with rye-pea included answers for **chemical weed control** linked to herbicides (advisors, consumers, farmers, policy makers and researchers), and site-specific spraying (advisors and policy makers), **physical weed control**, such as mechanical weeding (advisors, consumers, farmers, policy makers and researchers), mowing and mulching (policy makers), and **nature-based solutions** for weed control, such as cover crops (consumers) and false seedbed (advisors and researchers). An extended version analyzing the results obtained in the questionnaires can be found in Annex II.

Chemical weed control consisted on herbicides and site-specific spraying (SSS). Herbicides are considered of low relevance in rye-pea culture context, as advisors, farmers, consumers, policy makers, and researchers regarded most factors as irrelevant or low relevance. Similarly, SSS was selected as important by 2 stakeholders categories. Herbicide opportunities were deemed as irrelevant across all stakeholders categories, similarly, SSS was considered as a practice with limited opportunities according to advisors and policy makers. Some of the identified aspects were associated with the improvement of ecosystem services, and fostering IPM. Economic opportunities were emphasized by policy makers and researchers, including increases in business profitability and stabilization of crop yields. Besides, advisors, farmers, and consumers acknowledge that herbicide use in AWM can reduce overall herbicide reliance. Both chemical weed control methods were considered to have relevant needs. Herbicides and SSS main needs were related to education, as training, management expertise practicing knowledge skills were acknowledged by a majority of respondents across all stakeholders groups. Other need related to herbicides included increasing available knowledge with regard to ecosystem services impact of herbicides emerged as an important requirement as acknowledged by all herbicide stakeholders, whereas cost reduction was emphasized by SSS. Barriers associated with herbicide use included lack of funds, expense, training and time consumption were regarded as important obstacles to herbicides by most stakeholders of particular categories. Consumers specifically identified environmental and human harm as a paramount barrier to herbicides usage. On the other hand, queried barriers were considered as of low relevance by both stakeholders groups. Herbicides and SSS stakeholders shared high rates of consensus when appointing the practice disadvantages, customer demands to reduce or eliminate its use, were emphasized across both practices. Environmental and human harm was highlighted by herbicide respondents and by SSS policy makers. Additionally, expense was considered relevant by advisors, farmers, consumers, policy makers, and researchers considering herbicides usage.

Physical weed management control included several practices, such as **mechanical weeding, mowing and mulching**. Reduction of herbicide reliance, provision of ecosystem services were regarded as an opportunity by stakeholders across all physical strategies (MW, MO and MU). Besides, IPM fostering was considered as important by most MW stakeholders. Interestingly, advisors considered MW as a practice with no relevant opportunities. Among the identified needs, stakeholders emphasized practicing knowledge skills and management expertise as necessities related to MW and MO. Additionally, ecosystem services impact knowledge and regulatory challenges were considered as challenges by MW stakeholders. Addressing low efficiency was considered as the main need for mowing. Increasing expertise and adequate support and expertise while implementing mulching practices. Barriers for mechanical weeding and mowing include time consumption as the main concern. Lack of funds was considered as an impediment by MU stakeholders and MW actors. Disadvantages include time consumption (MW) and low efficacy (MO), whereas MU was considered as encompassing minimal relevant disadvantages.

Regarding **nature-based** solutions as **weed control methods**, only those linked to temporary used of biodiversity were acknowledged as relevant in Rye-pea cropping, including cover crops and false seedbed. Stakeholders shared a positive outlook with regard to both practices, provision of ecosystem services (CC) was acknowledged as an opportunity, whereas potential in the implementation of IPM strategies and the reduction in herbicide reliance was emphasized by FS stakeholders. Needs include training for FS, whereas CC stakeholders did not considered as relevant any of the queried needs nor barriers or disadvantages. Lack of training was considered as the most relevant barrier and expense was deemed as the most important disadvantage for FS implementation

3.3.1.5 Conclusions

SWOT analysis revealed that stakeholders are somehow reluctant to implement AWM practices, as they emphasized concerns regarding coming policies to eliminate herbicides. Stakeholders considered the environmental impact of herbicides as negative an considered AWM strategies as innocuous or positive to ecosystem health. Social benefits regarding AWM implementation were acknowledged. However, stakeholders share challenges related to labor availability and training as main weakness for AWM.

3.4 Annual crops: Horticultural crops

3.4.1 Onion analysis

3.4.1.1 Contextualization

Onion LL was located in the Netherlands, where about three quarters of EU's onions were produced in 2022 (Eurostat, 2024). The LL board meeting considered onions as a rotation crop. Total area consistent of Seed onions 29,322 ha (438 farms) and Plant onions 5,498 ha (317 farms). The produced onions are mainly exported to Africa (52%), Europe (27%) and Asia (12%).

LL board meeting participants considered agroecological products promotion as important, and state that short value chains already exist in the region, as many farmers are in contact with consumers and local supermarkets. Dutch agriculture is innovative, and LL participants did not considered that the region suffers from a lack of technology, they emphasized that progress in being made to improve sustainability. Increased pest and disease stress as well as drought are impacting regional production, in the province of Zeeland, onion acreage is in significant decline.

Common agronomic practices in the region included: Tillage, fertilization, sowing/planting, irrigation, crop protection, weed control, harvesting, processing. Weeds are mainly chemically managed, there are different weed control substances, however, year by year they are being reduced in the market. Spraying takes place 3-6 times per season depending on weather conditions in conventional farming, both pre and post emergence (no use of herbicides in organically managed plots). Herbicides are considered as highly efficient; however, they spray several times per season. LL workshop participants considered that alternatives to herbicides exist, but they rely heavily on weather condition, the development of an inexpensive alternative is important to allow transition. Interestingly, participants considered that strictly monitoring of chemical use, restrictions and buffer zones are sufficient to reduce chemical's impact on the environment.

Stakeholders considered that agriculture without herbicides is possible, as it is in the case of organic farming. According to them, the question is whether the market is ready. Transition to agroecological practices will rely on government plans to organize farm-level experiments, as well as business model for Dutch grower does not allow for experiments now. Barriers for agroecological transition include governments short-term vision, participants considered that there needs to be a policy redefinition.

Besides, participants considered that the drive force should come from the market, as these changes needs acceptance from consumers and sales increase. Farmers are exploring reduction of chemicals, participants considered that a drastic change dictated by governments might create resistance.

Drivers for weed dispersal include not properly cleaning the machines, organic fertilizers, soil tilling by ploughing, and less frequently via sprinkling with surface water, moving soil. Major weeds include Chamomile, Milkweed, Pigweed, Jacobs weed as well as Cleavers and black nightshade. Diversifying crops ensures no herbicide resistance events happened in the region. LL participants considered Thorn apple (*Datura stramonium*) as an extinct invasive plant, which is rising again in the last two years.

3.4.1.2 Weeding needs, barriers, gaps and opportunities

Table 11 shows the most relevant needs, barriers, gaps and opportunities found for onion. Identified **needs** by stakeholders included improvements in educational and technical aspects, including concerns related to AWM effectiveness. Increases of scientific knowledge was considered as important to foster AWM in onion cropping systems. Additionally, stakeholders considered changing policy's paradigm, as an important necessity, as main policies are designed with a short-term vision. Lastly, onion stakeholders claim that transition to more sustainable practices must be driven by the market and consumers. Therefore, raising consumer awareness constitutes a pivotal necessity. Most relevant **barriers** identified by onion stakeholders include regulatory changes, related to herbicide restrictions. Expenses and climate change concerns were considered as relevant barriers linked to AWM implementation. Lastly, complexity of application and treatment optimization were emphasized as important hurdles for AWM fostering. **Gaps** related to onion weed management included lack of knowledge and practical experience, the high cost of application related to AWM implementation. Additionally, onion stakeholders emphasized lack of drivers of change for farmers as important impediment to foster the usage of more sustainable practices. Low efficiency as well as cost of equipment and lack of labour are considered as important challenges in AWM usage. Identified **opportunities** are related to ecosystem services provision as well as other aspects related to economical development and business management, as AWM stabilizes crop yields and increases business profitability. Reduction of herbicide reliance, IPM fostering and evolution of AWM in relevant scientific disciplines were also emphasized by onion stakeholders. **Onion stakeholders recognized the importance of technical and educational improvements to enhance sustainable transition. However, they consider that the main driver for weeding needs to be changes in consumer behavior. Interestingly, and despite broad herbicide application in onion cropping, stakeholders did not regard chemical management as necessarily damaging to environmental health. Lack of long-term vision in policy design, of efficiency and high cost of application were regarded as important challenges. Additionally, stakeholders emphasized issues related to climate change and weather to ensure AWM implementation.**.

Table 11. Onion main needs, barriers, gaps and opportunities

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Onion (The Netherlands)	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. 2. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. Moreover, stakeholders emphasize **difficulties in operations** and reduced **effectiveness** of AWM practices. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 4. **Regulatory changes- Policy concerns.** Stakeholders consider that policies should be designing with long term vision. 5. **Market** and s**ales acceptance** of the products.	1. EU policies, **regulatory challenges** related to restrictions in herbicide use. 2. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. 3. **Weather** and especially **climate change** are considered as key barriers to AWM and non-chemical weeding use. 4. **Complexity** of application and treatment optimization. 5. **Environmental or human health harm** as well as **high carbon footprint** of some practices.	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. **Cost of application** in AWM practices compared to herbicides. 3. lack of drivers for **change in farmers habits**. As they are pessimistic about the adoption of AWM. Education and increases in knowledge and the adoption of multi-actor approaches might crucial. 4. **Low efficiency** of AWM practices compared to herbicide application. 5. **Cost** of **equipment** as well as **lack of labor**.	1. **Ecosystem services provision,** including increased water quality, improvements in biodiversity as well as an amelioration on soil health. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. 3. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 4. **AWM** practices have potential to evolve into relevant **scientific disciplines**. 5. **IPM fostering**. They consider that AWM increases IPM strategies adoption.

3.4.1.3 Weeding techniques SWOT analysis

3.4.1.3.1 Herbicides

From the SWOT analysis revealed that few **opportunities** were identified for herbicides, recognized were linked to technical benefits(efficacy (F,A), quick results (A), cheapness (A) and availability of equipment (F). **Strengths** were also associated with technical, efficacy, and economic aspects affordability (F, A, R). Quick results and simplicity (F, A) were also considered as relevant strengths for herbicides Lastly, their availability on the market was also considered as important by farmers and researchers. Pressure to reduce, lack of new (F) and withdrawal of existing (F, A, R) herbicides are considered as the most relevant technical **threats** to onion weeding. Additionally, all stakeholders considered maket instability as an economical in onion cropping. Lastly, identified **weaknesses** include technical aspects (herbicide resistance (F, A, R), selectivity and residues (A), treatment optimization (R)), environmental concerns (environmental impact (F,A)). Additionally, farmers emphasized social aspects related to lack of knowledge. **Onion herbicides SWOT analysis included few opportunities and strengths, being mainly related to technical aspects, as they are widely used in the region. Market instability, educational and educational aspects were considered as important threats and weaknesses of herbicide use.**

3.4.1.3.2 Agroecological Weed Management techniques

The SWOT analysis of AWM included several opportunities, strengths, few weakneses and no threats to its implementation. With regard to **opportunities**, all actors considered social (Training and subsidies) benefits, as well as other technical aspects (combination strategies, new technologies and site-specific spraying). Additionally, farmers and advisors emphasized the importance of availability of consultancy services. Farmers focused on other technical aspects, including efficacy, simplicity and case-specific tailoring of AWM. Besides, farmers identified peer-to-peer knowledge (social) as important social benefits related to AWM. Researchers emphasized environmental sustainability and operational (economic) management as important benefits of AWM, whereas advisors considered reducing inputs as a relevant opportunity (economic). Identified **strengths** included environmental aspects (improve soil health (R, A), low environmental impact and ground cover (A), reduction of herbicide input (F, R, A) as well as reducing soil disturbances (F)), social (increasing research (F, R, A), training (R) and their harmony with new green policies (R)), economic (reduction of labour (F, R, A), of fuel costs (A) general costs (A), and increase of economic benefits (R), as well as cost effectiveness (R)). Technical aspects were considered as important across stakeholders (efficacy (F, R, A), combination of strategies (R, A), equipment availability (F, R), applicability (F, A), deal with noxious weeds, farmers accessibility, reduction of weed seed production (R), simplicity (F)). No **threats** related to AWM were identified. **Weakneses** related to AWM were mostly related to technical challenges and identified by farmers (Timing of application (F, R), difficulties in operations, lack of technical assistance, efficacy and non-selectivity (F)). Besides, social challenges were also acknowledged (lack of training (F), and shortage of labour or labour intensity (F,R)). Lastly, some economical (cost of application and of purchasing equipment (F, R)) as well as environmental concerns (Soil pollution (A)) were shared. **In summary, AWM was positively perceived by stakeholders, opportunities and strengths related to all considered areas were identified. SWOT analysis revealed that stakeholders do not consider any relevant threat to AWM. Besides, some weaknesses were identified, mostly by farmers in the technical field, which can be easily solved by increasing farmer professionalization.**

3.4.1.4 Weeding techniques evaluation

Onion questionnaire was answered by 29 actors in total (Annex II), including advisors, consumers and researchers (Table 12). Most important practices, as recognized by stakeholders, included cover crops, false seedbed, herbicides, mechanical weeding, natural enemies and site-specific spraying (Figure 10). Consumers were the stakeholder categories that shared more knowledge with regard to onion weeding.

Table 12 . Actors vs practices matrix awareness in Onion weed management. Cells highlighted in light green correspond to practices considered as relevant across all crop types, whereas rows highlighted in red correspond to practices considered irrelevant across all crop types. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle.

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
AWC	1	1	0	0	0	0
BH	0	2	0	0	0	0
CCI	0	0	0	0	0	0
CC	7	7	1	1	0	2
FS	4	0	1	1	0	2
Gr	0	2	0	0	0	0
H	5	5	1	2	0	3
I	1	2	0	0	0	0
MW	5	3	1	1	0	3
MO	2	2	0	0	0	2
MU	1	0	0	0	0	0
NE	1	3	0	0	0	0
Other	0	1	0	0	0	0

SSS	**5**	**3**	**0**	**0**	**0**	**0**
TW	**0**	**2**	**0**	**0**	**0**	**1**
UAV	**1**	**0**	**0**	**0**	**0**	**0**

The **questionnaires** associated with onion included answers for **chemical weed control** linked to herbicides (advisors, consumers) and site-specific spraying (advisors, consumers), **physical weed control**, such as mechanical weeding (advisors, consumers and researchers), and **nature-based solutions** for weeding, such as cover crops (advisors, consumers), false seedbed (advisors) as well as natural enemies (consumers). An extended version analysing the results obtained in the questionnaires can be found in Annex II.

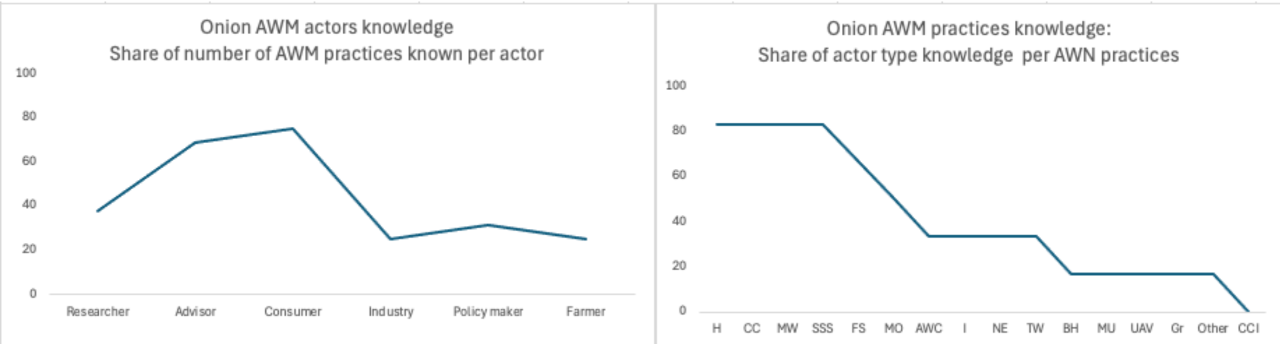


Figure 10 Onion AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle

Chemical weed control consisted on herbicides and site-specific spraying (SSS). Stakeholders perceived herbicides differently, consumers and researcher held a more pessimistic perspective, whereas advisors emphasized several herbicide-related opportunities. Consumers and advisors prioritized economical-related opportunities, such as business profitability. Reduced herbicide reliance as well as crop yield stabilization were considered as relevant with different relative importances across all stakeholders groups. Primary needs include regulatory changes, as acknowledge across all stakeholder types. Besides, cost and timing reduction were also identified by advisors. As per the most relevant barriers, in line with expressed needs, include regulatory challenges, as well as environmental and human harm and expense. Main disadvantages include customer demand to reduce herbicides. SSS outlook differ among consumers and advisors. Consumer unanimously regard site-specific spraying as conducive to crop yield stabilization and a reduction in herbicide reliance as the main opportunities, whereas advisors shared a more conservative view toward the practice benefits. Needs, include regulatory changes, timing reduction, practicing knowledge skills, and training, as highlighted by both advisors and consumers. Main barriers inclide expense and training, as highlighted by both groups. Finally, both advisors and consumers consider customer demands to reduce site-specific spraying as a relevant disadvantage, with advisors particularly emphasizing expense, while consumers also highlight environmental and human harm and high carbon footprint.

Physical weed control consisted on mechanical weeding (MW). Stakeholders (advisors and consumers) shared different perceptions toward MW. All stakeholders concur on mechanical weeding's potential to reduce herbicide reliance, with both advisors and researchers acknowledging its capacity to enhance water quality, as main opportunities with regard to the practice. Besides, needs include cost reduction (advisors), ecosystem services impact knowledge and regulatory changes (consumers), with researchers emphasizing practicing knowledge skills and management expertise. Stakeholders unanimously identified time consumption as the most important barrier. Consumers and researchers perceive complexity and time consumption as significant disadvantages.

Natural-based solutions for onion weeding include both **temporal** (cover crops and false seedbed) and **spatial** (natural enemies) use of biodiversity. Cover crops potential to reduce herbicide reliance and to provide ecosystem services were emphasized by stakeholders as method main opportunities. Besides, main needs include practicing knowledge skills (advisors) and regulatory changes (consumers).Lack of funds was considered by consumers as the main barrier whereas advisors do not consider that the practice as presenting any impediments. In a similar line, customer demands to reduce cover crop usage as the main disadvantage as perceived by consumers, whereas advisors did not considers cover crops as having relevant disadvantages. False seedbed was perceived as offering limited opportunities. Primary needs include practicing knowledge skills and training, while barriers include concerns about low efficiency and time consumption. Notably, none of the queried disadvantages were considered relevant by the majority of respondents. Spatial use of biodiversity included natural enemies, which encompass several opportunities, such as improved ecosystem services and potential economic advantages. No concerns with regard to method needs, nor any barriers were shared. Concerns related of high carbon footprint and expense remain as the main disadvantages as important in Natural enemies implementation.

3.4.1.5 Conclusions

In conclusion, onion cropping in the Netherlands is highly innovative, with a focus on precision and sustainability, although it faces significant challenges regarding the adoption of practical AWM. While herbicides remain effective and economical, their use is threatened by increasing resistance and regulatory pressures. On the other hand, agroecological weed management presents weaknesses such as high costs and operational complexity, but offers opportunities to improve ecosystem services, increase profitability and reduce herbicide dependency. More training, technical advances and regulatory changes are required to boost its adoption.

3.5 Permanent crops

3.5.1 Permanent crops global analysis

3.5.1.1 Contextualization

Permanent crops analysis includes the dissection of five permanent crops in various European countries, that are highly relevant for Europe, such as Apple (Spain), Citrus (Italy), Grapes (Spain, Italy, Greece), Cherry (Spain) and Olives (Cyprus and Portugal). Apple orchards are widespread across Europe, representing 36.6% of total area of fruit plantation. The production of the other permanent crops is linked to Southern European Countries. Spain, Italy and Greece are EU's largest citrus fruit producing countries, accounting for 60%, 27%.

3.5.1.2 Weeding needs, barriers, gaps and opportunities

The assessment of weeding needs, barriers, gaps, and opportunities across apple, bergamot, cherry, grape, and olive production in various regions reveals a comprehensive view of the challenges and potential in agroecological weed management (AWM). Across all examined crops, the primary **needs** center on improving farmer education and training. Stakeholders consistently emphasize the necessity for enhanced technical improvements to reduce costs and maintenance times. For apple and cherry production, the need for increased scientific knowledge on the impact of agroecological practices is vital, while grape and olive producers similarly highlight the need for better understanding of ecosystem services. In Cyprus and Portugal, there is a clear demand for specialized advisors to assist farmers in adopting AWM practices. Significant **barriers** persist across all crops, including high implementation costs and environmental damage from chemical practices. In particular, stakeholders in regions like Greece and Cyprus cite EU regulatory restrictions and climate change as major challenges, mirroring the concerns raised in other regions. The lack of labor and professionalization among farmers also appears consistently, complicating the transition to sustainable practices. These barriers collectively hinder the progress toward adopting AWM strategies effectively. Identified **gaps** primarily involve insufficient practical knowledge and experience with AWM practices. Across the different types of crops, there is a lack of motivation among farmers to change established habits, which is compounded by the high costs of adopting non-chemical methods. The absence of promotion among consumers further limits market acceptance of agroecological products, creating additional hurdles for adoption. Labor shortages and inadequate equipment also represent critical gaps across regions, highlighting the need for more resources and support for farmers. Despite the challenges, several **opportunities** emerge consistently across crops and regions. The potential for improving ecosystem services and stabilizing agricultural yields is evident in all cases. Promoting integrated pest management (IPM) is another common theme, as stakeholders recognize its importance in reducing reliance on herbicides and enhancing overall sustainability. Furthermore, the scientific potential of AWM and the professionalization of farmers through targeted training present valuable pathways for fostering sustainable agricultural practices. The alignment of regulatory changes, financial incentives, and certification processes across regions could further bolster the adoption of AWM and its associated benefits.

3.5.1.3 Weeding techniques SWOT analysis

3.5.1.3.1 Herbicides

The SWOT analysis of herbicides across various permanent crops such as apples, citrus, cherries, grapes, and olives reveals a concerning landscape dominated by weaknesses, particularly in environmental and health impacts. Stakeholders consistently emphasize the negative effects associated with herbicides, including environmental pollution, biodiversity decline, and human health risks. In Greece and Portugal, the high costs of herbicides emerged as a significant economic weakness, while herbicide resistance was noted as a growing concern across multiple regions. Furthermore, stakeholders expressed fears regarding the potential withdrawal of herbicides from the market, reflecting a broader societal pressure to reduce their usage. Despite these weaknesses, certain strengths are associated with herbicides, particularly in terms of their efficacy and ease of use, which can yield quick results. For example, farmers noted that herbicides are not labor-intensive and are relatively inexpensive, making them an appealing option in the short term. However, the reliance on herbicides poses significant long-term risks, as the environmental consequences and increasing regulatory pressures may undermine their viability in the future. **In summary, while herbicides offer immediate advantages in weed management, their substantial weaknesses in terms of environmental sustainability and health risks highlight the need for alternative approaches.**

3.5.1.3.2 Agroecological Weed Management techniques

In contrast to herbicides, the SWOT analysis of Agroecological Weed Management (AWM) techniques indicates a more promising outlook, showcasing several opportunities and strengths across the same permanent crops. Stakeholders universally identified training and education as crucial opportunities for enhancing the adoption of AWM practices. Environmental sustainability was a significant theme, with stakeholders emphasizing improvements in soil health, water resource management, and biodiversity safeguarding. In regions like Italy and Greece, researchers and advisors pointed out the importance of consultancy services, economic benefits, and the potential for peer-to-peer knowledge exchange to facilitate the transition toward AWM. The strengths of AWM lie in its technical effectiveness and environmental benefits. Stakeholders recognized the ability of AWM practices to improve soil health, reduce reliance on chemical inputs, and contribute to a more sustainable agricultural system. Additionally, AWM practices were noted for their adaptability to green policies, which aligns with the growing demand for environmentally friendly practices in agriculture. Unlike herbicides, AWM techniques present fewer identified threats, although some weaknesses, such as the need for larger-scale operations and lack of technical assistance, were acknowledged. **Overall, AWM techniques offer a more sustainable alternative to herbicides, promoting long-term ecological health while addressing the pressing need for reduced chemical reliance in permanent crop management.**

In conclusion, the contrasting SWOT analyses of herbicides and AWM techniques highlight the need for a shift towards more sustainable practices in permanent crop cultivation. While herbicides may provide short-term benefits, the long-term environmental and health concerns associated with their use necessitate a transition towards AWM strategies that can offer ecological benefits and resilience in agricultural systems.

3.5.1.4 Weeding techniques evaluation

A significant number of respondents share their perception on weeding practices in different cropping systems in European countries. Grazing, herbicides, intercropping, mechanical weeding and mowing were considered (Table 13).

Table 13 . Actors vs practices matrix awareness in Permanent Crops weed management. Cells highlighted in light green correspond to practices considered as relevant across all crop types, whereas rows highlighted in red correspond to practices considered irrelevant across all crop types. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle.

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
AWC	1	2	0	0	1	0
BH	1	9	4	1	2	3
CCI	0	0	0	0	0	1
CC	3	11	7	3	1	7
FS	0	1	0	1	1	0
Gr	9	17	18	3	6	9
H	29	48	35	9	16	32
I	2	3	8	1	4	3
MW	30	22	30	15	14	24
MO	20	12	25	11	10	14
MU	2	10	8	1	1	5
NE	1	1	0	0	0	1
Other	1	0	1	1	3	0
SSS	6	4	6	1	1	6
TW	0	1	0	0	0	1
UAV	0	0	0	0	0	1

Permanent crops share of knowledge was relevant among advisors, followed by consumers, researchers, farmers and industry representatives. Most knowledgeable practices were grazing, herbicides, mowing, mechanical weeding, site-specific spraying and UAV (Figure 11).

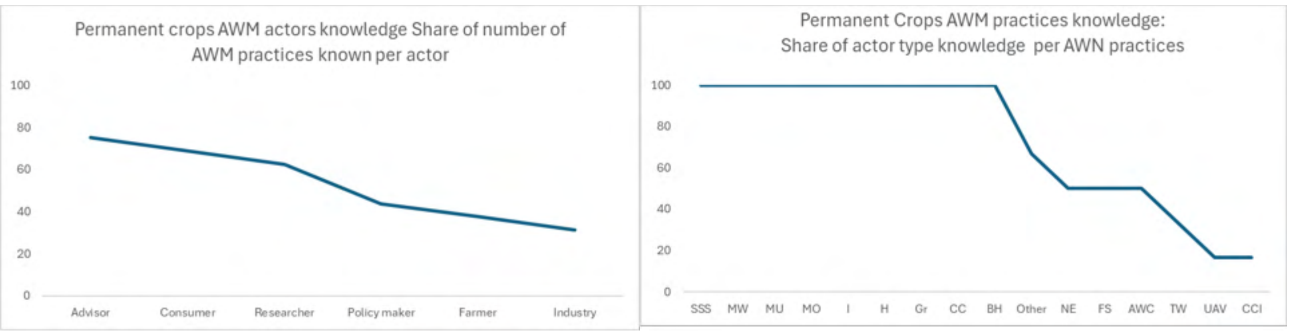


Figure 11 Permanent crops AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle

Knowledge-based questionnaires included responses from 183 stakeholders, consisting on an analysis of **chemical weed control** practices, encompassing herbicides in most cases and biobased herbicides (citrus, Spanish grapes) and site specific spraying (citrus, Cyprus olives) in some particular crops.

Interestingly, grape production in Italy did not consider any chemical weeding practice as relevant. As per the use of **physical methods** for weed control, mechanical weeding (apple, citrus, Spanish, Greek and Italian grapes, Portuguese and Cypriot olives) and mowing (citrus, cherry, Spanish, Greek and Italian grapes, Cypriot olives) were recognized in most cases, with mulching being also acknowledged by Spanish and Italian grapes stakeholders. As per the implementation of **nature-based solutions**, grazing was considered as a spatial use of biodiversity to control weed in Apples, Spanish and Italian grapes, as well as Portuguese and Cypriot olives. As per other spatial uses, only intercropping was considered as an important weeding control strategy by Cypriot olives stakeholders. Additionally, temporal use of biodiversity by stablishing cover crops was positively regarded as a control method in Spanish grapes orchards.

3.5.1.5 Conclusions

It can be concluded that in permanent crops, weeds are not as challenging as in the case of arable species. Most cropping systems use a combination of strategies to ensure control of weeds.

3.6 Permanent crops: Apple

3.6.1 Apple analysis

3.6.1.1 Contextualization

The description provided by the Apple LL (Annex III) shows that apple orchards in Galicia are generally agroecologically managed. Apple orchards represent 4,395 hectares in Galicia as of 2022. Apple production is widespread across the European Union, representing 36.6% of total area of fruit plantations. The area devoted to apple orchards in Spain represent 5.8%, being the sixth EU member state in area of production (Eurostat, 2024).

Weed control is not usually a problem in apple production, being differently managed in the orchard corridors compared to lines. LL board members noted that herbicides are the most common weed management practice in lines, with mulching, compost, or bark also used. In corridors, weeds are cut or grazed. With regard to cover crop use, Galician climate ensures spontaneous vegetation to grow in the soil.

LL participants emphasized that weeds are not a problem in apple orchards. Main weeds related to apple production include *Rumex obtusifolius*, whose dispersal and growth appears to be promoted by soil clearing and pasture sowing, as well as *Convolvulus arvensis*, being categorized as the most noxious weed in Galician apple production.

Herbicides are not generally used in regional apple production, sometimes, copper is applied. Stakeholders state that apple orchards are already agroecologically managed in the region. Moreover, they emphasize that agriculture without herbicides is viable in the region due to Galician traditions. **Apple LL board meeting participants emphasize the importance of increasing professionalism among apple farmers. In general, weeds are not a problem in apple production. Therefore, herbicides are not widespread and farmers do not encounter any problems related to herbicides resistance or contamination. Additionally, LL board meeting attendees were interested in grazing treatments in combination with shepherds and virtual fencing system, increasing professionalization.**

3.6.1.2 Weeding needs, barriers, gaps and opportunities

Table 14 shows the most relevant needs, barriers, gaps and opportunities found for apple production. Apple weeding **needs** are related to concerns linked to lack of farmers professionalization, including technical issues related to maintenance, costs and timing. Additionally, stakeholders expressed the need for increased scientific knowledge as well as educational activities to better farmers knowledge and boost agroecological management uptake. **Barriers** in apple weed management were related to lack of funds and expenses, including concerns related to complexity and time. Other barriers related to apple weed management are related to unsustainability of the physical practices, including concerns related to carbon footprint. Perceived **gaps** were associated with farmer's lack of knowledge and practical experience, as well as lack of incentives-subsidies to uptake and promote agroecological practices. Appointed **opportunities** related to apple production are linked to ecosystem services provision, considering IPM fostering and reduction of herbicide reliance as having a positive impact on Economical-business aspects of the production, and therefore fostering farmers professionalization. The interviews (Annex III) revealed that regional apple production is not hindered by weeds. Regional climate ensures that the soil is usually covered by spontaneous vegetation during the whole year. Additionally, the lack of professionalization and the implementation of traditional practices to manage the orchards minimize the use of chemical weed management, which was considered as expensive. **Apple stakeholders emphasize the importance of increasing professionalization of the production as one of the major problems of apple**

production in the region. Stakeholders considered promotion of AWM as important. Weeds are not considered as a major problem and no issues related to herbicide resistance were raised.

Table 14. Apple LL main needs, barriers, gaps and opportunities.

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Apple (Spain)	1. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. **2. Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 4. **Market** and s**ales acceptance** of the products, value ecosystem services provision. Stakeholders consider that regional apple value chain is not sustainable. 5. **Treatment optimization** and design of **combination strategies**.	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. 2. **Complexity** of application and **time consumption**. 3. **Lack of professionalization** and absence of training, hinder the adoption of effective strategies. 4. **Unsustainability of the regional apple value chain**, deter the professionalization and the adoption of new practices 5. High **carbon footprint** and **environmental impact** of some mechanical practices.	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. Lack of **incentives-subsidides** to farmers and lack of promotion of agroecological practices. 3. **Low** ratio of **organic farms**. 4. Lack of **economic innovation strategies** that value ecosystem services and sustainable practices in agriculture. 5. **Lack of labour**. Stakeholders shared concerns with regard to generational renewal.	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity as well as an amelioration on soil health. These practices are in harmony with **European green policies**. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social and employment where they are implemented. Stakeholders consider the reduction in inputs as a key opportunity. 3. **IPM fostering**. They consider that AWM and non-chemical weed management increase IPM strategies adoption. 4. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. Most production is agroecological 5. **Farmers professionalization**. As the implementation of more AWM practices will lead to **increase in training and education programs.**

3.6.1.3 Weeding techniques SWOT analysis

3.6.1.3.1 Herbicides

Regarding the SWOT analysis of **herbicides**, there is virtually no mention of opportunities, only available equipment (R) was emphasized. Strengths related to chemical weed management include technical aspects, as ease of use (A) and herbicide presence in the markets (R) were emphasized. However, stakeholders recognizing that there is a societal increase in pressure to reduce their use. Threats related to herbicides are linked to technical difficulties, including the lack of new herbicides and the withdrawal of existing substances (R), societal concerns, related to pressure from consumers to reduce their use, as well as economic aspects (Markets unsatability (F, R)). Lastly, weaknesses related to herbicides include environmental concerns, such as their pollutant ability, environmental impact (F, R, A), associated risks for human health (F,R) as well as biodiversity decline (F, A) linked to herbicide usage. One economical aspect was emphasized across all stakeholder types, related to herbicides expense. Lack of training (F) and knowledge (F,R) were consider as the main societal weaknesses regarding herbicide use. Identified adpects with regard to technical were linked to residues management (R) as well as selectivity (F). **In summary, herbicides are considered harmful for environment. Farmers emphasized herbicide availability as a strength. However, they acknowledge societal concerns related to chemical control use. Most weaknesses were related to environmental and societal aspects.**

3.6.1.3.2 Agroecological Weed Management techniques

According to stakeholders, adoption of AWM techniques is considered to be promising, although few **opportunities** were identified, including societal (training (F, A), subsidies (F) and synergies (A)), environmental (soil health (R), Sustainable management of agroecosystem and environmental sustainability (R)), as well as some technical aspects (design of combination strategies (R), new technologies implementation (F, A), feed source for animals (F), and increasing product quality (A)). **Strengths** related to AWM encompass some environmental (environmental balance (F, R), improve soil health (F, R, A), being associated with low environmental impact (A) and sustainable management of water resources (F)), as well as technical (combination of strategies and AWM efficacy (F, A), their applicability (R), ease of use (F, R) and their integration within organic agriculture (A)), as well as societal aspects (need for research (F, R)). No **threats** were considered of relevance by stakeholders and only a few answers considered **weaknesses** for apple agroecological weed management, including commitment (R), limitations on large-scale operations (F) and lack of labor (A). **In summary, educational aspects are considered pivotal for AWM uptake. Additionally, stakeholders acknowledge the need for inputs and equipment and recognize AWM effectiveness as its main strength.**

3.6.1.4 Weeding techniques evaluation

Apple questionnaire was answered by 49 actors (Annex III). Consumers and advisors are the most informed stakeholder group. Weeding techniques knowledge exceeds 30% across all actor types, being industry representatives the group with fewer knowledge (~30%)(Figure 12 left).

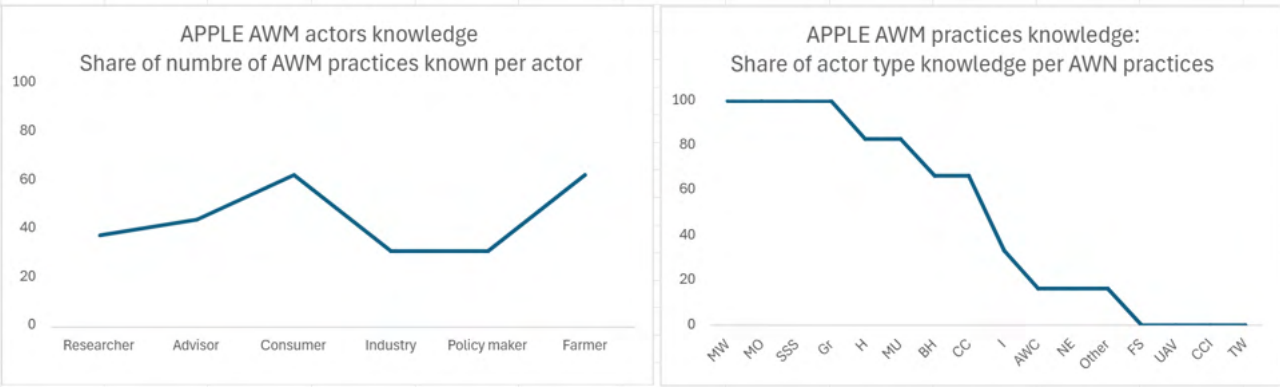


Figure 12. Apple AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle.

The most knowledgeable apple AWM were grazing, herbicides, mechanical weeding, mowing, site-specific spraying and use of unnamed aerial vehicles, as at least one respondent across all stakeholder categories consider the practice as important within apple wedding. More than eighty percent of the respondents considered intercropping and mulching as valuable practices for weeding apple. The matrix actors x AWM practices can be seen in Annex III as well as a deeper analysis of the stakeholders perception about the different types of AWM techniques. Natural enemies use was not known as important for apple weeding across all stakeholder types (**Figure 12** right).

The description of apple results from the questionnaires classified by type of actors are shown in Annex III, where a deep stakeholders analysis is shown. The main weeding methods considered by more than one stakeholder type included chemical use (herbicides), physical methods (mechanical weeding and mowing), and biodiversity use (grazing).

Stakeholders had differing views on ***herbicides***: consumers and policymakers recognized few benefits, while researchers viewed herbicides positively, noting their potential to foster IPM and provide ecosystem services. All stakeholders emphasized the importance of training, addressing regulatory challenges, and reducing costs for rational herbicide use. Concerns centered on environmental and human health impacts and societal worries, though more than half of the researchers believed herbicide use posed no significant problems. **Physical methods**, such as mowing and mechanical weeding, were generally seen as beneficial for providing ecosystem services, promoting IPM, and reducing herbicide dependence. However, stakeholders cited expense, time consumption, and a high carbon footprint as significant drawbacks. Grazing, as a **nature-based** weeding method, was considered rich in opportunities, similar to physical methods, for fostering IPM, providing ecosystem services, and reducing herbicide reliance. Stakeholders recognized the need to overcome regulatory challenges, reduce maintenance, and better understand the impact on ecosystem services, while time consumption was noted as a disadvantage.

3.6.1.5 Conclusions

Apple weeding involves several methods, including physical, chemical, and biodiversity-based practices. Low professionalization leads to the use of a wide range of techniques in apple orchards. However, stakeholders, especially farmers and advisors, acknowledge concerns about the lack of funds and high costs of weed control. Farmers believe that most apple orchards are mostly agroecologically managed, with herbicides rarely used. Consumers, farmers, and policymakers expressed concerns about the effects of herbicides on human and environmental health, though researchers did not share these concerns. No issues related to herbicide resistance were raised during the LL meeting.

3.7 Permanent crops: Citrus

3.7.1 Citrus analysis

3.7.1.1 Contextualization

Citrus production in the EU covers 455,000 hectares, with Spain (60%), Italy (27%), and Greece (9%) being the largest producers. Small citrus fruits make up 31% of total fruit production and are primarily grown in southern Europe (Eurostat, 2024). Bergamot, the selected crop in the Citrus Italian LL (Annex III), occupies about 1,500 hectares and involves 500 primary agricultural operators. The main products include bergamot essence used in perfumes worldwide. Recently, bergamot has also been used as a cooking ingredient, and its juice is now being marketed. Additionally, pharmaceutical products made from bergamot are being developed to manage cholesterol, triglycerides, and blood sugar levels. The diversity of outcomes for the produce ensures sustainability of the regional value chain, with stakeholders stating that most orchards are managed according to organic criteria, although not always certified as so. Weed management in the region primarily relies on herbicides and mechanical weeding. However, stakeholders recognize challenges with both methods. Herbicides are not viewed as a definitive solution due to concerns about environmental safety. Mechanical weeding is considered effective but is criticized for damaging soil structure. The LL board meeting reported that there are 10 herbicide active ingredients available, featuring various modes of action such as burn down, pre-emergence, and post-emergence. Herbicides are typically applied once per season. The most significant noxious weed in bergamot crops is *Cynodon dactylon*, with *Datura stramonium*, *Sorghum halepense*, and *Amaranthus* sp. also identified as notable invasive plants. **In general, actors considered that bergamot cropping without herbicides is viable, while raising concerns related to time consumption of the alternative practices. Therefore, participants considered financial sustain as pivotal to allow transition to implement more sustainable cropping strategies.**

3.7.1.2 Weeding needs, barriers, gaps and opportunities

Table 15 highlights the key needs, barriers, gaps, and opportunities for bergamot weeding strategies. The main **needs** include improving technical aspects such as reducing maintenance and increasing the number of advisors. Stakeholders also emphasized the importance of enhancing education and scientific knowledge to support the transition to AWM in bergamot cropping systems. **Barriers** identified include expenses, lack of funds, time consumption, labor shortages, and the complexity of application. **Gaps** relate to costs (both application and equipment), knowledge, and labor. Stakeholders recognized the need for multi-actor and holistic approaches to facilitate long-term AWM adoption. **Opportunities** include providing ecosystem services, boosting business and economic viability through established markets for added-value products, and the sustainability of the value chain and cropping techniques, with most operations adhering to organic criteria. **Despite this, stakeholders see implementing AWM practices in bergamot cropping, especially for weeding, as a significant opportunity. Funding, education, and multi-stakeholder approaches are deemed essential for ensuring the long-term uptake of AWM**.

Table 15. Citrus LL main needs, barriers, gaps and opportunities.

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Citrus (Italy)	1. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. Stakeholders recognize that AWM practices are simple to use and effective. Increase the number of **advisors**. 2. Improvements in **educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. Stakeholders consider that there should be more workshops and demo days in farms. **3. Increases in scientific knowledge** related to practices impact on ecosystem services. **4. Regulatory changes- Policy concerns.** Stakeholders consider that there needs to be a redefinition in policies, emphasizing the need for financial incentives and increasing administrative support to farmers. **5.** Increase **Treatment optimization** and design of **combination strategies**. Stakeholders emphasize that is necessary to improve weed management strategies, specially to reduce time consumption.	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. Stakeholders consider the increase of costs when applying AWM as the most relevant barrier. 2. **Time consumption** and **lack of labor**. Stakeholders consider that agriculture without herbicides is possible, being more time consuming. 3. Absence of **training**. Farmers are willing to change as they recognize that herbicides have a negative impact in the environment. **Lack of knowledge** about effective alternatives to herbicides. 4. **Complexity of application** of certain AWM practices. 5. **Lack of equipment** and cost of **machinery** to implement other practices.	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. **Cost of application** in AWM practices compared to herbicides. 3. **Cost** of **equipment** to implement AWM practices. 4. Enhance **multi-actor and holistic approaches** to implement peer to peer to ensure **changes in farmers habits**. 5. **Lack of labor**. Stakeholders shared concerns with regard to generational renewal.	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity, and on soil health, as well as an amelioration in overall environmental balance. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social aspects where they are implemented. 3. Stakeholders consider that AWM practices will become **relevant scientific disciplines.** 4. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 5. **IPM fostering**. Stakeholders consider that AWM and non-chemical weed management increase IPM strategies adoption.

3.7.1.3 Weeding techniques SWOT analysis

3.7.1.3.1 Herbicides

Regarding the SWOT analysis of **herbicides**, there is no opportunities, strengths or threats identified. Considered weakeneses included environmental concerns, consisting of herbicide pollution capacity, environmental impact, risk for human health and biodiversity decline (F, A, R). Expense emerged as an economical weakness as acknowledged by advisors. **In summary, herbicides are considered as a practice with no associated opportunities, nor threats or strengths. However, stakeholders emphasized several weaknesses associated with environmental challenges.**

3.7.1.3.2 Agroecological Weed Management techniques

With regard to SWOT analysis for citrus **AWM**, main opportunities were related to environmental (human health and environmental sustainability (F, A, R), as well as biodiversity safeguarding (F, R)). Other societal benefits were emphasized, including training (F, A, R) and social impact of AWM (A, R). Besides, provision of consultancy services were also considered as an opportunity as acknowledged by researchers. Main strengths were related to environmental aspects(improve soil health and other factors related to smart management of water resources (F, A, R), ground cover (F, A) and overall environmental balance (R, A) as well as decreasing soil disturbances (A)). Besides, technical regards, such as the combination of strategies (F) and the integration of AWM within organic agriculture (A), were also regarded as relevant strengths. Lastly, maximization of economic benefits (R) and increased training (F) were emphasized economic and societal aspects. Citrus stakeholders did not identified as important any of the poposed weaknesses nor threats. **AWM in Citrus was regarded as a set of practices that encompass relevant opportunities and strengths, while presenting no threats or needs.**

3.7.1.4 Weeding techniques evaluation

Citrus questionnaires were answered by 28 actors, around the 5,3% of the whole interviewees. From those consumers (39%) with the higher number of responses, being the rest below the 14 % of participation.

Figure 13 (left) reveals a low number of responses about AWM practices for farmer stakeholder, what is aligned with the lack of confidence reflected in the LL board of the region about this practices and also with the low knowledge in the technical and mechanical part of this practices.

Within each technique, mowing and site specific straying are the most knowledgeable techniques to weed citrus. The organic profile of citrus production in the region was manifested by the high percentage response of this and other agroecological practices that were not related to the use of chemical products. Figure 13 (right) demonstrates that digital and precision techniques, as well as recent techniques (such as thermal weeding) and nature-based solutions (such as natural enemies and cover crop inoculated), are not utilized in the weeding of citrus, indicating a dearth of technological advancements within the industry.

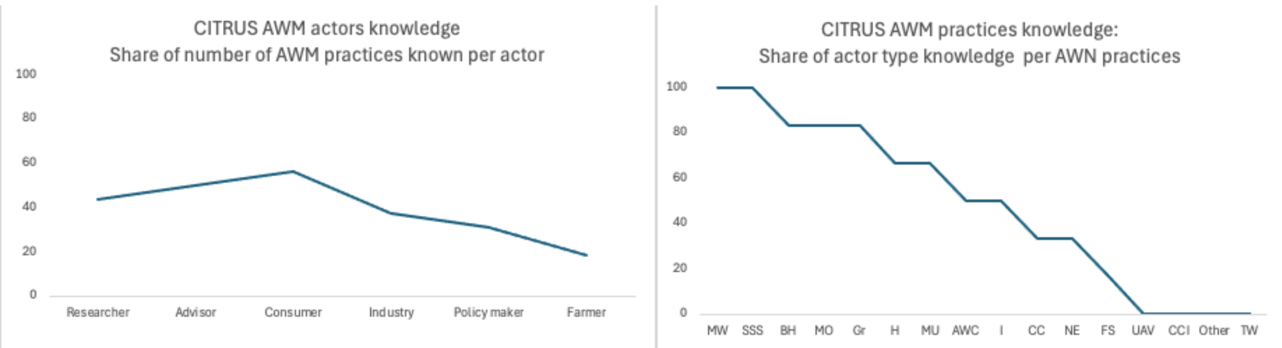


Figure 13. Citrus AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle

The description of citrus results from the questionnaires classified by type of actors are shown in Annex III, where a deep stakeholders analysis is shown. The main weeding methods considered by sufficient stakeholders included **chemical weeding**, herbicides, biobased herbicides and site-specific spraying (both acknowledged by consumers); **physical methods**, consisting of mechanical weeding (advisors, consumers, industry and policy makers) and mowing (advisors).

Chemical weed control consisted on herbicides (H), biobased herbicides (BH) and site-specific spraying (SSS). **Herbicide** opportunities include biodiversity enhancement as well as stabilized crop yields among other business-related aspects. Main needs include improved knowledge and regulatory changes. Primary barriers were related to expense and environmental concerns. Environmental and human harm, public opposition, efficacy concerns, and expense are considered as notable disadvantages. **Biobased herbicides** opportunities include their potential to provide ecosystem services and foster IPM strategies. Improved knowledge or management expertise were considered as relevant needs, whereas selected barriers include time consumption and lack of funds. Meeting customer demand for reduced usage and addressing expense and time concerns are paramount for overcoming disadvantages. **Site-specific spraying** opportunities were included crop yield stabilization as well as provision of ecosystem services. Needs include increasing ecosystem services impact knowledge, practicing knowledge skills along with management expertise. Training emerges as the main barrier, accompanied by concerns about complexity and time consumption. Disadvantages include expense, complexity, and time consumption.

Physical weed control consisted on mechanical weeding (MW) and mowing (M). Stakeholders (advisors and consumers) shared different perceptions toward MW. **Mechanical weeding** most relevant opportunities included provision of ecosystem services, being acknowledged across virtually all stakeholder categories. Besides, advisors, consumers, and policymakers recognize that mechanical weeding results in a reduction in herbicide reliance among other benefits. Regarding primary needs, stakeholders differ in the importance of the different categories. advisors emphasize management expertise, consumers emphasize practicing knowledge skills, while policymakers consider reduction of cost and maintenance crucial, a viewpoint shared by industry representatives. Training was considered as a relevant barrier across all stakeholder categories. Additionally, consumers, industry representatives, and researchers emphasize time consumption as relevant impediments. None of the queried disadvantages were considered highly relevant by advisors or consumers. However, industry representatives and policymakers regarded expense and time consumption as significant. **Mowing** was considered as offering various opportunities, including ecosystem services provision as well as IPM fostering and its evolution into relevant scientific discipline. Primary needs include management expertise, reduced maintenance and cost. Additionally, lack of funds was considered as the most relevant barriers, along with concerns regarding complexity, time consumption and training. No single disadvantage was deemed as significant by a significant proportion of respondents.

3.7.1.5 Conclusions

We can conclude that in order to improve the citrus sector in Italy, it is essential to promote mandatory organic certification in those farms that already follow these criteria and to invest in technology that reduces the dependence on subcontracted machinery and the promotion of more efficient practices. This would strengthen consumer confidence and increase the value of products in the local market.

It is necessary to implement training programs on agroecological weed management, which include the use of non-chemical methods such as mechanical and automated control. These programs should include practical workshops to facilitate the adoption of these sustainable practices. In addition, research into alternatives to herbicides should be encouraged, along with financial incentives that make the transition to more sustainable management viable.

Finally, public policies should focus on providing financial support to farmers who adopt sustainable practices, such as subsidies for the purchase of machinery or access to credit. Promoting IPM fostering is also key to reduce reliance on herbicides, improving soil health and increasing biodiversity, which in the long term will contribute to a more profitable and sustainable agricultural system.

3.8 Permanent crops: Cherry

3.8.1 Cherry analysis

3.8.1.1 Contextualization

In 2022, the EU produced 6.3 million tonnes of stone fruit such as peaches, nectarines, apricots, cherries, and plums. (Eurostat, 2024). Spanish cherry production in 2023 was 109,000 MT, seven percent lower than the previous season due to damage from heavy rains that took place in a large part of the producing regions, especially significant in the Jerte Valley, Extremadura. (Stone fruit annual, USDA, 2023). Spanish Cherry LL board meeting detailed that regional production consist of around 5,000 farmers, including three surrounding valleys in Cáceres (Jerte, la Vera and el Ambroz). The cropping system differs among valleys, with monocropping predomination and associations with chestnut and plum trees appearing in big plots La Vera Valley. Fresh cherries are the principal derived produce, with derived goods, such as jams, wine or liquor representing little importance in local economy.

LL board meeting participants considered that agroecological products should be promoted in local markets, while sharing some regional initiatives that promote regionally source and sustainable cherries (*Ecocomedores*). Stakeholders shared concerns linked to organic cherry production as in-farm prices are low due to distribution and commercial intermediaries benefits. The region does not suffer for a lack of technologies with local sprayers being available, sensorization applied water saving and fertilization. LL workshop attendants raised concerns regarding expense of these new cropping practices.

The sustainability of the regional agri-food value chain caused some discussion within the workshop, being tied to production inputs and climatic situation. Sustainability depends on market prices, including fertilizers, herbicides, pesticides and fuel. Fuel prices in organic farming represent the main input. Participants shared concerns regarding generational renewal and labor availability as main concerns to ensure value chain sustainability. Weather events have impacted production in recent years, reducing economical margins and investments in new technologies.

Regarding weeding practices in the crop, tilling is virtually not used, as it may damage tree roots and soil is usually covered all year round, being a more favorable situation for weed management compared to other regions. Local advisors are promoting IPM, applying these criteria is reducing herbicide use in the region. Crop diversification and increasing technology and digitalization are considered to be opportunities to attract new generation to farms.

Most common agronomic practices in cherries consist of fertilization treatments. Mowing is used to control weeds in organic plots, being done 2 or 3 -times in spring, and no intervention from November to February. Herbicides are applied once or twice per season (conventional production). Most relevant ingredients are glyphosate, MCPA systemic, Oxifluorfen. Both pre-emergence and post-emergence treatments are applied. Herbicides are considered as efficient; however, attendants have observed resistance events.

Alternatives to herbicides are considered equally efficient with some requisites, including progress with regard to grazing under organically managed plots, regarding hen, goats and sheeps. LL board meeting attendees have recognized environmental problems with regard to herbicide use, including lack of biodiversity, reduction in insects, enhancement of soil compaction and contamination as well as reduction in soil microbiome. The LCA analysis of the different alternatives is considered important to educate conventional producer of AWM benefits. Overall, organic farmers considered agriculture without herbicides as viable. However, conventional farmers considered the viability of more sustainable practices as being dependent to market prizes.

LL board meeting participants considered incentives as the most relevant policies to boost AWM uptake. The region is suffering for climate change and pollution, acknowledging that organic management are the ones improving the environment and asking for changes in prices related to sustainable production as well as raising consumer awareness.

Considered barriers toward AWM implementation include economic innovation strategies, being needed to value ecosystem services provisions, and carbon markets awareness. Increasing administration support toward more sustainable farms was considered as the route to redefine policies to allow for agroecological transition. Additionally, LL attendants considered increasing farmers professionalization as an essential aspect for increasing sustainability, and considered that more policies should be included in this sense.

The adoption of AWM practices in the region may be hindered because of traditional way of measuring productivity. Creatin synergies between livestock farmers and cherry producers was considered as key to ensure transition to AWM.

Drivers for weed dispersal includes machinery, seeds in manure, and farmers walks among others. The most noxious weed in the area is *Lolium rigidum*, which is becoming resistant to herbicides in some areas. No invasive plants were identified by LL board meeting attendants in the region.

3.8.1.2 Weeding needs, barriers, gaps and opportunities

Table 17 highlights the key needs, barriers, gaps, and opportunities for cherry weeding strategies in Spain. Main **needs** are related with technical improvements to reduce costs and time, as well as increased training for farmers and studies on the impact on ecosystem services. A redefinition of policies with financial incentives and administrative support is also necessary. The main **barriers** for cherry cultivation in Spain include lack of funds, environmental damage caused by herbicides and restrictive EU policies. There are **gaps** in knowledge about agroecological practices and the high costs of their implementation. In addition, there is a lack of incentives, labour shortages and concern about generational renewal. However cherry cultivation in Spain is plenty of **opportunities** like include improvements in biodiversity, soil and water health, along with the promotion of IPM fostering and reduced dependence on herbicides. Regarding farmers, a greater professionalization through training programs is also expected. **Cherry stakeholders emphasize the importance of efficiency in technology and mechanization of the production in the region in order to break the cost barrier. The implementation of these practices must be tied to some kind of incentive. Stakeholders considered that promotion of AWM was important as a good way to contribute with soil health.**

Table 16. Cherry LL Spain main needs, barriers, gaps and opportunities.

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Cherry (Spain)	1. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. **2. Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise, emphasizing the importance of peer to peer knowledge and multi-actor approaches. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. Treatment optimization for regional weed management. 4. **Regulatory changes- Policy concerns.** Stakeholders consider that there needs to be a redefinition in policies, appointing financial incentives and increasing administrative support to farmers. 5. **Market** and s**ales acceptance** of the products, value ecosystem services provision.	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. 2. **Environmental or human health harm** as a result of herbicide use, leading to decline in biodiversity and soil microbiome as well as environmental pollution. 3. EU policies, **regul atory challenges** related to restrictions in herbicides and economic compensations to farmers. Stakeholders consider that administration should promote market recognition and consumer education. 4. **Weather** and especially **climate change** are considered as key barriers to AWM and non-chemical weeding use. 5. Some farmers reported instances of **herbicide resistance** which are increasingly concerning in the recent years.	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. **Cost of application** in AWM practices compared to herbicides, in an instable market. Lack of incentives to farmers 3. Lack of drivers for **change in farmers habits**. They consider that agriculture without herbicides is possible, and demand for increased knowledge and dissemination through the adoption of multi-actor approaches to boost AWM practices intake. 4. Lack of **economic innovation strategies** that value ecosystem services and sustainable practices in agriculture. 5. **Cost** of **equipment** as well as **lack of labour**. Stakeholders shared concerns with regard to generational renewal.	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity as well as an amelioration on soil health. These practices are in harmony with **European green policies**. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social and employment where they are implemented. Stakeholders consider the reduction of inputs as a key opportunity. 3. **IPM fostering**. They consider that AWM and non-chemical weed management increase IPM strategies adoption. 4. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies 5. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.**

3.8.1.3 Weeding techniques SWOT analysis

3.8.1.3.1 Herbicides

The SWOT analysis of **herbicides** revealed that no strengths nor opportunities were acknowledged by interviewees. Markets were considered as the sole threat by farmers. However, several weaknesses were identified, being related to environmental aspects, including concerns regarding herbicides environmental impact and the resulting biodiversity decline (F, A, R), as well as pollution (F) and risks to human health (A). Aside from the environmental aspect, technical (Herbicide resistance events (F, R, A), residues management (F, R), selectivity (R) and acquisition of new equipment (A)), economic (expense (F, R, A)) and societal (lack of knowledge (R)) concerns were raised. **In summary, herbicides are considered as a practice with no associated opportunities, nor threats or strengths. However, stakeholders emphasized several weaknesses associated with environmental challenges.**

3.8.1.3.2 Agroecological Weed Management techniques

The SWOT analysis of AWM included several **opportunities**, consisting mostly of technical (Consultancy (F, R, A), combination of strategies and available machinery (F, A), establishment of synergies (R, A)efficacy (A), feed source for animals (F)), economical (reduction in inputs (F, R, A), economic benefits (A), as well as opening of new markets, prices and products (A)), and environmental aspects (human health (F, R)). Several **strengths** related to AWM were recognized, including mostly aspects related to technical benefits, including reduction of herbicide input (F, R), availability of equipment (R, A), their beneficial long-term effect (R), applicability and relation to cultural aspects (F). Besides, social (establishment of training programs (F, R, A), increasing general research (R, A) and knowledge related to weeds biology and ecology (R)), environmental (improving soil health and ground cover (F, R), harmonization with green policies (A)) as well as proper management of water resources (R)), and economical aspects (reduction of labor and costs (R)). Recognized **threats** related to AWM include environmental aspects, such as appearance of invasive speces (A) and changes in weed flora (R, A), as important in the region. **Weaknesses** include technical (costs of application (F), lack of technical assistance (A), need for large-scale operation (F, R) and social aspects (lack of training (A)). **In summary, AWM included several opportunities and strengths linked to technical and economical aspects. Virtually no threats nor weaknesses were considered.**

3.8.1.4 *Weeding techniques evaluation*

Cherry questionnaires were answered by 17 actors. From those, consumers (41%) were those with the higher share of knowledge, followed by advisors (29%), being the rest below the 10 %. Industry is the group with the lowest representation of responses in the questionnaires, which reflects the reality seen in the LL board of a clear lack of mechanization of the sector in Spain and the need for financing and changes in policies that limit its progress. (Figure 14 left)

Within each technique, none of the techniques was known for the 100% of the actors and only herbicide application is known for more than the 60% of actors. mowing is the most knowledgeable techniques to weed wheat after herbicides and mechanical wedding. Figure 14 right reveals that digital and precision technics (such as automatic weed control, unmanned aerial vehicle or cover crop inoculated) are also unknown and not used by farmers. Recent techniques (thermal weeding) is not used to weed cherry, wich means a lack of technology advances in the sector. Other techniques nature-based solutions (natural enemies, biobased herbicides) are not being used to weed cherry.

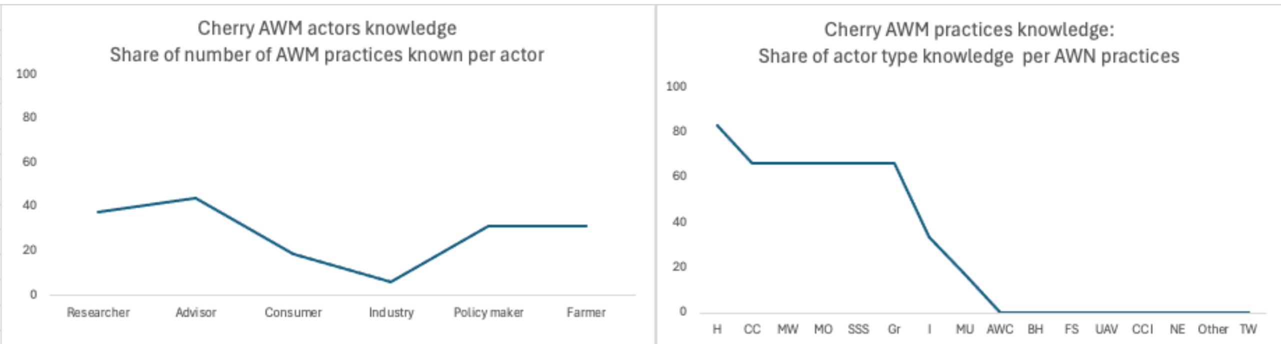


Figure 14 Citrus AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle

The description of cherry results from the questionnaires classified by type of actors are shown in Annex III, where a deep stakeholder's analysis is shown. The main weeding methods considered by sufficient stakeholders included **chemical weeding**, herbicides (advisors, consumers) and **physical methods**, mowing (advisors).

Chemical weeding included **herbicides** main opportunities tied to their use include provision of ecosystem services, consisting of improvements in water quality and soil health. Interestingly, consumers recognized other ecosystem services. Advisors prioritize regulatory changes, maintenance, and timing reduction as primary needs, while consumers identify ecosystem services impact knowledge as the most relevant necessity. Advisors unanimously recognize time consumption, lack of funds, and expense as main barriers, whereas consumers consider training as the most relevant impediment. Advisors identify public opposition to herbicide use as the main disadvantage, a concern shared by consumers who unanimously consider environmental and human harm as the most relevant drawback.

The sole **physical methods** include mowing. Stakeholders recognize opportunities linked to ecosystem services provision, foreseeing positive impacts on water quality and soil health, while recognizing the practice impact to reduce herbicide reliance. Regulatory changes, reduction of maintenance and cost reduction were unanimously acknowledged as relevant needs. Main barriers consist of training, lack of funds, time consumption and regulation. Expense was regarded as the most important disadvantages.

3.8.1.5 Conclusions

We can conclude that herbicide use faces critical challenges. No significant opportunities or strengths were identified, but threats related to market pressure and weaknesses due to their environmental impact, risks to human health and high prices were highlighted. Farmers are concerned about pollution, while advisors focus on the lack of new technologies.

On the other hand, agroecological management techniques show clear opportunities, mainly in training, consulting and reduced use of inputs. Synergies between actors, available machinery and support from green policies are key to their success. Positive aspects as improved soil health, vegetation cover and reduction of harmful inputs were highlighted.

To sum up, agroecological techniques offer a more efficient and economically beneficial approach. Investing in training, synergies between actors and technologies can overcome current weaknesses and maximize environmental and productive benefits.

3.9 Permanent crops: Grapes

3.9.1 Grapes global analysis

3.9.1.1 Contextualization

The European Union (EU) had 3.2 million hectares of vines in 2020, equivalent to about 45 % of the world’s wine-growing áreas. Spain, France and Italy together accounted for three-quarters of the area under vines in the EU and about two-fifths of vineyard holdings in 2020. The main vine varieties for red wine accounted for a small majority (52.7 %) of all main vine varieties, with those for white wine accounting for most of the rest (44.6 %). Vines for quality wines dominate EU vineyards; 82.4 % of the area of vineyards in the EU were dedicated to quality wine production in 2020. (Eurostat, 20224)

The vast majority (82.4 %) of the EU's vineyards in 2020 were dedicated to the production of grapes for quality wine. Quality wine refers to products of both protected designation of origin (2.1 million ha, equivalent to 65.3 % of the EU's vineyards) and protected geographical indication (0.5 million ha, equivalent to 17.1 %).

Between 2015 and 2020, there were 257 000 fewer vineyard holdings in the EU, equivalent to a 10.3 % reduction. Despite these losses, the area of vineyards for wine production remained relatively stable (-1.1 %) between 2015 and 2020. (Eurostat, 2024)

An analysis of the Living Live surveys conducted in the different regions reveals that main products derived from the vine include mainly grapes, wine, brandy, sultanas, vinegar, and compost from by-products. In addition, vine leaves can be used in the pharmaceutical industry due to their content of anthocyanins, which have antioxidant properties.

Agroecological products have the potential to be promoted in local markets, as consumers are willing to pay higher prices for organic and agro-ecological products. However, one of the main challenges is the lack of adequate technologies to implement agroecological practices, especially in smaller wineries. Although technology is available for chemical weed management, it is limited when it comes to agroecological methods, and some regions rely on outsourced equipment for farming.

The most common agronomic practices in vineyards include pruning, tillage (used for mechanical weed control and soil aeration), harvesting, and fertilization with both solid and foliar products. In terms of weed management, the most common combination is the use of herbicides (chemical control) together with cover crops in the aisles between vine rows.

Herbicides are frequently used, and are generally considered efficient, especially in large plots. However, there are concerns about their impact on the environment, such as water pollution, reduction of biodiversity and effects on human and animal health. Despite these concerns, many winegrowers believe that herbicide-free agriculture is viable, particularly in vine production.

To encourage the transition to agroecological practices, workshops and demonstrations are needed to show farmers the benefits of these methods. However, the adoption of agroecology faces significant barriers, such as high costs, lack of appropriate machinery and labour shortages. Although some farmers are already adopting alternative weed management methods, the full transition is expected to take several years. To improve the adoption of agroecological practices, it is proposed to strengthen communication, increase field activities and create information networks to support farmers in the transition to more sustainable crop management.

3.9.1.2 Weeding needs, barriers, gaps and opportunities

In all the regions, there is a clear **need** for improvement in the technical aspects related to agroecological weed management (AWM). This involves optimizing strategies that reduce maintenance costs and the time needed to implement these practices. In addition, it is essential to improve farmer education and training, providing both practical knowledge and management skills, including field demonstrations and the training of more advisors to support farmers in adopting these techniques.

The most significant barrier in all regions is the high cost of implementing AWM practices, especially for farmers with limited resources. This barrier is compounded by the lack of adequate funding, which hinders the adoption of these techniques across much of the agricultural sector. In addition, the complexity and time required to implement AWM, especially on small farms, represents a major challenge, which discourages many farmers.

One of the most significant **gap** is the lack of practical knowledge and experience in agroecological weed management, which hinders the effective implementation of AWM. Although these practices are knowledge-intensive, insufficient channels have been developed for the transmission of this know-how to farmers, which limits their adoption. There is also a lack of economic incentives and innovative strategies that adequately value the ecosystem services derived from sustainable practices.

Finally, there are several **opportunities** that could be seized to enhance the uptake of AWM. One of the main opportunities is the provision of ecosystem services such as improved water quality, biodiversity and soil health, which is in line with European environmental policies. **European grapes stakeholders consider that reducing reliance on herbicides through the use of non-chemical strategies also represents a move towards more sustainable agriculture. In business terms, AWM practices can stabilize crop yields and improve exploitation profitability, as well as generate positive social impacts in the communities where they are implemented such as increased employment and social cohesion.**

3.9.1.3 Weeding techniques SWOT analysis

3.9.1.3.1 Herbicides

SWOT analysis of different regions have a conservative view on herbicides, with around 50% of respondents identifying opportunities, especially in Greece, where 62% see them as drivers of IPM strategies. However, consumers do not consider these opportunities as relevant.

Most advisors emphasize reduced maintenance costs as the main need, along with regulatory changes and training. Most advisors emphasize reduced maintenance costs as the main need, along with regulatory changes and training. Training and understanding the impact on ecosystems is more important on Spanish group.

Regarding barriers, both groups highlight regulatory challenges and environmental concerns. Spaniards express these concerns more strongly. In addition, environmental and human damage, along with public pressure to reduce herbicide use, are considered significant disadvantages, especially among consumers and researchers in Spain, while in Greece, the industry sees few disadvantages.

3.9.1.3.2 Agroecological Weed Management techniques

SWOT analysis is clear for AWM techniques. Those are recognized for its multiple benefits, such as improving soil health, protecting biodiversity and reducing weed seed production. Education and training are highlighted as key opportunities to promote AWM among all stakeholders, including farmers, researchers and advisors. The researchers also noted the importance of integrating diverse strategies to increase the effectiveness of AWM.

However, AWM techniques faces several challenges, especially in grape growing in Spain and Greece. Among the weaknesses identified were lack of training and knowledge, insufficient manpower, funding and high application costs the most included ones. Stakeholders expressed similar views on the weaknesses of non-chemical and chemical weed management. Some farmers also expressed concerns about the costs, environmental impact and potential human health risks associated with AWM techniques.

In terms of threats, the main obstacles to adopting non-chemical alternatives were identified as high costs and low effectiveness in certain situations. In addition, farmers' usual practices, together with the need for manpower and knowledge, hinder the transition to non-chemical methods.

To conclude, there is a consensus among all the groups about the benefits of AWM and the need of better training and resources to overcome barriers in implementing non-chemical and agroecological practices effectively.

3.9.1.4 Conclusions

We can conclude that on the regions requested, vineyards are mainly producing grapes, wine and other subproducts (on a low percentage). Although there is growing interest in agroecological products in local markets, the lack of appropriate technologies and high implementation costs are significant challenges, especially for smaller wineries. Common practices include pruning, tillage and fertilization, with herbicides often used for weeding control, although their use raises environmental concerns. To facilitate the transition to agroecological practices, workshops and training are needed, but high costs, lack of machinery and labor shortages hinder this adoption.

A clear need for improved education and training in AWM is identified. The main barriers are the high cost of implementation and lack of funding. However, there are opportunities to improve water quality, biodiversity and soil health, aligning with European environmental policies. The SWOT analysis of AWM shows that, although it offers significant benefits, it faces challenges such as lack of training and resources, as well as high costs and low effectiveness in some situations. There is consensus on the benefits of AWM and the need for better resources and training for effective implementation.

3.9.1.5 Weeding techniques evaluation

Grapes questionnaires were answered by 98 actors, the 18 % of the whole interviewees. From those consumers (32%) were those with the higher share of answers.

In Grapes, the initial perception gathered in the **questionnaires** were that most of technique were known as shown in Figure 15 right. The unique unknown technique for stakeholders was the use of natural enemies (NE) and inoculated cover crops.

Figure 15 right also makes clear that there is a complex knowledge of AWM practices combined with the use of herbicides. This knowledge highlights the reality of the crops in the three countries, and the farmers' knowledge of various AWM techniques reveals the importance on this sector in the questioned regions, where grape growing traditions go far back in the past.

Figure 15 (left) shows the low number of advisors and policy makers in terms of responses. This low percentage reflects the reality of the LL board: there is a need for more advisory services, more policies adapted to the regions and the improvement of the scientific-technical knowledge of AWM practices.

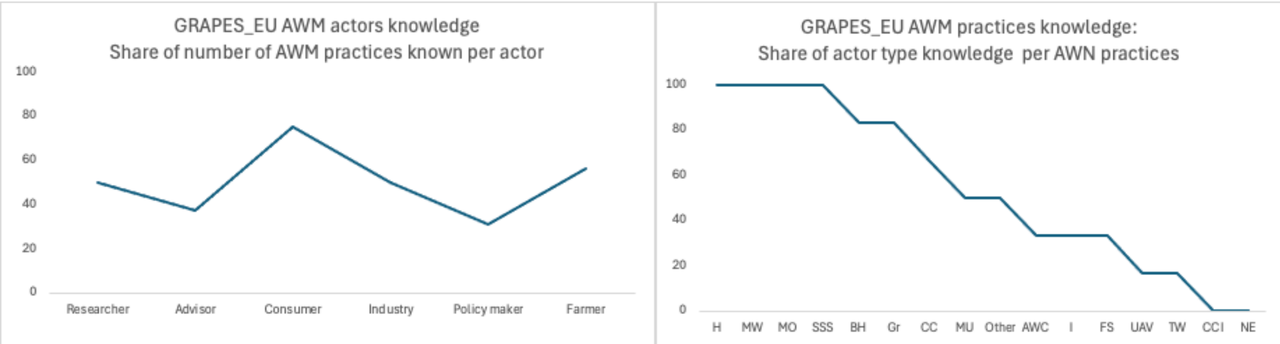


Figure 15 Grapes Global AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle

3.9.2 Spanish grapes LL analysis

3.9.2.1 Contextualization

The LL in Spain revealed that there are 25,041 hectares of vineyards in Galicia, although the exact number of farmers is unknown. The main products are grapes, wine and schnapps, and by-products such as compost and vine leaves are used in the pharmaceutical industry. Vine growers see potential in agroecological products in local markets, although they recognize a lack of appropriate technologies for these practices compared to chemical weed control. The sustainability of the agri-food value chain is questioned, as some producers consider that it is not based on agroecological principles.

Common agronomic practices include pruning, tillage and harvesting, with a combination of herbicides and cover crops for weed management. Although herbicides are efficient, they create environmental problems. Workshops and legislative changes are proposed to encourage the adoption of agroecological practices, facing barriers such as high costs. Farmers show interest in alternatives to herbicides and recognize the impact of crop management on weed spread, including the presence of invasive species.

3.9.2.2 Weeding needs, barriers, gaps and opportunities

Table 18 shows the most relevant needs, barriers, gaps and opportunities found for grapes cultivation in Spain. The main **needs** include improving technical aspects to reduce costs and time, as well as strengthening farmer training in AWM. More scientific knowledge is also needed on the impact of these practices on ecosystem services and market acceptance of agroecological products. The identified **barriers** include the high cost of implementation, the complexity and time required for AWM practices and potential environmental damage from herbicides. Regarding **gaps**, the lack of practical knowledge, high costs compared to herbicides, and lack of manpower. Collaborative approaches are needed to change farmers' habits. **Opportunities** pointed were the improvement on water quality, biodiversity and soil health. **Spanish stakeholders pointed that AWM reduces reliance on herbicides, encourages integrated pest management and boosts the professionalization of farmers. Besides this, AWM techniques adoption for farmers should be easier to implement, so funds and policies must be aligned with the regional production in order to promote agroecology in grape sector in Spain.**

Table 17 Grapes Spain LL main needs, barriers, gaps and opportunities.

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Grapes (Spain)	1. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. **2.** Improvements in **educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise, that boost AWM practices implementation. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 4. **Market** and **sales acceptance** of the products, value ecosystem services provision. Some stakeholders consider that grapes value chain is not sustainable because production is not based on agroecological principles. 5. **Treatment optimization** and design of **combination strategies**. Stakeholders consider that the use of various practices may increase cost-efficiency, and create synergies	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. Stakeholders consider the increase of costs when applying AWM as the most relevant barrier. 2. **Complexity** of application and **time consumption**. Especially when considering AWM practices. 3. **Environmental or human health harm** as a result of herbicide use, leading to decline in biodiversity and soil microbiome as well as environmental pollution. As well as high carbon footprint. 4. EU policies, **regulatory challenges** related to restrictions in herbicides and economic compensations to farmers. Stakeholders consider that eco-schemes should integrate agroecological management of crops. 5. **Weather** and especially **climate change** are considered as key barriers to AWM and non-chemical weeding use.	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. **Cost of application** in AWM practices compared to herbicides. 3. **Cost of equipment** to implement AWM practices. 4. Enhance **multi-actor and holistic approaches** to implement peer to peer to ensure **changes in farmers habits**. 5. **Lack of labor**. Stakeholders shared concerns with regard to generational renewal.	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity as well as an amelioration on soil health. These practices are in harmony with **European green policies**. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social and employment where they are implemented. 3. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 4. **IPM fostering**. They consider that AWM and non-chemical weed management increase IPM strategies adoption. 5. **Farmers professionalization**. As the implementation of more AWM practices will lead to **increase in training and education program**

3.9.2.3 Weeding techniques SWOT analysis

3.9.2.3.1 Herbicides

From the SWOT analysis revealed that several weaknesses and strengths and few opportunities or threats. Only researchers included **opportunities** for herbicides use: efficacy, available equipment and cheap prices. Regarding **threats** the main concern is related with the mandatory withdrawal of herbicides (R, A). Main **strengths** on the use of herbicides were their efficacy and the low prices of the products (F, R, A). Its simplicity was emphasized for researchers and advisors. Other aspects included were the balance cost-effectiveness (R), the economic benefits (A) and the available of herbicides on markets (R). Lastly, **weaknesses** related with environmental issues, human health or economic were highlighted from at least two different stakeholders: environmental impact (F, R A), pollutants (R, A), herbicides resistance (F, R), biodiversity decline (R, A), risks to human health (R, R) and finally high cost of the products (F, R). Additionally, farmers emphasized their concern with the lack of knowledge and advisors with the certificates. **Grapes herbicides SWOT analysis in Spain included several weaknesses, being mainly related to environmental impacts, human health risks and prices. Strengths are related with cost-benefit aspects and main concerns regarding threats is linked with the mandatory end of herbicide use.**

3.9.2.3.2 Agroecological Weed Management techniques

The SWOT analysis of AWM revealed several opportunities and strengths and no weaknesses and threats. Main **opportunities** and selected for all actors (F, R, A) were related to technical skills related with combination of strategies. Social aspects were also pointed as relevant. Main ones were training and subsidies (F,A). Advisors emphasised new technologies and site-specific management, researches soil health, quality of products and sustainable management and finally, farmers pointed environmental sustainability and the positive social impact. Regarding **strengths,** only improving soil health was included as one by all the groups. Besides this, other ones were pointed: environmental balance (F, R) and combination of strategies (F, R). Researchers highlighted reduction of fuel costs, ground cover, simplicity, training and management of water resistance. For advisors efficacy was also remarked as a strength.

3.9.2.4 Weeding techniques evaluation

The **grapes questionnaire** (Annex III) was responded by 41 actors in Spain answering about cover crops, false seedbed, grazing, herbicides, intercropping, mechanical wedding, mowing, mulching, site specific spraying. Herbicides, mechanical weeding, mowing and site-specific spraying were the most knowledgeable techniques for vineyards, with a 100 % knowledge of the stakeholders. This clearly reflect the traditional knowledge of grape cropping in this country. Is remarkable the low share of knowledge on digital tools (unmaned aerial vehicle or termal weeding), or nature-based solutions (natural enemies). This shows that viticulture is on process of modernization and adaptation to new agroecological paradigms of production and need more inputs of technology for AWM practices. (Figure 16 right)

The analysis of the number of responses per stakeholder reveals that consumers and farmers show the highest knowledge of the questioned techniques, with industry and policy makers showing the lowest knowledge. Figure 16 left, is the clear representation of the contents of the living lab in the region, where consumers and farmers demanded more scientific participation and more and a clear advance on policies and simplification of AWM techniques and knowledge.

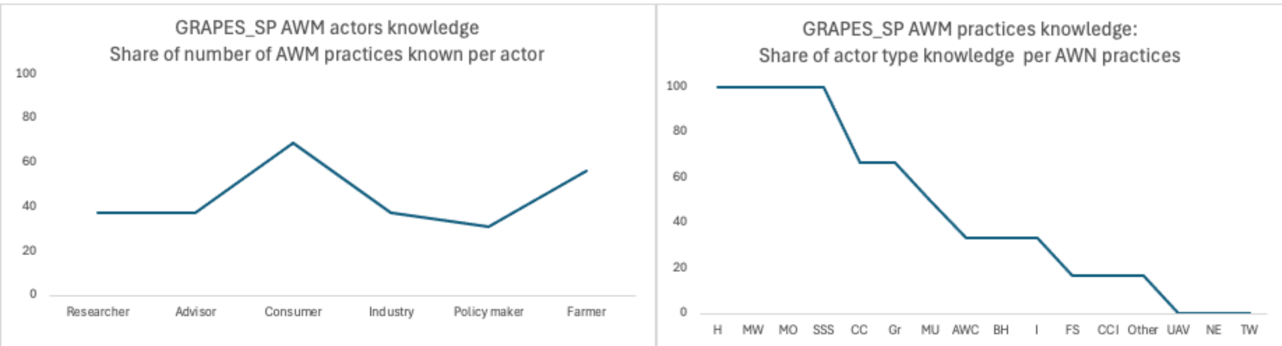


Figure 16 Spain Grapes AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle

The **questionnaires** associated with grapes included answers for **chemical weeding**, biobased herbicides (consumers) and herbicides (advisors, consumers, farmers, industry and researchers), **physical weed control** practices, such as mechanical weeding (consumers, farmers, industry, researchers), mowing (consumers, farmers, researchers), mulching (consumers, farmers), and **nature-based solutions** include temporal (cover crops (farmers)) as well as spatial use of biodiversity (grazing (consumers)). An extended version analyzing the results obtained in the questionnaires can be found in Annex III.

Chemical weeding practices include **biobased herbicides**, considered opportunities related to IPM implementation, and consider that its use might stabilize crop yields. High prices and inefficiency were considered as barriers toward its use. Stakeholders shared diverging regards toward **herbicides**. Opportunities include IPM fostering, as well as provision of ecosystem services. As per the primary needs recognized in the questionnaires, increasing the knowledge on ecosystem services as well as navigating regulatory changes were considered as the main necessities. Stakeholders recognition of main barriers differ, advisors consider regulatory challenges as the main impediment, consumers spotlight environment and human and a high carbon footprint. Farmers and industry representatives considered operational knowledge and financial constraints. Stakeholders coincide identifying customers and the public as principal disadvantages to herbicide use.

Physical control methods include mowing, mechanical weeding and mulching. **Mowing** opportunities include its role in reducing herbicide reliance and consider it a provider of ecosystem services, fostering IPM strategies, among others. Stakeholders did not shared consensus with regard to mowing main needs. Consumers emphasize ecosystem services impact, farmers highlighted the importance of training and agree with researchers acknowledgement of maintenance and cost reduction. Most relevant barriers, as identified by consumers, were related to training, lack of funds, and regulatory challenges; while farmers considered time consumption, environmental and human harm, and expense as relevant, these concerns were shared by one third of researchers, who did not regarded any of the queried impediments as relevant by a majority of respondents. Disadvantages considered by consumers and farmers considered the method's low efficacy and time consumption, respectively, as the most significant drawbacks. Conversely, industry representatives acknowledged expense and time consumption as relevant disadvantages, consistent with perceived needs. **Mechanical weeding** main opportunities were related to reduction in herbicide reliance, as well as fostering IPM and provision of ecosystem services. There was no consensus among stakeholders regarding the primary needs associated with the practice, consumers cited a lack of advisors, farmers emphasized the importance of timing reduction, and industry representatives mentioned the need for proficiency in practical skills. Researchers highlighted the importance of understanding the impact on ecosystem services, proficiency in practical skills, and cost and maintenance reduction. With regard to the method main barrier, consumers, farmers and researchers considered method's carbon footprint, whereas researchers and industry representatives considered expense as a significant barrier. Expense and time consumption were considered relevant disadvantages across all stakeholders. Additionally, consumers and researchers highlighted the method's high carbon footprint, while farmers cited complexity, and industry representatives mentioned a lack of funds as highly significant drawbacks. Recognized **mulching** opportunities include several opportunities, such as IPM fostering and provision of ecosystem services. As per the method's main needs, farmers considered regulatory changes and reduction of maintenance as the most important feature, whereas consumers did not considered any of the queried necessities as relevant. Farmers unanimously consider time consumption as the primary barrier, emphasizing method complexity, lack of funds and training, as well as expense, as relevant barriers. In contrast, consumers did not mainly regard any of these factors as relevant, with only 25% of them, in agreement with farmers, considering low efficiency, complexity, time consumption, and lack of training as relevant. Regarding the main disadvantages of the method, farmers emphasize expense and complexity, while none of the queried drawbacks were considered relevant by consumers.

Nature-based solutions include both spatial and temporal use of biodiversity. Acknowledged temporal use of biodiversity consisted of **cover crops** use, recognized opportunities were ecosystem services provision and crop yield stabilization, increased profitability and reduction in herbicide reliance were additionally regarded by farmers. Essential needs include regulatory changes as well as reduction of costs and maintenance. Main considered barriers include expense. Disadvantages were related to environmental impacts and the scarcity of advisors and skills. Spatial use of biodiversity for weeding considered included **grazing**. Perceived opportunities, consisted on improvements in soil health, reduced herbicide use, and economic benefits. Besides, primary needs include knowledge, training, and maintenance reduction. Training was considered as the main barrier for grazing implementation. Expense was emphasized as the main disadvantage.

3.9.2.5 Conclusions

Herbicides present strengths related with effectiveness, low cost and market availability, but also important weaknesses, mainly related to environmental impact, risks to human health and weed resistance. On the other hand, AWM practices show multiple opportunities and strengths, without identifying weaknesses or threats. Opportunities include the use of new technologies, training and sustainable management. The highlighted strengths are the improvement in soil health, environmental balance and effectiveness. **To sum up, herbicides are effective and low cost, but they present major environmental and health problems, with the risk of being eliminated. In contrast, agroecological approaches are more sustainable and provide both environmental and social benefits, positioning themselves as a safer and long-term alternative**.

3.9.3 Italian grapes LL analysis

3.9.3.1 Contextualization

Italy had a total of 0.7 million ha of vineyards on its territory, which represents 21% of the total European territory under vineyards. Like the other two major wine producers in Europe, Italy has a high degree of regional specialisation. The number of vineyards is lower than in countries such as Spain or Romania, but the size of the vineyards is higher in terms of cultivated area per vineyard (Eurostat,2024).

Italian grapes LL board meeting was located in Calabria, were there are about 10,000 hectares of vineyards, mainly of red grape varieties. Wine is a key product for the region, and there is potential for agroecological products. Common practices include pruning, tillage and fertilisation, and weed management is mostly by mowing and tillage, without the use of herbicides on the farms involved. Drivers of weed spread are inadequate tillage and over-fertilisation, with *Cynodon* sp. and *Elytrigia* sp. being the most harmful.

Italian viticulture needs to improve in technology and education to facilitate the transition to agroecological practices with a collaborative approach among all actors in the sector.

3.9.3.2 Weeding needs, barriers, gaps and opportunities

Table 18 shows the most relevant needs, barriers, gaps and opportunities found for grapes cultivation in Italy. Main **needs** to improve agroecological weed management, are to strengthen farmers' education and training, optimize technical aspects and increase knowledge about the impact of these practices on ecosystem services. Farmers face significant **barriers**, such as high implementation costs and time required, especially on small farms. Lack of training and concerns about the environmental impact of some practices limit the adoption of new strategies and those points are highlighted as a **gap**. Regulatory challenges affecting small farmers must also be overcome. Despite these difficulties, the implementation of agroecological practices offers **opportunities**, such as improving water quality, increasing biodiversity and strengthening soil health. **Italian stakeholders point that AWM practices can stabilize yields and increase profitability, while reducing dependence on herbicides and encouraging IPM fostering. Stakeholders consider the increase of costs derivated from AWM is a barrier that can be easily broken increasing the founds in more precise and efficient technologies and knowledge.**

AGROECOLOGY FOR WEEDS

Table 18 Grapes Italy LL main needs, barriers, gaps and opportunities.

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Grapes (Italy)	1. Improvements in **educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise, including field demonstration activities to boost AWM practices implementation. Increase the number of **advisors**. 2. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. 4. **Market** and **sales acceptance** of the products, value ecosystem services provision. Stakeholders emphasize that Italian organic vineyards have a sustainable agri·food value chain. 5. Increase **Treatment optimization** and design of **combination strategies**. Vineyard weed management is one of the most diverse of the analyzed crops. However, stakeholders emphasize that is necessary to improve weed management strategies	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. Stakeholders consider the increase of costs when applying AWM as the most relevant barrier. 2. **Time consumption**. Especially when considering AWM practices implementation in small farms. 3. Small farm's **lack of professionalization** and absence of **training**, hinder the adoption of effective strategies 4. Soil disturbances and **environmental impact** of some of the non chemical weeding practices. 5. EU policies, **regulatory challenges**. Stakeholders consider that policies should financially protect small farms owners from decreased production.	1. **Lack of knowledge** and **practical experience**. Stakeholders consider that AWM are knowledge intensive. There is a lack of "know-how" transmission. 2. **Cost of application** in AWM practices compared to herbicides, in an instable market. Lack of incentives and financial protection especially to small farms. 3. Lack of drivers for **change in farmers habits**. They consider that agriculture without herbicides is possible, and demand for increased knowledge and adequate training through the adoption of multi-actor approaches to boost AWM practices intake. 4. Lack of **economic innovation strategies** that value ecosystem services and sustainable practices in agriculture. 5. **Cost** of **equipment** as well as **lack of labor**. Especially in small farms.	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity, and on soil health, as well as an amelioration in overall environmental balance. These practices are in harmony with **European green policies**. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social aspects where they are implemented. 3. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 4. **IPM fostering**. They consider that AWM and non-chemical weed management increase IPM strategies adoption. 5. **Farmers professionalization**. As the implementation of AWM practices will lead to **increase in training and education programs.**

3.9.3.3 Weeding techniques SWOT analysis

3.9.3.3.1 Herbicides

The SWOT analysis in Italy revealed that the use of herbicides only presents **weaknesses**. Main aspects pointed for all stakeholders group (F, R, A) were environmental and health related: pollutants, environmental impacts, biodiversity decline and human health risks. Herbicide resistance (F, A) and expensive of products (F, R) were also pointed. Researchers emphasized selectivity, optimized treatment and lack of knowledge as weaknesses. **Grapes herbicides SWOT analysis in Italy revealed a big concern with the environmental issues associated with the use of herbicides**

3.9.3.3.2 Agroecological Weed Management techniques

The SWOT analysis of AWM revealed several opportunities and strengths and also few weaknesses. Main **opportunities** selected for all actors (F, R, A) were related to social aspects such as training and positive social impact. Environmental sustainability (F, A) was also included. Advisors remarked soil health, researchers peer to peer knowledge and farmers quality of products. Regarding **strengths,** environmental aspects were included for all groups of stakeholders such as environmental balance and safeguard biodiversity and improving soil health. Other environmental aspects were highlighted for other groups like less soil disturbance and management of water resources (F, A). Advisors emphasized knowledge of weeds biology and ecology, efficacy, ground cover and reduction of weed seed production. Farmers pointed low environmental impact, increase of labor and work safety as main strengths for AWM practices. **Threats** and **weaknesses** are agricultural policies, cost of application, environamental impact, soil pollution and risks to human health and were pointed for farmers. **As a summary, AWM main opportunities and strengths are related with environmental, economic and social aspects. Main strengths are connected with environment health and efficiency of practices.**

3.9.3.4 Weeding techniques evaluation

The **grapes questionnaire** (Annex III) was responded by 28 actors in Italy answering about cover crops, false seedbed, grazing, herbicides, intercropping, mechanical wedding, mowing, mulching, site specific spraying. Mechanical weeding, mowing and site-specific spraying were the most knowledgeable techniques for vineyards, with a 100 % knowledge of the stakeholders and the rest of AWM practices were known for at least a half of actors. Analysis of the questionaries shows a clear low share of knowledge on digital and precision tools (unmaned aerial vehicle or termal weeding), or nature-based solutions (natural enemies). This shows that viticulture is on a process of modernization and adaptation to new agroecological paradigms of production and need more inputs of technology for AWM practices. (Figure 17 right). The analysis of the number of responses per stakeholder (Figure 17 left) reveals a clear balance between the knowledge between actors and practices, excepting advisors, a very important figure for farmers in order to improve in the development of their crops in terms of technology and precision.

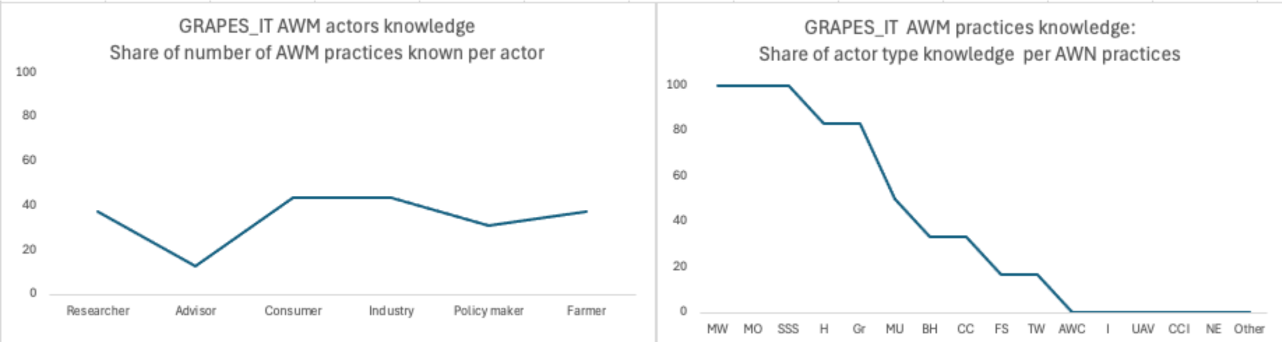


Figure 17 Italian Grapes AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle

The **questionnaires** associated with grapes included answers for **physical weed control** practices, such as mechanical weeding (industry), mowing (advisors, farmers, industry, policy maker), mulching (consumers)and **nature-based solutions** including as spatial use of biodiversity (grazing (consumers)). An extended version analyzing the results obtained in the questionnaires can be found in Annex III.

Physical weeding control consists of mechanical weeding, mowing and mulching. **Mechanical weeding** opportunities include fostering of IPM strategies as well as reduction in herbicide reliance. Numerous needs (lack of training,) and significant barriers (high costs, and regulatory challenges) were recognized. Expense was considered as the main disadvantage for mechanical weeding. **Mowing** encompasses several opportunities, with all stakeholders considering its potential to foster IPM strategies and to reduce herbicide reliance to different degrees. Most stakeholders consider ecosystem services provision as important. Training was considered a primary need by advisors and industry representatives, while farmers emphasized ecosystem services knowledge and researchers considered practicing knowledge skills and cost reduction as paramount. All stakeholders acknowledge training as the most relevant barrier. Expense and time consumption were considered as the practice main disadvantages. Perceived **mulching** opportunities include improved soil health and reduced herbicide reliance. However, addressing needs like improved knowledge and cost reduction, alongside barriers such as lack of training and financial constraints, is essential for wider adoption. Time consumption and expense remain significant disadvantages.

Nature-based solutions include spatial use of biodiversity, **grazing** was considered as the most mportant practice. Opportunities include its potential for promoting IPM practices and ecosystem services, despite acknowledging various barriers such as high carbon footprints. They prioritize reducing maintenance, timing and costs while emphasizing the need for increasing the knowledge and training for successful implementation.

3.9.3.5 Conclusions

Herbicides in Italy only presents significant weaknesses, primarily related to environmental impact, biodiversity decline and health risks. Weed resistance and high costs are also highlighted as major issues. On the other hand, AWM approaches offer important opportunities and strengths, focusing on environmental sustainability, training, and positive social impact. Oportunities include improved soil health, biodiversity protection, and reduced environmental impact. Some weaknesses include agricultural policies and application costs. **We can conclude that use of herbicides in Italy faces serious environmental and health challenges, while agroecological approaches provide more sustainable and efficient solutions, with clear advantages for the environment, economy, and society. Adopting these methods is more beneficial in the long term.**

3.9.4 Greek grapes LL analysis

3.9.4.1 Contextualization

Grape production in Greece accounts for 3.2% of the European territory devoted to grape cultivation. As in other smaller countries, the average size of production is low, with small vineyards being abundant. (Eurostat,2024).

The LL board conducted in the region finds that in Greece there are between 20 and 25 wineries involving more than 100 farmers dedicated to the cultivation of vines, producing mainly wine, raisins, vinegar and table grapes. As for the market, consumers are willing to pay more for agroecological products.

Although winegrowers are open to smart farming technologies, their use is not common. The most frequent agronomic practices include pruning, tilling and harvesting, while weed management combines herbicides and mechanical methods. There are seven active ingredients and four modes of action, with 1 to 2 herbicide applications per season. The main weeds are *Convolvulus arvensis* and *Sorghum halepense*, with herbicide resistance in species such as Conyza canadensis. The aim is to maintain the living laboratory as a tool for sustainable solutions in weed management.

3.9.4.2 Weeding needs, barriers, gaps and opportunities

Table 20 shows the most relevant needs, barriers, gaps and opportunities found for grapes cultivation in Greece. Stakeholders identify several **needs** in the implementation of AWM practices, such as improving technical aspects to reduce costs and time, training farmers through workshops, and increasing scientific knowledge on the impact of these practices on ecosystem services. Despite this, there are significant **barriers,** such as high implementation costs, EU regulatory challenges, lack of labor and professionalization in small farms, and a severe lack of training and resources. Among the **gaps,** they point out insufficient practical experience with AWM, lack of motivation to change agricultural habits, and the absence of economic strategies that value ecosystem services. Despite these difficulties, there are significant **opportunities**, including improving ecosystem services, promoting IPM strategies, stabilizing crop yields, and reducing dependence on herbicides. **Greek stakeholders point out that AWM practices can improve social aspects where they are implemented, but they must be accompanied by more funding, in order to preserve production and allow the sector to professionalize farmers and also to create a network for disseminating and valorizing products in the markets to increase consumption of organic wine by citizens. Stakeholders consider that eco-schemes should integrate AWM in grape crops and a major presence of advisors in the technical process of implementation its necesary.**

Table 19 Grapes Greece LL main needs, barriers, gaps and opportunities.

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Grapes (Greece)	1. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. Stakeholders recognize that AWM practices are simple to use and effective. 2. Improvements in **educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise, through workshops. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Stakeholders consider that AWM are not adequately tested and demand for increases in dissemination. 4. **Market** and **sales acceptance** of the products, value ecosystem services provision. Stakeholders emphasize that produce should be promoted, as consumers are willing to pay more for organic wine. 5. Increase **Treatment optimization** and design of **combination strategies**. Stakeholders emphasize that is necessary to improve weed management strategies.	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. Stakeholders consider the increase of costs when applying AWM as the most relevant barrier. 2. EU policies, **regulatory challenges**. Stakeholders consider that eco-schemes should integrate AWM, emphasizing that most producers are willing to integrate these practices in their production. 3. **Time consumption** and **lack of labor** are relevant barriers to implement AWM. 4. Small farm's **lack of professionalization** and absence of **training**, hinder the adoption of AWM strategies. 5. **Cost of application** and effectiveness of non-chemical weeding strategies.	1. **Lack of knowledge** and **practical experience**. Stakeholders consider that AWM are not adequately tested. 2. Lack of drivers for **change in farmers habits**. They consider that agriculture without herbicides is possible, and demand for increased knowledge and adequate training through the adoption of multi-actor approaches to boost AWM practices intake. 3. Lack of **economic innovation strategies** that value ecosystem services and sustainable practices in agriculture. 4. **Consumer** education and **promotion** of AWM and agroecology to the public. 5. Technical **assistance** and lack of advisors.	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity, and on soil health, as well as an amelioration in overall environmental balance. 2. **IPM fostering**. Stakeholders consider that AWM and non-chemical weed management increase IPM strategies adoption. 3. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social aspects where they are implemented. 4. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 5. **Farmers professionalization**. As the implementation of AWM practices will lead to **increase in training and education programs.**

3.9.4.3 Weeding techniques SWOT analysis

3.9.4.3.1 Herbicides

The SWOT analysis in Greece revealed strengths and weaknesses in the use of herbicides. Main strengths are connected with performance aspects such as efficacy (F, R, A), simplicity (R, A) and quick results (F, A). Researchers remarked optimized treatment and available equipment as strength also. On the other hand, several weaknesses were highlighted, mostly those ones related with environmental and economic aspects. Pollutants, herbicide resistance and environmental impact were main concerns for all the groups of stakeholders regarding environment and high price of products regarding economics. Risk on human health were also included in the list for researchers and advisors. For farmers lack of knowledge and awareness were remarked also as a weakness associated to the use of herbicides. **Grapes herbicides SWOT analysis in Greece revealed a big concern with the environmental issues but despite this, stakeholders remarked several strengths related with performing and efficiency of herbicides.**

3.9.4.3.2 Agroecological Weed Management techniques

The SWOT analysis of AWM revealed several opportunities and strengths. Main opportunities selected for all actors (F, R, A) were related to social and technical aspects such as training and available machinery. Efficacy was also pointed as an opportunities for farmers and advisors. Several strengths linked with technical aspects were noted for farmers, researchers and advisors. Main ones were efficacy (F, R, A), available equipment (R,A) and speed and simplicity (F, R).**As a summary, AWM main opportunities and strengths are related with social and technical aspects .**

3.9.4.4 Weeding techniques evaluation

The **grapes questionnaire** (Annex III) was responded by 29 actors in Greece answering about, herbicides, mechanical wedding, mowing, site specific spraying. Mechanical weeding, herbicides, mowing and site-specific spraying were the most knowledgeable techniques for vineyards, with a 100 % knowledge of the stakeholders. Analysis of the questionaries shows a clear low share of knowledge on digital and precision tools, or nature-based solutions. This demonstrate that viticulture in Greece is an agricultural practice that is not advanced in terms of mechanization and industrialization, which coincides with the information collected by the LL board and also with the data collected by Eurostat on grape production in this region. (Figure 16 right)

The analysis of the number of responses per stakeholder (Figure 18 left) reveals a clear low knowledge between actors and AWM practices.

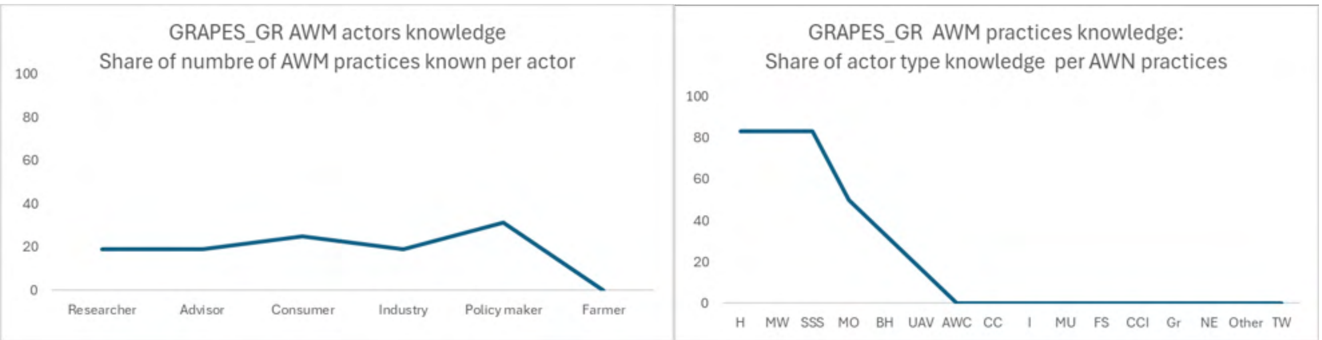


Figure 18 Greek Grapes AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle

The **questionnaires** associated with grapes included answers for **chemical weed control** including herbicides (advisors, consumers, industry, researchers), as well as **physical weed control** practices, such as mechanical weeding (advisors, consumers, industry) and mowing (advisors, consumers). An extended version analyzing the results obtained in the questionnaires can be found in Annex III.

Chemical weed control practices include **herbicides**. Considered opportunities advisors perceive herbicides as fostering IPM strategies, while industry representatives emphasize improvements in business profitability and crop yield stabilization as relevant opportunities. None of the queried opportunities were regarded as highly relevant by a majority of consumers or researchers. Stakeholders generally considered herbicides as presenting important needs, advisors prioritize reduction of maintenance, researchers emphasize cost reduction, and consumers identify regulatory changes. However, industry representatives did not mainly consider any of the queried necessities as highly relevant. Regulatory challenges were considered the most relevant barriers by advisors, consumers, and researchers, while industry representatives considered that herbicides face no significant barriers. Environmental and human harm were considered as relevant disadvantages by advisors, consumers, and researchers, while industry representatives considered that the practice faces no relevant drawbacks.

Physical weed control practices include mechanical weeding and mowing. Most relevant **mechanical weeding** opportunities include ecosystem services provision, reduction of herbicide reliance and fostering of IPM services, with some stakeholders considering that MW presents no relevant opportunities. Advisors and industry representatives consider cost reduction as the primary need, while consumers believe that timing reduction is the most relevant requirement for mechanical weeding. Time consumption and high carbon footprint are considered the most relevant barriers and disadvantages across all stakeholder's categories. **Mowing** was considered as a relevant practice by stakeholders. Opportunities were related to IPM strategies fostering, reduction of herbicide reliance. While advisors identify timing reduction as a primary need, consumers acknowledge ecosystem services impact knowledge as an important requirement. Time consumption was considered as a relevant barrier and disadvantage by advisors, while this factor was only regarded as a relevant drawback by consumers.

3.9.4.5 Conclusions

Herbicide use in Greece presented notable strengths, primarily concerning their effectiveness, simplicity and ability to deliver quick results. In contrast, AWM approaches reveal several opportunities and strengths, focusing on social and technical aspects, such as training and machinery availability. Key strengths noted include effectiveness and machinery availability. It can be concluded that herbicides demonstrate effectiveness but are associated with critical environmental and health issues. On the other hand, agroecological practices present promising opportunities for improvement and sustainability, emphasizing the need for education and resources to enhance their adoption and effectiveness in agricultural practices.

3.10 Permanent crops: Olives

3.10.1 Olives global LL analysis

3.10.1.1 Contextualization

The EU the largest producer of olive oil in the world, typically accounting for around two thirds of global production. Most of the world's production comes from southern Europe, northern Africa and the Near East, as 95 % of the olive trees in the world are cultivated in the Mediterranean region. With production concentrated in a relatively small area, the effects of a disease outbreak can have significant implications. Spain is by far the largest producer of olives for olive oil in the EU (48,7 %), followed by Italy, Greece and Portugal in the 4th position with 10,3% of EU production. Olives produces oil, olives and other by-products that are key to the economy and food security. Although monocultures predominate, some farmers intercrop other crops.

Agroecological products could be promoted if appropriate education is provided, although there are technological gaps that hinder the adoption of these practices. The agrifood chain is sustainable due to the growing demand for olive oil, but education and training are needed to ensure its long-term viability.

Despite the problems, the agri-food chain is sustainable due to the growing demand and prices for olive oil. Common practices include planting, pruning and weeding, with a focus on synchronisation of activities. To facilitate the transition to agroecological practices, training, financial resources and collaboration on machinery are required. In addition, problematic weeds and herbicide resistance complicate the situation. However, there is uncertainty about the promotion of agroecological products, as these are not well defined, which can lead to misleading practices. Lack of appropriate technology and the use of herbicides, such as glyphosate, are challenges in weed management, although some organic farmers avoid these chemicals.

Living Labs are seen as a key tool to implement these sustainable practices, but more support, machinery and training are required to overcome current barriers. Farmers are interested in the continuation of these projects to improve agroecological management.

3.10.1.2 Weeding needs, barriers, gaps and opportunities

In both regions where LL were organized, **needs** for improved farm management include training for farmers and technical advances to reduce costs and maintenance times were highlighted. Main **barriers** are lack of funds, environmental damage from chemical practices, EU regulatory challenges and the impact of climate change. There are **gaps** in knowledge about agroecological practices and market acceptance. However, there are significant **opportunities**, such as the provision of ecosystem services, stability in agricultural yields, reduced reliance on herbicides, the development of AWM as a scientific discipline and the promotion of IPM strategies.

3.10.1.3 Weeding techniques SWOT analysis

3.10.1.3.1 Herbicides

SWOT analysis shows that herbicides have been identified as pollutants that contribute to biodiversity decline and have a significant negative environmental impact. However, some comments highlight that their use provides quick results, is selective and requires little work. The risks associated with herbicides have been pointed out mainly by researchers, who highlight the possible elimination of active ingredients from the market and the lack of new herbicides.

3.10.1.3.2 Agroecological Weed Management techniques

Advisors and researchers are the ones who identified opportunities and weaknesses in agroecological weed management and herbicides more than farmers. All the stakeholders agreed that training and education in agroecology are the main opportunities for AWM, as well as being a strength in facilitating peer-to-peer knowledge exchange. Water resource management and improving soil health are also highlighted as key strengths. While weaknesses in the use of herbicides are recognized, indicating a growing awareness of their impact, the need for more research and knowledge to justify the transition to non-chemical practices is also noted. The adoption of agroecological practices could be accompanied by a reform of financial support, increasing subsidies and incentives. No significant weaknesses or threats to AWM were identified.

3.10.1.4 Weeding techniques evaluation

The olives **questionnaire** was answered by 83 actors (Annex III). This is a 15 % of the whole interviewers. As can be seen in the Figure 19 researchers, advisors, consumers and farmers are the stakeholders group that know a large number of technologies to weed olives, however, in any case they know more than the 30% of the possibilities of weeding. Industry and Policy makers are the ones with a lower amount of olive weeding methodologies knowledge.

The most knowledgeable olive AWM is associated with the use of herbicides or mechanical wedding. 100% of stakeholders declare to know it, followed far away mowing, grazing, and biobased herbicides (Figure 19 right). The unique unknown technique is the unmaned aerial vehicle, with very low responses in all the stakeholders

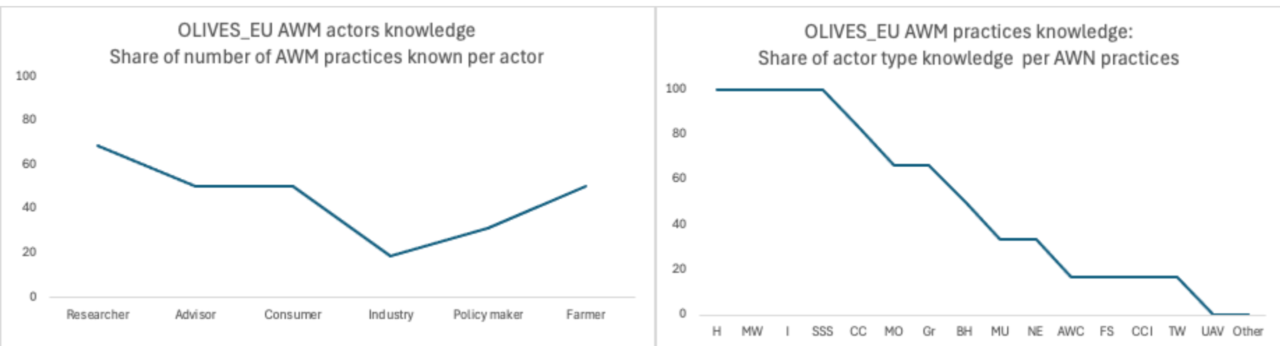


Figure 19 Olives Global AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle

3.10.1.5 Conclusions

It can be concluded that despite monocultures predominate, some farmers intercrop other crops, and olive products are key to the economy and food security. The sustainability of the agri-food chain is maintained by the growing demand for olive oil, although education and resources are needed to adopt agroecological practices.

Main challenges are herbicide resistance, lack of appropriate technology and uncertain promotion of agroecological products. Needs include training and technical advances, while barriers include lack of funds and the impact of climate change. Opportunities include the enhancement of ecosystem services and the development of IPM strategies.

The SWOT analysis reveals that, although herbicides are pollutants that affect biodiversity, they offer quick results and require little work. In contrast, advisors and researchers consider agroecology training to be crucial for AWM, highlighting water management and soil health as strengths. No significant weaknesses were identified for AWM, but the need for more research and financial support to encourage its adoption is highlighted.

3.10.2 Portugal olives LL analysis

3.10.2.1 Contextualization

The total harvested production of olives for olive oil in the EU was 7.6 million tonnes in 2022. After a bumper harvest in Portugal in 2021, there was a considerable decline of 0.6 million tonnes in 2022 (the equivalent of a fall of 42.6 %). Efficient olive plantations occupy 63.8% of the area, 32.2% being high density olive groves and 31.6% super-high intensity olive groves. They predominate over traditional olive grove plantations, which represent 36.2% of the total cultivated area, with wider plantation frames. The 61.7% of the plantations are cultivated in the rainfed regime and the remaining 38.3% in irrigated regime. (Eurostat, 2024).

The LL Board reveals hundreds of farmers cultivating olive trees, mainly in monoculture, producing olive oil and olives, key products for the economy and food security. Although there is interest in promoting agroecological products, the lack of clear definition and appropriate technologies hinders their adoption. Herbicides, although efficient, raise environmental concerns and there are technological barriers to their replacement. The need for training, education and appropriate policies to promote agroecological practices is highlighted. Farmers require more financial support, shared machinery and practical solutions to manage crops and weeds sustainably.

3.10.2.2 Weeding needs, barriers, gaps and opportunities

Table 20 shows the most relevant needs, barriers, gaps and opportunities found for olives cultivation in Portugal. The main **needs** highlighted on Portuguese questionaries include improving farmer education, optimizing technical aspects and increasing scientific knowledge on the impact of agroecological practices. The main **barriers** are high costs, environmental damage from chemicals, climate change and regulatory barriers in the EU. There are **gaps** in the adoption of non-chemical practices due to lack of experience, efficiency, and adequate equipment. However, there are important **opportunities** in the provision of ecosystem services, yield stabilization, herbicide reduction, and the promotion of IPM as a scientific discipline. **Portuguese stakeholder`s priorities regarding AWM are related with farmers' training, technical aspects and increasing scientific. Key challenges include high costs, environmental damage from the use of chemicals, climate change and restrictive EU regulations. In addition, lack of experience, low efficiency and inadequate equipment hinder the adoption of non-chemical methods. Despite these obstacles, there are promising areas, such as providing ecosystem services, stabilising agricultural yields, reducing herbicide use and promoting IPM.**

Table 20. Olive Portugal LL main needs, barriers, gaps and opportunities.

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Olive (Portugal)	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise, emphasizing peer to peer knowledge. 2. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. Moreover, stakeholders emphasize **difficulties in operations** and reduced **effectiveness** of AWM practices. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 4. **Regulatory changes- Policy concerns.** Stakeholders consider that there needs to be a redefinition in policies, including a modification on CAP payments 5. **Increase in investments** to acquire new machinery and enhance farmers knowledge.	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. 2. **Environmental or human health harm** as a result of chemical practices, leading to decline in biodiversity and soil microbiota, as well as environmental pollution. 3. EU policies, **regulatory challenges** related to restrictions in herbicides, economic incentives to farmers. 4. **Weather** and especially **climate change** are considered as key barriers to AWM and non-chemical weeding use and to production in general. 5. **Market** acceptance and lack of **recognition** of more **sustainable practices.**	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. **Cost of application** and **time consumption** of AWM use. 3. Lack of **consumer education** on AWM and agroecology in general to make informed decisions. 4. **Low efficiency** of AWM practices compared to herbicide application. AWM practices usually need for soil operations resulting in erosion. 5. **Cost** of **equipment** as well as **lack of labor**.	1. **Ecosystem services provision,** including increased water quality, improvements in biodiversity as well as an amelioration on soil health. These practices are in harmony with **European green policies**. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social and employment where they are implemented. 3. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 4. **AWM** practices have potential to evolve into relevant **scientific disciplines**. 5. **IPM fostering**. They consider that AWM and non-chemical weed management increases IPM strategies adoption.

3.10.2.3 Weeding techniques SWOT analysis

3.10.2.3.1 Herbicides

The SWOT analysis in Portugal for olives revealed several weaknesses in the use of herbicides. **Weaknesses** highlighted were those ones related with environmental and economic aspects (F, R, A). Environmental impact, biodiversity decline and hight prices of product were the aspects more answered in the three stakeholders group. Pollutants, herbicide resistance, risks to human health and residues were remarked for researchers and advisors. Regarding **threats** only researchers demonstrate concerns about agricultural policies and farmers on markets. **Grapes herbicides SWOT analysis in Portugal revealed a big concern with the environmental issues, high prices and identified threats on markets and policies.**

3.10.2.3.2 Agroecological Weed Management techniques

The SWOT analysis of AWM revealed several opportunities and strengths for AWM practices. Main **opportunities** selected for all actors (F, R, A) were related to social aspects such as training. Economic benefits and peer to peer knowledge was also pointed as an opportunity for farmers and advisors. Soil health, new market prices and product was important for researchers and advisors. Researchers emphasised human health, consultancy, subsidies, less inputs, social impacts and quality of products as aspects to take into account. Finally, for farmers was important the feed source for animals. Several **strengths** related with environmental and social aspects were taken into account for the three group of stakeholders such as environmental balance, improve soi health and training. Besides this, some other aspects connected with crop performance and economics were pointed: economic benefits (F, A), management of water resources (R, A), reduction of labor (R), efficacy,less soil disturbance and reduction of costs for farmers and finally applicability and accessibility for farmers (A). **As a summary, AWM main opportunities and strengths are related with environmental, social and technical aspects but also with crop performance and economic aspects.**

3.10.2.4 Conclusions

Herbicide use is associated with environmental and economic issues. Key concerns include negative impacts on the environment, biodiversity loss, and high product prices. On the contrary, AWM demonstrate several opportunities and strengths. Training is a notable opportunity for all stakeholders, besides economic benefits and knowledge. The strengths associated with these AWM practices include improvements in soil health, environmental balance, training and other aspects include economic benefits. **It can be concluded that while traditional methods are associated with environmental and economic challenges, AWM practices offer promising benefits that enhance sustainability and efficiency. Focusing on education and resource accessibility can significantly improve agricultural practices and contribute to a healthier ecosystem.**

3.10.2.5 Weeding techniques evaluation

The **olives questionnaire** (Annex III) was responded by 28 actors in total answering about cover crops, false seedbed, grazing, herbicides, intercropping, mechanical wedding, mowing, mulching, site specific spraying. Herbicides and mechanical weeding and site-specific spraying were the most knowledgeable techniques to weed olives (Figure 20 right), with a 100 % knowledge of the stakeholders. Is remarkable the low share of knowledge on digital tools (automated weed control, unmaned aerial vehicle), recent techniques (thermal weeding) or nature-based solutions (natural enemies). The analysis of the number of responses per stakeholder (Figure 20 left) reveals that the group of researchers and advisors show the highest knowledge of the questioned techniques, with industry and farmers showing the lowest knowledge.

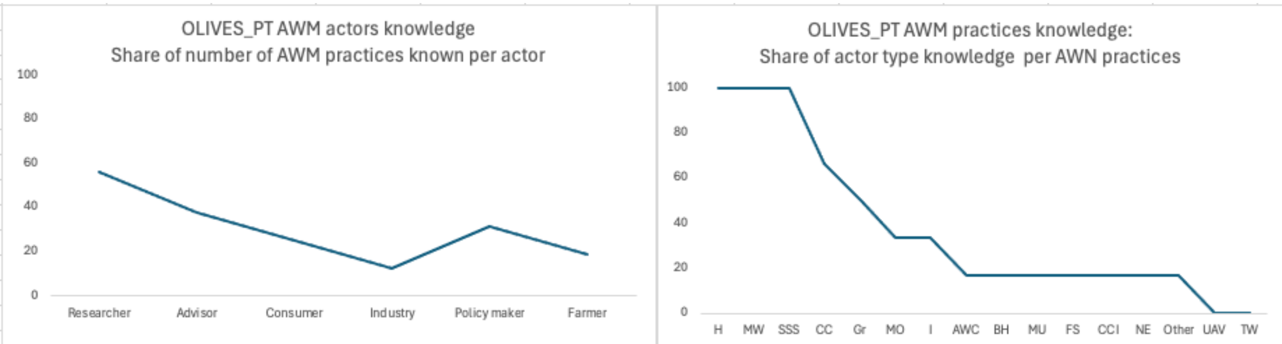


Figure 20 Olives Portugal AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle

The **questionnaires** associated with Portuguese olives included answers for **chemical weed control** including herbicides (Advisors, consumers, policy makers, researchers). **Physical weed control** practices, such as mechanical weeding (Advisors, consumers, policy makers, researchers). Besides, the use of **nature-based** solutions, focusing on spatial use of biodiversity grazing (advisors). An extended version analyzing the results obtained in the questionnaires can be found in Annex III.

Chemical weed control consist of herbicide and site-specific spraying use. Policy makers unanimously identify **herbicides** as fosterers of IPM strategies and providers of several ecosystem services, whereas the other stakeholders did not massively recognize those opportunities.

Stakeholders view the potential for herbicides to become an important scientific discipline. Ecosystem services impact knowledge, training, lack of advisors, and practicing knowledge skills, among other crucial needs, were regarded as highly relevant necessities across stakeholders. Environmental and human harm, high carbon footprint, regulation, as well as training and expense were regarded as relevant barriers by surveyed stakeholders. All stakeholders considered environmental and human harm as well as customer demand to reduce or eliminate herbicide use as the most relevant disadvantages. **Site specific spraying** opportunities acknowledge its potential to evolve into a significant scientific discipline and reduce herbicide reliance. They emphasize the critical importance of ecosystem services impact knowledge and training, underscoring the need regulatory changes. However, concerns about regulatory barriers, environmental and human harm disadvantages, and the financial burden associated with the practice remain prominent.

Physical weed control methods include mechanical weeding. **Mechanical weeding** opportunities perceived by stakeholders consisted of provision of ecosystem services as well as fostering of IPM strategies. Regarding the primary needs, actors shared different perspectives: while advisors and consumers prioritize ecosystem services impact knowledge as the primary need, policymakers and researchers opt for practicing knowledge skills and training, and cost reduction, respectively. Advisors, policymakers, and researchers unanimously identify training as the most relevant barrier, with lack of funds and expense also considered significant impediments. Conversely, consumers do not consider any queried barriers as relevant, mostly deeming them as low or irrelevant. Expense emerges as the most significant disadvantage for all stakeholders. While a significant proportion of advisors and consumers perceive mechanical weeding as lacking significant disadvantages, policymakers highlight its high carbon footprint, and researchers emphasize environmental and human harm, as well as low efficacy, as significant drawbacks.

Nature-based solutionsconsisted of spatial use of biodiversity with grazing. Advisors perceive grazing as a technique with promising opportunities for IPM strategies and ecosystem services provision, alongside significant needs like practicing knowledge skills and management expertise. While they acknowledge barriers such as complexity and time consumption, they find few significant disadvantages, except for concerns over customer demand to reduce grazing and its high carbon footprint.

3.10.3 Cyprus olives LL analysis

3.10.3.1 Contextualization

The cultivation of olive trees in Cyprus has been well established since the late Bronze Age. There are approximately 500.000 trees occurring throughout northern range of Cyprus. Olive trees are grown all over the island in compact groves, irrigated or non-irrigated, and scattered on uncultivated rain fed land. (Ozge Ozden, 2021). Cyprus olive production for oil was 16.500 tones in December 2023 (EUROSTAT,2024).

In Cyprus, olive trees are mainly grown in monoculture, although it is also possible to intercrop them with other crops, such as vetch. Olive products have a significant socio-economic impact in Cyprus. The most important are olive oil, table olives and olive paste.

There is the possibility of promoting agroecological products in local markets, but it would be necessary to train and inform both producers and consumers about their benefits. The lack of technologies for agroecological management is noted as a barrier.

Common agronomic practices include pruning, irrigation, insecticide use, fertilization and harvesting. In addition, plant protection products are used to manage pests, while weeds are controlled by chemical herbicides, tillage and mowing.

Weed control in Cyprus' olive groves is mainly done with chemical herbicides, which have a negative impact on the environment, reducing biodiversity and affecting soil and water quality. Although some farmers consider herbicides more economical, agroecological alternatives have proven to be equally effective and more sustainable.

To boost the adoption of agroecological practices, collaboration between farmers, researchers and policy makers is essential, in addition to providing financial incentives and certifications for agroecological products. The main barriers to implementing these practices include the lack of adequate machinery and the reluctance of some farmers to be trained in alternative methods.

3.10.3.2 Weeding needs, barriers, gaps and opportunities

Table 21 shows the most relevant needs, barriers, gaps and opportunities found for olives cultivation in Cyprus. Living lab reveals the most important **needs** for improving agroecological weed management AWM, that include more education and training for farmers, technical improvements to reduce costs, and more scientific knowledge on the impact of these practices. Regulatory changes, financial incentives and certification of agroecological products are also needed, as well as specialized advisors to promote the adoption of AWM. Main **barriers** include high costs, environmental damage from herbicides, EU regulatory restrictions, climate change effects and increasing herbicide resistance. **Gaps** include lack of practical knowledge on AWM, high costs compared to herbicides, low motivation to change habits and lack of promotion among consumers. In addition, there is a shortage of labour and expensive equipment. For the LL board there are some good **opportunities** including the improvement of ecosystem services, promote integrated pest management, reduce herbicides, the scientific potential of AWM and professionalize farmers through further training. **Greek stakeholders point that to improve AWM more farmer training and more technical improvements and deepened scientific knowledge are essential. Regulatory changes, financial incentives and certifications are also needed to boost the adoption of these practices, along with specialized advisors. However, high costs, environmental damage from herbicides, EU restrictions, lack of practical knowledge and resistance to changing habits are major challenges. Despite these difficulties, AWM offers important possibilities, such as improving ecosystem services, reducing herbicide use and professionalizing farmers.**

Table 21. Olive Cyprus LL main needs, barriers, gaps and opportunities

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Olive (Cyprus)	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise, emphasizing the importance of peer to peer knowledge and multi-actor approaches. 2. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 4. **Regulatory changes- Policy concerns.** Stakeholders consider that there needs to be a redefinition in policies, appointing financial incentives as well as promotion of agroecological approaches from the administrations. Additionally, they consider that AWM practices should have a certification to be easily identified by consumers. 5. **Lack of advisors** to promote AWM adoption among producers.	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. 2. **Environmental or human health harm** chemical practices, leading to decline in biodiversity and pollution. 3. EU policies, **regulatory challenges** related to restrictions in herbicides and economic compensations to farmers. Stakeholders consider that administration should promote market recognition and consumer education. 4. **Weather** and especially **climate change** are considered as key barriers to AWM and non-chemical weeding use. 5. Some farmers reported instances of **herbicide resistance** which are increasingly concerning in the recent years.	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. **Cost of application** in AWM practices compared to herbicides. 3. Lack of drivers for **change in farmers habits**. They consider that agriculture without herbicides is possible, and demand for increased knowledge and dissemination through the adoption of multi-actor approaches to boost AWM practices intake. 4. lack of **consumer** education and **promotion** of AWM and agroecology to the public. 5. **Cost** of **equipment** as well as **lack of labor**.	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity as well as an amelioration on soil health. These practices are in harmony with **European green policies**. 2. **IPM fostering**. They consider that AWM and non-chemical weed management increase IPM strategies adoption. 3. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 4. **AWM** practices have potential to evolve into relevant **scientific disciplines**. 5. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.**

3.10.3.3 Weeding techniques SWOT analysis

3.10.3.3.1 Herbicides

The SWOT analysis in Greece for olives revealed several weaknesses in the use of herbicides and a few threats and strengths. **Weaknesses** highlighted were those ones related with environmental and economic aspects (F, R, A). Environmental impact, biodiversity decline, herbicide resistance and hight prices of product were the aspects more answered in the three stakeholders group. Pollutants (R, A), risks to human health (F, A) and lack of training (F, A) were taken in account as weaknesses for herbicides use. Despite this, some **strengths** were pointed as important, mostly associated with crop performance and effectiveness such as quick results (F,A), not labor intense (F), cheap products (F) and optimized treatments and selectivity (R). Regarding **threats** only researchers demonstrate concerns about markets, no new herbicides and aligned with advisors both showed concern on the withdrawal of herbicides. **Olives herbicides SWOT analysis in Portugal revealed a big concern with environmental issues and high prices but despite this, strengthens associated with crop performance were pointed. Main threats were related with the end of the use of herbicides.**

3.10.3.3.2 Agroecological Weed Management techniques

The SWOT analysis of AWM revealed several opportunities and strengths for AWM practices. Main **opportunities** selected for all actors (F, R, A) were related to social aspects such as training and subsidies. For researchers was important to remark consultancy, economic benefits and new technologies as an opportunity. Farmers highlighted soil health as main opportunity. Several **strengths** related with environmental and social aspects were taken into account for the three group of stakeholders such as improve soil health. Low environmental impact was remarked also from farmers and advisors. Advisors remarked effcicacy, reduction of costs, training, work safety and adaptation to green policies as main strengths on AWM practices. For researchers, combination of strategies, cost- effectiveness, applicability and available equipment was taken seriously in account. **As a summary, AWM main opportunities and strengths are related with environmental, social and technical aspects but also with crop performance and economic aspects, similar to Portugal olive crops.**

3.10.3.4 Weeding techniques evaluation

The **olives questionnaire** (Annex III) was responded by 56 actors in Cyprus, answering about cover crops, false seedbed, grazing, herbicides, intercropping, mechanical wedding, mowing, mulching, site specific spraying.

Mechanical weeding, intercropping and site-specific spraying were the most knowledgeable techniques to weed olives, with a 100 % knowledge of the stakeholders (Figure 21 right). Use of herbicides is close to 100 % with some other techniques. Is remarkable the low share of knowledge on digital tools (automated weed control, unmaned aerial vehicle), recent techniques (thermal weeding) or nature-based solutions (natural enemies).

The analysis of the number of responses per stakeholder (Figure 21 left) reveals that the group of researchers and farmers (aligned with the fact of ancestral knowledge of this crops) show the highest knowledge of the questioned techniques, with industry and policy makers the lowest knowledge, as the LL board reveals the lack of advisoring in order to improve agroecological techniques.

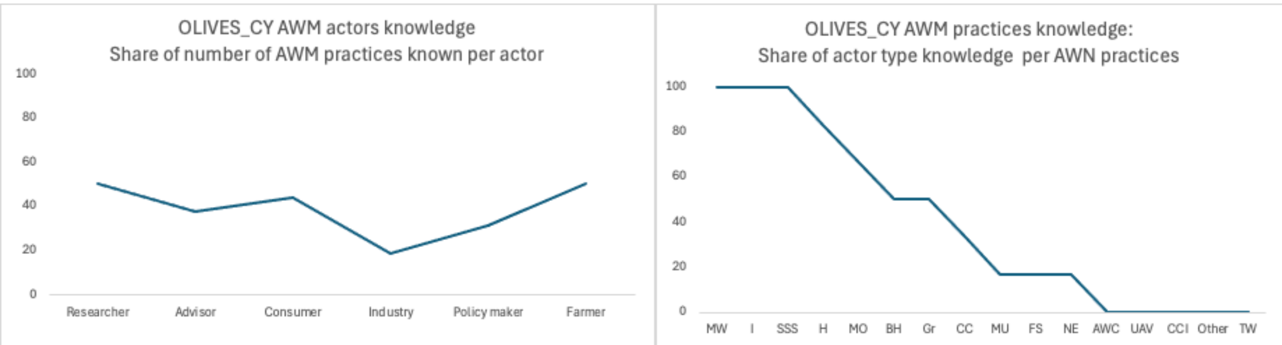


Figure 21 Olives Cyprus AWM practices (right) and actors (left) knowledge as percentage of the matrix of actors and practices. AWC: Automated weed control BH: Biobased herbicides, CC: Cover crop; CCI: Inoculated cover crops, Gr: Grazing; FS: False seed, H: Herbicide, I: Intercropping, MO: Mowing; MU: Mulching, MW: Mechanical weeding, Ne: Natural enemies; O: Other, SSS: Site specific spraying; TW: Thermal weeding and UAV: Unmaned aerial vehicle

The **questionnaires** associated with olives in Cyprus included answers for **chemical weed control** including herbicides (advisors, consumers, farmers, policy makers, researcher), site-specific spraying (farmers). **Physical weed control** practices, such as mechanical weeding (advisors, farmers, industry, researchers), mowing (advisors, farmers, policy makers, researchers). Besides, the use of **nature-based** solutions, focusing on spatial use of biodiversity grazing (advisors) and intercropping (farmers). An extended version analyzing the results obtained in the questionnaires can be found in Annex III.

Chemical weed control includes herbicides and site-specific spraying. Stakeholders hold a negative perspective on **herbicide** use, as none of the groups deemed any of the queried opportunities as highly relevant. The overview suggests that herbicides are not commonly utilized as an AWM technique in olives. Advisors prioritize timing reduction as critical needs, while consumers and researchers emphasize regulatory changes, lack of advisors, management expertise, and cost reduction. Policy makers prioritize management expertise, maintenance, and cost reduction as primary needs. Notably, farmers did not consider any of the queried needs as highly relevant by more than half of the respondents. Advisors and consumers identified training as the most relevant barrier, while farmers, policy makers, and researchers highlighted environmental and human harm as significant impediments. Additionally, all stakeholders underscored regulatory challenges as relevant. Environmental and human harm were unanimously considered the most relevant disadvantage, followed by public opposition to the practice, expense, and high carbon footprint as relevant drawbacks. **Site-specific spraying** evaluation revealed several opportunities linked to its implementation, including IPM fostering as well as provision of ecosystem services. As per the methos primary needs, stakeholders identified regulatory changes as well as improvement in technical aspects, such as reduction of maintenance and costs. Training and lack of funds were regarded as te most important barriers. With few disadvantages being recognized, including expense.

Physical weed control included mechanical weeding and mowing. **Mechanical weeding** was positively regarded by stakeholders, with most relevant opportunities include its potential to foster IPM strategies and provide essential ecosystem services like improved biodiversity, water quality, and soil health. They also anticipate its role in reducing herbicide reliance and foresee its evolution into a crucial scientific discipline. Farmers, in particular, expressed the most optimism regarding mechanical weeding. Stakeholders did not identify numerous needs for mechanical weeding. Advisors stressed the importance of ecosystem services impact knowledge, while farmers emphasized timing reduction. Industry representatives and researchers cited practicing knowledge skills, and cost and timing reduction as crucial needs. None of the queried barriers were widely regarded as significant across stakeholder groups. Similarly, none of the disadvantages were considered significant by a sufficient proportion of respondents in each stakeholder category. **Mowing** was regarded as a positive practice, with numerous opportunities being highlighted. Both advisors and farmers believe that mowing fosters IPM strategies and provides essential ecosystem services, such as increased biodiversity, with potential for further development into a scientific discipline. Policy makers acknowledge the provision of ecosystem services, particularly improvements in soil health, and emphasize the opportunity to reduce herbicide reliance. Advisors prioritize ecosystem services impact knowledge as a relevant need, while practicing knowledge skills and cost reduction are important for both advisors and farmers. Timing reduction emerges as a relevant need across all stakeholder groups, with farmers, policy makers, and researchers emphasizing its importance.

Advisors identify training as the most significant barrier, while policy makers emphasize time consumption, lack of funds, and regulatory challenges. Researchers highlight time consumption as the primary impediment. Additionally, researchers are unique in considering low efficiency as a significant disadvantage, with less than 40% of respondents from each stakeholder group considering other categories as relevant, such as expense, time consumption, and customer demand to reduce mowing use.

Nature-based solutions include spatial use of biodiversity, with grazing and intercropping being the most important practices. **Grazing** opportunities included biodiversity and soil health enhancement, while most important needs were related to training and addressing complexity. Efficacy and expense were considered as important barriers. Farmers did not recognize major disadvantages as a result of grazing implementation. **Intercropping** was positively regarded by farmers, opportunities were related to ecosystem services provision, stabilizing crop yields and environmental health, addressing challenges such as time consumption and ensuring efficacy are considered as essential needs. Main barriers were training and lack of funds. Notably, farmers did not perceive any of the queried disadvantages as highly significant.

3.10.3.5 Conclusions

Herbicide use in olive crops in Greece reveals several weaknesses, particularly in terms of environmental impact, biodiversity loss, herbicide resistance, and high product prices. In contrast, AWM practices offer opportunities and strengths. Key opportunities include training, subsidies, soil health improvements, and economic benefits. Strengths involve low environmental impact, efficacy, cost reduction, and better alignment with green policies. For researchers, strategies such as combining methods and ensuring cost-effectiveness are critical. **It can be concluded that herbicides in olive crops are linked with environmental and economic challenges but their effectiveness in crop performance is still valued. On the other hand, AWM practices offer a sustainable and cost-effective alternative, with strong advantages in environmental health and social benefits, making them a promising long-term solution.**

4 AWM: SWOT analysis and gaps for all the living labs

The responses of stakeholders across all LLs and questions are summarized in the Table below.

Table: Opportunities, strengths, weaknesses and threats identified by the responses of interviewees

OPPORTUNITIES for Agroecological Weed Management (29 responses)			
Case-specific use of AWM	Reduction of crop-weed competition	Site-specific weed management	New technologies and machinery
Effectiveness	Simple to use	Combination of strategies	Operational management
Feed source for animals	Available machinery and equipment	Less inputs	Environmental sustainability
Reduction of herbicide resistance evolution	Soil health	Sustainable management of agroecosystem	Reduced tillage
Quality of products	New markets, prices and products	Circular economy	Economic benefit
Safeguard biodiversity	Peer-to-peer knowledge	Consultancy	Training-Education
Synergies and associations	Social impact	Subsidies-Incentives-Funding	Pushed by European Community
Human health			
STRENGTHS of Agroecological Weed Management (36 responses)			
Environmental balance-Safeguard biodiversity	Improve soil health	Consultancy	Knowledge on weeds biology and ecology
Low energy consumption	Reduction of herbicide input	Reduction of labor	Low environmental impact
Reduction of fuel costs	Economic Benefit	Deal with noxious weeds	Research is needed
Combination of strategies	Effectiveness	Long-term effect	Cost-effectiveness
Ground cover	Less soil disturbance	Applicability	Reduction of costs

Accessible to farmers	Available machinery and equipment	Reduction of weed seed production	Tied to cultural aspects
Speed-Quick results	Simple to use	Training-Knowledge-Education	Subsidies-Funding
Integrated in organic agriculture	Management of water resources	No residues	Repeated applications
Increase of labour	Work safety	Prevention of fires	Harmonized with new green policies
THREATS for Agroecological Weed Management (10 responses)			
Climate change	EU policies	Invasive species	Changes in weed flora
Disappearance of livestock	Lack of active compounds	Bureaucracy	Uncertainty
Inaccurate long-term planning	Agricultural policy		
WEAKNESSES of Agroecological Weed Management (27 responses)			
Cost of applications	Difficulties in operation	More commitment	No viable alternatives to herbicides
Lack of technical assistance	Complexity	Lack of extension services	Environmental impact
Effectiveness	Impact in crop production	Lack of training	Replacement of herbicides
Short-term effect	Timing of application	Large-scale application	Damage to main crop
Licences-Certificates	Cost of purchasing of modifying equipment	Reliance on a single practice	Limited knowledge on weeds
Non-selectivity	Lack of experience-knowledge	Soil pollution-Soil disturbance	Lack of bioherbicides

Risks to human health	Accessibility to knowledge	Shortage of labor OR labor intensive	
THREATS for non-chemical weed management (6 responses)			
Climate and weather conditions	Lack of recognition from markets	Invasive species	Energy sector
Agricultural policy	Market		
WEAKNESSES of non-chemical weed management (29 responses)			
Cost of application	Lack of knowledge	Lack of training	Lack of experience
Effectiveness	Replacement of herbicides	Timing of application	Complexity
Availability of machinery-equipment-products	Large-scale operation OR smallholder farmers	Repeated applications	Difficulty to control perennial weeds
Cost of purchasing equipment	Non-selectivity	Applicability	Difficulties in operation
Lack of sharing equipment, machinery and knowledge	Lack of labor OR labor-intensive	Low ratio of organic farms and interference with conventional	Difficulties in acquiring certification
Different priorities (of stakeholders)	Environmental impact	Time-consuming	Changes in weed flora
Impact on livestock	Lack of funding	Habits of farmers	Increase fire probability
Low yields			
OPPORTUNITIES for herbicides (11 responses)			
Fast operation-Simple to use	Less fuel consumption	Reduction of crop-weed competition	Broad spectrum of weeds
Available equipment, knowledge and herbicides	Optimized treatment	Light machinery	Selectivity
Cheap	Quick results	Efficacy	

STRENGTHS of herbicides (14 responses)			
Available herbicides on market and knowledge	Broad spectrum of weeds	Reduce crop-weed competition	Available equipment
Economic benefit	Quick results	Efficacy	Not labor intensive
Simple to use	Cheap	Optimized treatment	Yields
Cost-effectiveness	Selectivity		
THREATS for herbicides (8 responses)			
Less subsidies	Agricultural policy	Market	No new herbicides
Withdrawal of herbicides	Spraying from bordering fields	Environmental factors	Pressure to reduce herbicides
WEAKNESSES of herbicides (16 responses)			
Herbicide resistance	Environmental impact	Pollutant	Risks to human health
Herbicide mixtures	Biodiversity decline	Residues	Selectivity
Optimized treatment	Expensive	Lack of training	Accessibility
Lack of knowledge	Certificates-Registration	Lack of awareness	New equipment

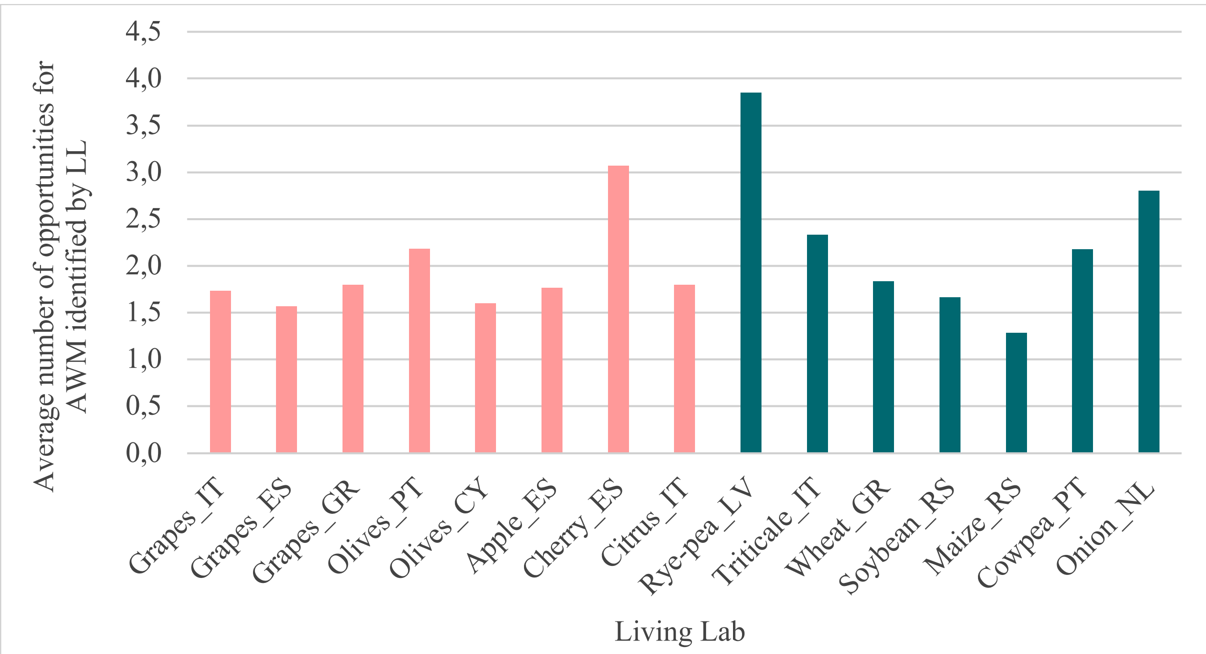


Figure 22. Average (for all interviewees) number of opportunities for agroecological weed management in each Living Lab. Pink columns for permanent crops and blue for arable crops.

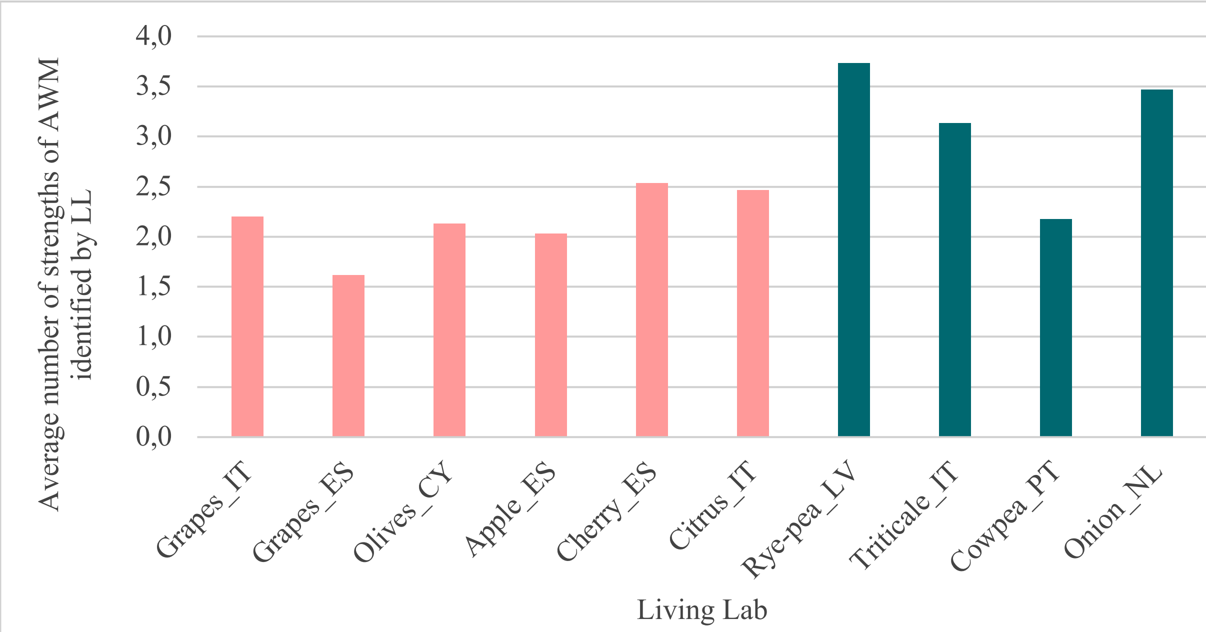


Figure 23. Average (for all interviewees) number of strengths of agroecological weed management in each Living Lab. Pink columns for permanent crops and blue for arable crops.

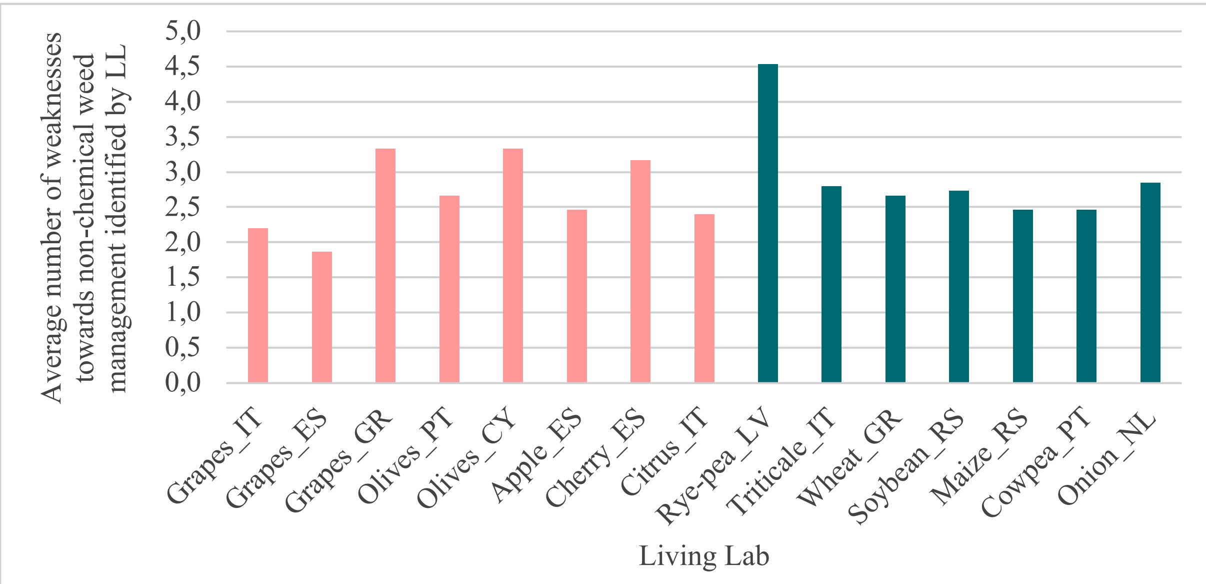


Figure 24. Average (for all interviewees) number of weaknesses of non-chemical weed management in each Living Lab. Pink columns for permanent crops and blue for arable crops.

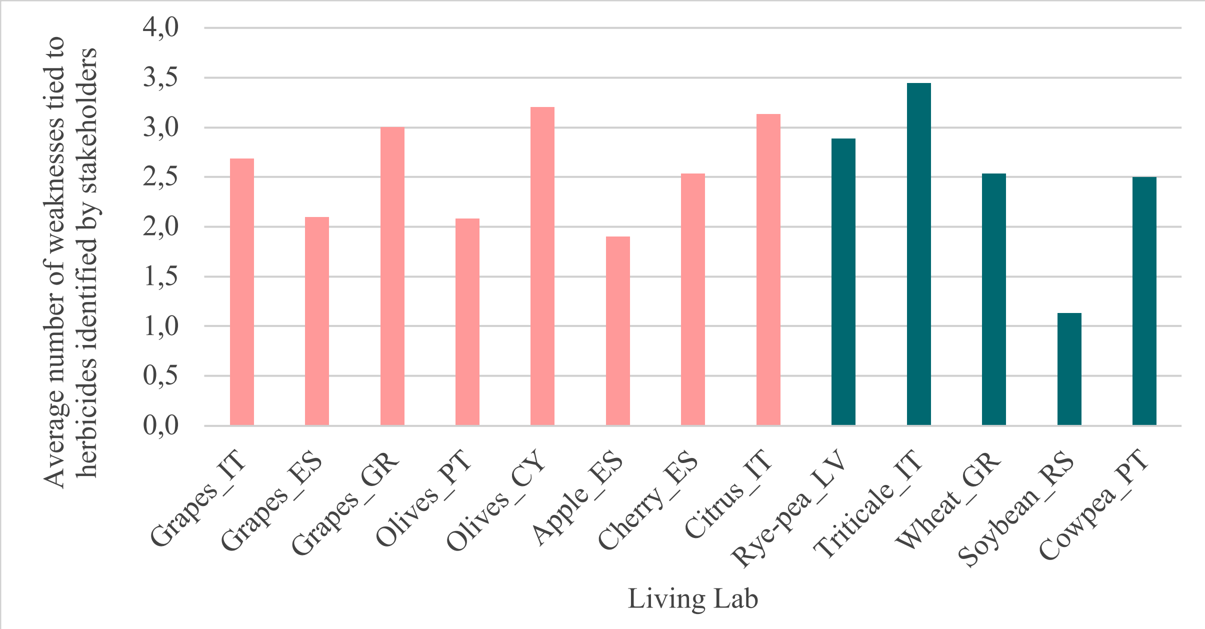


Figure 25. Average (for all interviewees) number of weaknesses of herbicides in each Living Lab. Pink columns for permanent crops and blue for arable crops.

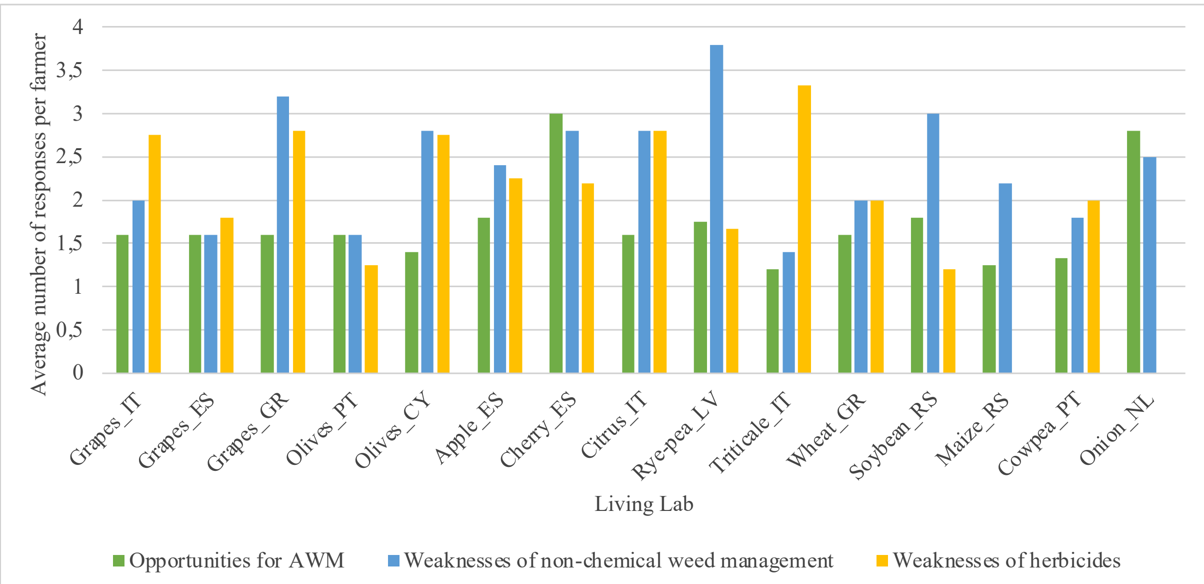


Figure 26. Average number of responses of farmers to opportunities for agroecological weed management, weaknesses of non-chemical weed management, and weaknesses of herbicides in each Living Lab

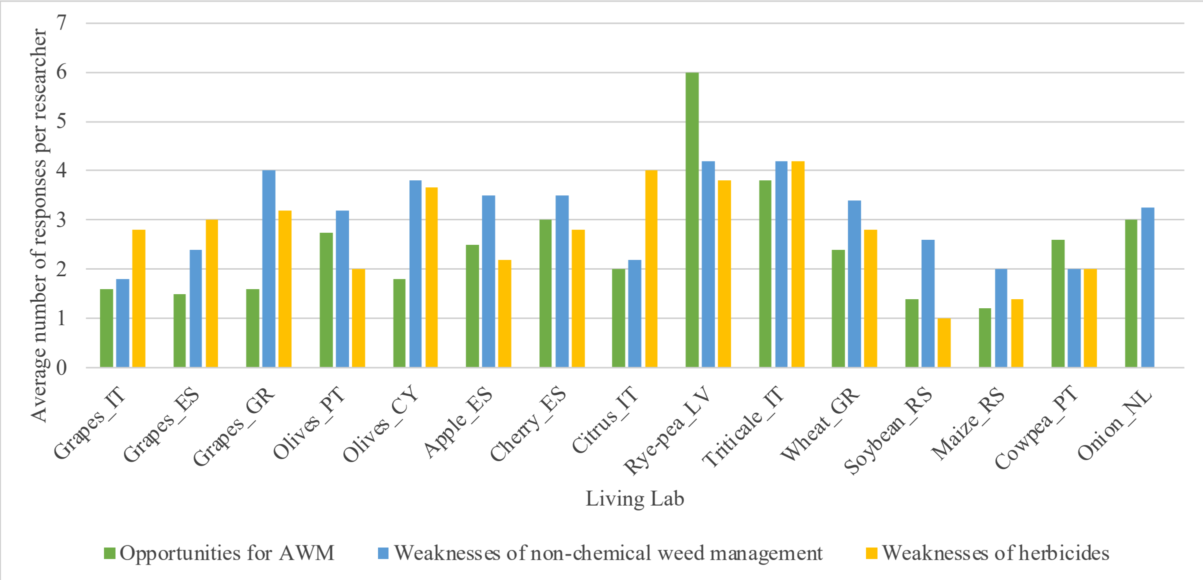


Figure 27. Average number of responses of researchers to opportunities for agroecological weed management, weaknesses of non-chemical weed management, and weaknesses of herbicides in each Living Lab

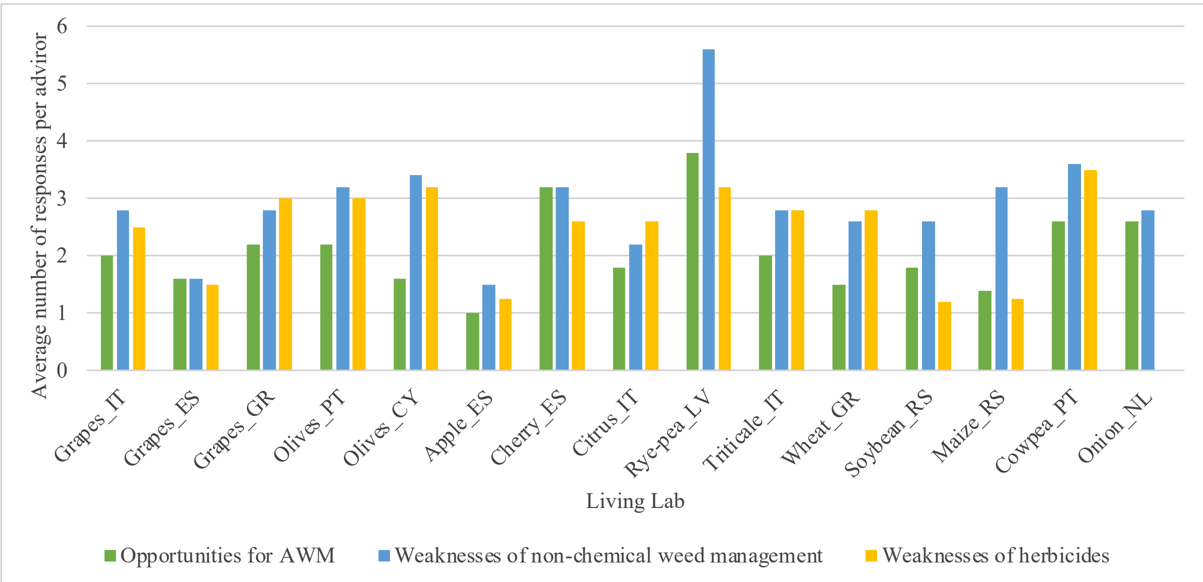


Figure 28. Average number of responses of advisors to opportunities for agroecological weed management, weaknesses of non-chemical weed management, and weaknesses of herbicides in each Living Lab

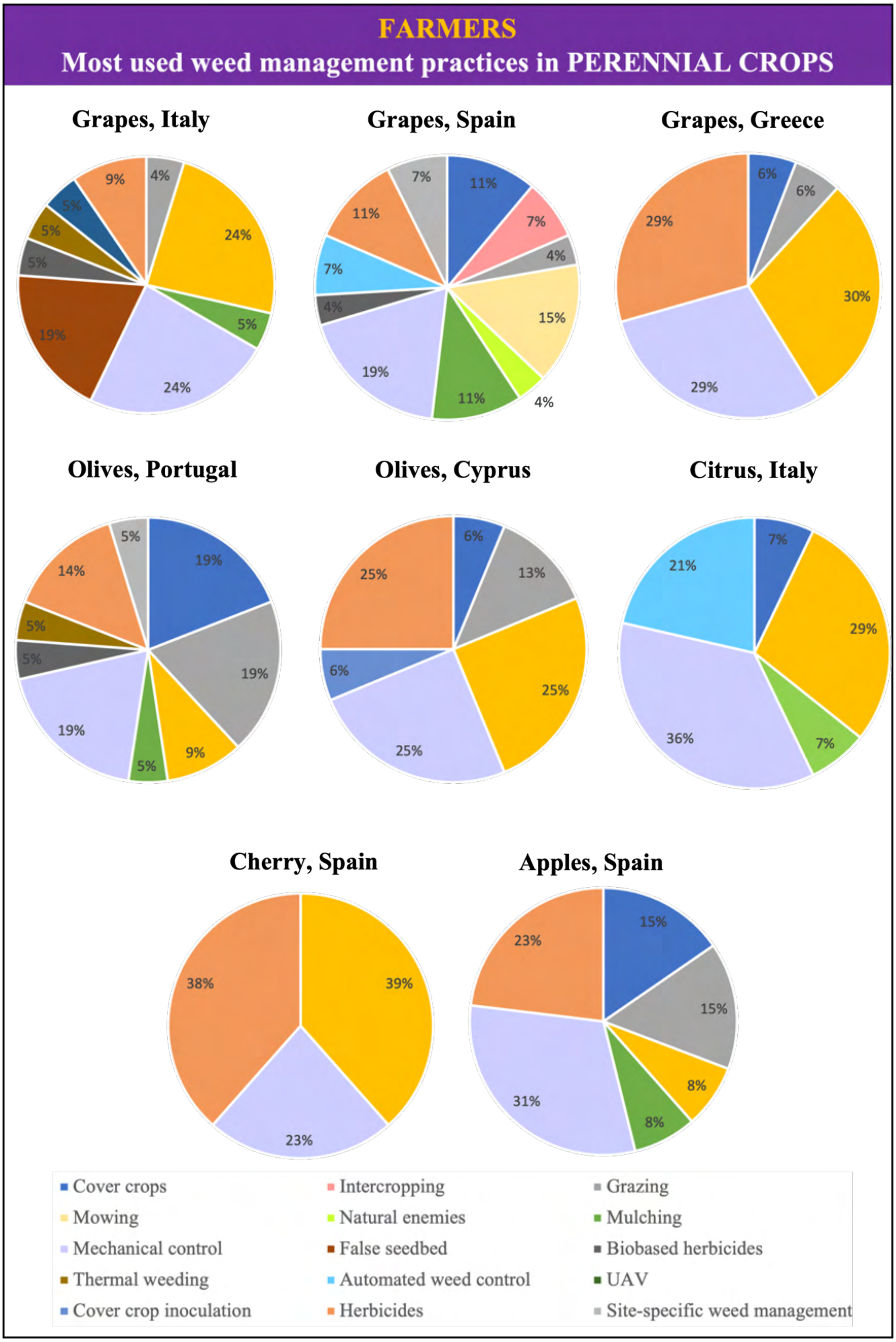

FARMERS
Most used weed management practices in PERENNIAL CROPS
Grapes, Italy
4%
24%
5%
24%
19%
5%
5%
5%
9%
Grapes, Spain
11%
7%
4%
15%
4%
11%
19%
4%
7%
11%
7%
Grapes, Greece
6%
6%
30%
29%
29%
Olives, Portugal
19%
19%
9%
5%
19%
5%
5%
14%
5%
Olives, Cyprus
6%
13%
25%
25%
6%
25%
Citrus, Italy
7%
29%
7%
36%
21%
Cherry, Spain
39%
23%
38%
Apples, Spain
15%
15%
8%
8%
31%
23%
Cover crops
Intercropping
Grazing
Mowing
Natural enemies
Mulching
Mechanical control
False seedbed
Biobased herbicides
Thermal weeding
Automated weed control
UAV
Cover crop inoculation
Herbicides
Site-specific weed management

Figure 29. Most used weed management practices by farmers in perennial crops in each Living Lab

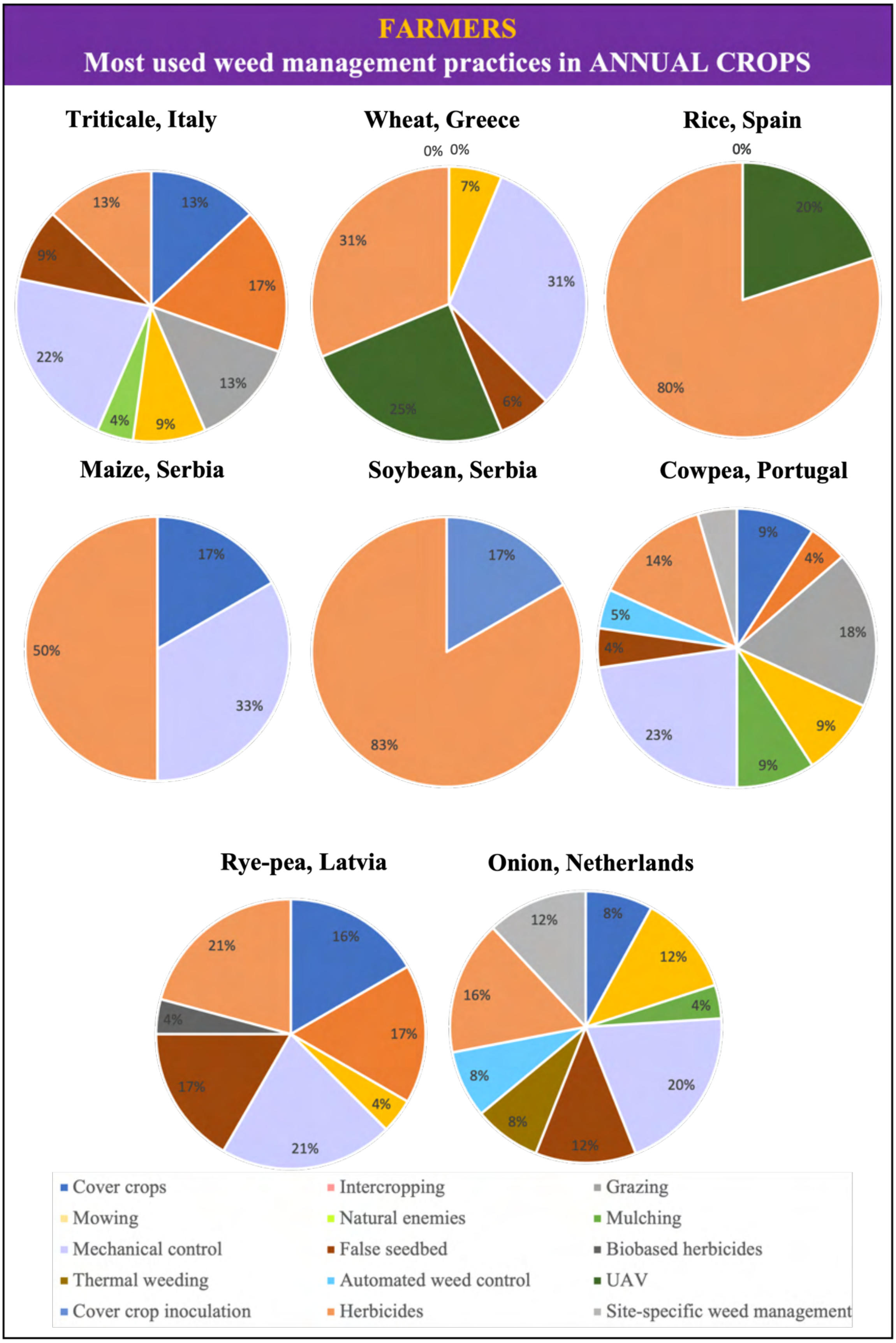


Figure 30. Most used weed management practices by farmers in annual crops in each Living Lab

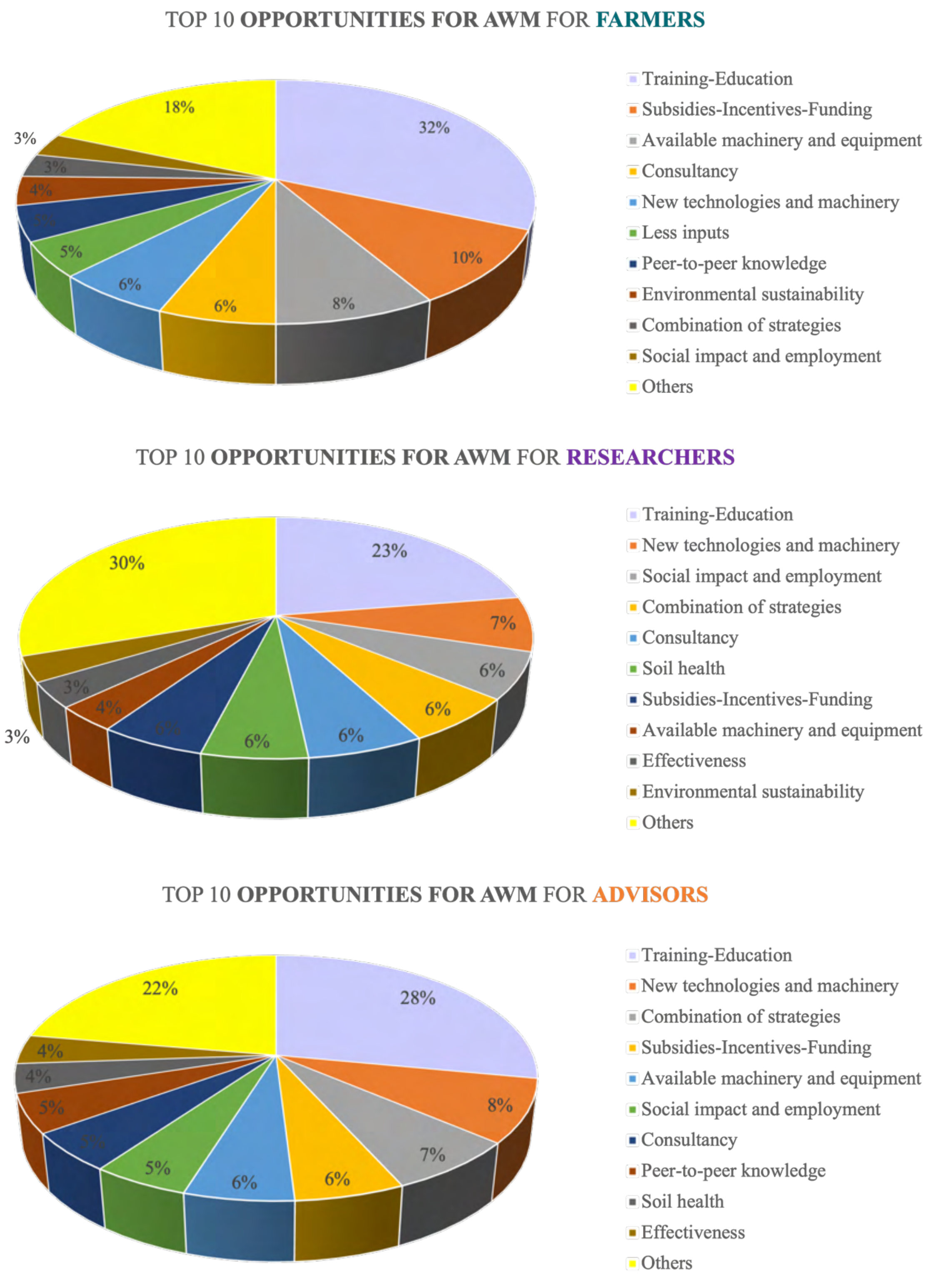


Figure 31: Top 10 opportunities for agroecological weed management for farmers, researchers and advisors (aggregated in all Living Labs)

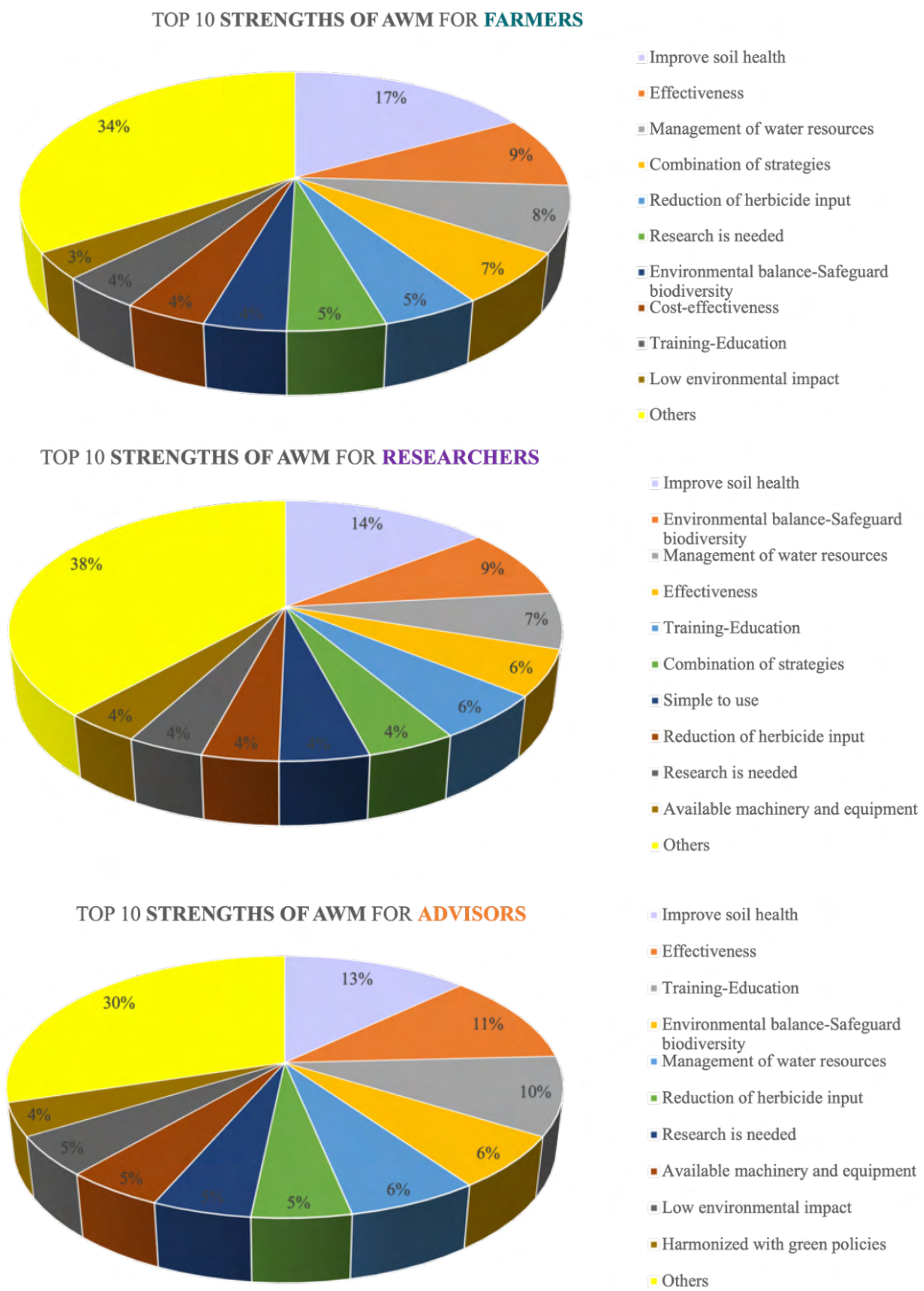


Figure 32: Top 10 strengths for agroecological weed management for farmers, researchers and advisors (aggregated in all Living Labs)

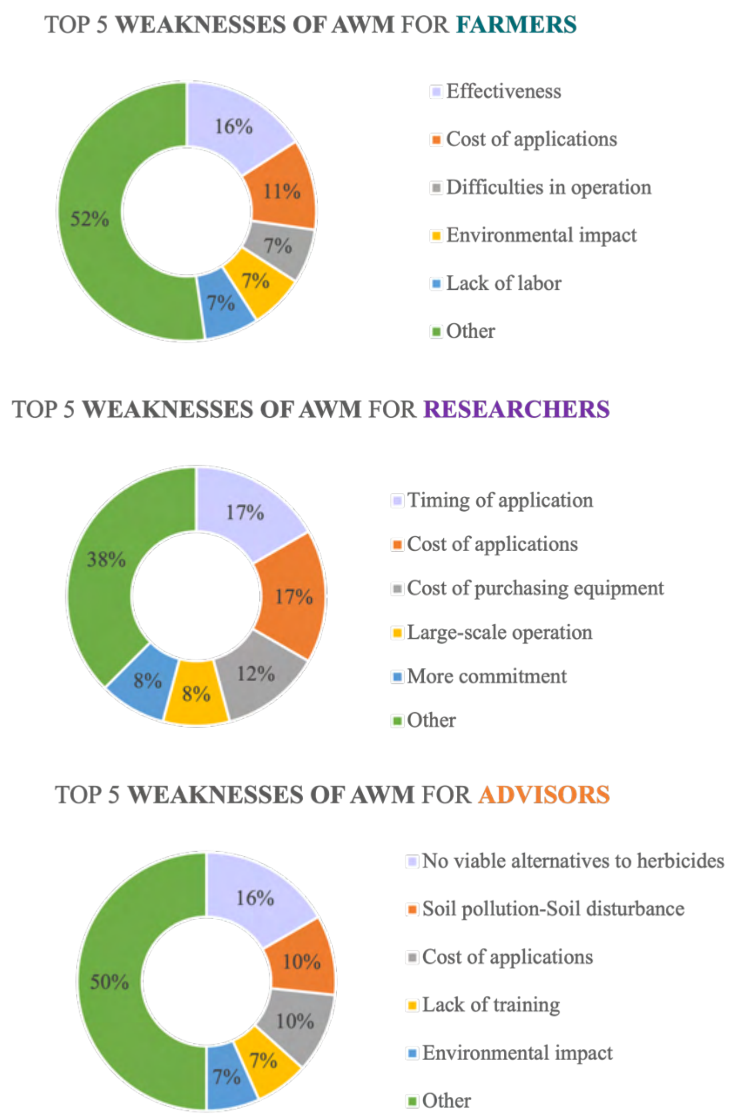


Figure 33: Top 5 weaknesses of agroecological weed management for farmers, researchers and advisors (aggregated in all Living Labs)

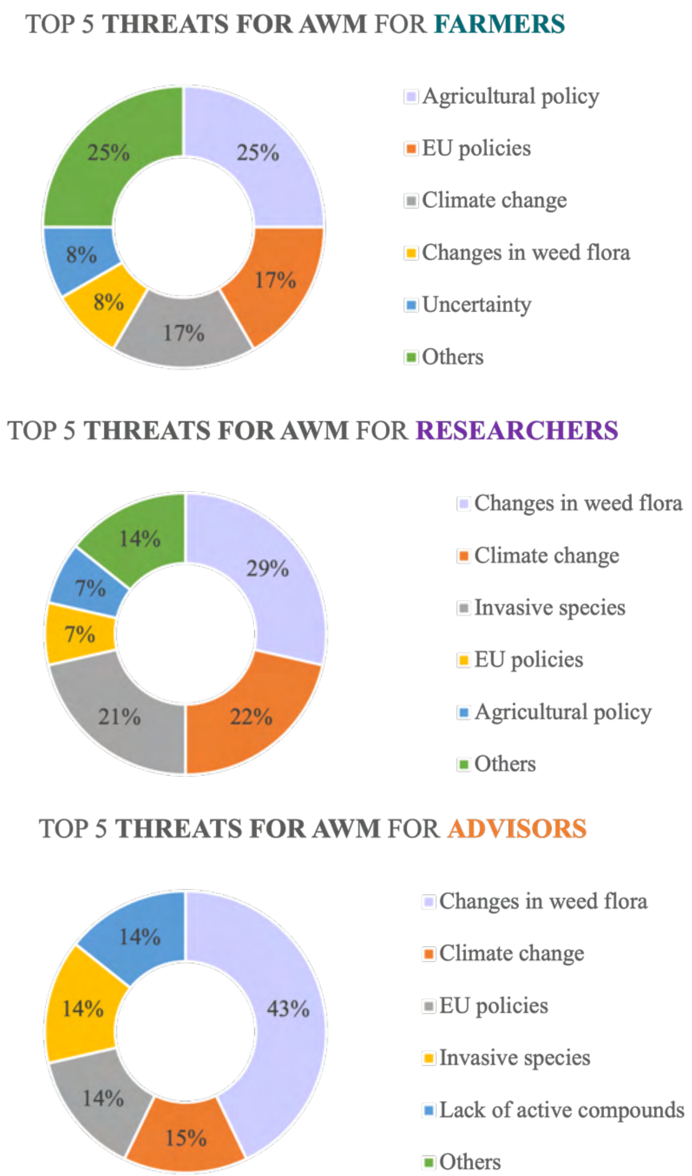


Figure 34: Top 5 threats for agroecological weed management for farmers, researchers and advisors (aggregated in all Living Labs)

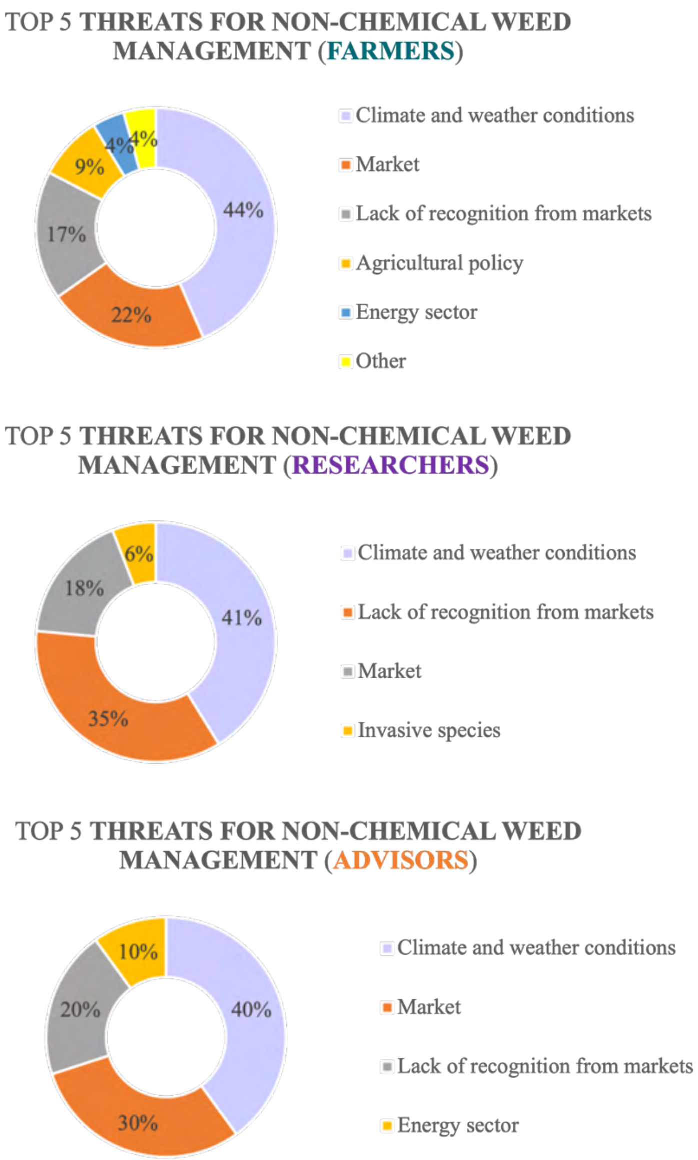


Figure 35: Top 5 threats for non-chemical weed management for farmers, researchers and advisors (aggregated in all Living Labs)

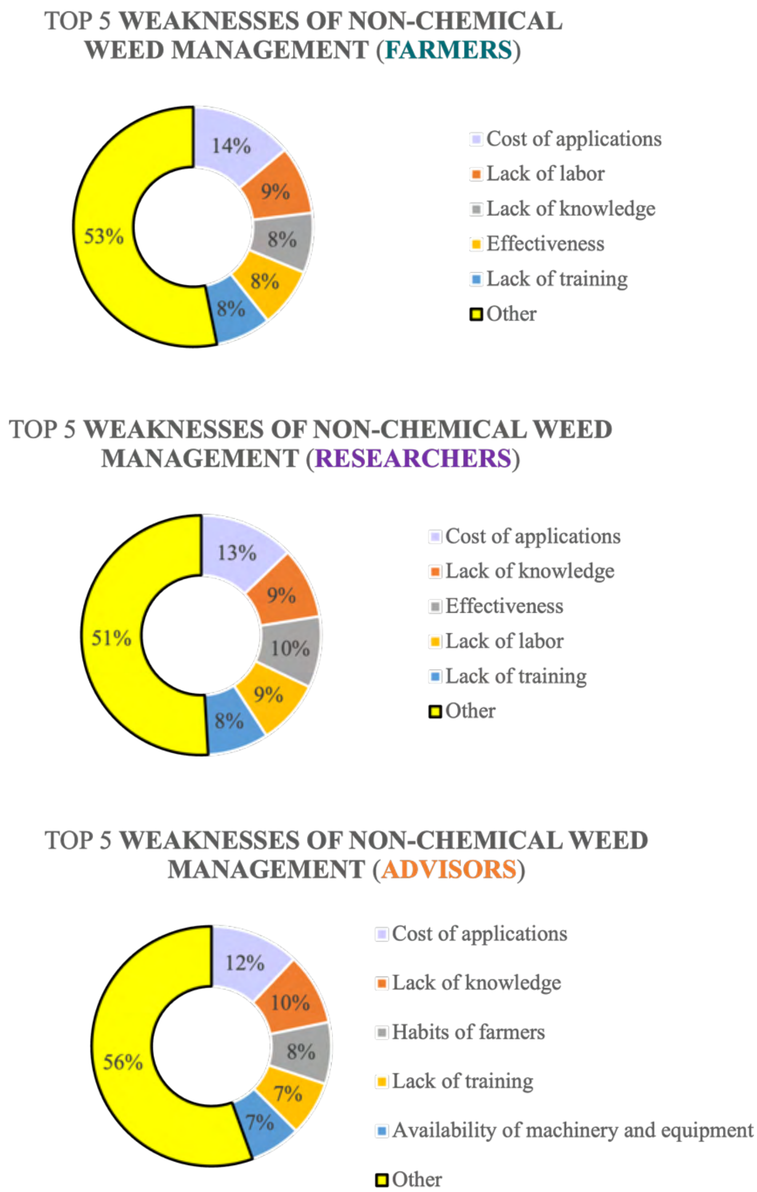


Figure 36: Top 5 weaknesses of non-chemical weed management for farmers, researchers and advisors (aggregated in all Living Labs)

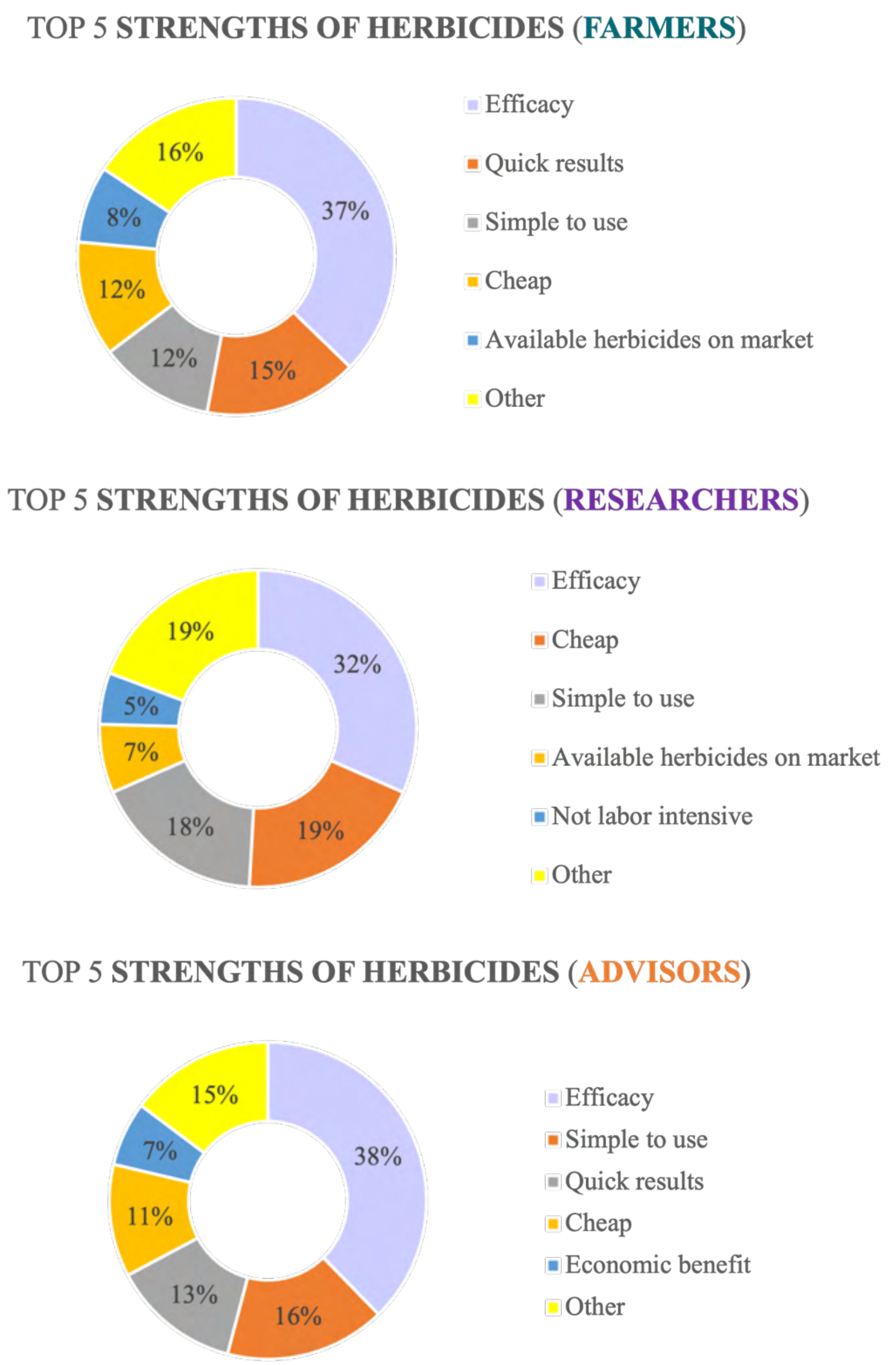


Figure 37: Top 5 strengths of herbicides for farmers, researchers and advisors (aggregated in all Living Labs)

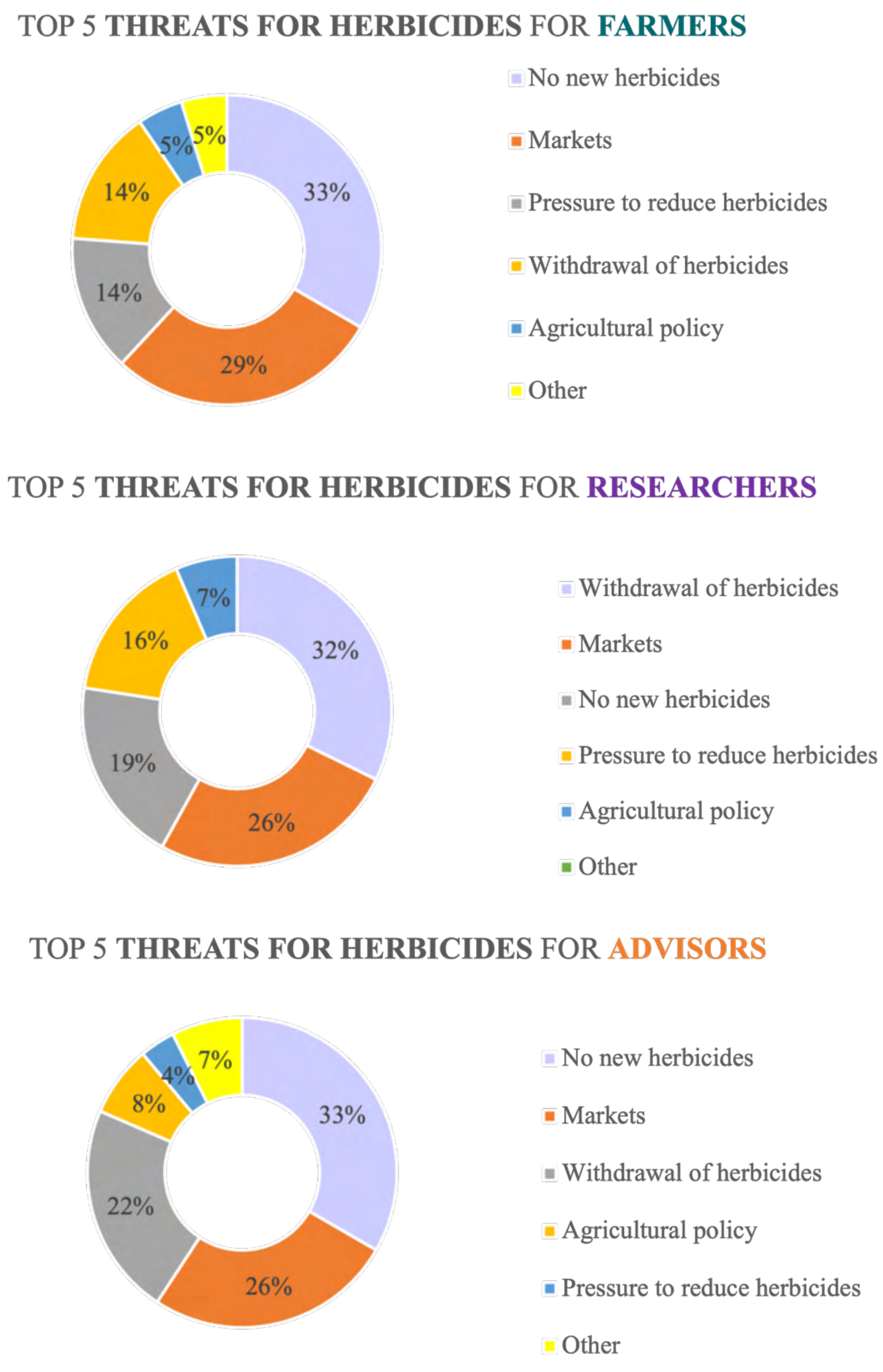


Figure 38: Top 5 threats for herbicides for farmers, researchers and advisors (aggregated in all Living Labs)

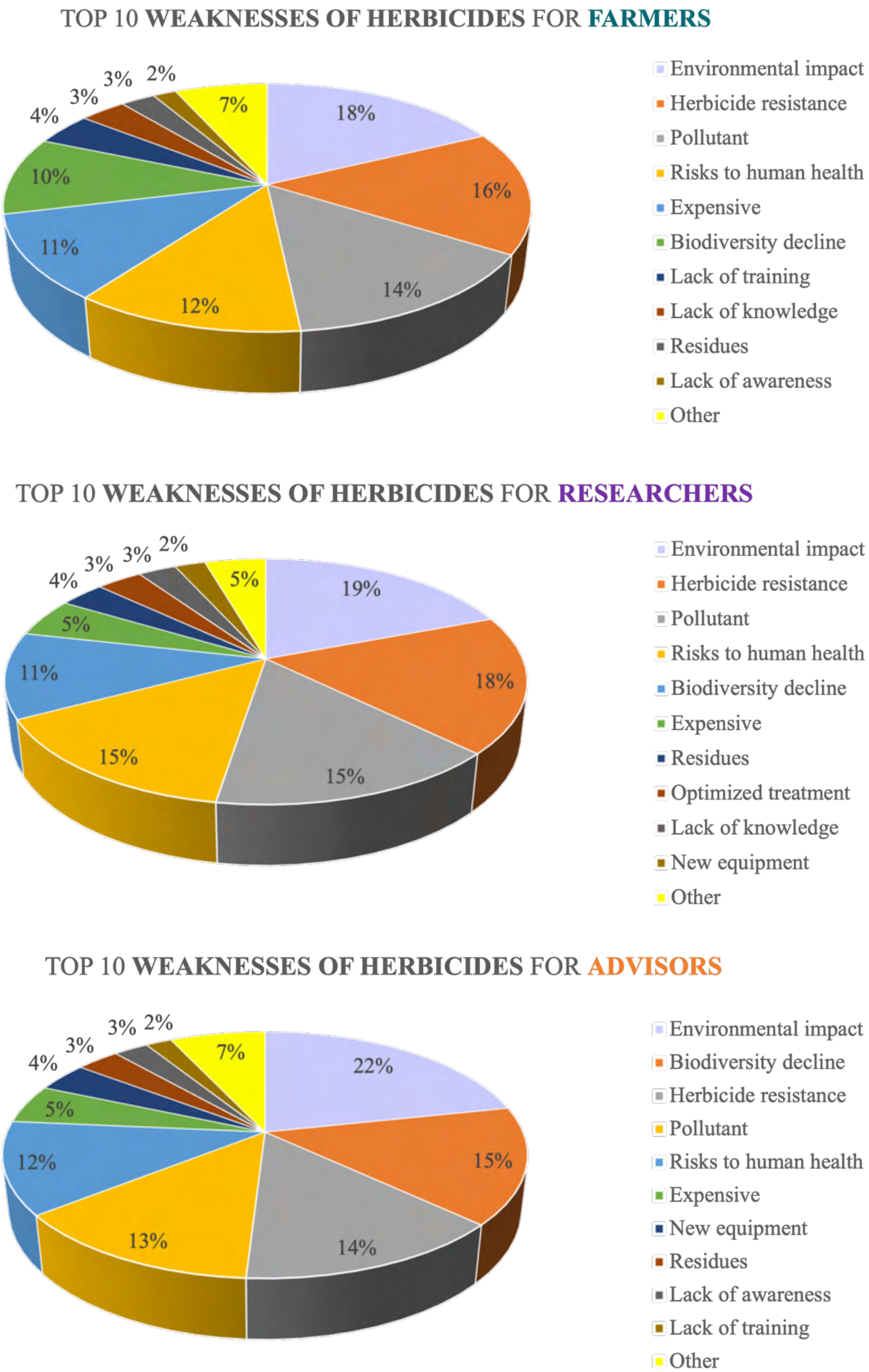


Figure 39 Top 10 weaknesses of herbicides for farmers, researchers and advisors (aggregated in all Living Labs)

Below there are some explanations for some of the responses using, in most of the cases, the wording of interviewees.

Economic benefit does not only mean profit, but also savings, which is really important for the effective management of farming systems. A researcher from Cyprus describes it accurately when refers to AWM, "*The opportunity should be identified with economic benefit, not related to what the producer will receive, but to what he will save from the inputs.* ".

Lack of knowledge refers to knowledge gaps on (i) weed biology, ecology, distribution and management, (ii) crop-weed interactions and competition for water, air, nutrients, radiant, (iii) timing of application of various weed management practices, etc.

Subsidies and **funding** are an important driver of farming systems transformation and, if are distributed in a fair and meaningful way, could support farmers to adopt AWM practices. This is what a farmer from Cyprus confesses "*subsidies for new farmers to provide farm equipment is an incentive for them to be able to implement alternative weed management practices*" and an advisor from the Netherlands supports "*Then subsidy on system application or purchase will grow the implementation of weed control. In other words, financially incentivise the systems*. ".

Social impact refers to increase of employment rate, e.g., for qualified personnel. A vine producer farmer in Italy said "*The possibility of having specialized personnel for operations which also involves maintaining a constant workforce in the area with a certain socio-economic impact, also for the communities*.". The increase in labor was often linked with territorial development, which is an intrinsic characteristic of agroecology.

Training is an inherent characteristic of the adoption of AWM practices and in general, the transition towards non-chemical weed management. It can be considered both an opportunity and a strength. For the latter, personnel and operating staff may be already qualified which is a strength considering that skilled personnel could train more people. It is also an opportunity because the new knowledge that surrounds those environmentally friendly agendas (i.e., agroecology and AWM) facilitates and accelerates training and educational opportunities that will benefit all actors across the agri-food value chain. A farmer in Cyprus said "*Education is very important. Farmers need to be informed and educated on how to use agroecological weed management practices properly and the correct way to use herbicides.*".

Management of water resources means actions to make efficient use of water, decrease evapotranspiration and make more water available to crops.

New technologies include new machinery or products e.g., bioherbicides, UAV, robots.

Climate and weather conditions refer to climatic, soil and weather conditions that affect the effectiveness of a method to control weeds. For instance, a farmer from Latvia stated, "*If it is raining, if it is drizzly, if it is foggy, then this mechanical weed treatment is extremely ineffective*.". The changing weather conditions were found to affect the applicability and effectiveness of several methods too. From the same country, an advisor mentioned "*An external threat that can affect the timing of the method is the weather. You have to make sure that you go to harrow the crop at a certain stage of its development, but if the weather is inappropriate, wet and rainy, and it is not possible to get on to the field, you may already be late for the planned operation and therefore not be able to control the weeds.* ". Weather conditions could be catastrophic as related to the effectiveness of an

AWM method. A cereal farmer in Italy gives an example "*If I do false sowing and it doesn't rain quickly, the weeds whose seed is in the ground do not grow, nullifying the false sowing technique.* ".

Applicability refers to the practical difficulties to use a weed management practice that may be effective. For example, a researcher in Latvia stated about mechanical control "*Once the plants have closed the leaves between the rows, you can no longer use the cultivator and all sorts of harrows.*" and another one from Greece said " *Also, we cannot apply them in all areas because there are areas with sloping soils where it is more difficult to apply such techniques*". On the contrary, applicability is a strength for certain weed management practices such as drones. An advisor from the Netherlands said "*UAV: No need to move across the land and can also provide weed control in places less accessible due to poor load-bearing capacity* ".

Timing of application is associated with the optimal time to manage weeds in the field. It may be linked with the growth stage of the weed or the crop, the sowing of the crop or cover crop, or even early or late applications which may lead to increased or decreased weed infestations. For example, as stated from a researcher in Latvia "*Well, very often you can see that organic fields are not just weedy because it is an organic field, but they are covered with weeds because the field was not treated on time*".

Non-selectivity of agroecological weed management practices is tied to many methods that do not distinguish the weeds that are noxious and must be treated and those that are non-harmful. Another interpretation of non-selectivity of AWM practices refers to possible damages of the main crop. As an example, an advisor from Latvia said, "*The disadvantage of mechanical weed control is that there is a risk of traumatizing the main crop, for example when harrowing*.".

Complexity was often mentioned as a weakness of non-chemical weed management practices. It was mainly linked with complex decision-making on weed management (e.g., what to use, when to treat, how to do it, why it is important, who should be involved). Moreover, complexity also implies association with difficulties in operation (mainly due to weather conditions), timing of application and effectiveness of the methods to manage weeds. An example comes from an advisor in Latvia "*A disadvantage of mowing pasture grasses is that, after mowing, the weeds remain right there on the surface of the soil. This could be a nuisance for the main crop. If the weather is as wet and warm as it is at the moment, the weeds that have been cut, as they decompose and decay, contribute to the development of various diseases that can be detrimental to the main crop afterward.*". Overall, complexity is a common weakness (or opportunity as mentioned before) of many non-chemical weed management practices, which, however, does not necessarily mean that they are not effective under certain conditions and scenarios.

The introduction of new species of cover crops, green manures or crops to integrated them into crop rotations may lead to **alterations of (weed) flora**, either in the field of the landowner or neighboring fields. This is considered a weakness by a Latvian advisor who said "*Purely from an application point of view, you can endanger others in the sense that you release green manure into flowering and seed production stages and these seeds can contaminate some nearby fields. This is a possibility.*". On the contrary, changes in weed flora could be also considered a threat tied to AWM practices, as the introduction of exotic species or the dominance of noxious weeds due to climate change and/or farming practices affect the effectiveness of those practices making it more difficult for farmers to make the proper decisions for weed management.

The presence of animals and the livestock sector is strongly linked with agroecological weed management, as farmers exploit animals (e.g., goats, sheep, cattle) for grazing weeds. This is a traditional practice in agro-pastoral systems and mainly in extensive livestock. It is considered a key factor for keeping the livestock sector sustainable because weeds are considered a **feed source for animals**, often rich with nutrients and available in times when other external feed sources are either non-available or expensive. Nevertheless, this also implies a weakness and an impact to livestock is possible if the weeds are toxic.

Lack of experience is strongly tied to lack of knowledge. It mainly refers to farmers and how they are applying falsely certain methods or applications. For instance, as stated by a Latvian advisor about mulching "*The internal weaknesses of mulching are purely technological, when you apply mulch incorrectly, not according to the requirements, it fails to perform the function of mulch and it is there, but it does not do what you expect it to do against weeds*.".

Organic farming has been associated with **time-consuming** management of weeds and in general, crop production. This is a weakness, especially when talking about transition to non-chemical weed management. It is also a fact that organic farmers are in need of more "hands", thus, the cost for labor increases and subsequently the economic benefit largely varies.

In (semi)arid conditions of the Mediterranean, leaving the soil bare is always an extra threat due to wildfires. Keeping the **ground covered** with living mulches is an option to **reduce the probability of fire** or at least limit the expansion of a fire. For this reason, it is considered a strength for a researcher in Calabria, Italy, who said "*We also have advantages, let's say, that (cover crops) are closely related to preventing the danger of fires*.".

Although AWM is a relatively new scientific topic that has started recently to be mentioned and cited in **EU policies**, it was interesting to capture the opinion of an advisor from Cyprus who said, " *The advantage is the harmonisation with the new situation, legislation and regulations of green policy and circular economy*.".

AWM is at the heart of **EU Green Deal and global agendas for the transformation of agri-food systems**. We cite the opinion of an advisor from Cyprus who seems to be advocate of AWM "*When education is provided, specializations increase, therefore product quality increases and recognition by the general public, consumers and those who are involved in agriculture. All of this is within the provisions of the FAO's Sustainable Development Goals and the 17 goals that have been established can be met through agroecological weed management practices*. ".

There are two sides of a coin for herbicides. The negative perception for herbicides refers to negative environmental impact and contribution to **biodiversity decline**. A Cypriot farmer said, "*The use of herbicides affects beneficial soil microorganisms, various natural enemies and bees*.".

There is evidence that certain areas in Europe are in danger of climate change and environmental degradation. Herbicides could be linked with ongoing **contamination and degradation of soils and water resources**. For example, we captured a statement from a Cypriot advisor "*The biggest problem for Cyprus is water, because of the limited quantities, it can easily be contaminated by herbicides. Also, another threat of the use of herbicides is the destruction of microorganisms in the soil*. ".

It is rather optimistic to see that certain AWM practices have been already part of farmers' arsenal for weed management, however, they don't know about them. This was obvious from the words of a

Serbian advisor "*Personally, I think that some measures are already in the game due to the old habits of the producers, but that the producers are currently not aware that they are doing agro-ecological weed control measures. It is necessary to raise the awareness of producers about these measures and to organize trials where this, new weed control technology will be demonstrated*.". Therefore, **demonstration events** and more **research are needed** to showcase to farmers the applicability of AWM practices and convince them using evidence to adopt them.

Markets and the demand of consumers define the offer and how food is produced. **Lack of recognition from markets** is a vital factor for the dissemination and adoption of agroecological practices. For instance, an olive producer from Portugal made the following conclusion "*If we do AWM practices, our costs will increase but the income per kilo will stay the same. If we don't promote these practices or if the consumers don't see this as an increased value to pay or also if we don't try to create other subproducts from the olive orchard it will be very difficult in the next years to survive economically with an environmentally sustainable olive orchard because it will be very difficult to compete with conventional super-intensive ones*.". There is an obvious **lack of recognition from markets** about agroecological practices and food produced in agroecological farms. This is confessed by two farmers in Spain " *lack of information for the end consumer; unwillingness of consumers to pay extra for the product*. " and " *Lack of market recognition of those products that have been produced under agroecological practices. Value chains not adapted to these types of agroecological products*.". Overall, this constitutes an external threat for the transition to non-chemical weed management and in general, towards the adoption of agroecological practices and principles. Even if niche agroecological markets existed or agroecological products could be integrated into current value chains, it would be difficult to give added value to the production cycle because there is currently a **lack of certifications or the process to acquire certification** is complex. An orchard Spanish farmer supports "*complex administrative processes for certifying agro-ecological practices*".

Availability of machinery or **capacity to purchase new equipment** or **modify the existing equipment** are critical factors affecting AWM adoption. A farmer in Sardinia, Italy, says "*Not having the equipment, I have not pursued the path of agroecological control, so the opportunities are there, but I am not yet practicing them*. ".

Integrated weed management and ecologically based weed management rely on the **combination of different strategies and methods** to reduce weed pressure and achieve high weed control and long-term management. For example, an Italian researcher stated, "*The practices of mechanical control, mowing and grazing have the common strength (opportunity) of being environmentally friendly and furthermore, they are suitable for the livestock and extensive farms which we remember in Sardinia constitute the majority of the agricultural sector*.".

Optimized treatment of herbicides is considered by some interviewees as an opportunity and strength and by others as a weakness. The latter is supported by the opinion of an Italian advisor "*When post-emergence weeding needs to be done in February and March, it is often impossible to carry out due to the high winds. This is not a minor problem that sometimes forces us to operate in extreme conditions and reduces the effectiveness of the treatment. There are nozzles with anti-drift functions available for the weed control bars, which partly compensate for this issue, but it remains an important problem*.". Therefore, the option to treat weeds with herbicides at a specific growth stage is strongly tied to the conditions (e.g., wind, equipment, nozzles) and whether these are optimal or not.

Peer-to-peer knowledge is an inherent privilege of agroecological transitions. Farmers learn from each other's experience, thus, assisting decision-making on crop production and protection. A Portuguese farmer described a nudge to use cover crops " *In my region, one or two farmers have started to (use) cover crops in vineyards and now several farmers are also starting to implement this practice as they have seen the positive effects of it, mostly because of the costs that (were) decreased with this practice*".

The **habits of farmers** constitute an important factor that drives the success or failure of AWM practices adoption. A pessimistic opinion tied to this unwillingness to reduce chemical inputs comes from an advisor in Portugal "*Farmers still practice that way (herbicides and excessive till) because they like to see a "clean" field without weeds but somehow if they gain knowledge about the impacts of that practice, I do think that the mentality can change*.".

The **replacement of herbicides** was often mentioned as a weakness towards non-chemical weed management, mainly because there is no clear and horizontal regulatory framework to support this transition. That said, **training, raising of awareness and synergies** are essential to path the way towards gradual acceptance and adoption of less harmful weed management practices. A Portuguese farmer admitted "*We need new protocols to replace herbicides. The farmers don't have the knowledge for this organic EU promoted transition, mostly the conventional ones. We need more data and training to be able to apply to AWM.* ".

An opinion that perfectly summarizes the situation in the Mediterranean countries was captured in Portugal "*Our farmers' representative population is very old, that means that in general terms, farmers are formatted to keep the soil without any weed instead of doing AWM, they prefer to do aggressive mechanical control or to apply herbicides. There must be a much wider and effective communication and demonstration of the advantages of practicing AWM at the same time as the negative effects of applying conventional methods have to be disclosed. There's a lack of awareness for benefits in AWM and drawbacks for conventional practices*.". Therefore, more **training of farmers, dissemination and demonstration of AWM practices**, and awareness about their benefits are needed to be included in transformative and transition territorial agendas.

Operational management refers to methods that make the life of farmers "easier". For example, a researcher from the Netherlands said about automated weed control "*Automated weed control: possibilities to use 24/7* ".

Site-specific weed management is gaining attention by farmers, advisors and researchers. A Dutch advisor shared his experience on how chemical input is feasible when a combination of strategies is an option "*Opportunities within chemicals; Applying chemicals at the plant level and thus applying care only on the plants that need it. Sequential control. This can be done by using drones and camera techniques. Our experience is a >80% reduction per ha by using camera techniques. This keeps the amount of active substance far below the set standards per ha and may allow chemicals to be used for longer using these new site-specific techniques*. ".

A Portuguese researcher concluded "*To show them the benefits of AWM is not enough if we don't show them also the success for the crops and the potential income related to the change of practices.*". Demonstration and dissemination of AWM practices and overall, more diversified and environmentally friendly farming approaches should be done at local level, focusing on peer-to-peer exchange of experience and knowledge.

5 Overview of needs, barriers, gaps and opportunities tied to AWM per living lab

The following Table shows a summary of the needs, barriers, gaps and opportunities tied to AWM at national level in the participating countries. The conclusions presented are drawn as a combination of the results and views obtained from all the stakeholder groups approached during the project.

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Rice LL (Spain)	1. **Regulatory changes- Policy concerns.** Rice is highly dependent on herbicides. Stakeholders consider that severe policies hinder transition to AWM. 2. **Improvements in educational related aspects**. Including farmers training, management expertise and practicing knowledge skills. 3. **Enhancement in technical aspect**s, including reductions of maintenance and cost. 4. **Treatment optimization** and increases in the design of **combination strategies**. 5. Development of new herbicides.	1. **Educational aspects** they consider lack of training as the most relevant barrier. 2. **Expense** and farmers **lack of funds** to implement AWM practices. 3. EU policies-**regulatory challenges**. Stakeholders consider that no transition will take place if requirements continue to be instated and demand taxation and increased customer information on produce imports. 4. Farmers reported instances of **herbicide resistance** which are increasingly concerning in the recent years. 5. **Environmental** or **human** health **harm** and **Public's opposition** to herbicides**.** Stakeholders consider that herbicides have a negative impact on the environment and on sales.	1. **Cost of application** of AWM practices compared to herbicides. **Transition** does not imply an **economic benefit**. 2. **Herbicide resistance** and **lack of** development of **new chemicals** due to regulation. 3. Technical **assistance** as well as lack of advisors. **Low efficiency** of AWM practices compared to herbicide application. 4. **Lack of technology** and other **technical aspects** in the region. That may hinder the adoption of AWM practices. 5. Lack of drivers for **change in farmers habits**. As they are pessimistic about the adoption of AWM. Education and increases in knowledge and the adoption of multi-actor approaches might crucial.	1. **IPM fostering**. They consider that the combination of sustainable practices has beneficial social impact as well as improvements in their produce. 2. **Ecosystem services provision,** including increased water quality and availability, improvements in biodiversity as well as an amelioration on soil health. 3. High **efficacy** and selectivity of herbicides compared to AWM. 4. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.** 5. **Reduction of herbicide reliance**. As a result of the adoption of combination strategies.

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Triticale LL (Italy)	1. **Improvements in educational related aspects**. Including farmers training and practicing knowledge skills. 2. **Increases in scientific knowledge** related to practices impact on ecosystem services. 3. **Enhancement in technical aspect**s, including reductions of maintenance, cost, and application time. 4. **Regulatory changes- Policy concerns.** Farmers would prefer less severe policies on herbicide reduction, thought they only use herbicides in extreme situations. 5. **Climate change and weather** vastly affect weed behavior in this region. More extreme climate scenarios may lead to increase in chemical weeding use, need to **adapt AWM strategies**.	1. **Expense and time consumption** in agroecological weed management strategies 2. **Educational aspects** they demand increased training about weed management strategies. 3. **Changes in the flora** and particularly in the presence of **invasive species**, as stakeholders shared concerns about poppy distribution in the island 4. EU policies, **regulatory challenges,** and the European system of incentives, particularly those related to CAP payments. 5. **Climate change** and high **carbon footprint** of certain AWM practices.	1. **Time consumption** in AWM strategies as well as non-chemical weed management approaches. 2. **Cost of application**. The isolation of the region hinders the importation of machinery and limits the export of the produce. 3. **Environmental impact** of weed management strategies. 4. Technical **assistance** as well as lack of advisors. 5. **Herbicide resistance,** human health and environmental concerns were voiced for the use of chemical weeding.	1**. Ecosystem services provision,** including increased water quality and availability, improvements in biodiversity as well as an amelioration on soil health. 2. **IPM fostering**. The socio-economic environment in the island promotes the adoption of combination strategies to successfully manage weeds. 3**. Reduction of herbicide reliance**. As a result of the adoption of combination strategies. 4. **Source of food for livestock.** 5. **Economical-business aspects,** such as crop yield stabilization and income increase

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Wheat LL (Greece)	1. Enhancement in **technical aspects**, especially those related to decreased maintenance, costs, and timing. 2. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studied. They emphasize the importance of communication among stakeholders. 3. **Regulatory changes- Policy concerns.** Herbicides are the main weed management practice in the region, respondents acknowledge the problems with herbicides. In contrast with other LL, Greek participants consider AWM practices as reasonable weed management solution, they consider that labor an other costs will increase, there needs to be a political solution, for example with increased payments. 4. **Improvements in educational related aspects**. They emphasized practicing knowledge skills as a key need. 5. **Lack of advisors** and reliable knowledge related to AWM practices (UAV).	1. **Environmental or human health harm.** Stakeholders recognize herbicides and site-specific spraying as potentially dangerous (soil pollution…), however, they consider that proper manage reduces risks. 2. Need for **certifications** for the application of certain practices. 3. EU policies, **regulatory challenges** related to restrictions in herbicide use. They considered that eco-schemes should integrate AWM. 4. **Expense and lack of fund** in certain agroecological weed management strategies 5. **High carbon footprint** of mechanical weeding.	1. **Cost of application** in AWM practices compared to herbicides. 2. Development of a sustainable system for **organic farming**. 3. **Low efficiency** of AWM practices compared to herbicide application 4. Stakeholders shared concerns with regard to some method's **high carbon footprint**. 5. **Herbicide resistance,** human health and environmental concerns were voiced for the use of herbicides.	1. **Economical-business aspects,** were recognized by industry, policy makers and researchers. 2. **IPM fostering**. They consider that the combination of sustainable practices has beneficial social impact as well as improvements in their produce. 3. **Reduction of herbicide reliance**. As a result of the adoption of combination strategies, especially after mechanical weeding. 4. **The availability of machinery and equipment**, contributes to cost effectiveness of AWM. 5. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.**

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Maize LL **(Serbia)**	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. 2. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 3. **Regulatory changes- Policy concerns.** They consider that there needs to be a redefinition in policies, increasing subsides to implement sustainable practices. Stakeholders, especially farmers are skeptical about nonchemical methods. 4. Enhancement in **technical aspects**, especially those related to decreased maintenance, costs and timing. Stakeholders also emphasize the need for increased efficiency in non-chemical weed management. 5. **Treatment optimization** and increases in the design of **combination strategies**.	1. **Expense** emerges as the most relevant barrier. Farmers consider that the use of herbicides as the sole weed management practice is not viable. 2. **Environmental or human health harm.** Stakeholders consider that herbicides have a negative impact on the environment. 3. **Educational aspects** they demand increased training about AWM and combination of strategies 4. **Lack of technology** and other **technical aspects** in the region. That may hinder the adoption of AWM practices. 5. Some farmers reported instances of **herbicide resistance** which are increasingly concerning in the recent years.	1. **Lack of technology** and other **technical aspects** in the region. That may hinder the adoption of AWM practices. 2. **Cost of application** of AWM practices compared to herbicides. 3. **Herbicide resistance,** human health and environmental concerns were voiced for the use of herbicides. Besides, stakeholders considered **treatment optimization** as a relevant gap. 4. Create **market for organic produce**. 5. Lack of drivers for **change in farmers habits**. As they are pessimistic about the adoption of AWM. Education and increases in knowledge and the adoption of multi-actor approaches might crucial.	1. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. 2. **IPM fostering**. They consider that AWM increases IPM strategies adoption. 3. **Ecosystem services provision,** including increased water quality and availability, improvements in biodiversity as well as an amelioration on soil health. 4. **Reduction of herbicide reliance**. As a result of the implementation of mechanical weeding, mowing or automated weed management. 5. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.**

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Cowpea LL (Portugal)	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. They emphasize the importance of site-specific practices. 2. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 3. Enhancement in **technical aspects**, especially those related to decreased maintenance, costs and timing. 4. **Lack of advisors** and **few extension services** hinder cowpea AWM practices. 5. **Regulatory changes- Policy concerns.** Stakeholders consider that there needs to be a redefinition of policies, aiming subsidies to specific and measurable goals and especial cases. Additionally, they consider that AWM practices should have a certification to be easily identified by consumers.	1. **Expense** emerges as the most relevant barrier. Farmers acknowledge the costs of AWM in this crop. They acknowledge that herbicide use as the sole control practice is not a possibility in cowpea. 2. Cowpea fields are rainfed, therefore **weather** and especially **climate change** are considered as key barriers. 3. **Environmental or human health harm** as well as **high carbon footprint** of some practices**.** Stakeholders consider that herbicides, site-specific spraying and mowing as practices that may be detrimental to environment and human health. 4. Emergence of **invasive species**. 5. **Public's opposition** to the application of certain approaches (specially chemical management) as well as **customer demand** to **reduce** their use.	1. **Lack of extension services**, which hinder adoption of greener practices. Farmers consider that **advisory services** are often far from field reality. 2. Lack of drivers for **change in farmers habits**. As they are pessimistic about the adoption of AWM, they do not envision agriculture without herbicides as possible. 3. Absence of **market recognition** of crops produced using greener approaches. 4. Increase in e**nergy prices** and other energetic inputs, as well as **lack of technology** in the region. 5. **High timing of application** of AWM practices compared to chemical weeding.	1. **IPM fostering**. They consider that AWM increases IPM strategies adoption. 2. **Ecosystem services provision,** including increased water quality and availability, improvements in biodiversity as well as an amelioration on soil health. 3. **Creation of synergies** as a result of the adoption of AWM approaches and their combinations. 4. Harmony with new **European policies** (Fork2Farm) as well as consumer sentiments. 5. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.**

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Soybean LL (Serbia)	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. They emphasize the importance of increasing the knowledge related to cost structure and economical analysis. 2. Enhancement in **technical aspects**, especially those related to decreased maintenance, costs and timing. 3. **Regulatory changes- Policy concerns.** Stakeholders adopt a positive stance toward non-chemical weed management. They consider that there needs to be a redefinition of policies, aiming to an increase the government subsidies. 4. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 5. **Lack** of **funding and labour** for the implementation of AWM practices in soybean	1. **Expense** emerges as the most relevant barrier. Farmers consider that the use of non-chemical weed management is equally efficient yet not economically viable. 2. **Environmental or human health harm.** Stakeholders consider that herbicides have a negative impact on the environment. 3. **Educational aspects** they demand increased training about AWM and combination of strategies 4. **Lack of technology** and other **technical aspects** in the region. That may hinder the adoption of AWM practices. 5. Some farmers reported instances of **herbicide resistance** which are increasingly concerning in the recent years.	1. **Lack of technology and equipment** and other **technical aspects** in the region. That may hinder the adoption of AWM practices. 2. **Cost of application** in AWM practices compared to herbicides. 3. **Herbicide resistance,** human health and environmental concerns were voiced for the use of herbicides. Stakeholders considered **treatment optimization**, to decrease potential environmental harm as a relevant gap. 4. Create **market for organic produce**, which may result difficult as soybean is mainly used in livestock nutrition. 5. Drivers for **change in farmers habits**. As they are pessimistic about the adoption of AWM, yet the envision agriculture without herbicides as possible.	1. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. 2. **IPM fostering**. They consider that AWM increases IPM strategies adoption. 3. **Ecosystem services provision,** including increased water quality and availability, improvements in biodiversity as well as an amelioration on soil health. 4. **Reduction of herbicide reliance**. As a result of the implementation of mechanical weeding, mowing or automated weed management. 5. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.**

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Rye-pea (Latvia)	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. 2. Enhancement in **technical aspects**, especially those related to decreased maintenance, costs and timing. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration and active dissemination of the results. 4. **Regulatory changes- Policy concerns.** They consider that there needs to be a redefinition in policies, they consider that there needs to be more subsides to implement more sustainable practices. Stakeholders, especially farmers are skeptical about nonchemical methods. 5. **Treatment optimization** and design of **combination strategies**.	1. **Expense** emerges as the most relevant barrier, emphasizing farmers **lack of funds** as important. 2. **Public's opposition** to the application of certain chemical weed management as well as **customer demand** to **reduce** their use. 3. **Changes in the flora** and particularly in the presence of **invasive species**. 4. **Educational aspects** they demand increased training about AWM and combination of strategies. 5. EU policies, **regulatory challenges** related to restrictions in herbicide use and CAP payments.	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. Risks for **human health** and **environmental impact**, including biodiversity decline were voiced for the use of herbicides. 3. **EU policy** and increases in **bureaucracy**. Stakeholders consider that EU policy does not articulate sufficient **tools** to implement AWM practices. 4. Enhance **multi-actor and holistic approaches** to implement peer to peer to ensure **changes in farmers habits**. 5. **Low** market **prices** and instability.	1. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 2. **Ecosystem services provision,** including increased water quality, improvements in biodiversity as well as an amelioration on soil health. 3. **Creation of synergies** as a result of the adoption of AWM approaches and their combinations. 4. Farmers professionalization. **Increase in training** programs, especially **peer to peer knowledge**. 5. **Ease to use** and integration of the practice in **organic agriculture**.

Living lab	NEEDS	BARRIERS	GAPS	OPPORTUNITIES
Onion (The Netherlands)	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. 2. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. Moreover, stakeholders emphasize **difficulties in operations** and reduced **effectiveness** of AWM practices. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 4. **Regulatory changes- Policy concerns.** Stakeholders consider that policies should be designing with long term vision. 5. **Market** and **sales acceptance** of the products.	1. EU policies, **regulatory challenges** related to restrictions in herbicide use. 2. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. 3. **Weather** and especially **climate change** are considered as key barriers to AWM and non-chemical weeding use. 4. **Complexity** of application and treatment optimization. 5. **Environmental or human health harm** as well as **high carbon footprint** of some practices.	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. **Cost of application** in AWM practices compared to herbicides. 3. lack of drivers for **change in farmers habits**. As they are pessimistic about the adoption of AWM. Education and increases in knowledge and the adoption of multi-actor approaches might crucial. 4. **Low efficiency** of AWM practices compared to herbicide application. 5. **Cost** of **equipment** as well as **lack of labor**.	1. **Ecosystem services provision,** including increased water quality, improvements in biodiversity as well as an amelioration on soil health. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. 3. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 4. **AWM** practices have potential to evolve into relevant **scientific disciplines**. 5. **IPM fostering**. They consider that AWM increases IPM strategies adoption.

Living lab	**NEEDS**	**BARRIERS**	**GAPS**	**OPPORTUNITIES**
Olive (Portugal)	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise, emphasizing peer to peer knowledge. 2. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. Moreover, stakeholders emphasize **difficulties in operations** and reduced **effectiveness** of AWM practices. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 4. **Regulatory changes- Policy concerns.** Stakeholders consider that there needs to be a redefinition in policies, including a modification on CAP payments 5. **Increase in investments** to acquire new machinery and enhance farmers knowledge.	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. 2. **Environmental or human health harm** as a result of chemical practices, leading to decline in biodiversity and soil microbiota, as well as environmental pollution. 3. EU policies, **regulatory challenges** related to restrictions in herbicides, economic incentives to farmers. 4. **Weather** and especially **climate change** are considered as key barriers to AWM and non-chemical weeding use and to production in general. 5. **Market** acceptance and lack of **recognition** of more **sustainable practices.**	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. **Cost of application** and **time consumption** of AWM use. 3. Lack of **consumer education** on AWM and agroecology in general to make informed decisions. 4. **Low efficiency** of AWM practices compared to herbicide application. AWM practices usually need for soil operations resulting in erosion. 5. **Cost** of **equipment** as well as **lack of labor**.	1. **Ecosystem services provision,** including increased water quality, improvements in biodiversity as well as an amelioration on soil health. These practices are in harmony with **European green policies**. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social and employment where they are implemented. 3. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 4. **AWM** practices have potential to evolve into relevant **scientific disciplines**. 5. **IPM fostering**. They consider that AWM and non-chemical weed management increases IPM strategies adoption.

GOOD AGROECOLOGY FOR WEEDS

Living lab	**NEEDS**	**BARRIERS**	**GAPS**	**OPPORTUNITIES**
Olive (Cyprus)	1. **Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise, emphasizing the importance of peer to peer knowledge and multi-actor approaches. 2. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 4. **Regulatory changes- Policy concerns.** Stakeholders consider that there needs to be a redefinition in policies, appointing financial incentives as well as promotion of agroecological approaches from the administrations. Additionally, they consider that AWM practices should have a certification to be easily identified by consumers.	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. 2. **Environmental or human health harm** chemical practices, leading to decline in biodiversity and pollution. 3. EU policies, **regulatory challenges** related to restrictions in herbicides and economic compensations to farmers. Stakeholders consider that administration should promote market recognition and consumer education. 4. **Weather** and especially **climate change** are considered as key barriers to AWM and non-chemical weeding use. 5. Some farmers reported instances of **herbicide resistance** which are increasingly concerning in the recent years.	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. **Cost of application** in AWM practices compared to herbicides. 3. Lack of drivers for **change in farmers habits**. They consider that agriculture without herbicides is possible, and demand for increased knowledge and dissemination through the adoption of multi-actor approaches to boost AWM practices intake. 4. lack of **consumer** education and **promotion** of AWM and agroecology to the public. 5. **Cost** of **equipment** as well as **lack of labor**.	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity as well as an amelioration on soil health. These practices are in harmony with **European green policies**. 2. **IPM fostering**. They consider that AWM and non-chemical weed management increase IPM strategies adoption. 3. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 4. **AWM** practices have potential to evolve into relevant **scientific disciplines**. 5. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.**

	5. **Lack of advisors** to promote AWM adoption among producers.			
Living lab	**NEEDS**	**BARRIERS**	**GAPS**	**OPPORTUNITIES**
Cherry (Spain)	1. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. **2. Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise, emphasizing the importance of peer to peer knowledge and multi-actor approaches. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. Treatment optimization for regional weed management. 4. **Regulatory changes- Policy concerns.** Stakeholders consider that there needs to be a redefinition in policies, appointing financial incentives and increasing administrative support to farmers.	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. 2. **Environmental or human health harm** as a result of herbicide use, leading to decline in biodiversity and soil microbiome as well as environmental pollution. 3. EU policies, **regul atory challenges** related to restrictions in herbicides and economic compensations to farmers. Stakeholders consider that administration should promote market recognition and consumer education. 4. **Weather** and especially **climate change** are considered as key barriers to AWM and non-chemical weeding use. 5. Some farmers reported instances of **herbicide resistance** which are increasingly concerning in the recent years.	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. **Cost of application** in AWM practices compared to herbicides, in an instable market. Lack of incentives to farmers 3. Lack of drivers for **change in farmers habits**. They consider that agriculture without herbicides is possible, and demand for increased knowledge and dissemination through the adoption of multi-actor approaches to boost AWM practices intake. 4. Lack of **economic innovation strategies** that value ecosystem services and sustainable practices in agriculture. 5. **Cost** of **equipment** as well as **lack of labour**. Stakeholders shared	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity as well as an amelioration on soil health. These practices are in harmony with **European green policies**. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social and employment where they are implemented. Stakeholders consider the reduction of inputs as a key opportunity. 3. **IPM fostering**. They consider that AWM and non-chemical weed management increase IPM strategies adoption. 4. **Reduction of herbicide reliance**. As a result of the implementation of

	5. **Market** and **sales acceptance** of the products, value ecosystem services provision.		concerns with regard to generational renewal.	non-chemical weed management strategies 5. Farmers professionalization. As the implementation of more AWM practices will lead to **increase in training and education programs.**
Living lab	**NEEDS**	**BARRIERS**	**GAPS**	**OPPORTUNITIES**
Apple (Spain)	1. Enhancement in **technical aspects,** especially those related to reduce maintenance, costs and timing. **2. Improvements in educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 4. **Market** and **sales acceptance** of the products, value ecosystem services provision. Stakeholders consider that regional apple value chain is not sustainable. 5. **Treatment optimization** and design of **combination strategies**.	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. 2. **Complexity** of application and **time consumption**. 3. **Lack of professionalization** and absence of training, hinder the adoption of effective strategies. 4. **Unsustainability of the regional apple value chain**, deter the professionalization and the adoption of new practices 5. High **carbon footprint** and **environmental impact** of some mechanical practices.	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. Lack of **incentives-subsidides** to farmers and lack of promotion of agroecological practices. 3. **Low** ratio of **organic farms**. 4. Lack of **economic innovation strategies** that value ecosystem services and sustainable practices in agriculture. 5. **Lack of labour**. Stakeholders shared concerns with regard to generational renewal.	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity as well as an amelioration on soil health. These practices are in harmony with **European green policies**. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social and employment where they are implemented. Stakeholders consider the reduction in inputs as a key opportunity. 3. **IPM fostering**. They consider that AWM and non-chemical weed management increase IPM strategies adoption.

				4. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. Most production is agroecological 5. **Farmers professionalization**. As the implementation of more AWM practices will lead to **increase in training and education programs.**
Living lab	**NEEDS**	**BARRIERS**	**GAPS**	**OPPORTUNITIES**
Grapes (Spain)	1. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. **2.** Improvements in **educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise, that boost AWM practices implementation. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Including both field demonstration as well as economical studies. 4. **Market** and **sales acceptance** of the products, value ecosystem services provision. Some stakeholders consider that grapes value chain is not sustainable because production is not based on agroecological principles.	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. Stakeholders consider the increase of costs when applying AWM as the most relevant barrier. 2. **Complexity** of application and **time consumption**. Especially when considering AWM practices. 3. **Environmental or human health harm** as a result of herbicide use, leading to decline in biodiversity and soil microbiome as well as environmental pollution. As well as high carbon footprint. 4. EU policies, **regulatory challenges** related to restrictions in herbicides and economic compensations to farmers. Stakeholders consider that eco-	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. **Cost of application** in AWM practices compared to herbicides. 3. **Cost** of **equipment** to implement AWM practices. 4. Enhance **multi-actor and holistic approaches** to implement peer to peer to ensure **changes in farmers habits**. 5. **Lack of labor**. Stakeholders shared concerns with regard to generational renewal.	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity as well as an amelioration on soil health. These practices are in harmony with **European green policies**. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social and employment where they are implemented. 3. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies.

	5. **Treatment optimization** and design of **combination strategies**. Stakeholders consider that the use of various practices may increase cost-efficiency, and create synergies.	schemes should integrate agroecological management of crops. 5. **Weather** and especially **climate change** are considered as key barriers to AWM and non-chemical weeding use.		4. **IPM fostering**. They consider that AWM and non-chemical weed management increase IPM strategies adoption. 5. **Farmers professionalization**. As the implementation of more AWM practices will lead to **increase in training and education programs.**
Living lab	**NEEDS**	**BARRIERS**	**GAPS**	**OPPORTUNITIES**
Grapes (Italy)	1. Improvements in **educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise, including field demonstration activities to boost AWM practices implementation. Increase the number of **advisors**. 2. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. 4. **Market** and **sales acceptance** of the products, value ecosystem services provision. Stakeholders emphasize	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. Stakeholders consider the increase of costs when applying AWM as the most relevant barrier. 2. **Time consumption**. Especially when considering AWM practices implementation in small farms. 3. Small farm's **lack of professionalization** and absence of **training**, hinder the adoption of effective strategies 4. Soil disturbances and **environmental impact** of some of the non chemical weeding practices.	1. **Lack of knowledge** and **practical experience**. Stakeholders consider that AWM are knowledge intensive. There is a lack of "know-how" transmission. 2. **Cost of application** in AWM practices compared to herbicides, in an instable market. Lack of incentives and financial protection especially to small farms. 3. Lack of drivers for **change in farmers habits**. They consider that agriculture without herbicides is possible, and demand for increased knowledge and adequate training through the adoption of multi-actor approaches to boost AWM practices intake.	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity, and on soil health, as well as an amelioration in overall environmental balance. These practices are in harmony with **European green policies**. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social aspects where they are implemented. 3. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies.

	that Italian organic vineyards have a sustainable agri·food value chain. 5. Increase **Treatment optimization** and design of **combination strategies**. Vineyard weed management is one of the most diverse of the analyzed crops. However, stakeholders emphasize that is necessary to improve weed management strategies.	5. EU policies, **regulatory challenges**. Stakeholders consider that policies should financially protect small farms owners from decreased production.	4. Lack of **economic innovation strategies** that value ecosystem services and sustainable practices in agriculture. 5. **Cost** of **equipment** as well as **lack of labor**. Especially in small farms.	4. **IPM fostering**. They consider that AWM and non-chemical weed management increase IPM strategies adoption. 5. **Farmers professionalization**. As the implementation of AWM practices will lead to **increase in training and education programs.**
Living lab	**NEEDS**	**BARRIERS**	**GAPS**	**OPPORTUNITIES**
Grapes **(Greece)**	1. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. Stakeholders recognize that AWM practices are simple to use and effective. 2. Improvements in **educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise, through workshops. 3. **Increases in scientific knowledge** related to practices impact on ecosystem services. Stakeholders consider that AWM are not adequately tested and demand for increases in dissemination.	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. Stakeholders consider the increase of costs when applying AWM as the most relevant barrier. 2. EU policies, **regulatory challenges**. Stakeholders consider that eco-schemes should integrate AWM, emphasizing that most producers are willing to integrate these practices in their production. 3. **Time consumption** and **lack of labor** are relevant barriers to implement AWM. 4. Small farm's **lack of professionalization** and absence of	1. **Lack of knowledge** and **practical experience**. Stakeholders consider that AWM are not adequately tested. 2. Lack of drivers for **change in farmers habits**. They consider that agriculture without herbicides is possible, and demand for increased knowledge and adequate training through the adoption of multi-actor approaches to boost AWM practices intake. 3. Lack of **economic innovation strategies** that value ecosystem services and sustainable practices in agriculture. 4. **Consumer** education and **promotion** of AWM and agroecology to the public.	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity, and on soil health, as well as an amelioration in overall environmental balance. 2. **IPM fostering**. Stakeholders consider that AWM and non-chemical weed management increase IPM strategies adoption. 3. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social aspects where they are implemented.

	4. **Market** and **sales acceptance** of the products, value ecosystem services provision. Stakeholders emphasize that produce should be promoted, as consumers are willing to pay more for organic wine. 5. Increase **Treatment optimization** and design of **combination strategies**. Stakeholders emphasize that is necessary to improve weed management strategies.	**training**, hinder the adoption of AWM strategies. 5. **Cost of application** and effectiveness of non-chemical weeding strategies.	5. Technical **assistance** and lack of advisors.	4. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 5. **Farmers professionalization**. As the implementation of AWM practices will lead to **increase in training and education programs.**
Living lab	**NEEDS**	**BARRIERS**	**GAPS**	**OPPORTUNITIES**
Citrus **(Italy)**	1. Enhancement in **technical aspects**, especially those related to reduce maintenance, costs and timing. Stakeholders recognize that AWM practices are simple to use and effective. Increase the number of **advisors**. 2. Improvements in **educational related aspects**. Including farmers training, practicing knowledge skills as well as management expertise. Stakeholders consider that there should be more workshops and demo days in farms.	1. **Expense** emerges as a relevant barrier, emphasizing farmers **lack of funds** as important. Stakeholders consider the increase of costs when applying AWM as the most relevant barrier. 2. **Time consumption** and **lack of labor**. Stakeholders consider that agriculture without herbicides is possible, being more time consuming. 3. Absence of **training**. Farmers are willing to change as they recognize that herbicides have a negative impact in the environment. **Lack of knowledge** about effective alternatives to herbicides.	1. **Lack of knowledge** and **practical experience** on agroecological and non-chemical weed management practices, hindering adoption. 2. **Cost of application** in AWM practices compared to herbicides. 3. **Cost** of **equipment** to implement AWM practices. 4. Enhance **multi-actor and holistic approaches** to implement peer to peer to ensure **changes in farmers habits**.	1. **Ecosystem services provision,** including increased water quality, availability, improvements in biodiversity, and on soil health, as well as an amelioration in overall environmental balance. 2. **Economical-business aspects.** Stakeholders considered that AWM stabilizes crop yields and increases business profitability. Additionally, stakeholders consider that AWM practices can enhance social aspects where they are implemented. 3. Stakeholders consider that AWM practices will become **relevant scientific disciplines.**

	3. Increases in scientific knowledge related to practices impact on ecosystem services. **4. Regulatory changes- Policy concerns.** Stakeholders consider that there needs to be a redefinition in policies, emphasizing the need for financial incentives and increasing administrative support to farmers. **5.** Increase **Treatment optimization** and design of **combination strategies**. Stakeholders emphasize that is necessary to improve weed management strategies, specially to reduce time consumption.	4. **Complexity of application** of certain AWM practices. 5. **Lack of equipment** and cost of **machinery** to implement other practices.	5. **Lack of labor**. Stakeholders shared concerns with regard to generational renewal.	4. **Reduction of herbicide reliance**. As a result of the implementation of non-chemical weed management strategies. 5. **IPM fostering**. Stakeholders consider that AWM and non-chemical weed management increase IPM strategies adoption.

6 Conclusions

Most LL consider that agriculture without herbicides is viable. Stakeholders share a positive perception with regard to AWM practices and consider that a reduction of costs and an increase of knowledge and dissemination through multi-actor and holistic approaches as key to ensure farmers adoption of more sustainable practices. Next, the most relevant conclusions with regard to AWM needs, barriers, gaps and opportunities found through this study will be mentioned.

NEEDS
- Stakeholders considered educational aspects and improvement on technical matters as the most relevant needs. - Regulatory changes and policy redefinitions were considered as important requirements in all arable crops. - Increase in scientific knowledge, emphasizing ecosystem services impact knowledge emerged as a shared concern in virtually all LL.
BARRIERS
- Expense and lack of funds were considered as the most relevant barrier in all permanent and most arable crops. - Environmental and human harm, as well as changes in native flora and emergence of invasive species were shared concerns in crops where herbicides are regularly used. - Stakeholders shared concerns with regards to policy barriers, most of them consider that they can overcome the challenges by increasing farm's funding through specific incentives or including agroecological management as eco-schemes in CAP payments.
GAPS
- Lack of knowledge and of practical experience arose as the most relevant gap in all permanent crop, and was considered as relevant by most arable crops LL. - Stakeholders consider that there is absence of advisory and extension services, and multi-actor or holistic approaches, hindering farmers adoption, as there is a clear lack of drivers for change in their habits. - Market recognition and consumer education were massively cited as relevant gap throughout the studied crops.
OPPORTUNITIES
- Ecosystem services provision was considered as an important opportunity in all studied crops. Most stakeholders emphasize its harmony with green policies and consider that it should be reflected in produce price. - Farmers professionalization through workshops and field demos were considered as key to early adoption across most LL. - Overall reduction in herbicide reliance was considered as an important opportunity in all studied crops.

1 ANNEX I – INTERVIEWS

2 ANNEX II – QUESTIONNAIRES, SURVEYS AND LL ANALYSIS FOR ARABLE CROPS

2.1 ARABLE CROPS

2.1.1 Cereals

2.1.1.1 Rice (Spain)

2.1.1.1.1 Questionnaires

Rice questionnaires provided insight regarding stakeholder's perception on two AWM practices (herbicides and mechanical weeding), specifically concerning the perceived disadvantages, needs, barriers, and opportunities. Interestingly, none of the techniques garnered responses from sufficient respondents across all stakeholder categories, which encompassed advisors, consumers, farmers, industry representatives, and researchers. A detailed breakdown of stakeholder participation in the questionnaires for distinct AWM practices is provided in Table 22.

Table 22 Number of responses for each AWM practice and stakeholder category in rice

	Advisor	**Consumer**	**Farmer**	**Industry**	**Policy maker**	**Researcher**
Automated weed control						1
Biobased herbicides						1
Cover crop inoculation to increase competitiveness						
Cover crops						2
False seedbed		1				1
Grazing		2	1			
Herbicides	5	3	1	1		6
Intercropping						
Mechanical weeding	1	2	1	1		3
Mowing						1
Mulching						1
Natural enemies						

Other	1	2				
Site-specific	1					1
Thermal weeding						
UAV						
n= 18	**5**	**5**	**1**	**1**		**6**

2.1.1.1.1.1 Herbicides

2.1.1.1.1.1.1 Advisors

Advisors concur on the available opportunities associated with herbicide use. All respondents emphasize the potential of herbicides in fostering IPM and link their usage to increased biodiversity and enhanced soil health. A substantial 80% believe that implementing herbicide practices may lead to improved water quality and foresee it evolving into a significant scientific discipline in the future. Consensus remains high when examining the necessities of herbicide practices. All advisors assert that changes in regulations, a reduction in maintenance, and cost considerations are paramount. Additionally, categories related to increasing knowledge of ecosystem service impacts, addressing method inefficiency, and the shortage of advisors and practical knowledge skills are consistently highly ranked. On the subject of barriers to herbicide use, advisors unanimously identify the lack of training and funds as the most critical hurdles. Furthermore, four out of five respondents deem regulatory problems and time-consuming aspects as significant barriers. The primary disadvantage, as highlighted by advisors, centres around the perceived high cost of herbicides. Notably, 40% of advisors express concerns that the public opposes herbicide use, citing reasons such as a high carbon footprint, potential harm to the environment and humans, and inefficiency as noteworthy drawbacks.

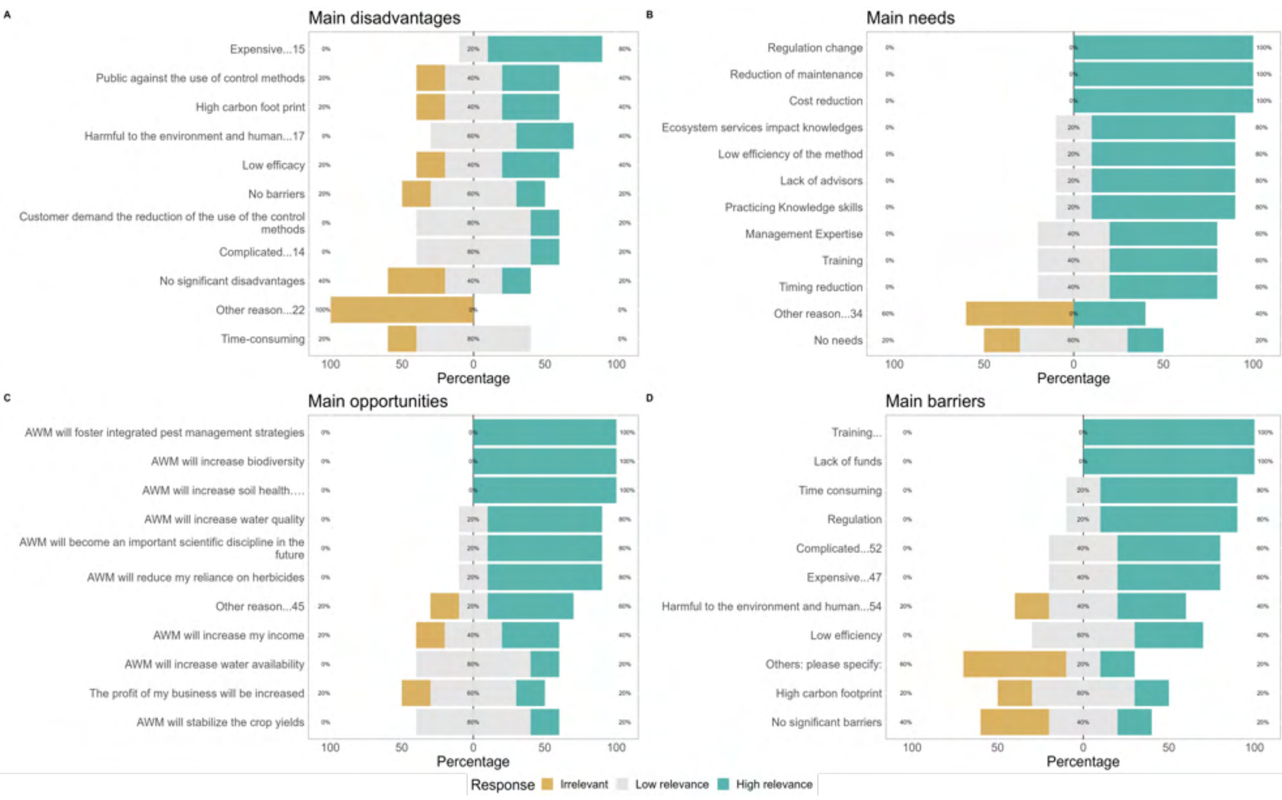


Figure 40 Main disadvantages, needs, barriers and opportunities for herbicides identified by advisors

2.1.1.1.1.1.2 Consumers

Consumers exhibit a high level of consensus when ranking various opportunities related to herbicide use. All respondents believe that this practice will promote IPM strategies and contribute to improved soil health. Additionally, a significant proportion, ranging from 75% to 50%, views herbicides as providers of ecosystem services, anticipating positive impacts on biodiversity, water quality, and availability. Furthermore, three out of four consumers express the belief that AWM will decrease herbicide reliance among producers. There is unanimous agreement among consumers regarding the primary needs associated with herbicide use, emphasizing regulatory changes and cost reduction. The importance of understanding the impact of ecosystem services and addressing the lack of advisors is also stressed. Seventy-five percent of consumers identify the main barriers to herbicide use as its complexity, time consumption, and regulatory concerns. Half of the respondents perceive inefficiency, lack of funds, and training, as well as high expenses as notable challenges. Consumers show consensus in stating that the public opposes herbicide use, and they unanimously agree that the primary disadvantage of herbicide use lies in its potential harm to the environment and human health. It is noteworthy that while these factors are viewed as main drawbacks, consumers consider them irrelevant as barriers. Additionally, more than 60% of consumers find herbicides to be expensive, believe that customers demand a reduction in their use, and acknowledge their high carbon footprint. Interestingly, these aspects are recognized as important drawbacks but are considered irrelevant as barriers by consumers.

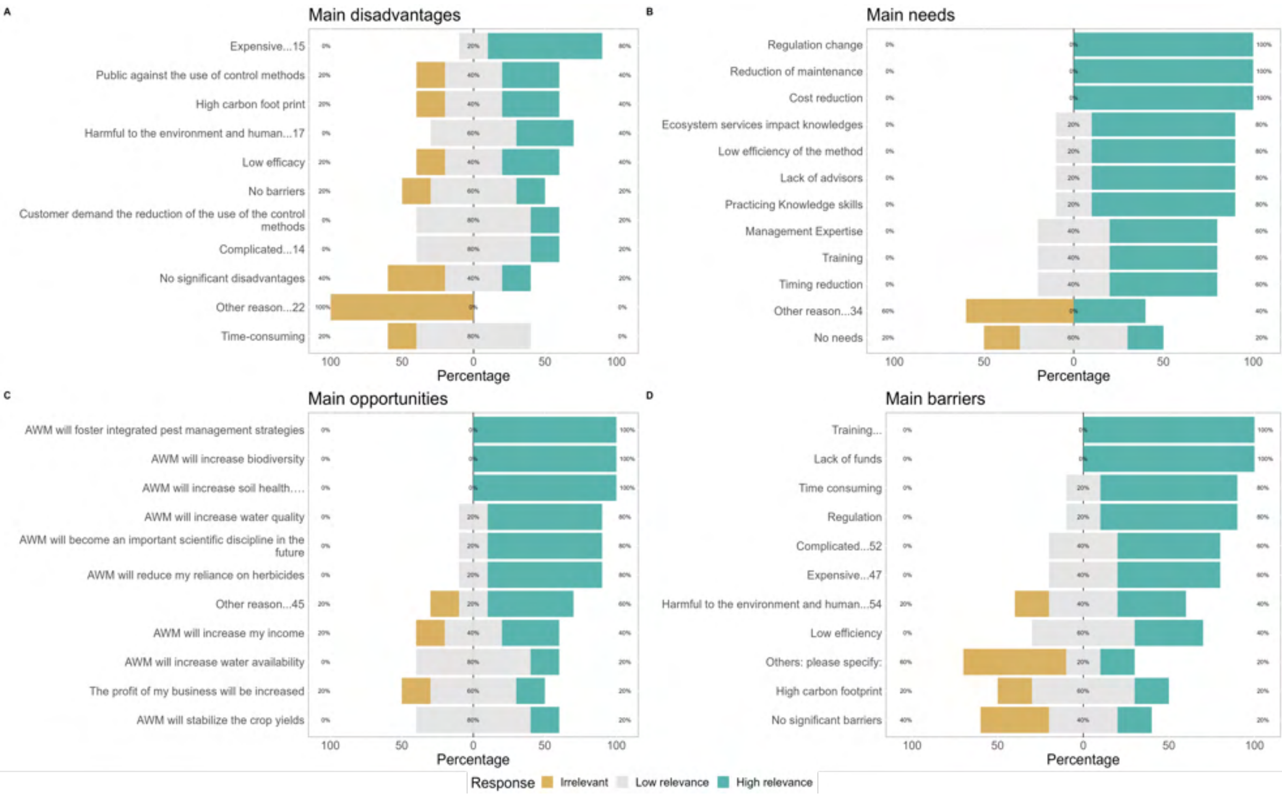


Figure 41 Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

2.1.1.1.1.1.3 Researcher

Researchers, aligning with advisors and consumers, perceive herbicides as contributors to ecosystem services. The majority of respondents believe that herbicide use will facilitate IPM and contribute to increased water quality, biodiversity, and improved soil health. Additionally, most researchers anticipate a reduction in herbicide reliance. Identified as essential needs for herbicide use, researchers unanimously emphasize the importance of practicing knowledge skills, management expertise, and training. Furthermore, 83% of respondents highlight the necessity for increased knowledge concerning the impact on ecosystem services and a reduction in costs. Consensus prevails among researchers regarding the main barriers to herbicide use, identifying training and complexity as the primary obstacles, with 83% noting its expensive nature. Moreover, more than 60% of respondents consider the carbon footprint and potential harm to the environment and human health as significant barriers. In terms of main disadvantages, all researchers state other reason as highly relevant, citing resistance, lack of new substances, low efficacy, and other factors. Additionally, 83% of respondents highlight the high carbon footprint, potential harm to the environment and human, and the high cost as significant disadvantages in herbicide use. A majority of researchers also emphasize that customer demands for reducing or eliminating herbicide use are key drawbacks to its implementation.

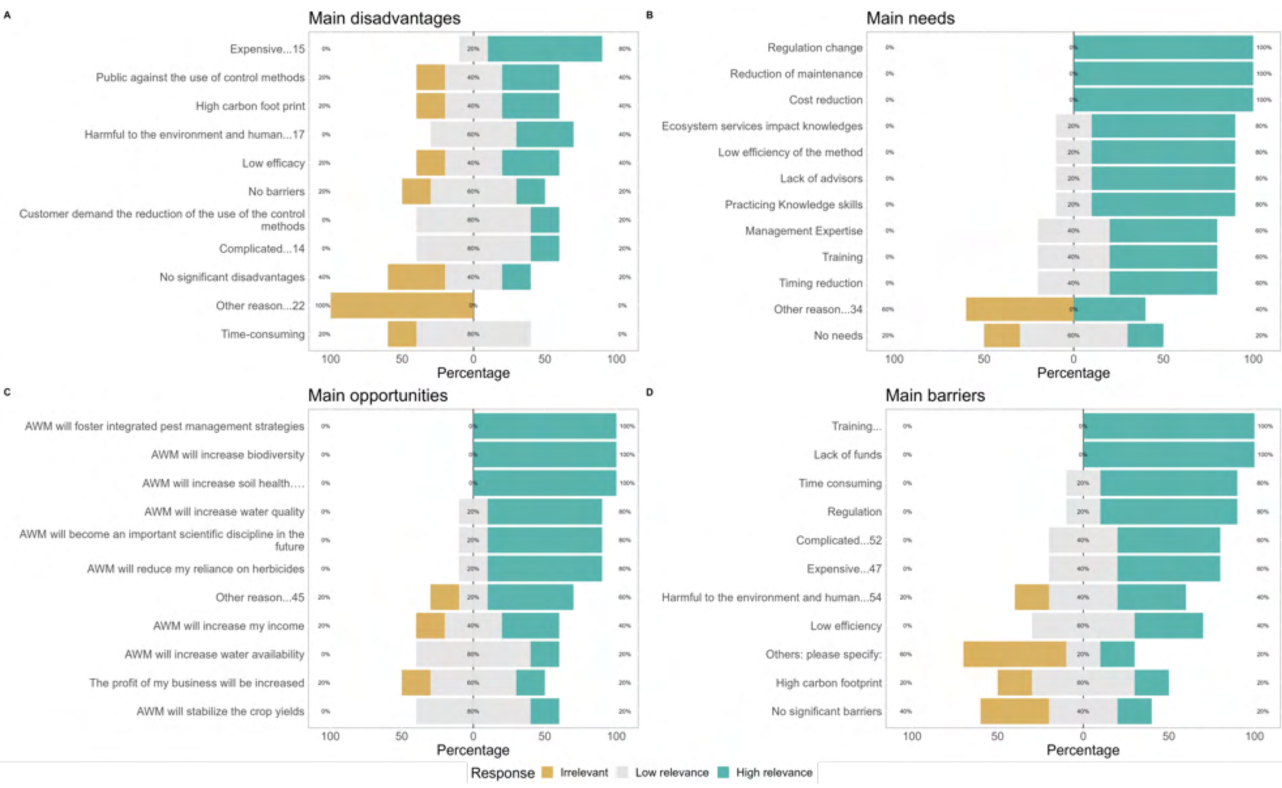


Figure 42 Main disadvantages, needs, barriers and opportunities for herbicides identified by researchers.

2.1.1.1.1.1.4 Conclusion

Advisors, consumers, and researchers exhibit a shared perspective on herbicide opportunities. They highlight the potential for IPM and the positive impact on biodiversity, water quality, and soil health. While all stakeholders emphasize regulatory changes and cost reduction as essential needs, advisors specifically note the importance of training and a reduction in maintenance. Despite high consensus on opportunities and needs, there are variations in the perceived barriers. Advisors unanimously see the lack of training and funds as critical hurdles, while consumers emphasize complexity, time consumption, and regulatory concerns. Researchers align with advisors and consumers but place a higher emphasis on the expensive nature of herbicides. Concerns about the potential harm to the environment and human health, high carbon footprint, and cost are unanimously recognized as significant drawbacks by all stakeholders. Notably, consumers acknowledge these as drawbacks but consider them irrelevant as barriers. The researchers additionally highlight resistance, lack of new substances, and low efficacy as important factors. Overall, stakeholders converge on the importance of addressing customer demands for reducing herbicide use.

2.1.1.1.1.2 *Mechanical weeding*

2.1.1.1.1.2.1 *Researcher*

Researchers unanimously view mechanical weeding as a potential enabler of IPM and a contributor to ecosystem services, positively impacting water quality, biodiversity, and soil health. There's unanimous agreement among researchers that mechanical weeding could lead to a reduction in herbicide reliance. Moreover, the majority sees it as an emerging research discipline, presenting opportunities for increased business profitability and income. Consensus persists among researchers when identifying the main needs in mechanical weeding. Regulatory changes and management expertise are universally cited, with additional emphasis on training, reduction of maintenance, and cost and timing reduction. Examining barriers to mechanical weeding, 67% of researchers perceive it as a complicated and expensive technique, expressing regulatory concerns as well. In terms of disadvantages, researchers find mechanical weeding to have few drawbacks, with 67% highlighting its expense and complexity. Other categories are considered either irrelevant or of low relevance by more than half of the respondents.

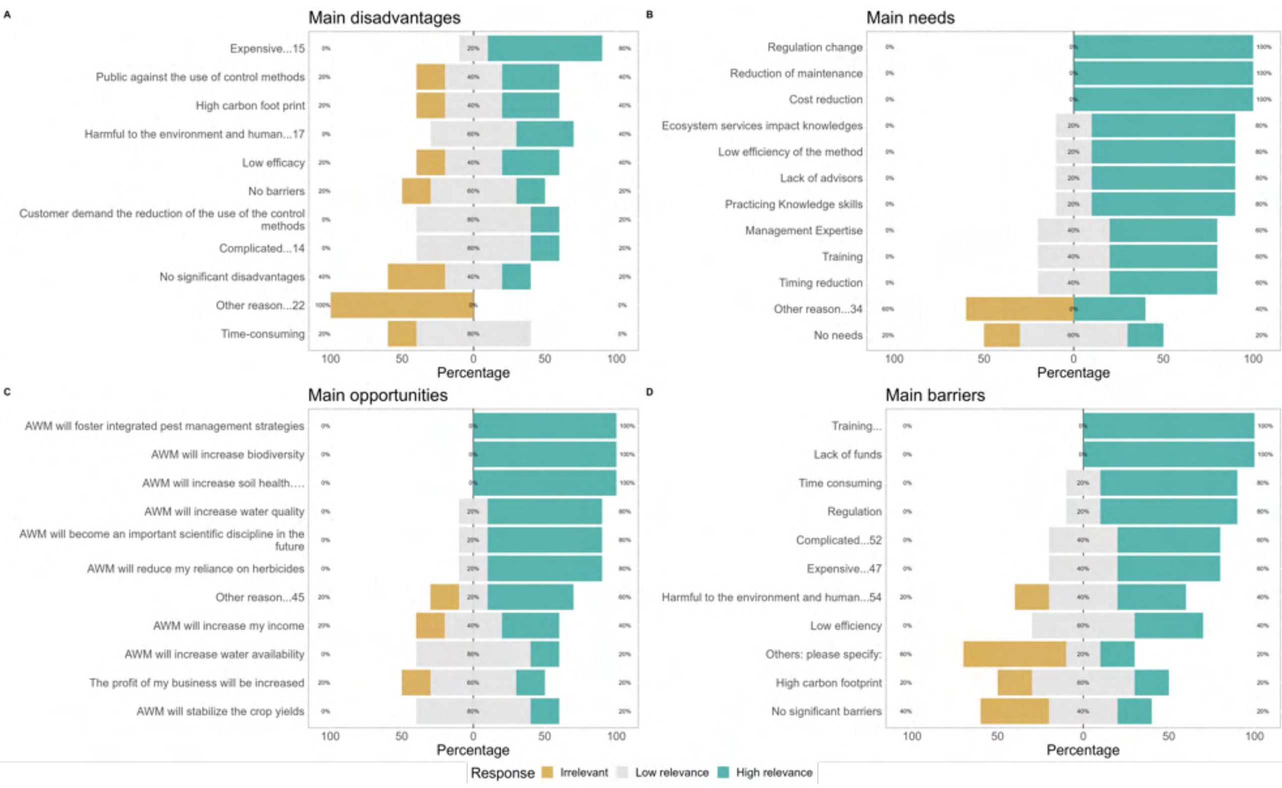


Figure 43 Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by researchers.

2.1.1.1.1.2.2 Conclusion

Researchers unanimously recognize the potential of mechanical weeding, viewing it as an avenue for fostering IPM and enhancing ecosystem services. They see it as a valuable research discipline and an opportunity for increased business profitability. Common needs identified by researchers include regulatory changes, management expertise, training, and cost reduction. While 67% find mechanical weeding complicated and expensive, they generally perceive it as a technique with few disadvantages, with other categories being considered irrelevant or of low relevance by more than half of the respondents.

2.1.1.1.2 Interviews

Some of the interviewees did not share their year of birth and gender, thus, the infographic with the description of the interviewees is not presented for the rice LL.

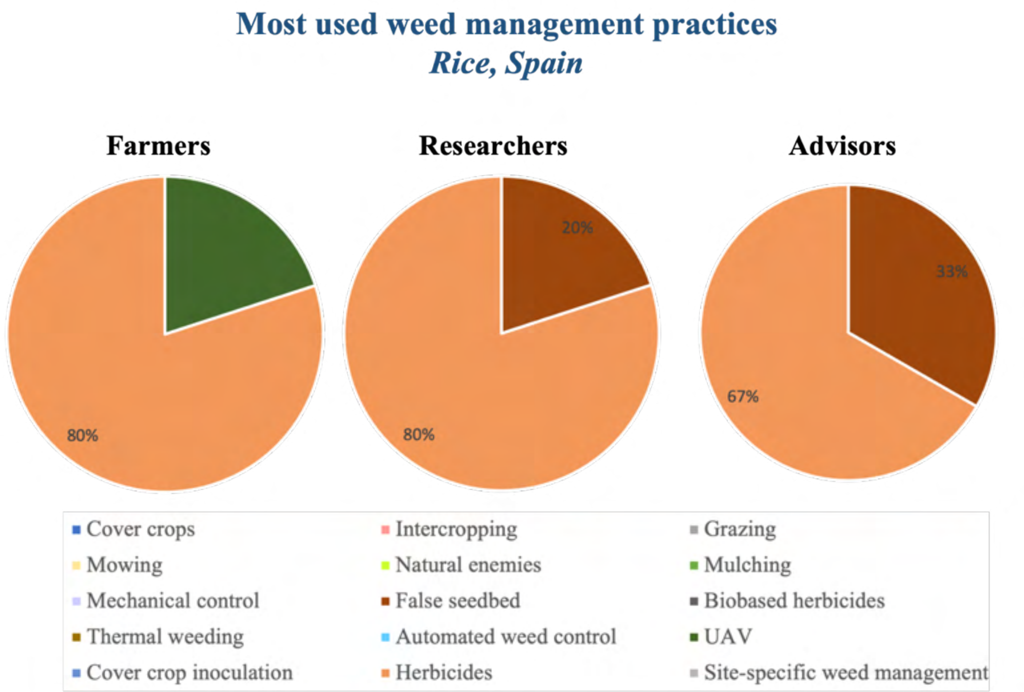


Figure 44. Most used weed management practices in the Rice Living Lab (Spain)

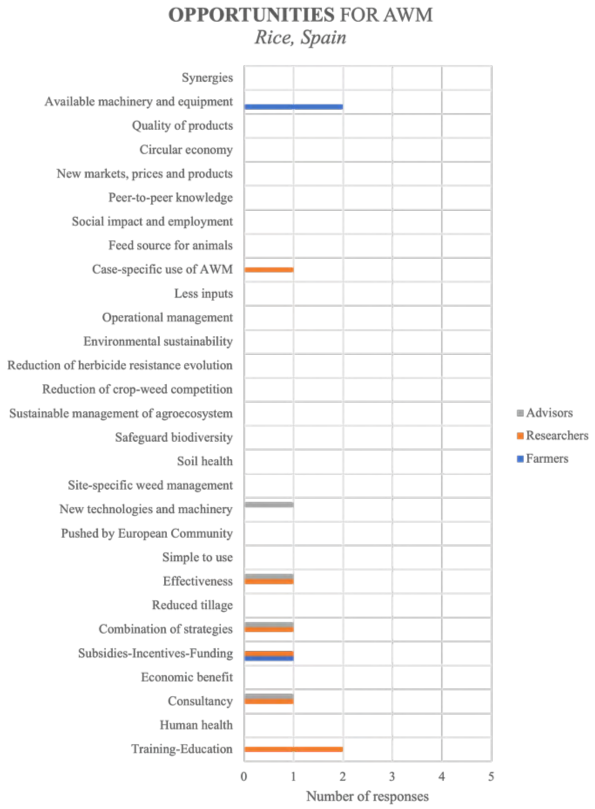
Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: Presented in the figure below.

THREATS: There were only two answers to this question: changes in weed flora and agricultural policy.

WEAKNESSES: This question was answered only by a few interviewees. In detail, two farmers and four advisors think that there are no viable alternatives to herbicides. In addition, some weaknesses are the effectiveness, cost of applications, replacement of herbicides, short-term effect, possible damage to main crop and cost of purchasing equipment.



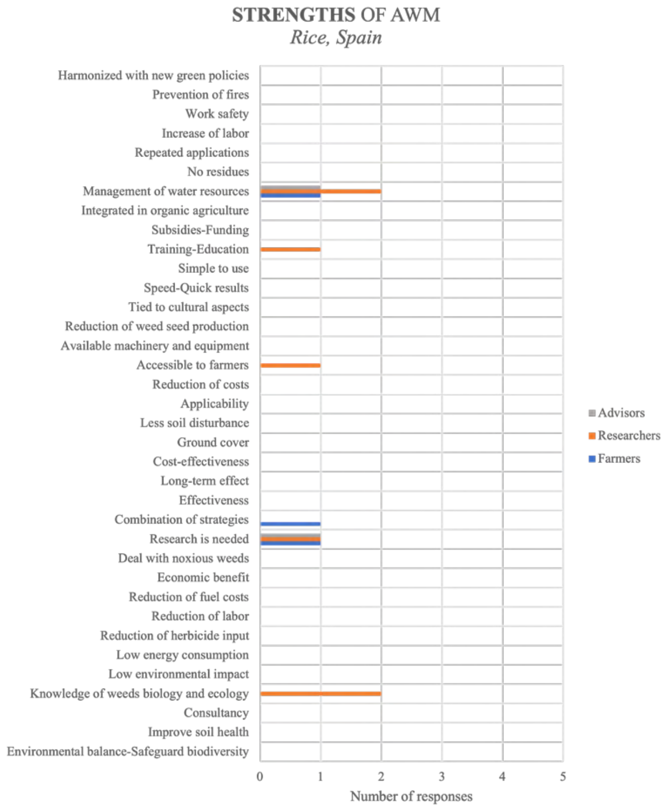


Figure 45. Opportunities and strengths of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: Only two were identified, the lack of recognition from the markets and the market itself.

WEAKNESSES: Presented in the figure below.

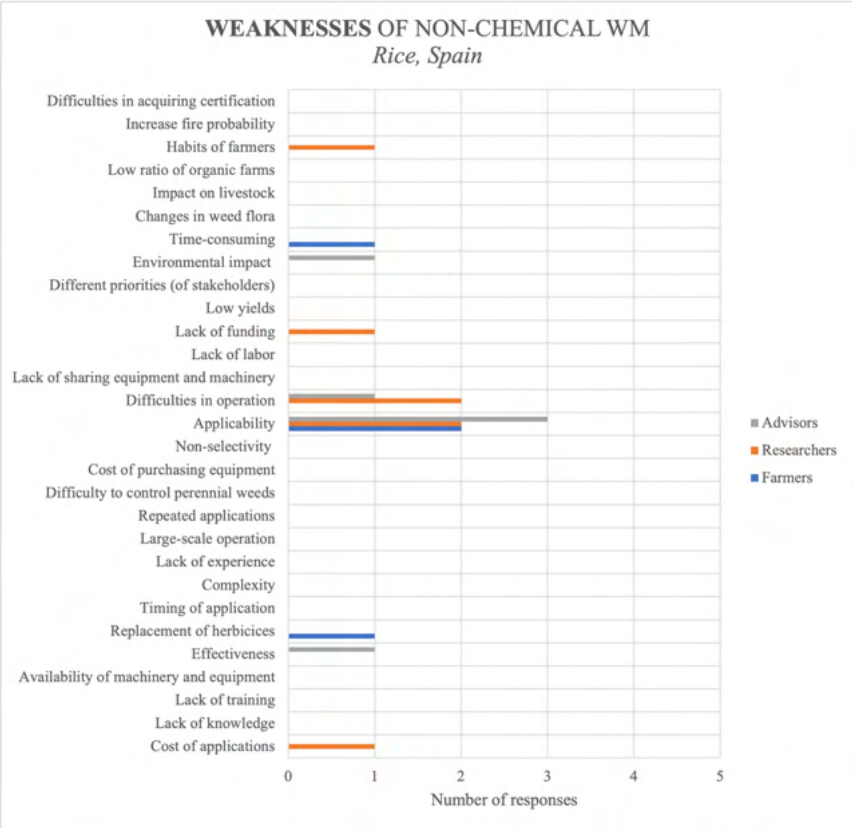


Figure 46: Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: Only two answers received, selectivity, and efficacy.

STRENGTHS: Two farmers think that the efficacy and the availability of herbicides on markets are strengths.

THREATS: Withdrawal of herbicides, lack of new herbicides and the market are considered threats for herbicides by a few respondents.

WEAKNESSES: Presented in the figure below.

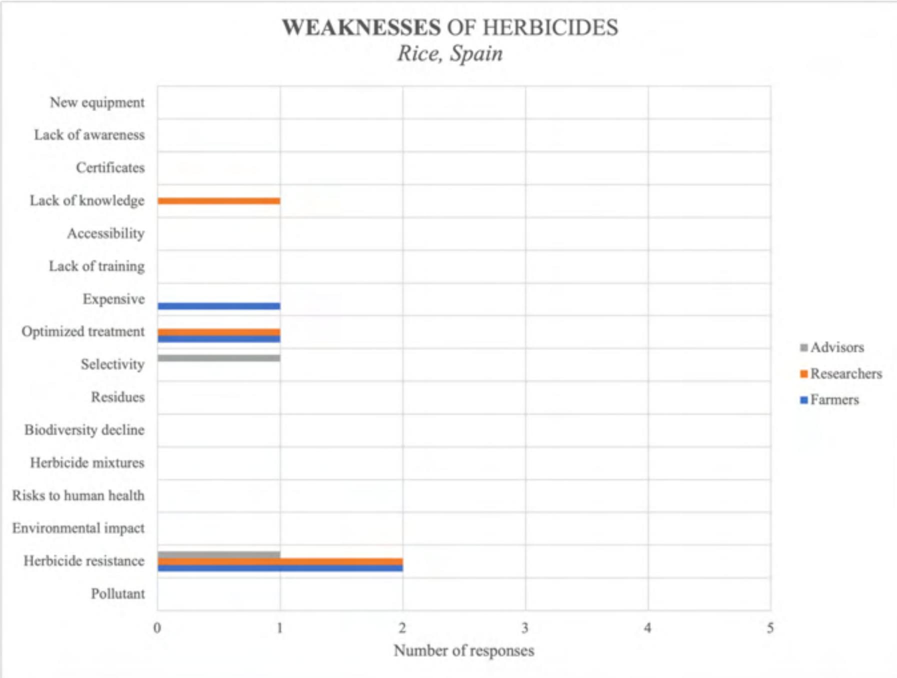


Figure 47: Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – RICE, SPAIN
Most used weed management practices: Rice cultivation in Spain (and broadly) is heavily dependent on herbicides due to the particular characteristics of this crop (i.e., farming system and techniques). All stakeholder groups agreed that the use of chemical herbicides in rice is really common in Badajoz area of Spain. False seedbed is a practice that has been reported by researchers and advisors to be followed in rice. A farmer mentioned the use of Unmanned Aerial Vehicles (UAV). **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: Since AWM practices are not widely spread in rice cultivation, there were only a few opportunities identified. Among them, effectiveness, subsidies and funding, available machinery and equipment and combination of strategies. The strengths are more and are related to the management of water resources, training and combination of strategies, but more research is needed and in-depth knowledge on weeds biology and ecology. The replacement of herbicides is considered a weakness for AWM practices as there are currently no effective and cheap alternatives to herbicides. **Threats, and weaknesses for non-chemical weed management**: Non-chemical weed management is accepted by rice stakeholders as an opportunity for the cultivation. Nevertheless, there are serious concerns about the applicability of several techniques and

strategies that exclude chemicals and may also lead to difficulties in operation. Moreover, any attempts to reduce the herbicide input and act upon agroecological principles may not be highly appreciated by the markets if the prices remain the same for both conventional and organic production, hence, farmers think that in that scenario there will not be economic benefit to convert to non-chemical weed management. The greatest problem in rice cultivation is still considered the lack of diversification, as rice is cultivated as monoculture. This fact has led to high weed infestations and increased use of herbicides. Although, direct dry sowing of rice is increasing, the impact on herbicide input still remains a debate between farmers.

Opportunities, strengths, weaknesses, and threats for herbicides: Rice stakeholders are quite positively opinionated to the use of herbicides because the particularities of rice crop constitute a challenge for any alternative scenarios. Therefore, the efficacy and availability of herbicides on markets are considered threats for herbicides. The lack of new herbicides and the withdrawal of existing active ingredients is a problem for rice producers and researchers, mainly due to rise of costs and the increase of herbicide resistance.

2.1.1.1.3 Living lab board meeting

Rice LL meeting was held in mixed form, some people (4) were in CASAT centre at Don Benito (Badajoz) including the GOOD partner who conducted the meeting, and others were present online in a zoom format meeting. The date to conformation of living lab was 11th January 2024 from 12:00h to 13.30h. It was attended by 12 people (3 researchers, 2 companies, 2 farmers, 2 policy maker, 3 advisors). One more policy maker, other farmer, a researcher and 1 company could not attend but are interested. Consent forms to participate in the LL board were sent to people present in online form. And the other consent forms were collected from all attendees. We keep the records for the incidences that could arise on the part of the European Commission, as a sample of the conformation of the LL and the constitution with these members present. The multi-stakeholder conformation of the driving group is to make the debate more diverse and to see if the methodologies are appropriate or not. A GOOD partner conducted the meeting and presented the project and the activities carried out so far. In CICYTEX (Finca la Orden, Badajoz) one plot is managed organically, and another plot is managed in a traditional-conventional way. In the two experimental plots, 4 types of cover crops have been sown and will remain throughout the project. Avena, Cebada, Medicago which is a leguminous plant and spontaneous weeds. The management will be applied at a certain time, the aim is to encourage the establishment of the cover crop to prosper. The last clearing applied to the cover crop is done before sowing rice. We will study the cover crop's ability to diminishing weeds incidence and compare it with the usual management methods used by farmers, which in the case of conventional crops were usually makes two or three applications of herbicide. Organic plots were conducted without herbicides, and strategies to control weeds were false seed beed, refreshing, mechanical control and manual as necessary. The following year, the best cover crop (inoculated and non inoculated) will also be planted. Microorganisms theoretically benefit the implantation and development of this cover crop. These are AMF that make the cover crop plant better to see if we see any difference in competition. Research team from Pisa University is in charge of identifying the micro-organisms in each site to multiply (en masse) and isolate the micro-organisms that most interest us in order to inoculate them. Afterwards, the attendees discussed and answered questions about the rice sector and weed management issues. The weed control techniques were discussed. It has been seen which things are feasible and which are not. The next steps in this direction are aimed at holding a specific meeting to work on this issue and to finalise which possible strategies would be interesting. There is a great interest in the project but due to the format of meeting the group is poorly dynamic. Most people present were camera off and silence, and only people present in the room of meeting were talking about the topic presenting at meeting. It has been decided that we will identify concrete issues to work on in order to better define weed management strategies for rice growing in Guadianas Valley. During the next year at least two discussion and co-creation workshops will be held on: (1) the different rice production models and possible rotation crops to move off the principal and persistent weeds in rice, (2) discussion on the results of ground covers and weeds incidence at beginning of rice cropping. In addition, a field visit will be made in summer to the experimental plots to see the development of rice. We intend to carry out many transfer actions and materials will be published, creating digital tools within this AWM network so that they are accessible to producers, technicians, to any entity, and over the next four years the LL will be attentive to decision making. That is why we have invited representatives of all profiles to participate. In addition, in order for it to make sense to include new (agroecological) techniques, there must be the normative and regulatory stakeholders, the companies, and the cooperatives. It is important to contact consumers or associations to be more complete the Living Lab and can be a good manner for the whole issue of dissemination. There are no organic farmers, will be interesting to integrate a little group of organic farmers into the LL board (from outside of Extremadura) to enhancing the real vision of them. During the LL board meeting, this information was also collected:

<table>
<tr><td rowspan="4">What are the market characteristics of rice?</td><td>1. How many farmers cultivate rice in the region (approx.)? Is it mostly monoculture or can rotations be made with other crops?</td></tr>
<tr><td>The number of growers is not known, the cultivated area was 8000 hectares more than last year when, due to irrigation restrictions, only 1000 hectares were cultivated. In years with abundant rainfall and stable water levels in the reservoirs, up to 28000 hectares are cultivated.</td></tr>
<tr><td>2. How many products are derived from the rice? Are they important for the economy and/or food security?</td></tr>
<tr><td>There are no products derived from rice cultivation. For some years, the extraction of levulinic acid from rice straw for pharmaceutical uses has been promoted. However, its realistic implementation has not been relevant. It has also been proposed for use in biomass plants, but all efforts have been in vain because it contains a high amount of silica and the slag produced after combustion is crystalline and large and cannot be used for soil application. What is usually done is to bury the straw, or to burn it (with environmental restrictions).</td></tr>
</table>

	3. Do you think that agroecological products could be promoted in local markets?
	No organic rice is present in the region. It is debated whether this is due to a lack of demand for these products domestically, or whether it is the lack of availability that prevents anyone from demanding the products. If weed problems were reduced or strategies for improved weed control could be devised, perhaps a farmer might consider it. There was an attempt at organic farming but the experience was disastrous. If it is normal for a producer to obtain 7,000 to 10,000 kilos of rice, 2000 kg were obtained.
	4. Do you believe that the region has a lack of technologies?
	It is not a problem of available technologies, drone detection models have been proposed, and we have increasingly suitable machinery for liquid application. Any substance could be applied, what is dramatic is that almost none is 100% efficient. There are problems for commercial herbicide companies, who cannot get their products out, as it takes 8 years from the start. These are bureaucratic problems that slow down the improvement of molecules, and opportunities for improvement are lost. The new molecules would be more beneficial to the environment, but they do not end up coming onto the market due to the inattention of the pharmaceutical companies.
	5. Is the regional agri-food value chain sustainable?
	Production costs are very high, the more weeds there are and when they are not controlled at the beginning. Farmers do not want to use chemicals to eliminate weeds, but they have no choice. The 80% of the production costs are due to the use of herbicides and pesticides.
What are the most common agricultural and weed management practices in rice?	1. What are the most common agronomic practices in rice?
	Dry sowing of rice is carried out with a cereal seed drill, and before sowing, pendimentalin is applied against *Echinochloas* and *Leptochloas*, which are the most important grass weeds in the region. After 25-30 days, another herbicide is added together with the fertiliser. A common rice fertilization scheme that is used by a large number of rice farmers involves 2 main fertilizer applications: The first application is made at about the same time with sowing (or about 20 days later) and the second

	application is made about 45-60 days after the first application. Many farmers apply 0.5 tonnes of N-P-K 30-10-10 per hectare on the day of sowing (or 20 days later). And already approximately 45-60 days after the first application, they apply 0.2-0.3 tonnes of N-P-K 40-0-0 or 33-0-0-0 per hectare.
	2. What are the most common weed management practices in rice?
	Herbicides to manage: *Echinochloa, Leptochloa, Cyperus, Heterantera, Ammania*
What is the herbicide use in rice?	1. How many active ingredients there are available? How many different mode of actions?
	Pendimentaline is applied before sowing, and then bentazone+MCPA and MCPA are applied, suffers some ups and downs depending on the presence of broadleaves. Benzobicyclon 40% is included in group F2, is an herbicide with a different mode of action, effective at least against *Leptochloa* spp., *Heteranthera* sp. and *Cyperus difformis* with limitations as all. Penoxsulam is commonly-used to control *Echinochloa* ssp. and with some effect on *Cyperaceae*, but it belongs to an herbicide group prone to develop resistant biotypes. Oxadiazon presowing followed by an application of profoxydim at 1-3 leaves stages of the rice and a third treatment until rice tillering of bentazone + MCPA or halosulfuronmetil and propanil + bispyribac-Na at 1-3 leaves stage of the rice, a second treatment until rice tillering of bentazone + MCPA controlling both *Echinochloa* spp. and C*yperaceous* weeds. There is a wide variety of herbicides in ROPO, but almost all with the same mode of action, with the limitations that this entails for weed control.
	2. How many times do you spray in-season?
	2 or 3 times
	3. Do you use pre-emergence, post-emergence or both herbicides?
	Both
	4. Are herbicides efficient?
	Not always as we have been commenting
	5. Do you think that alternatives to herbicides are equally efficient?
	No

	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?
	The products used at the appropriate doses do not have to cause any harm to the environment. Abuse, misuse or meaningless repetition of applications could have some persistence in the environment and in the soil. But they generally have a short retention time
	7. Do you believe that agriculture without herbicides is viable?
	No
What are the needs and barriers to assist agroecological transitions & adopt agroecological weed management approaches?	1. What is needed to boost the uptake of agroecological practices?
	At least, it would be necessary to test the alternative products, to verify their effectiveness before sowing the rice. Crop losses could be dramatic and this is not sustainable for the farmer. It is important not to criminalize farmers for doing their work. Management alternatives must be economically and socially sustainable. The current market prices for grain rice are very low. It would be necessary not to favor imports from third countries (ie., Camboia) where the product has a much lower quality than what Europe requires to comply with integrated and ecological production standards
	2. What are the barriers towards agroecology implementation?
	In rice, weeds are the common problem to this. There are autonomous communities such as Catalonia and Andalusia that, when availability of water and climatological conditions are good, organic rice is possible to perform on their farms because the soils are saline, which limits the growth of weeds.
	3. Should policies need be redefined to allow agroecological transitions?
	Obviously, transition is not possible for this crop if requirements continue to be placed in Europe, much more restrictive than in third countries, it does not benefit the industry to have more expensive national product when product that comes from outside Spain can be packaged in bulk at a margin higher cost.
	4. How confident you feel about the adoption of agroecological weed management practices?
	Those present explain that farmers are the first interested in not applying herbicides, mainly because of the high cost involved. The problem is that there is no alternative.

	Some rice producers are rotating with rapeseed and triticale in other cases in the same year, because they can get 2 crops, if they cannot plant the following year due to the lack of rain. Farmers have adapted and are always accepting the situations that come with resilience. They adapted to dry sowing to control weeds and save water. But it is important to make visible that they are the ones who have the problems, and that in rotations there are places (ZEPA zone) where the crop cannot be alternated with any other. We must investigate those soils that do not have rotation alternatives. In these sites, burning is one of the options that has been studied to reduce the incidence of *Echinochloa*.
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	1. What are the main drivers of weed dispersal?
	Water, machinery, …
	2. Which are the major and most noxious weeds in your area?
	Echinochloa
	3. Are there any herbicide resistant weeds?
	Yes, ACCase and ALS resistant were monitoring since 2015.
	4. Do you know any invasive plants in your area?
	No, or at least not worrying.
What do you think about the Living Lab?	1. Which proposals do you have for a good performance of the LL?
	The next meetings be held in person so that the debate is more nutritious. That the format is not mixed (some online and others in person). If it is online, everyone present can activate the camera to promote knowledge and better interaction among the members of the living lab.
	2. Would you like it to remain over time?
	Yes

2.1.1.2 *Triticale (Italy)*

2.1.1.2.1 Questionnaires

Triticale questionnaires shed light on nine AWM techniques, among which grazing, mechanical weeding, and mowing garnered responses from all stakeholder groups, yet industry and policymakers did not provide enough responses to be considered. A detailed breakdown of stakeholder participation in the questionnaires for distinct AWM practices is provided in Table 23.

Table 23 Number of responses for each AWM practice and stakeholder category in triticale

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control						
Biobased herbicides				1		
Cover crop inoculation to increase competitiveness	1				1	
Cover crops	3	1			1	4
False seedbed	4		1			1
Grazing	7	7	6	2	2	4
Herbicides	6	3	7	2		3
Intercropping	3	2	2	1		1
Mechanical weeding	6	4	6	1	1	4
Mowing	6	7	7	4	1	4
Mulching	6	3	1		1	2
Natural enemies						
Other	1				1	
Site-specific spraying	5		3	1	1	
Thermal weeding						
UAV						
N=41	**8**	**10**	**9**	**4**	**3**	**7**

2.1.1.2.1.1 Cover crops

2.1.1.2.1.1.1 Advisors

Advisors are aligned in recognizing the main opportunities associated with cover crops, unanimously considering this AWM technique as a provider of ecosystem services, contributing to improved water quality, biodiversity, and enhanced soil health. They also share consensus on the potential benefits of cover cropping for increasing farmers' income and reducing herbicide reliance. Additionally, a substantial proportion of respondents believe that cover cropping contributes to the stabilization of crop yields. Advisors unanimously agree on the primary needs for implementing cover crops, with a focus on the reduction of maintenance as a paramount factor. Other key necessities highlighted by advisors include knowledge in ecosystem services impact, addressing the lack of advisors, and considerations for cost and timing reduction. Advisors perceive cover crop implementation in triticale culture as having few or low-relevant barriers. Only one-third of the respondents considered given barriers as highly relevant, including a high carbon footprint, time-consuming nature, training requirements, absence of significant barriers, and other factors. Notably, advisors express that cover cropping has no significant disadvantages, with only 67% considering a high carbon footprint and time-consuming aspects as drawbacks. The remaining queried categories were deemed as irrelevant by more than half of respondents.

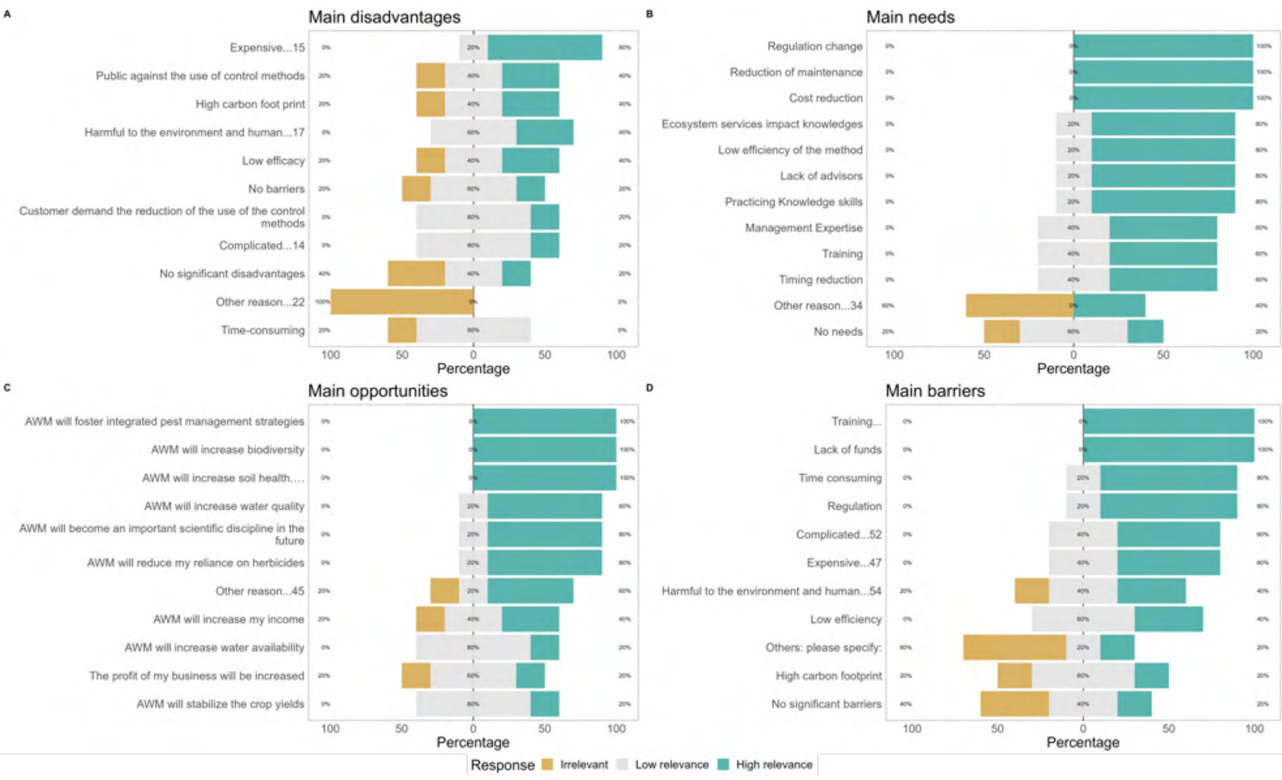


Figure 48 Main disadvantages, needs, barriers and opportunities for cover crop identified by advisors.

2.1.1.2.1.1.2 Researchers

More than half of the researchers highly value all the identified opportunities associated with cover crops, with three-fourths envisioning cover crops as an AWM strategy fostering IPM and serving as a provider of ecosystem services. Researchers foresee positive impacts on water quality, biodiversity, and soil health, indicating that cover crops will likely emerge as a significant scientific discipline in the future. Additionally, more than half of the queried categories were considered as relevant needs by researchers, emphasizing the importance of knowledge about the impact of ecosystem services, addressing the lack of advisors, practicing knowledge skills, management expertise, and training—all identified by 75% of respondents as key requirements. Cover crop barriers, according to researchers, encompass its perceived complexity, time consumption, lack of training and funding, and the associated implementation costs, as indicated by 75% of researchers. Importantly, researchers assert that cover crops do not present any significant disadvantages, with only 25% considering price and time consumption as highly relevant concerns.

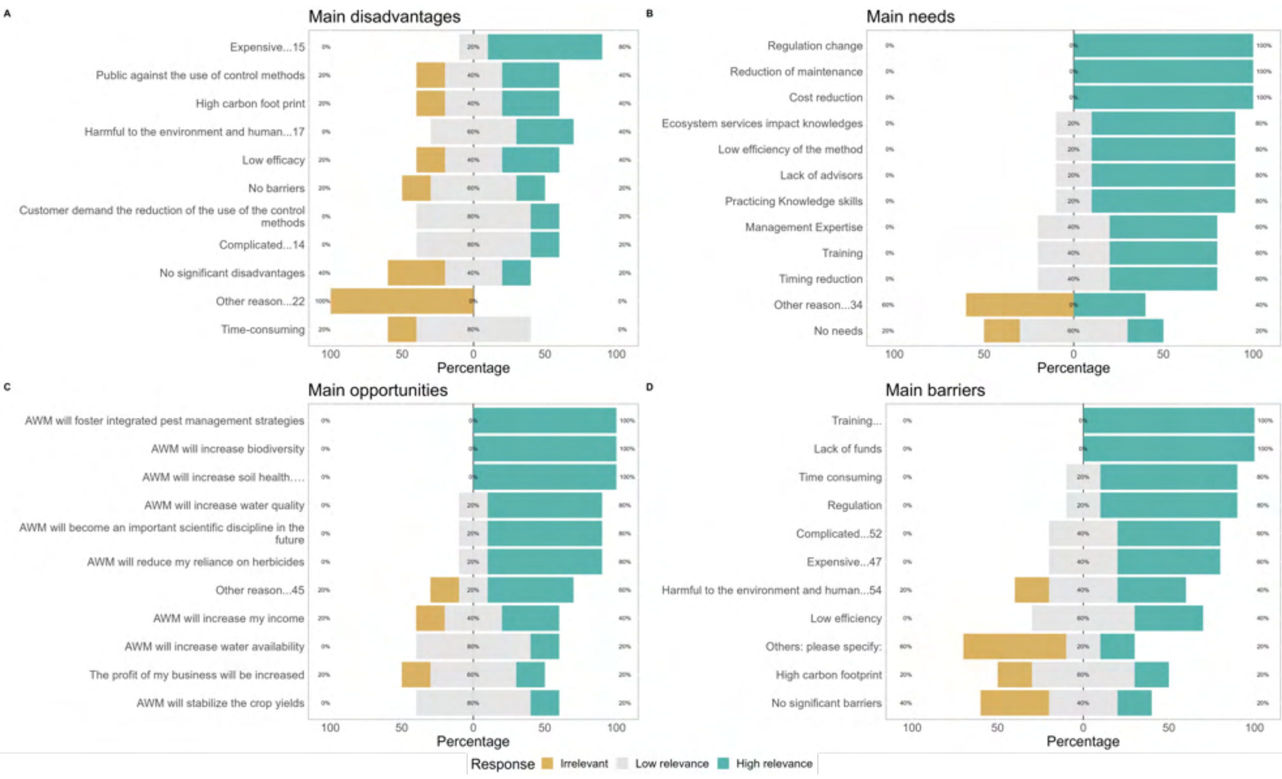


Figure 49 Main disadvantages, needs, barriers and opportunities for cover crop identified by researchers.

2.1.1.2.1.1.3 Conclusion

Advisors and researchers share consensus on the significant opportunities presented by cover crops in agriculture. Both groups unanimously recognize cover crops as valuable contributors to ecosystem services, including improvements in water quality, increased biodiversity, and enhanced soil health. There is alignment in perceiving cover crops as fostering IPM and becoming a crucial scientific discipline in the future. There are subtle differences in the perceived needs for cover crop implementation. While both advisors and researchers prioritize the reduction of maintenance, advisors emphasize knowledge in ecosystem services impact, addressing the lack of advisors, and considerations for cost and timing reduction. Researchers, on the other hand, place greater importance on a broader set of needs, including knowledge about ecosystem service impacts, practicing knowledge skills, management expertise, and training. When it comes to barriers, both advisors and researchers agree on the complexities and time-consuming nature of cover crop implementation. Additionally, advisors and researchers tend to emphasize the lack of training and funding, as well as the associated costs as key barriers. Interestingly, while both groups perceive cover crops as having no significant disadvantages, advisors show concern about a high carbon footprint and time-consuming aspects, whereas researchers consider price and time consumption as less relevant concerns. In summary, while there is alignment on the overarching benefits of cover crops, subtle differences emerge in the specific priorities and concerns between advisors and researchers.

2.1.1.2.1.2 *False seedbed*

2.1.1.2.1.2.1 *Advisors*

Advisors perceive the false seed bed technique as presenting numerous opportunities, with unanimous agreement that its implementation will reduce reliance on herbicides. A significant proportion of advisors views false seed bed as a facilitator of IPM and a contributor to ecosystem services, particularly in terms of increasing water availability and quality, as well as stabilizing crop yields. Additionally, more than half of the respondents believe that the technique offers highly relevant opportunities as enhancing biodiversity, improving soil health, and increasing profitability. In terms of needs, advisors unanimously identify practicing knowledge skills as the most crucial requirement for successful false seed bed implementation. Furthermore, 75% of advisors consider management expertise, training, and reduction of maintenance as key necessities. Notably, most queried barriers are deemed irrelevant or of low relevance for false seed bed, with only 75% expressing concerns about the technique being time-consuming, and 50% indicating that training and price are significant barriers. In terms of disadvantages, time consumption emerges as the primary concern for all advisors, while 75% of them also highlight the price of false seed bed as a notable drawback.

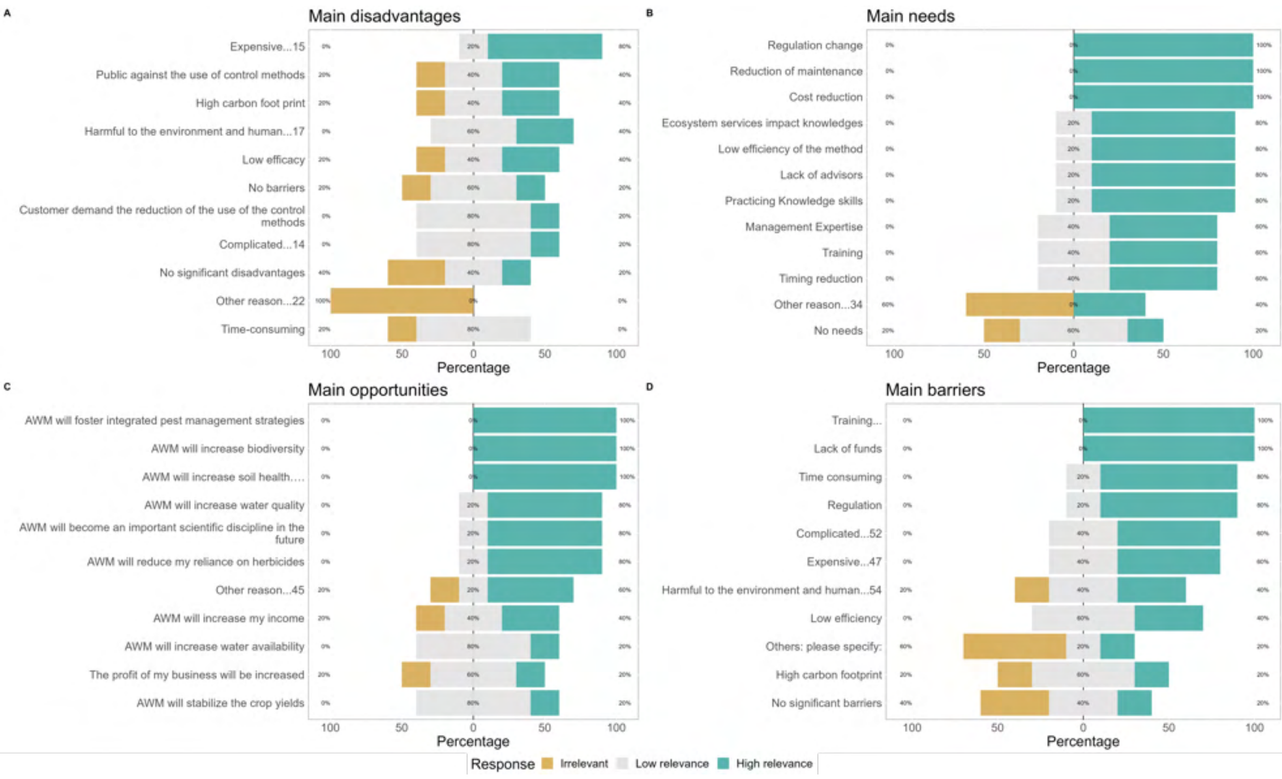


Figure 50 Main disadvantages, needs, barriers and opportunities for false seedbed by advisors.

2.1.1.2.1.2.2 Conclusion

Advisors see the false seed bed technique as offering numerous opportunities, emphasizing its potential to reduce herbicide reliance, foster IPM, and contribute to ecosystem services. The technique is perceived as beneficial for water availability, crop yield stabilization, biodiversity, soil health, and profitability. Advisors unanimously prioritize practicing knowledge skills as the most crucial need, with 75% emphasizing management expertise, training, and maintenance reduction. Barriers are largely considered irrelevant, except for concerns about time consumption (75%) and, to a lesser extent, training and price (50%). The primary disadvantage is seen as time consumption, with 75% also noting expense as a notable drawback.

2.1.1.2.1.3 *Grazing*

2.1.1.2.1.3.1 *Advisors*

Advisors perceive grazing as a technique with several opportunities, with over 70% believing it enhances soil health and reduces herbicide reliance. While 43% consider grazing a fosterer of IPM and acknowledge its potential in providing ecosystem services such as improved water quality, biodiversity, and increased farmers' income. Advisors, in general, view grazing as having no significant needs, with the highest ranked categories being low efficiency, deemed as high relevance by 57%, and considerations related to ecosystem service impact knowledge, practicing knowledge skills, management expertise, and maintenance reduction considered by 43%. Similarly, advisors find the listed barriers and disadvantages to grazing mostly irrelevant or of low relevance.

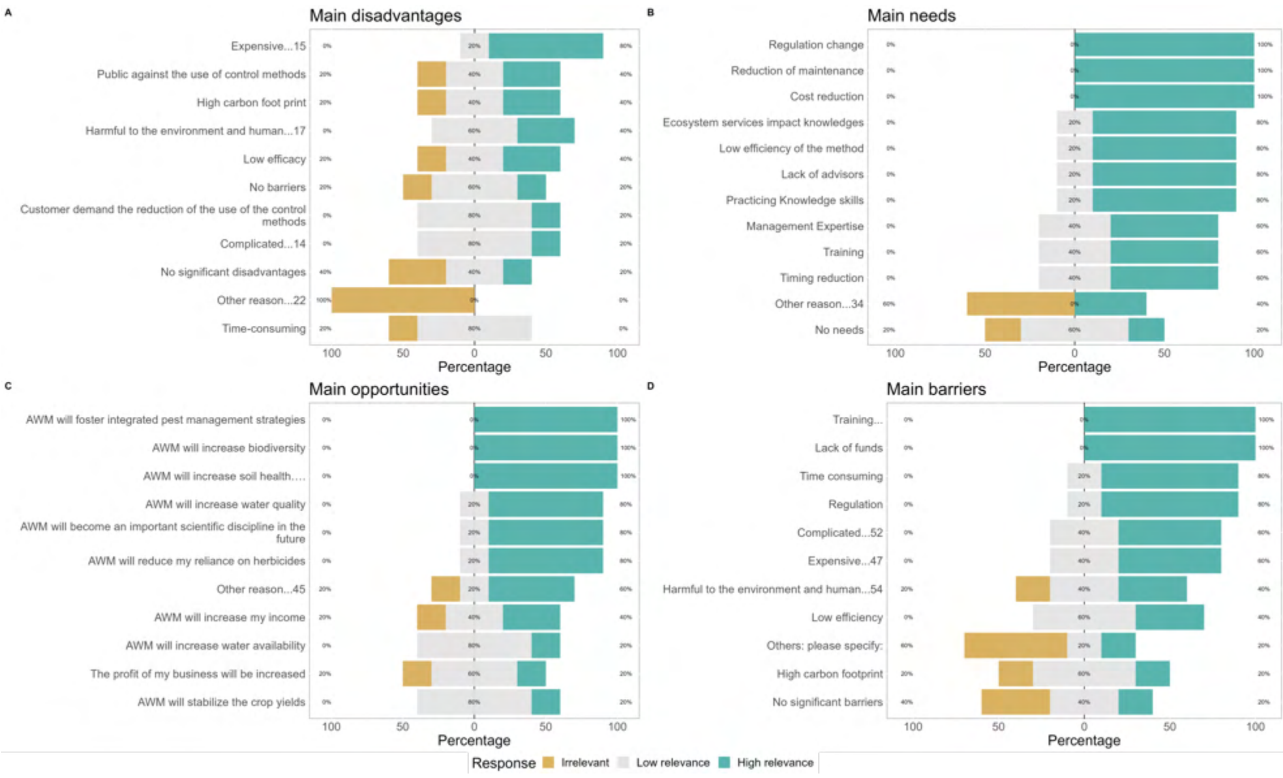


Figure 51 Main disadvantages, needs, barriers and opportunities for grazing by advisors.

2.1.1.2.1.3.2 Consumers

Consumers align with advisors in recognizing grazing as a technique with numerous opportunities, emphasizing its potential for fostering IPM and serving as a provider of ecosystem services, contributing to improved water quality, availability, biodiversity, and soil health. Additionally, consumers believe grazing may evolve into an important scientific discipline, playing a role in reducing herbicide reliance and stabilizing crop yields. Notably, consumers identify key needs in grazing, with 57% emphasizing the importance of addressing the lack of advisors, practicing knowledge skills, management expertise, and training. Other queried categories were generally considered irrelevant or of low relevance by a majority of consumers. Training emerged as the primary barrier to grazing, noted by 86% of respondents, while the lack of funds and time consumption were also deemed important barriers. Interestingly, none of the proposed disadvantages gained majority support, with "time-consuming" being the highest ranked, supported by only 43% of the consumer sample.

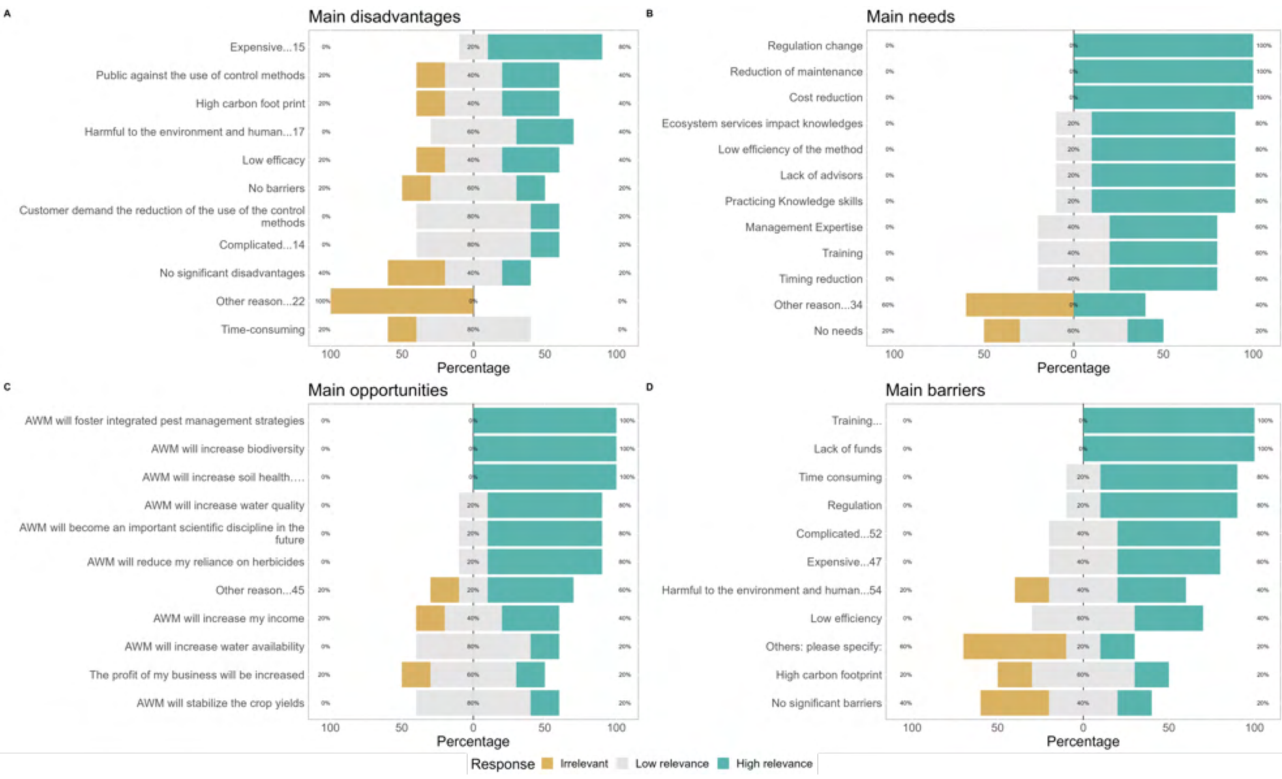


Figure 52 Main disadvantages, needs, barriers and opportunities for grazing by consumers.

2.1.1.2.1.3.3 Farmers

Farmers, akin to the views expressed by advisors and consumers, perceive grazing as a comprehensive provider of ecosystem services with substantial potential to evolve into an important scientific discipline in the future. It is also seen as a means to increase income and reduce reliance on herbicides. The farmers' perspectives on grazing needs exhibit an even distribution among the three categories of relevance: irrelevant, low, and high relevance. Fifty percent of farmers consider factors such as low efficiency, lack of advisors, management expertise, reduction of maintenance, and costs as highly relevant necessities in implementing grazing. While there is partial alignment with the categories highlighted by advisors and consumers, there are also divergences in farmers' opinions on grazing barriers. Unlike needs, there is no prominent category that a significant proportion deems as important: fifty percent find its complexity and lack of funds highly relevant, while the other half considers these categories as irrelevant. Most farmers assert that grazing does not present any significant disadvantages. Furthermore, farmers concur with the views expressed by advisors and consumers regarding grazing disadvantages, with 50% of farmers and 29% of advisors and consumers stating that customers demand a reduction in its use.

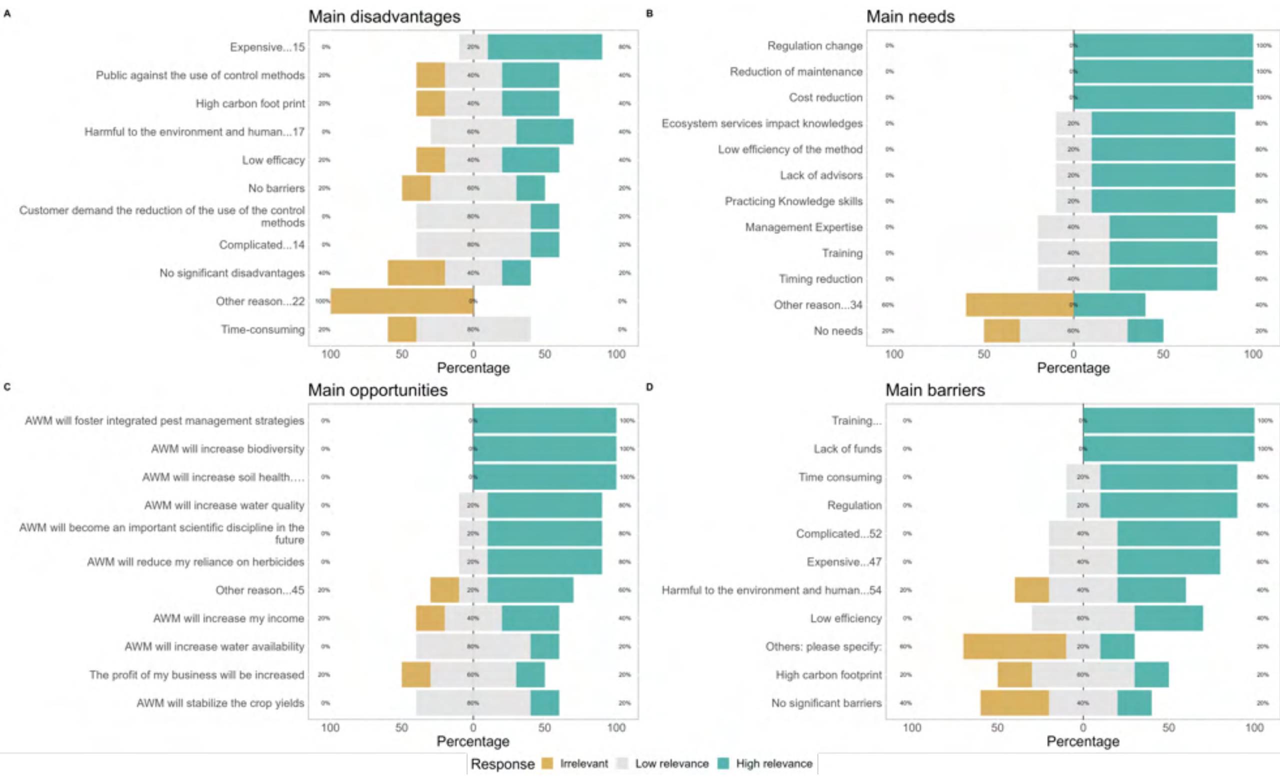


Figure 53 Main disadvantages, needs, barriers and opportunities for grazing by farmers

2.1.1.2.1.3.4 Researchers

Researchers align with other stakeholder groups in perceiving grazing as a technique brimming with opportunities, emphasizing its potential in fostering IPM, improving water quality and soil health, and becoming a significant scientific discipline in the future. Regarding main needs, all researchers highlight the importance of management expertise, and 75% express that having more advisors and enhancing practicing knowledge skills will be crucial for successful grazing implementation. There is consensus among researchers regarding the main barriers, with all of them considering training as their primary concern. Additionally, 50% of respondents point to the lack of funds as an important barrier. Researchers' opinions about the main disadvantages differ from those expressed by other stakeholders, as only 25% of them deem the time-consuming factor of grazing as a relevant drawback. Notably, only 25% of researchers consider customer demand for the reduction of grazing as of low relevance, in contrast to the views expressed by other stakeholders.

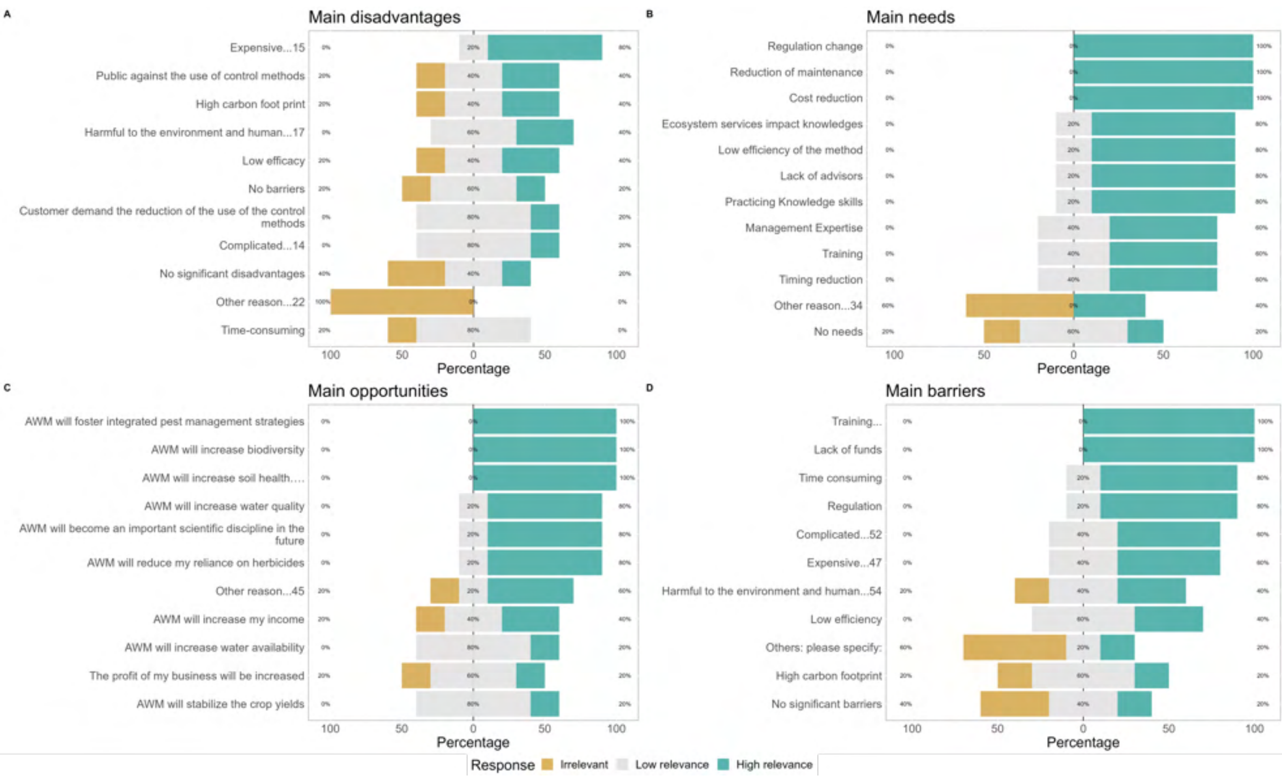


Figure 54 Main disadvantages, needs, barriers and opportunities for grazing by researchers.

2.1.1.2.1.3.5 Conclusion

In summary, stakeholders' perceptions of grazing as an agricultural technique reveal a spectrum of viewpoints. Advisors emphasize benefits to soil health and reduced herbicide reliance. Consumers align closely with this positive outlook, recognizing opportunities in IPM and ecosystem services. However, consumers emphasize key needs, such as addressing the lack of advisors and training, with training identified as a primary barrier. Intriguingly, proposed disadvantages gain limited support among consumers. Farmers share the positive sentiment regarding grazing's potential for ecosystem services and income increase. Their views on needs, barriers, and disadvantages are varied, with an even distribution of relevance. Farmers align with advisors and consumers in recognizing customer demands for a reduction in grazing. Researchers, like other stakeholders, perceive grazing as rich in opportunities, particularly in fostering IPM and enhancing water quality and soil health. Their emphasis on management expertise and the need for more advisors indicates key considerations for successful implementation. Notably, researchers diverge in their opinions on barriers and disadvantages, suggesting nuanced perspectives within the research community. In essence, while stakeholders generally acknowledge the potential benefits of grazing, there are nuanced differences in priorities and concerns across advisors, consumers, farmers, and researchers.

2.1.1.2.1.4 Herbicides

2.1.1.2.1.4.1 Advisors

Advisors regard herbicide use in AWM as presenting abundant opportunities. A significant 83% believe its adoption will lead to a reduction in herbicide reliance, while 67% envision it promoting IPM strategies. Half of the respondents identify herbicides as providers of ecosystem services, contributing to enhanced water quality, biodiversity, and soil health. Advisors assert herbicides as a key scientific discipline in the near future and stress the potential for increased business profitability with their use. Main needs, as identified by advisors, include changes in regulation (100%), training, and cost reduction (83%), along with practicing knowledge skills and management expertise (67%). Advisors perceive herbicide use as highly effective. However, advisors acknowledge certain barriers to implementation. Training is highlighted as the primary obstacle, with 67% considering it of high relevance. Other notable barriers include concerns about potential harm to the environment and human health, regulatory issues, and price concerns. Importantly, the distribution of relevance is even among these three categories. Advisors also point out that the main disadvantage of herbicide use is its perceived harm to humans and the environment, accounting for 67% of respondents. The second most significant category is the high cost of herbicides, deemed highly relevant by 50% of advisors. Interestingly, only 17% of advisors consider public concerns about herbicide use as highly relevant.

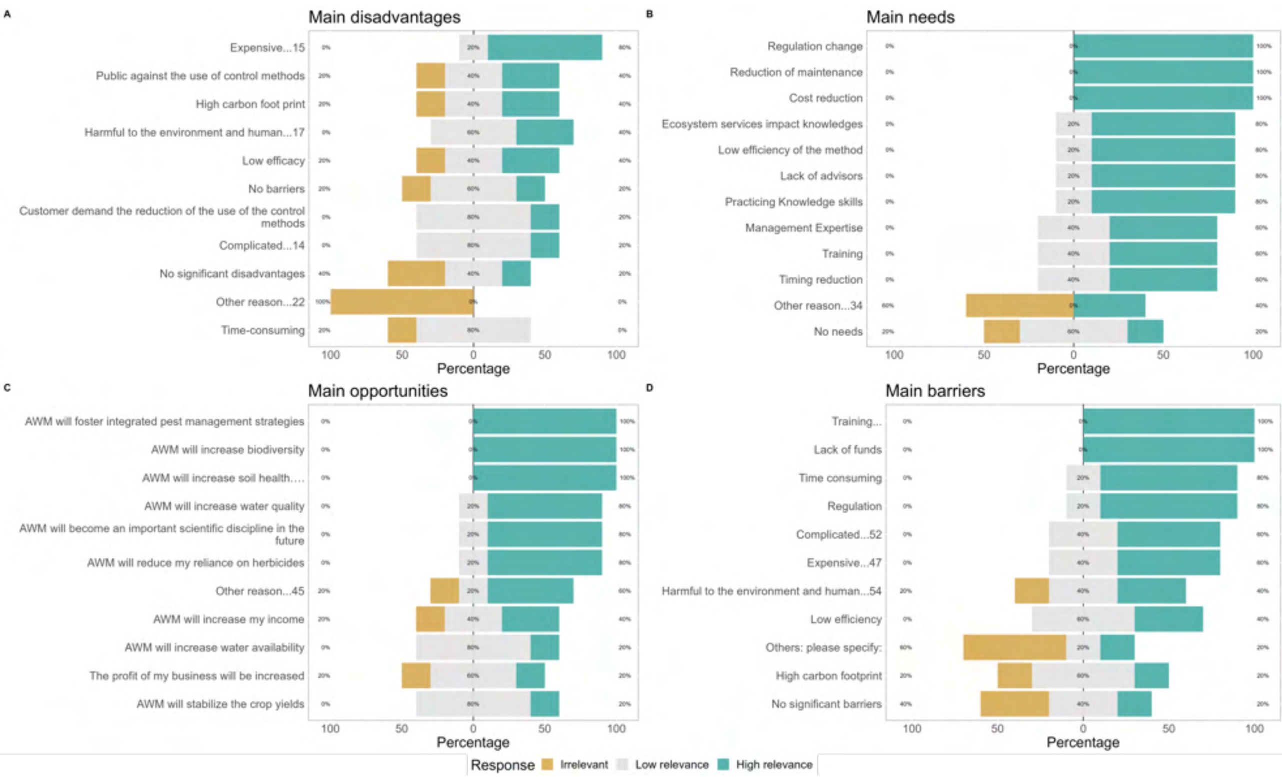


Figure 55 Main disadvantages, needs, barriers and opportunities for herbicides identified by advisors.

2.1.1.2.1.4.2 Consumers

Advisors and consumers share a positive outlook on herbicide use in the context of AWM, perceiving it as a practice filled with opportunities. Consumers unanimously believe in its potential to stabilize crop yield. Consumers express optimism about herbicides fostering the implementation of IPM strategies and providing ecosystem services, contributing to increased water availability, improved water quality, biodiversity, and soil health. The same unanimous proportion sees herbicides as a potential scientific discipline in the future, anticipating a reduction in farmers' reliance on herbicides. Consumer consensus is strong regarding the needs for herbicides, with all respondents deeming ecosystem services impact knowledge, regulation change, practicing knowledge skills, and management expertise as highly relevant. Additionally, 67% of consumers and advisors alike emphasize the importance of training and the lack of advisors as crucial needs. Additionally, 67% of consumers and advisors alike emphasize the importance of training and the lack of advisors as crucial needs. Consumers align when identifying the main barrier to herbicide use as training, with 67% stating that time consumption, regulation, and price are highly significant obstacles. Notably, the categories of high carbon footprint and potential harm to the environment and humans, deemed low or not relevant barriers by the majority of consumers, are unanimously considered the main disadvantages. Furthermore, 67% of consumers express the view that customer demands for reduction or opposition to herbicide use are highly relevant.

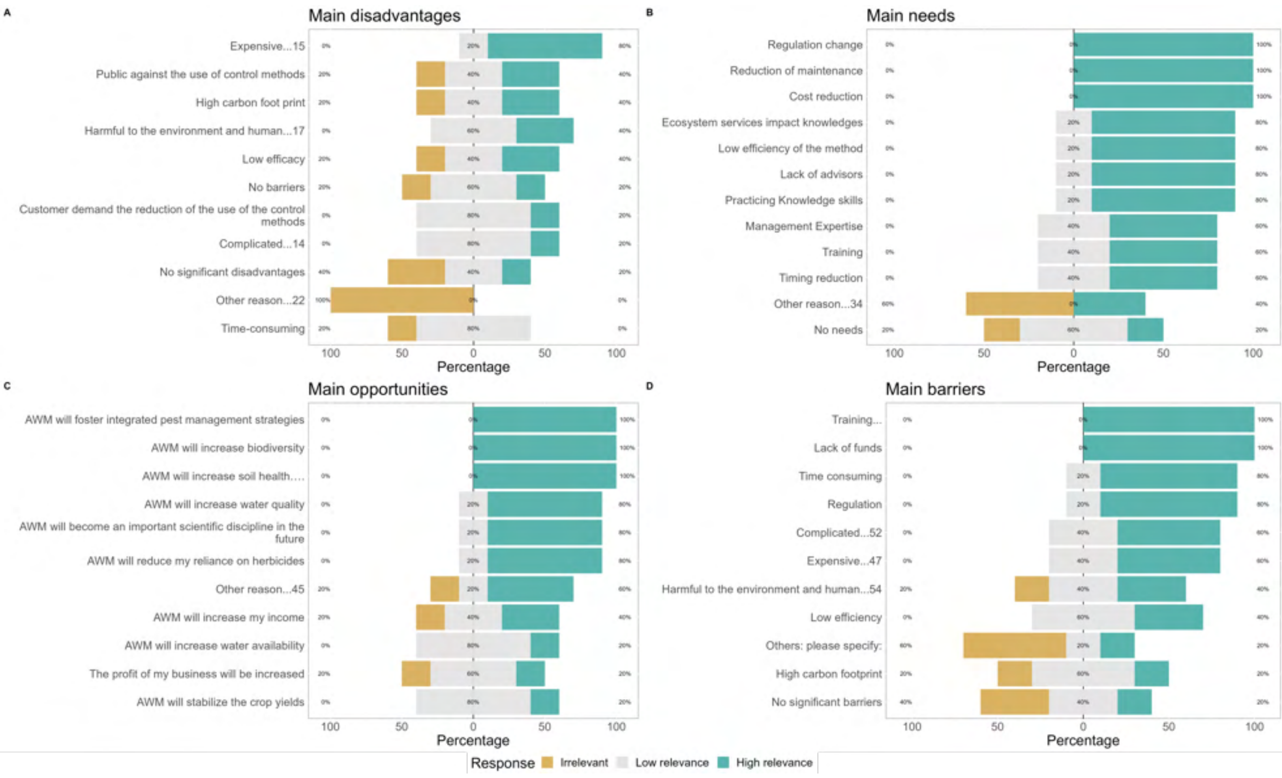


Figure 56 Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

2.1.1.2.1.4.3 Farmers

Farmers, aligning with advisors and consumers, perceive herbicides as a practice offering numerous opportunities, with over 70% recognizing positive impacts on water quality, biodiversity, and soil health. A substantial 57% view herbicides as contributors to IPM and water availability, while also anticipating a reduction in herbicide reliance. Farmers envision herbicides evolving into an important scientific discipline. The primary needs identified by farmers revolve around cost and timing reduction, with 57% emphasizing the importance of regulatory changes and practicing knowledge skills. When it comes to limitations in herbicide use, farmers express concerns across various categories. An overwhelming 86% highlight the potential harm to the environment and humans as the most relevant factor. Additionally, more than half of the respondents identify high carbon footprint, difficulty in use, lack of training and funds as key barriers. About 43% of farmers consider herbicide use to be time-consuming, face regulatory issues, and are expensive. Farmers uniformly agree on the disadvantages of herbicides, with all respondents acknowledging public opposition to herbicide use. Furthermore, 86% express concerns about the perceived harm to the environment and humans, and farmers believe that customers demand a reduction in herbicide use. The high carbon footprint is another significant disadvantage, as highlighted by 57% of farmers.

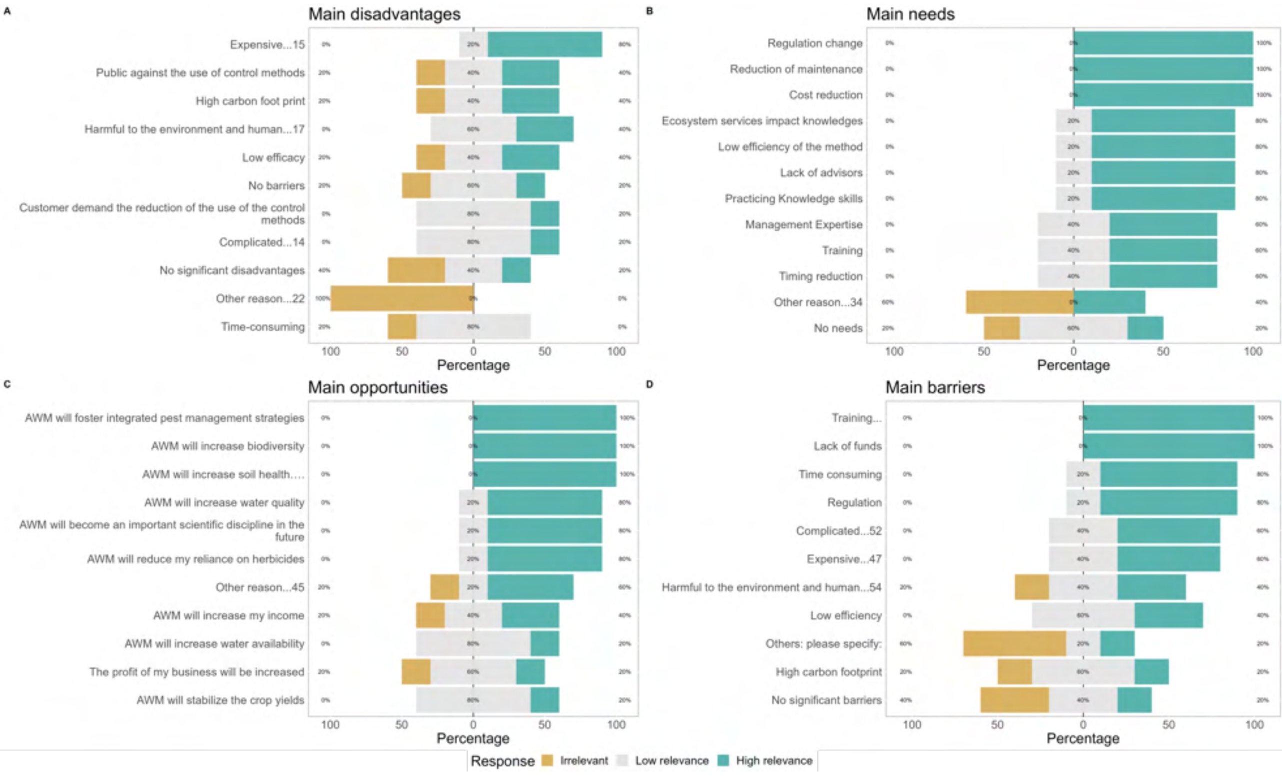


Figure 57 Main disadvantages, needs, barriers and opportunities for herbicides identified by farmers.

2.1.1.2.1.4.4 Researchers

Researchers, aligning with other stakeholders, perceive herbicides as a technique filled with opportunities. A unanimous agreement exists among researchers that herbicide use will effectively reduce farmers' reliance on herbicides. A significant proportion of researchers express the belief that herbicides play a pivotal role in fostering IPM and ecosystem services, contributing to improvements in water quality, biodiversity, and soil health. Additionally, researchers anticipate herbicides becoming a significant scientific discipline. Consensus prevails among researchers regarding the primary needs for herbicide use, with a focus on practicing knowledge skills and management expertise. Eighty percent of respondents emphasize the importance of addressing the lack of training and cost reduction as crucial requirements. Other factors, including regulatory changes, the lack of advisors, and maintenance reduction, are deemed relevant needs by 60% of respondents. When researchers were asked about impediments to herbicide use, unanimous agreement is observed, with all considering deficiencies in training, regulatory challenges, and pricing as highly relevant barriers. Following closely, complexity and time consumption factors associated with herbicide use are noted by 80% of respondents. Sixty percent of researchers cite the lack of funds as a significant hurdle, aligning with concerns about pricing expressed by the entire sample. The primary disadvantage associated with herbicide use, as highlighted by all researchers, is its potential harm to the environment and human health. Additionally, 80% of researchers consider customer demands for the reduction of herbicide use and pricing as highly relevant. Moreover, 60% of respondents find that the public is against its use.

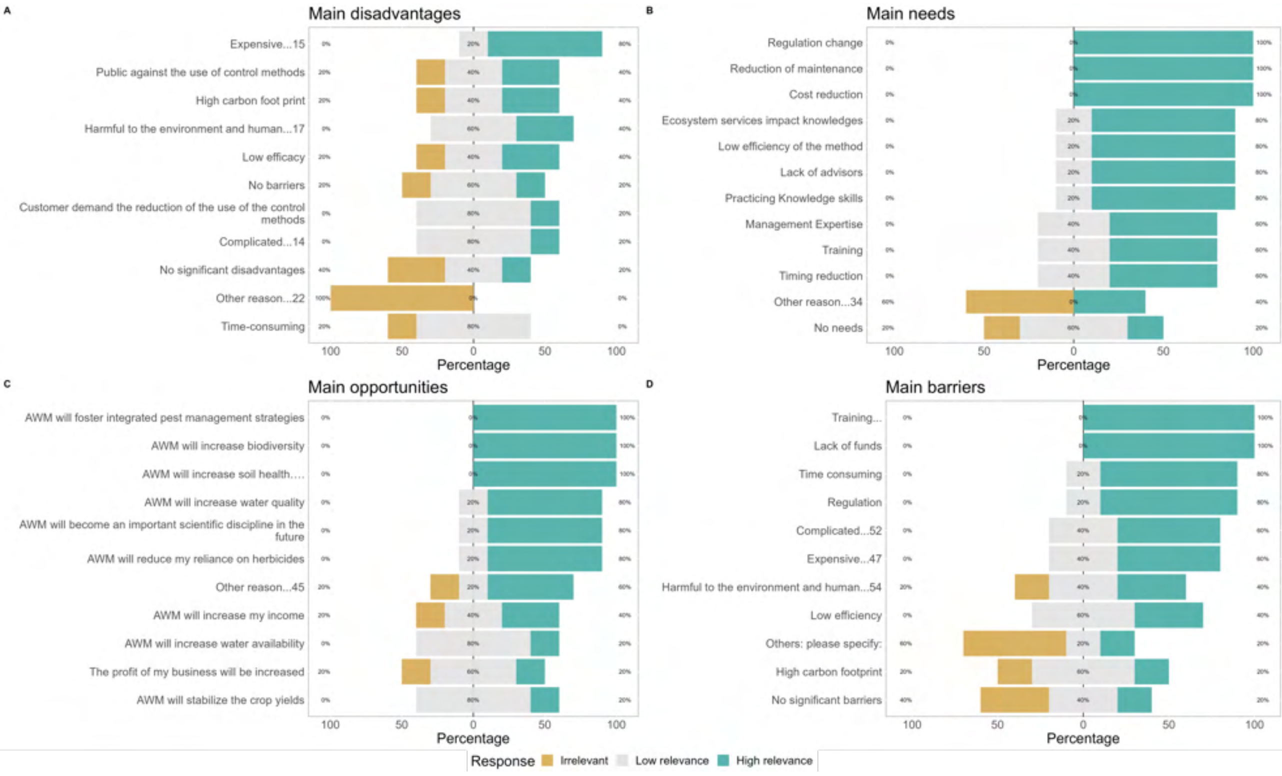


Figure 58 Main disadvantages, needs, barriers and opportunities for herbicides identified by researchers.

2.1.1.2.1.4.5 Conclusions

Stakeholders across diverse groups share an optimistic perspective on herbicide use in AWM. All stakeholder groups agree on the potential of herbicides to promote IPM strategies and provide ecosystem services, contributing to enhanced water quality, biodiversity, and soil health. Moreover, advisors and researchers believe herbicide adoption will reduce herbicide reliance, and consumers unanimously believe in its potential to stabilize crop yields.

The identified needs underscore the importance of education, training, regulatory changes, and cost considerations for the effective and responsible use of herbicides in AWM practices. Stakeholders recognize the significance of acquiring and applying knowledge and expertise for the successful implementation of herbicide use. Concerns revolve around the potential harm to the environment and humans, with time consumption, regulatory issues, and expense also noted.

Training emerges as a significant barrier to the effective implementation of herbicide use in AWM. It is essential to note that the concerns regarding potential harm, regulatory challenges, and pricing were not explicitly listed as barriers to herbicide use. Nonetheless, they are critical considerations that stakeholders emphasize as disadvantages associated with herbicide application. Public perception and the demand for reduction are also highlighted, emphasizing the importance of addressing societal concerns and ensuring transparency in herbicide practices. Cost-related concerns, such as the high carbon footprint and pricing, emerge as significant disadvantages across stakeholder groups. This shared recognition underscores the importance of balancing the benefits of herbicide use with addressing environmental, health, and economic considerations for a sustainable and responsible AWM approach.

2.1.1.2.1.5 Intercropping

2.1.1.2.1.5.1 Advisors

Advisors consider intercropping as an interesting technique, with all respondents linking its use to increased water quality, soil health, farmers' income, and a reduction in herbicide reliance. Most advisors, precisely 67%, view intercropping as a promoter of IPM practices, enhancing biodiversity, business profitability, and stabilizing crop yields. Advisors also show high consensus on intercropping needs, unanimously agreeing on the importance of ecosystem services impact knowledge, reduction of maintenance, and cost and timing reduction in implementing intercropping as AWM Additionally, almost 70% of respondents emphasize the significance of regulatory changes, the lack of advisors, practicing knowledge skills, management expertise, and training as crucial necessities. Training is categorized as the most important barrier by 67% of advisors, followed by high carbon footprint, time consumption, lack of funds, regulation, and expense, which are labeled as highly relevant by 33% of respondents. Leading disadvantages regarding intercropping include customer demand for the reduction of its use, noted by 67% of respondents, and public opposition to its use, along with its high carbon footprint, accounting for 33% of respondents. It is noteworthy that the distribution of rankings in these two categories is evenly spread among the three relevance levels.

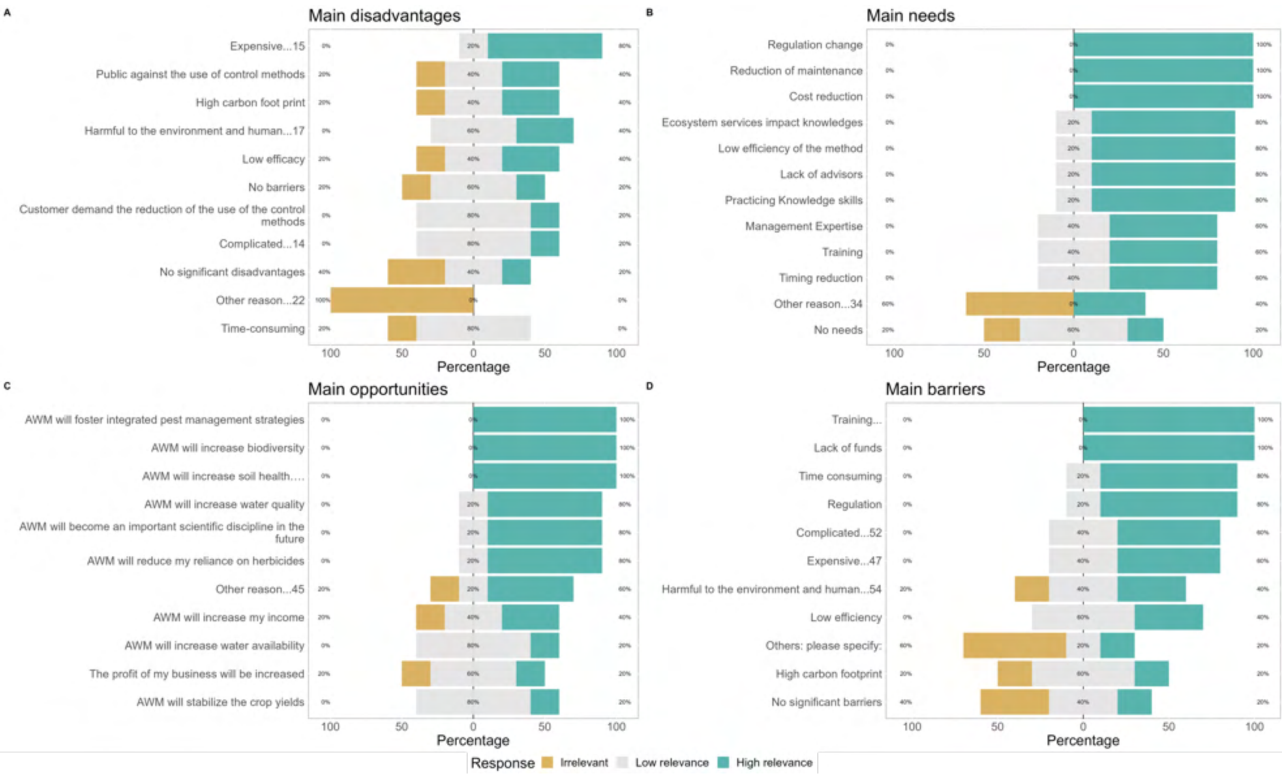


Figure 59 Main disadvantages, needs, barriers and opportunities for intercrop identified by advisors.

2.1.1.2.1.5.2 Conclusions

Advisors view intercropping as a promising and beneficial technique within AWM. They associate it with positive outcomes such as improved water quality, enhanced soil health, increased farmers' income, and reduced reliance on herbicides. A majority of advisors, 67%, also see intercropping as a facilitator of IPM, biodiversity enhancement, and stabilization of crop yields. Primary challenges include the need for increased knowledge about the impact of intercropping on ecosystem services, the reduction of maintenance efforts, and cost and timing reduction during implementation. Additionally, regulatory changes, the lack of advisors, practicing knowledge skills, management expertise, and training were considered key necessities. Advisors highlighted training as the most critical barrier, followed by concerns about the high carbon footprint, time consumption, lack of funds, regulatory issues, and overall expenses. Despite recognizing challenges, advisors express high consensus on the potential of intercropping, considering it a valuable strategy with diverse benefits for sustainable agriculture.

2.1.1.2.1.6 *Mechanical weeding*

2.1.1.2.1.6.1 *Advisors*

Advisors perceive numerous opportunities associated with mechanical weeding, such as reducing herbicide reliance (83%), potential advancement as a scientific discipline, crop yield stabilization, and income increase, all deemed highly relevant by 67% of respondents. Additionally, half of the advisors see mechanical weeding as fostering IPM strategies and providing ecosystem services. Despite these opportunities, advisors recognize several needs, with cost reduction being the most pressing demand, emphasized by 83% of respondents. Management expertise and timing reduction are also considered highly relevant needs by 67% of advisors, while practicing knowledge skills, training, and maintenance reduction are regarded as important needs by 50%. The primary barrier identified by advisors is the time-consuming nature of mechanical weeding, aligning with the expressed need for timing reduction. The second most significant challenge is the lack of funds and overall expenses, both considered highly relevant by 50% of respondents. Advisors acknowledge limitations to mechanical weeding, citing expense, complexity in implementation, and time consumption as the main disadvantages of this practice.

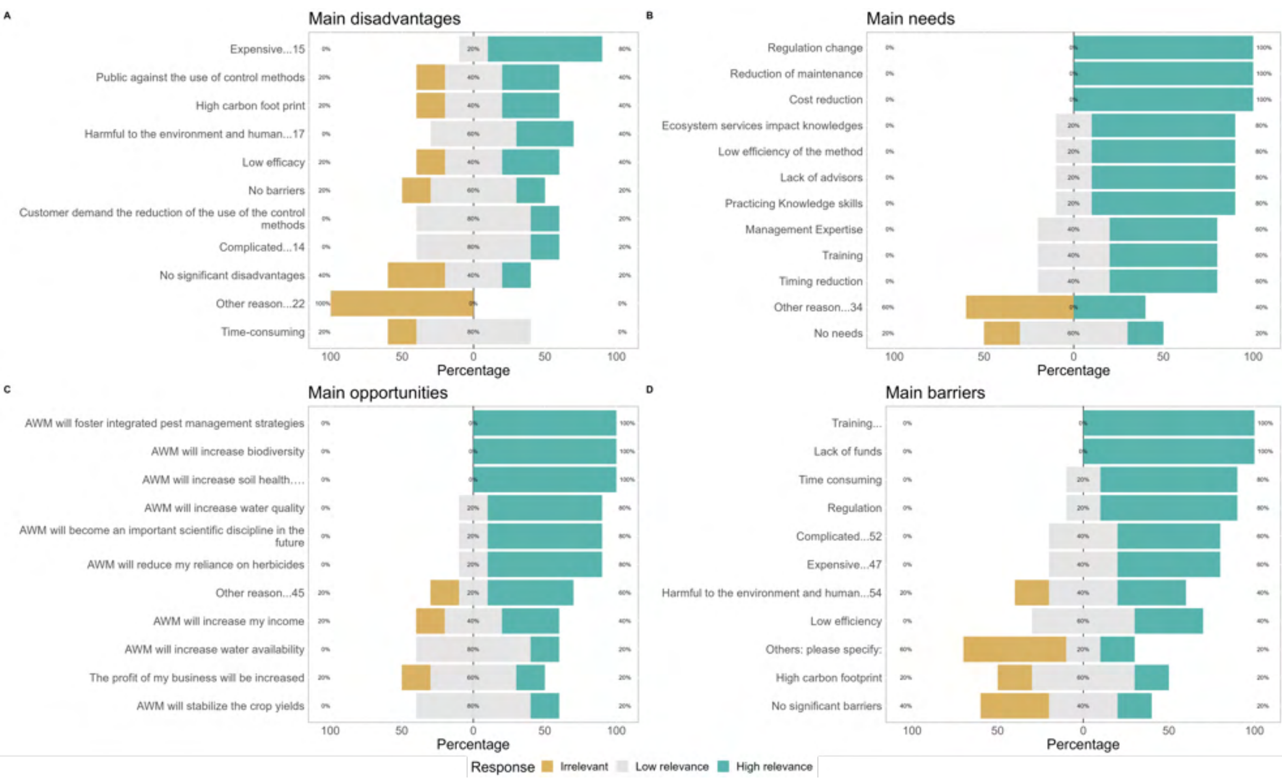


Figure 60 Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by advisors.

2.1.1.2.1.6.2 Consumers

Consumers hold an optimistic view of mechanical weeding, with unanimous agreement that this practice stimulate IPM strategies and enhances ecosystem services, contributing to improved water quality, biodiversity, and soil health. Three-quarters of participants also recognize the potential of mechanical weeding to become an important scientific discipline. However, consumers acknowledge important needs associated with this practice. All interviewees prioritize timing reduction as a highly relevant need, echoing the sentiments expressed by a significant number of advisors. Other identified necessities include knowledge on ecosystem services impact, practicing knowledge skills, management expertise, training, maintenance reduction, and cost reduction, all highlighted by 75% of participants. In alignment with the primary need, consumers unanimously identify time consumption as the main barrier to adopting mechanical weeding. Additionally, 75% of consumers express that training is a highly relevant impediment, while a quarter of them consider economic factors, such as the lack of funds and expenses, as relevant barriers. The top disadvantages cited by consumers are expense and time consumption, noted by 100% and 75% of respondents, respectively. Half of the interviewees also assert that complexity poses a detrimental factor when implementing mechanical weeding.

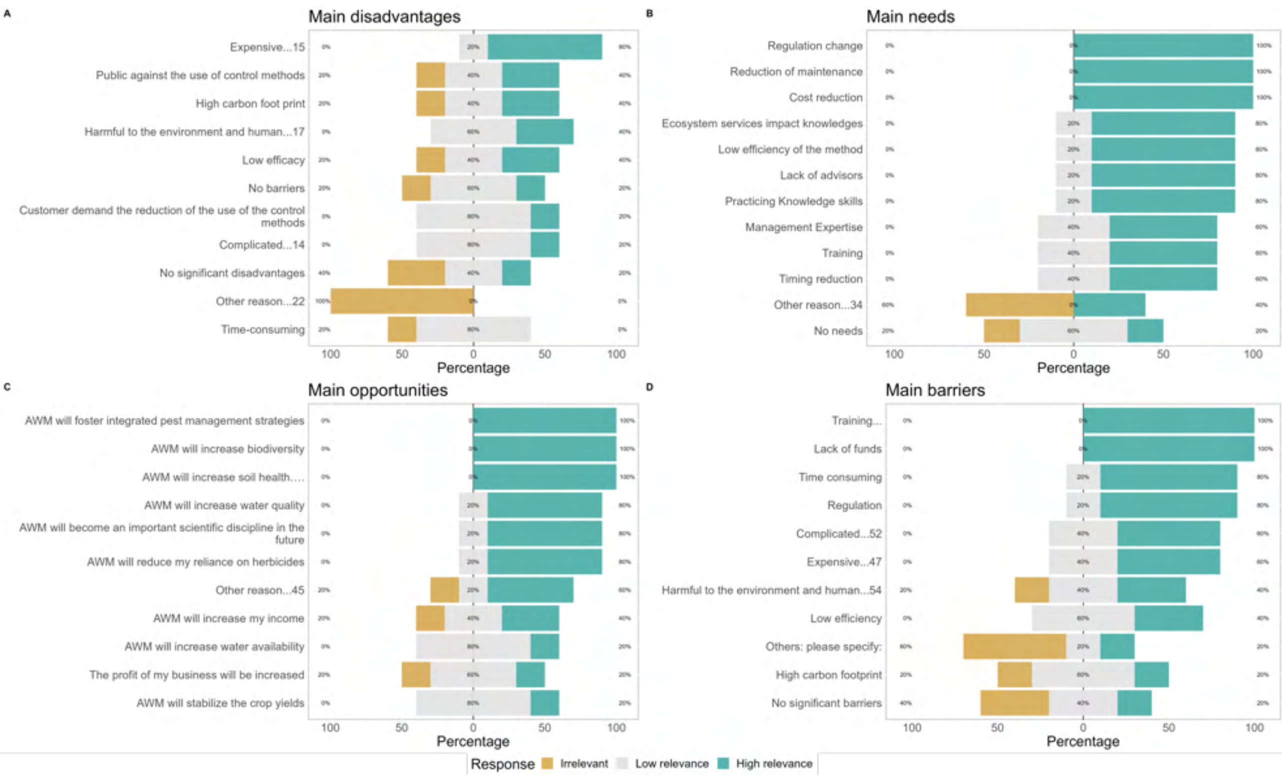


Figure 61 Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by consumers.

2.1.1.2.1.6.3 Farmers

Farmers collectively recognize numerous opportunities associated with mechanical weeding. Eighty-three percent of respondents believe it serves as a comprehensive provider of ecosystem services, contributing to increased water quality, biodiversity, enhanced soil health, and reduced herbicide reliance. Additionally, farmers anticipate that mechanical weeding will evolve into an important scientific discipline. Water availability is considered highly relevant by 67% of respondents, while stabilization of crop yields and income increase are viewed similarly by half of the participants. Farmers are attuned to the needs of mechanical weeding, with 83% identifying practicing knowledge skills as the primary necessity. Sixty-seven percent prioritize management expertise and maintenance reduction. Half of the respondents agree on the importance of knowledge in ecosystem services impact, regulatory change, and cost and timing reduction. Farmers are also aware of the challenges posed by mechanical weeding, with 83% highlighting time consumption and 67% acknowledging expense as significant hurdles. Fifty percent of respondents point out the high carbon footprint, potential harm to the environment and humans, lack of training, and funds as highly relevant barriers. In terms of disadvantages, 67% of farmers consider expense and time consumption as noteworthy drawbacks. However, the remaining queried factors do not garner relevance from more than 50% of the sample.

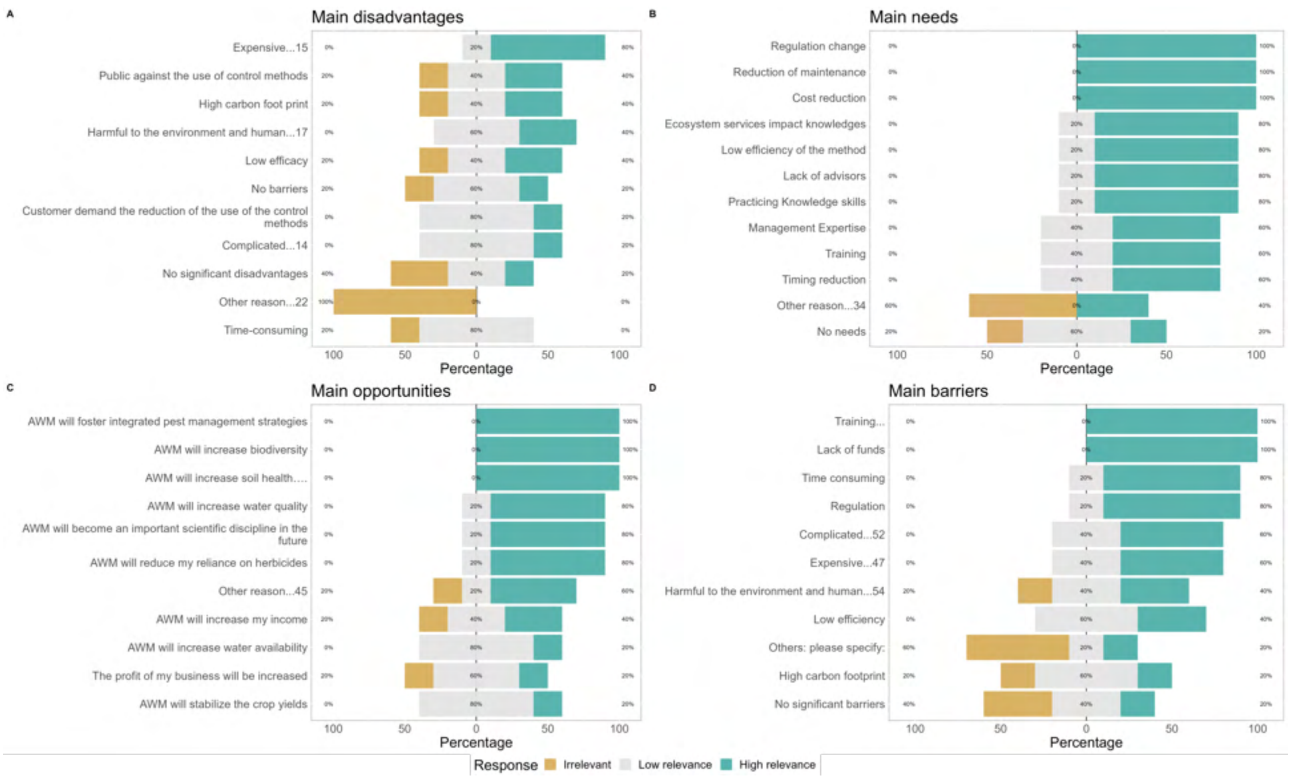


Figure 62 Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by farmers.

2.1.1.2.1.6.4 Researchers

Researchers, like other stakeholders, recognize mechanical weeding as a practice brimming with opportunities. All respondents believe it will enhance water quality, soil health, and potentially become an important scientific discipline, while also reducing reliance on herbicides. Two-thirds of researchers perceive mechanical weeding as a promoter of IPM and biodiversity. However, researchers emphasize specific needs, with 100% highlighting the importance of knowledge in ecosystem services impact, and 75% prioritizing reduction of maintenance and cost reduction. The main barriers identified by researchers are time consumption and expense, both considered highly relevant impediments. Moreover, expense and time consumption are also identified as the primary disadvantages by all researchers, with 50% considering the high carbon footprint as an important drawback. Interestingly, other queried factors as disadvantages are not deemed highly important by researchers.

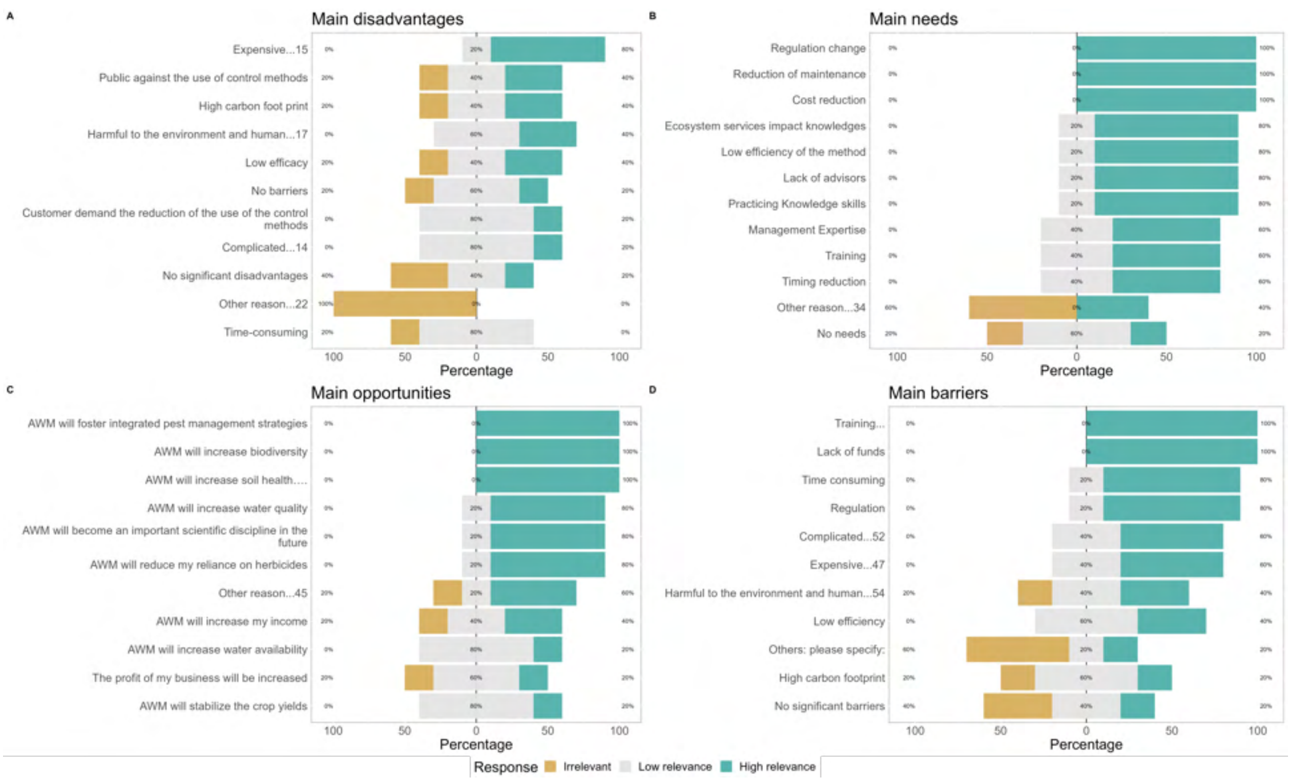


Figure 63 Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by researchers.

2.1.1.2.1.6.5 Conclusions

All stakeholders recognized mechanical weeding as a practice rich in opportunities. Advisors, farmers, and researchers shared the perception that this practice would lead to a reduction in herbicide reliance. Additionally, all stakeholders, albeit in varying proportions, viewed mechanical weeding as a promoter of IPM and as a provider of ecosystem services. Mechanical weeding necessities were noted by all interviewed stakeholders. Advisors aligned with researchers in acknowledging cost reduction (83%) and shared common ground with farmers, emphasizing the importance of management expertise as a primary need. Consumers, as the only stakeholder group, placed particular emphasis on timing reduction and shared concerns with researchers regarding ecosystem impact knowledge. Time consumption was recognized as the primary barrier by all stakeholders, followed by expense (farmers, researchers), lack of funds (advisors), and training (consumers). Main disadvantages broadly coincide with barriers, as time consumption and expense were considered significant drawbacks by a considerable proportion of respondents across all stakeholder groups.

2.1.1.2.1.7 Mowing

2.1.1.2.1.7.1 Advisors

Advisors perceive mowing as an AWM practice brimming with opportunities, with at least 50% considering all queried factors highly relevant. They view mowing as a provider of various ecosystem services, emphasizing soil health increase (83%) and water availability (67%). Economic opportunities are also deemed highly relevant, with more than half of the respondents highlighting increased business profitability, yield stabilization, and income increase. Furthermore, 67% of the respondents believe that mowing can reduce reliance on herbicides. Advisors identify cost reduction (100%) and timing (67%) as the primary needs associated with mowing. Half of the respondents consider practicing knowledge skills and management expertise as key necessities. Interestingly, most advisors do not perceive mowing as having significant barriers, as only 33% state that time consumption and training are relevant impediments in this context. Similarly, most advisors do not consider queried factors as relevant disadvantages, as only 33% cite efficiency and time consumption as noteworthy drawbacks.

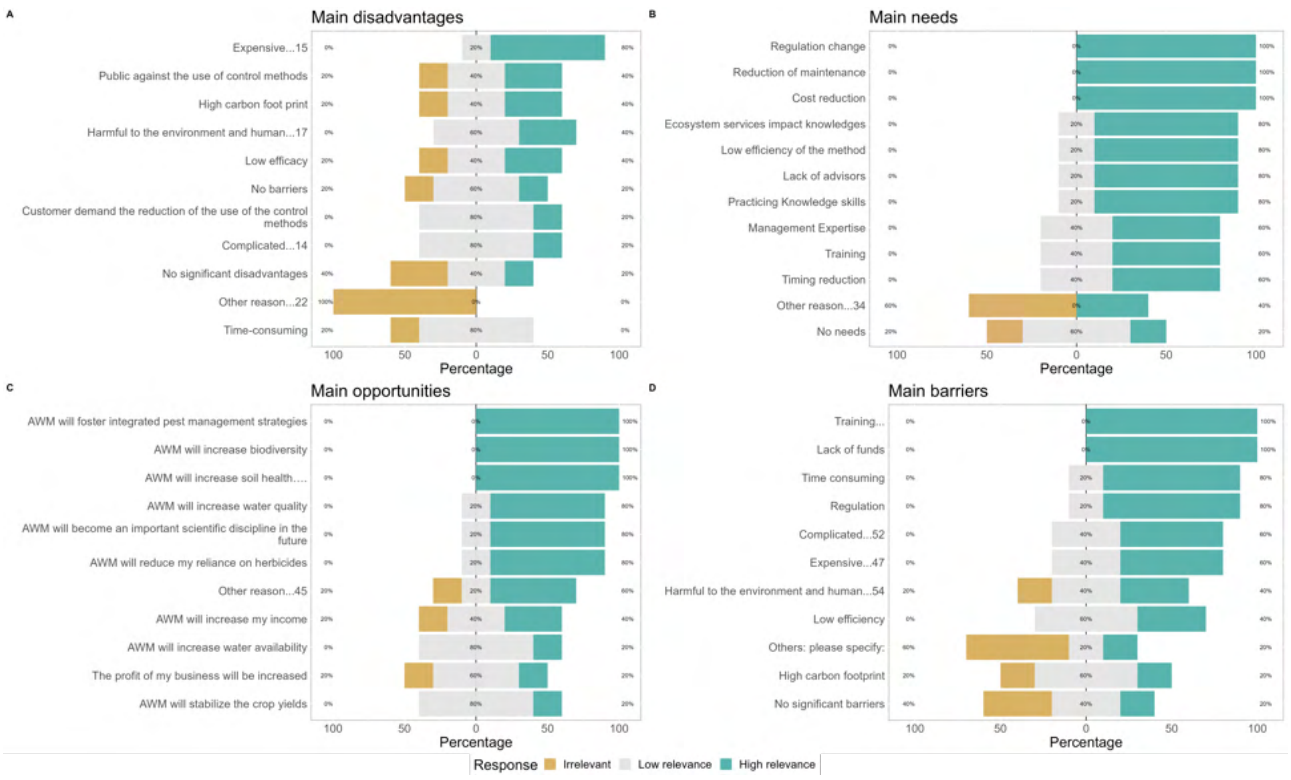


Figure 64 Main disadvantages, needs, barriers and opportunities for mowing identified by advisors.

2.1.1.2.1.7.2 Consumers

Consumers, akin to advisors, hold a positive view of the opportunities associated with mowing, perceiving it as an ecosystem services provider. All consumers believe it will enhance biodiversity, with 86% expecting it to foster IPM strategies, improve water quality, soil health, and reduce herbicide reliance. Additionally, almost three-quarters see potential benefits in increased water availability and the prospect of mowing evolving into an important scientific discipline. Identified needs for mowing, as highlighted by 71% of consumers, include training, cost reduction, and timing improvement. Furthermore, 57% consider ecosystem impact knowledge, practicing knowledge skills, and management expertise as crucial requirements for this practice. Time consumption is unanimously viewed as the main barrier to mowing by consumers, with 71% also identifying expense as a highly relevant impediment. In alignment with the primary barrier, 86% of consumers recognize mowing as a time-consuming technique and consider it a significant disadvantage. Additionally, 57% of respondents point to its perceived low efficacy and expense as important drawbacks when considering this technique.

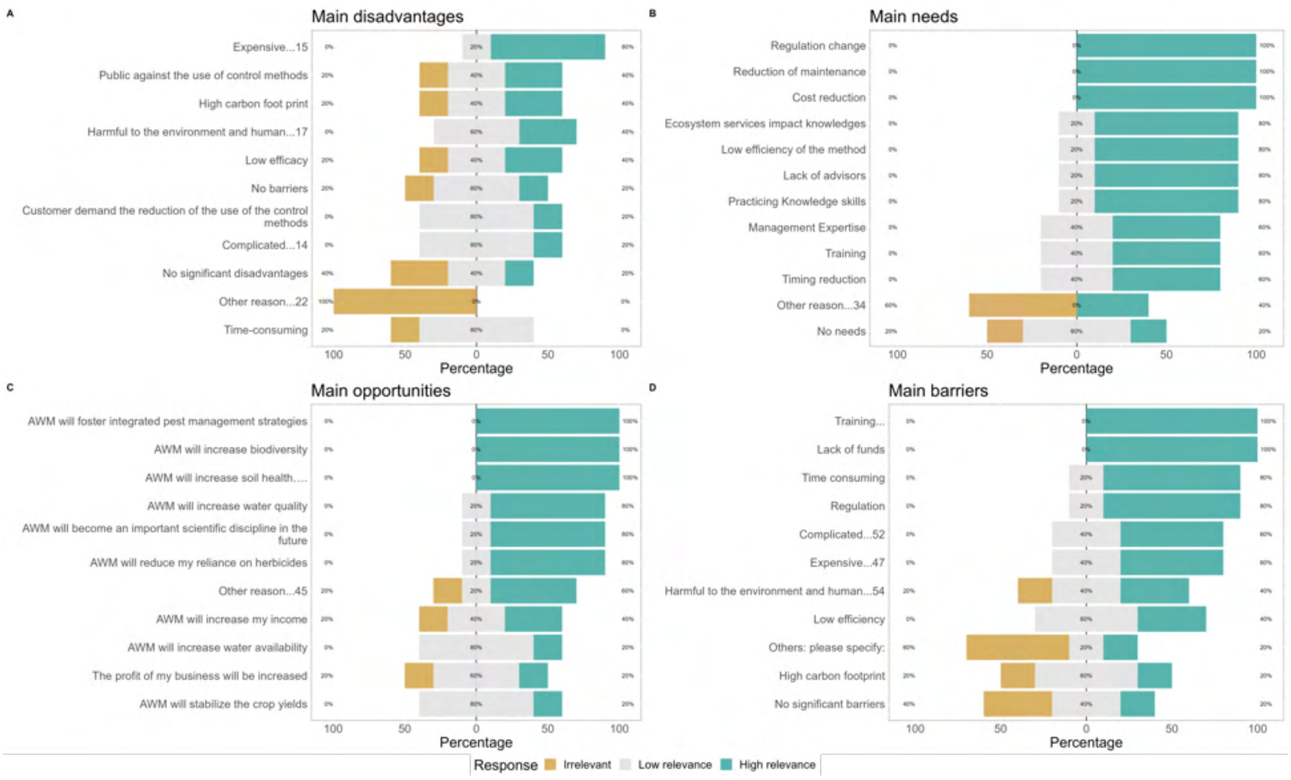


Figure 65 Main disadvantages, needs, barriers and opportunities for mowing identified by consumers.

2.1.1.2.1.7.3 Farmers

Farmers, aligning with consumers and advisors, maintain a positive perspective on the opportunities associated with mowing, emphasizing its role as an ecosystem service provider with potential benefits for water quality, biodiversity, and soil health. Additionally, they foresee mowing evolving into an important scientific discipline in the future. Nearly three-quarters of surveyed farmers regard mowing as a technique that will foster IPM, increase water availability, stabilize crop yields, and reduce herbicide reliance, with 57% emphasizing these aspects. Reduction in timing and maintenance are identified as the most crucial needs by farmers, followed by practicing knowledge skills, management expertise, and cost reduction, all considered highly relevant by 57% of respondents. Farmers generally do not perceive significant impediments when it comes to mowing, with training being the most relevant barrier, noted by 57% of respondents. Moreover, most farmers do not consider mowing to have significant disadvantages. The most notable drawbacks cited by this group include the public's demand to reduce or eliminate this method, yet they are considered highly relevant and irrelevant by the same proportion of respondents (43%).

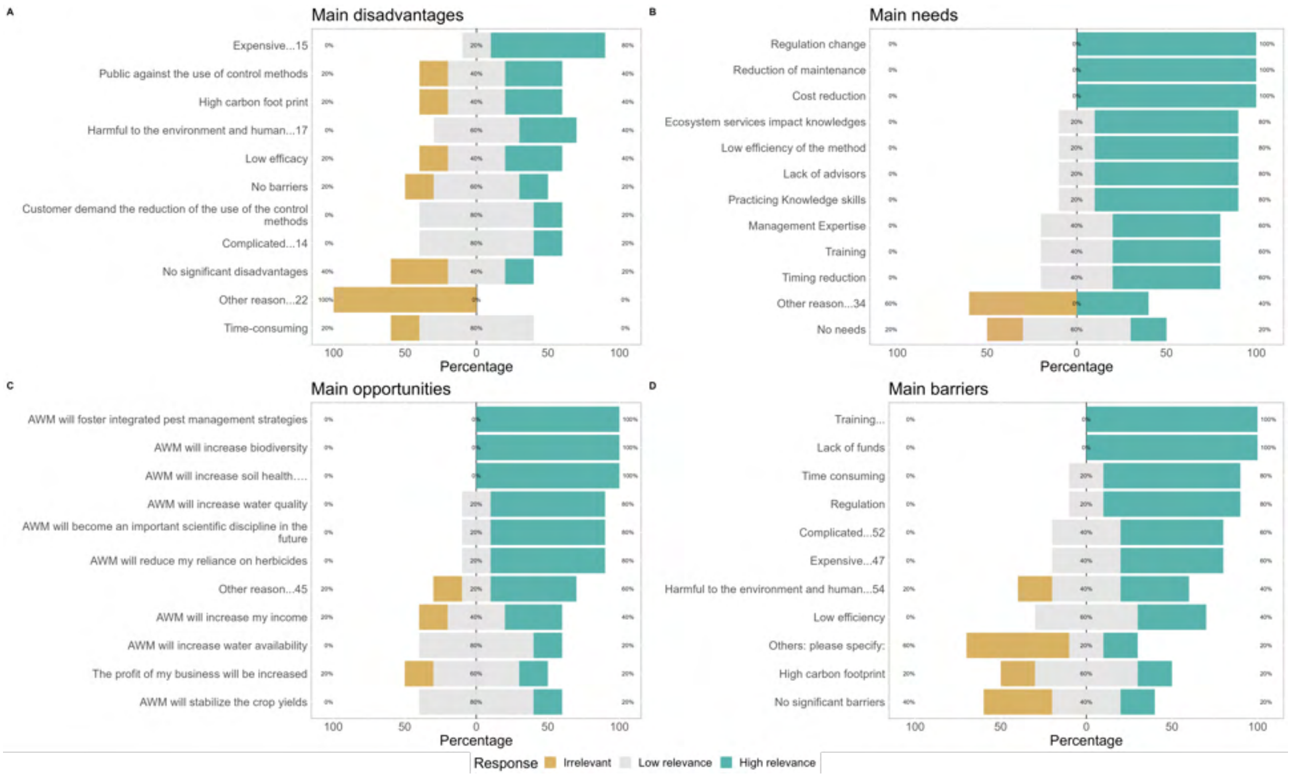


Figure 66 Main disadvantages, needs, barriers and opportunities for mowing identified by farmers.

2.1.1.2.1.7.4 Industry

Industry representatives, like other stakeholders, recognize the opportunities associated with mowing, acknowledging its positive contributions as an ecosystem service provider. They align with advisors, consumers, and farmers in highlighting ecological benefits, such as increased water quality and availability, biodiversity enhancement, improved soil health, crop yield stabilization, and reduced herbicide reliance. Additionally, industry representatives emphasize the economic advantages, including increased income and profitability, as well as the potential to enhance IPM strategies and its importance as a scientific discipline. Regarding needs for mowing implementation, industry representatives do not identify significant requirements, with only 25% considering ecosystem services impact knowledge, regulatory changes, lack of advisors, and training as highly relevant. However, as main impediments, 75% of respondents point to the time-consuming nature of this technique, while 50% note its expense and low efficiency as relevant barriers to mowing implementation. Overall, industry representatives do not perceive mowing as having many significant disadvantages. In line with the primary impediment, 75% of industry representatives express that they find this technique to be time-consuming, and 50% identify expense and low efficacy as the main disadvantages.

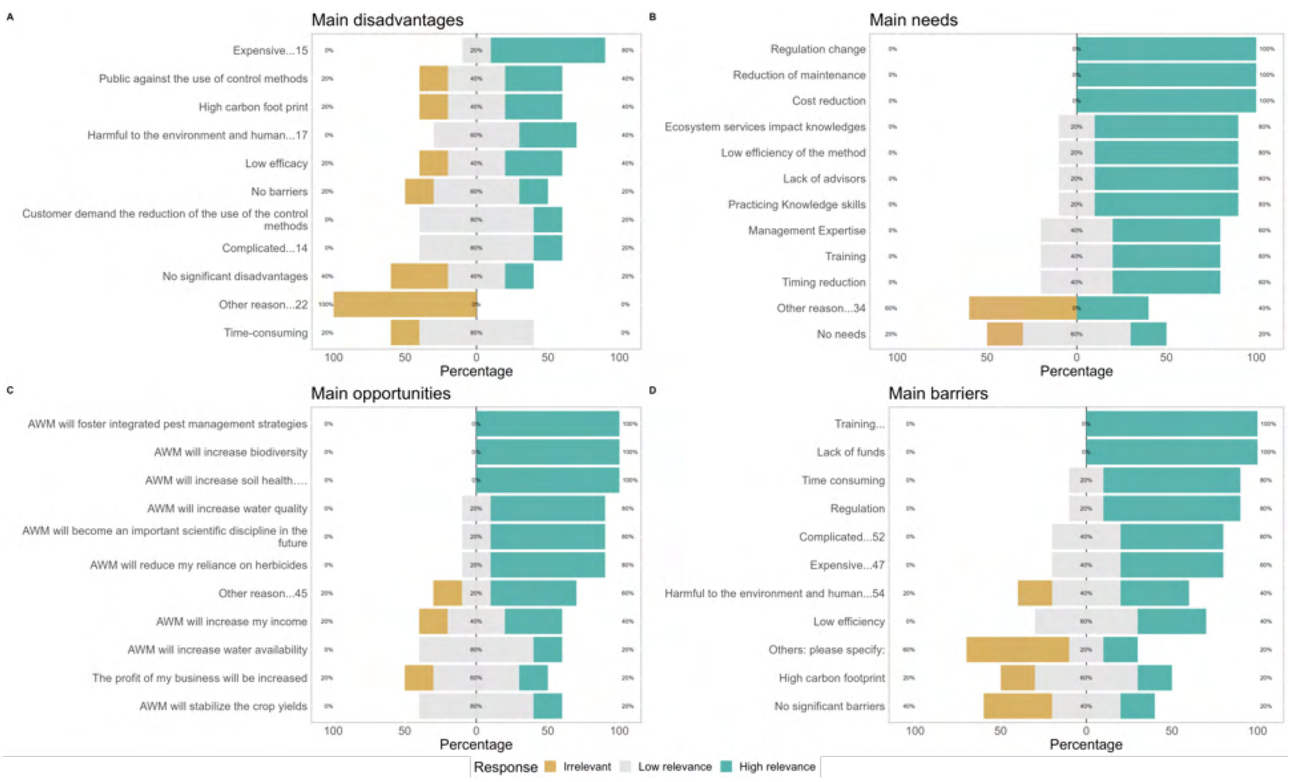


Figure 67 Main disadvantages, needs, barriers and opportunities for mowing identified by industry.

2.1.1.2.1.7.5 Resarchers

In line with other stakeholders, researchers recognize numerous opportunities associated with mowing. All respondents emphasize its positive impact on the implementation of IPM strategies, its role as an ecosystem service provider, soil health enhancement, its potential to reduce herbicide reliance, and its possibilities to become an important scientific field in the future. Moreover, three out of four respondents link this practice with increased water quality, biodiversity, profitability, and income. Recognizing the relevant potential of mowing, researchers unanimously agree on the main needs, emphasizing ecosystem impact knowledge and cost reduction. Seventy-five percent of respondents also view critical factors such as the lack of advisors, practicing knowledge skills, management expertise, and training. Similarly, researchers unanimously identify the main impediment with regards to mowing as a lack of funds, followed by 75% agreeing that factors like "time-consuming" and "training" are key barriers. Researchers, like other stakeholders, did not identify many of the queried factors as disadvantages. In accordance with highlighted needs and barriers, respondents consider that the main disadvantages of mowing are time consumption and expense.

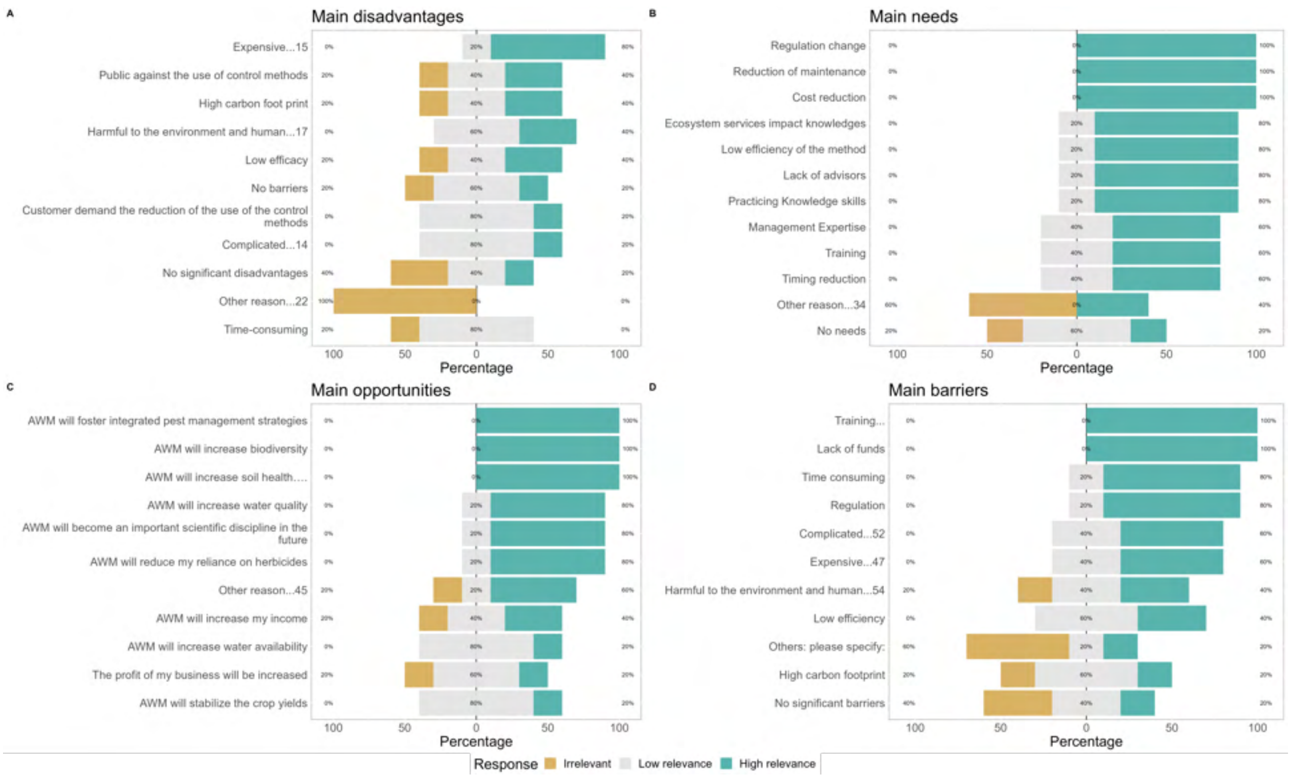


Figure 68 Main disadvantages, needs, barriers and opportunities for mowing identified by researchers.

2.1.1.2.1.7.6 Conclusions

All stakeholders unanimously recognize mowing in AWM as a practice filled with opportunities. Advisors, consumers, farmers, and industry representatives see it as a provider of various ecosystem services, emphasizing soil health, water availability, and economic benefits. Mowing is perceived as a tool to reduce reliance on herbicides and foster IPM strategies. Advisors prioritize cost reduction and timing, while consumers highlight training and cost reduction. Farmers emphasize timing and maintenance reduction, and industry representatives underscore economic advantages. Although researchers emphasize ecosystem services impact knowledge and cost reduction, all stakeholders converge on the significance of these needs. Time consumption is universally acknowledged as the primary barrier to mowing, followed by expense, lack of funds, and training. Main disadvantages align with these barriers, as time consumption and expense are considered significant drawbacks by a considerable proportion of respondents across all stakeholder groups.

In conclusion, stakeholders across the board share a positive outlook on mowing, recognizing its multifaceted benefits and economic potential.

2.1.1.2.1.8 Mulching

2.1.1.2.1.8.1 Advisors

Advisors perceive mulching as a technique with numerous opportunities. All respondents affirm that this practice reduces herbicide reliance, with 83% stating that it enhances biodiversity and business profitability. Additionally, 67% of advisors believe mulching contributes to IPM strategies and provides ecosystem services, including improved water quality, availability, soil health, and farmers' income. Advisors recognize several needs in mulching implementation, notably cost reduction highlighted by 83% of respondents. Half of the respondents emphasize the importance of reducing timing and maintenance. Moreover, training, lack of funds, and expense are considered key barriers by 67% of advisors. The main disadvantages, aligning with the identified barriers, include expense (83%), time consumption (67%), and complexity (50%).

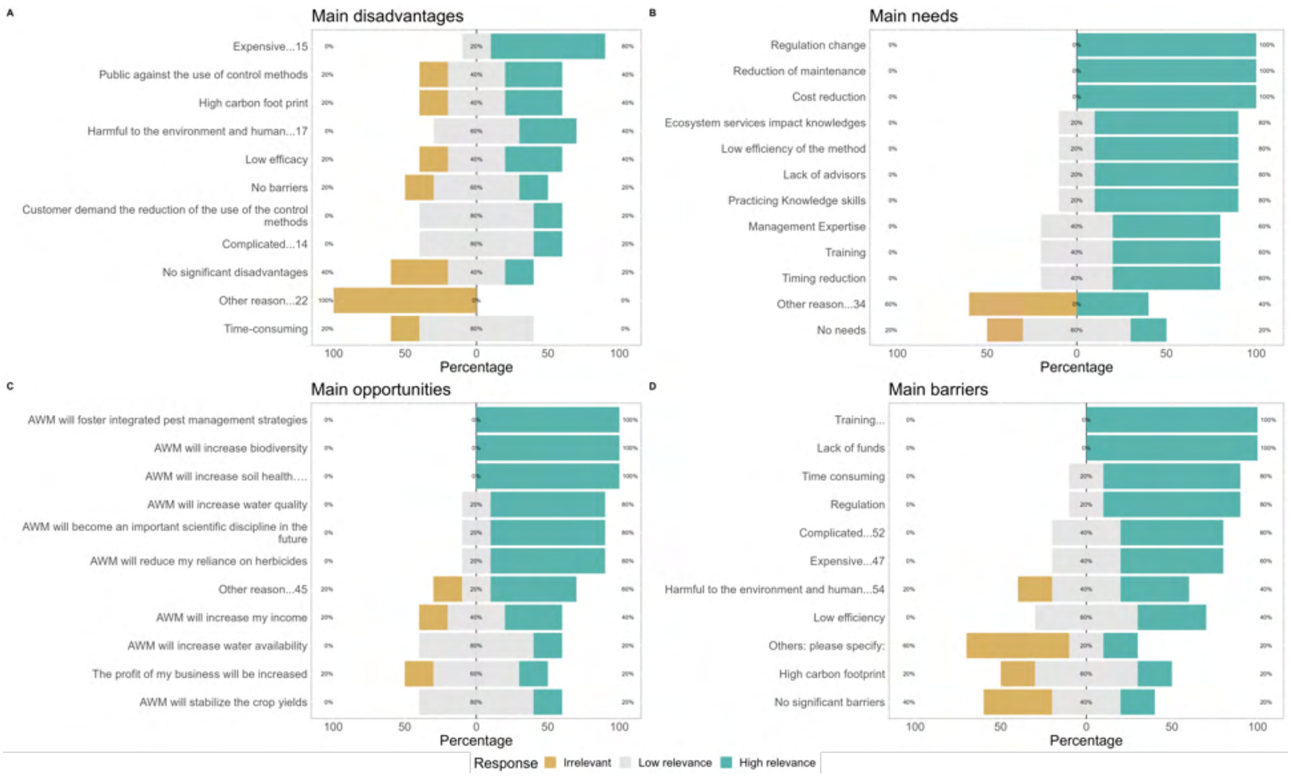


Figure 69 Main disadvantages, needs, barriers and opportunities for mulching identified by advisors.

2.1.1.2.1.8.2 Consumers

Consumers express a positive perspective on mulching, unanimously recognizing its role in encouraging IPM strategies and providing ecosystem services, including increased water availability and quality, biodiversity, and soil health, while reducing herbicide reliance. All consumers believe that mulching will become an important scientific discipline in the future. In addition to the identified opportunities, consumers unanimously highlight the need for knowledge about the impact of mulching on ecosystem services. Furthermore, practicing knowledge skills, management expertise, training, and maintenance, along with cost and timing reduction, were considered as relevant needs by 67% of respondents. Lack of funds was identified as the primary barrier by 100% of consumers, with time consumption, training, and expense also seen as relevant barriers by 67% of respondents, aligning with the factors considered as needs. Finally, in line with identified needs and barriers, expense and time consumption were deemed the main disadvantages by 67% of respondents.

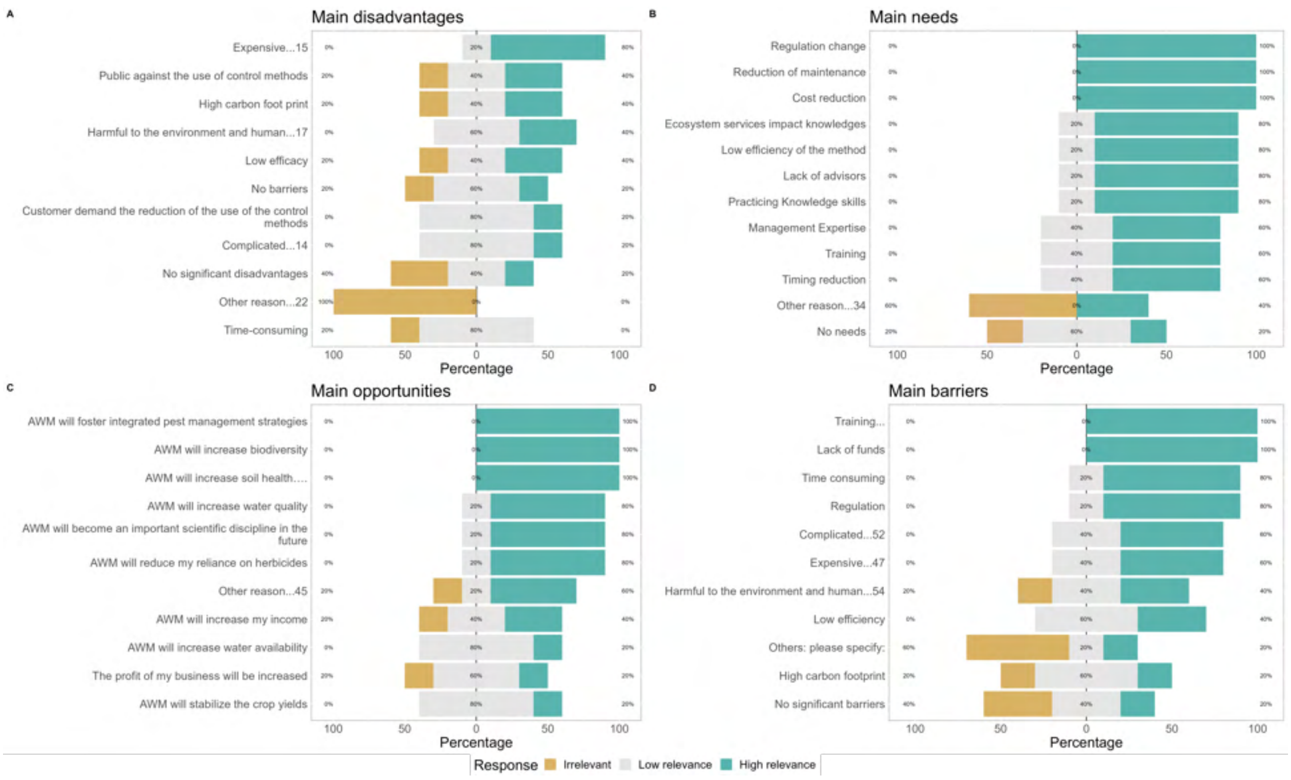


Figure 70 Main disadvantages, needs, barriers and opportunities for mulching identified by consumers.

2.1.1.2.1.8.3 Conclusions

Advisors and consumers share a positive perspective on mulching. The former group considers the reduction in herbicide reliance crucial, while the latter views fostering IPM strategies as the most relevant factor. Both stakeholders express that this practice provides important ecosystem services. In terms of needs, advisors prioritize cost reduction and emphasize the importance of reducing timing and maintenance, while all consumers highlight the need for knowledge about the impact of mulching on ecosystem services. Moreover, practicing knowledge skills, management expertise, training, and maintenance, along with cost and timing reduction, are considered as relevant needs by of consumers. Advisors and consumers concurrently state lack of funds, training, and expense as relevant barriers, as stated by more than half of respondents in each group. In line with identified needs and barriers, expense and time consumption are deemed the main disadvantages by both consumers and advisors.

2.1.1.2.1.9 Site-specific spraying

2.1.1.2.1.9.1 Advisors

Advisors identify several opportunities linked to site-specific spraying implementation: 60% of respondents consider that this technique will foster IPM strategies, provide ecosystem services (increase water quality and biodiversity), as well as increase farmers' income and reduce herbicide reliance. Besides opportunities, advisors pointed clearly to the practice needs, as eighty percent of our sample considered that practicing knowledge skills, management expertise, training, and cost reduction are highly relevant factors. Training and expense were identified as the main impediments to implementing site-specific spraying, and 40% of respondents considered this technique as potentially harmful to the environment and humans, stating that regulation may be a crucial barrier. Advisors considered that site-specific spraying's main disadvantages were the expense (60%) and the potential harm to the environment and humans (40%).

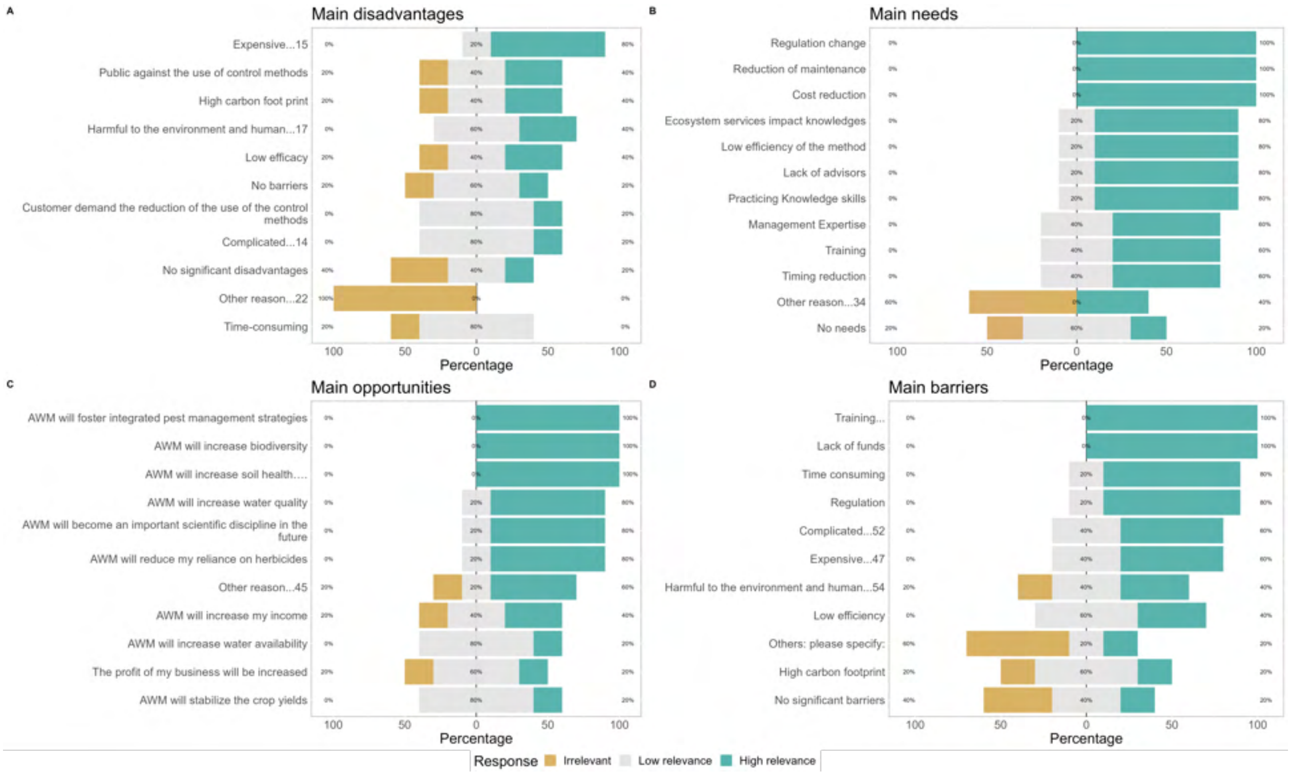


Figure 71 Main disadvantages, needs, barriers and opportunities for Site specific spraying identified by advisors.

2.1.1.2.1.9.2 Farmers

Farmers unanimously agree on the opportunities with regards to site-specific spraying; all of them assert that its use will result in an increase in water quality and availability, biodiversity, soil health, and a decrease in herbicide reliance. Farmers also recognize the potential of site-specific spraying to become an important scientific discipline. The other queried factors were considered highly relevant by a notable 67% of respondents, indicating that this technique is viewed favourably by farmers. They share an agreement regarding needs, as all farmers assert that the main requirement to implement this technique is a change in regulation. Other highlighted factors include ecosystem services impact knowledge, practicing knowledge skills, and management expertise. Having a high carbon footprint and potential concerns regarding harm to the environment and humans were regarded as highly relevant barriers by all farmers, who also showed high levels of consensus when asked about main impediments. Regulation was asserted as an important barrier by more than half of the respondents. Lastly, main disadvantages as stated by farmers were high carbon footprint and potential harm to the environment and humans, in accordance with responses in other categories.

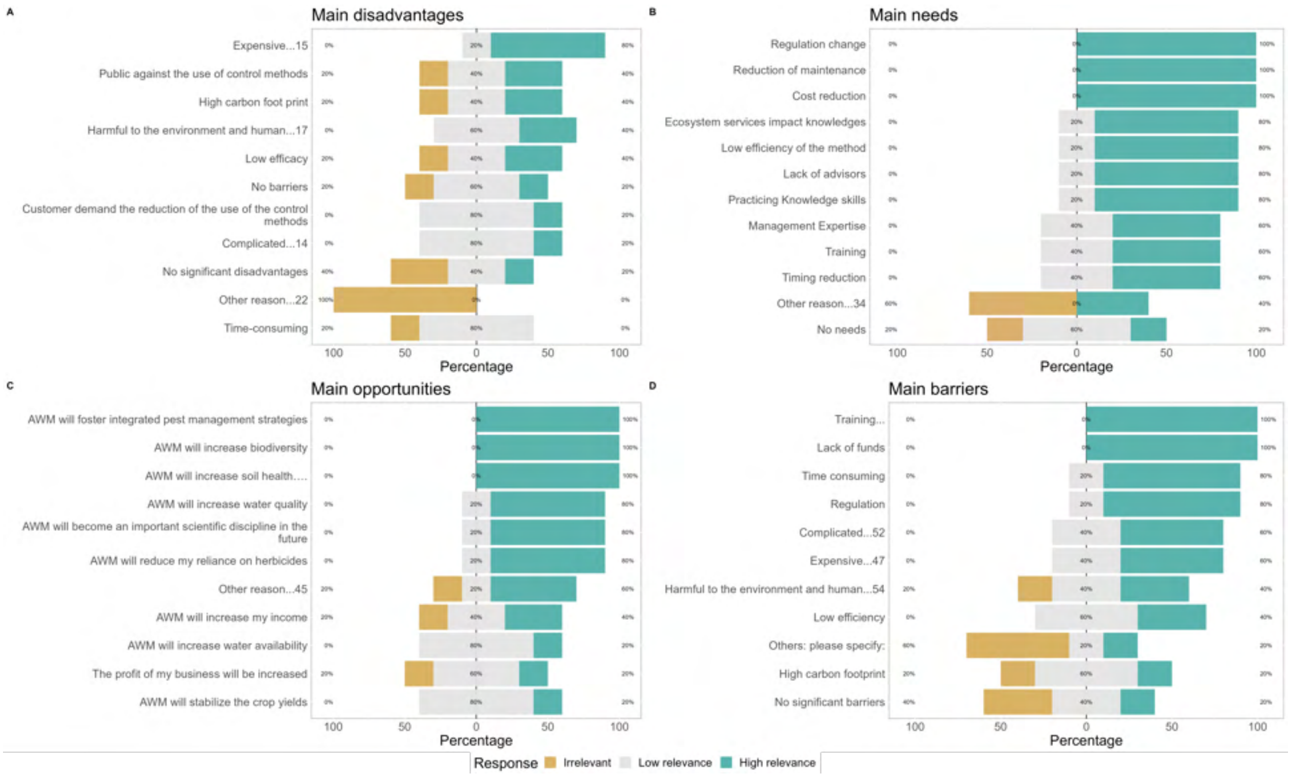


Figure 72 Main disadvantages, needs, barriers and opportunities for Site specific spraying identified by farmers.

2.1.1.2.1.9.3 Conclusions

The conclusion drawn from the perspectives of both advisors and farmers on site-specific spraying reveals a generally positive outlook. Regarding opportunities, 60% of advisors view site-specific spraying as a catalyst for IPM strategies, providing ecosystem services, boosting farmers' income, and reducing herbicide reliance. Farmers unanimously expect improvements in water quality and availability, biodiversity, soil health, and a decrease in herbicide reliance. They also recognize its potential as an emerging scientific discipline.

Advisors highlight the importance of knowledge skills, management expertise, training, and cost reduction for successful implementation. Farmers collectively emphasize the need for regulatory change to facilitate the implementation of site-specific spraying. Other relevant factors include ecosystem services impact knowledge, practicing knowledge skills, and management expertise.

Training and expense are identified as the main impediments, with 40% expressing concerns about potential harm to the environment and humans, particularly emphasizing the role of regulation. High carbon footprint and concerns about harm to the environment and humans are viewed as significant barriers by all farmers, with regulation also being identified by more than half of the respondents. Advisors primarily see expense (60%) and potential harm to the environment and humans (40%) as the main drawbacks. Farmers echo the concerns raised by advisors, identifying a high carbon footprint and potential harm to the environment and humans as the main disadvantages.

In summary, both advisors and farmers see promising opportunities in site-specific spraying, particularly in promoting sustainable practices and reducing herbicide reliance. However, challenges such as training, expense, and regulatory barriers need to be addressed to fully harness the potential benefits of this technique. The concerns about environmental and human impact, while acknowledged, do not outweigh the perceived advantages, emphasizing the importance of strategic regulation and support for successful adoption.

2.1.1.2.2 Surveys

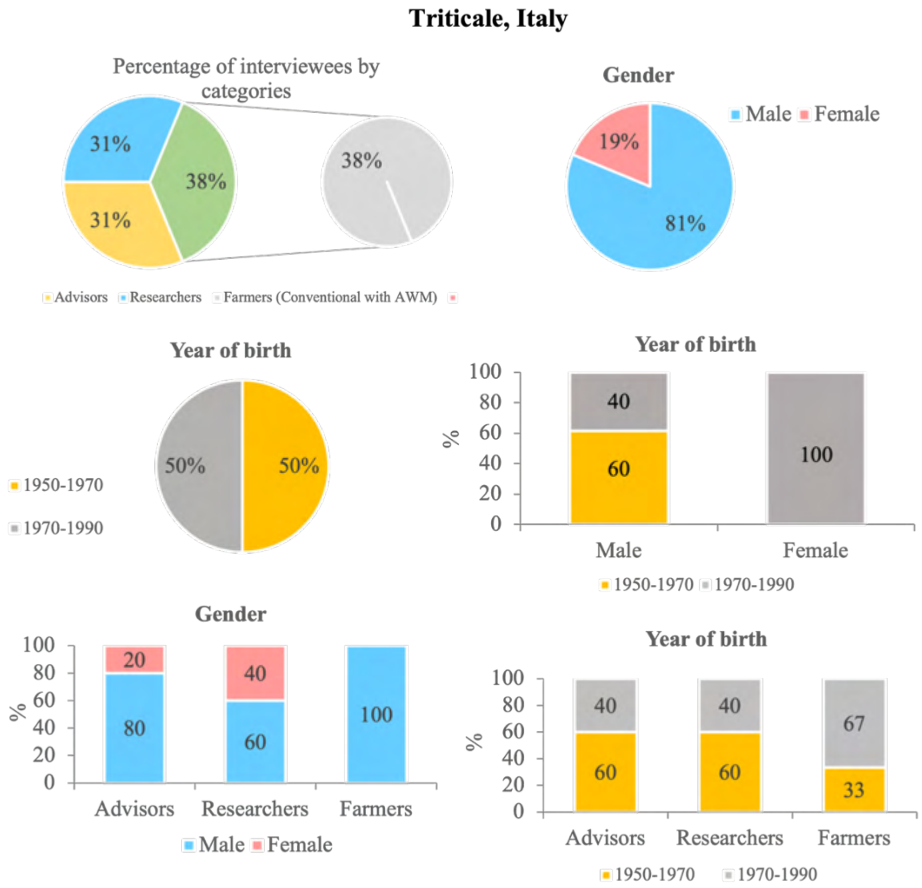


Figure 73 Interviewees description in the Triticale Living Lab (Italy)

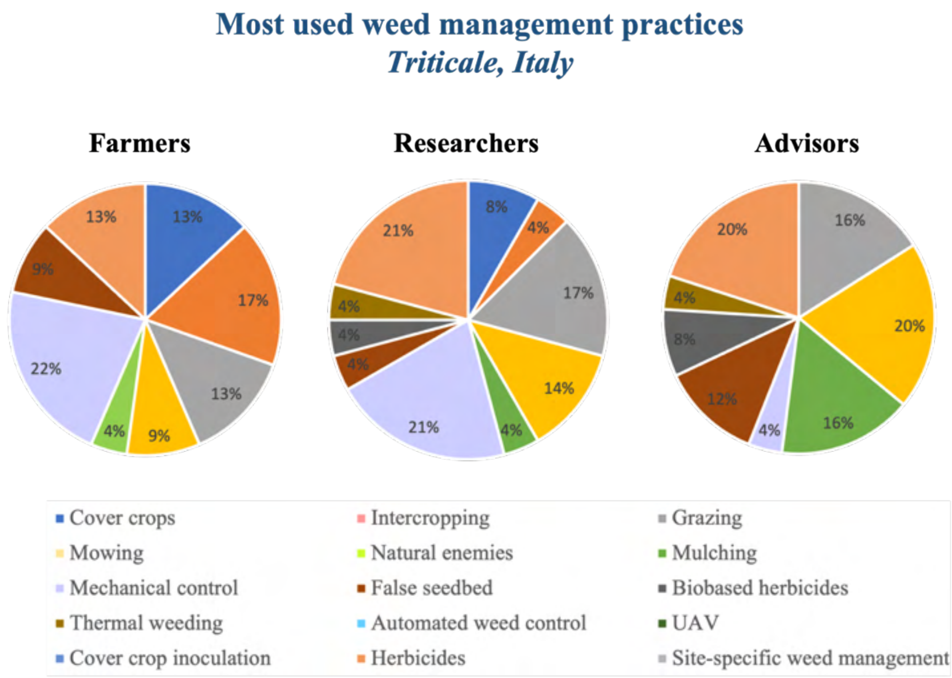


Figure 74 Most used weed management practices in the Triticale Living Lab (Italy)

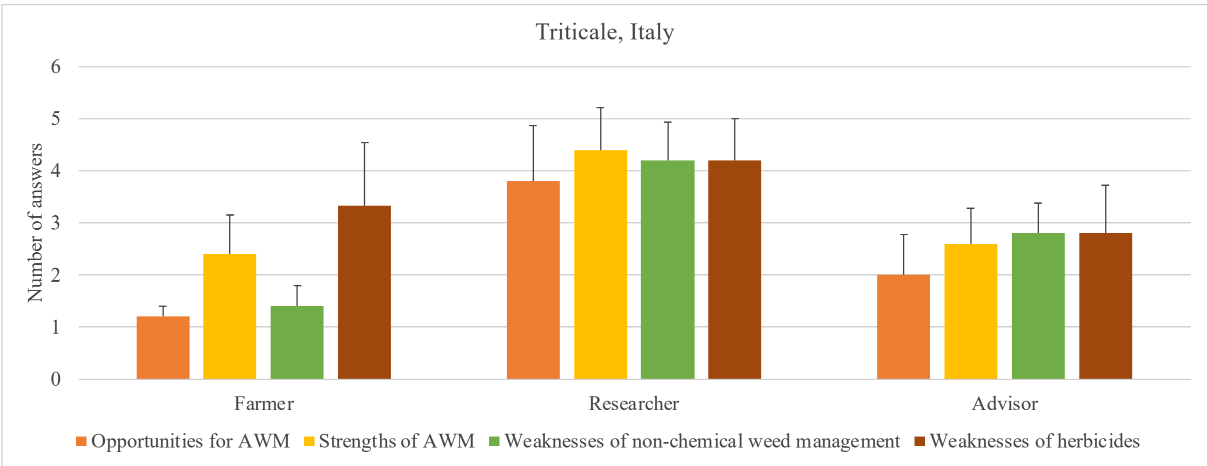


Figure 75 Mean number of answers (±se) per stakeholder group in the Triticale Living Lab (Italy)

Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: Presented in the figure below.

THREATS: Presented in the figure below. The *triticale LL* was among a few that provided answers about threats for AWM.

WEAKNESSES: Presented in the figure below. The *triticale LL* was the only one that provided many answers about weaknesses of AWM.

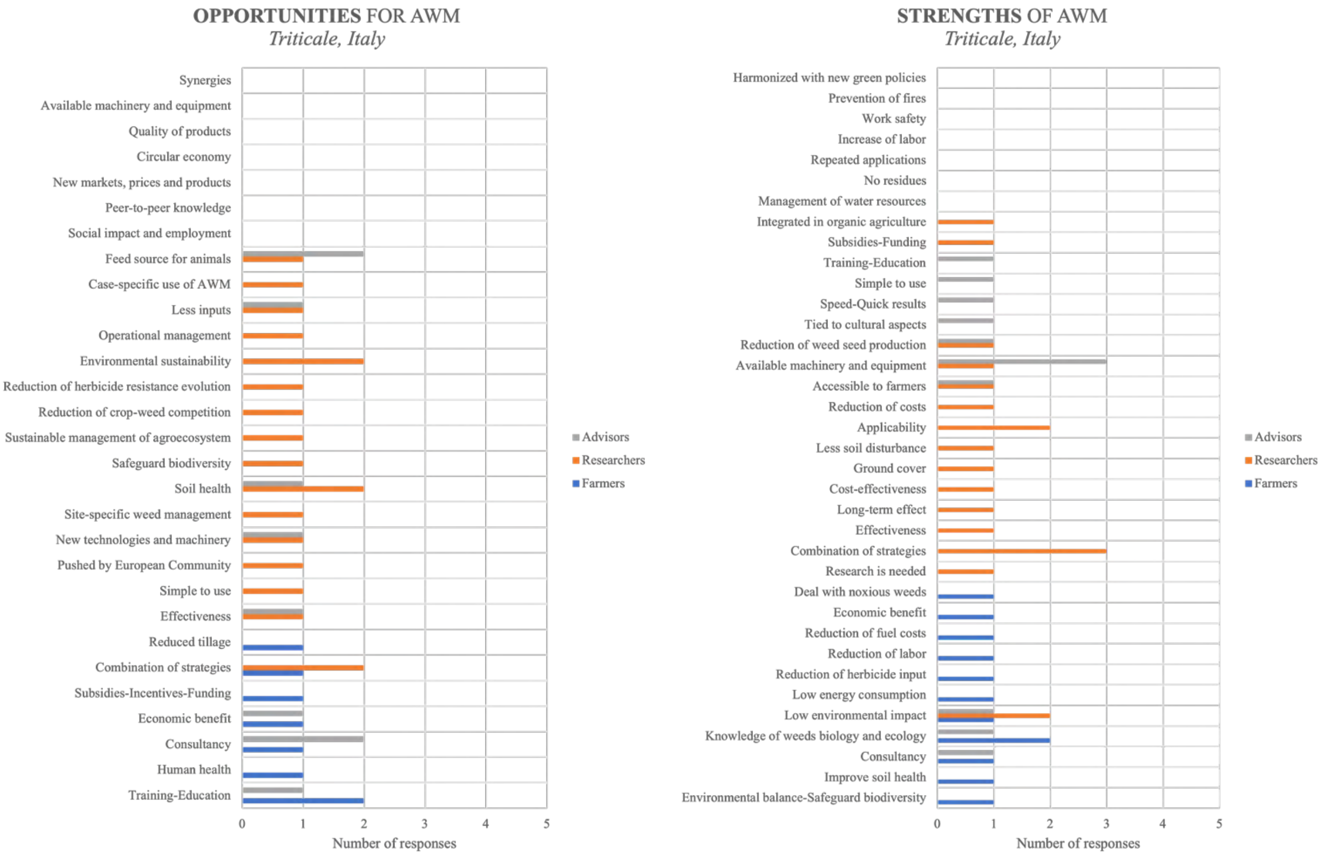


Figure 76 Opportunities and strengths of Agroecological Weed Management

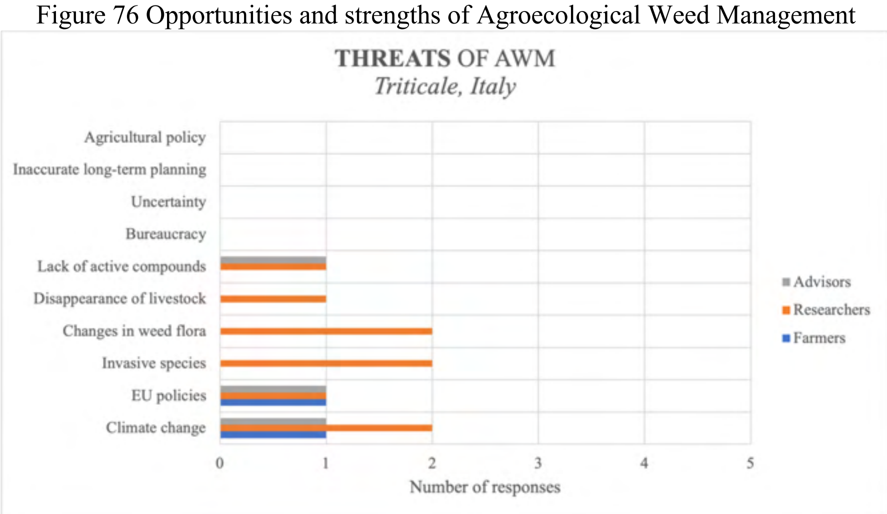


Figure 77 Threats for Agroecological Weed Management

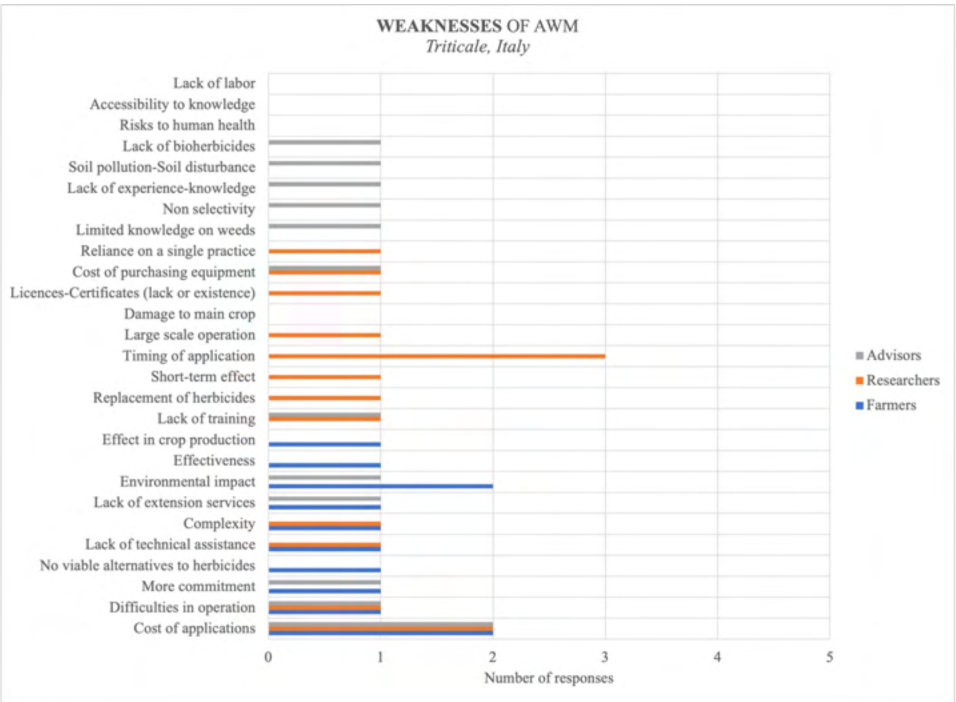


Figure 78 Weaknesses of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: One farmer mentioned the climate and weather conditions, while there were three responses from researchers who mentioned climate, lack of recognition from markets and invasive species as threats for non-chemical weed management.

WEAKNESSES: Presented in the figure below.

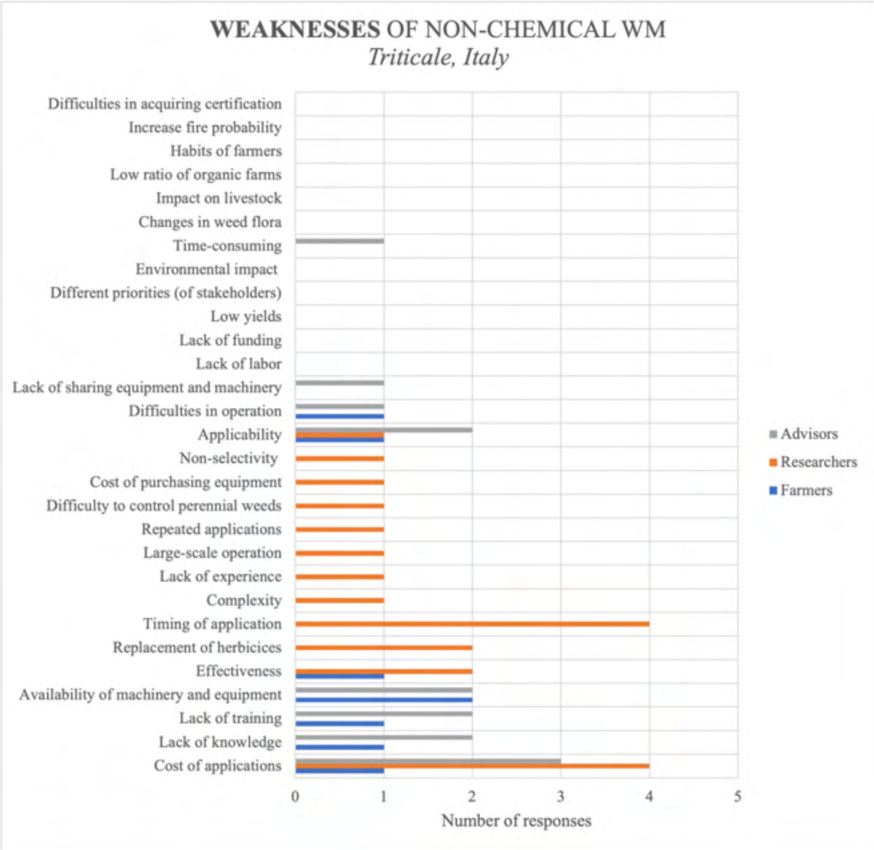


Figure 79 Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: There were a few answers on opportunities for herbicides. In detail, only one farmer thinks that efficacy is an opportunity. Two responses from advisors concentrated on the quick results and selectivity of herbicides. From the researchers' group, there were five responses referring to opportunities for herbicides: fast operation, efficacy, available equipment, selectivity, low cost.

STRENGTHS: It is repeated here that researchers and advisors give more answers compared to farmers. Efficacy, simplicity and selectivity of herbicides are considered strengths of herbicides for researchers, while low cost, optimized treatment, available equipment and low cost were identified by advisors.

THREATS: Markets and how herbicides are sold/distributed was identified as threat. One researcher mentioned the pressure for herbicide reduction as an added threat.

WEAKNESSES: Presented in the figure below.

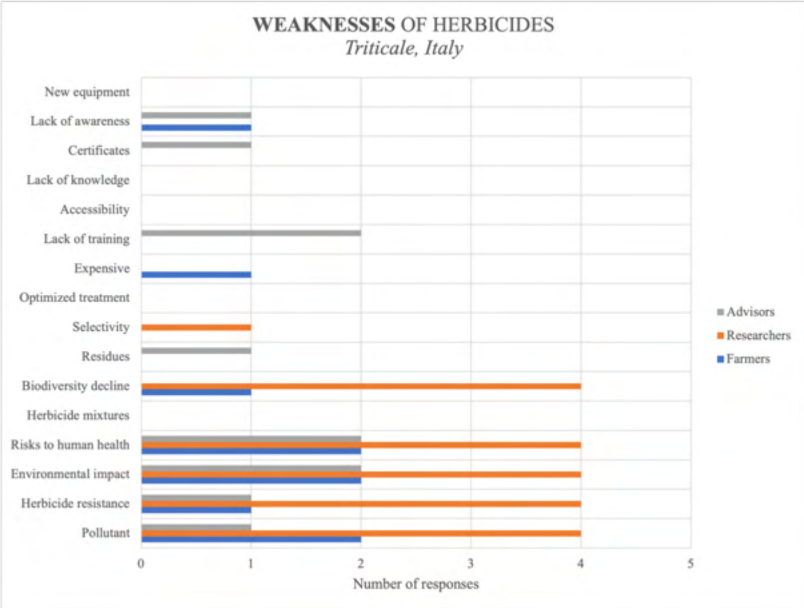


Figure 80 Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – TRITICALE, ITALY
Most used weed management practices: The Triticale Living Lab has the unique feature of being located in Sardinia, an island where the inhabitants depend heavily on livestock and local crop production to feed their animals. Therefore, grazing is a practice linked to cultural aspects and intrinsic characteristics of agricultural systems. It is noteworthy that the interviewees mentioned several weed management practices (8 for farmers, 10 for researchers, 8 for advisors). That means that combination of strategies is possible and necessary in cereals.   **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group**: It was obvious that the researchers could say more and mention more opportunities, strengths and weaknesses compared to farmers and advisors. Farmers had the lowest response rate on opportunities for AWM across all stakeholder groups. However, the weaknesses of herbicides identified by farmers were multiple, suggesting that they want to learn more about non-chemical weed management and be trained in AWM practices.   **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: The opportunities for AWM that farmers identified were mostly related to training and education in these new practices or their combination, consultancy, and financial

support to apply them. Researchers could be able to identify more positive impacts of AWM (e.g., improve of soil health, safeguard biodiversity, enviromental sustainability). Advisors highlighted the need to increase training of farmers and technical assistants, which will be a nudge to invest on new machinery and technologies as well. Weeds could be a feed source for animals and AWM prioritizes when it is critical to control the weeds or not, thus, it is suggested as an opportunity. The availability of machinery, the low environmental impact, the knowledge on local weeds' biology and ecology, as well as the combination of strategies are the major strengths to apply AWM practices in Sardinia. However, climate change, disappearance of livestock and invasive species cause changes in weed flora and overall, these constitute threats for AWM. Among many weaknesses of AWM practices identified by the interviewees, timing of application cost of applications and possible environmental impact were the top answers.

Threats, and weaknesses for non-chemical weed management: The weaknesses of non-chemical weed management are mainly focused on the applicability of non-chemical practices, the cost and timing of applications, while the availability of machinery and equipment and the lack of training and knowledge are critical parameters to be considered. Similar to threats for AWM, climate change and invasive species are challenges for the successful transition to non-chemical weed management.

Opportunities, strengths, weaknesses, and threats for herbicides: The efficacy, selectivity and low cost of herbicides, as well as the availability of equipment, are among the advantages of herbicides. However, the market structure and the way herbicides are made available on the markets is a threat. The majority of respondents acknowledged that herbicides pose risks to human health, have environmental impacts and are polluting, and their use leads to an increase in cases of herbicide resistance.

2.1.1.2.3 Living lab board meeting

The living lab board meeting was an online meeting held on 24th November 2023. The total number of participants in the meeting was 13 people. During the meeting, it was discussed about the importance of agroecological weed management in triticale and other cereal species in the Mediterranean context of Sardinia. The key messages collected in the meeting were: i) The importance of interaction among researchers, farmers, consumers, industry, decisor, and consultants, ii) Triticale is a multiple-use and renewed crop in almost all areas of Sardinia, iii) Chemical weeding suggested only in the most extreme conditions (severe infestations), iv) Suggestion for integrated and chemical control for resistant weeds, v) False sowing suggested for triticale, but not possible in this season, vi) List of key weed species and some invasive plants in Sardinia, vii) Importance of knowledge and dissemination to promote agroecological practices, viii) Agroecological products could be promoted in the market, ix) Lack of promotion and implementation of new technologies for agroecology weed control by public bodies. During the LL board meeting, this information was also collected:

What are the market characteristics of triticale?	1. How many farmers cultivate triticale in the region (approx.)? Is it mostly monoculture or can rotations be made with other crops?
	In Sardinia triticale has become a well-known crop in almost all areas, whereas until 15 years ago it was little known and not widespread. The cultivation of triticale develops along two lines, that of biogas and as silage, especially in farms not served by irrigation where it is grown instead of corn. It has spread in livestock cereal farms in rotation with grasses, legumes, or in association with grasses and legumes. In most farms, there is widespread adherence to the PSR (Rural Development Plan) measure, which provides for annual rotation between green cereals grain and crops for soil improvement. In AGRIS (Sardinian Regional Agency for Agricultural Consultancy) it is cultivated in Ussana and Bonassai sites to produce grain and it is used as grass for grazing. In non-irrigated areas, it is in rotation with fodder legumes or grain legumes. Participants in the LL board meeting highlighted that they grew triticale and it worked very well. They used it as grain and chopped and in rotation with grain legumes. Moreover, a participant in the meeting said that he was very interested in triticale as a student, then, once he took over the farm, the reality of the farm slowed him down. Perhaps, listening to the experience of his parents and the owners of nearby farms also

	discouraged him. It is a problem of the species because, in his livestock farming, he produces grain for self-consumption (animal feeding). However, not knowing triticale adequately, because he studied it but not in-depth, the focus was still on cereals, but on other species. Another participant said that there is a very broad and diversified range of triticale varieties, so perhaps the use of a material that is not entirely suitable leads to unsatisfactory results. Precisely for planting the wrong variety to use, even when you decide to plant triticale for grazing you need to be careful. The alternative very early varieties, when grazed, make a maximum of two regrowths. Triticale has, however, great resistance to cold even to waterlogging, greater than barley and oats which tend to suffer and succumb. Furthermore, it has good resistance to foliar diseases, so it does not yellow from rusts in December, as often happens with oats. Triticale is a machine that is not well known, to be explored better, especially by breeders and for use. Different tests were done with triticale at high altitudes sites (Sorgono, Tonara) indicating its excellent resistance, results and persistence. Finally, it is important to be aware that triticale also does well on sandy and acidic soils much more than other cereals. It is palatable for livestock, they eat it well; it has a protein content comparable to that of barley and therefore rusticity.
	2. How many products are derived from the triticale? Are they important for the economy and/or food security?
	Fodder, grain, silage (you have to be careful on it as it contains a lot of fiber), biogas. Moreover, triticale is a very plastic plant and can also be used for grassing, as a cover crop, as green manuring for soil organic matter improvement (e.g., as a cover crop in the inter-row of vineyards, to be chopped at the end of March during the earing phase).
	3. Do you think that agroecological products could be promoted in local markets?
	There is also triticale bread and should be promoted.
	4. Do you believe that the region has a lack of technologies?
	There is no shortage of technologies. The cost is important and since Sardinia is an island there is an increase in the transportation costs from the mainland. Therefore, a type of investment could be made and the market could be found. Moreover, there is a

	lack of promotion and implementation of technologies. Sellers are tied to the high costs of non-innovative machines compared to novel machines.
	5. Is the regional agri-food value chain sustainable?
	In Sardinia, a series of products are imported because a few of them are produced. The quality of the Sardinian product is recognized, this is the value. Sustainability depends on the sectors, some sectors can produce well and others are more marginal, and need help and subsidies. Moreover, in Sardinia, triticale does not reach 200 hectares according to ISTAT data, it is a marginal crop compared to others that could be more interesting. However, it is important to take into account that ISTAT data refers exclusively to grain triticale, ensiled triticale is not recognized. Most of it is triticale silage, not only for companies that use biodigesters but also for livestock farms that use silage. This crop destination does not fall under the statistical standard, which is why it disappears. Only in the close area of Nurra, in the former Rossi farm there are 150 hectares, in the Olmeo company there will be the same number. Both are more than in the ISTAT data. On the other hand, the agroecological management of triticale, depending on the use to be made of the product, is done with completely different cultivation management, that is, it is one thing to grow triticale to produce grain, another thing to make silage or something else. They are two completely different agronomic managements. Finally, a participant in the meeting indicated that he grows durum wheat and believes in the supply chain. There is no help from the Sardinia region (money not received for three years) or money wasted as it was given to those who followed the grain supply chain for only one year. There is a lack of seriousness in the Sardinia region.
	1. What are the most common agronomic practices in triticale?
What are the most common agricultural and weed management practices in triticale?	A participant in the meeting said that he normally sows in rows, sowing rates not very different from that of wheat, around 140-150 kg per hectare. He has always been an opponent of chemical weed control but sometimes in extreme conditions, like in livestock farms, weed control must be carried out periodically using active ingredients; the thistle problem is a long-standing problem. There is a herbicide called Atlantis, or he also uses 2-4 D, which only acts on dicotyledons. He always recommends early sowing, done by October or early November, which allows the crop to be grazed between December and 2 weeks of January, then grazing must be suspended, according

	to a management common to all cereals. So last grazing by the second half of January, which allows for a satisfactory grain production. In short, more or less the standard management of triticale is that of a dual-purpose cereal, i.e. herbage plus grain. Another participant explained that the agronomic practices are more or less the same as those for wheat, they require a few kilos less of fertilizer. Triticale includes a very broad varietal framework with very different characteristics, varieties of triticale that can be sown very early, and other varieties that cannot be sown very early. Agris used medium cycle varieties (Capria or Trick). There is a very wide choice of vegetal materials. Other participants indicated that they used minimal tillage for triticale.Triticale is an autumn-winter cereal and the cultivation technique is extremely simplified and does not require special care.
	2. What are the most common weed management practices in triticale?
	A participant in the meeting explained that weeding is done with grazing (within the correct rest times). With grazing they have had excellent results with other seed crops that are not cereals such as fodder crops (sulla or burr medic). Very intense grazing, with sheep that do not select the species but completely shave, if done within the times I was talking about before, has an excellent ability to weed control. If the correct timing of chemical weeding is used, in theory, the animal can also graze when the weeding is done in early post-emergence. If you sow in October, there is plenty of time for the active ingredient to decay and a herbicide shortage time. Another participant prefers chemical weeding only in the most extreme conditions when the history of a field is already known and the field is particularly infested with thistles or chrysanthemums, which are both very invasive weeds. Alternatively, try to orient weed management with animals. He also worked with barley, before triticale, which has an important regrowth capacity. It always depends on what we want to do, because if we are producing certified seed to sell it, which is not the case with most livestock farms, then the crop must necessarily be cleaned of various weeds. On the contrary, if you are only producing grain for livestock feeding use, triticale grain contaminated with impurities is tolerated as well as lower yields due to weeds. In any case, triticale seed is easily separable from weed seeds. There can be very invasive thistle infestations that just don't allow the use of the combine harvester.

	Other participants said that triticale as Capelli wheat resists weeds well. Weeds can be controlled with false sowing alone because triticale tends to tillering vigorously (i.e. to occupy the inter-row).
What is the herbicide use in triticale?	1. How many active ingredients there are available? How many different mode of actions?
	There is a wide range of active ingredients now registered on triticale because for 10-15 years the cultivation in Italy, perhaps even more so in the Po Valley area, has spread. Hence the industry's interest in registering the active ingredients of this species too. Concerning the methods of action, from a herbicide used at emergence, an early or late post-emergence. At the moment there are around forty registered active ingredients, with all five biochemical mechanisms of action: inhibition of ACCase (HRAC A), ALS (HRAC B), photosynthesis (HRAC C1 and HRAC C2), EPSP synthase (HRAC G).
	2. How many times do you spray in-season?
	A participant in the meeting said that to weed triticale used the Granstar herbicide (dicotyledonicidal) combined with a monocotyledonocidal one with a single post-emergency treatment. Another participant indicated that they are asked very little about Triticale. Herbicides are used mainly for cereals such as wheat and are sometimes used too late. The management of chemical weed control must be done with great care, there are no products capable of resolving very compromised situations. Therefore, those who want to defend their crops from weeds must necessarily manage them promptly and carefully, otherwise, they risk wasting money, polluting unnecessarily and not obtaining the expected results. The active ingredients available are tribenuron and metasulfuron for dicotyledonous weeds, which also include fumaria. So, they are inhibitors of the acetolactate synthase enzyme and then the others are the classic hormones (2-4D). The thistle was mentioned among the most complicated weeds to manage but Fumaria spp. showed their resistance, first of all. For the thistle, if you want to use that type of product, you must intervene very early, because there is the risk of stimulating growth. Moreover, a participant highlighted that we must use the prescribed herbicide rates; the risk if we do not do so is to further stimulate the resistance of this species. If we have

	to intervene early with both tribenuron and metasulfuron; moreover, they are not always sufficient alone and it is still necessary to add hormones such as 2-4 D and MCPA to eliminate the thistle, because it is necessary to attack the thistle using different mechanisms of action. Here, otherwise, there is a risk that the thistle will not be eliminated, or - but this is a not-so-agroecological practice - using products to be used in very early post-emergence situations, when the crop is just emerged (second, third, fourth leaf stage), using products that have a different mechanism of action and are therefore able to guarantee a residual active ingredient in the soil. Thus, practices that are not ecologically desirable may be useful if we want to escape the phenomenon of resistance in weeds. Some products have a very short life in the soil, so from today and after 15 days, 20 days, a month, we have nothing left. When we intervene with very early post-emergence products, it is clear that they are products that work on the soil, therefore they are either anti-germine or root absorption herbicides, therefore they are products whose active ingredient persists in the soil for a longer period (2, 3, 4 months). These products can solve certain problems with weeds that have gradually become more persistent and have replaced all the other weeds (replacement weeds), which is how sometimes less than ecological practices can come in handy when the situation has gotten out of hand. The picture is complex, but the farmer often knows it better than us. Currently, for the thistle, the solution is to use a mix of pre-emergence or very early post-emergence products with different mechanisms of action. Therefore, the mechanism of action is no longer systemic but with an anti-germine or radical absorption action.
	3. Do you use pre-emergence, post-emergence or both herbicides?
	For triticale, post-emergence herbicides are mainly used. A participant said that it is important to take into account the timeliness and need to carry out chemical weed control at very precise times, when the plants to be weeded are in a young phase, in which they are susceptible to the herbicide, because if we wait too long, we can even double the herbicides rates for the thistle, but nothing happens. Unfortunately, when we are on clay soils that have poor bearing capacity it is not possible the distribution of herbicides. We happened to have extremely rainy autumns after sowing and not be able to get machinery into the field, so we didn't weed because the conditions weren't right. It's different if we're on sandy soil. There may be this

	additional problem; so any alternative system to the chemical that requires all this expertise is welcome.
	4. Are herbicides efficient?
	The herbicides used in triticale are effective but depending on the active ingredient and the used rate.
	5. Do you think that alternatives to herbicides are equally efficient?
	A participant in the meeting indicated that saying that agroecological alternatives are equally effective seems a bit risky, but they can be experimented with. It's best to try them first. Even false sowing can be done with some varieties of triticale. Some strategies work with some varieties, especially with alternative ones, totally alternative and early. For example, if there is not a too insistent infestation, additional and quick-acting nitrogen can be administered to stimulate the tiller elongation process which is very fast in certain varieties and may ooverwhelm the weeds, due to also to their tiller height. On the other hand, he does not fertilize those varieties which are very fast growing and which manage to compete quite effectively with weeds. For thistle it is a different matter. Another participant indicated that the alternatives will be effective with super-technological machines that will take the place of chemical weeding methods. Moreover, nowadays, with research and technology, farmers can weed with less impact on the environment using cutting-edge sprayers or weeders, harrows and other equipment to eliminate weeds mechanically. In addition, there is special machinery for alternative weeding.
	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?
	A participant in the meeting believes that in Sardinia the problem, i.e. the use of herbicides and their rates does not have global implications on the quality of the water and the health of the soil because we use little of it. According to this participant, the crop that uses herbicide most heavily is corn and, in that context, (intensive system) there may also be some problems because corn is always associated with irrigation, with possible problems of leaching, percolation of the active ingredients, therefore to pollute the groundwater. However, there is no problem with biodiversity, we use herbicides in a non-massive manner and not in all areas to impact biodiversity; we have

	a very rich seed bank and high biodiversity. He thinks that agroecological management is more important where biodiversity is lower (e.g. probably the same Northern Europe sites of the project, or even more so in Australia) where there it could be some biodiversity problem, but I don't think we have this problem. Another participant agrees with this opinion because in Sardinia it is common to do chemical weed control on cereals in a single application and with reduced dosages. Instead, in other parts of Italy, France or other areas, in short, they also apply with two and three treatments. Another farmer said that he uses herbicides responsibly, and he is aware of the impact on the environment. In previous experiences on the artichoke farm of his family he had noticed the massive and indiscriminate use of pesticides by sharecroppers.
	7. Do you believe that agriculture without herbicides is viable?
	A participant thinks that It's not possible an agriculture without herbicides. However, another participant said that depends on the sector. That is, the livestock farms he visited do not use weed control and the livestock sector is the most widespread in Sardinia. The situation is different if we move on to more intensive systems, such as corn and vegetables, where working without herbicides is challenging. Other participants are optimistic about the feasibility of agriculture without herbicides because today we have the technology to be able to do it.
What are the needs and barriers to assist agroecological transitions & adopt agroecological weed management approaches?	1. What is needed to boost the uptake of agroecological practices?
	Knowledge and dissemination of practices at the farm level to farmers and breeders. Moreover, it is important to take into account that the consumers decide whether or not to adopt agroecological practices.
	2. What are the barriers towards agroecology implementation?
	In Sardinia, at least for extensive and non-irrigated crops, for example, cereals weed pressure is closely linked to the Mediterranean climate trend, which is quite inconstant, with ups and downs in terms of rainfall and temperature. Furthermore, the picture is worsened by climate change. For example, in the past year, at least in the Nurra area of North Sardinia, the rain arrived when plants were in the ripening phase (end of May); as a result, some weeds have prolonged, when present, their activity and competitive pressure. Furthermore, we have in Sardinia, this is in some ways fortunate, a large seed

	bank that decides to wake up depending on the vagaries of the weather. This complicates management. Moreover, obstacles are linked to ourselves; they are the people who don't want to change. We need to leave room for the new generations. Agroecology is poorly adapted to large agricultural farms.
	3. Should policies need be redefined to allow agroecological transitions?
	A participant in the meeting indicated that the system of subsidies with incentives per hectare is profoundly wrong, or at least exclusively per hectare, because very often, taking the ideological concept to the extreme, it is interpreted at least for some crops as doing nothing, not intervening on the crops. This is profoundly wrong because if we want to be honest, it ends up that all the taxpayers of the European Union put in a lot of money for a few quintals of product. When you grow crops where organic is interpreted, you don't produce on that hectare. However, around 200 euros per hectare are spent by taxpayers. The new system must be incentivized for production. Another participant added that the main recipients of organic farming, are the landowners, so paradoxically these incentives often go to replenish the coffers of those who are already rich, of those who perhaps do not practice any cultivation. Finally, it was also indicated that the policies need to be reviewed. The new CAP imposes on us eco-schemes that are not feasible (e.g. they do not provide intercrop cover crops in the two-year period between wheat and corn.
	4. How confident you feel about the adoption of agroecological weed management practices?
	A participant indicated that If by security we mean the agronomic crop result, therefore economic, it is clear that the uncertainty exists and is high and for everything we have, for a series of reasons which are in some ways also characteristic of our island in middle of the Mediterranean. Another person said that he feels safe, that is, capable of carrying out agroecological management. The problem is the cost of new agricultural machinery (e.g. latest generation harrow). The Sardinia region has not encouraged this change.
What are the main drivers of weed dispersion (e.g.,	1. What are the main drivers of weed dispersal?
	We are in an agropastoral system so the same ewe spreads a lot of it both with its faeces (as undigested seeds) and with its fleece. Furthermore, the distribution of late cut hay

mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	containing mature seeds constitutes an excellent vector for the spread of weeds. This is a big problem. Moreover, other factors that can favour weed dispersal are the use of non-pure seeds, the use of non-certified seeds produced on the farm, the lack of weeding and mowing, the use of unclean self-produced seeds and uncleaned agricultural machinery.
	2. Which are the major and most noxious weeds in your area?
	Important weeds are: thistle, *Chrysanthemum*, mustard, horseradish, knotweed, poppy, *Matricaria*, milk thistle (particularly where there is nitrogen), *Inula*, *Galium*, cruciferous plants, chamomile and *Veronica*, among the grasses wild avena and wild *Hordeum*, *Agrostis* and *Bromus*.
	3. Are there any herbicide resistant weeds?
	Yes, the main weed in Sardinia, I think also in Italy, is always the poppy and therefore the poppy weed, very difficult and also resistant to sulfonylureas which are those which for about twenty years they had almost wiped the cereal off. The poppy was selected by the use of hormones, therefore 2-4 D. The new molecules made it disappear for about twenty years, now it is slowly reappearing and is becoming complicated to manage. Also *Amaranthus* spp. is a herbicide resistant weed.
	4. Do you know any invasive plants in your area?
	Hemp lately, *Inula*, *Centaurea diluta*, *Ailanthus*.
What do you think about the Living Lab?	1. Which proposals do you have for a good performance of the LL?
	A participant indicated that in his opinion it would be very interesting. With respect to the integrated management of weeds, because here in the Mediterranean environment we have and today some peculiarities have emerged and some problems in other areas will have different problems and therefore a comparison with other countries and living labs of the project would be very interesting. Another participant said that he is fresh from a four-year European project, he did living labs every year and he must tell the truth, it was very constructive because it was a Mediterranean-wide project and with these Living Labs, having direct interaction with businesses and with the stakeholders, practically from a research point of view we have learned a lot and have given an answer to the real problems of different production realities. Furthermore, these Living Labs have given rise to problems that perhaps some

	countries have today, and we don't have them, but we have found solutions that we have developed together with the other project partners. These Living Labs no longer aim to carry out abstractive research in themselves but to provide answers to problems. If those who actually should benefit from the answers from the research are directly involved, the Living Lab in this case is very interesting. In the living labs that we did, it was always a Living Lab linked to the sustainability of agriculture, but it was linked to the recovery of waste from the agro-industry, in this case here it is always for sustainable agriculture. But starting from the problem on the field is certainly very interesting. I think we chose to use triticale because it allows for multiple uses. It is also considered a very resistant plant which has been studied for many years because I remember when I was a student in the 80s in Cagliari (South Sardinia) we did a lot of tests with triticale and it was very promising but perhaps in those conditions (in the 80s the rains were more regular and abundant compared to today) so the results were good. Today we have a greater quantity of triticale varieties than in the past and above all we are heading towards a period of climate change there is a shift in rainy periods and therefore it is important to have a wide range of triticale varieties to choose.
	2. Would you like it to remain over time?
	Yes,yes yes …

2.1.1.3 Wheat (Greece)

2.1.1.3.1 Questionnaires

The wheat questionnaires provided insights regarding five AWM techniques, including herbicides, mechanical weeding, mowing, site-specific spraying, and UAV. Only herbicides garnered responses from all stakeholder groups. A detailed breakdown of stakeholder participation in the questionnaires for distinct AWM practices is provided in Table 24.

Table 24 Number of responses for each AWM practice and stakeholder category in wheat

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control						
Biobased herbicides		2	1			

Cover crop inoculation to increase competitiveness						
Cover crop	1	1				
False seedbed	1					
Grazing	1		2		1	
Herbicides	**6**	**9**	**4**	**4**	**4**	**3**
Intercropping						1
Mechanical weeding	**4**	**5**	**4**		**3**	**3**
Mowing	**3**	**3**	2		1	
Mulching						
Natural enemies						
Other						
Site-specific spraying	2	**3**	2		2	
Thermal weeding						
UAV	**3**	2	1	2		1
n=34	6	11	4	4	4	5

2.1.1.3.1.1 Herbicides

2.1.1.3.1.1.1 Advisors

Advisors generally express a pessimistic outlook on herbicide opportunities, as none of the queried factors were considered highly relevant by more than one-third of the respondents, notably business profitability and income increase. The main need, as expressed by 83% of advisors, was cost reduction, followed by 50% of respondents deeming ecosystem services impact knowledge as highly relevant. One-third of advisors considered regulatory changes, management expertise, training, maintenance, and training reduction as highly relevant needs for herbicide use. Advisors stated that the main impediments for herbicide use were the potential harm to the environment and human (67%), its high carbon footprint (50%), and its regulation (33%). The most significant drawbacks with regards to herbicide use were public opposition to their use and the potential harm it may cause to the environment and human, as asserted by 83% of respondents. Half of the advisors expressed concerns regarding the reduction in demand by customers and its high carbon footprint.

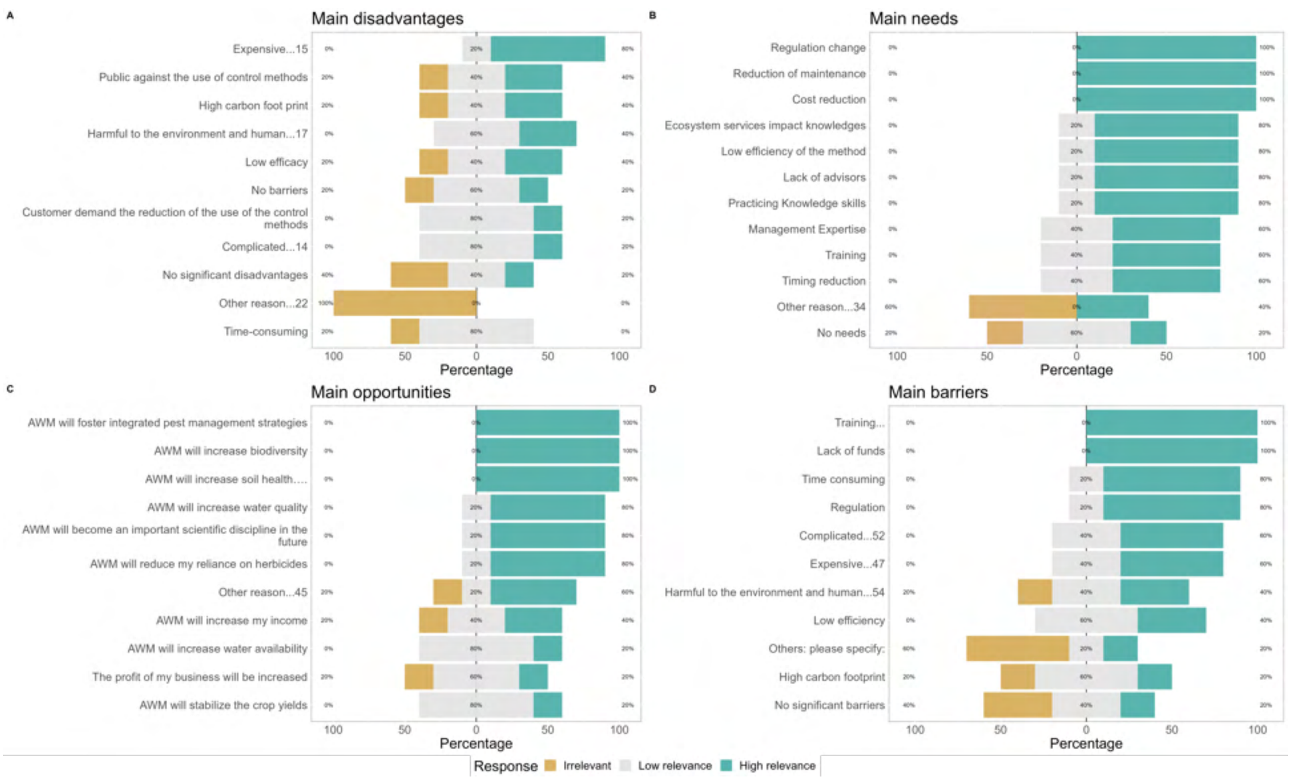


Figure 81 Main disadvantages, needs, barriers and opportunities for herbicides identified by advisors.

2.1.1.3.1.1.2 Consumers

Similar to advisors, consumers hold a pessimistic view on herbicide opportunities, with only 22% of respondents deeming the potential of this practice to stabilize crop yields, increase business profitability, and become an important scientific discipline in the future as highly relevant. Several factors are identified by consumers as main needs in the context of herbicide use: 67% believe that regulatory changes are essential, while more than half consider ecosystem impact knowledge and maintenance and cost reduction as key necessities. Additionally, one-third of consumers express that the lack of advisors and timing reduction are highly relevant needs. Similar to advisors, a significant proportion of respondents identify the potential harm to the environment and humans as the main impediment, with 78% expressing this concern. Additionally, the high carbon footprint and regulatory challenges are deemed relevant by more than half of the respondents. Training and expense are considered relevant by 44% and 33% of consumers, respectively. The expressed main disadvantages align with the advisors' view, as 78% of consumers cite harm to the environment and humans, and 44% consider that the public is either against or demands a reduction in herbicide use. One-third of respondents also consider the high carbon footprint as a highly relevant drawback.

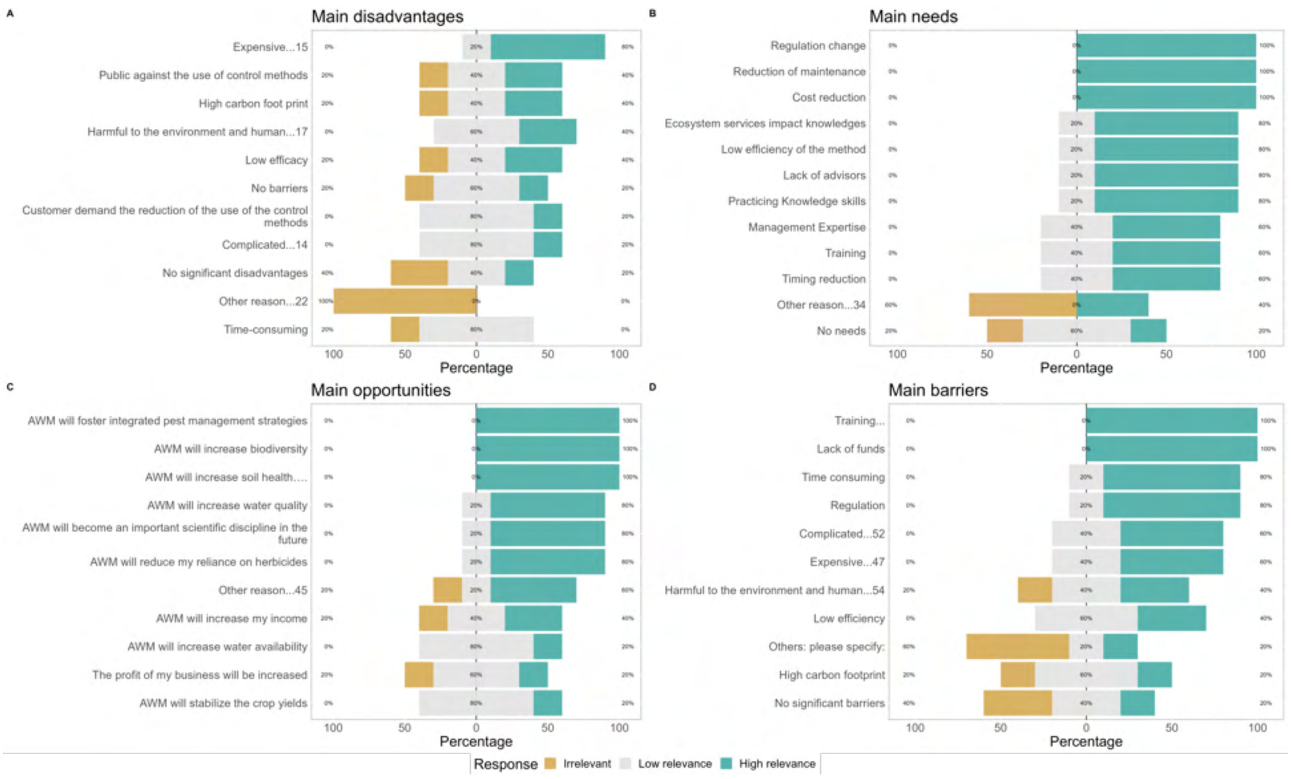


Figure 82 Main disadvantages, needs, barriers and opportunities for Herbicides identified by consumers

2.1.1.3.1.1.3 Farmers

Farmers align with advisors and consumers in their perspective on herbicide-related opportunities, with only 25% considering all queried factors highly relevant. Key needs for farmers in this practice include the lack of advisors and cost reduction, highlighted by 75% of respondents. Over half of the farmers emphasize the importance of changes in regulation, practicing knowledge skills, management expertise, and training as relevant requirements. The potential harm to the environment and humans is deemed a highly relevant barrier by 75% of farmers, aligning with the views of consumers and advisors who consider this factor the most important impediment. Half of the interviewed farmers point to regulation challenges in herbicide implementation. There is unanimous agreement among farmers that public opposition to herbicides and the potential harm to the environment and humans are highly relevant drawbacks, consistent with the perspectives of advisors and consumers. Additionally, 75% of farmers express a significant concern about the reduction in herbicide demands from consumers.

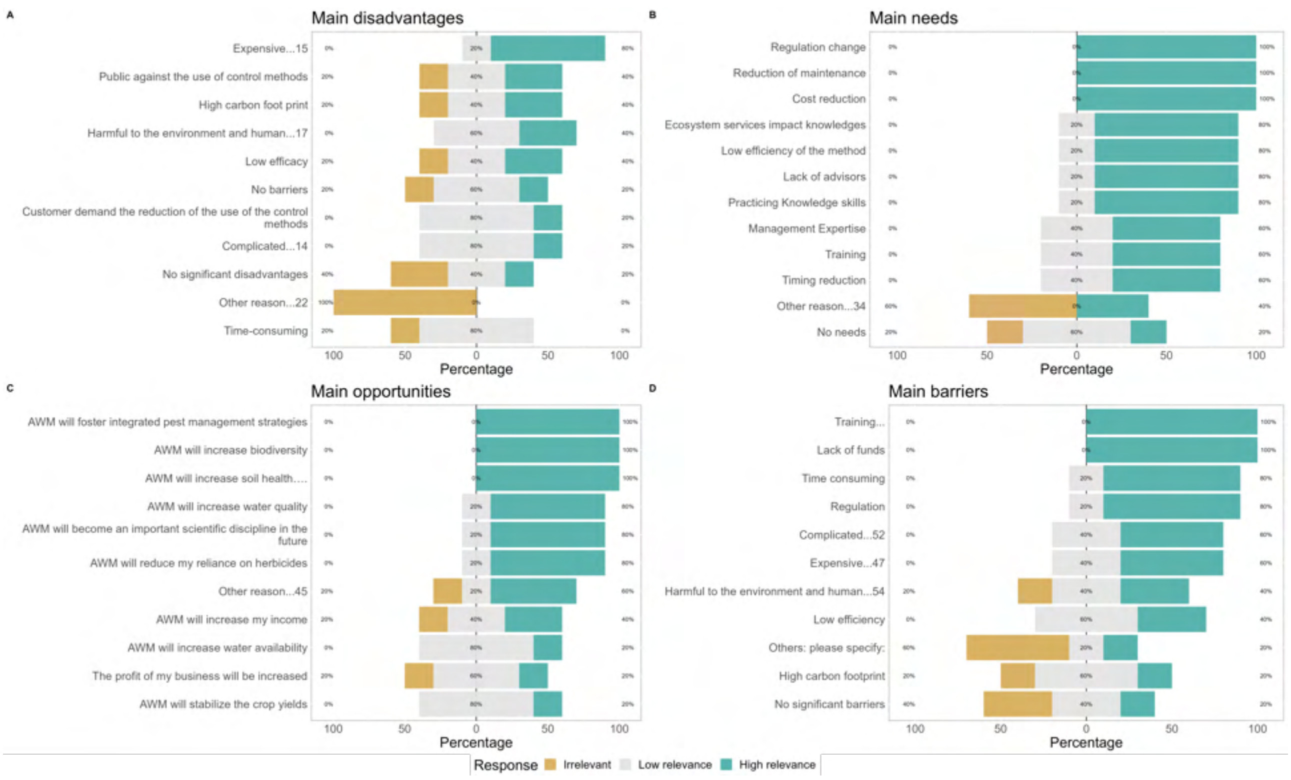


Figure 83 Main disadvantages, needs, barriers and opportunities for herbicides identified by farmers

2.1.1.3.1.1.4 Industry

Industry representatives present a relatively positive outlook on herbicide opportunities compared to advisors, consumers, and farmers. Half of the respondents believe that herbicides can increase business profitability and stabilize crop yields, with a quarter stating that herbicides could become an important scientific discipline and lead to an increase in farmer's income. Regulatory changes are unanimously cited as the most relevant requirement for herbicide use, emphasizing the importance of a supportive regulatory environment. Three-quarters of the industry representatives express the need for more knowledge regarding ecosystem services impact knowledge. Additionally, half of the industry representatives identify maintenance and cost reduction as relevant requirements for herbicide use, underlining practical considerations. Unanimously, industry representatives agree that high carbon footprint and harm to the environment and humans are the main impediments to this practice, aligning with the views of advisors. The main disadvantages highlighted by this stakeholder group coincide with those expressed by advisors, consumers, and farmers. However, a unique perspective emerges as all industry representatives unanimously agree that customer demands for either elimination or reduction, the high carbon footprint, and the environmental and human harm are highly relevant drawbacks, reflecting the importance of addressing public concerns and preferences.

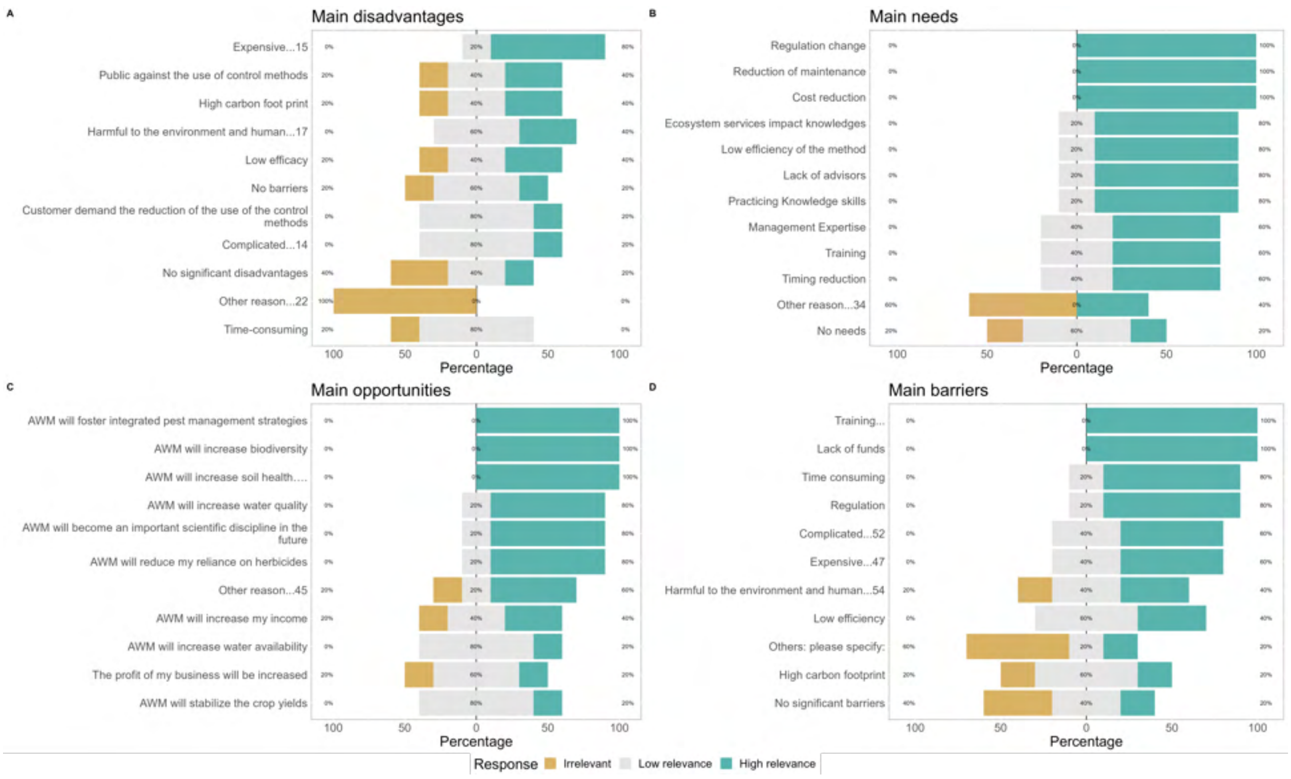


Figure 84 Main disadvantages, needs, barriers and opportunities for herbicides identified by industry.

2.1.1.3.1.1.5 Policy makers

Policy makers' perspectives on herbicide opportunities were evenly distributed between the categories of irrelevant and highly relevant. Half of the respondents believed that herbicide use would foster IPM, water quality, biodiversity, soil health, and had the potential to become an important scientific discipline in the future. This indicates a split sentiment among policy makers, with half aligning with other stakeholders in recognizing relevant opportunities. In terms of needs, half of the policy makers agree with advisors, consumers, and industry representatives in considering ecosystem services impact knowledge as a key requirement for herbicide use. Additionally, they emphasized the importance of training in meeting the requirements for herbicide use. Policy makers identified several factors as important barriers, and their ranking was unique compared to the relatively homogeneous responses from other stakeholders. Training and lack of funds (75%) were deemed the main impediments, followed by environmental and human harm, considered important by only 50% of respondents. Additionally, half of the policymakers emphasized the complexity of the practice, time consumption, and expense as relevant barriers. Despite considerations of barriers, policy makers unanimously agreed that environmental and human harm was the main disadvantage, aligning with the trend expressed by other stakeholders. Notably, only 50% of policy makers considered public demand to either eliminate or reduce herbicides and their high carbon footprint as relevant factors in herbicide use, in contrast to the higher proportion of other stakeholders who found these factors more relevant.

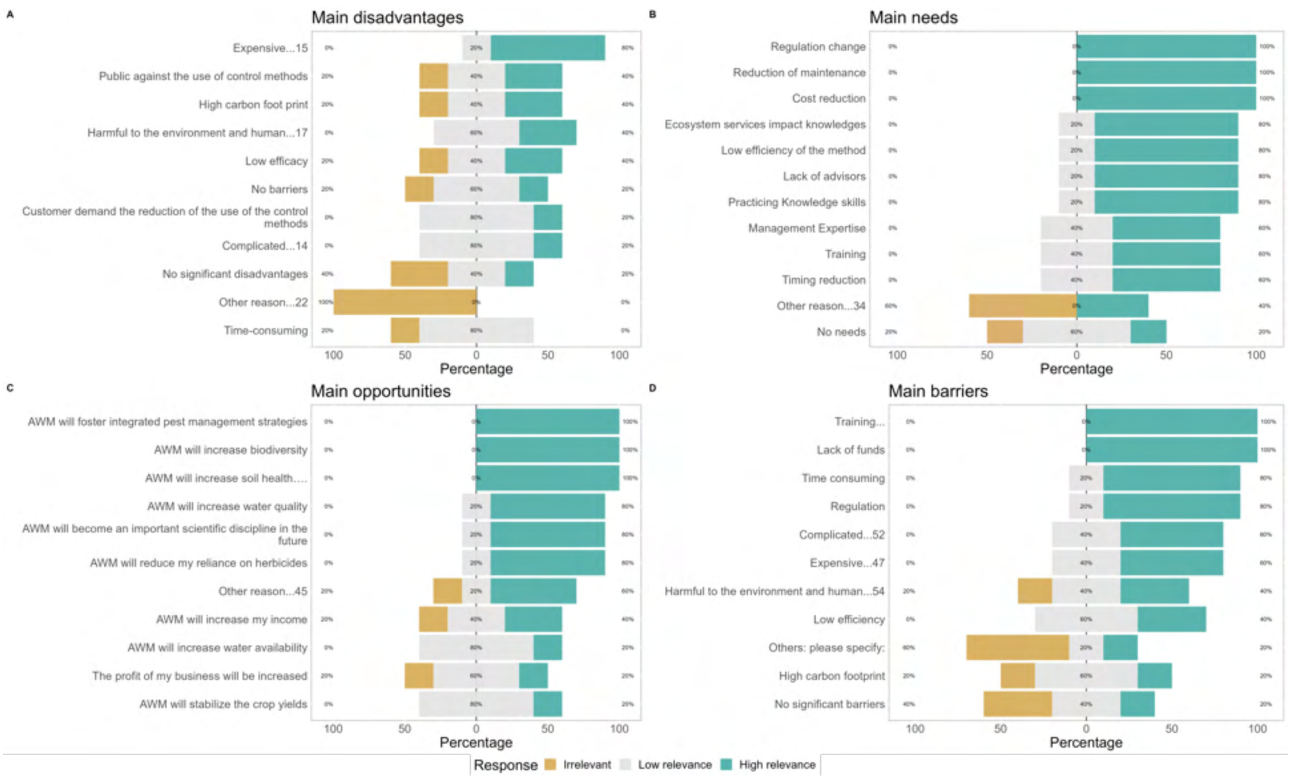


Figure 85. Main disadvantages, needs, barriers and opportunities for Herbicides identified by policy makers.

2.1.1.3.1.1.6 Researchers

Researchers share a perspective on herbicide opportunities that aligns with policy makers, as a substantial proportion of both groups see significant opportunities in this practice. Sixty-seven percent of researchers believe that herbicides will evolve into an important scientific discipline, contributing to increased business profitability, farmers' income, and stabilized crop yields. Similarly, regulatory changes and cost reduction are identified as key factors, highlighting the importance of supportive regulations and practical considerations in herbicide use. One-third of researchers, in harmony with other stakeholders, emphasize various herbicide-related needs, including ecosystem services impact knowledge, practicing knowledge skills, management expertise, and reduction of maintenance. As with all stakeholders except industry representatives, the main barrier to herbicide use perceived by researchers is harm to the environment and humans. Additionally, one-third of researchers highlight high carbon footprint, complexity, training, lack of funds, and regulation as relevant impediments. Researchers, in consensus with other stakeholder groups, unanimously agree that harm to the environment and humans is the primary concern associated with herbicide use. Sixty-seven percent of respondents emphasize that customer demands to either eliminate or reduce herbicides, along with their high carbon footprint, represent significant drawbacks to their implementation.

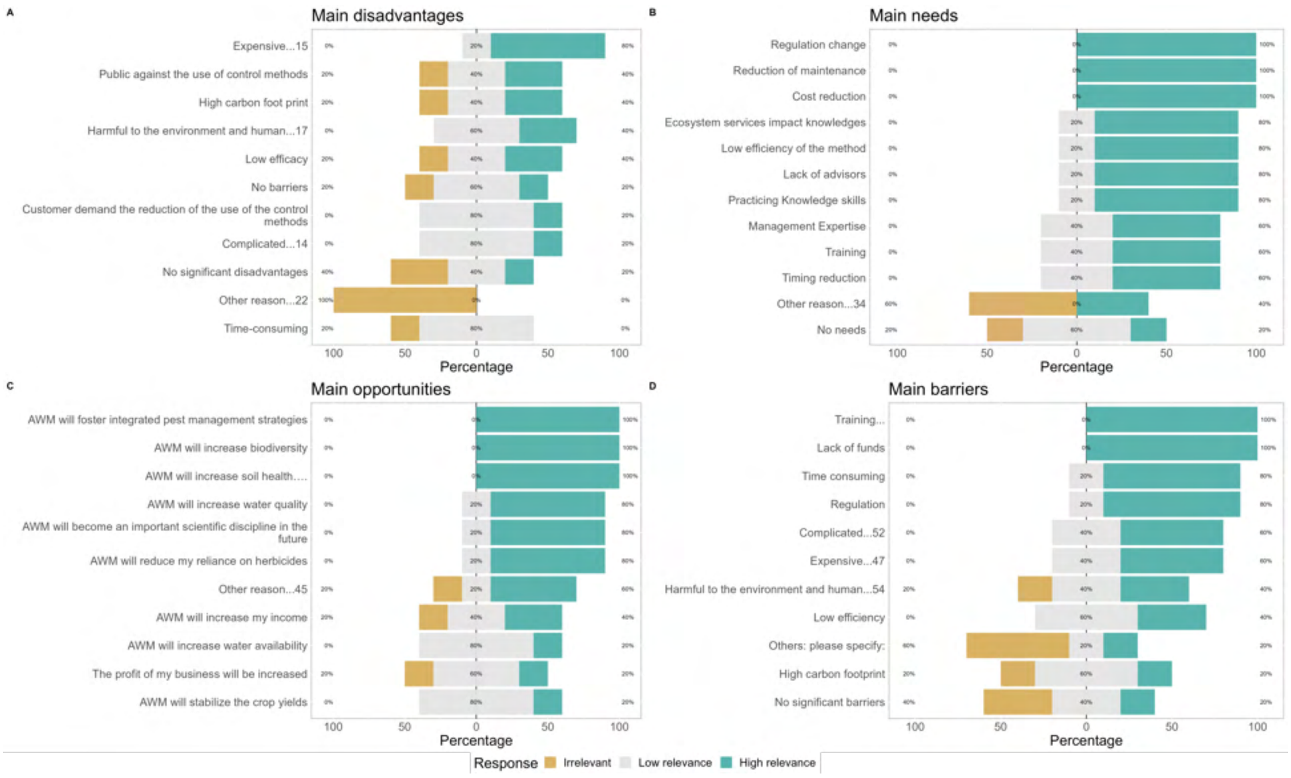


Figure 86. Main disadvantages, needs, barriers and opportunities for herbicides identified by researchers.

2.1.1.3.1.1.7 Conclusions

Farmers, advisors, and consumers collectively share a pessimistic view on herbicide-related opportunities. In contrast, industry representatives, policy makers, and researchers hold a more optimistic perspective, partially considering the practice to increase business profitability and stabilize crop yields, foster IPM, and potentially evolve into an important scientific discipline. Stakeholders consistently express, in varying proportions, that cost reduction and regulatory changes are highly relevant needs for herbicide use. Additionally, over half of advisors, consumers, industry representatives, and policy makers emphasize the necessity of ecosystem services impact knowledge.

Regarding main barriers, advisors, consumers, farmers, industry representatives, and researchers unanimously identify environmental and human harm as the most relevant factor. Regulation and high carbon footprint are also cited by most stakeholders as significant impediments to herbicide use. Notably, only half of surveyed policy-makers do not perceive environmental and human harm as a highly relevant challenge. Almost all stakeholders agree that harm to the environment and humans, customer demands to either eliminate or reduce herbicides, and high carbon footprint are relevant impediments to herbicide use, with at least 50% agreement in each group.

2.1.1.3.1.2 *Mechanical weeding*

2.1.1.3.1.2.1 *Advisors*

Advisors did not find any of the queried opportunities highly relevant, with only half considering mechanical weeding as potentially stimulating IPM strategies, reducing herbicide reliance, and increasing water quality. Among the identified needs, practicing knowledge skills was deemed most relevant by 75% of respondents, followed by ecosystem services impact and timing reduction, considered relevant by half of the surveyed advisors. Concerns over mechanical weeding's high carbon footprint were identified as the main impediment by 75% of advisors, with expense also considered significant by 50%. None of the queried disadvantages were deemed as highly relevant by more than half of the sample. However, half of the advisors identified customer demand for reduced use and the high carbon footprint as main drawbacks.

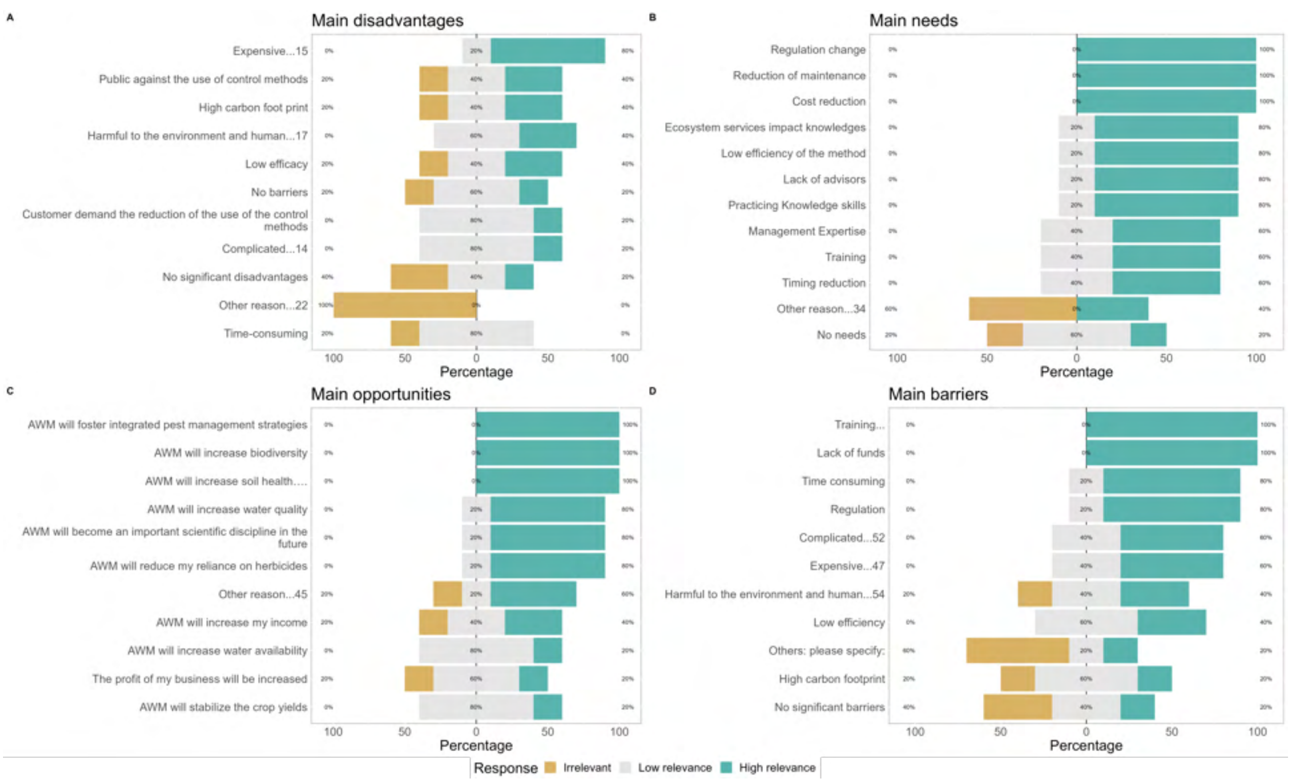


Figure 87. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by advisors.

2.1.1.3.1.2.2 Consumers

Consumers expressed that the implementation of mechanical weeding will reduce herbicide reliance (80%) while encouraging IPM strategies and improving soil health (60%). Forty percent of the respondents stated that this practice represents an opportunity to increase water quality and that it will become an important scientific discipline in the future. Consumers' perceptions about mechanical weeding needs were evenly distributed among relevance categories, with the highest proportion of "highly relevant" responses being 40%. These factors included ecosystem services impact knowledge, practicing knowledge skills, management expertise, and training, among others. The high carbon footprint was deemed as the most relevant impediment to mechanical weeding implementation by 60% of consumers. The perceptions of this stakeholders group with regards to its main disadvantages were also evenly distributed, with 40% of consumers stating that the main disadvantages were customer demands for its reduction, the expense, and the environmental and human harm.

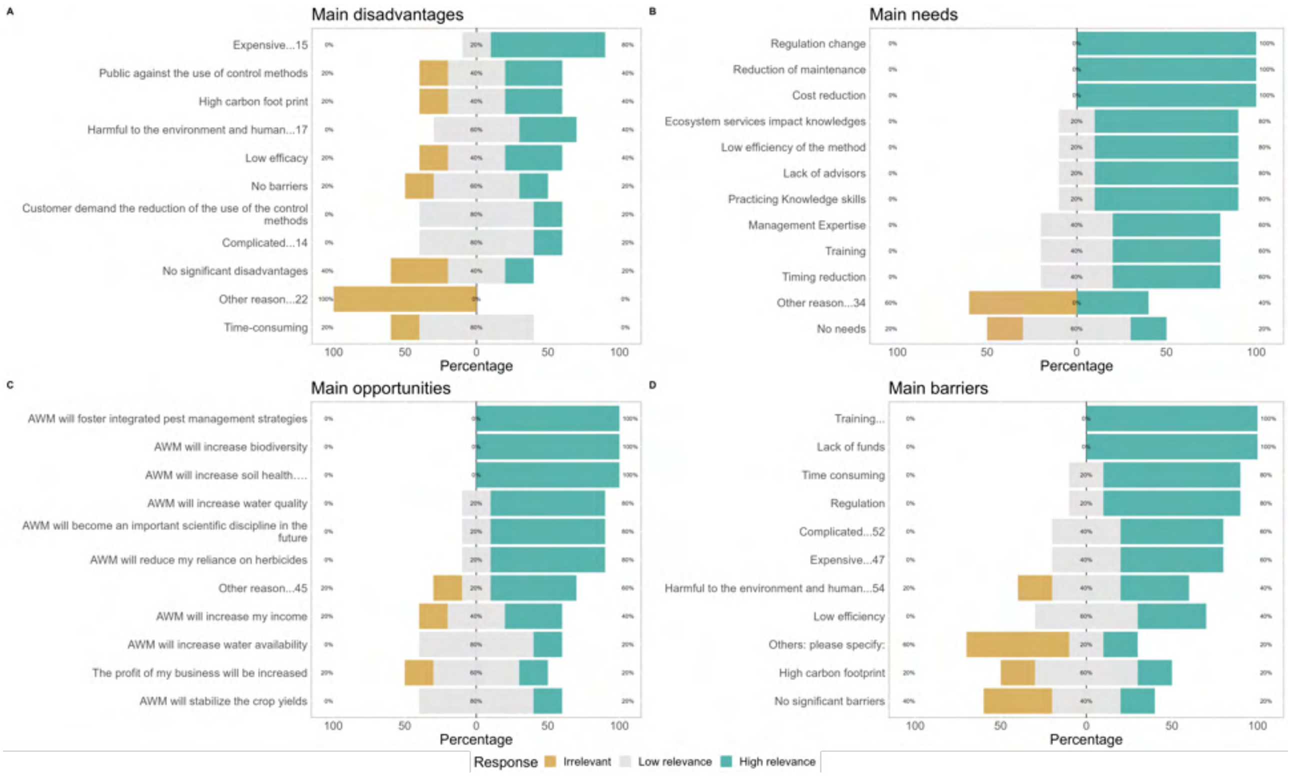


Figure 88 Main disadvantages, needs, barriers and opportunities for Mechanical weeding identified by consumers.

2.1.1.3.1.2.3 Farmers

Farmers mostly agree that mechanical weeding will promote the use of IPM strategies, with only 25% seeing this practice as a provider of ecosystem services, including improvements in water quality and availability, biodiversity increases, and enhancement of soil health. Half of the respondents identified the main needs for this practice as ecosystem services impact knowledge, cost reduction, and timing reduction. One quarter of respondents pointed to regulatory changes, the method's low efficiency, lack of advisors, practicing knowledge skills, management expertise, and reduction of maintenance as relevant topics regarding this method's requirements. One out of two farmers identified expense and lack of funds as the most relevant impediments, followed by one quarter of the respondents who pointed to a high carbon footprint, training, and regulatory challenges as relevant barriers. Seventy-five percent of the farmers stated that mechanical weeding did not present any significant disadvantages. Fifty percent of them cited as highly relevant the following factors: high carbon footprint, expense, and time consumption.

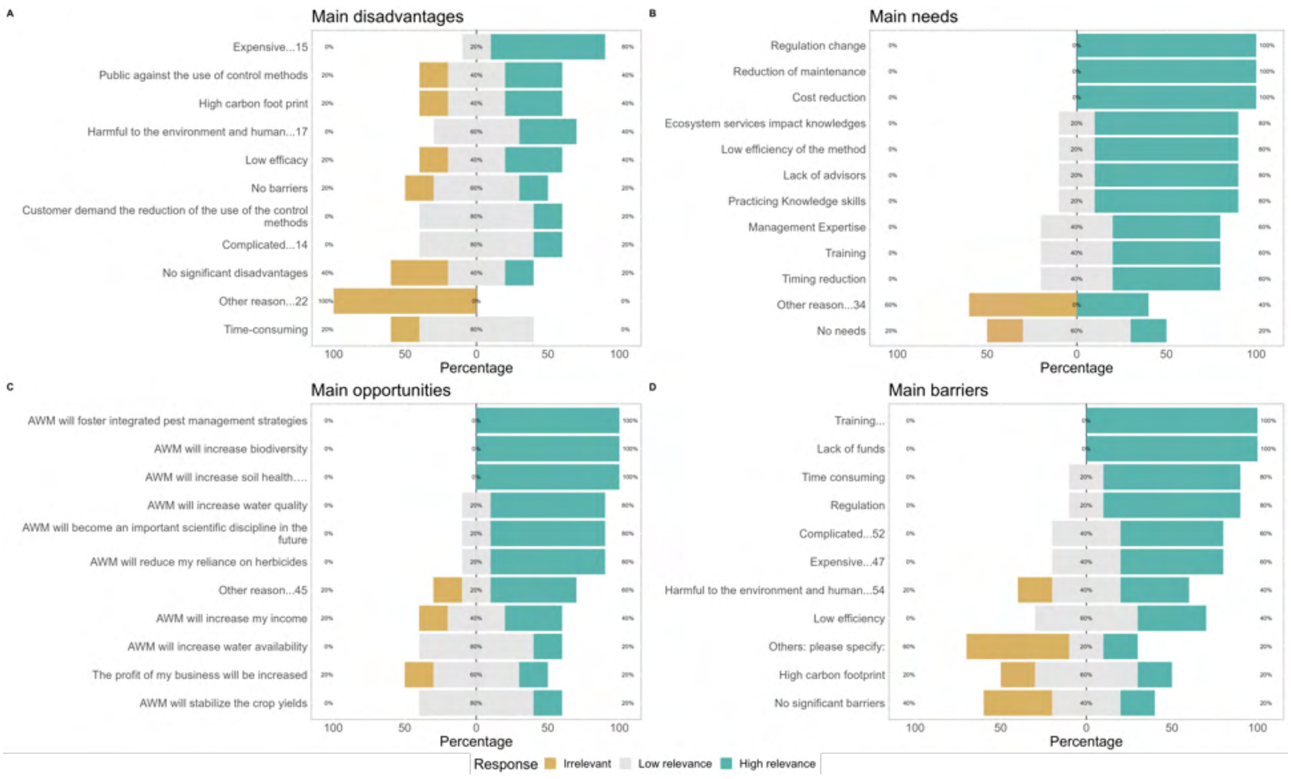


Figure 89 Main disadvantages, needs, barriers and opportunities for Mechanical weeding identified by farmers

2.1.1.3.1.2.4 Policy makers

Policy makers expressed a positive outlook with regards to mechanical weeding opportunities, with sixty-seven percent perceiving that this practice will foster IPM strategies and provide a series of ecosystem services, including an increase in water quality, biodiversity, and soil health. Policy makers view mechanical weeding as a potentially fundamental scientific discipline. Only one-third of policy makers considered three of the proposed needs as highly relevant: ecosystem service impact knowledge, reduction of maintenance, and timing reduction. The main barriers, according to 67% of policy makers, were the lack of funds, followed by one-third of respondents who deemed a high carbon footprint, time consumption, and training as key impediments to implementing mechanical weeding practices. Policy makers considered that the high carbon footprint was the most relevant disadvantage of this technique, with 67% expressing concern with regards to this factor.

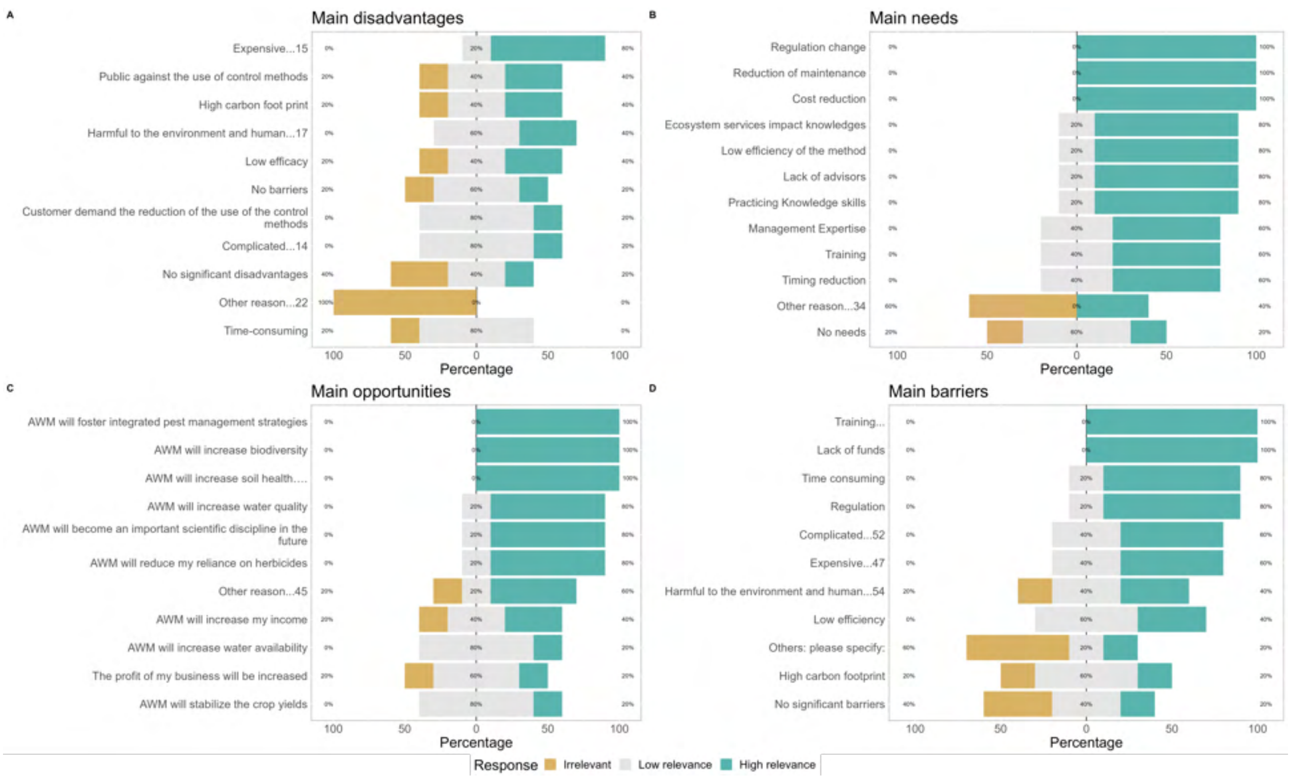


Figure 90 Main disadvantages, needs, barriers and opportunities for Mechanical weeding identified by policy makers.

2.1.1.3.1.2.5 Researchers

Most researchers did not find any of the queried opportunities highly relevant, as only 33% considered that mechanical weeding as a fosterer of IPM strategies while providing ecosystem services (increase water availability and quality, biodiversity, better soil health), evolving into a significant scientific discipline, and stabilizing crop yields as highly relevant factors. Researchers unanimously identify maintenance and cost reduction as the main needs of mechanical weeding, noting that 67% of respondents recognize timing reduction as a relevant need. High carbon footprint (67%), complexity, training, lack of funds, and expense (33%) were deemed as the most important barriers to mechanical weeding implementation. More than half of the surveyed researchers agreed that customer demands for the reduction of this practice, along with its high carbon footprint and time consumption, represent important disadvantages to mechanical weeding use.

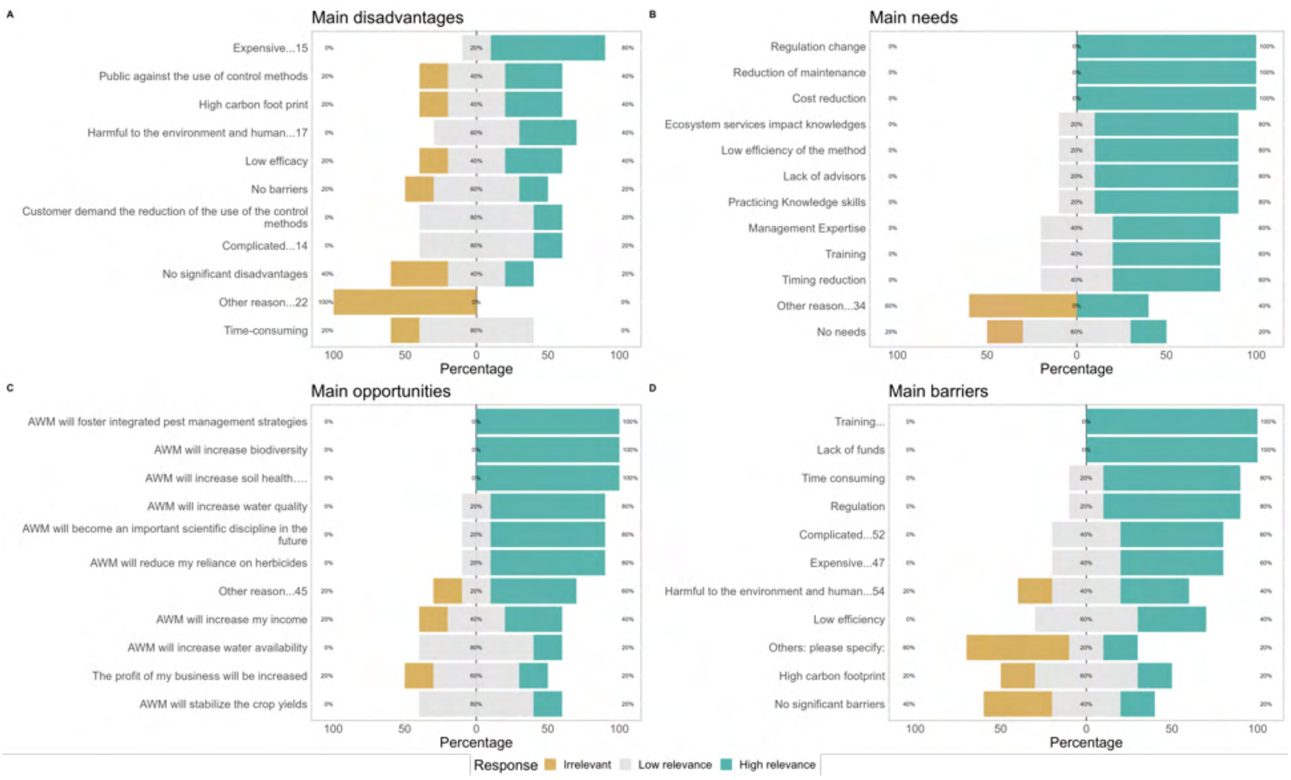


Figure 91 Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by policy makers.

2.1.1.3.1.2.6 Conclusions

Stakeholders, including advisors, consumers, farmers, policy makers, and researchers, exhibit diverse perspectives on mechanical weeding. Consumers and advisors identify that the implementation of this practice will reduce herbicide reliance and agree with farmers and policy makers on its potential promotion of IPM strategies. Most researchers did not find any relevant opportunities. Advisors identified practicing knowledge skills as the most relevant need, which was also deemed as relevant by 40% of consumers. Forty percent of the latter group deemed that ecosystem services impact knowledge as highly relevant. This factor was considered as crucial by half of the farmers and advisors plus one third of the policy makers. Reduction of maintenance, cost, and timing were also stated as relevant necessities by all researchers and half of the farmers and one third of the policy makers. Advisors, consumers, and researchers identified high carbon footprint as the main barrier for mechanical weeding. Expense was deemed as highly relevant by advisors and as the main impediment by farmers, in line with what policy makers expressed as they view lack of funds as the most important barrier. Concerns over customer demand for mechanical weeding reduction are shared between advisors, consumers, and researchers. Besides, a high carbon footprint was considered by a relevant proportion of advisors, farmers, policy makers, and researchers. Lastly, concerns with regards to expense were expressed by consumers and farmers.

2.1.1.3.1.3 Site-specific spraying

2.1.1.3.1.3.1 Consumers

Consumers share a pessimistic outlook with regards to site-specific spraying opportunities, as none of the queried factors was deemed as highly relevant by any of the respondents. Lack of advisors and timing and maintenance reduction were deemed as highly relevant necessities by 67% of consumers. One-third of consumers considered that ecosystem services impact knowledge, regulatory changes, low efficiency, management expertise, and cost reduction were relevant requirements to implement site-specific spraying. Consumers unanimously agreed that environmental and human harm was the highest relevant barrier, followed by a high carbon footprint and expense (67%). One out of every three respondents considered that training, lack of funds, and regulation were relevant impediments to site-specific spraying use. Main disadvantages were the public demand to either eliminate or reduce the use of this practice, high carbon footprint, and the potential harm to the environment and human health by one-third of respondents.

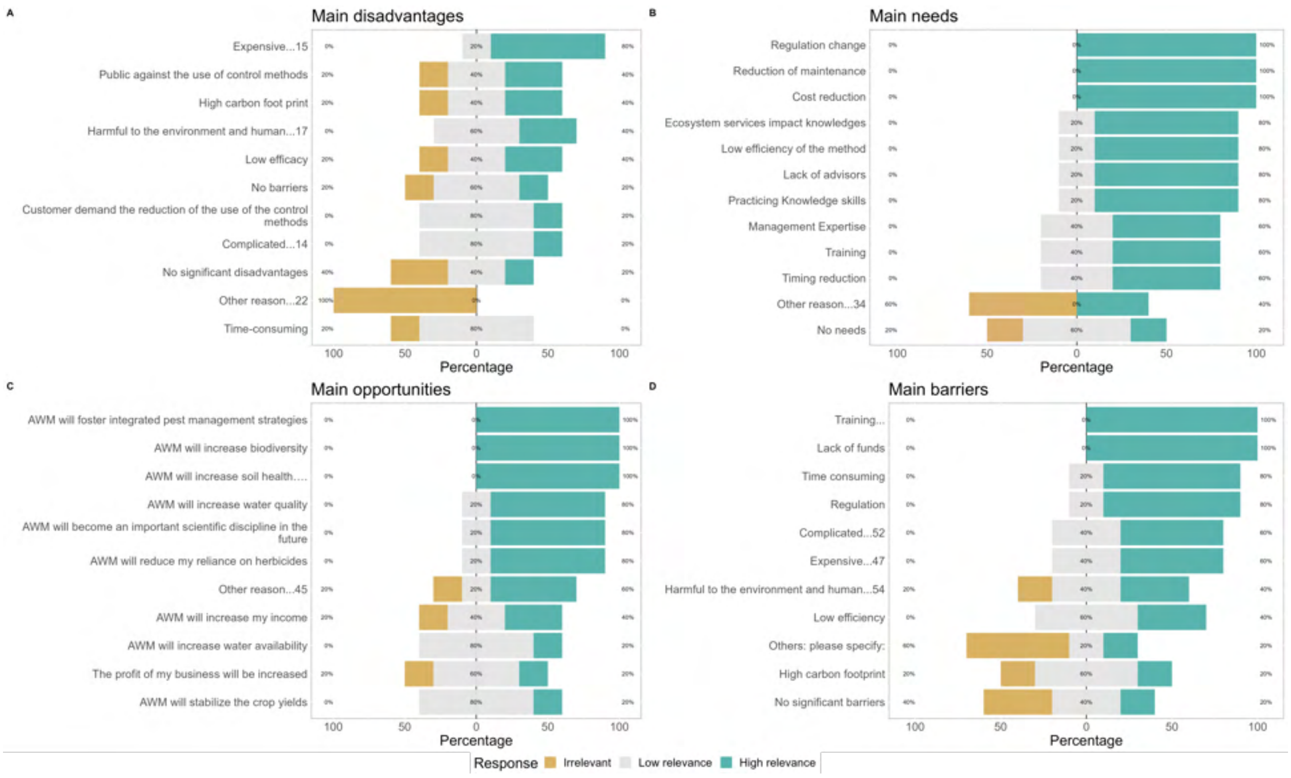


Figure 92 Main disadvantages, needs, barriers and opportunities for Site-specific spraying identified by consumers.

2.1.1.3.1.3.2 Conclusions

Consumers express a pessimistic view on site-specific spraying, deeming no factors highly relevant. Key needs include advisors, timing, and maintenance reduction. Environmental and human harm is unanimously identified as the primary barrier, followed by a high carbon footprint and expense. Training, lack of funds, and regulation are additional impediments. Main disadvantages include public demand for reduced use, high carbon footprint, and potential harm to the environment and human.

2.1.1.3.1.4 UAV

2.1.1.3.1.4.1 Advisors

Advisors' views on UAV-related opportunities were evenly distributed, with only one-third identifying fostering IPM strategies, providing ecosystem services, evolving UAV into a scientific discipline, increasing business profitability and income, and reducing herbicide reliance. Respondents considered UAV-related needs more relevant, including ecosystem services impact knowledge, regulatory changes, management expertise, training, and timing reduction, as stated by 67% of respondents. When analyzing the main barriers, a similar pattern to opportunities emerged, with most factors deemed highly relevant by 33% of respondents, including environmental and human harm, practice complexity, time consumption, training, lack of funds, regulation, and expense. Complexity, expense, and environmental and human harm were identified as the main disadvantages by 67% of respondents.

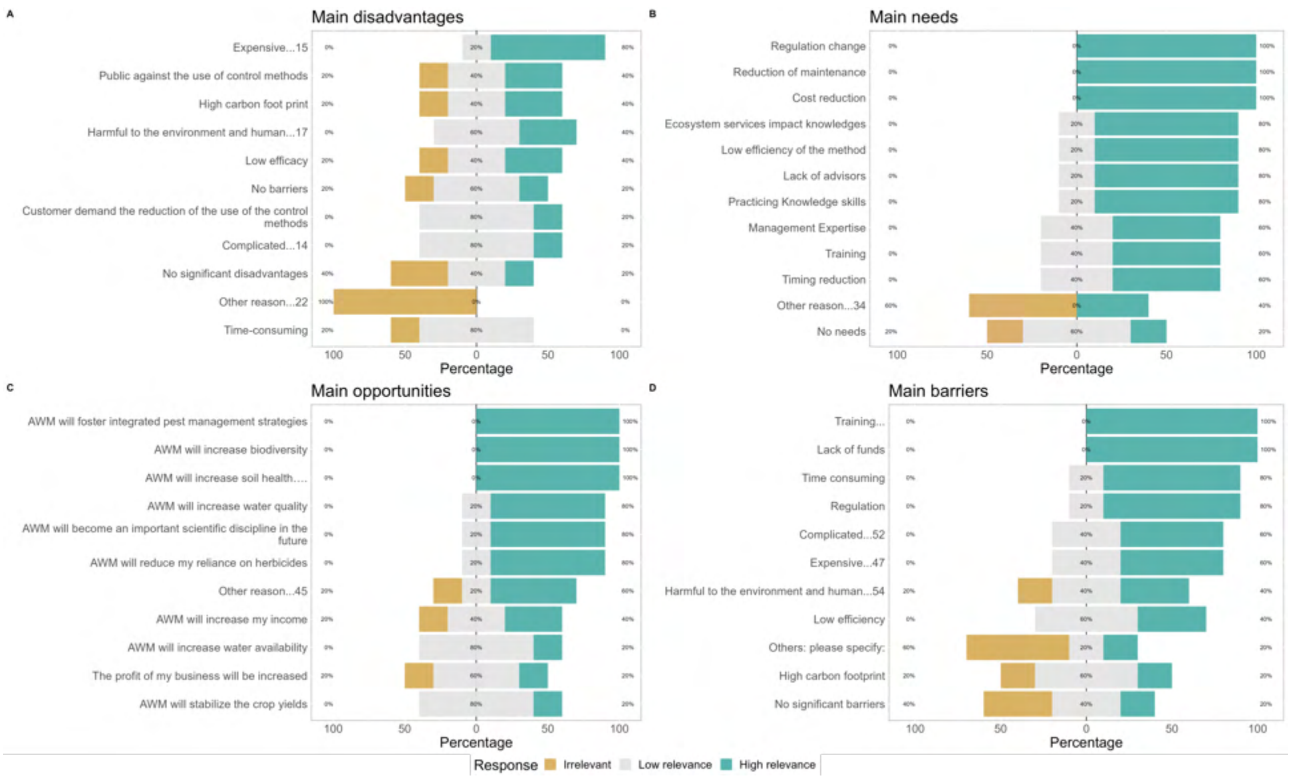


Figure 93 Main disadvantages, needs, barriers and opportunities for UAV identified by advisors.

2.1.1.3.1.4.2 Conclusions

Advisors show a nuanced view on UAV opportunities, with one-third recognizing its potential. Key needs include ecosystem impact knowledge and regulatory changes, while barriers and disadvantages, such as environmental harm and expense, align with the distributed nature of opportunities. This suggests a cautious yet informed stance among advisors on UAV integration in agriculture.

2.1.1.3.2 Surveys

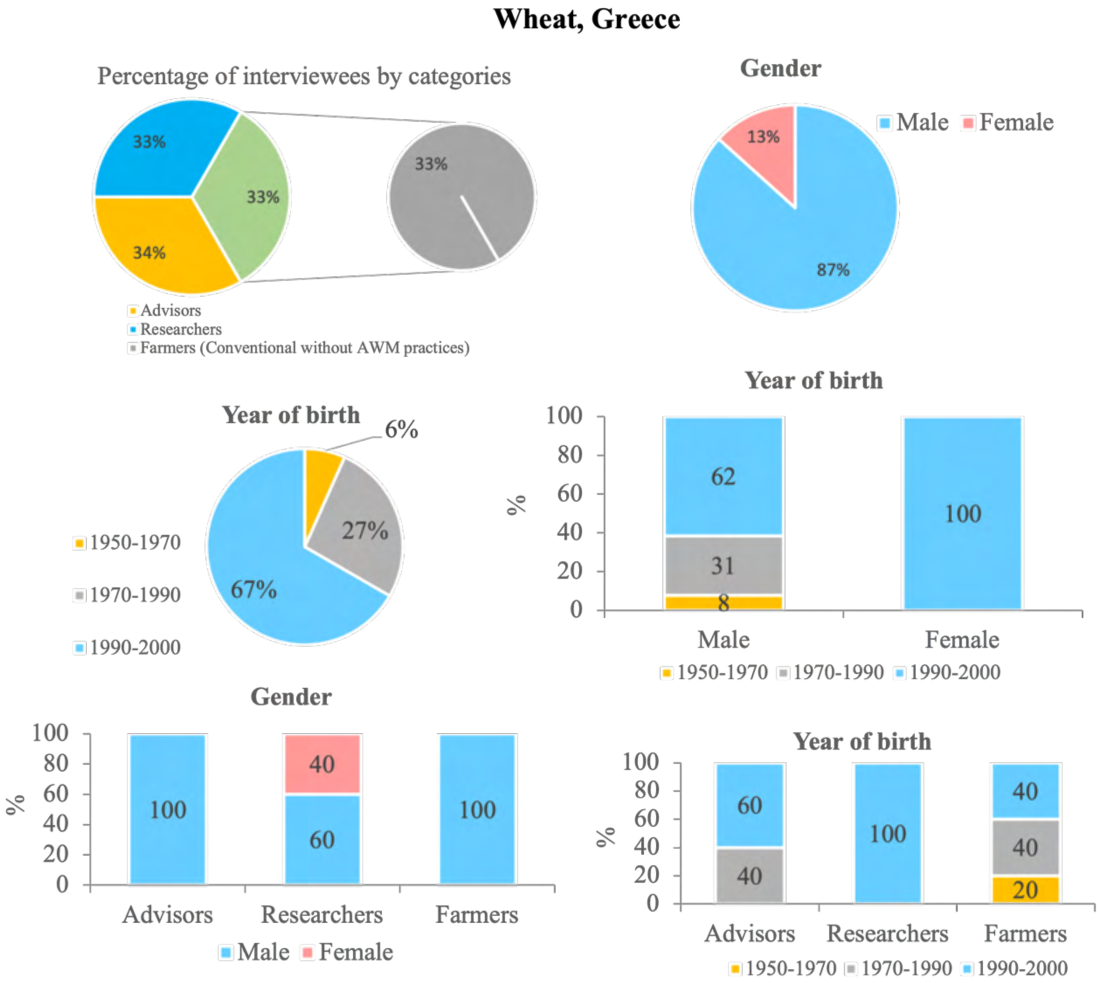


Figure 94 Interviewees description in the Wheat Living Lab (Greece)

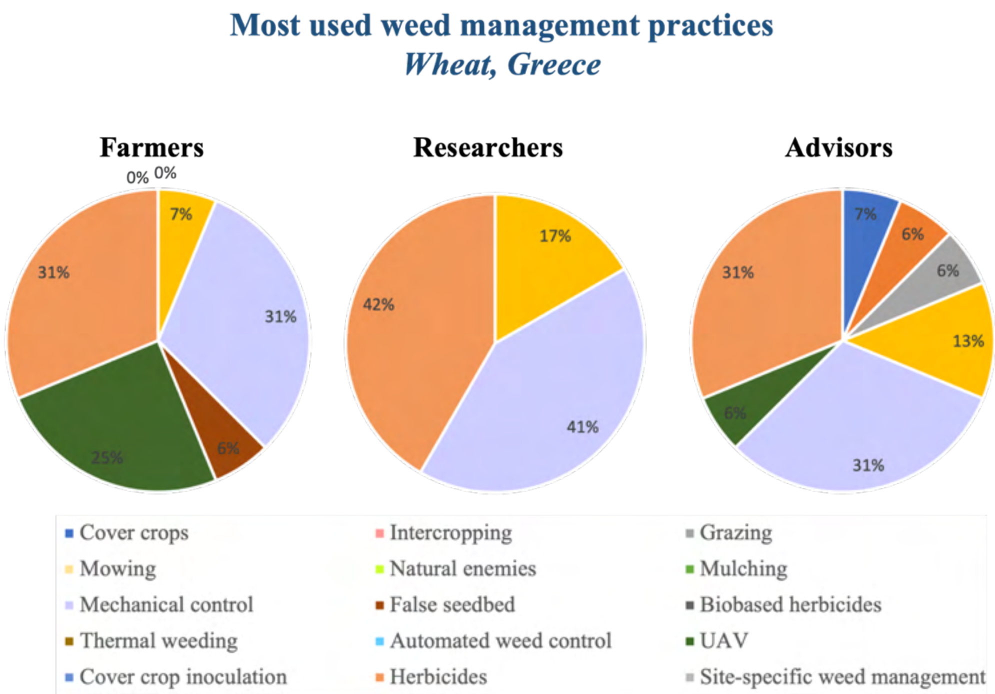


Figure 95 Most used weed management practices in the Wheat Living Lab (Greece)

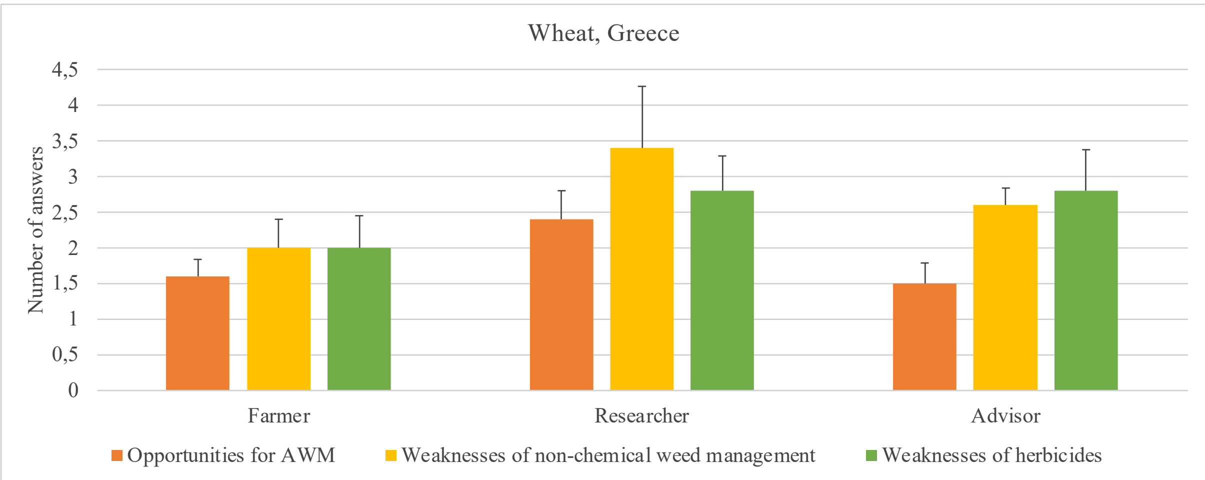


Figure 96 Mean number of answers (±se) per stakeholder group in the Wheat Living Lab (Greece)

Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: There were only a few answers to the question of strengths of AWM. In particular, combination of strategies and cost-effectiveness were considered strengths.

THREATS: None.

WEAKNESSES: Researchers did not present any weaknesses of AWM. However, advisors considered that the cost of applications, soil pollution-disturbance, risks to human health, and certificates needed are considered weaknesses for certain AWM practices. From the farmers group, effectiveness and need for certificates were the only two responses.

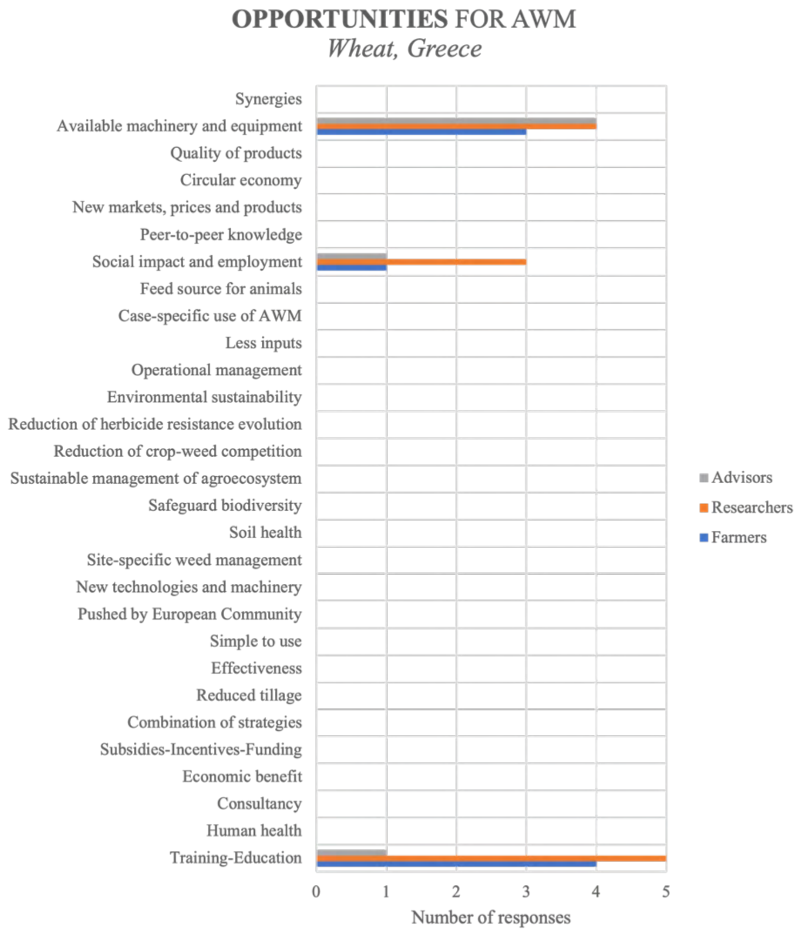


Figure 97: Opportunities of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: None.

WEAKNESSES: Presented in the figure below.

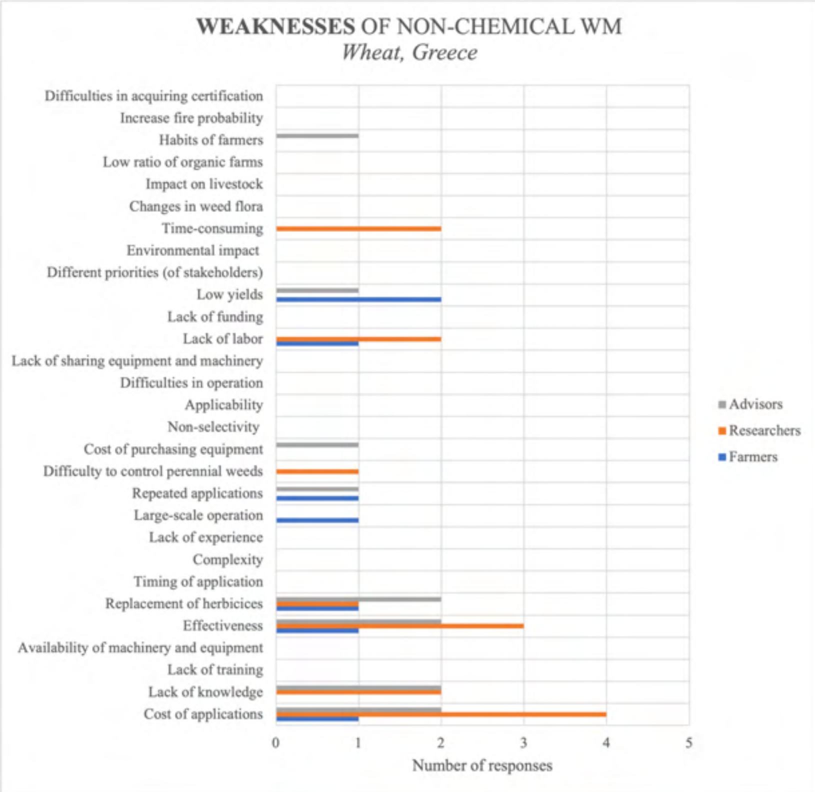


Figure 98: Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: None.

STRENGTHS: Many strengths of herbicides were identified by respondents in the Greek LL of wheat. In particular, all interviewees from all stakeholder groups mentioned efficacy as the main strength of herbicides. Low cost was also a very popular answer, followed by quick results and simplicity to use. Additionally, a few answers referred to cost-effectiveness, optimized treatment, and the fact that the use of herbicides does not demand intensive labor.

THREATS: An advisor mentioned agricultural policy.

WEAKNESSES: Presented in the figure below.

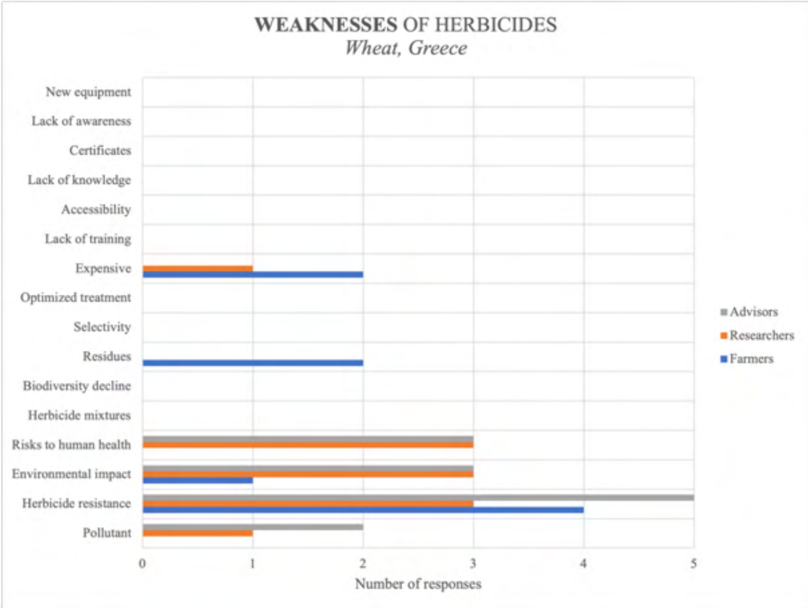


Figure 99: Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – WHEAT, GREECE
Most used weed management practices: The weed management in wheat is heavily depended on herbicides and mechanical control. The narrow row spacing of winter cereals makes several AWM practices not applicable. Interesting is that a few farmers mentioned the use of UAV to assist weed management decision making. In fact, weed prescription maps is a valuable tool recently to identify weed spots in the field, and optimize mechanical and chemical treatments. **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group**: The three stakeholder groups presented similar number of responses, while researchers could share their experience and opinion by referring to more opportunities and weaknesses. **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: AWM is not well documented yet, and certainly not properly disseminated with farmers, advisors and the research community. However, stakeholders acknowledge that AWM is tied to social impact and increase of employment rates, could be adopted due to the availability of machinery and equipment and could lead to more educational and training programs.

Threats, and weaknesses for non-chemical weed management: The cost of applications, effectiveness, possible low yields and the fact that some of AWM practices are time-consuming constitute factors that do not easily permit the replacement of herbicides. Lack of knowledge and lack of labour are two extra key weaknesses.

Opportunities, strengths, weaknesses, and threats for herbicides: Many strengths of herbicides were identified by respondents in the Greek LL of wheat. In particular, all interviewees from all stakeholder groups mentioned efficacy as the main strength of herbicides. Low cost was also a very popular answer, followed by quick results and simplicity to use. About the weaknesses, risks to human health, environmental impact and herbicide resistance were among the most popular answers.

2.1.1.3.3 Living lab board meeting

The living lab board meeting was an online meeting held on 13th November 2023. The total number of participants in the meeting was 9 people. During the meeting, the GOOD project, LL, and the technical details - interventions were presented. In the region of Thessaly, there is a considerable amount of durum wheat. In particular, more than 100,000 ha in the area are covered by durum wheat and this area produces more than 20% of the national production. There is interest in agroecological approaches, and perhaps even in a potential agroecology label (as an optional certification). Regarding weeds, organic farming is not effective, and there are also serious issues of herbicide resistance. It was proposed to study the impacts of weed management methods on economic data and potentially some qualitative factors (significant for the flour industry and pasta). As for the policy aspect is concerned, cover crops in general are already included in Annex 6 of good practices (mulching from November to March), but also in the intervention- eco-schemes (31.3). In the LL board meeting, this information was also collected:

What are the market characteristics of wheat?	1. How many farmers cultivate wheat in the region (approx.)? Is it mostly monoculture or can rotations be made with other crops?
	In the specific area, more than 200 farmers grow wheat (in Thessaly more than 1000). It is mostly monoculture but in some cases, there is some crop rotation with crops like cotton (irrigated) or winter legumes (non-irrigated).
	2. How many products are derived from the wheat? Are they important for the economy and/or food security?
	There are many wheat products such as flour, bread (from soft wheat) and pasta (from durum wheat). Wheat has enormous importance for the global agricultural economy and for the nutrition and survival of the entire world population (globally, the most important crop for human nutrition).
	3. Do you think that agroecological products could be promoted in local markets?
	Nowadays, consumers are interested in how and where the products are produced, so they would buy agroecological products to strengthen and support local communities and markets.
	4. Do you believe that the region has a lack of technologies?
	Young farmers use new technologies, but it is not a common practice.
What are the most common	1. What are the most common agronomic practices in wheat?
	The crop is not irrigated, it needs fertilization and weed control.

agricultural and weed management practices in wheat?	2. What are the most common weed management practices in wheat?
	The most common weed management practice is the use of herbicides (chemical control).
What is the herbicide use in wheat?	1. How many active ingredients there are available? How many different mode of actions?
	There are about 15 active ingredients available for wheat crop but there are only 4 modes of action.
	2. How many times do you spray in-season?
	They spray 1 or 2 times in season.
	3. Do you use pre-emergence, post-emergence or both herbicides?
	Mostly post-emergence herbicides are used, pre-emergence applications are rare in wheat.
	4. Are herbicides efficient?
	Since farmers use only a few modes of actions, there are many problems with weed resistance and consequently herbicides are not always efficient.
	5. Do you think that alternatives to herbicides are equally efficient?
	Agroecological practices are not as efficient as herbicides but with pressure from the European Union to reduce chemicals we will be forced to switch to new methods.
	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?
	In general, herbicides and all plant protection products pollute soil and water, reduce biodiversity and are harmful to humans and animals. However, if there is a limited number of applications and in full accordance with the registration (label), then the negative impact is minimum.
	7. Do you believe that agriculture without herbicides is viable?
	Organic farming is not really effective for weed management in wheat crops.
	1. What is needed to boost the uptake of agroecological practices?

What are the needs and barriers to assist agroecological transitions & adopt agroecological weed management approaches?	To strengthen agroecological practices, workshops and demonstrations could be organized to show farmers the results of these practices and convince them.
	2. What are the barriers towards agroecology implementation?
	The obstacles are that more labor, higher cost and more hours are needed to implement these practices.
	3. Should policies need be redefined to allow agroecological transitions?
	Eco schemes could be created that integrate agro-ecological management of crops.
	4. How confident you feel about the adoption of agroecological weed management practices?
	They are confident that they can apply agroecological practices but research under real field conditions is necessary.
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	1. What are the main drivers of weed dispersal?
	The main causes of weed spread are rain, the transfer of weed seeds by uncertified seeds and the transfer of weed seeds from one field to another by farmers' machinery.
	2. Which are the major and most noxious weeds in your area?
	The major and most noxious weeds in wheat crop are *Sinapis arvensis* and *Avena sterilis*. Also, weeds such as *Galium aparine, Convolvulus arvensis, Lolium rigidum and Papaver rhoeas* are considered important weeds.
	3. Are there any herbicide resistant weeds?
	Yes, there are herbicide-resistant weeds such as *Avena sterilis, Galium aparine and Papaver rhoeas* in the area.
	4. Do you know any invasive plants in your area?
	There are invasive plants in the area such as *Amaranthus palmeri* and *Solanum eleagnifolium* but not in wheat fields
What do you think about the Living Lab?	1. Which proposals do you have for a good performance of the LL?
	It was proposed to study both economic and qualitative data and have often communication and demonstration of the agroecological practices.
	2. Would you like it to remain over time?
	The aim is to maintain the living lab for the next years so that it can become a new tool for more sustainable solutions for weed control and integrated crop management.

2.1.1.4 Maize (Serbia)

2.1.1.4.1 Questionnaires

The maize questionnaires offered insights into four AWM techniques: automated weed control, herbicides, mechanical weeding, and mowing. It is noteworthy that no farmers took part in the questionnaire, and none of the evaluated practices had sufficient respondents from all stakeholder categories. A comprehensive breakdown of stakeholder participation in the questionnaires for distinct AWM practices is outlined in Table 25.

Table 25 Number of responses for each AWM practice and stakeholder category in maize

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control	**4**	**4**		2		**3**
Biobased herbicides		1		1		1
Cover crop inoculation to increase competitiveness						
Cover crop	1				1	1
False seedbed						1
Grazing						
Herbicides	**3**	**3**		**3**	2	**5**
Intercropping	2					1
Mechanical weeding	**3**	**5**				**3**
Mowing	1	**7**				**3**
Mulching	1	1				
Natural enemies						
Other						
Site-specific spraying				1		
Thermal weeding						
UAV				1		
n=31	5	9		5	3	9

2.1.1.4.1.1 Automated weed management

2.1.1.4.1.1.1 Advisors

Advisors widely perceive automated weed control as a technique brimming with opportunities, accompanied by important necessities and potential disadvantages. Unanimously, they believe its implementation will stabilize crop yields, with three-quarters expressing positive views on other aspects such as promoting IPM strategies and serving as an ecosystem services provider. Additionally, they anticipate economic benefits, foreseeing increased income and reduced herbicide reliance, while foreseeing its evolution into a significant scientific discipline. When assessing the main needs, all advisors agree on the significance of addressing the lack of advisors, practicing knowledge skills, training, and cost, maintenance, and timing reduction. Secondary needs, identified by 75% of respondents, include ecosystem services impact knowledge, regulatory changes, and management expertise. Training is considered the primary barrier by all advisors, followed by concerns about environment and human harm, lack of funds, and regulatory issues, deemed important barriers by 75% of respondents. Prime drawbacks, as stated by 75% of advisors, include customers' demand to reduce its use, potential harm to the environment and humans, and time consumption. Half of the respondents also find relevant concerns expressed by the public against its use and the associated expense.

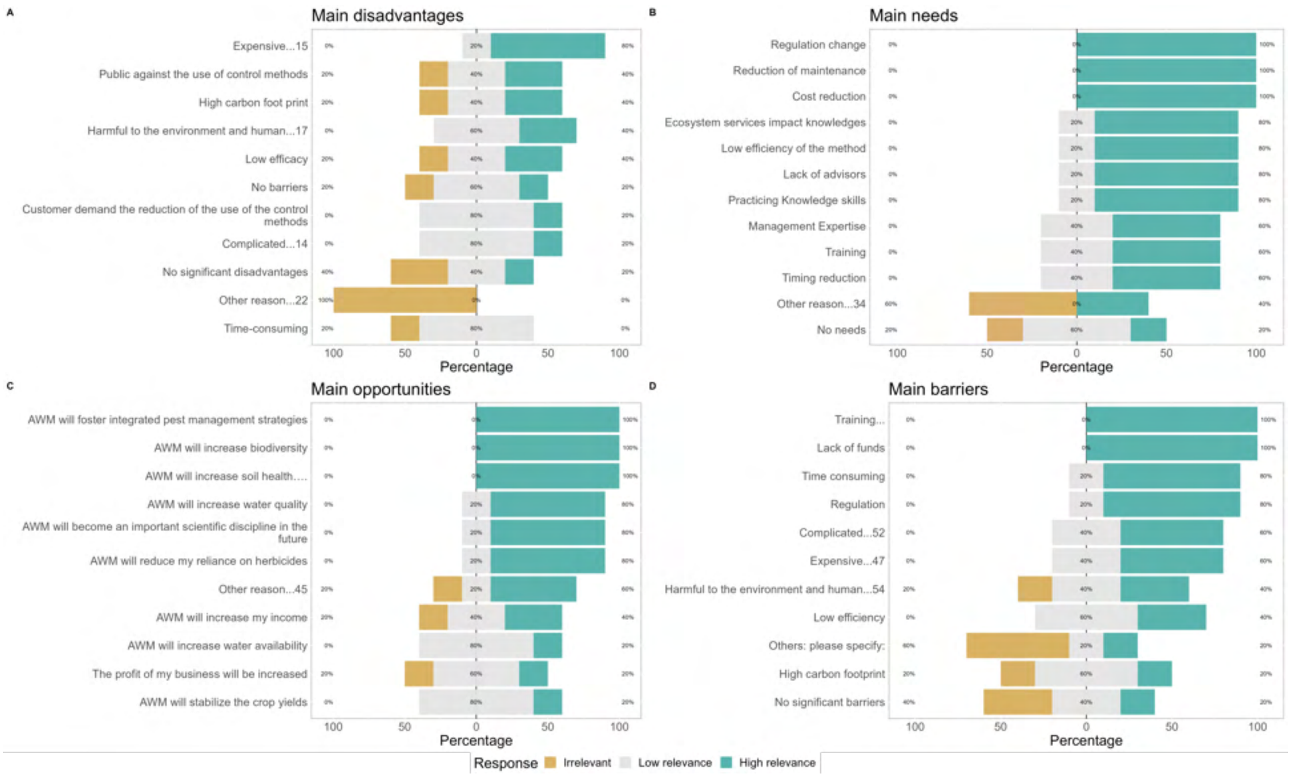


Figure 100 Main disadvantages, needs, barriers and opportunities for Automated weed management identified by advisors.

2.1.1.4.1.1.2 Consumers

Consumers perceive automated weed control as a technique teeming with opportunities, with 75% emphasizing its potential for increasing water quality and stabilizing crop yields. Half of the respondents believe it will foster IPM, provide crucial ecosystem services (enhancing water availability, biodiversity, and soil health), and foresee its evolution into an important scientific discipline. Consumers exhibit high consensus, with 75% deeming ecosystem services impact knowledge, regulatory changes, management expertise, training, and cost reduction as highly relevant needs for automated weed control. Half of the consumers identify lack of advisors, practicing knowledge skills, and maintenance and timing reduction as significant challenges. Training emerges as the primary barrier, acknowledged by three-quarters of consumers, while half recognize environment and human harm, lack of funds, and regulatory challenges as relevant impediments to automated weed control. Lower consensus is observed regarding disadvantages, with 50% of consumers highlighting customer demand for method reduction, environmental and human harm, and time consumption as the most relevant drawbacks.

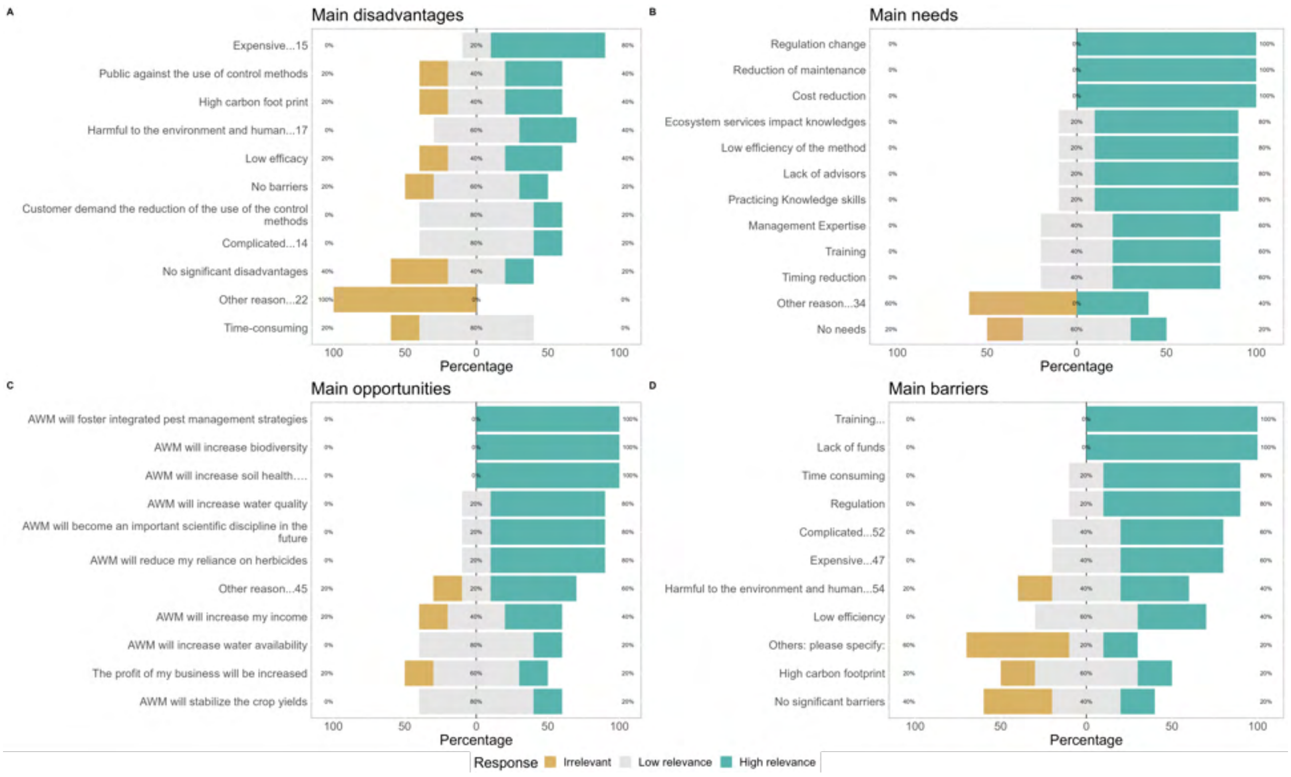


Figure 101 Main disadvantages, needs, barriers and opportunities for Automated weed management identified by consumers.

2.1.1.4.1.1.3 Researchers

Researchers considered automated weed control as a practice full of opportunities that faces a series of serious needs and some important barriers and disadvantages. This stakeholders group show high rates of consensus as all of them considered that automated weed control will evolve into an important scientific discipline, that its use increases business profitability and stabilises crop yields. Besides, other factors were deemed as relevant by a significant proportion of researchers, 67% of respondents believe that this practice will foster IPM strategies and provide several ecosystem services, such as increase of water quality and availability, biodiversity, and better soil health, plus, researchers considered that it will have a positive impact on farmers automated weed control use had relevant needs: regulatory changes, practicing knowledge skills, cost and maintenance reduction. Then, 67% of respondents find that ecosystem services impact knowledge, lack of advisors, management expertise, training and timing reduction were also relevant hurdles. Main barriers with regard to the implementation of automated weed control were environment and human harm plus lack of fund, as stated by 67% of researchers. Researchers, in accordance with what they considered as needs and barriers, considered that customer demands for either elimination or reduction of automated weed control, environment and human harm, overall expense and time consumption were the highest relevant drawbacks for 67% of respondents.

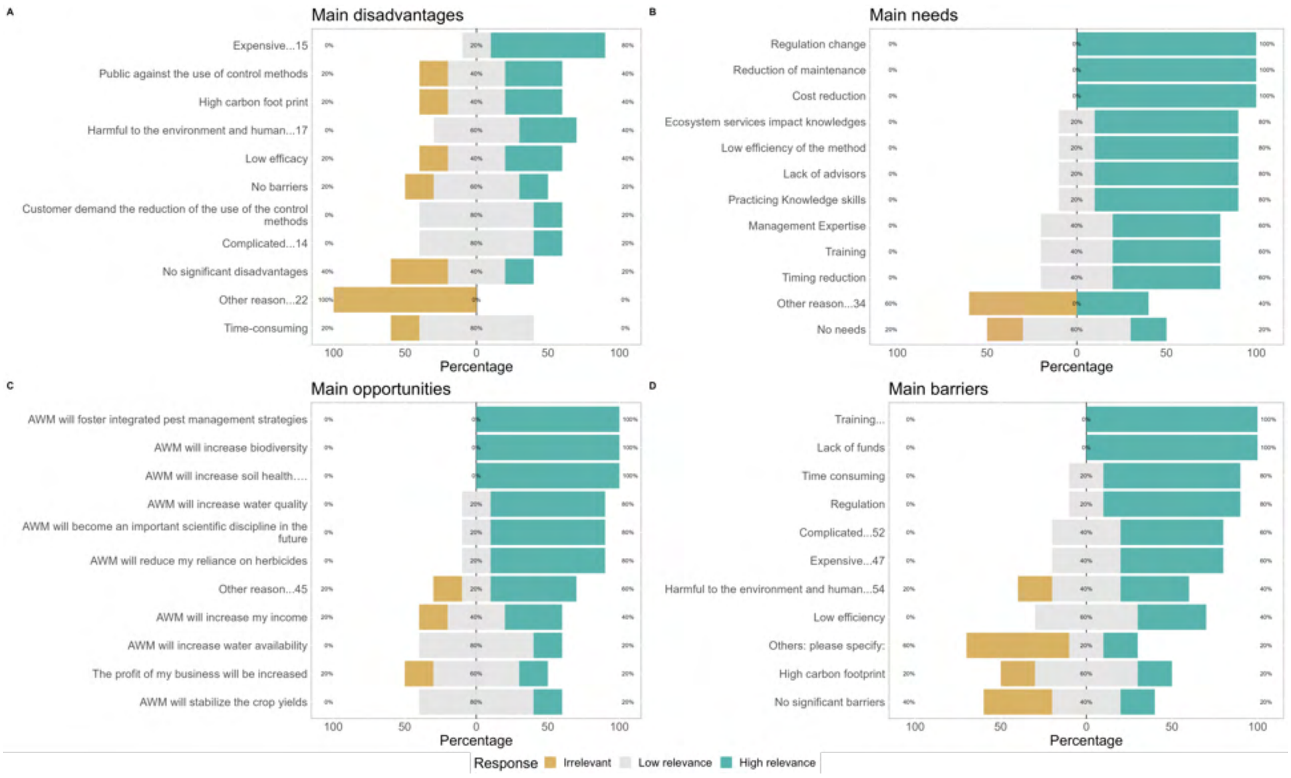


Figure 102 Main disadvantages, needs, barriers and opportunities for Automated weed management identified by Researchers.

2.1.1.4.1.1.4 Conclusions

Perceptions surrounding automated weed control among advisors, consumers, and researchers converge on a perspective filled with opportunities, yet they acknowledge substantial needs, barriers, and drawbacks. Advisors uniformly anticipate its potential to stabilize crop yields, promote IPM strategies, and serve as an ecosystem services provider, simultaneously foreseeing economic benefits. Consumers, in alignment, accentuate its role in improving water quality and stabilizing crop yields. Both stakeholders identify ecosystem services impact knowledge, regulatory changes, management expertise, training, and cost reduction as imperative needs, and emphasize training as the primary barrier. Meanwhile, researchers, affirming the optimistic outlook, underscore the potential for increased business profitability, crop yield stabilization, and evolution into a scientific discipline. Critical needs articulated by advisors encompass, enhancing knowledge skills, training, and mitigating costs, maintenance, and timing concerns. Noteworthy needs for researchers encompass regulatory changes, knowledge skills enhancement, and reduction of costs and maintenance. The unanimity in identifying training as a primary barrier across all stakeholders is noteworthy, as is the shared concern about environment and human harm. The varied perspectives on drawbacks, ranging from customer demands to reduce automated weed control, to time consumption, underscore the multifaceted nature of challenges associated with the adoption of automated weed control. In synthesis, while the stakeholders unanimously acknowledge the promising aspects of automated weed control, the divergent emphasis on specific needs, barriers, and drawbacks emphasizes the importance of nuanced considerations in its implementation and integration within agricultural practices.

2.1.1.4.1.2 Herbicides

2.1.1.4.1.2.1 Advisors

Advisors perceive herbicides as a practice with numerous opportunities but important necessities, barriers, and drawbacks. They unanimously agree on herbicide application leading to crop yield stabilization and income increase. Additionally, 67% believe it fosters IPM strategies, provides ecosystem services, and may evolve into a significant scientific discipline. High consensus is observed on the main needs, including ecosystem services impact knowledge, regulatory changes, lack of advisors, practicing knowledge skills, training, and reduction of maintenance, cost, and timing. However, there is an inconsistency regarding herbicide barriers, as advisors unanimously consider harm to the environment and humans as the main impediment, yet they also claim no significant barriers. Second-tier impediments, deemed relevant by 67% of respondents, include high carbon footprint, low efficiency, method complexity, time consumption, training, lack of funds, regulatory challenges, and expense. Advisors unanimously identify potential harm to humans and the environment, along with time consumption, as the most significant drawbacks. Sixty-seven percent express concern about customer demands for herbicide elimination or reduction, along with expense and efficacy as relevant disadvantages.

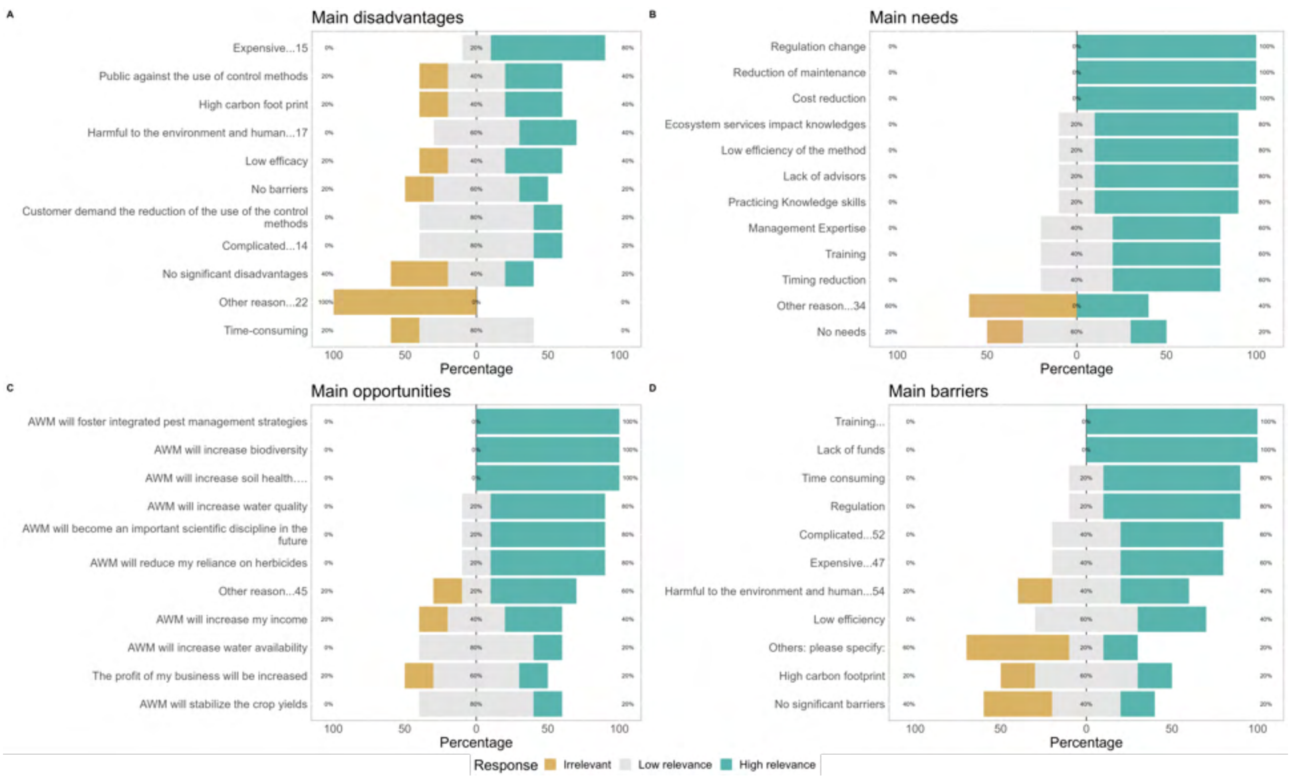


Figure 103. Main disadvantages, needs, barriers and opportunities for Herbicides identified by advisors.

2.1.1.4.1.2.2 Consumers

Consumers perceive herbicide use as having crucial needs and barriers, with few opportunities. Regarding opportunities, 67% see herbicides as providing various ecosystem services, contributing to business profitability, stabilizing crop yields, and increasing farmers' income. There is unanimous agreement among consumers on the main necessities, with regulatory changes, management expertise, training, and cost reduction identified as key impediments. As secondary needs, 67% of respondents prioritize ecosystem services impact, lack of advisors, and reduction of maintenance and timing. Consumers unanimously identify training, lack of funds, and regulation as the most significant barriers, with secondary barriers including low efficiency, complexity, and expense. Main disadvantages, unanimously agreed upon, are environmental and human harm, along with expense. Like advisors, 67% of consumers highlight customer demands for herbicide elimination or reduction.

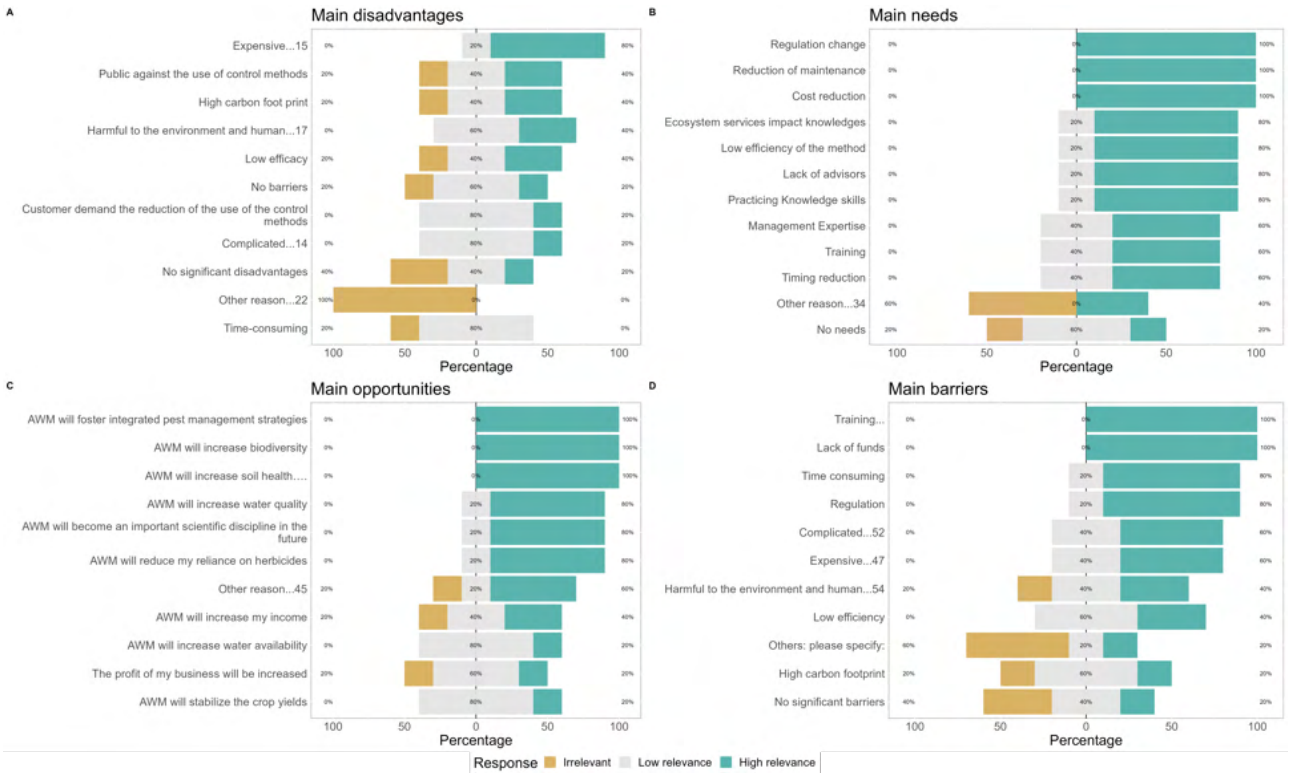


Figure 104. Main disadvantages, needs, barriers and opportunities for Herbicides identified by consumers.

2.1.1.4.1.2.3 Researchers

Researchers, like advisors, hold an overall positive view of the opportunities associated with herbicide use, but they also express concerns about the method's significant needs, barriers, and disadvantages. They unanimously agree that herbicide use can lead to increases in biodiversity and soil health, and they foresee its evolution into a vital scientific discipline. Eighty percent of researchers believe that herbicides will promote IPM strategies and provide essential ecosystem services, such as improving water availability and quality while reducing reliance on herbicides. In terms of needs, researchers widely prioritize ecosystem services impact knowledge and timing reduction. Additionally, eighty percent of researchers emphasize the importance of regulatory changes, knowledge skills, management expertise, training, and maintenance reduction for successful herbicide use. The main barriers identified by researchers include time consumption, lack of training and funds, and regulatory issues. Moreover, sixty percent of researchers view environmental and human harm, complexity, and expense as significant hurdles to herbicide implementation. Researchers unanimously recognize public opposition to herbicide use and its potential environmental and health risks. As such, eighty percent of stakeholders see reducing customer demand for herbicide use and lowering costs as relevant disadvantages of this technique.

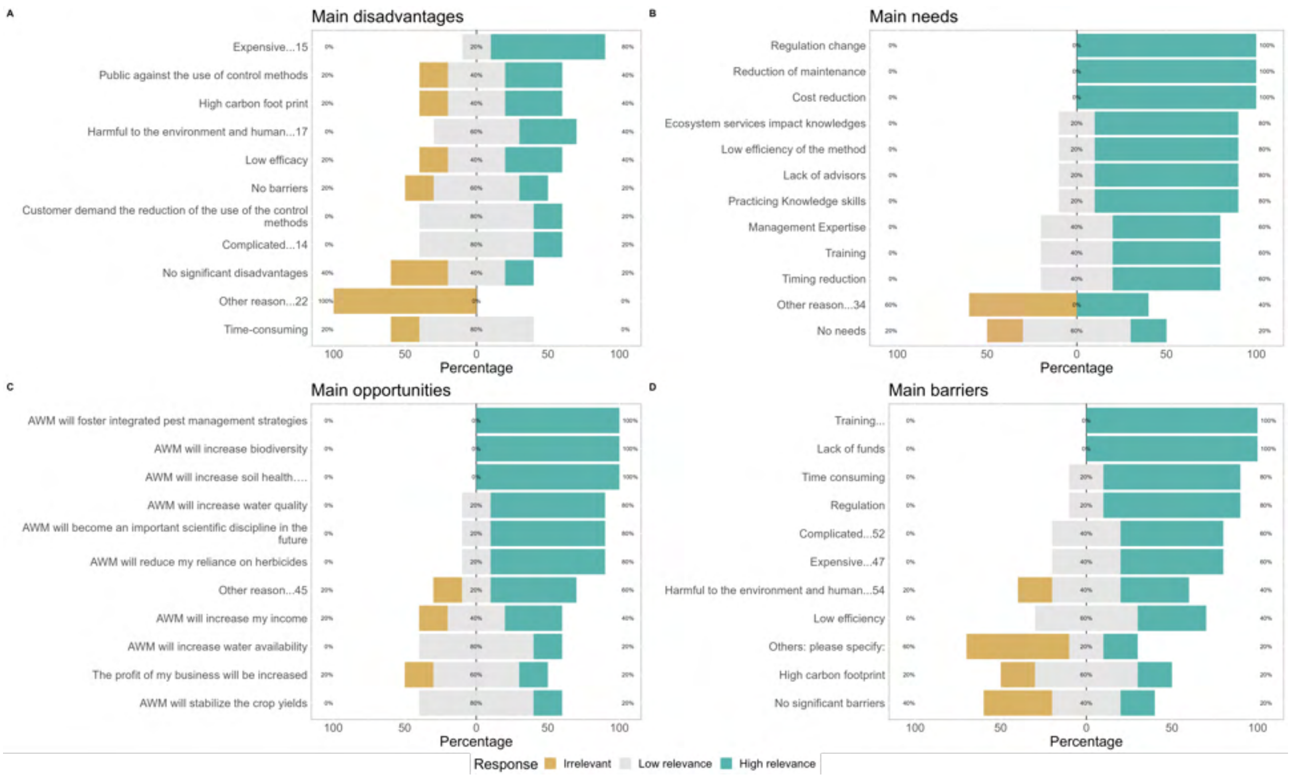


Figure 105. Main disadvantages, needs, barriers and opportunities for Herbicides identified by researchers.

2.1.1.4.1.2.4 Conclusions

Stakeholders unanimously recognize the potential of herbicide use in addressing critical agricultural needs, such as crop yield stabilization, income increase, and ecosystem service provision. Advisors emphasize opportunities like crop yield stabilization, income increase, and the potential for fostering IPM strategies and providing ecosystem services. Consumers also highlight ecosystem service provision and crop yield stabilization, with business profitability as a relevant opportunity. Researchers underscore ecosystem service provision, biodiversity increase, and soil health improvement, seeing potential for herbicides to evolve into a vital scientific discipline. Key necessities identified across stakeholders include regulatory changes, management expertise, training, and cost reduction, with researchers emphasizing ecosystem services impact knowledge. However, there is notable disparity in perceptions of barriers, with advisors downplaying significant obstacles despite acknowledging environmental and human harm, while consumers and researchers identify various challenges from training and regulatory issues to environmental concerns and expense. Despite differing views, stakeholders unanimously acknowledge the drawbacks of herbicide use, particularly environmental and human harm, expense, and customer demands for reduction. Overall, the diversity in perspectives underscores the complexity of herbicide use and the importance of considering a range of factors, from regulatory frameworks to environmental impact, in decision-making processes within the agricultural sector.

2.1.1.4.1.3 Mechanical weeding

2.1.1.4.1.3.1 Advisors

Mechanical weeding is viewed as a technique with numerous opportunities but also faces several needs, barriers, and disadvantages. Advisors unanimously agree that its use will reduce herbicide reliance, with 67% believing it will foster IPM strategies and provide various ecosystem services like improved water quality, biodiversity, and soil health. They also see potential for increased business profitability and crop stabilization, envisioning its evolution into a significant scientific discipline. Advisors unanimously stress the need for improved efficiency and timing reduction. Sixty-seven percent emphasize ecosystem services impact knowledge, lack of advisors, training, cost reduction, and maintenance reduction as primary necessities. Expense is unanimously cited as the primary barrier, followed by concerns over high carbon footprint, environmental and human harm, low efficiency, complexity, time consumption, training, lack of funds, and regulatory issues. Sixty-seven percent of respondents highlight customer demands to reduce mechanical weeding, expense, and time consumption as significant drawbacks. Other factors are considered less relevant by more than one-third of respondents.

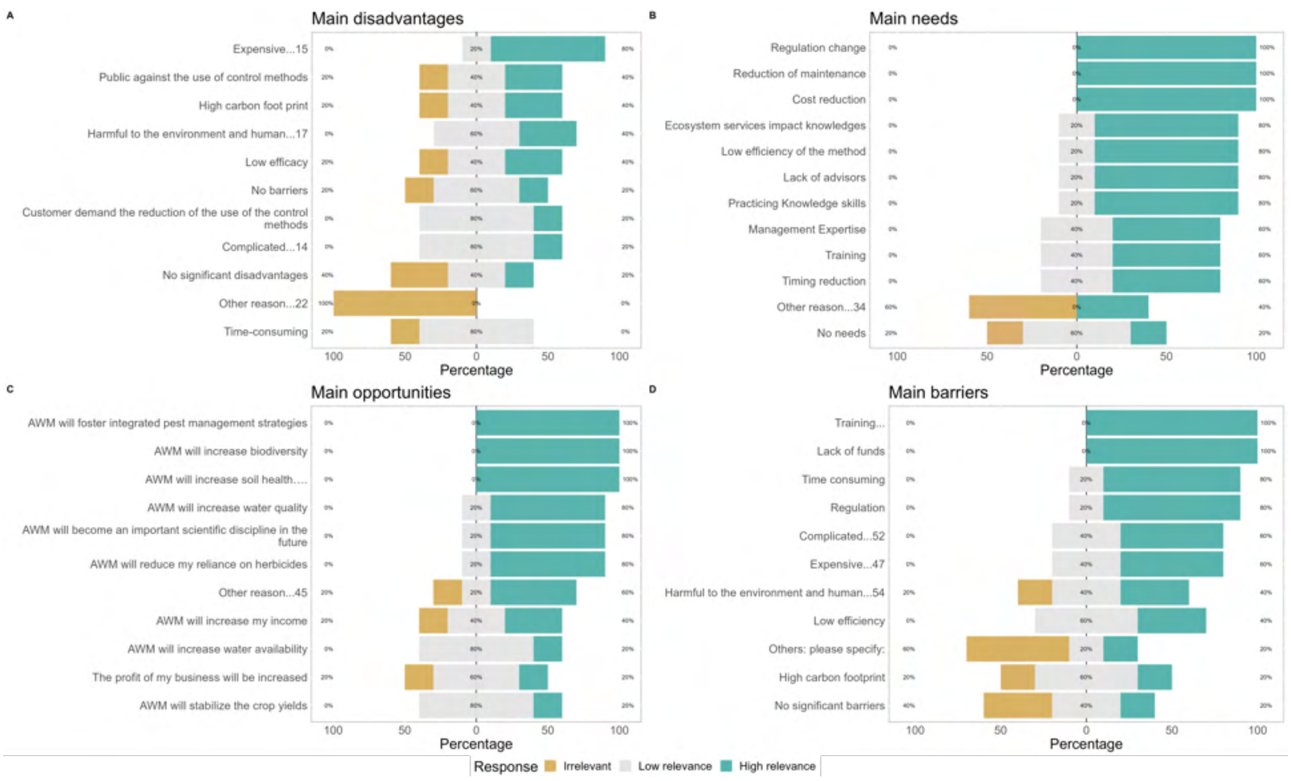


Figure 106. Main disadvantages, needs, barriers and opportunities for Mechanical weeding identified by advisors.

2.1.1.4.1.3.2 Consumers

Consumers perceive mechanical weeding as a method teeming with opportunities and essential necessities; they did not consider relevant the queried disadvantages or barriers. Mechanical weeding was unanimously perceived by consumers as a technique that will increase water quality and ameliorate soil health, while reducing herbicide reliance. Besides, an important 80% of the respondents considered its potential in reducing herbicide reliance and increasing biodiversity as relevant. Moreover, 60% of consumers view mechanical weeding as evolving into an important scientific discipline. Consumers show relatively high rates of consensus when expressing this method’s main needs, as 80% considered management expertise and timing reduction as relevant topics. Sixty percent of the respondents considered the lack of advisors, practicing knowledge skills, training, and maintenance reduction as relevant necessities. Most consumers did not consider the queried barriers as relevant impediments; only mechanical weeding complexity was deemed relevant by 60% of the sample. Similarly, only expense was considered relevant by more than half of the respondents among the queried disadvantages.

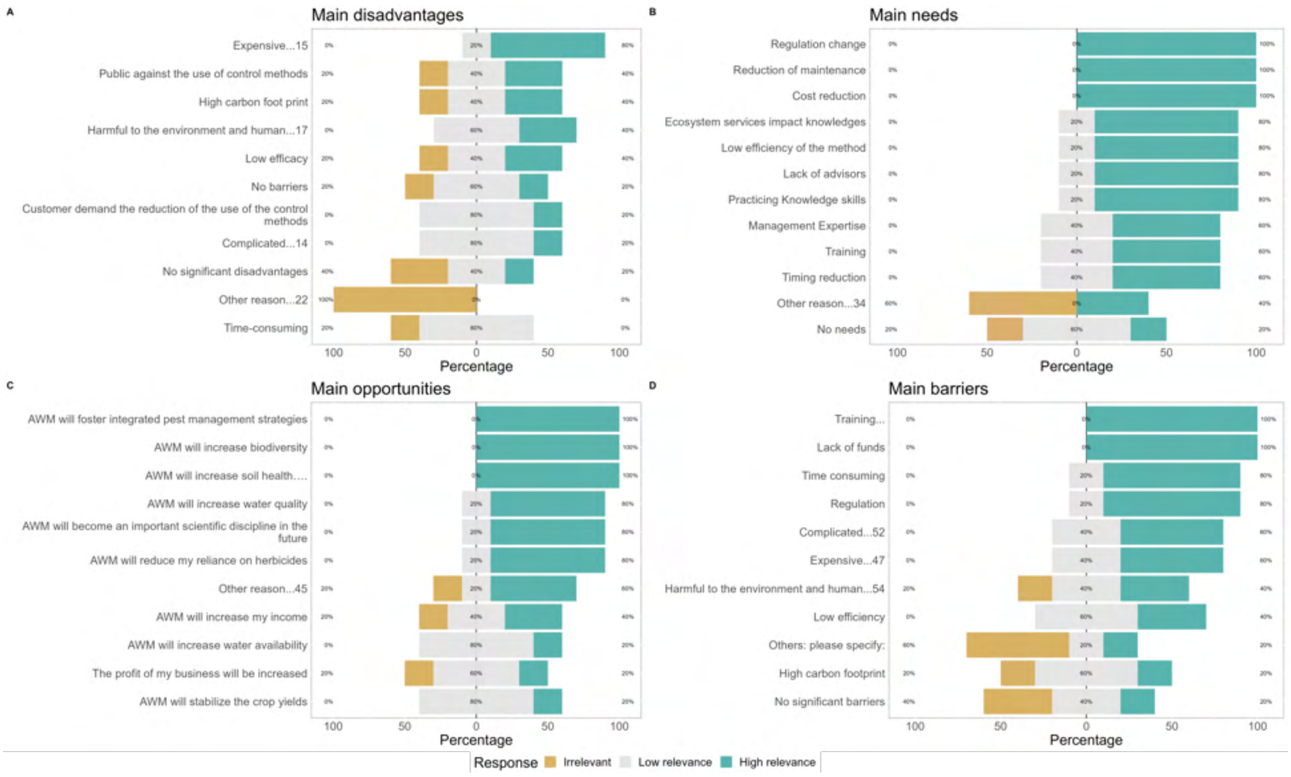


Figure 107. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by consumers.

2.1.1.4.1.3.3 Researchers

Researchers perceive mechanical weeding as a method brimming with opportunities and essential necessities, while also encountering key barriers and few disadvantages. Mechanical weeding was unanimously considered a fosterer of IPM strategies and a provider of ecosystem services, including increases in water availability and quality, biodiversity, and soil health. Additionally, researchers unanimously believe that mechanical weeding will evolve into an important scientific discipline and reduce herbicide reliance. Sixty-seven percent of respondents identified increased business profitability and crop yield stabilization as significant opportunities. As main needs, all researchers emphasized regulatory changes, method efficiency, practicing knowledge skills, and cost and maintenance reduction. Sixty-seven percent of researchers also highlighted ecosystem services impact knowledge and timing reduction as highly relevant needs. However, researchers did not exhibit high rates of consensus regarding the main barriers, although 67% agreed on the importance of low efficiency, complexity, time consumption, training, lack of funds, regulatory issues, and expense. Sixty-seven percent also identified low efficacy, expense, and complexity as the main disadvantages of mechanical weeding. Interestingly, none of the other queried disadvantages were deemed relevant by researchers.

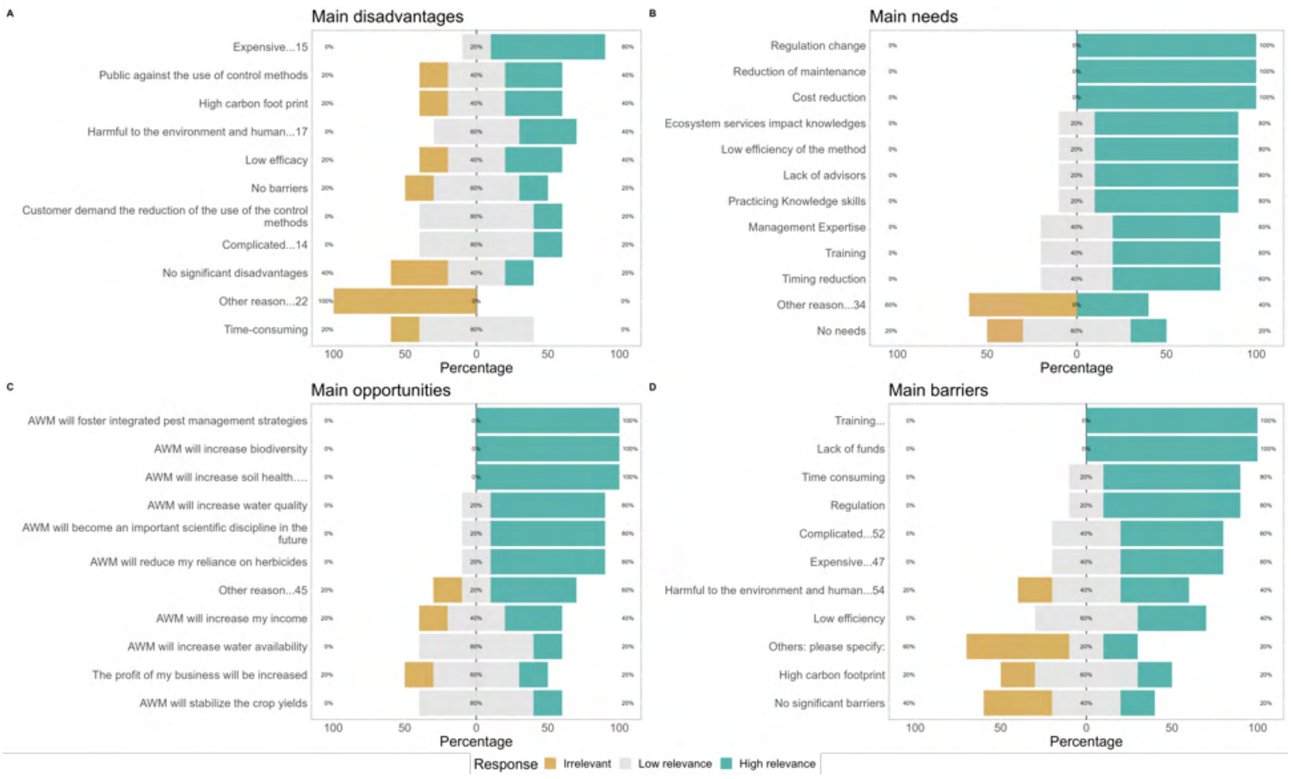


Figure 108. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by Researchers.

2.1.1.4.1.3.4 Conclusions

Stakeholders recognize the vast opportunities presented by mechanical weeding, as they all consider the potential reduction of herbicide reliance, fostering IPM strategies, providing ecosystem services, and its possible evolution into an important scientific discipline as highly relevant. There is a range of perspectives on the associated necessities, barriers, and drawbacks. Regarding primary needs, advisors and researchers emphasize improvements in efficiency, while consumers prioritize management expertise. Additionally, a considerable proportion of all stakeholder categories consider timing reduction as an important need for mechanical weeding. As for the main barriers, advisors unanimously cite expense, while researchers consider a plethora of topics relevant, including low efficiency, complexity, time consumption, training, lack of funds, and regulatory issues, alongside expense. In contrast, consumers consider few barriers as relevant for mechanical weeding. Notably, while advisors highlight customer demands to reduce mechanical weeding, expense, and time consumption as the main disadvantages, consumers only consider expense, and researchers point to low efficacy, expense, and complexity as the most relevant drawbacks.

2.1.1.4.1.4 Mowing

2.1.1.4.1.4.1 Consumers

Consumers exhibit a strong consensus regarding the opportunities presented by mowing, with a notable 86% stating that it will enhance water quality, biodiversity, and soil health. Additionally, 86% believe that mowing will foster IPM strategies, while 71% anticipate its potential to stabilize crop yields, reduce herbicide reliance, and evolve into an important scientific discipline in the future. The primary need identified by 86% of consumers is practicing knowledge skills, with over 70% also recognizing the importance of management expertise and cost reduction in mowing practices. However, when it comes to barriers, 71% of respondents highlight time consumption and lack of funds. Interestingly, none of the queried disadvantages were deemed highly relevant by more than half of the consumers, with the most significant disadvantage being identified by only 43% of respondents.

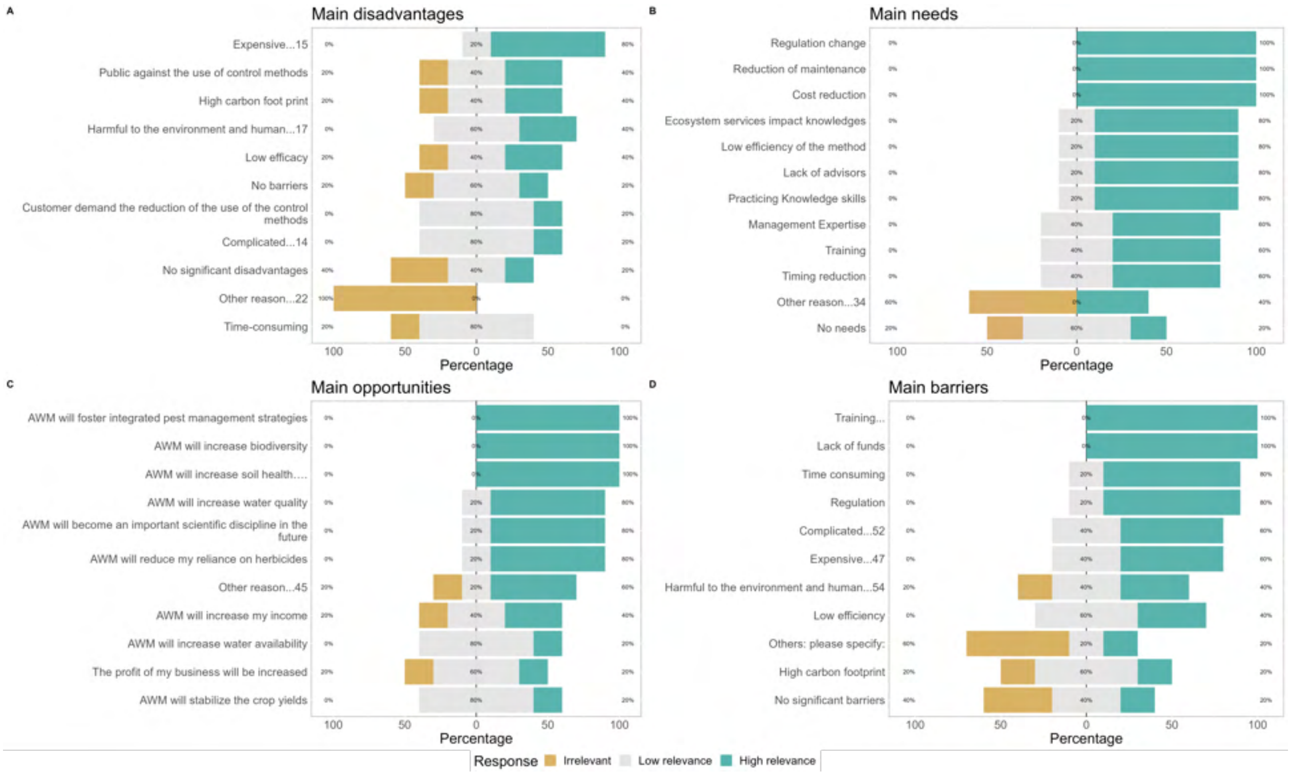


Figure 109. Main disadvantages, needs, barriers and opportunities for Mowing identified by consumers..

2.1.1.4.1.4.2 Conclusions

Consumers recognize the opportunities presented by mowing, including its potential to enhance water quality, biodiversity, and soil health. While they emphasize the need for knowledge and skills development, concerns about time consumption and lack of funds are prominent. Interestingly, few disadvantages were deemed highly relevant by respondents, indicating a generally positive outlook on mowing as an agricultural practice.

2.1.1.4.2 Surveys

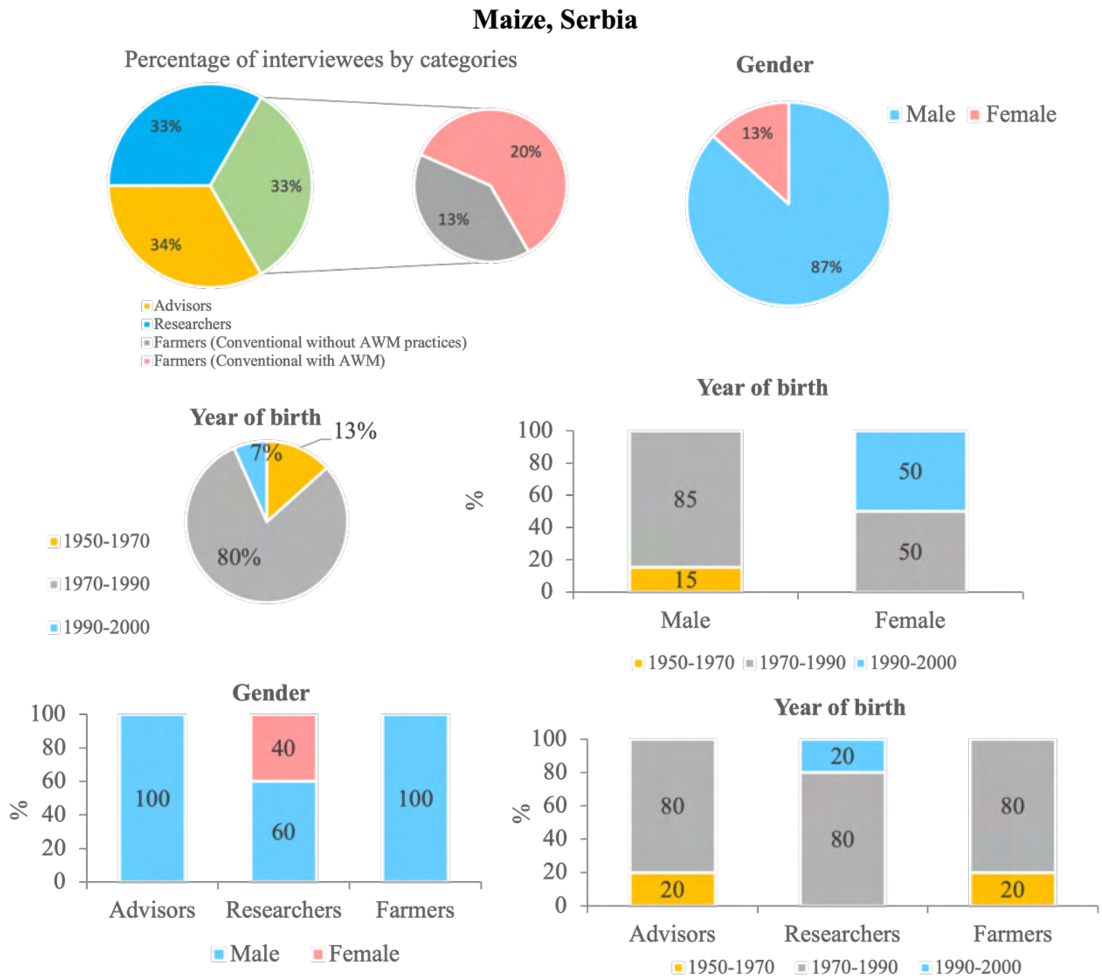


Figure 110 Interviewees description in the Maize Living Lab (Serbia)

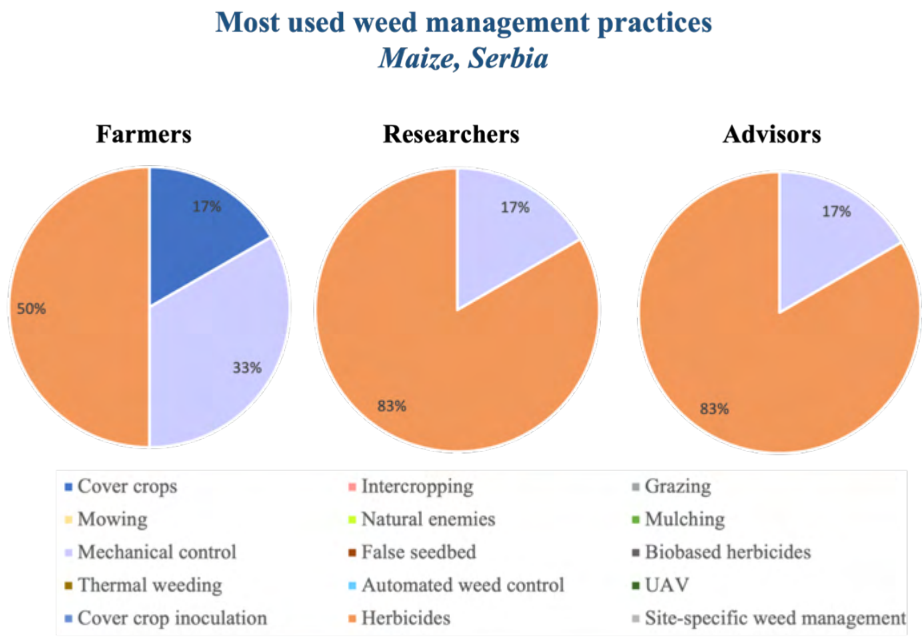


Figure 111 Most used weed management practices in the Maize Living Lab (Serbia)

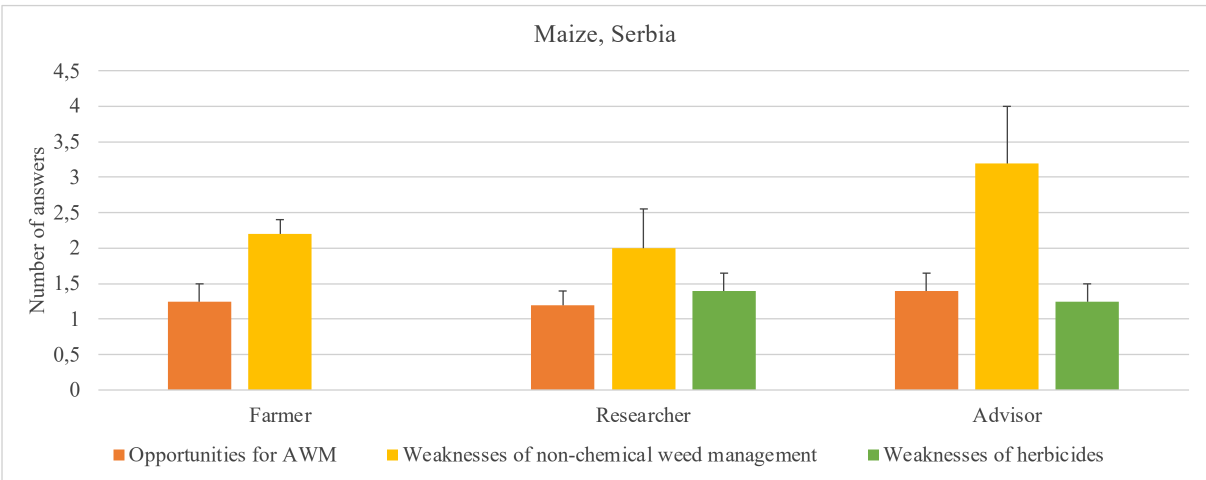


Figure 112 Mean number of answers (±se) per stakeholder group in the Maize Living Lab (Serbia)

Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: None.

THREATS: None.

WEAKNESSES: None.

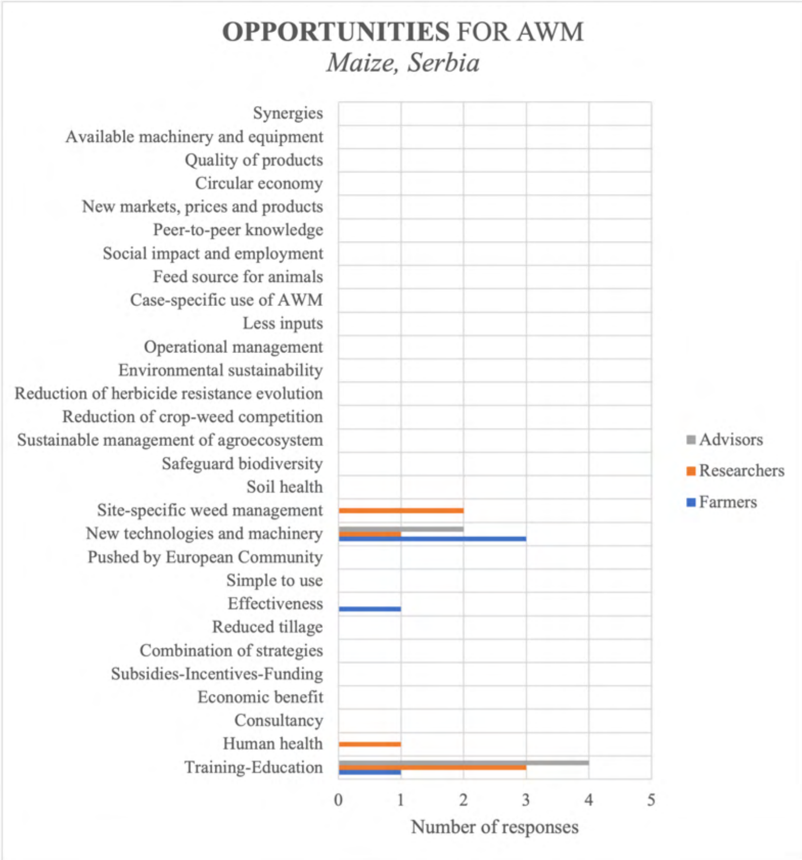


Figure 113 Opportunities of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: Only one answer of a farmer referred to markets as a threat for non-chemical weed management.

WEAKNESSES: Presented in the figure below.

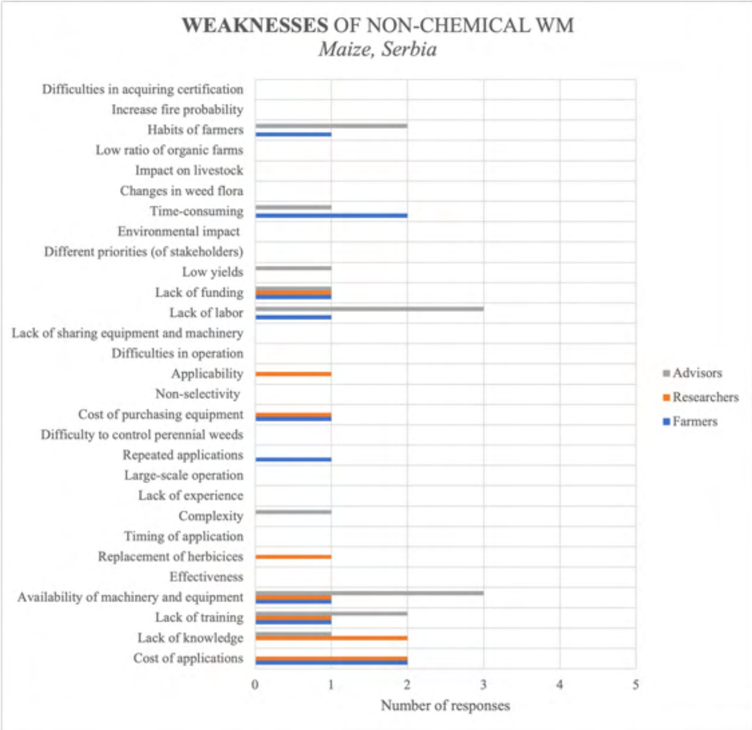


Figure 114 Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: None.

STRENGTHS: Efficacy and low cost were the two main answers of respondents, especially from the researchers' group. Additionally, economic benefit and simplicity to use were also mentioned.

THREATS: Several interviewees mentioned the lack of new herbicides and the withdrawal of existing active ingredients as a major threat.

WEAKNESSES: Presented in the figure below.

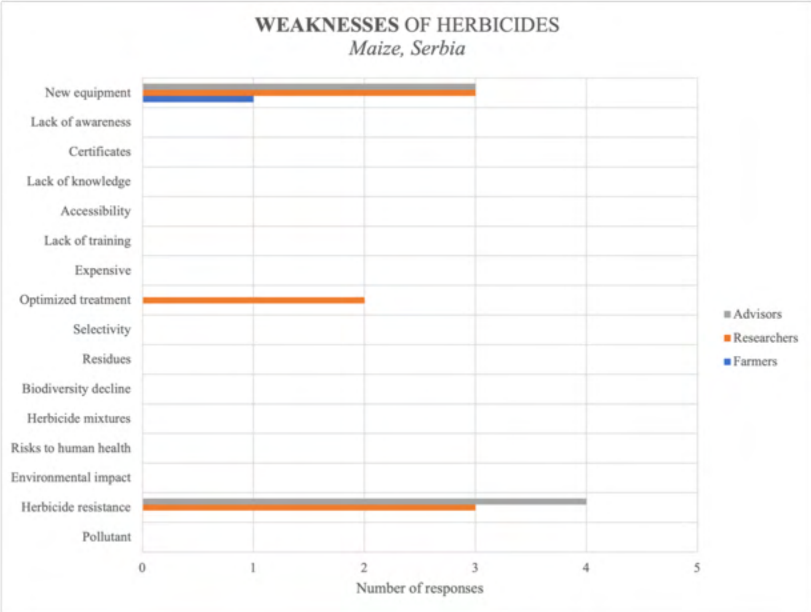


Figure 115 Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – MAIZE, SERBIA
Most used weed management practices: The responses from the Serbian LL in maize revealed that all stakeholder groups recognize herbicides and mechanical control as the only major practices to manage weeds. The integration of cover crops is still low in maize crop and there is an obvious lack of combination of strategies. **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group**: The interviewees identified more weaknesses of non-chemical weed management than opportunities for AWM (almost double), which means that they are still sceptical about the applicability and effectiveness of several methods that are non-chemical. **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: The Serbian interviewees in the maize LL (especially the advisors and researchers) highlighted the need for training and education around AWM, which is considered an opportunity. The adoption of AWM practices requires new machinery and use of new technologies, a fact that is seen positively by farmers if certain assumption are met (see below weaknesses of non-chemical weed management and reference to labour, availability of machinery, funding and training). The lack of any strengths, weaknesses and

threats reveals that knowledge on agroecology and more sustainable weed management is missing. **Threats, and weaknesses for non-chemical weed management**: As previously mentioned, the lack of labour, machinery and equipment, funding, training, and knowledge are considered weaknesses of non-chemical weed management. Habits of farmers is also another factor preventing farmers from applying less chemical weed management treatments, which is also amplified by the lack of young generation of farmers. Regarding the applicability of the techniques, the cost of applications and the costs for purchasing new equipment make non-chemical weed management weak as an alternative. **Opportunities, strengths, weaknesses, and threats for herbicides**: The strengths of herbicides in the maize LL were concentrated on the efficacy and the low cost. It is worth mentioning that farmers did not identify any weaknesses of herbicides. However, advisors and researchers highlighted the increasing problem of herbicide resistance and the lack of new equipment for sprayings.

2.1.1.4.3 Living lab board meeting

Eight (8) participants in total attended the first RS maize/14 Living lab meeting, held on 23rd November 2023. Two members did not attend the meeting. The meeting was held at the Maize Research Institute "Zemun Polje, Belgrade, Serbia. The GOOD partners gave a short introductory speech about Living labs, and then the project was presented in 15 minutes. After that, 15-minute discussion was held, about the soybean LL, possible outcomes of the results, herbicide application in Serbia and weed resistance, and agroecological weed control. The main outcome was that agroecological weed management will be a very challenging process, bearing in mind that farmers use mostly herbicides for weed control and that without any subsidies this process would be very challenging. During the LL board meeting, this information was also collected:

What are the market characteristics of [crop]?	1. How many farmers cultivate [crop] in the region (approx.)? Is it mostly monoculture or can rotations be made with other crops?
	About 100 farmers plant maize each year and it is planted in 10% in as continuous cropping, 60-70% use winter wheat in rotation, while others combine maize/wither wheat/and soybean or sunflowers
	2. How many products are derived from the [crop]? Are they important for the economy and/or food security?

	The majority of producers use maize for livestock feeding, while others sell it on the market
	3. Do you think that agroecological products could be promoted in local markets?
	Yes, most of farmers do think that it would be an excellent idea
	4. Do you believe that the region has a lack of technologies?
	Yes, definitely
	5. Is the regional agri-food value chain sustainable?
	More-less
What are the most common agricultural and weed management practices in Maize?	1. What are the most common agronomic practices in Maize?
	Weed control in maize is very problematic bearing in mind that some populations of Johnsongrass are resistant on ALS herbicides
	2. What are the most common weed management practices in Maize?
	Herbicides are the most used practices for weed control, while ¼ of farmers combine it with mechanical weed control
What is the herbicide use in Maize?	1. How many active ingredients there are available? How many different mode of actions?
	There are more than 15 active ingredients of 6 MOAs
	2. How many times do you spray in-season?
	Most farmers spray twice per year: pre-emergence and post-emergence herbicides
	3. Do you use pre-emergence, post-emergence or both herbicides?
	Most of farmers and advisors use both groups
	4. Are herbicides efficient?
	Up to now, herbicides have been efficient, while in recent years the problem in herbicide resistance occurrence started
	5. Do you think that alternatives to herbicides are equally efficient?
	Probably yes, but it is more expensive compared to herbicide application
	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?
	All stakeholders do know that herbicides are not good option for the environment while for using of alternative measures requires more money

	7. Do you believe that agriculture without herbicides is viable?
	No
What are the needs and barriers to assist agroecological transitions & adopt agroecological weed management approaches?	1. What is needed to boost the uptake of agroecological practices?
	Knowledge and subsidies from the government; a market for those kind of products
	2. What are the barriers towards agroecology implementation?
	Lack of knowledge and equipment
	3. Should policies need be redefined to allow agroecological transitions?
	Yes, definitely
	4. How confident you feel about the adoption of agroecological weed management practices?
	It depends on each perspective: farmers have very low confidence, end-users strongly support this action; advisors find as a very complex task, researchers are very interested in weed control combined with cover crops
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	1. What are the main drivers of weed dispersal?
	Spraying only herbicides as a weed control method
	2. Which are the major and most noxious weeds in your area?
	Johnsongrass, common ragweed, *Chenopodium* and *Amaranth* species
	3. Are there any herbicide resistant weeds?
	Yes, there are many cases of Johnsongrass and Redroot pigweed resistant to some ALS herbicides
	4. Do you know any invasive plants in your area?
	Common ragweed
What do you think about the Living Lab?	1. Which proposals do you have for a good performance of the LL?
	The stakeholders pointed out the economic analyses of each alternate weed control measure are very important because they might influence the total price
	2. Would you like it to remain over time?
	Very interesting field experiments in maize in both conventional and organic systems, and stakeholders cannot wait to see the outcomes of the project

2.1.2 Legumes

2.1.2.1 Cowpea (Portugal)

2.1.2.1.1 Questionnaires

Cowpea questionnaires yielded insights into seven AWM techniques: biobased herbicides, cover crops, grazing, herbicides, mechanical weeding, mowing, and site-specific spraying. Perspectives were provided by advisors, consumers, industry representatives, and researchers, as we did not gather sufficient responses from farmers and policymakers. A detailed breakdown of stakeholder participation in the questionnaires for each AWM practice is presented in Table 26.

Table 26 Number of responses for each AWM practice and stakeholder category in cowpea.

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control					1	
Biobased herbicides		1			1	**3**
Cover crop inoculation to increase competitiveness						
Cover crops	1	1		1		**3**
False seedbed						1
Grazing	2	1				**5**
Herbicides	2	**4**		**3**	2	**1**
Intercropping						2
Mechanical weeding	**3**	**3**	1	**3**	2	**7**
Mowing		2				**4**
Mulching			1	1		1
Natural enemies			1			1
Other						
Site-specific spraying	1	1			1	**3**
Thermal weeding						
UAV						
n=28	4	5	1	3	2	11

2.1.2.1.1.1 Biobased herbicides

2.1.2.1.1.1.1 Researcher

Researchers view biobased herbicides as a technique with significant needs and barriers, along with some opportunities and few disadvantages. Two-thirds of the respondents believe that biobased herbicides will increase water availability and quality, reduce herbicide reliance, and potentially become an important scientific discipline in the future. Primary needs identified by all researchers include practicing knowledge skills, management expertise, training, and cost reduction. Sixty-seven percent of respondents also highlighted ecosystem services impact knowledge, regulatory changes, lack of advisors, and timing reduction as critical needs for biobased herbicides implementation. Training and lack of funds were unanimously identified as highly relevant barriers by all researchers. Moreover, two-thirds of the respondents considered complexity, time consumption, regulation, and expense as significant impediments. Finally, low efficacy and expense were deemed important disadvantages by 67% of respondents.

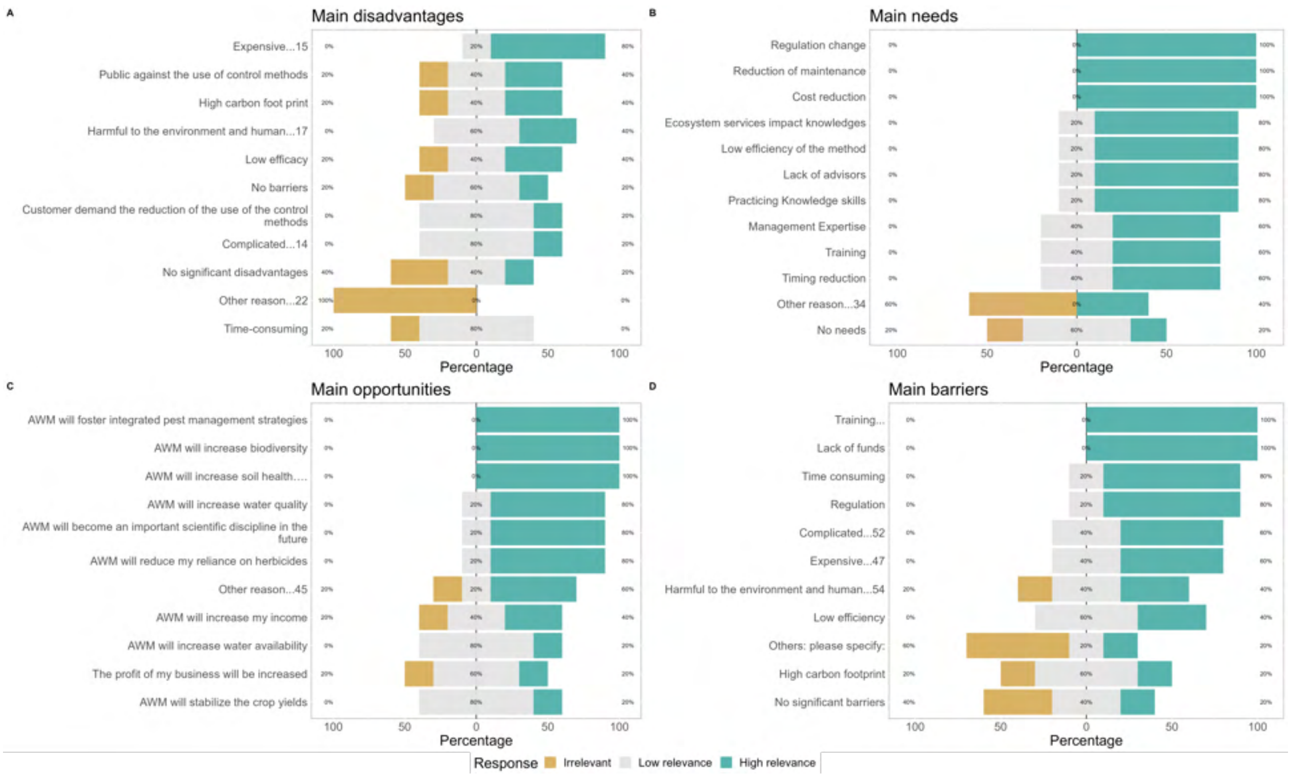


Figure 116. Main disadvantages, needs, barriers and opportunities for Biobased herbicides identified by researchers.

2.1.2.1.1.1.2 Conclusion

Researchers view biobased herbicides as promising but requiring significant attention to needs and barriers. They anticipate benefits like increased water quality and reduced herbicide use, along with the potential for scientific advancement. Primary needs include knowledge, management, training, and cost reduction, with additional emphasis on ecosystem understanding and regulatory changes. Barriers include training, lack of funds, complexity, time consumption, regulation, and expense, while low efficacy and cost are highlighted as important drawbacks.

2.1.2.1.1.2 Cover crops

2.1.2.1.1.2.1 Researcher

Cover crops are viewed as a technique filled with opportunities, along with some needs and potential disadvantages. Researchers unanimously agree that cover crops will foster IPM strategies and provide various ecosystem services, such as increasing biodiversity and soil health. Two-thirds of the respondents also believe that cover crops offer opportunities for increasing water quality, business profitability, reducing herbicide reliance, and potentially evolving into an important scientific discipline. Training is unanimously identified as the primary need for this technique, with sixty-seven percent of respondents considering practicing knowledge skills and timing reduction as highly relevant. However, no significant proportion of respondents deemed any of the queried barriers as highly relevant. Regarding disadvantages, researchers expressed concerns about customer demands for reducing its use and expense.

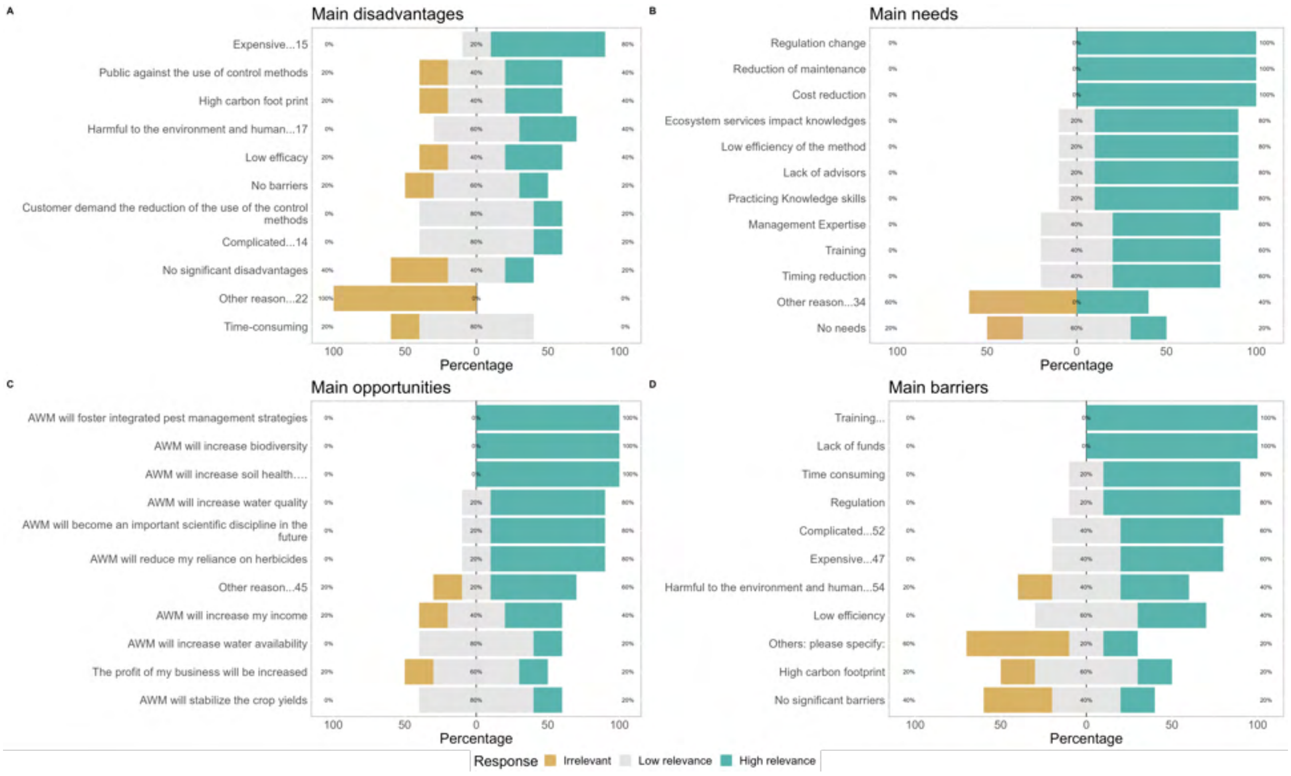


Figure 117. Main disadvantages, needs, barriers and opportunities for cover crops identified by researchers.

2.1.2.1.1.2.2 Conclusion

Researchers unanimously view cover crops as rich in opportunities, foreseeing benefits like fostering IPM strategies and enhancing biodiversity. Two-thirds anticipate advantages in water quality improvement, profitability, and reduced herbicide reliance. Training is unanimously identified as the primary need, with some emphasis on knowledge skills and timing. While no significant barriers were noted, concerns about customer demands and expense were highlighted as potential drawbacks.

2.1.2.1.1.3 Grazing

2.1.2.1.1.3.1 Researcher

Grazing presents abundant opportunities alongside several needs and barriers, but relatively few disadvantages. The majority of researchers, eighty percent, view grazing as beneficial for soil health, income generation, and reducing herbicide usage. Additionally, more than half see it as conducive to IPM strategies. Cost reduction is overwhelmingly seen as the primary need, followed by practicing knowledge skills and management expertise. Lack of funds stands out as the main impediment, with time consumption and training also noted as significant barriers by sixty percent of respondents. Among the few disadvantages identified, expense emerges as the most prominent concern for sixty percent of researchers.

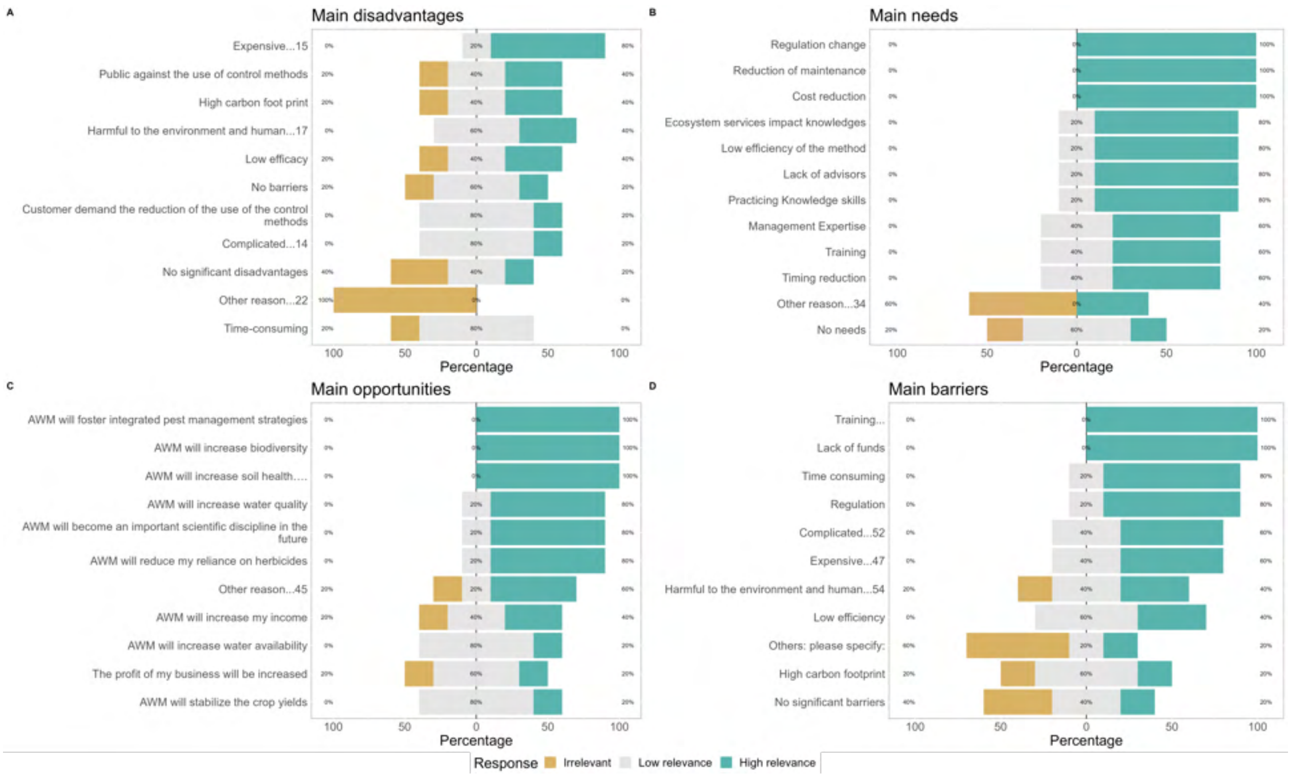


Figure 118. Main disadvantages, needs, barriers and opportunities for grazing identified by researchers.

2.1.2.1.1.3.2 Conclusion

In summary, researchers overwhelmingly view grazing as beneficial for soil health, income generation, and reducing herbicide usage. Cost reduction is seen as the primary need, with lack of funds identified as the main barrier. Among the few disadvantages, expense stands out as a prominent concern.

2.1.2.1.1.4 Herbicides

2.1.2.1.1.4.1 Consumer

Consumers perceive herbicides as offering numerous opportunities alongside significant needs, barriers, and disadvantages. They believe herbicides will support IPM strategies and contribute to various ecosystem services, such as enhancing water quality, biodiversity, and soil health. Additionally, consumers anticipate herbicides stabilizing crop yields and reducing reliance on other chemicals, with unanimous agreement that herbicides will evolve into a vital scientific discipline. Regarding primary needs, consumers unanimously prioritize timing reduction, with seventy-five percent also emphasizing management expertise, training, and maintenance reduction. However, consumers express significant concerns about training, environmental and human harm, and expense as key barriers to herbicide implementation. Notably, consumers unanimously recognize the potential environmental and human harm posed by herbicides as the main disadvantage, yet they asserted that this technique does not present any relevant barrier.

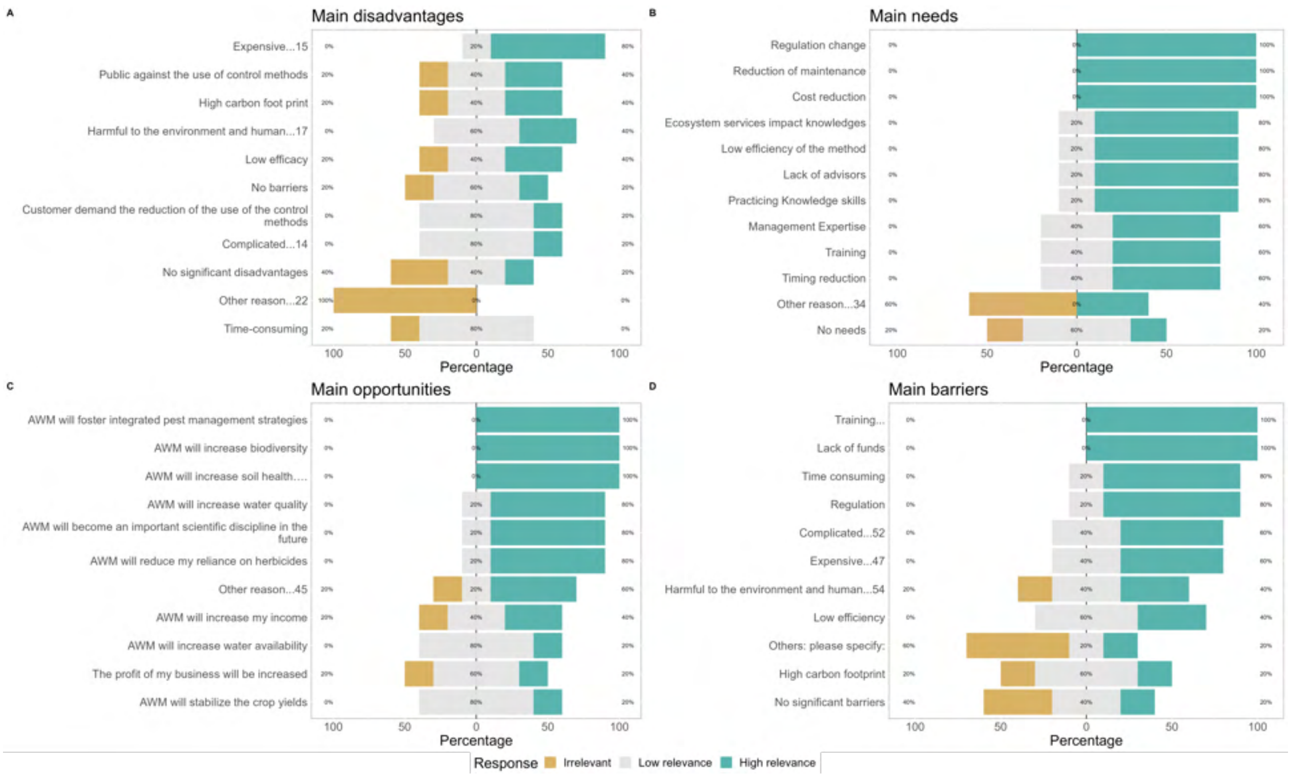


Figure 119. Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

2.1.2.1.1.4.2 Industry

Industry representatives regard herbicides as offering numerous opportunities alongside significant needs, barriers, and some disadvantages. They unanimously view herbicides as potential enhancers of IPM strategies and providers of ecosystem services, including improvements in water quality, availability, biodiversity, and soil health. Moreover, all industry representatives foresee herbicides evolving into an important scientific discipline and reducing reliance on other chemicals. Identifying primary needs, they unanimously prioritize ecosystem services impact knowledge, regulatory changes, lack of advisors, practicing knowledge skills, and training in herbicide implementation. Additionally, two-thirds of respondents emphasize management expertise, cost and maintenance reduction, and timing as crucial needs. While industry representatives unanimously acknowledge regulatory barriers, nearly seventy percent identify environmental and human harm, time consumption, training, and expense as significant barriers. Furthermore, they express concerns about public demands to reduce or eliminate herbicide use and potential harm to the environment and human health. However, in line with consumer sentiment, industry representatives do not perceive any barriers to herbicide implementation.

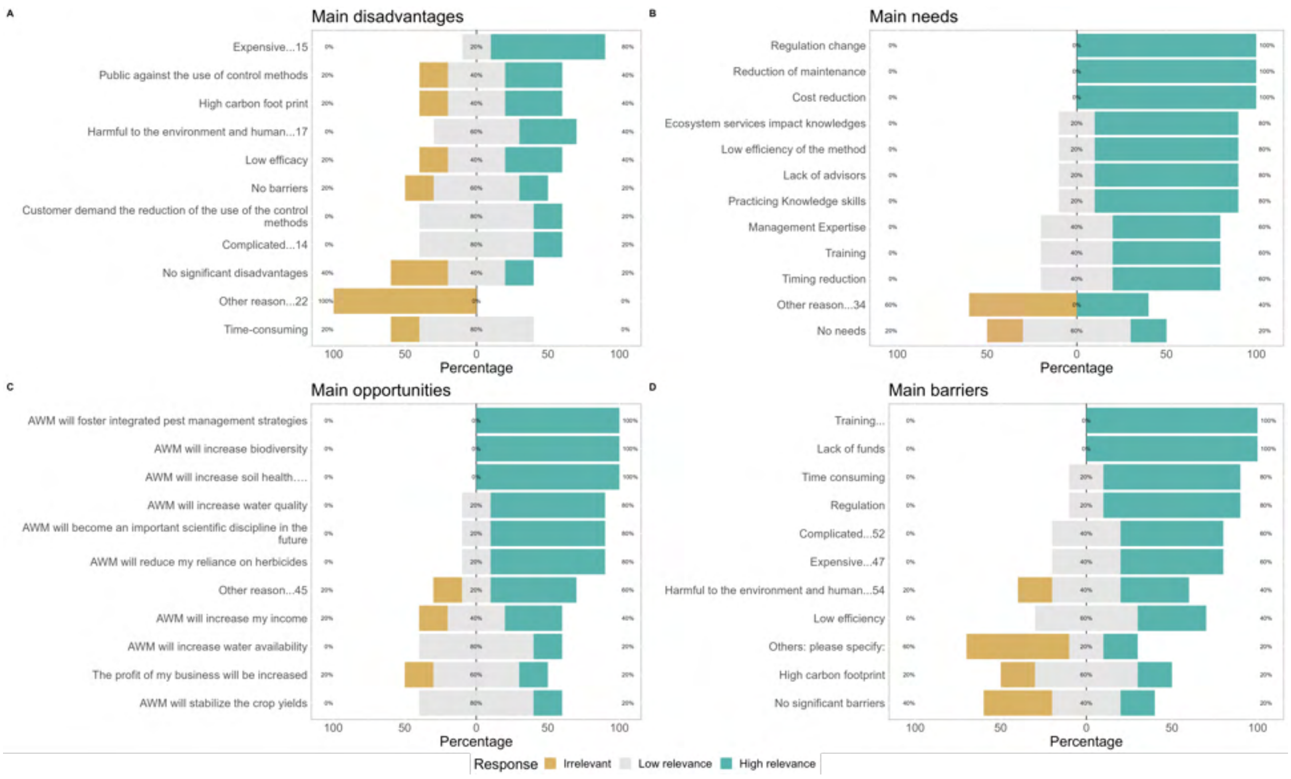


Figure 120. Main disadvantages, needs, barriers and opportunities for herbicides identified by industry.

2.1.2.1.1.4.3 Researchers

Nearly three quarters of the researchers believe that herbicide use will foster IPM strategies, increase farmers' income, and evolve into an important scientific discipline in the future. Moreover, more than half of the respondents anticipate that herbicides will enhance water availability and quality, biodiversity, soil health, and business profitability. Almost all researchers consider ecosystem services impact knowledge and regulatory changes as crucial needs, while lack of advisors, practicing knowledge skills, and training are seen as key necessities by 70% of researchers. Regulatory barriers and potential harm to the environment and human health are identified as significant barriers by 100% and 90% of researchers, respectively. Additionally, 80% of respondents highlight training as a key impediment for herbicide use. Main disadvantages, as perceived by researchers, include environmental and human harm (100%), public opposition to its use, expense (90%), customer demands for its reduction, and its high carbon footprint (80%).

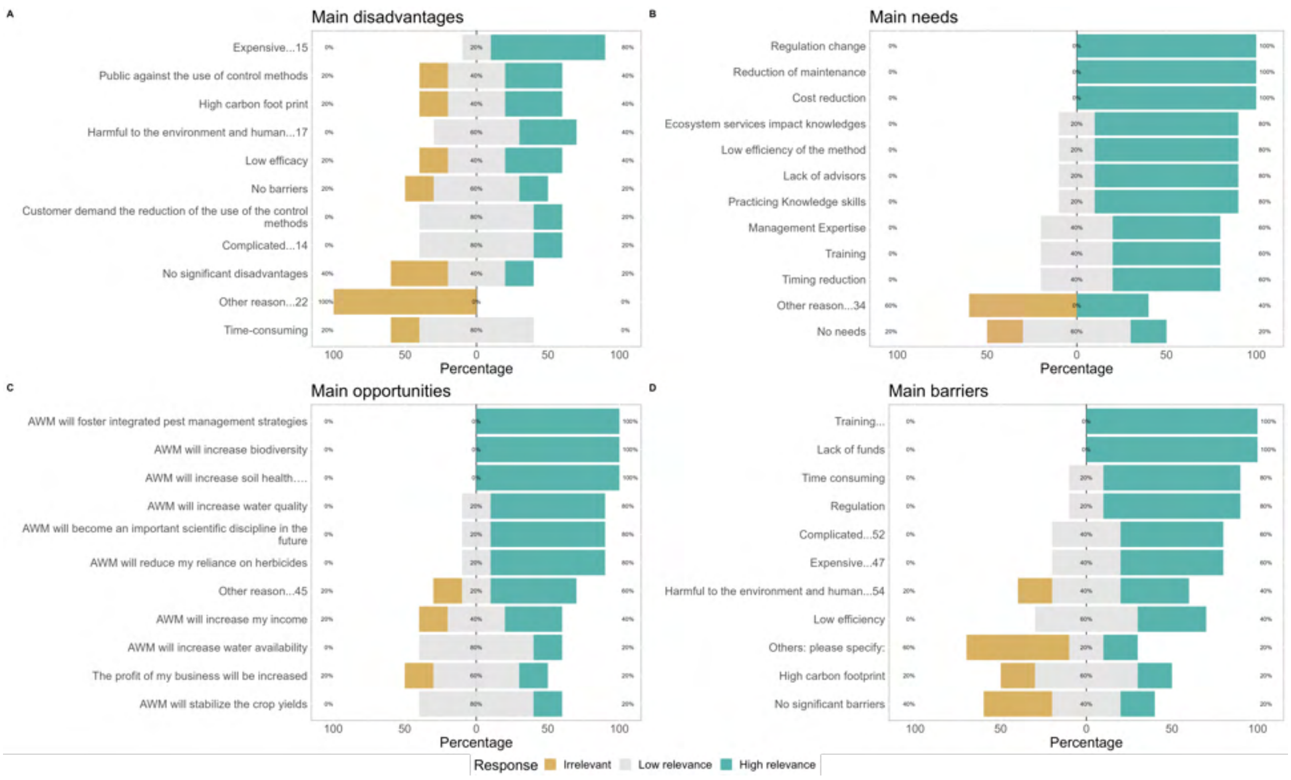


Figure 121. Main disadvantages, needs, barriers and opportunities for herbicides identified by researchers.

2.1.2.1.1.4.4 Conclusion

In conclusion, consumers, industry representatives, and researchers perceive herbicides as offering numerous opportunities alongside significant needs, barriers, and some disadvantages. All stakeholders anticipate the role of herbicides in providing ecosystem services, while also foreseeing their evolution into an important scientific discipline. Consumers consider that herbicide use will result in stabilizing crop yields and reducing reliance on other chemicals, whereas researchers anticipate an improvement in business profitability. Primary needs identified by consumers include timing reduction, management expertise, training, and maintenance reduction. Industry representatives prioritize ecosystem services impact knowledge, regulatory changes, lack of advisors, and training as primary needs. Almost all researchers consider ecosystem services impact knowledge and regulatory changes as crucial needs, while lack of advisors, practicing knowledge skills, and training are seen as key necessities by 70% of researchers. Both consumers and researchers express significant concerns about training, environmental and human harm, and expense as key barriers to herbicide implementation. While regulatory barriers are acknowledged unanimously, nearly seventy percent of industry representatives identify environmental and human harm, time consumption, and expense as significant barriers. As main disadvantages, industry representatives, like consumers, do not perceive any barriers to herbicide implementation. However, as perceived by researchers, include environmental and human harm, public opposition to its use, expense, customer demands for its reduction, and its high carbon footprint. In summary, while all stakeholders acknowledge the potential benefits of herbicides, they also recognize the importance of addressing various needs and barriers, particularly regarding environmental and human health impacts and regulatory compliance.

2.1.2.1.1.5 Mechanical weeding

2.1.2.1.1.5.1 Advisor

Advisors view mechanical weeding as a practice brimming with opportunities, with every queried category deemed highly relevant by more than half of the respondents. They believe its use will increase business profitability and farmers' income, while stabilizing crop yields and reducing herbicide reliance. Additionally, 67% of respondents consider mechanical weeding to foster IPM strategies and provide several ecosystem services, including an increase in water quality and availability, biodiversity, and soil health. As main needs, advisors unanimously consider practicing knowledge skills. Approximately two-thirds of the respondents consider ecosystem services impact knowledge and lack of advisors as the main necessities. Advisors identify training as the most relevant impediment and expense as the main disadvantage with regards to mechanical weeding.

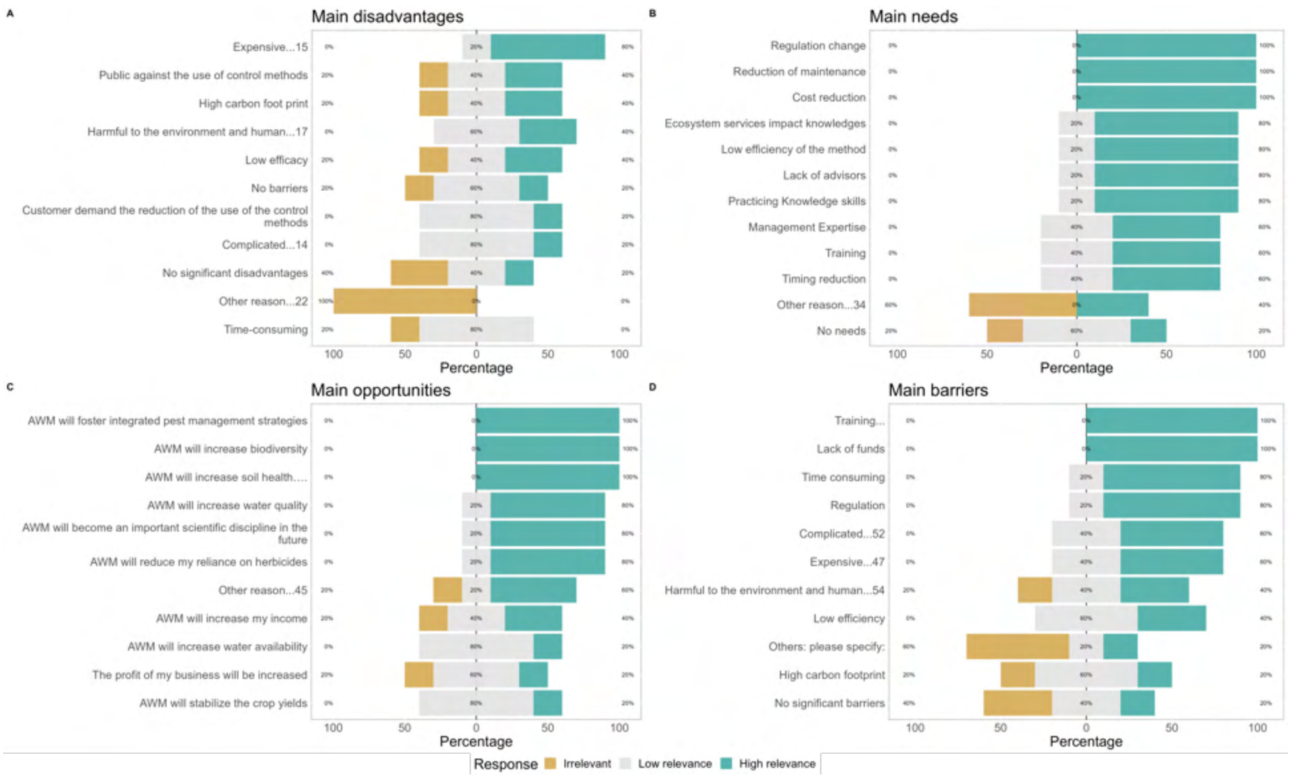


Figure 122. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by advisors.

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2.1.2.1.1.5.2 Consumer

Consumers, aligning with advisors 'view, perceive mechanical weeding as a technique offering numerous opportunities. They view it as a means to provide ecosystem services, such as enhancing water availability and quality, biodiversity, and soil health. Additionally, consumers believe that mechanical weeding has the potential to stabilize crop yields, reduce herbicide reliance, and evolve into an important scientific discipline. Unanimously, consumers identify ecosystem services impact, low efficiency, practicing knowledge skills, and timing reduction as the most relevant needs concerning mechanical weeding. Nearly seventy percent of the respondents emphasize the importance of addressing the lack of advisors, management expertise, and cost reduction as pressing necessities. All consumers also highlight low efficiency, training, and expense as the main impediments to mechanical weeding. Sixty-seven percent of consumers express concerns about the potential environmental and human harm, complexity, and time consumption associated with mechanical weeding. In consumers' view, the main disadvantages are low efficacy and time consumption, with other factors not deemed as relevant by more than half of the respondents.

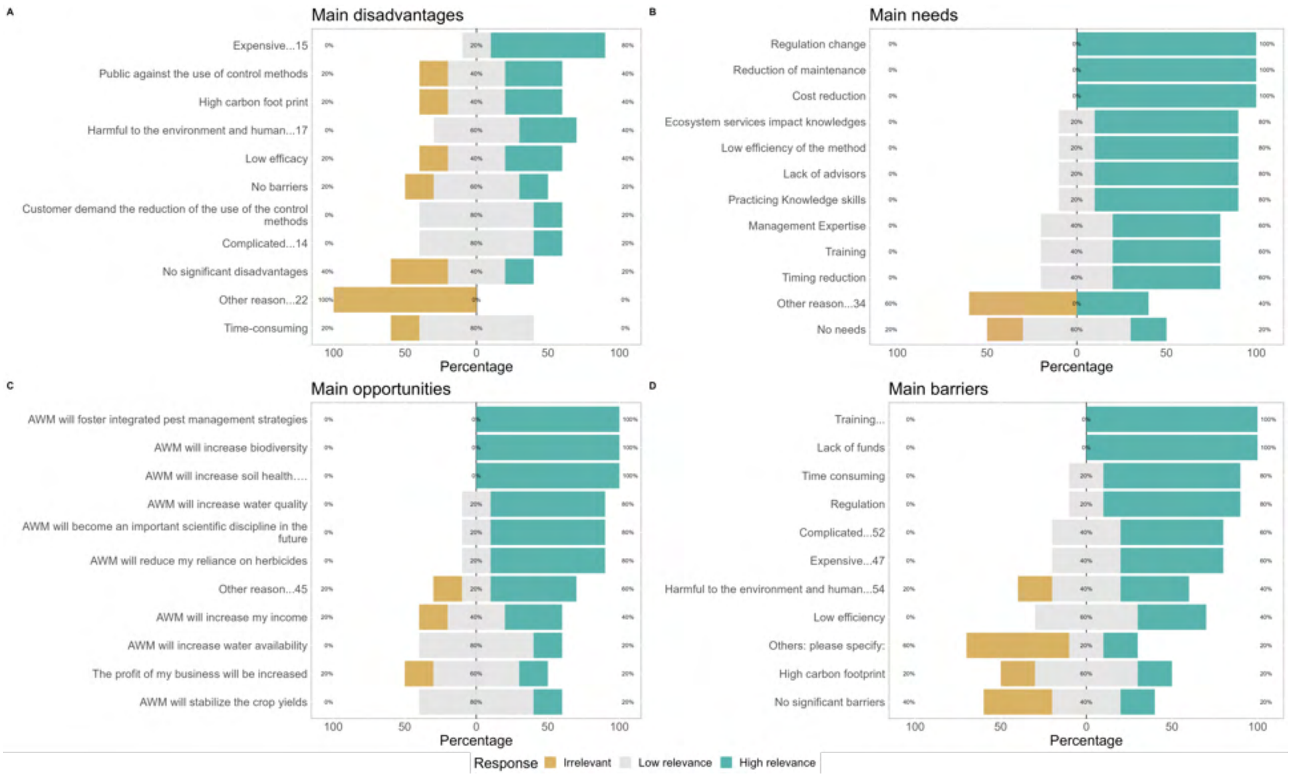

Figure 123. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by consumers.

2.1.2.1.1.5.3 Industry

Industry representatives, like other stakeholders, perceive mechanical weeding as presenting significant opportunities. All respondents believe it will foster IPM and provide various ecosystem services, such as enhancing water availability and quality, as well as biodiversity and soil health. They unanimously express that mechanical weeding will evolve into an important scientific discipline and reduce reliance on herbicides. There is high consensus among industry representatives regarding the necessities of mechanical weeding. All agree that ecosystem services impact knowledge, practicing knowledge skills, management expertise, training, reduction of maintenance, cost, and timing are the most relevant necessities. The most significant impediments identified by all respondents are regulation and expense. Lastly, the main disadvantage concerning mechanical weeding, as identified by all industry representatives, is the potential for environmental and human harm. Additionally, nearly seventy percent of the respondents consider public demand to reduce mechanical weeding, high carbon footprint, low efficacy, expense, complexity, and time consumption as relevant disadvantages.

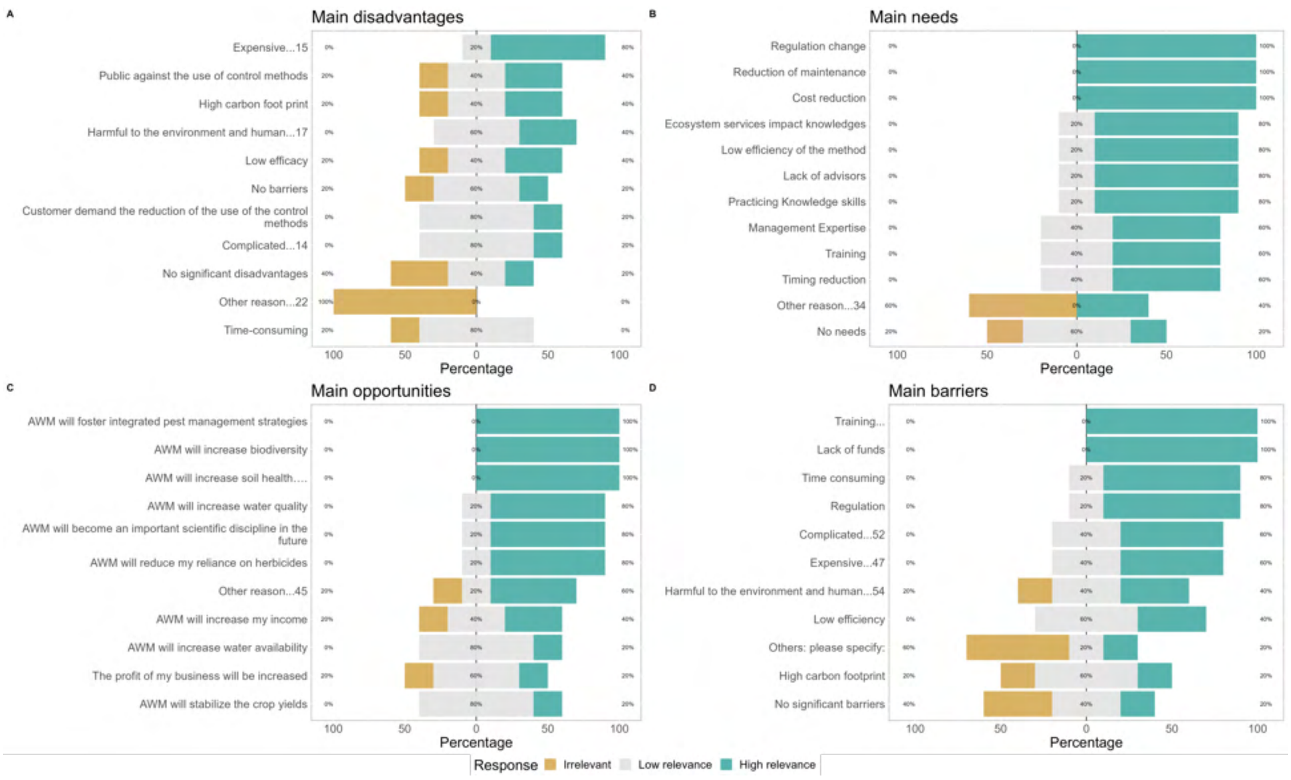

Figure 124. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by industry.

2.1.2.1.1.5.4 Researcher

Researchers have identified several opportunities associated with mechanical weeding, with 86% of respondents believing that its use will improve farmers' income and reduce their reliance on herbicides. Additionally, more than seventy percent of researchers expressed that it will stabilize crop yields, and 57% of them considered that it will foster IPM and may evolve into an important scientific discipline. However, the other queried opportunities were not considered relevant by more than 50% of respondents, although they were deemed of high relevance by a significant proportion of respondents in other stakeholder groups. In terms of needs, researchers identified ecosystem services impact knowledge as the primary necessity, consistent with the perspectives of consumers and industry representatives. They also emphasized the importance of cost and maintenance reduction when implementing mechanical weeding. Regarding barriers, researchers highlighted training as a relevant obstacle, aligning with the views of consumers and advisors. However, the other factors were not deemed relevant by more than half of the respondents. Expense (71%), high carbon footprint, and environmental and human harm (55%) were considered highly relevant disadvantages by researchers.

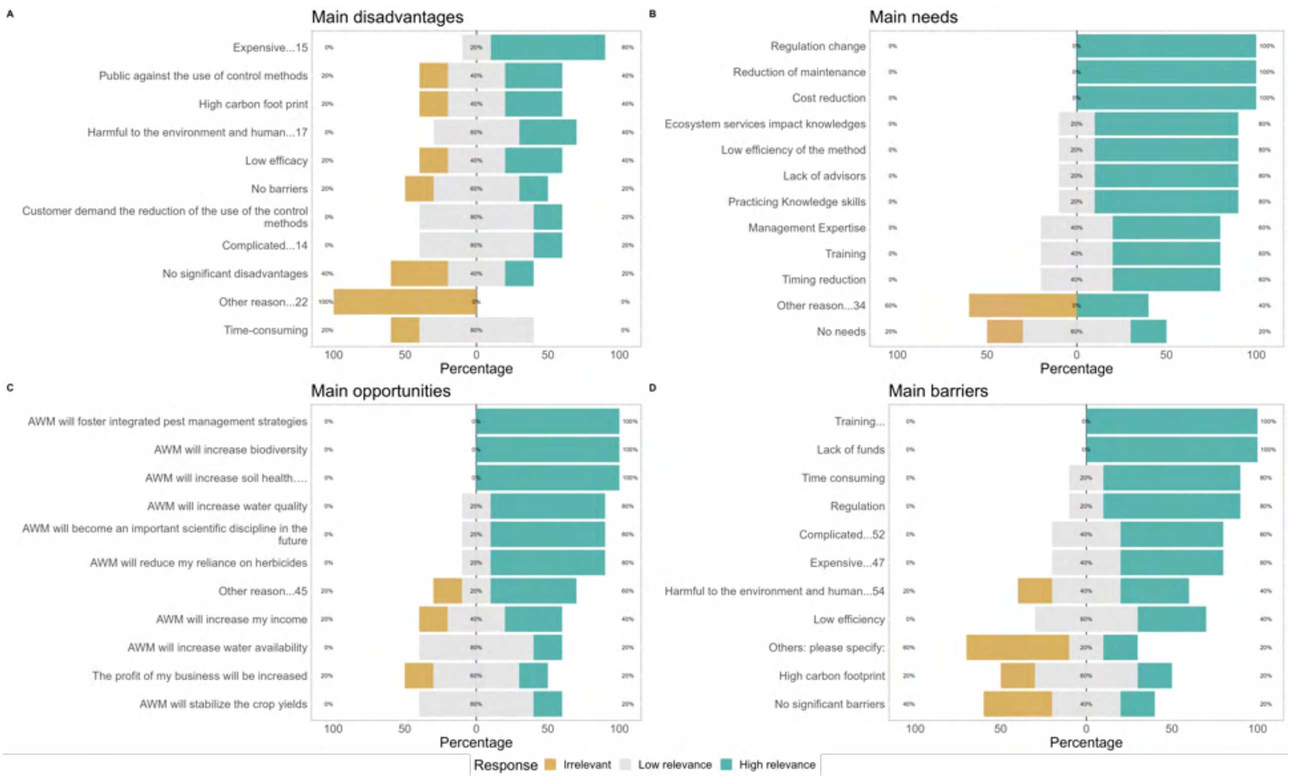

Figure 125. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by researcher.

2.1.2.1.1.5.5 Conclusion

In conclusion, mechanical weeding is perceived as a practice abundant with opportunities by advisors, consumers, industry representatives, and researchers. All stakeholders recognize its potential to increase profitability, stabilize crop yields, reduce herbicide reliance, and foster IPM strategies. Additionally, there is consensus that mechanical weeding can provide various ecosystem services, such as enhancing water quality, biodiversity, and soil health, and may evolve into an important scientific discipline. Primary needs identified across stakeholders include practicing knowledge skills, ecosystem services impact knowledge, and the reduction of maintenance, cost, and timing. However, advisors highlight training as the most critical need, while consumers and industry representatives prioritize ecosystem services impact knowledge. Meanwhile, researchers emphasize the importance of cost and maintenance reduction. Despite the unanimous acknowledgment of opportunities and needs, there are divergent perspectives on barriers and disadvantages. While training is a significant barrier for all stakeholders, industry representatives highlight regulation and expense as the most substantial impediments, while researchers emphasize expense and environmental and human harm. Consumers express concerns about environmental and human harm, complexity, and time consumption. The main disadvantages identified across all groups are environmental and human harm, expense, and low efficacy, with other factors receiving varying levels of emphasis. In summary, while stakeholders recognize the potential benefits of mechanical weeding, addressing the identified needs, barriers, and disadvantages will be essential for its successful implementation and integration within agricultural practices.

2.1.2.1.1.6 *Mowing*

2.1.2.1.1.6.1 *Researcher*

Researchers share an optimistic view on mowing, considering this technique as a provider of ecosystem services, including increases in water availability and soil health. They also recognize that mowing will stabilize crop yields and reduce herbicide reliance. Half of the respondents considered that mowing will foster IPM strategies, increase biodiversity, and evolve into an important scientific discipline. As for the main necessities, three quarters of the researchers identify lack of advisors and practicing knowledge skills. Additionally, half of the respondents considered management expertise, training, reduction of maintenance, cost, and timing as relevant necessities. Seventy-five percent of the researchers, in accordance with what was expressed as main needs, considered training as a relevant impediment with regard to mowing. Furthermore, fifty percent of the researchers recognize regulatory challenges as relevant barriers. Only half of the researchers considered expense and low efficacy as relevant disadvantages, while the rest of the queried factors were not deemed as relevant by a significant proportion of respondents.

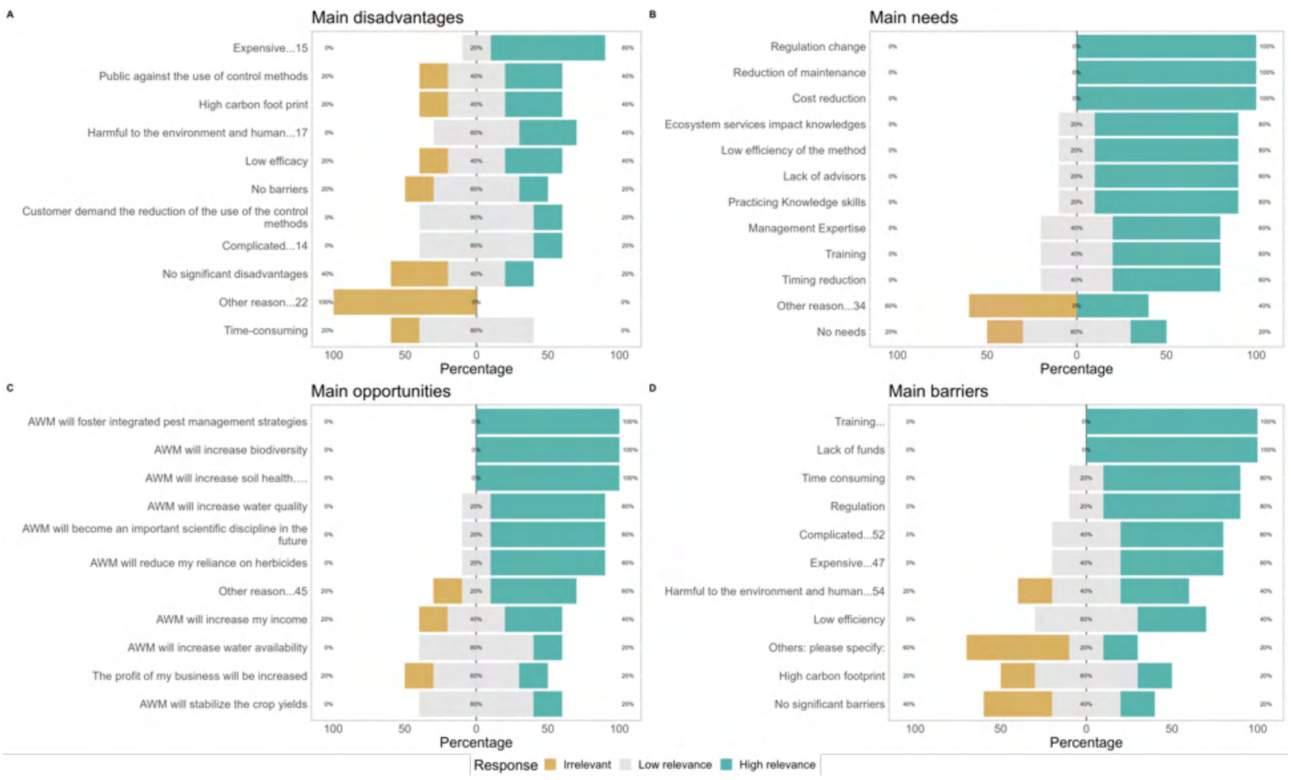

Figure 126. Main disadvantages, needs, barriers and opportunities for mowing identified by researchers.

2.1.2.1.1.6.2 *Conclusion*

In summary, researchers are optimistic about mowing, seeing it as a way to provide ecosystem services and stabilize crop yields while reducing herbicide use. They highlight the need for better training and management expertise, alongside addressing regulatory challenges. Despite recognizing some drawbacks like expense and low efficacy, researchers generally see mowing as a beneficial technique with potential for further development.

2.1.2.1.1.7 Site-specific spraying

2.1.2.1.1.7.1 Researchers

All of the researchers recognize site-specific spraying's potential in fostering IPM strategies; besides, it will evolve into an important scientific discipline in the future. Nearly seventy percent of the respondents considered site-specific spraying as a provider of ecosystem services, including the increase of water availability and quality as well as soil health. Besides, they recognize that it will reduce herbicide reliance. Researchers unanimously considered that site-specific spraying entails several needs, including ecosystem services impact knowledge, lack of advisors, practicing knowledge skills, management expertise, and training, as recognized by all of the respondents. The main impediments identified unanimously were environmental and human harm, training, and regulation, as stated by all of the researchers; the other queried factors were not deemed as highly relevant by a significant proportion of respondents. Researchers unanimously view that the potential harm to the environment and humans as the main disadvantages. Nearly 70% of respondents identified as relevant disadvantages the public's opposition to its use, its high carbon footprint, and expense.

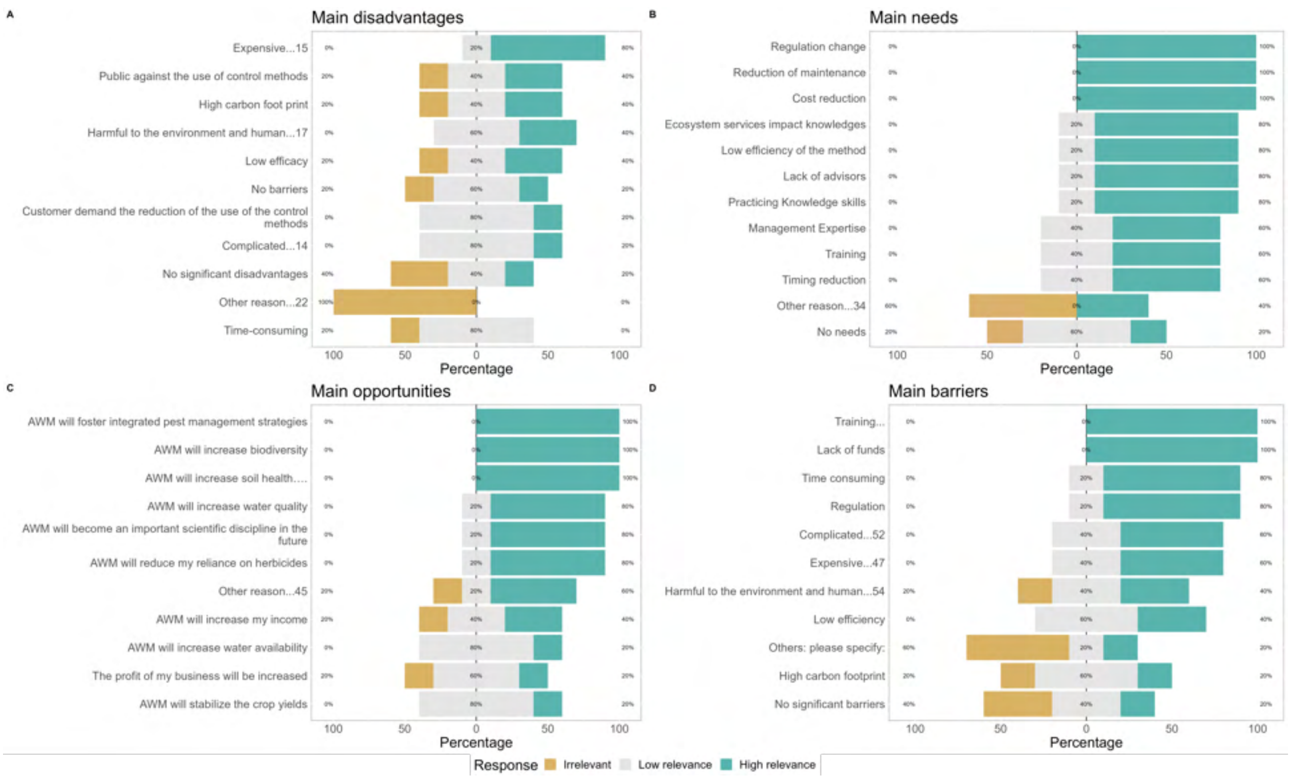

Figure 127. Main disadvantages, needs, barriers and opportunities for site-specific spraying identified by researchers.

2.1.2.1.1.7.2 Conclusion

In summary, researchers unanimously see site-specific spraying as beneficial for IPM strategies and ecosystem services. They emphasize the need for knowledge enhancement and training while identifying environmental and human harm, training, and regulation as key barriers. Overall, addressing these concerns is crucial for maximizing the technique's potential benefits.

2.1.2.1.2 Surveys

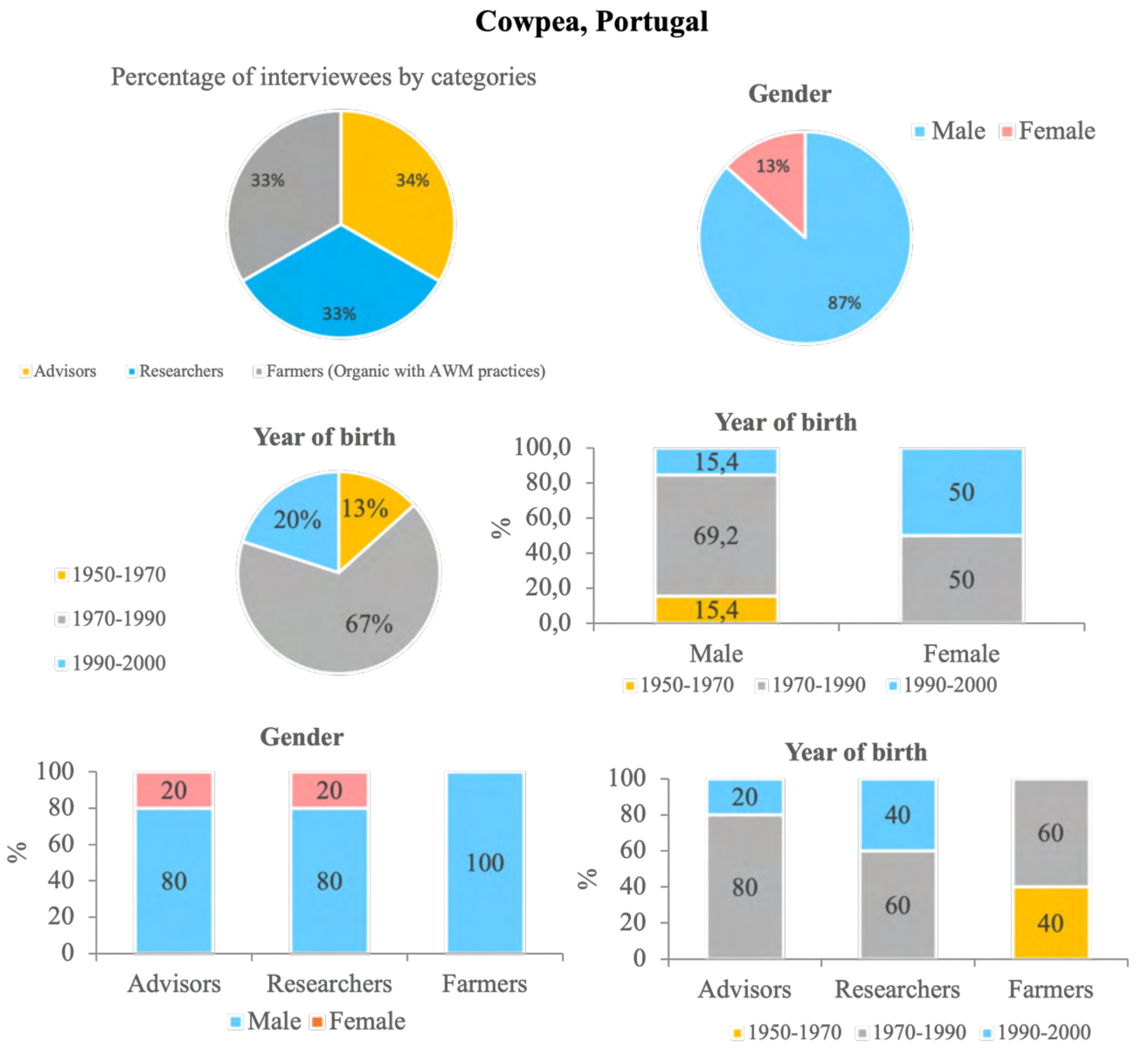

Figure 128 Interviewees description in the Cowpea Living Lab (Portugal)

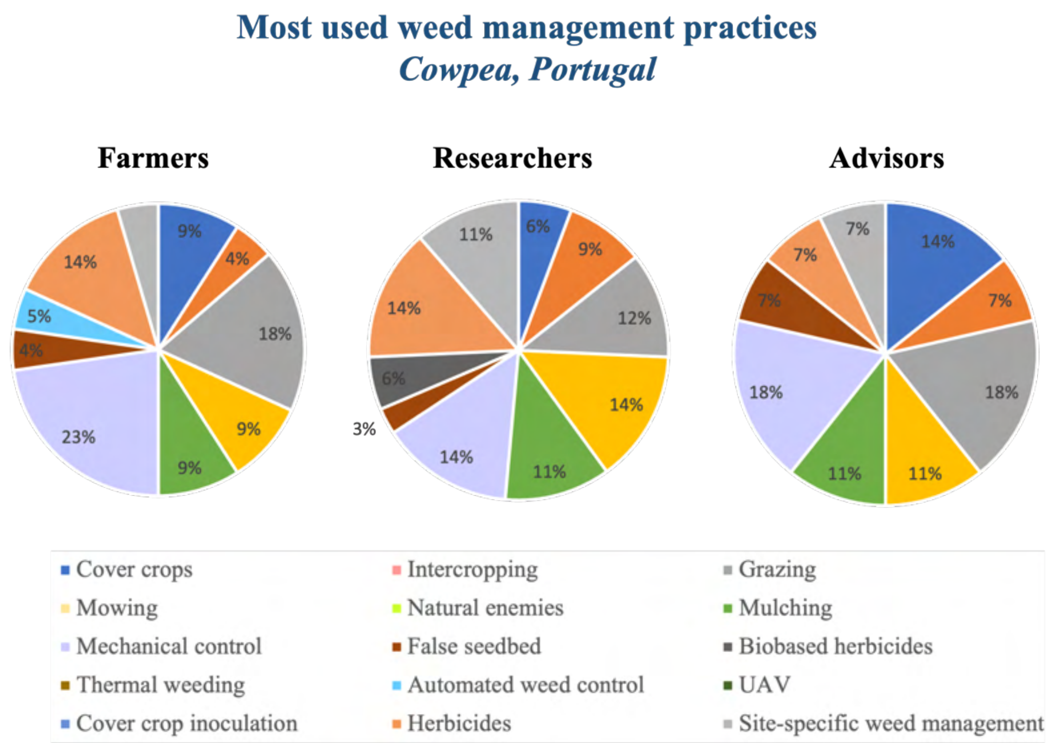

Figure 129 Most used weed management practices in the Cowpea Living Lab (Portugal)

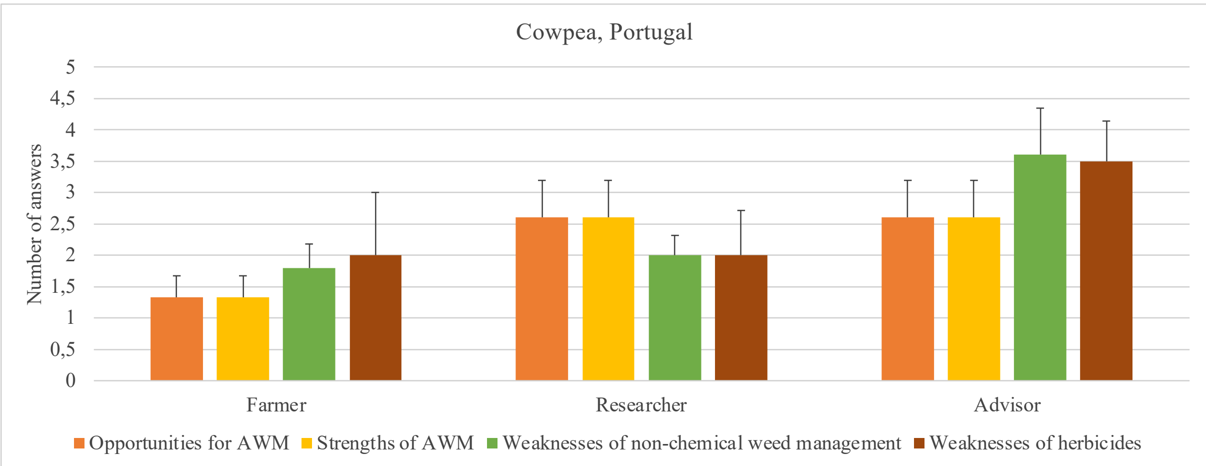

Figure 130 Mean number of answers (±se) per stakeholder group in the Cowpea Living Lab (Portugal)

Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: Presented in the figure below.

THREATS: Climate change was the only answer by a farmer.

WEAKNESSES: The lack of extension services and timing of application were considered weaknesses of AWM practices by a farmer.

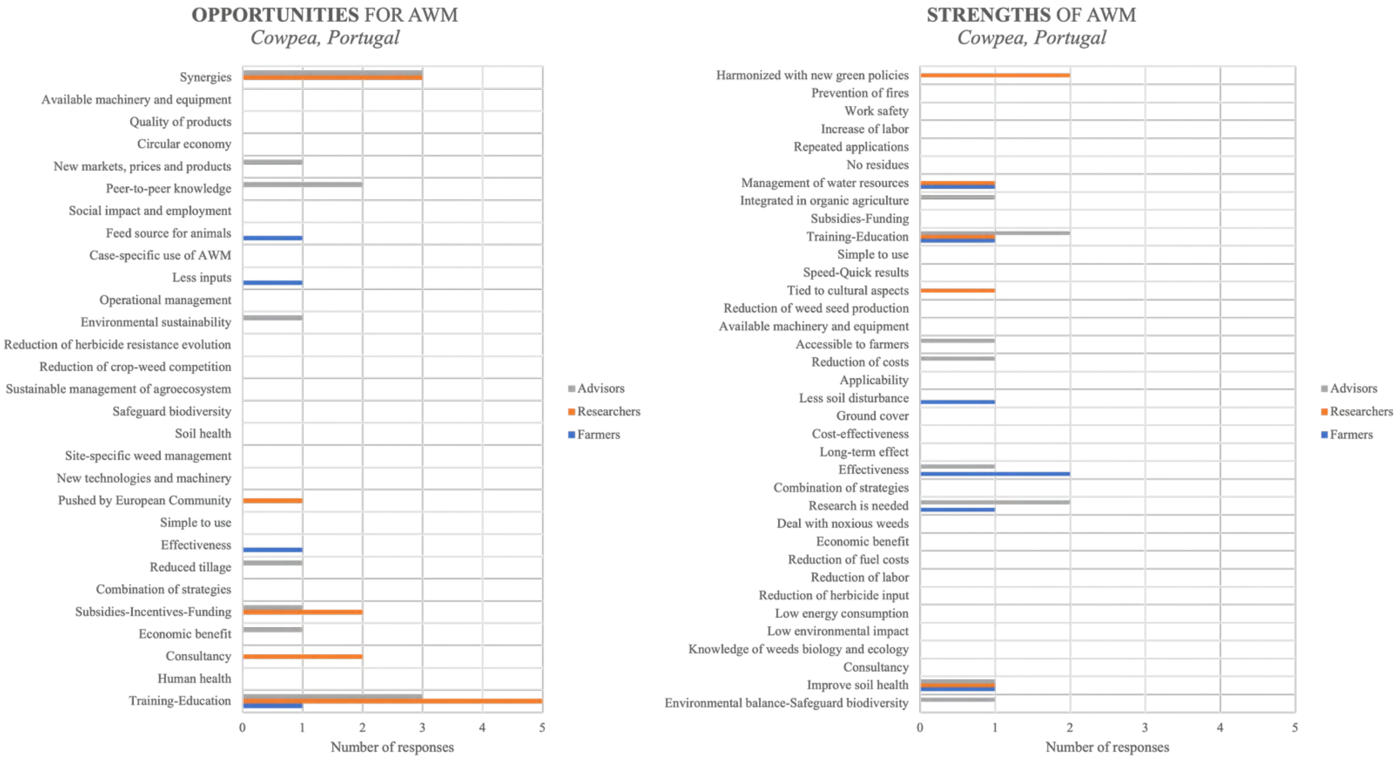

Figure 131 Opportunities and strengths of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: Farmers replied that climate and weather conditions, and invasive species are threats for the adoption of non-chemical weed management. A researcher mentioned the lack of recognition from markets and an advisor referred to the prices of the energy sector and the market as factors affecting the transition towards non-chemical weed management.

WEAKNESSES: Presented in the figure below.

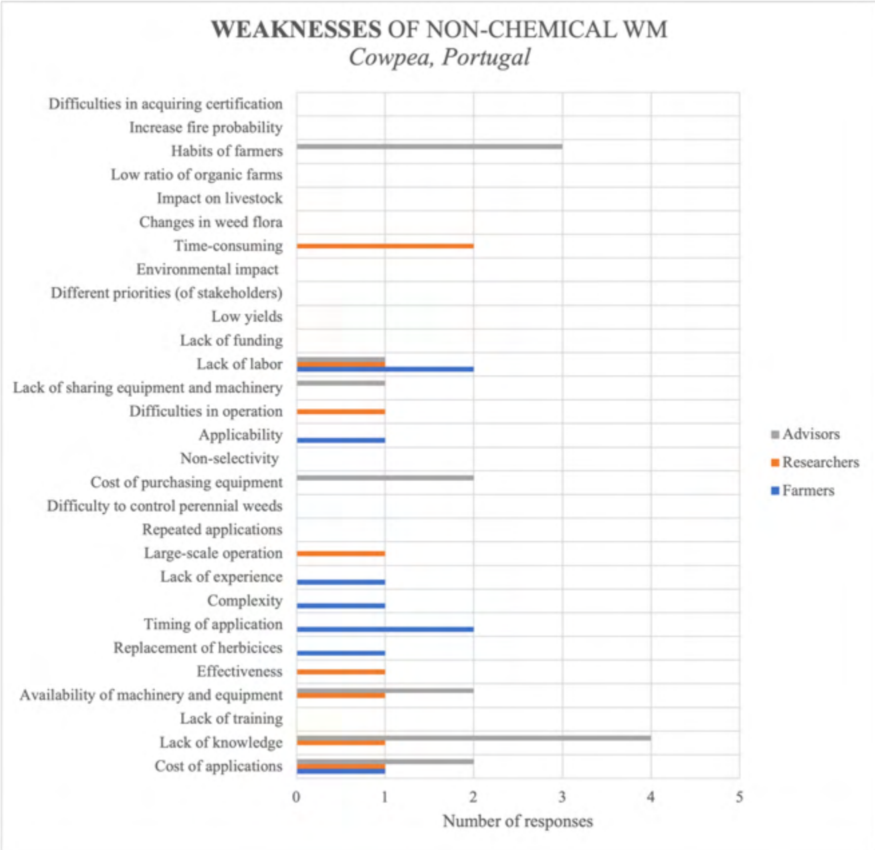

Figure 132 Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: None.

STRENGTHS: None.

THREATS: Markets and pressure to reduce herbicides were the only responses.

WEAKNESSES: Presented in the figure below.

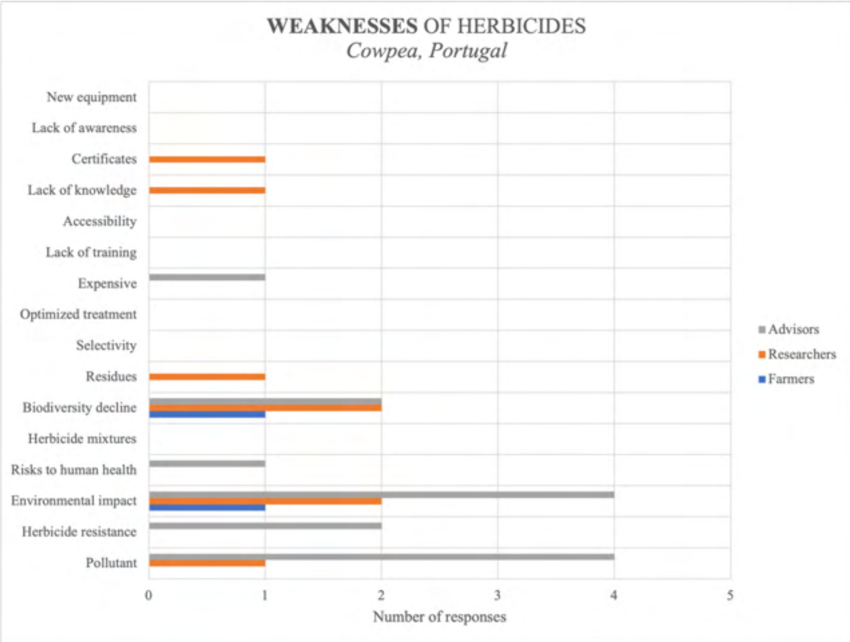

Figure 133 Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – COWPEA, PORTUGAL
Most used weed management practices: Weed management in cowpea was one of the most diverse across the crops of the GOOD LLs. More than 10 practices and several combinations were reported to be effective for sufficient weed management. Farming in Idahna region of Central Portugal is at a large extent dependent on weather conditions (e.g., precipitation and frequency of rainfalls, as well as drought) and livestock. Animals (especially cows and sheep) are used for grazing, which is a natural weed management method that is cost-effective for farmers and give them the chance to adjust the diet of the animals as well. Moreover, the use of mulches (e.g., using residues after pruning) is also common. The application of herbicides remains low, which is positive, while some farmers and associations are following several principles and practices of organic agriculture. **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group**: The group of advisors was the one that gave the most responses to all questions compared to the other two stakeholder groups. It is interesting that for all stakeholder groups the number of identified weaknesses of non-chemical weed management was almost equal to the number of identified weaknesses of herbicides. This result reveals that the interviewees are aware of the problems of herbicide use, but they are also keen to

know more, find evidence and support non-chemical weed management. Farmers were not able to identify many strengths and opportunities for AWM.

Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management: Besides training and education, which is a horizontal opportunity for AWM, the interviewees in the cowpea LL considered synergies and peer-to-peer knowledge as important opportunities for the thrive of AWM. Financial support of producers is one more opportunity for AWM. Regarding strengths of AWM, the need for more research and the harmonization with new green policies stand out.

Threats, and weaknesses for non-chemical weed management: Among several weaknesses of non-chemical weed management, the lack of labour and knowledge were the most prevalent. In addition, advisors mentioned the habits of farmers, the cost of applications and the costs for purchasing new equipment and machinery as weaknesses.

Opportunities, strengths, weaknesses, and threats for herbicides: It was captured from all stakeholder groups that herbicides cause biodiversity decline and pose a threat to the environment as they are pollutants. Herbicide resistance is not a big problem in cowpea cultivation as the combination of strategies for weed management does not allow the repetitive use of the same active ingredients.

2.1.2.1.3 Living lab board meeting

The meeting was divided into two sessions due to the limited availability of the various partners from the two living labs. In each session, both crops (olive and cowpea) were discussed. The first meeting started at 09:00 AM WET in person and the second meeting started at 06:30 PM WET online as a Microsoft Teams meeting. Both meetings lasted one hour. Present were members of both the olive and cowpea living lab. Due to the short amount of time leftover, it was impossible to find a date that allowed us to have a meeting per living lab separately. The agenda of the meetings was: i) Introduction to GOOD (What is GOOD, who are we, what is our vision and impact), ii) What is Agroecology (What, why, policies context), iii) What is the living lab board and what is ours? (trials and locations), iv) Discussion common weed management, v) Discussion herbicide use, vi) Discussion Barriers for agroecological transitions, vii) Drivers of weed dispersion, viii) Closing, what do you think about the living lab, socials and closure.

What are the market characteristics of [crop]?	1. How many farmers cultivate [crop] in the region (approx.)? Is it mostly monoculture or can rotations be made with other crops?
	Cowpea has around 10 farmers for production and many more because they are encouraged by subsidies but not for production. Normally in rotation systems. Olives hundreds of farmers, As monoculture.
	2. How many products are derived from the [crop]? Are they important for the economy and/or food security?
	Cowpea → dried. Olive → olive oil and olives for consumption.
	3. Do you think that agroecological products could be promoted in local markets?
	Discussion regarding how agroecological production methods are not protected, so it is not clear what it means, could be used to "greenwash" and seem organic
	4. Do you believe that the region has a lack of technologies?
	Yes, and that would help to avoid conventional management as we have some perennial plants in the olive orchard (*Genista*, *Cytisus*, *Lavandula*...) that are very difficult to remove without using heavy tillage machinery which is not good as it promotes soil erosion. .
	5. Is the regional agri-food value chain sustainable?
	Demand for cowpeas has increased in the past years so it's a great opportunity to produce and easy to sell. The same is happening with olive oil, with continuous increasing prices, making it a sustainable crop for the region.
	1. What are the most common agronomic practices in [cowpea]?

<table>
<tr><td rowspan="3">What are the most common agricultural and weed management practices in [crop]?</td><td>Sowing, pruning, terrain preparation, "weeding". Big difference in cowpea whether irrigated or rainfed, chosen the local model (rainfed). Rotation is mandatory in Organic as well as maintaining the soil cover.</td></tr>
<tr><td>2. What are the most common weed management practices in [olives]?</td></tr>
<tr><td>Herbicide, mowing, grazing, plowing (in combination with timing).</td></tr>
<tr><td rowspan="14">What is the herbicide use in [crop]?</td><td>1. How many active ingredients there are available? How many different mode of actions?</td></tr>
<tr><td>Main in olive orchards: musketier from Bayer + glyphosate or different versions of glyphosate, ingredients and detailed to be checked with one of the board members of the living lab and other projects in the area.</td></tr>
<tr><td>2. How many times do you spray in-season?</td></tr>
<tr><td>Only organic farmers were present.</td></tr>
<tr><td>3. Do you use pre-emergence, post-emergence or both herbicides?</td></tr>
<tr><td>Only organic farmers were present.</td></tr>
<tr><td>4. Are herbicides efficient?</td></tr>
<tr><td>They can be in the case of the olive orchard but not in cowpeas crop. In an economic perspective they are more efficient as it is much easier to apply herbicides than other strategies.</td></tr>
<tr><td>5. Do you think that alternatives to herbicides are equally efficient?</td></tr>
<tr><td>It’s not easy to substitute the easiness and effectiveness of herbicides. Crop yields without herbicides normally tend to be lower. For olive orchards with perennial and woody plants the AWM like grazing and cover cropping has not been that effective, forcing continuous soil operations.</td></tr>
<tr><td>6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?</td></tr>
<tr><td>Farmers must be conscious about the amount and doses that they apply to avoid environment contamination.</td></tr>
<tr><td>7. Do you believe that agriculture without herbicides is viable?</td></tr>
<tr><td>Yes</td></tr>
</table>

What are the needs and barriers to assist agroecological transitions & adopt agroecological weed management approaches?	1. What is needed to boost the uptake of agroecological practices?
	Training, education, policy; more producers organizations to be able to invest in shared machines for soil management, sowing and harvest. Practices can´t be generalized, each case may need a specific practice: e.g. cover cropping in Olive orchards installed in poor soils revealed not to be effective as the crops didn't grow as expected and needed.
	2. What are the barriers towards agroecology implementation?
	Knowledge, money; lack of machinery. Lack of human resources. Technicians are not providing real-life solutions. It is important to measure impacts between AWM or herbicides, maybe, in some cases it can be more harmful to apply AWM in terms of energy consumption, soil tillage and machinery usage than using a correct application of herbicides.
	3. Should policies need be redefined to allow agroecological transitions?
	Yes. And subsidies have to be re-thinked in terms of practical goals and specific cases.
	4. How confident you feel about the adoption of agroecological weed management practices?
	Confidence in general is high, discussion regarding the "conflict" with organics.
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	1. What are the main drivers of weed dispersal?
	Seeds and rizoma
	2. Which are the major and most noxious weeds in your area?
	Datura stramonium; *Lavandula* spp.; *Genista* spp.; *Citysus* spp.; *Cyperus* sp.; There's one weed (to be identified, maybe *Tribulus terrestris*), extended and prostrate, with yellow flowers and with a fruit with strong spikes.
	3. Are there any herbicide resistant weeds?
	Yes erva pau / avoadinha (*Conyza canadensis*).
	4. Do you know any invasive plants in your area?
	Yes, some of them listed as the major and most noxious weeds.
What do you think about the Living Lab?	1. Which proposals do you have for a good performance of the LL?
	More updates to keep up to date, every few months or so to keep involved. Meeting organized with more time up front.
	2. Would you like it to remain over time?
	Yes, participants are interested

2.1.2.2 *Soybean (Serbia)*

2.1.2.2.1 Questionnaires

Soybean questionnaires provided insights with regards to four AWM techniques: herbicides, mechanical weeding, mowing, and mulching. Perspectives were provided by advisors, consumers, industry representatives, and researchers, as we did not gather sufficient responses from farmers and policymakers. A detailed breakdown of stakeholder participation in the questionnaires for each AWM practice is presented in Table 27.

Table 27 Number of responses for each AWM practice and stakeholder category in soybean.

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control	1	2		2	1	2
Biobased herbicides	1	2		1		
Cover crop inoculation to increase competitiveness						
Cover crops	1	1				
False seedbed						
Grazing						
Herbicides	**3**	**6**		**4**	2	2
Intercropping	2	2		1	1	
Mechanical weeding	1	**6**		**3**	1	1
Mowing	2	**7**				**3**
Mulching	1	**3**				1
Natural enemies		1				
Other		1			1	
Site-specific spraying						
Thermal weeding						
UAV						
n=38	5	12	5	5	5	6

2.1.2.2.1.1 Herbicides

2.1.2.2.1.1.1 Advisors

Advisors unanimously acknowledge that herbicides offer several opportunities. They recognize that this technique will foster IPM strategies and provide ecosystem services, including an increase in water availability and quality, as well as an enhancement of biodiversity and soil health. Additionally, they unanimously recognize the potential for herbicides to become an important scientific discipline in the future, along with their capacity to stabilize crop yields and increase business profitability. Identifying the main necessities, all respondents consider ecosystem services impact knowledge, practicing knowledge skills, management expertise, and timing reduction as relevant challenges. Nearly seventy percent of respondents view regulatory changes, the method's low efficiency, lack of advisors, and cost reduction as significant needs. Advisors also acknowledge herbicides as a technique that entails relevant barriers. Environment and human harm, lack of funds, and regulatory challenges were unanimously stated as significant impediments by the respondents. Moreover, almost 70% of advisors consider high carbon footprint, time consumption, training, and expense as equally relevant barriers. There is a high rate of consensus among advisors when expressing the main disadvantages of herbicide use. Customer demands to reduce its use, environmental and human harm, and expense were deemed as highly relevant by all advisors. Additionally, 67% of respondents consider public opposition, high carbon footprint, and complexity as pressing disadvantages in herbicide implementation.

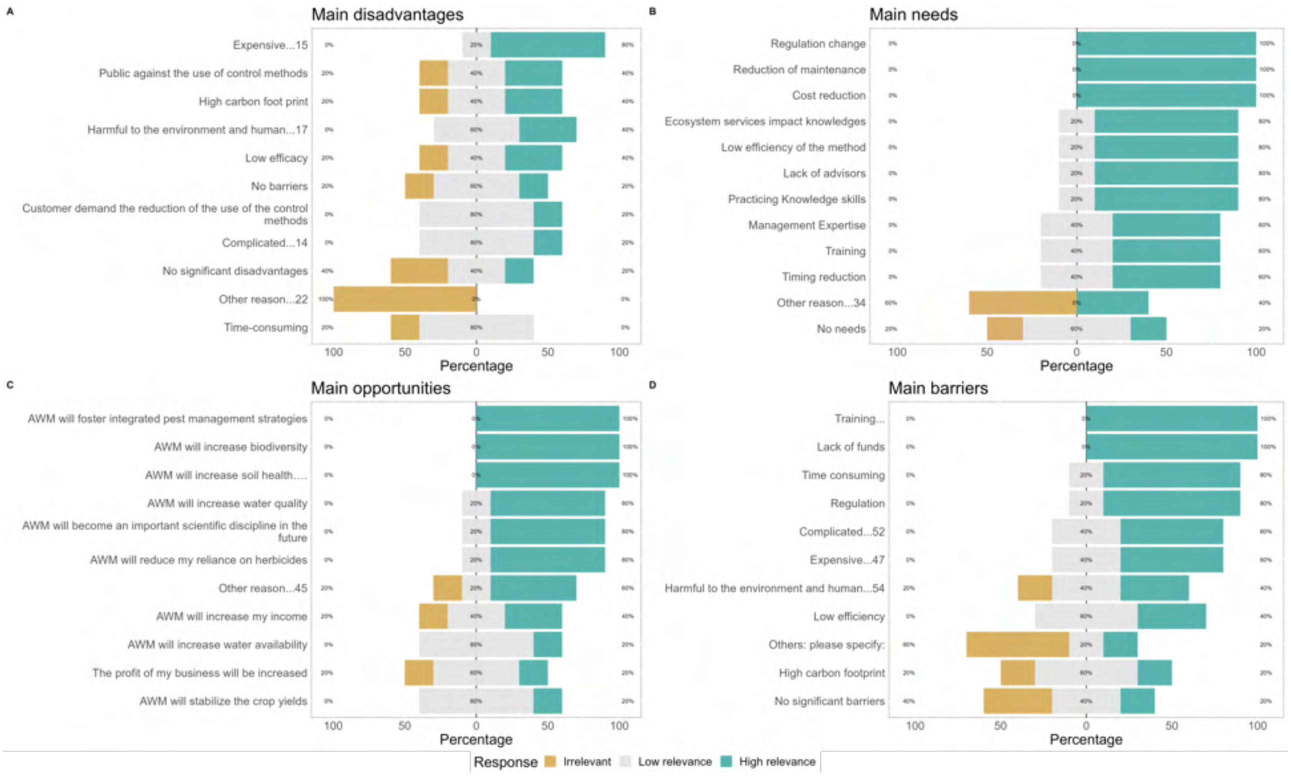

Figure 134. Main disadvantages, needs, barriers and opportunities for herbicides identified by advisors.

2.1.2.2.1.1.2 Consumers

Consumers consider herbicides as a technique brimming with opportunities. They believe that it will evolve into an important scientific discipline and that its use will lead to crop stabilization. Nearly 70% of respondents believe that herbicides will increase water quality and enhance soil health. Additionally, consumers recognize that its implementation will result in an increase in business profitability while reducing herbicide reliance. One out of two consumers views that its use will foster IPM strategies, increase water availability, and enhance biodiversity. Consumers unanimously identify ecosystem services impact knowledge and practicing knowledge skills as the main needs for herbicide implementation. Furthermore, 83% of respondents deem management expertise, maintenance, cost, and timing reduction as highly relevant. Lack of advisors and training were considered as highly relevant by almost 70% of respondents. Training was deemed as a highly relevant barrier by all consumers, while lack of funds, environmental and human harm, regulatory challenges, and expense were considered as relevant barriers by a significant proportion of consumers. They show high rates of consensus when appointing the technique's key disadvantages. All consumers consider that public concerns regarding the reduction or elimination of herbicides, as well as expense, are the most important disadvantages. Besides, 83% of respondents, in line with what was expressed as relevant barriers, recognize the potential environmental and human harm as key disadvantages.

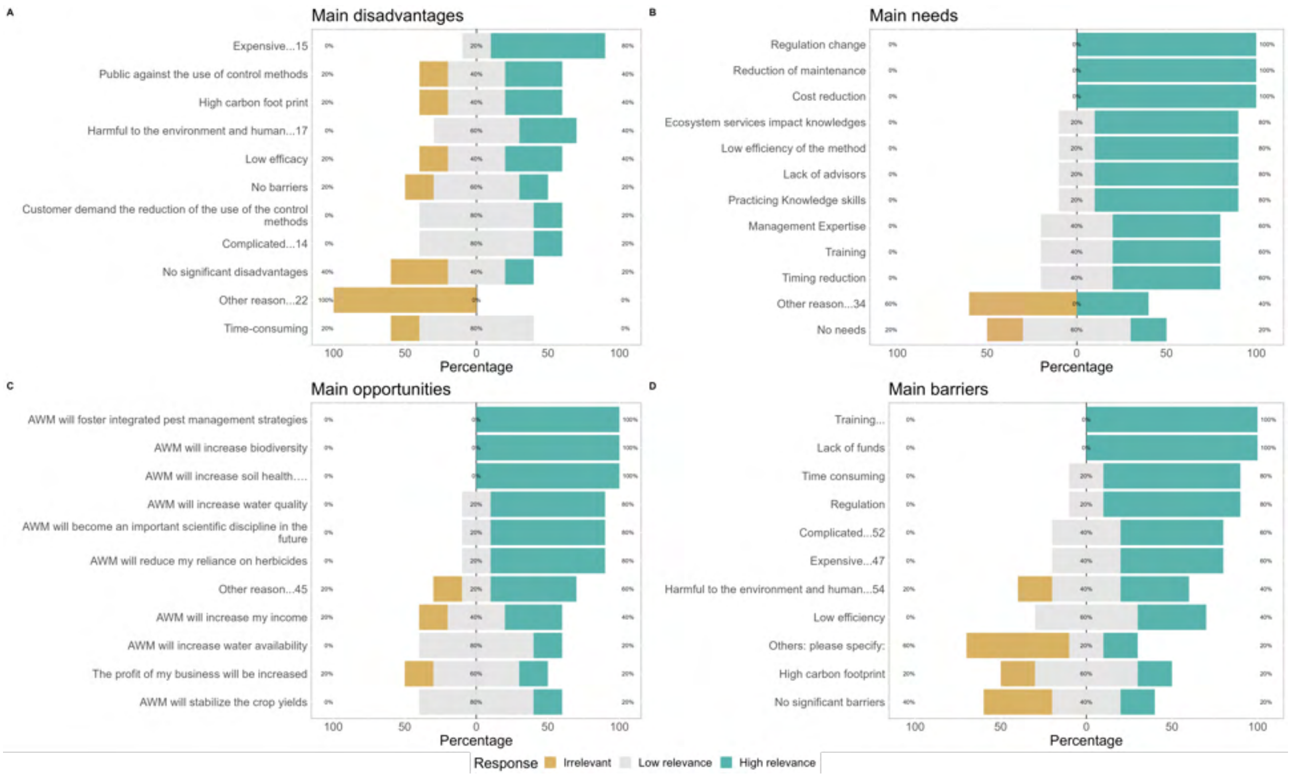

Figure 135. Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

2.1.2.2.1.1.3 Industry

Industry representatives view herbicides as a technique that will foster IPM strategies. They recognize its potential for becoming an important scientific discipline as well as its prospects for reducing herbicide reliance. One out of two respondents acknowledge that herbicides provide key ecosystem services, including an increase in water quality and availability, enhancement of biodiversity, and betterment of soil health. Industry representatives recognize that herbicides have many relevant needs. Two out of three respondents considered ecosystem services impact knowledge, regulatory changes, lack of advisors, practicing knowledge skills, management expertise, training, as well as cost, maintenance, and timing reduction as highly relevant needs. Half of the respondents considered training and lack of funds as relevant barriers to this technique. Main disadvantages, as stated by 75% of industry representatives, were the public opposition to this method and environmental and human harm. Additionally, 50% of respondents recognize customers' demands to reduce herbicide use as a relevant disadvantage.

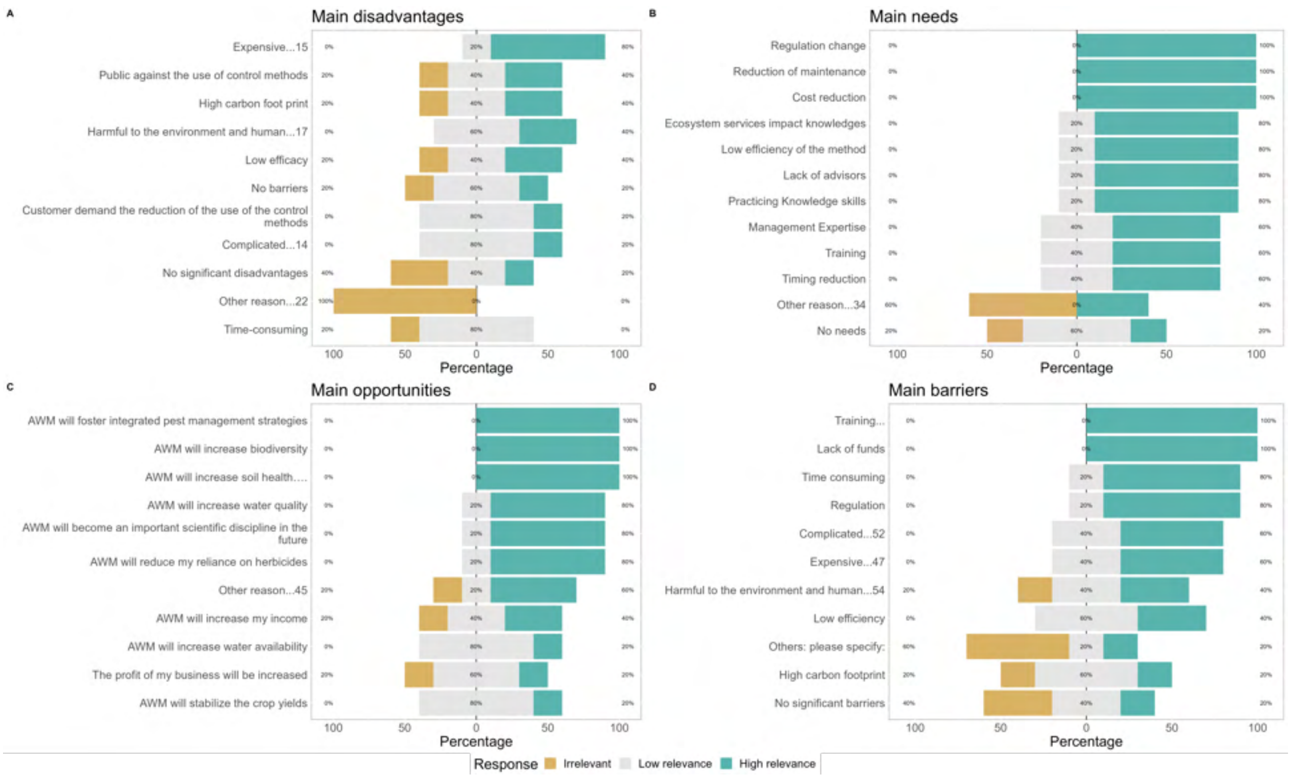

Figure 136. Main disadvantages, needs, barriers and opportunities for herbicides identified by industry.

2.1.2.2.1.1.4 Conclusions

Advisors, consumers, and industry representatives recognize that herbicides offer opportunities to foster IPM strategies and provide ecosystem services like improving water quality and soil health. They also acknowledge herbicides' potential to become an important scientific discipline. This sentiment is shared among all stakeholder groups. As main necessities, all stakeholders identify ecosystem services impact knowledge. Additionally, practicing knowledge skills, management expertise, training, and timing and cost reduction were deemed highly relevant by different proportions in every stakeholder category. Consumers and advisors considered more barriers compared to industry representatives. Among the categories selected as highly relevant, they recognize environmental and human harm as relevant barriers. All stakeholders considered lack of funds, regulatory challenges, training, and expense as relevant barriers. Stakeholders agree on the most relevant disadvantages regarding herbicide use, including opposition or reduction demands from the public and customers, as well as environmental and human harm. Advisors cited high carbon footprint and complexity of the technique, while consumers find expense as a relevant drawback.

2.1.2.2.1.2 Mechanical weeding

2.1.2.2.1.2.1 Consumers

Consumers view mechanical weeding as a technique that encompasses several opportunities. They unanimously recognize its potential to foster IPM strategies. Additionally, 83% of respondents identify this practice as an ecosystem services provider, including increases in water availability and quality, biodiversity, and soil health enhancement. Regarding the technique's necessities, more than 80% of consumers view practicing knowledge skills as the most relevant need, followed by 67% who consider cost reduction as a key requirement. Time consumption was identified as the principal barrier by 67% of respondents. Complexity, lack of funds, and expense were deemed as relevant impediments by half of our sample. Consumers did not view mechanical weeding as a technique with significant disadvantages. One out of every two respondents considered complexity as a relevant drawback, while the rest of the queried disadvantages were not considered as relevant by a substantial proportion of consumers.

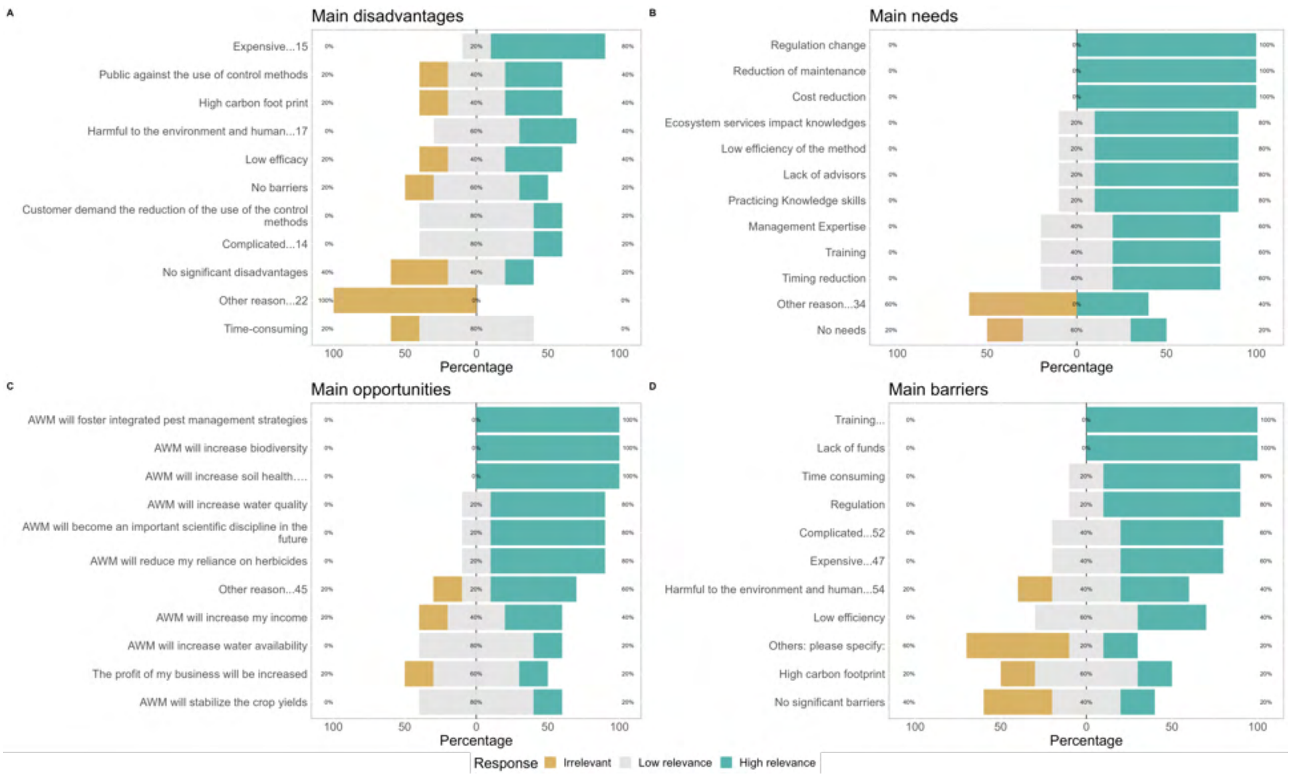

Figure 137. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by consumers.

2.1.2.2.1.2.2 Industry

Industry representatives unanimously recognize the opportunities presented by mechanical weeding, including the reinforcement of IPM strategies and a reduction in herbicide reliance. Additionally, more than two-thirds of the respondents recognize mechanical weeding's potential as an ecosystem services provider, including increases in water availability, quality, biodiversity, and soil health. They also acknowledge the technique's potential to become an important scientific discipline. Cost reduction was considered a relevant need by all respondents, while practicing knowledge skills and reduction of maintenance were evaluated as relevant requirements by almost seventy percent of respondents. Industry representatives identified complexity and time consumption as the main impediments, whereas they see customer demand to reduce its use as the primary disadvantage to mechanical weeding implementation.

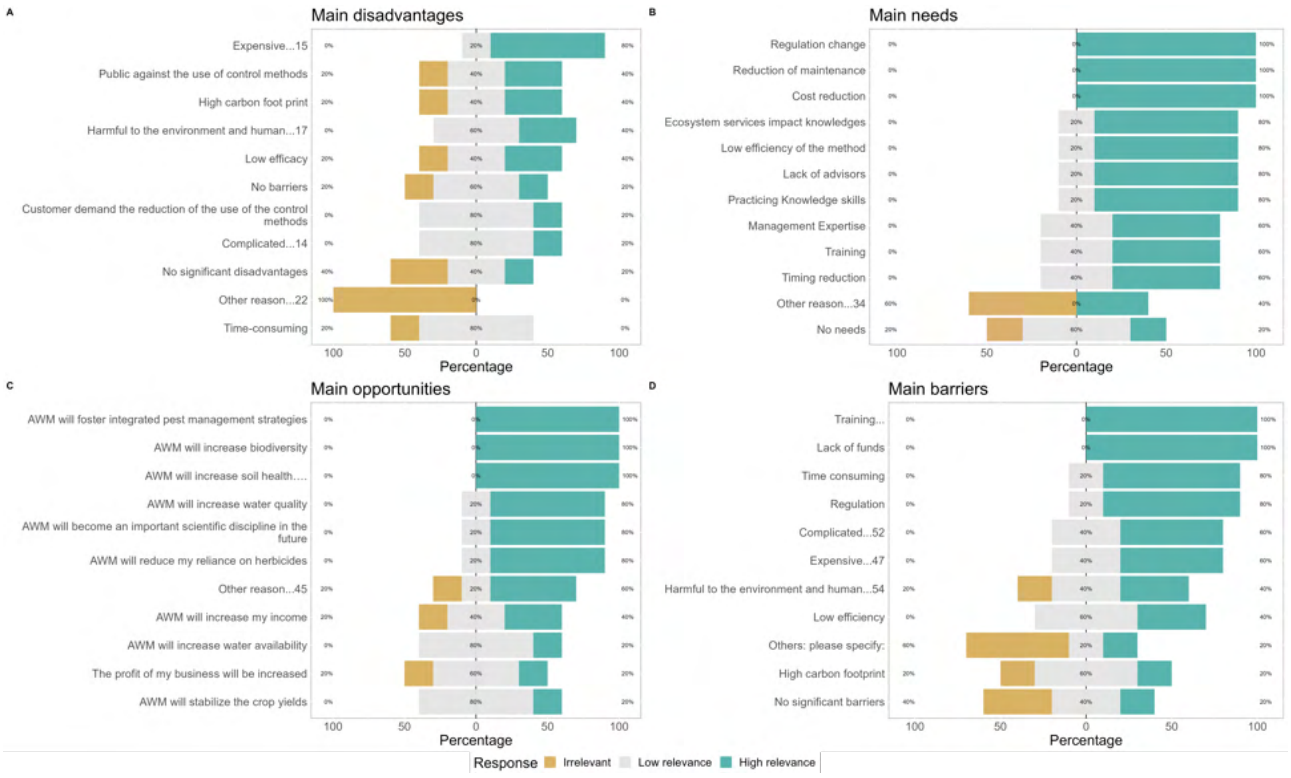

Figure 138. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by industry.

2.1.2.2.1.2.3 Conclusions

Consumers and advisors unanimously identify mechanical weeding as a technique that fosters IPM strategies. A considerable proportion of respondents in both categories, 83% of consumers and 67% of industry representatives, recognize mechanical weeding as an ecosystem services provider, including increases in water availability and quality, biodiversity, and soil health enhancement. Regarding the technique's necessities, both stakeholders consider practicing knowledge skills as the primary need, and industry representatives also stress the importance of cost reduction as the most pressing requirement. Consumers and industry representatives agree on the impact of time consumption and identify it as a relevant barrier to mechanical weeding implementation. Time consumption, complexity, and lack of funds were identified as key impediments by both stakeholders. Consumers and industry representatives did not view mechanical weeding as a technique with significant disadvantages. One out of every two consumers considered complexity as a relevant drawback, while the rest of the queried disadvantages were not considered as relevant by a substantial proportion of consumers. Industry representatives see customer demand to reduce its use as the primary disadvantage to mechanical weeding implementation.

2.1.2.2.1.3 Mowing

2.1.2.2.1.3.1 Consumers

Consumers recognize mowing as an AWM technique that presents significant opportunities, particularly in terms of ecosystem services provision. A unanimous 100% of respondents agree that its implementation will lead to increases in water quality and soil health. Additionally, almost 90% of consumers believe that mowing will contribute to biodiversity enhancement, crop yield stabilization, income growth for farmers, and a reduction in herbicide reliance. More than 70% of respondents also see mowing as a strategy that fosters IPM and predict its evolution into an important scientific discipline, with the potential to increase business profitability. Identifying practicing knowledge skills as the primary need for mowing implementation, consumers emphasize the importance of understanding and applying appropriate techniques. Furthermore, over fifty percent of respondents recognize the significance of addressing issues related to low efficiency, training, cost, and timing reduction. When it comes to barriers, 71% of consumers cite time consumption and lack of funds as the main challenges. Additionally, 57% of respondents express concerns about expense. Complexity and time consumption are highlighted as the most significant disadvantages by 57% of consumers. Other factors queried were not regarded as relevant by a considerable proportion of respondents.

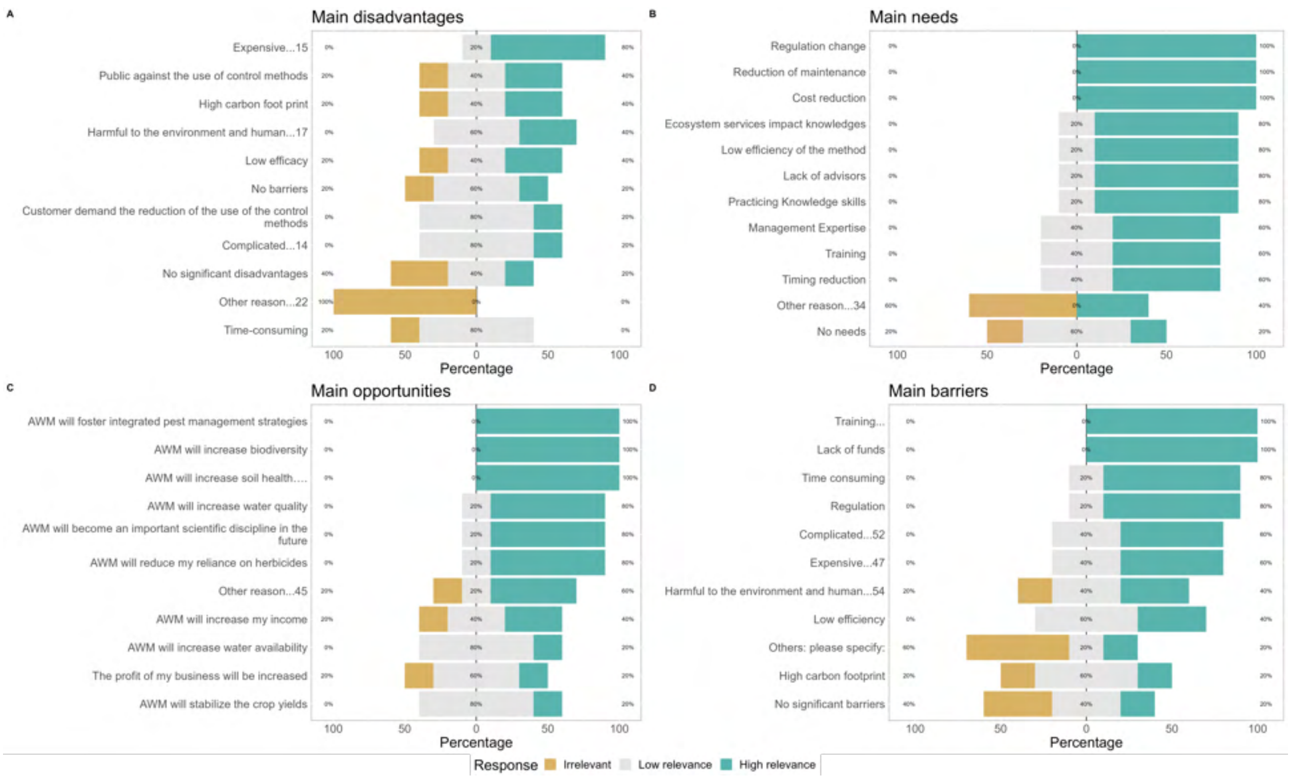

Figure 139. Main disadvantages, needs, barriers and opportunities for mowing identified by consumers.

2.1.2.2.1.3.2 Researchers

Researchers regard mowing as a technique brimming with opportunities. They unanimously recognize its potential in providing several ecosystem services, including increases in water availability and quality, as well as enhancements in biodiversity and soil health. Nearly 70% of respondents consider that mowing will foster IPM strategies, evolve into an important scientific discipline, stabilize crop yields, and reduce herbicide reliance. Researchers identify practicing knowledge skills as a relevant requirement. They also unanimously identify time consumption as the main impediment to mowing implementation. Other queried needs and barriers were not deemed as relevant by a considerable proportion of respondents. In line with the identified impediments, researchers unanimously consider time consumption as the most significant disadvantage. Additionally, 67% of respondents state that this practice has no significant barriers.

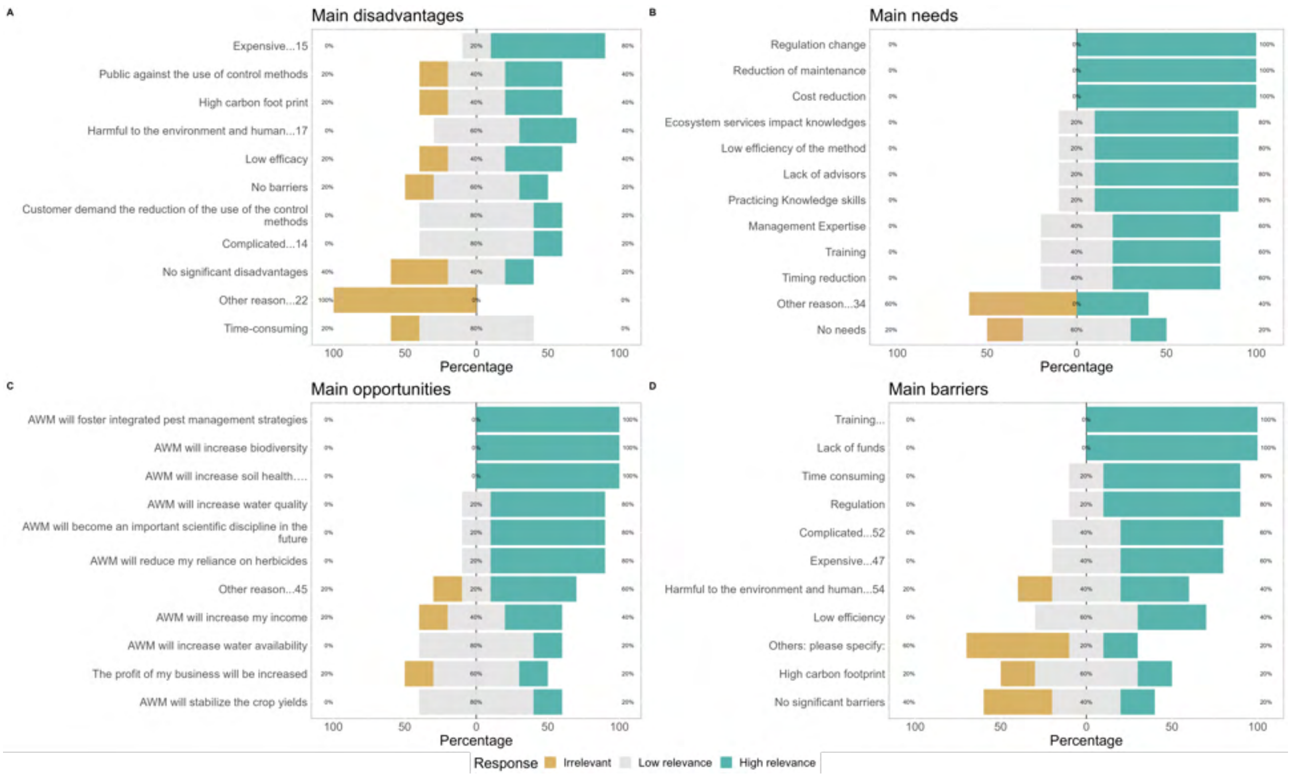

Figure 140. Main disadvantages, needs, barriers and opportunities for mowing identified by researchers.

2.1.2.2.1.3.3 Conclusions

Researchers and consumers alike recognize mowing as an AWM technique brimming with significant opportunities, particularly in terms of ecosystem services provision. They highlight its potential for improving water quality and availability, as well as enhancing biodiversity and soil health. Additionally, both stakeholders emphasize the practice's prospects for fostering IPM strategies and stabilizing crop yields, among other benefits. Both researchers and consumers consider practicing knowledge skills as the primary need for mowing implementation. Furthermore, consumers recognize the importance of addressing issues related to low efficiency, training, cost, and timing reduction. There is consensus between consumers and researchers regarding the most relevant barriers, with both groups identifying time consumption as the primary impediment. In line with the identified barriers, both consumers and researchers regard time consumption as the most significant disadvantage. Importantly, neither group deems the other queried drawbacks as relevant.

2.1.2.2.1.4 Mulching

2.1.2.2.1.4.1 Consumers

Consumers express a positive outlook regarding mulching, identifying numerous opportunities while not considering any of the queried needs, barriers, and disadvantages as relevant by a significant proportion of respondents. Nearly 70% of consumers recognize that mulching will foster IPM strategies and provide ecosystem services, including increases in water quality, availability, biodiversity, and soil health. Additionally, they believe that mulching will stabilize crop yields and reduce herbicide reliance. Most of the queried needs were deemed of low relevance by consumers. While ecosystem services impact knowledge, regulatory changes, lack of advisors, practicing knowledge skills, and reduction of cost and maintenance were considered relevant by one-third of respondents, none of the barriers inquired in this study was deemed highly relevant by more than 33% of consumers. The main disadvantage, according to 67% of consumers, was the customer's demand for the reduction of mulching. Other drawbacks were deemed relevant by 33% of respondents, including efficacy and expense, among others.

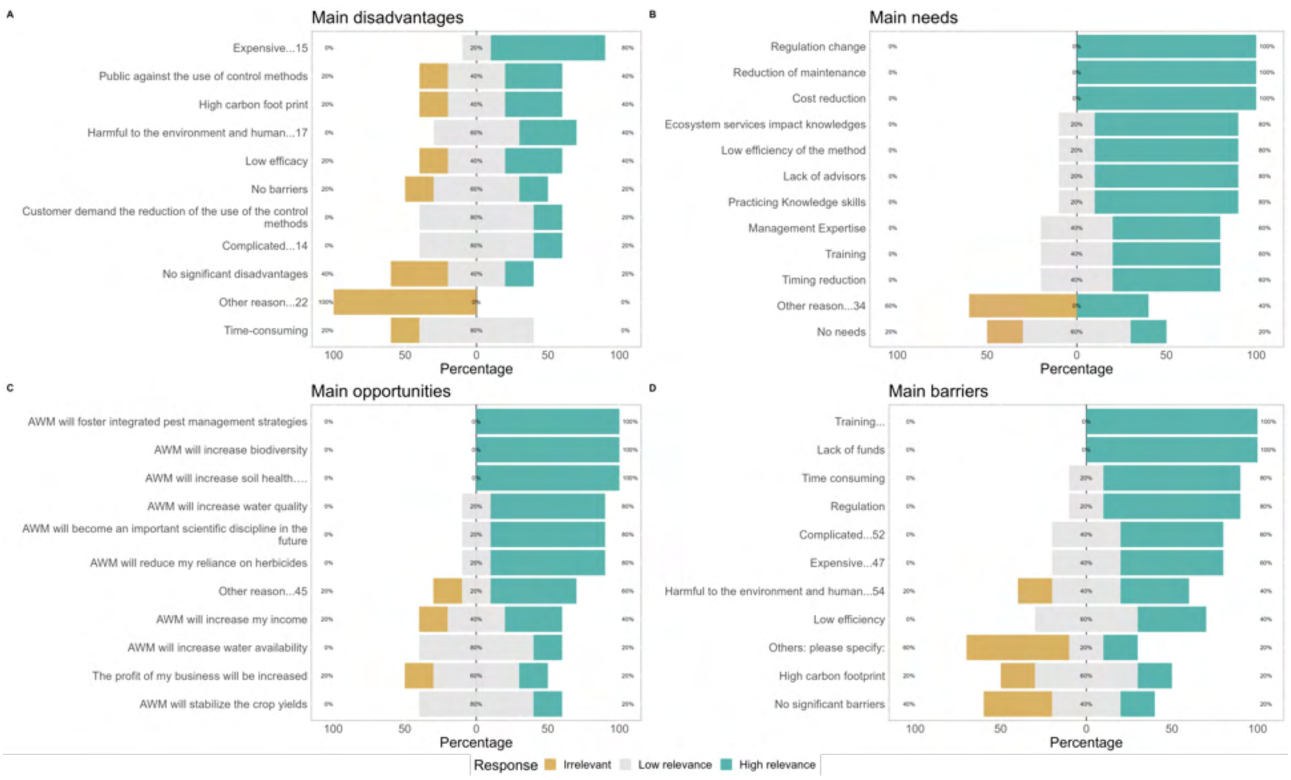

Figure 141. Main disadvantages, needs, barriers and opportunities for mulching identified by consumers.

2.1.2.2.1.4.2 Conclusions

Consumers view mulching positively, citing opportunities in ecosystem services and crop stability. They recognize its potential for IPM and reducing herbicide use. However, they do not find many specific needs, barriers, or disadvantages highly relevant, except for customer demand to reduce mowing, highlighted by 67% of respondents.

2.1.2.2.2 Surveys

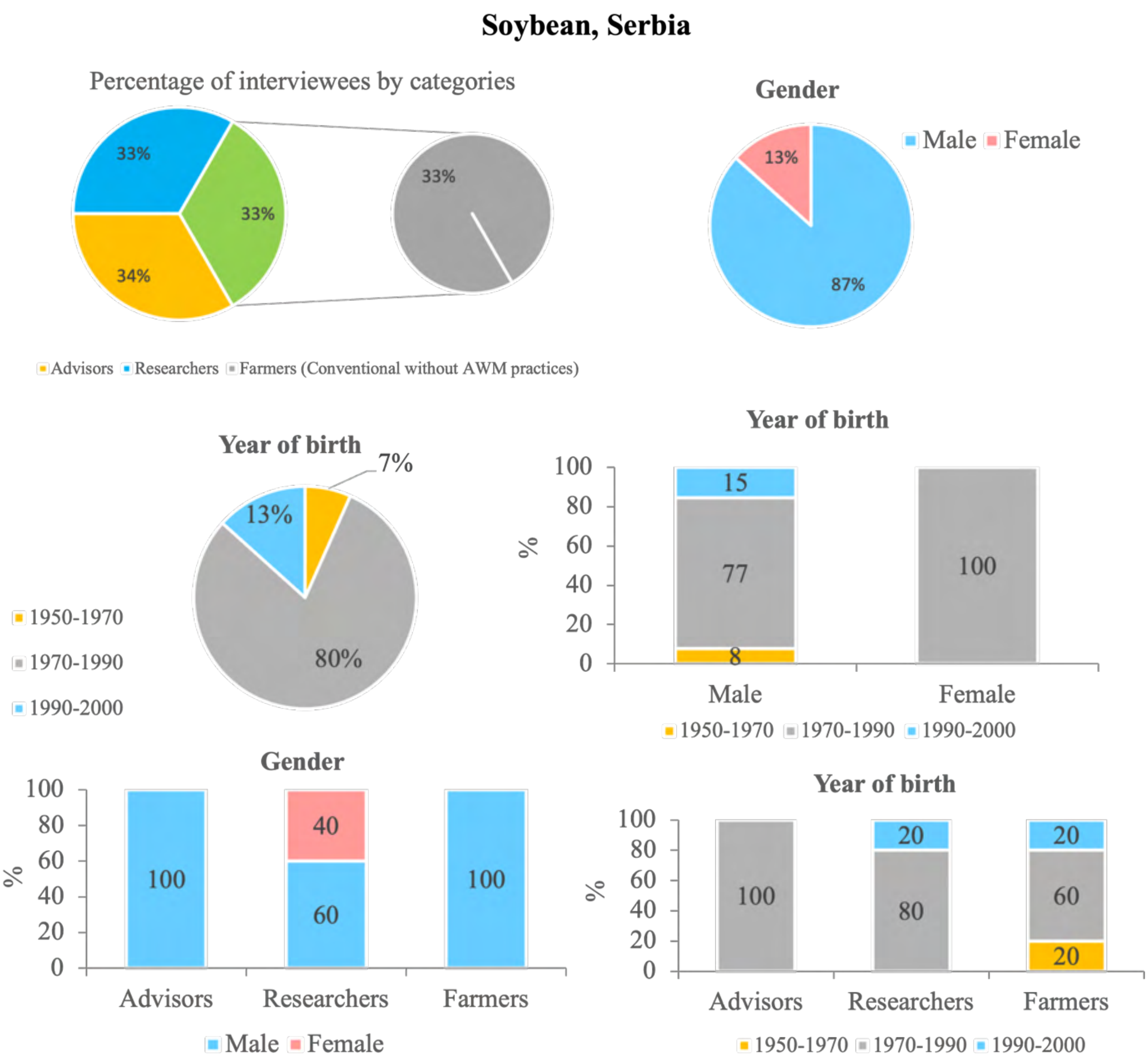

Figure 142 Interviewees description in the Soybean Living Lab (Serbia)

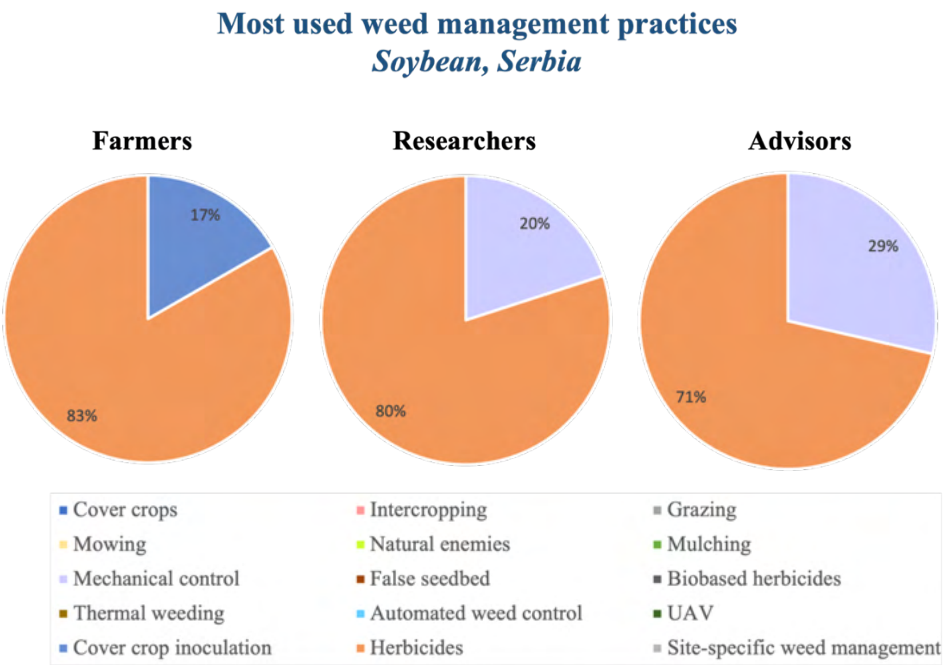

Figure 143: Most used weed management practices in the Soybean Living Lab (Serbia)

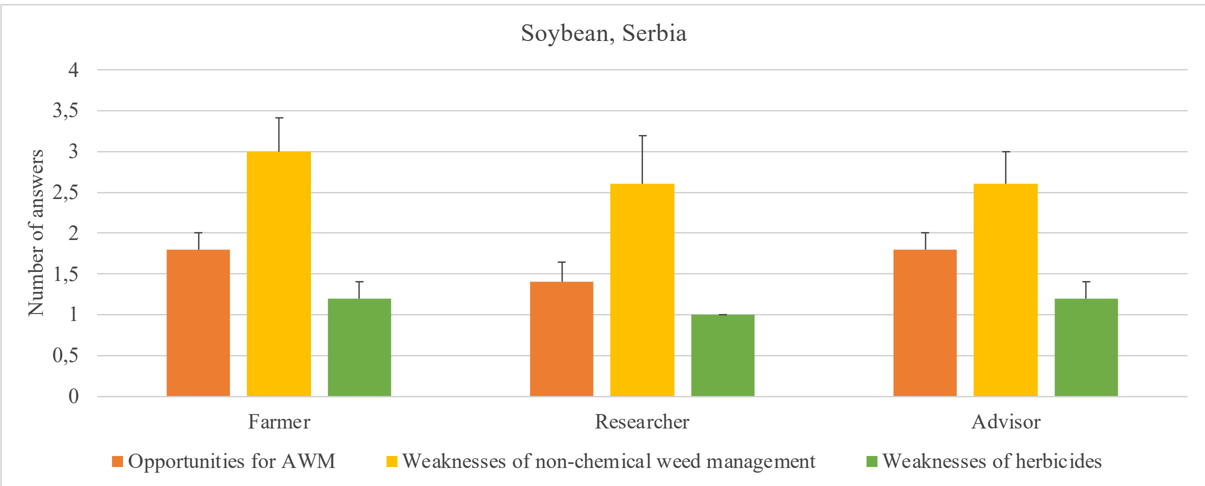

Figure 144 Mean number of answers (±se) per stakeholder group in the Soybean Living Lab (Serbia)

Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: None.

THREATS: None.

WEAKNESSES: None.

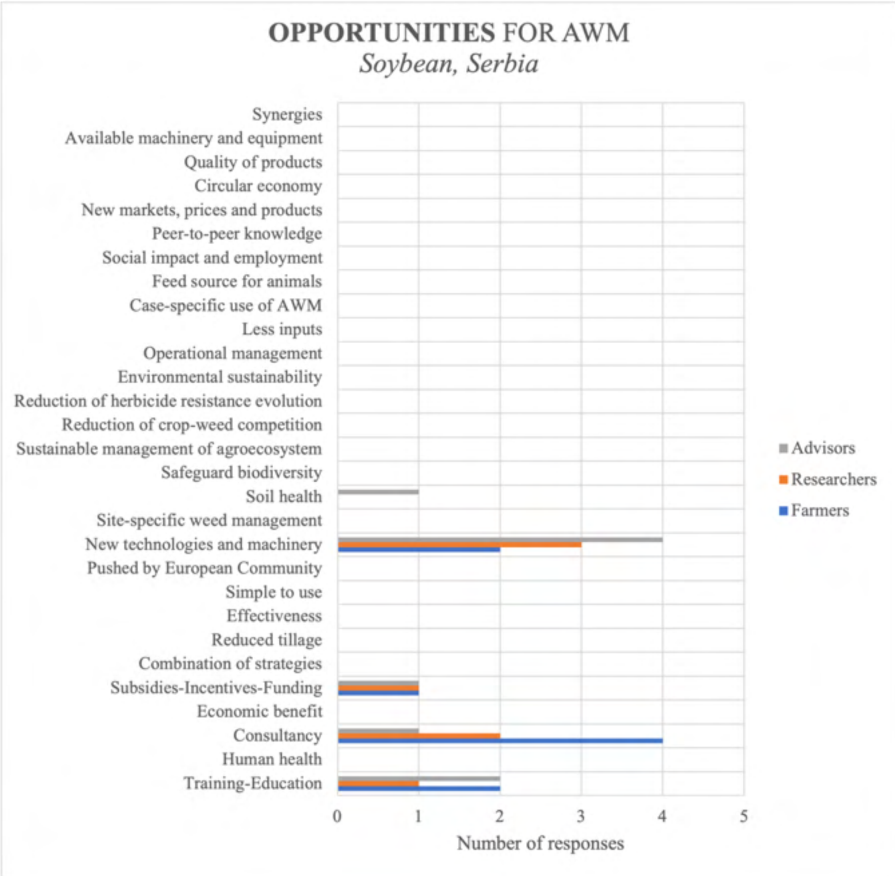

Figure 145 Opportunities of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: A farmer mentioned the agricultural policy and the market.

WEAKNESSES: Presented in the figure below.

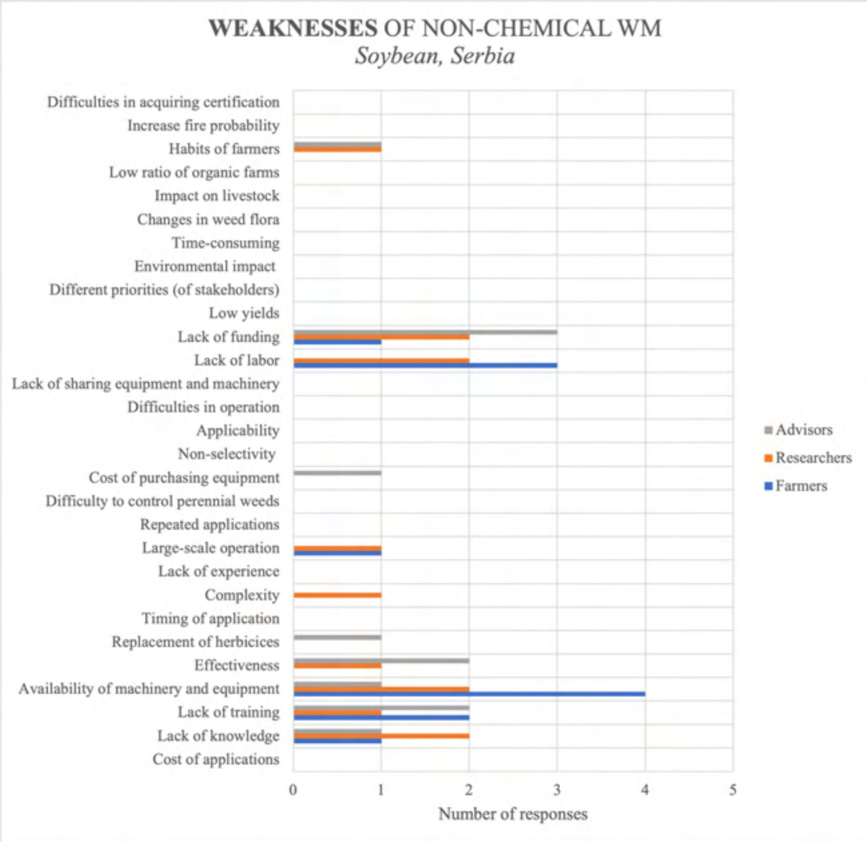

Figure 146 Weaknesses of non-chemical weed management.

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: None.

STRENGTHS: Low-cost and efficacy of herbicides were the two major strengths identified by all stakeholder groups. Besides these answers, economic benefit, quick results, low cost, optimized treatment, not-labor intensive were also identified.

THREATS: Similarly to the *soybean LL* in Serbia, the interviewees mentioned the lack of new herbicides, the withdrawal of existing products and the markets as threats for the herbicides.

WEAKNESSES: Presented in the figure below.

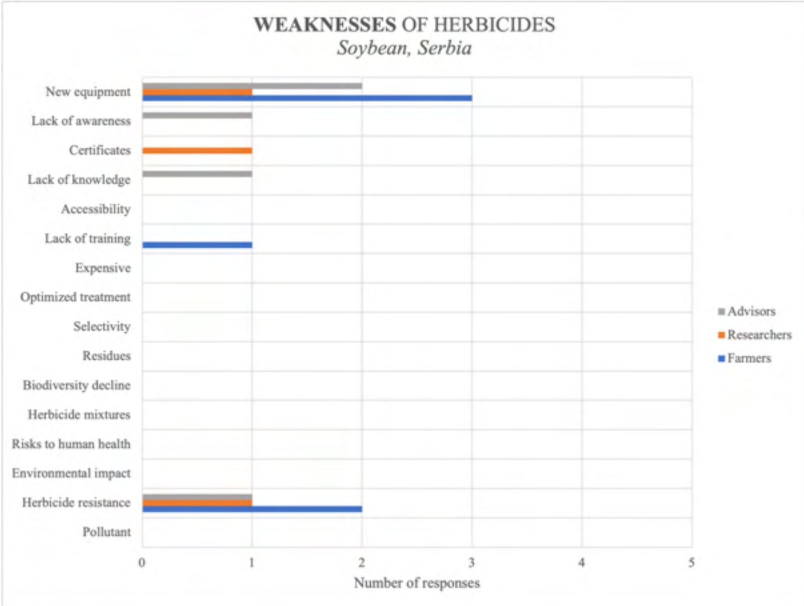

Figure 147 Weaknesses of herbicides.

SUMMARY OF THE INTERVIEWS – SOYBEAN, SERBIA
Most used weed management practices: The Serbian LL of soybean is aligned with that of Serbian LL of maize regarding the most used weed management practices in these crops. Herbicides and mechanical control monopolize the arsenal of tools for weed management. **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group**: A notable difference between the two LLs is noted in the group of farmers which mention way more weaknesses of non-chemical weed management in the case of soybean than the maize producers. The number of identified weaknesses of herbicides remains low across the interviewees of the soybean LL, revealing their importance or the lack of knowledge. **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: Transforming Serbian farming systems makes imperative the need for new machinery and equipment, as well as training and education. Both are opportunities tied to AWM, which reinforced by proper consultancy and subsidies can increase the adoption of AWM practices. **Threats, and weaknesses for non-chemical weed management**: The weaknesses of non-chemical weed management in the soybean LL are not limited only on a few categories,

rather include many practical and financial concerns. In particular, the lack of funding, labour, training and knowledge are hindering factors for the adoption of non-chemical weed management. In addition, the effectiveness and lack of necessary machinery and equipment are also weaknesses for non-chemical weed management.

Opportunities, strengths, weaknesses, and threats for herbicides: Several strengths of herbicides were identified in the soybean LL, especially the low cost and their efficacy. Nevertheless, the weaknesses of herbicides were not related to potential negative impacts of chemical inputs, rather to the lack of new equipment to make the use of herbicides more efficient. Herbicide resistance is, though, recognized as a weakness of herbicides.

2.1.2.2.3 Living lab board meeting

Eight (8) participants in total attended the first RS soybean/13 Living lab meeting, held on 23th November 2023. Two members did not attend the meeting. The meeting was held at the Maize Research Institute "Zemun Polje, Belgrade, Serbia. The GOOD partners gave a short introductory speech about Living labs, and then the project was presented in 15 minutes. After that, 15 minutes discussion was held, about the soybean LL, possible outcomes of the results, herbicide application in Serbia and weed resistance, agroecological weed control. The main outcome was that agroecological weed management will be a very challenging process, bearing in mind that farmers use mostly herbicides for weed control and that without any subsidies this process would be very challenging. During the LL board meeting, this information was also collected:

What are the market characteristics of [crop]?	1. How many farmers cultivate [crop] in the region (approx.)? Is it mostly monoculture or can rotations be made with other crops?
	35 farmers plant soybeans each year and it is planted always in a crop rotation with maize or in a triple rotation (maize/winter wheat/soybean)
	2. How many products are derived from the [crop]? Are they important for the economy and/or food security?
	Half of producers use soybean for livestock feeding, while others sell it on the market
	3. Do you think that agroecological products could be promoted in local markets?
	Yes, the most of farmers do think that it would be an excellent idea
	4. Do you believe that the region has a lack of technologies?
	Yes, definitely
	5. Is the regional agri-food value chain sustainable?
	More-less
What are the most common agricultural and weed management practices in [crop]?	1. What are the most common agronomic practices in [crop]?
	Weed control in soybeans is quite challenging, because of the occurrence of problematic weeds (Johnsongrass, Amaranth species, ragweed)
	2. What are the most common weed management practices in [crop]?
	Herbicides are the most used practices for weed control, while the minority of farmers combine it with mechanical weed control

What is the herbicide use in [crop]?	1. How many active ingredients there are available? How many different mode of actions?
	There are 10 active ingredients of 4 MOAs
	2. How many times do you spray in-season?
	Most farmers spray twice per year: pre-emergence and post-emergence herbicides
	3. Do you use pre-emergence, post-emergence or both herbicides?
	Most of farmers and advisors use both groups
	4. Are herbicides efficient?
	For the majority of weeds and especially grasses yes, while for broad-leaved weeds not
	5. Do you think that alternatives to herbicides are equally efficient?
	Probably yes, but it is more expensive compared to herbicide application
	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?
	All stakeholders do know that herbicides are not good options for the environment while for using of alternative measures requires more money
	7. Do you believe that agriculture without herbicides is viable?
	No
What are the needs and barriers to assist agroecological transitions & adopt agroecological weed	1. What is needed to boost the uptake of agroecological practices?
	Knowledge and subsidies from the government; a market for those kind of products
	2. What are the barriers towards agroecology implementation?
	Lack of knowledge and equipment
	3. Should policies need be redefined to allow agroecological transitions?
	Yes, definitely
	4. How confident you feel about the adoption of agroecological weed management practices?

management approaches?	It depends from each perspective: farmers have very low confidence, end-uses strongly support this action; advisors find as a very complex task, researchers are very interesting in weed control combining with cover crops
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	1. What are the main drivers of weed dispersal?
	Chemical industry which want to sell their expensive products.
	2. Which are the major and most noxious weeds in your area?
	Johnsongrass, common ragweed, Chenopodium and Amaranth species
	3. Are there any herbicide resistant weeds?
	Yes there are many cases of Johnsongrass and Redroot pigweed resistant to some ALS herbicides
	4. Do you know any invasive plants in your area?
	Common ragweed
What do you think about the Living Lab?	1. Which proposals do you have for a good performance of the LL?
	Stakeholders pointed the economic analyses of each alternate weed control measure very important because it might influence on the total price
	2. Would you like it to remain over time?
	Very interesting field experiments in soybean in both conventional and organic systems, and board members cannot wait to see outcomes of the project

2.1.3 Combination of cereals with legumes

2.1.3.1 Rye-pea (Latvia)

2.1.3.1.1 Questionnaires

Rye-pea questionnaires provided insights with regards to seven AWM techniques: cover crops, false seedbed, herbicides, mechanical weeding, mowing, mulching and site-specific spraying. Perspectives were provided by advisors, consumers, industry representatives, and researchers, as we did not gather sufficient responses from farmers. A detailed breakdown of stakeholder participation in the questionnaires for each AWM practice is presented in Table 28.

Table 28 Number of responses for each AWM practice and stakeholder category in Rye-pea.

	Advisor	**Consumer**	**Farmer**	**Industry**	**Policy maker**	**Researcher**
Automated weed control						1
Biobased herbicides		1				
Cover crop inoculation to increase competitiveness		1				1
Cover crops	1	**3**	1		2	2
False seedbed	**3**		1		2	**3**
Grazing	2	2	1		1	1
Herbicides	**3**	**3**	**4**	1	**4**	**3**
Intercropping			1			1
Mechanical weeding	**3**	**4**	**5**	1	**4**	**5**
Mowing	2	1	2		**3**	2
Mulching	1	1			**3**	2
Natural enemies	1	1				
Other						
Site-specific spraying	**3**	2			**3**	1
Thermal weeding		1				1
UAV						
n=29	4	7	7	1	5	5

2.1.3.1.1.1 Cover crops

2.1.3.1.1.1.1 Consumers

Consumers selected cover crops as a relevant practice for AWM management in rye-pea cropping, yet, virtually all queried opportunities, needs, barriers and disadvantages were considered as low or irrelevant by a majority of respondents. Increases in water quality was the only category considered as relevant by two thirds of the respondents.

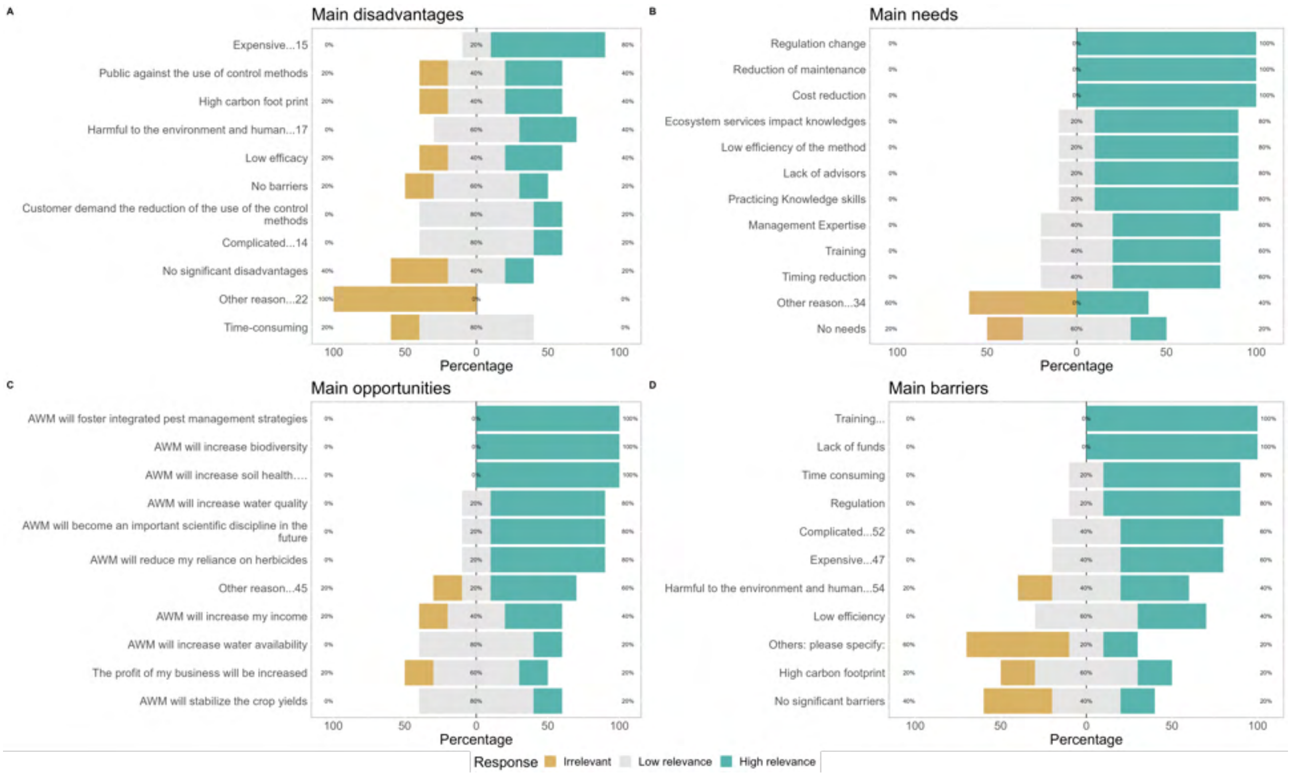

Figure 148. Main disadvantages, needs, barriers and opportunities for cover crop identified by consumers.

2.1.3.1.1.1.2 Conclusions

Consumers selected cover crops as relevant AWM technique in rye-pea cropping. However, they did not consider relevant any of the needs, barriers or disadvantages, and acknowledge increases in water quality as a result of cover crop use.

2.1.3.1.1.2 False seed bed

2.1.3.1.1.2.1 Advisors

Advisors did not consider false seedbed as a relevant weed management strategy in rye-pea. They did not deem any of the opportunities or barriers as relevant. However, they identified training as a relevant requirement and expense as a relevant disadvantage.

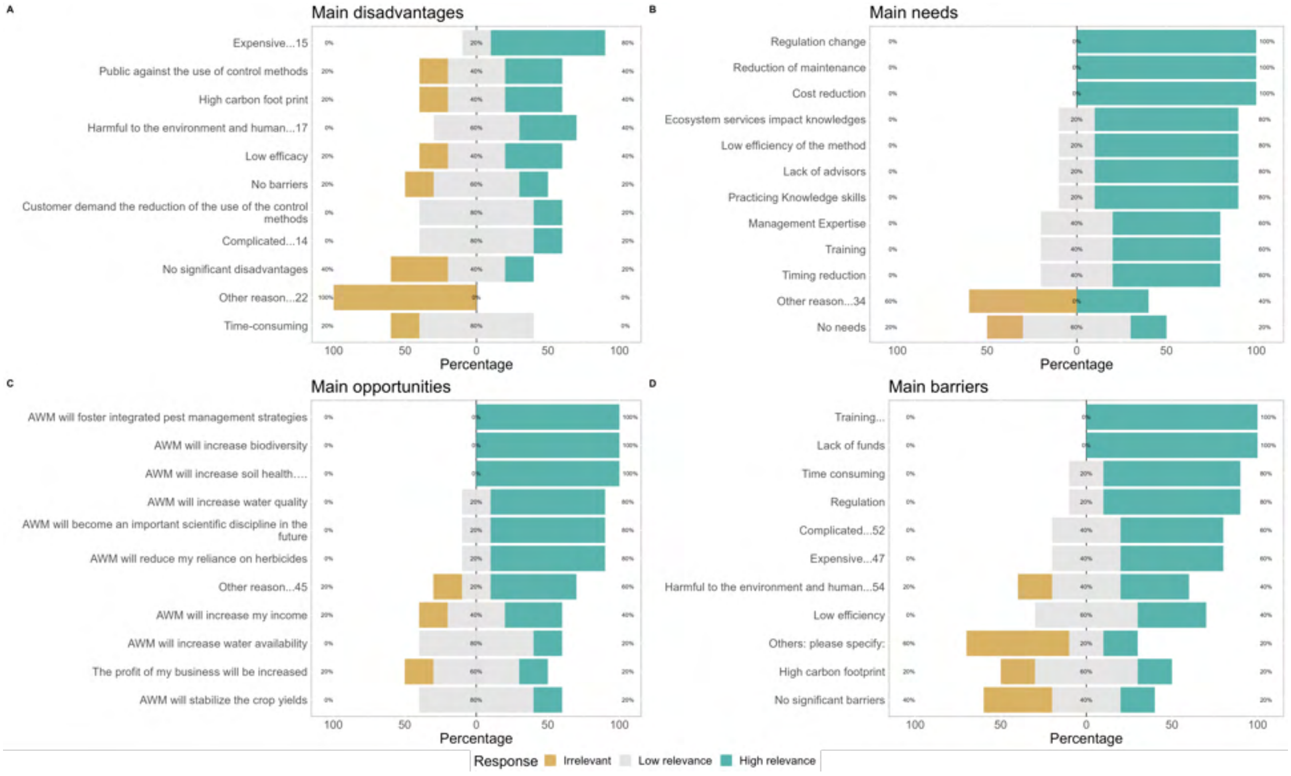

Figure 149. Main disadvantages, needs, barriers and opportunities for false seedbed by advisors.

2.1.3.1.1.2.2 Researchers

Researchers, unlike advisors, considered that false seedbed implementation presents some opportunities. They unanimously consider that this practice will foster IPM strategies, and 67% of respondents stated that it will reduce herbicide reliance. Besides, almost 70% of researchers recognize practicing knowledge skills and training as relevant requirements. In line with what they expressed as relevant needs, researchers stated that lack of training was the most relevant impediment to false seedbed implementation. Notably, none of the queried disadvantages was deemed as highly relevant by a significant proportion of researchers.

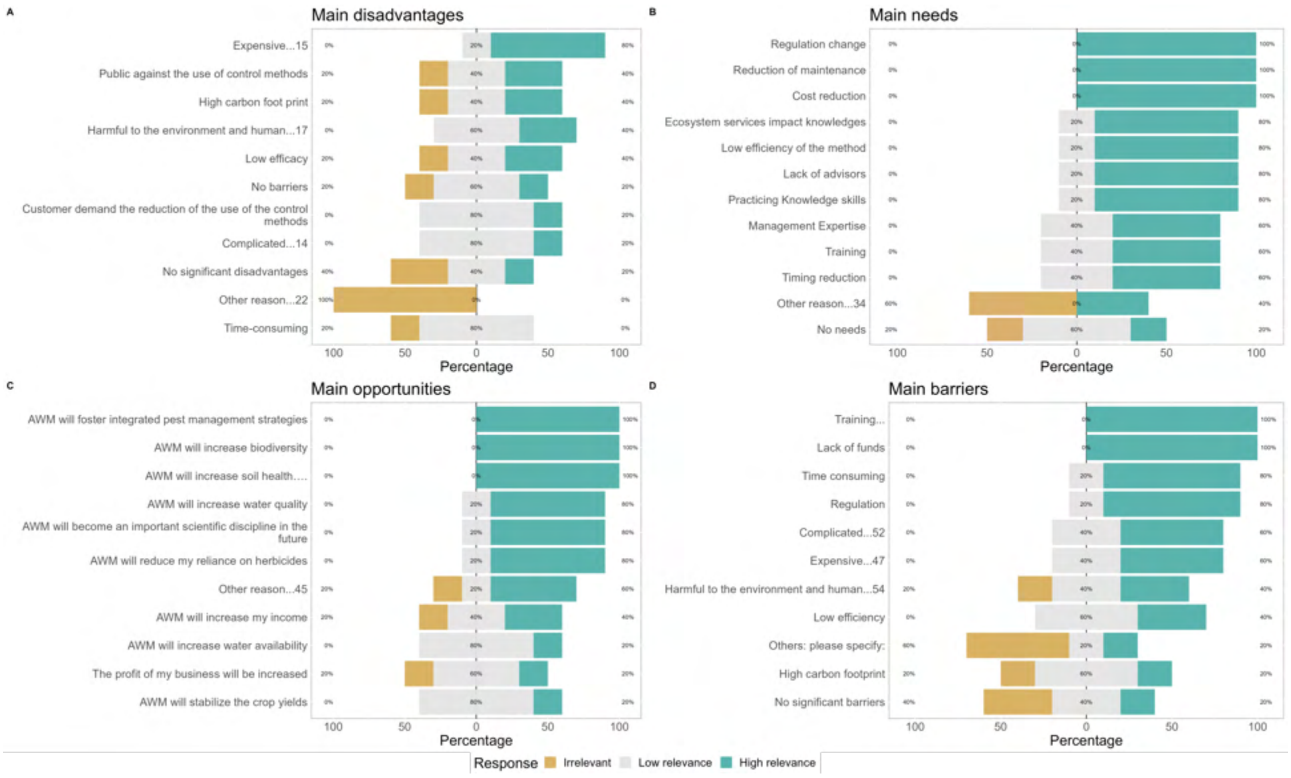

Figure 150. Main disadvantages, needs, barriers and opportunities for false seed bed by researchers.

2.1.3.1.1.2.3 Conclusions

Advisors did not consider false seedbed as a relevant weed management strategy in rye-pea. Unlike them, researchers considered its potential in the implementation of IPM strategies and the reduction in herbicide reliance. Researchers and advisors alike considered training as a relevant requirement for false seedbed implementation. In line with what they expressed as relevant needs, researchers stated that lack of training was the most relevant impediment. While advisors considered expense as a highly relevant disadvantage, researchers did not recognize any of the queried drawbacks as relevant.

2.1.3.1.1.3 *Herbicides*

2.1.3.1.1.3.1 *Advisors*

Advisors considered herbicides to be of low relevance in rye-pea culture, as most queried factors regarding opportunities, needs, barriers, and disadvantages were considered either irrelevant or of low relevance by respondents. Only one out of three respondents recognized increases in soil health and a reduction in herbicide reliance as relevant opportunities with regard to herbicide use. Regarding the primary need, training was deemed highly relevant by almost 70% of respondents, while the rest of the queried needs were considered as low or irrelevant by a majority of respondents. Lack of funds was considered highly relevant as a barrier by 67% of advisors. Additionally, as relevant disadvantages, almost 70% of advisors identified customer demands to reduce its use, environmental and human harm, and expense.

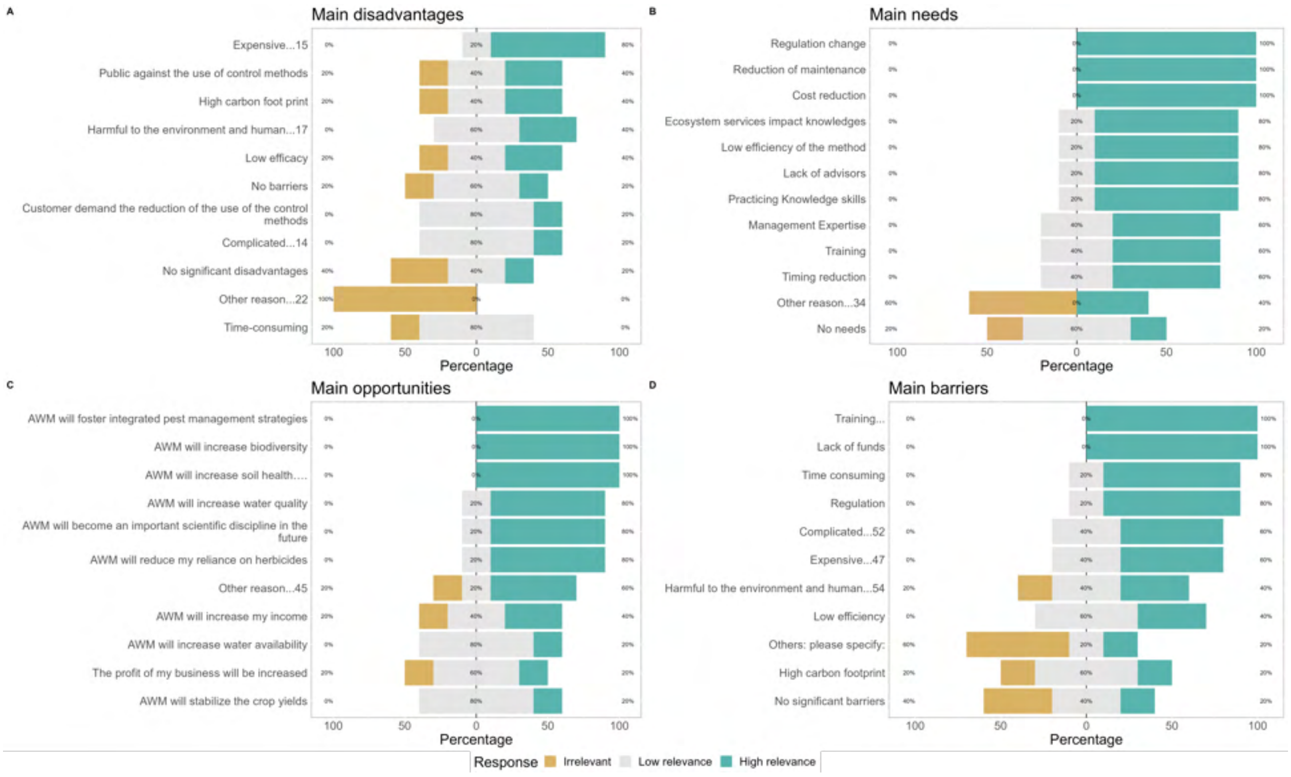

Figure 151. Main disadvantages, needs, barriers and opportunities for herbicides identified by advisors.

2.1.3.1.1.3.2 Consumers

Consumers regard herbicides as offering limited opportunities, but they recognize numerous needs, barriers, and disadvantages associated with their use. Nearly seventy percent of them acknowledge that herbicide use in AWM will reduce overall herbicide reliance. Additionally, one-third of respondents identify other opportunities related to herbicides, such as promoting IPM strategies, enhancing water availability and quality, biodiversity, and soil health, and their potential to become an important scientific discipline. They also note benefits like increased business profitability, stabilized crop yields, and improved farmer's income. Consumers prioritize ecosystem services impact knowledge, regulatory changes, management expertise, and timing reduction as primary needs. Other needs considered relevant by one-third of consumers include lack of advisors, practicing knowledge skills, training, and reductions in maintenance and cost. High carbon footprint, environmental and human harm, and training are recognized as the most significant barriers by 67% of consumers. Additionally, the same proportion of respondents believes that herbicides present no significant barriers to their use, although most other listed barriers were deemed relevant by 33% of respondents. Consumers unanimously agree that environmental and human harm is a relevant disadvantage. Moreover, almost 70% of respondents acknowledge that the public is either against or wants a reduction in herbicide use, and they identify expense as a relevant disadvantage.

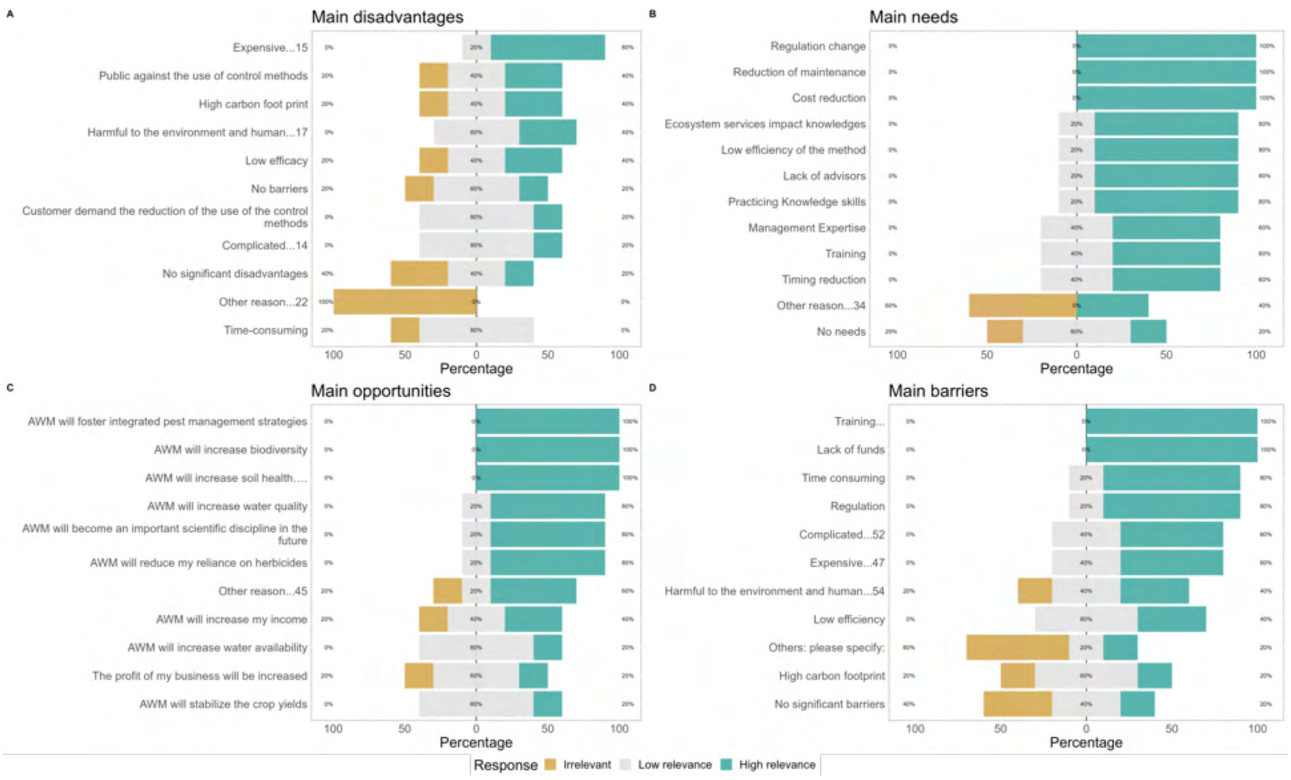

Figure 152. Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

2.1.3.1.1.3.3 Farmers

Farmers regard herbicides as a technique with limited opportunities and disadvantages, accompanied by several needs and barriers. Only one in four farmers recognizes that herbicides foster IPM, provide ecosystem services (such as increasing water quality, biodiversity, and soil health), and contribute to business profitability and income. They acknowledge that herbicide use in AWM can reduce overall herbicide reliance as a result of rational use, farmers do not merely depend on herbicides. As for relevant needs, three out of four farmers prioritize management expertise, training, cost reduction, and timing. Additionally, half of the respondents consider ecosystem services impact knowledge and maintenance reduction as significant requirements. More than seventy percent of farmers view training, lack of funds, and expense as relevant barriers to herbicide use. Interestingly, the same proportion of respondents believes that herbicides do not present significant impediments. Half of the farmers also highlight high carbon footprint and regulation as significant barriers. Expense, environmental and human harm, and customer demands to reduce herbicide use are considered relevant disadvantages by half of the interviewed farmers. The rest of the queried disadvantages are deemed as of low or irrelevant by all respondents.

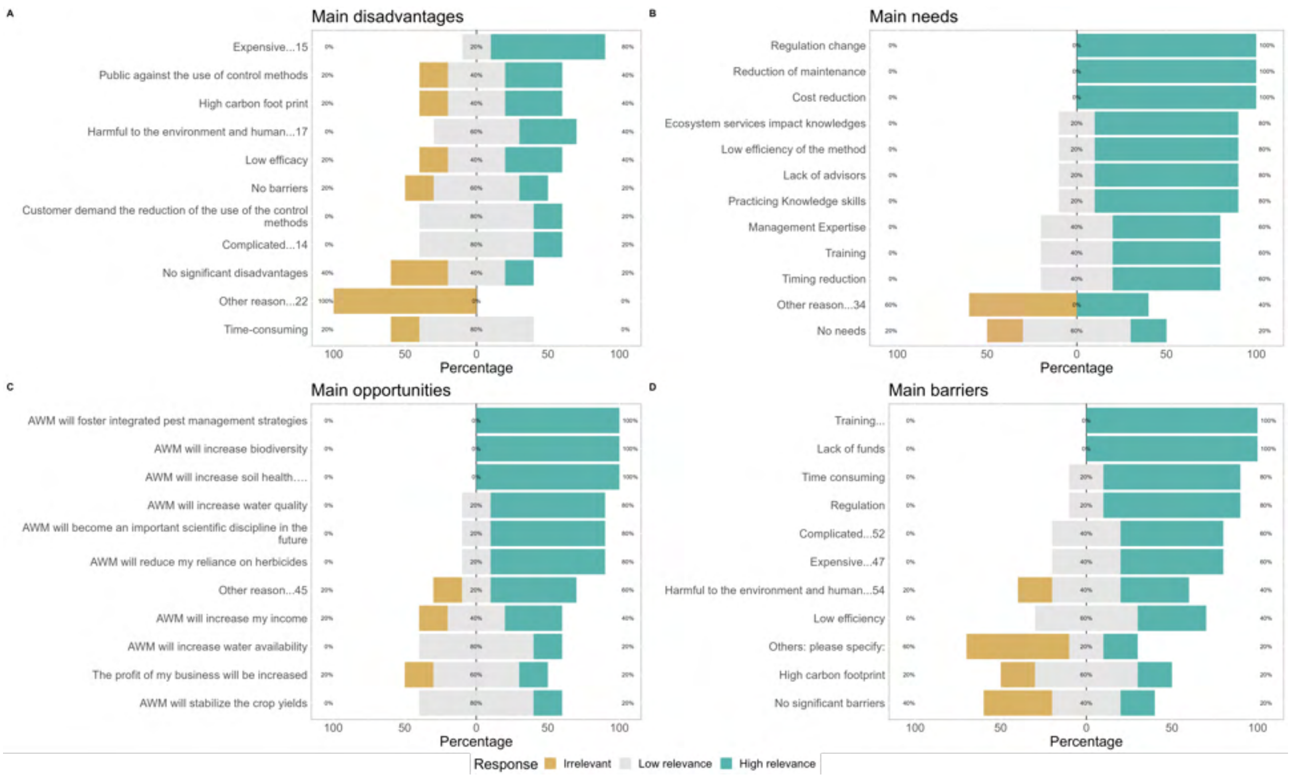

Figure 153. Main disadvantages, needs, barriers and opportunities for herbicides identified by farmers.

2.1.3.1.1.3.4 Policy makers

Policy makers, in alignment with consumers and farmers, perceive herbicides as offering limited opportunities while entailing several needs, barriers, and disadvantages. Only one in four respondents recognizes the potential opportunities of herbicides, such as fostering IPM strategies, evolving into an important scientific discipline, increasing business profitability, stabilizing crop yields, and boosting income. Policy makers demonstrate consensus on the key necessities of herbicide implementation, unanimously prioritizing practicing knowledge skills, management expertise, and training. Additionally, 75% of respondents emphasize the importance of ecosystem services impact knowledge, while 50% highlight the significance of cost reduction. When it comes to barriers, policymakers unanimously identify time consumption, training, and lack of funds as the most relevant obstacles to herbicide use. Moreover, 75% of respondents consider high carbon footprint and 50% view expense as highly relevant impediments. Seventy-five percent of policy makers express that customer demands to reduce or eliminate herbicides are the most relevant disadvantages. Additionally, half of the respondents recognize environment and human harm, while 25% identify expense as significant disadvantages associated with herbicides.

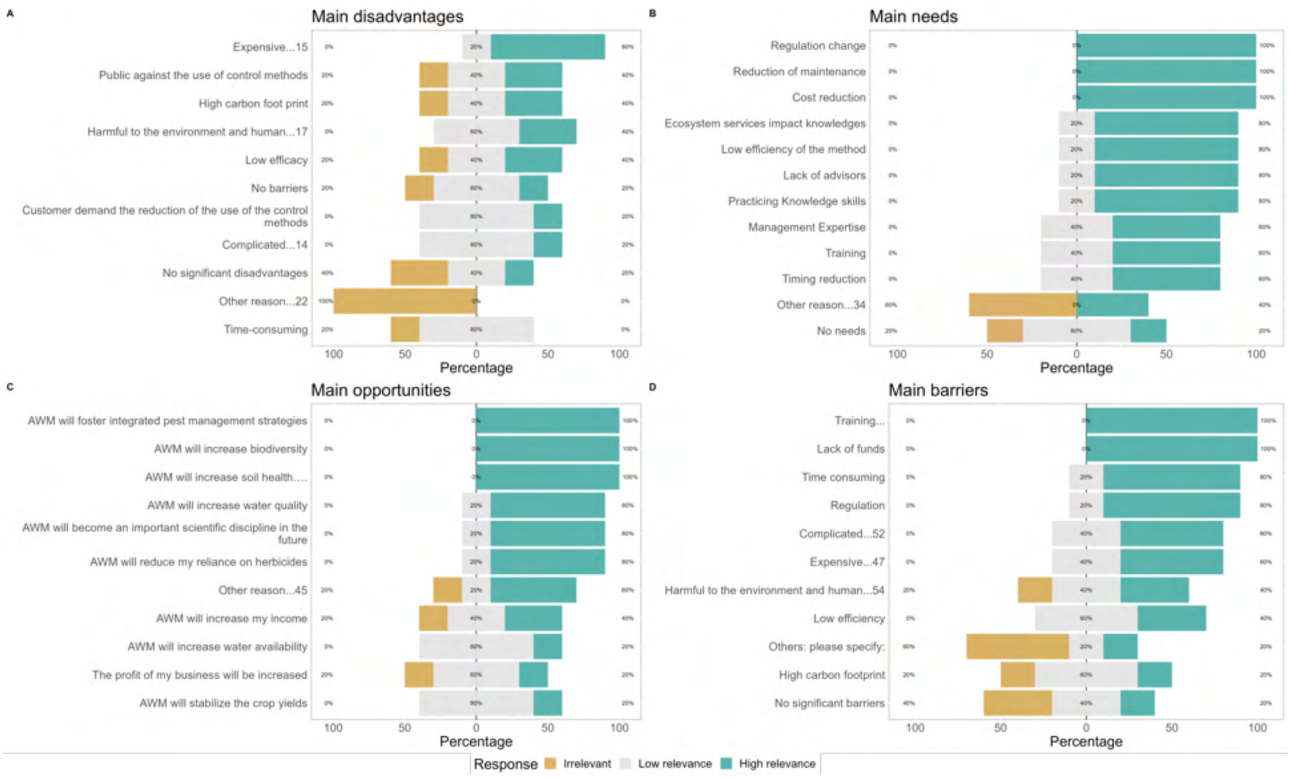

Figure 154. Main disadvantages, needs, barriers and opportunities for herbicides identified by policy makers.

2.1.3.1.1.3.5 Researchers

Researchers, like other stakeholders, perceive herbicides as offering few opportunities, some disadvantages, and several needs and barriers. Only one-third of respondents identified business profitability and crop yield stabilization as relevant opportunities. Researchers demonstrate consensus when identifying key necessities, unanimously prioritizing practicing knowledge skills and training for herbicide use. Additionally, nearly 70% of respondents emphasized the importance of ecosystem services impact knowledge, management expertise, and maintenance reduction. Time consumption and lack of funds were unanimously considered as the main barriers by researchers. Moreover, 67% of respondents highlighted high carbon footprint, training, and regulation as significant impediments. Researchers unanimously regarded customer demands to reduce or eliminate herbicide use as the most relevant disadvantages. Additionally, almost 70% of respondents identified environmental and human harm as relevant drawbacks in herbicide use.

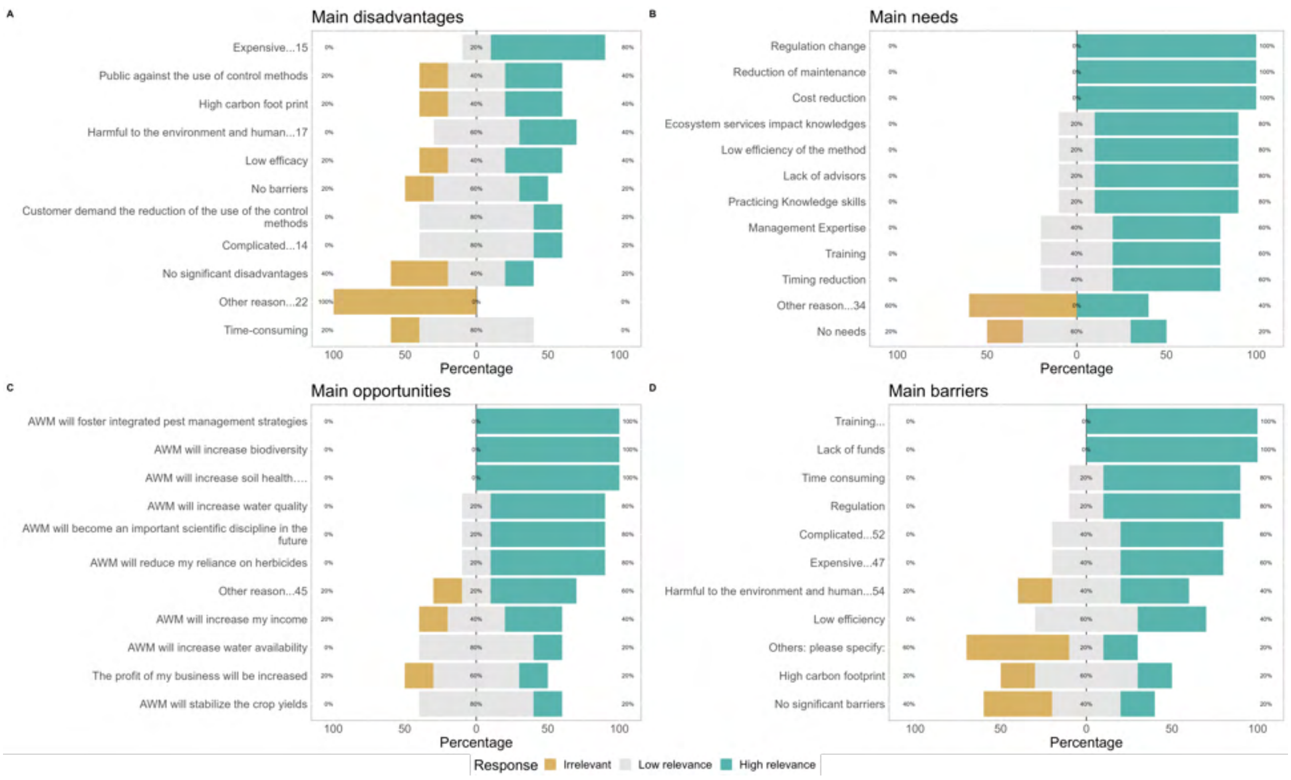

Figure 155. Main disadvantages, needs, barriers and opportunities for herbicides identified by researchers.

2.1.3.1.1.3.6 Conclusions

Across all stakeholder groups, there is a consensus that herbicides offer limited opportunities but come with numerous needs, barriers, and disadvantages. Advisors, farmers, consumers, policy makers, and researchers all share a similar perspective on herbicides in rye-pea culture. They perceive herbicides as lacking significance in this context, with most factors related to their use considered either irrelevant or of low relevance. Despite differing roles and perspectives, all stakeholders recognize the limited potential of herbicides while acknowledging the multitude of challenges associated with their implementation.

Stakeholders did not perceive herbicides as a technique with many opportunities in the context of rye-pea culture, the following highlighted categories were deemed as relevant by low proportions of respondents. Advisors recognize the potential of herbicides to increase soil health, a prospect also acknowledged by farmers and consumers, who emphasize the improvement of other ecosystem services resulting from herbicide use, such as enhancements in water availability and quality, and biodiversity. Additionally, farmers, consumers, and policymakers recognize herbicides' potential in fostering IPM strategies. Policy makers and researchers highlight more economic opportunities, including increases in business profitability and stabilization of crop yields. Notably, advisors, farmers, and consumers acknowledge that herbicide use in AWM can reduce overall herbicide reliance.

All stakeholder groups unanimously acknowledged that herbicide use encompasses several significant necessities. Training emerged as a crucial aspect, recognized by advisors, farmers, policy makers, and researchers, with one-third of consumers also deeming it essential. Additionally, practicing knowledge skills garnered recognition from a substantial proportion of policy makers and researchers, along with a third of consumers. Management expertise was deemed relevant by a considerable number of stakeholders across all categories. Furthermore, stakeholders emphasized the importance of ecosystem services impact knowledge as a fundamental requirement for effective herbicide implementation.

Stakeholders across various sectors identified several barriers associated with herbicide use. Lack of funds was highlighted as a significant obstacle by advisors, farmers, policy makers, and researchers. Training emerged as a paramount impediment, with farmers, consumers, policy makers, and researchers all recognizing its importance. Additionally, farmers and policy makers underscored expense as a key barrier, while policy makers and researchers emphasized the impact of time consumption. Furthermore, these groups, along with consumers, acknowledged that a high carbon footprint may pose a relevant barrier. Consumers specifically identified environmental and human harm as a paramount concern regarding herbicide use.

Stakeholders show higher rates of consensus when it comes to the practice disadvantages; customer demands to reduce or eliminate its use, environment and human harm, and expense were considered relevant by advisors, farmers, consumers, policy makers, and researchers.

2.1.3.1.1.4 *Mechanical weeding*

2.1.3.1.1.4.1 *Advisors*

Advisors considered mechanical weeding as a practice that present some relevant disadvantages and barriers, yet the queried needs and opportunities were regarded as low or irrelevant. None of the queried categories of opportunities was regarded as highly relevant by a significant proportion of advisors. As per main needs, only one third of advisors considered ecosystem services impact knowledge and regulatory changes as relevant. Time consumption and lack of funds were regarded as relevant impediments in mechanical weeding by almost 70% of advisors; one every three respondents also deemed expense as relevant, the same proportion considered that mechanical weeding does not present any significant barrier. Expense and time consumption were regarded as relevant disadvantages unanimously by advisors.

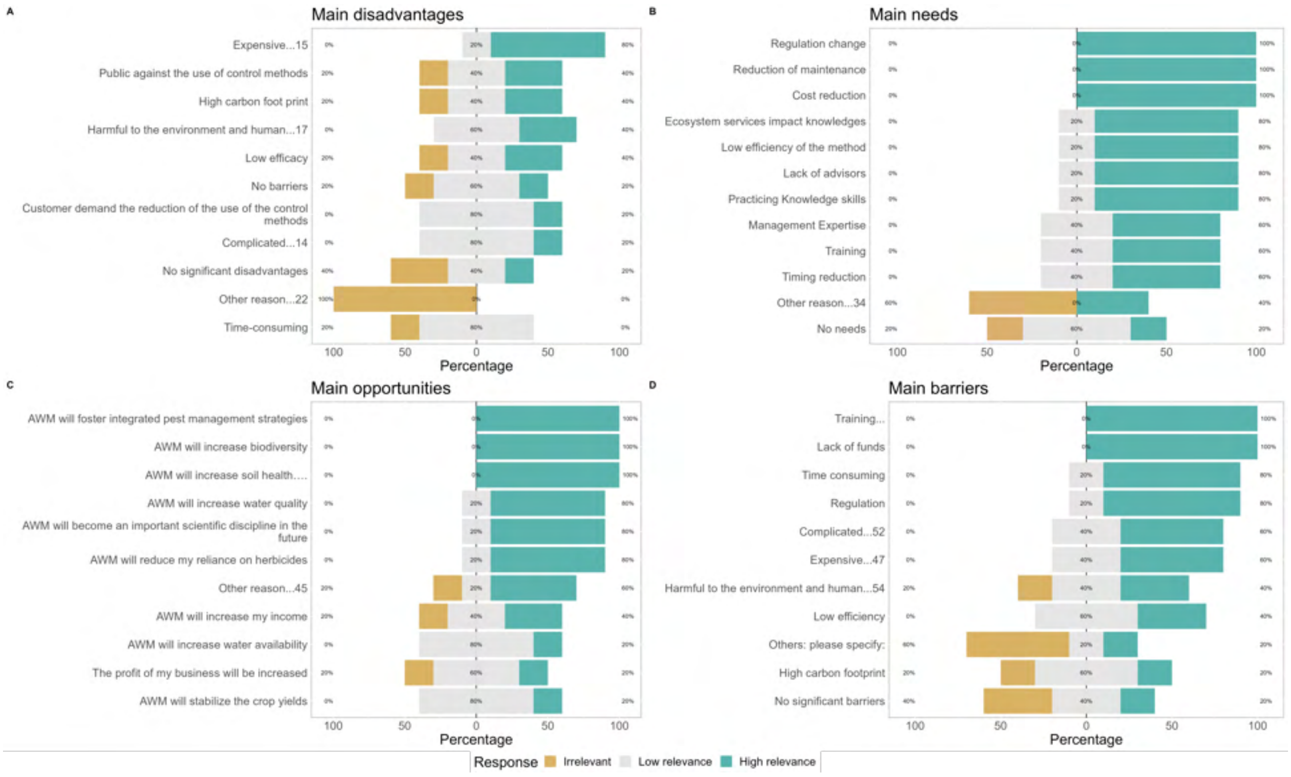

Figure 156. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by advisors.

2.1.3.1.1.4.2 Consumers

Consumers recognize a number of opportunities, needs, barriers, and disadvantages associated with mechanical weeding. As the main opportunity, 75% of respondents identify mechanical weeding as a technique that will reduce reliance on herbicides. The rest of the categories were deemed as low or irrelevant by the majority of respondents. Consumers consider practicing knowledge skills and timing reduction as key needs, while the rest of the queried needs were also deemed as low or irrelevant by most respondents. Time consumption was also identified as a relevant impediment by 75% of consumers. Additionally, half of the respondents stated that this practice does not present any significant barriers. Consistent with what was expressed as relevant impediments, no barriers (75%), time consumption, and the absence of significant disadvantages (50%) were deemed highly relevant by consumers.

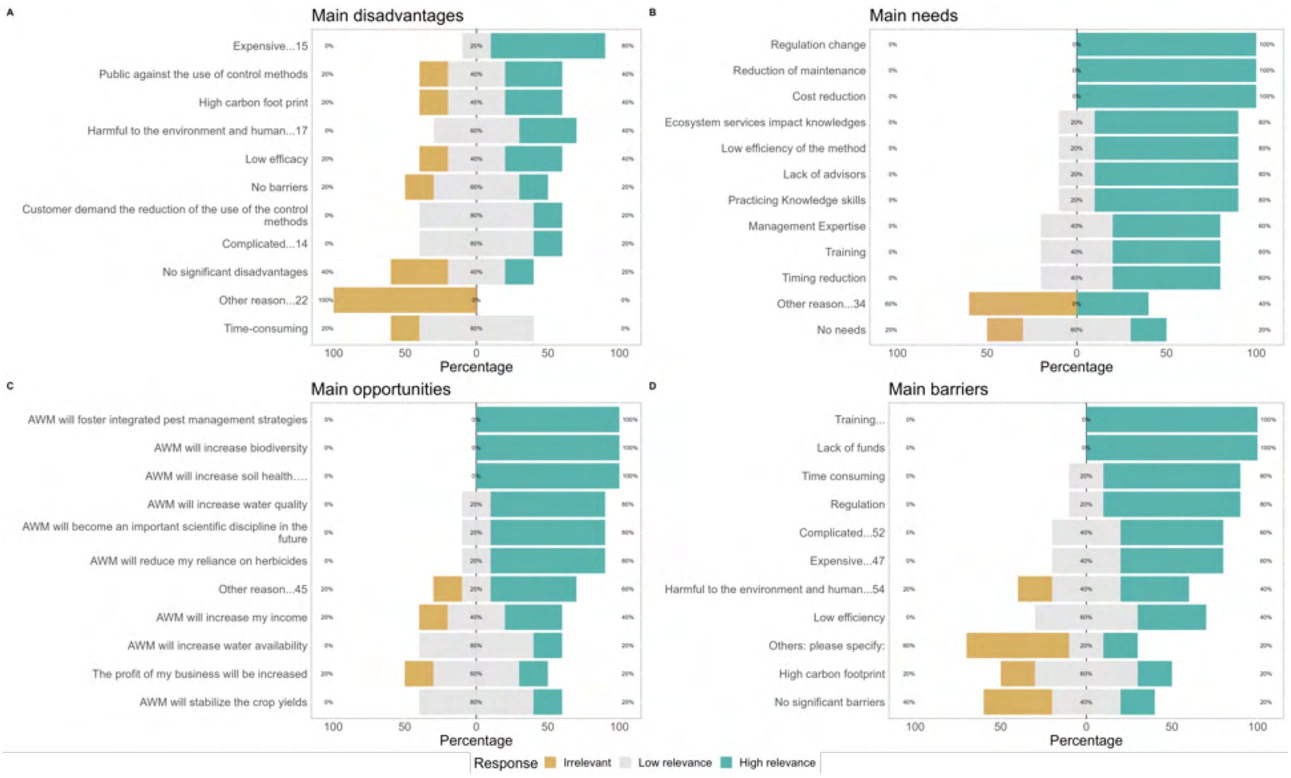

Figure 157. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by consumers.

2.1.3.1.1.4.3 Farmers

Farmers identify some opportunities and disadvantages while highlighting important needs and barriers associated with mechanical weeding. Consistent with consumers, 60% of farmers consider mechanical weeding a technique that reduces herbicide reliance, and 40% believe it fosters IPM strategies; other identified opportunities were deemed low or irrelevant. Farmers unanimously agree on management expertise as a relevant requirement for mechanical weeding. Additionally, 80% of respondents consider the reduction of maintenance relevant, while 60% cite lack of advisors, practicing knowledge skills, training, and cost and timing reduction as key necessities. Farmers emphasize time consumption (80%) and expense (60%) as highly relevant barriers to mechanical weeding. They do not consider mechanical weeding as a method with highly relevant disadvantages. Sixty percent of farmers identify complexity and time consumption as relevant drawbacks, while the majority consider other queried disadvantages as low or irrelevant.

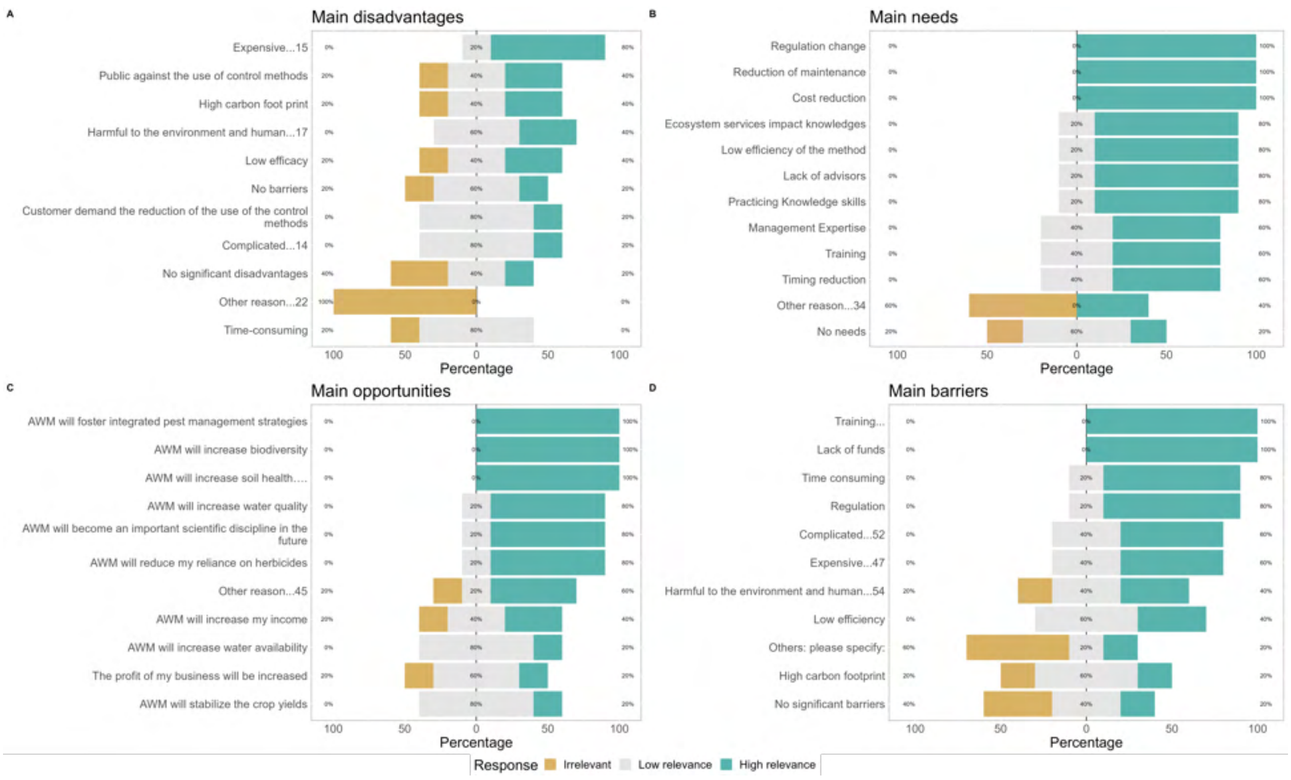

Figure 158. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by farmers.

2.1.3.1.1.4.4 Policy makers

Policy makers hold a balanced perspective on mechanical weeding's opportunities, needs, barriers, and disadvantages, with no single factor regarded as relevant by more than half of the respondents. Regarding the main opportunities of the method, half of the policy makers recognize its potential to provide ecosystem services, such as increasing biodiversity and improving soil health. Half of the respondents also identify practicing knowledge skills, management expertise, and training as relevant necessities. Similarly, half of the respondents view time consumption as a significant barrier. Finally, time consumption is seen as a relevant drawback by half of the policy makers.

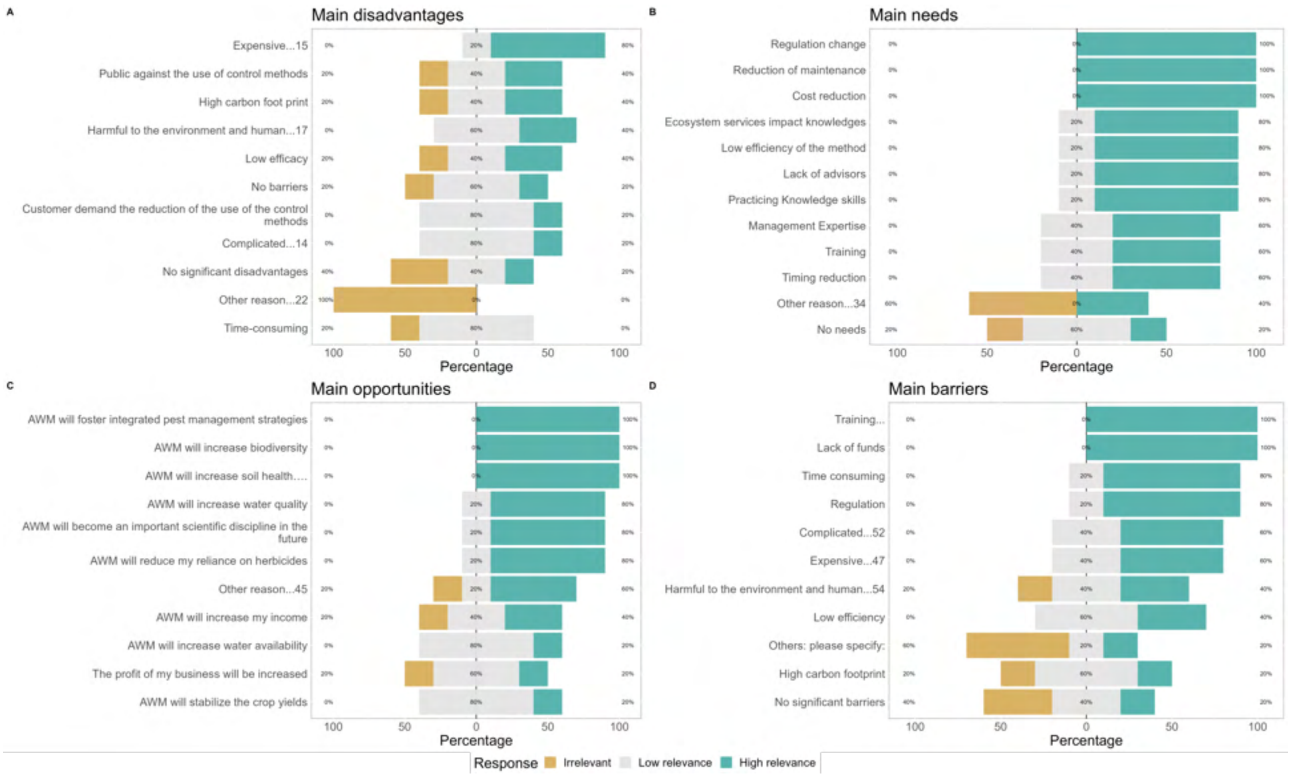

Figure 159. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by policy makers.

2.1.3.1.1.4.5 Researchers

Researchers, aligning with other stakeholders, acknowledge the various needs, disadvantages, and some low-importance barriers associated with mechanical weeding, along with potential opportunities. Sixty percent of researchers believe that mechanical weeding will reduce herbicide reliance, while 40% see it as fostering IPM strategies and potentially becoming an important scientific discipline. Among the relevant needs identified by researchers, 60% emphasize practicing knowledge skills and training, with 40% recognizing other requirements like ecosystem services impact knowledge, lack of advisors, management expertise, and maintenance reduction. No single barrier was deemed relevant by more than half of the respondents. However, 40% of researchers highlighted time consumption, training, and significant barriers as highly relevant obstacles. The main disadvantages identified by researchers include time consumption (80%) and expense (60%).

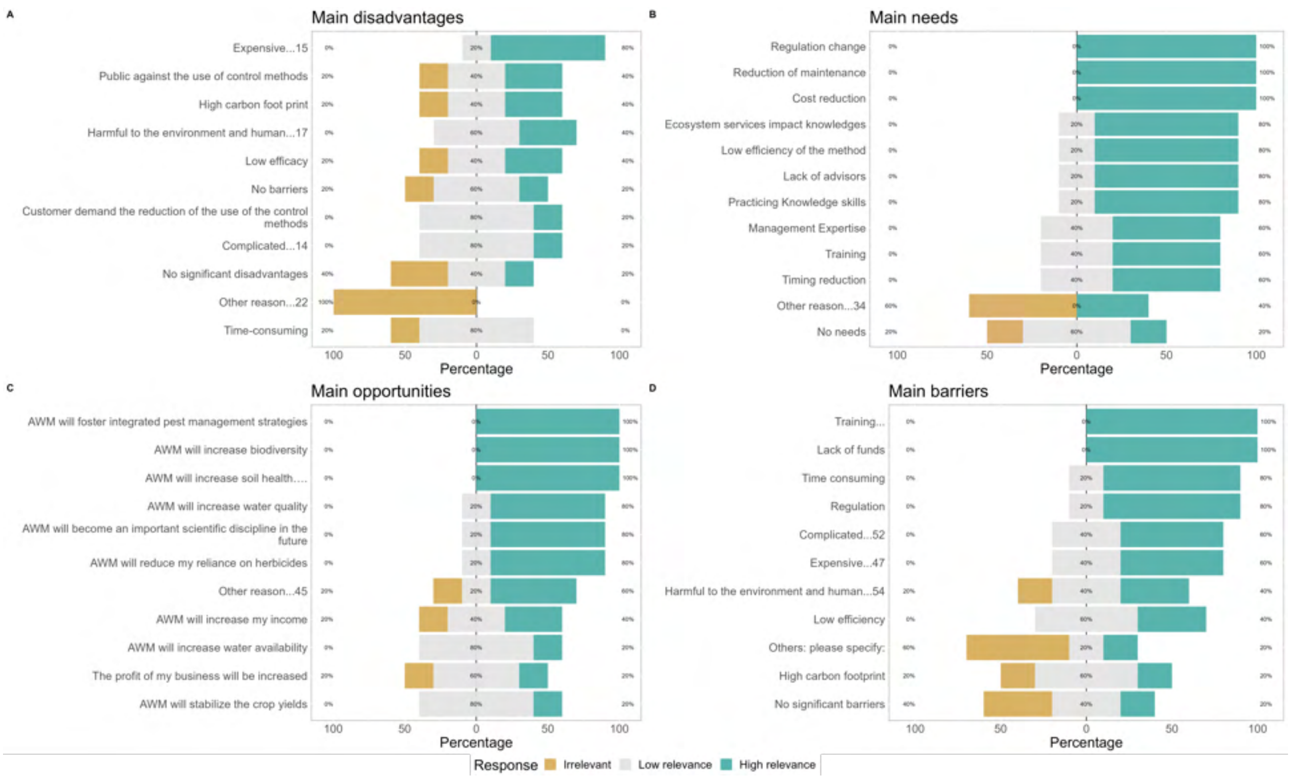

Figure 160. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by researchers.

2.1.3.1.1.4.6 Conclusions

Stakeholders across various sectors evaluated a range of opportunities, needs, barriers, and disadvantages associated with mechanical weeding. While advisors did not highlight any of the queried categories as highly relevant, consumers, farmers, and researchers identified mechanical weeding as a means to reduce herbicide reliance. Additionally, farmers and researchers emphasized its potential to foster IPM. Policy makers recognized mechanical weeding's capacity to provide ecosystem services, such as increasing biodiversity and improving soil health. Among the identified needs, practicing knowledge skills emerged as a priority for consumers, farmers, policy makers, and researchers, while management expertise was deemed relevant by farmers, policy makers, and researchers. Notably, only one third of advisors considered ecosystem services impact knowledge and regulatory changes as relevant. Time consumption emerged as a common barrier acknowledged by all stakeholders, with lack of funds and expense also recognized by a significant proportion. In line with these identified barriers, time consumption and expense were regarded as relevant by a significant proportion of respondents. Moreover, other queried disadvantages were generally perceived as low or irrelevant by the interviewed stakeholders.

2.1.3.1.1.5 Mowing

2.1.3.1.1.5.1 Policy makers

Policy makers regard mowing as an AWM practice offering limited opportunities, with only one-third of respondents viewing biodiversity increases, soil health improvement, and reduced herbicide reliance as highly relevant. Additionally, none of the queried opportunities were deemed as highly relevant by policy makers. However, they identified several significant necessities associated with mowing, with unanimous agreement on the method's low efficiency as the primary need. Nearly 70% of respondents considered lack of advisors, practicing knowledge skills, management expertise, and training as highly relevant requirements. Among the most significant barriers, 67% of policy makers identified time consumption. Moreover, policy makers predominantly viewed the method's low efficacy as the most relevant disadvantage.

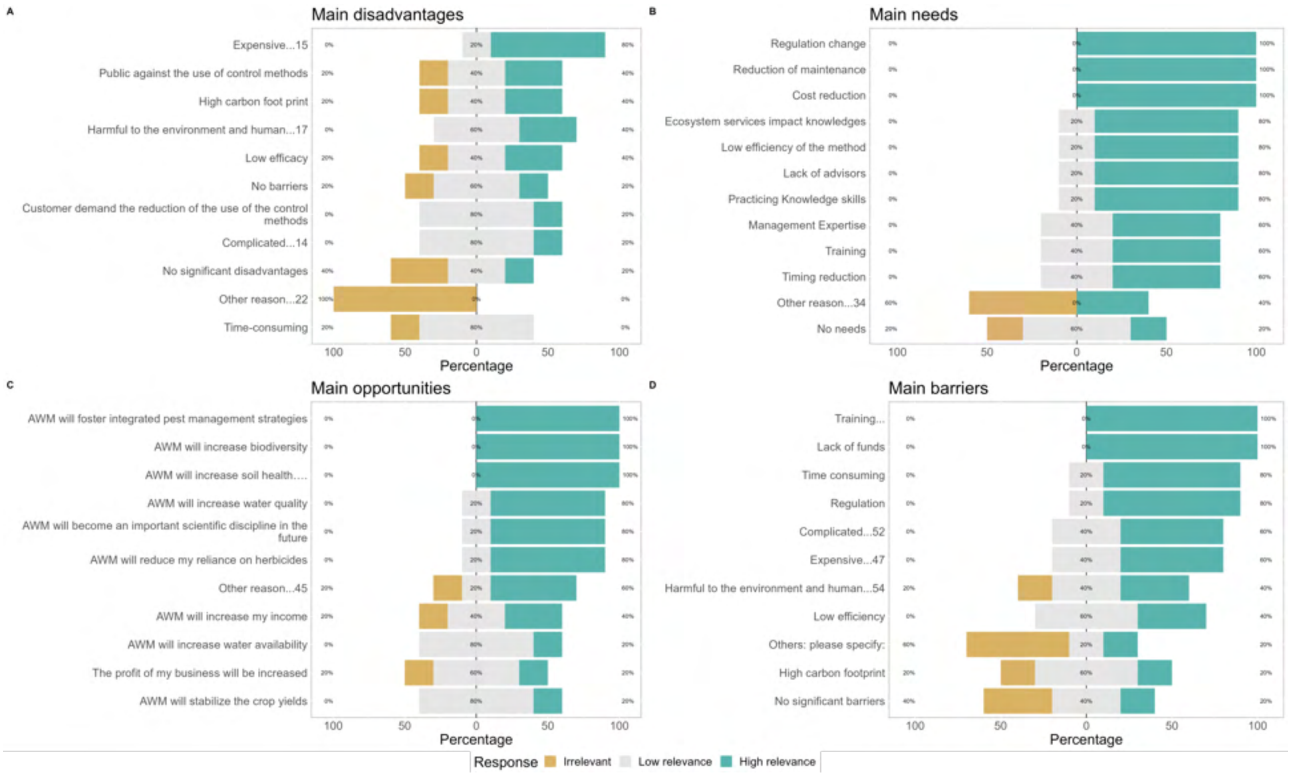

Figure 161. Main disadvantages, needs, barriers and opportunities for mowing identified by policy makers.

2.1.3.1.1.5.2 Conclusions

Policy makers consider mowing as an AWM strategy with limited opportunities, as few regard biodiversity enhancement, soil health improvement, and reduced herbicide reliance as highly relevant. Despite this, they recognize several crucial necessities linked to mowing, unanimously agreeing on the need to address its low efficiency. Additionally, nearly 70% highlight the importance of lack of advisors, practicing knowledge skills, management expertise, and training. Time consumption emerges as a significant barrier, identified by 67% of policy makers. Ultimately, policy makers view the method's low efficacy as its most notable disadvantage.

2.1.3.1.1.6 Mulching

2.1.3.1.1.6.1 Policy makers

Policy makers considered mulching as a technique with several opportunities. Most respondents considered that it provides ecosystem services, including increases in water quality and soil health amelioration. Additionally, they recognize that its implementation will reduce farmers' herbicide reliance. Nearly 70% of policy makers considered the lack of advisors, the need for practicing knowledge skills, and the requirement for management expertise as relevant necessities. Policy makers did not consider any of the queried barriers to be highly relevant; only training, the lack of funds, and expense were deemed so by one third of the policy makers. They considered mulching as a technique that entails no significant disadvantages.

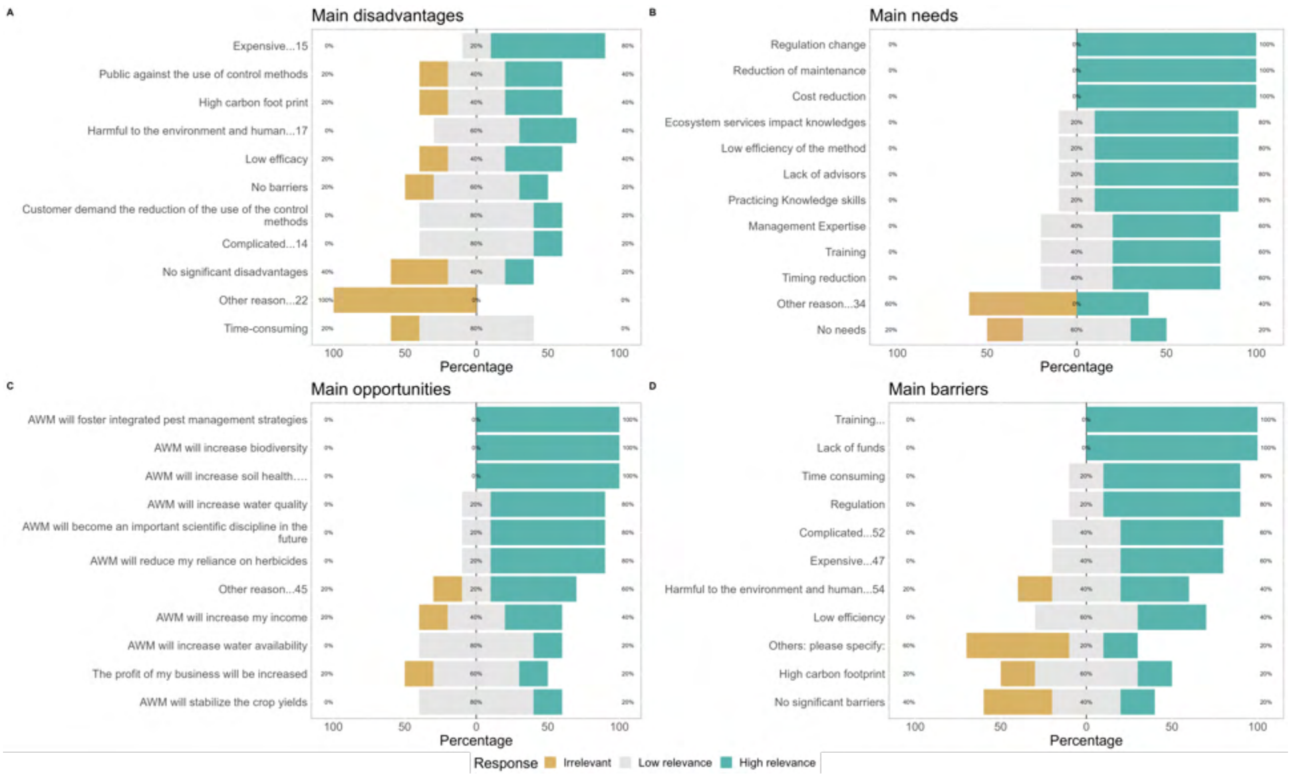

Figure 162. Main disadvantages, needs, barriers and opportunities for mulching identified by policy makers.

2.1.3.1.1.6.2 Conclusions

Policy makers recognize mulching as a technique offering several opportunities, including ecosystem services provision and reduced herbicide reliance. They emphasize the need for adequate support and expertise in implementing mulching practices. While few barriers are seen as highly relevant, such as training and financial constraints, overall, mulching is perceived as a beneficial strategy with minimal disadvantages.

2.1.3.1.1.7 *Site specific spraying*

2.1.3.1.1.7.1 *Advisors*

Advisors view site-specific spraying as a technique with limited opportunities, as only one-third of respondents considered its use to foster IPM strategies, increase business profitability and farmers' income, as well as stabilize crop yields. They also identify several significant necessities associated with site-specific spraying, with nearly 70% recognizing practicing knowledge skills, management expertise, training, and cost and timing reduction as highly relevant. While none of the queried barriers was deemed highly relevant by more than half of the respondents, nearly 70% considered customer demand to reduce its use and expense as relevant drawbacks. The rest of the queried drawbacks were not considered relevant by a significant proportion of respondents.

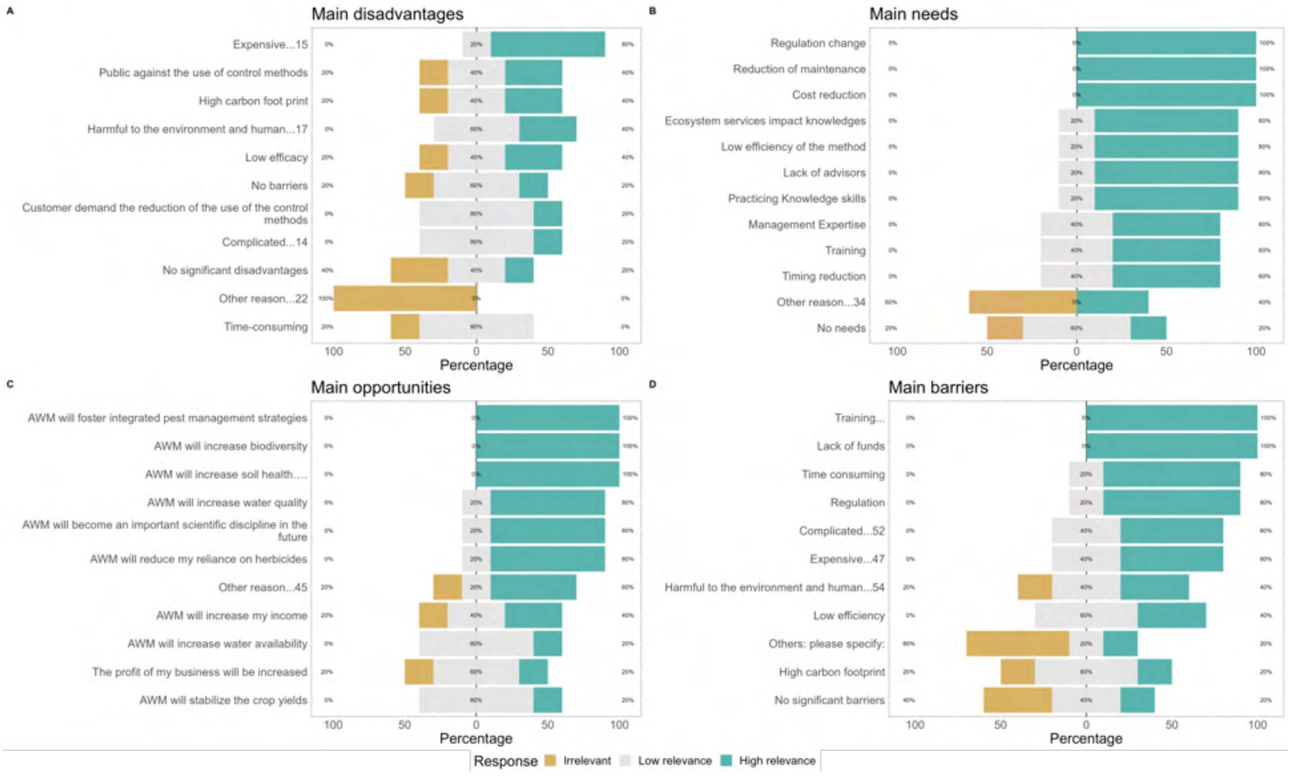

Figure 163. Main disadvantages, needs, barriers and opportunities for Site specific spraying identified by advisors.

2.1.3.1.1.7.2 Policy makers

Policy makers, aligning with the perspective of advisors, did not regard site-specific spraying as a practice with many opportunities, as none of the queried factors was considered relevant by more than half of the respondents. They unanimously recognize practicing knowledge skills, management expertise, and training as significant needs, aligning with advisors. Additionally, nearly 70% of policy makers considered ecosystem services impact knowledge, reduction of cost, and maintenance as relevant requirements for site-specific spraying implementation. Like advisors, policy makers considered this practice to present no significant barriers. Finally, almost 70% of respondents stated that customer demand to reduce its use and environmental and human harm were the most relevant disadvantages of this method.

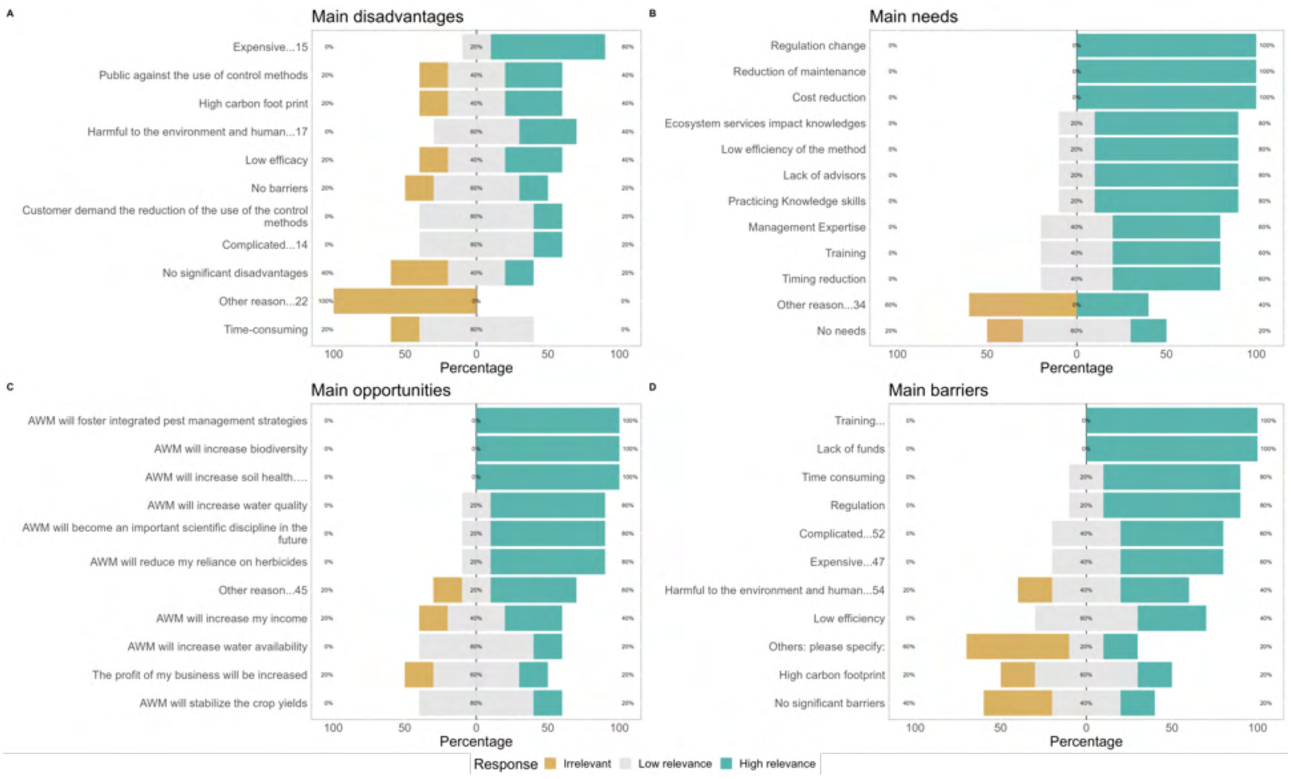

Figure 164. Main disadvantages, needs, barriers and opportunities for Site specific spraying identified by policy makers.

2.1.3.1.1.7.3 Conclusions

Advisors and policy makers view site-specific spraying as a practice with limited opportunities. Both groups identify several necessities; both stakeholders consider practicing knowledge skills, management expertise, training, and cost reduction as relevant. Besides, advisors emphasized timing reduction, while policy makers emphasize the importance of ecosystem services impact knowledge and maintenance. None of the queried barriers was considered highly relevant by advisors or policy makers. Finally, both stakeholder groups regarded customer demand to reduce site-specific spraying as a relevant disadvantage; besides, advisors highlighted expense, and policy makers emphasized the importance of environmental and human harm.

2.1.3.1.2 Surveys

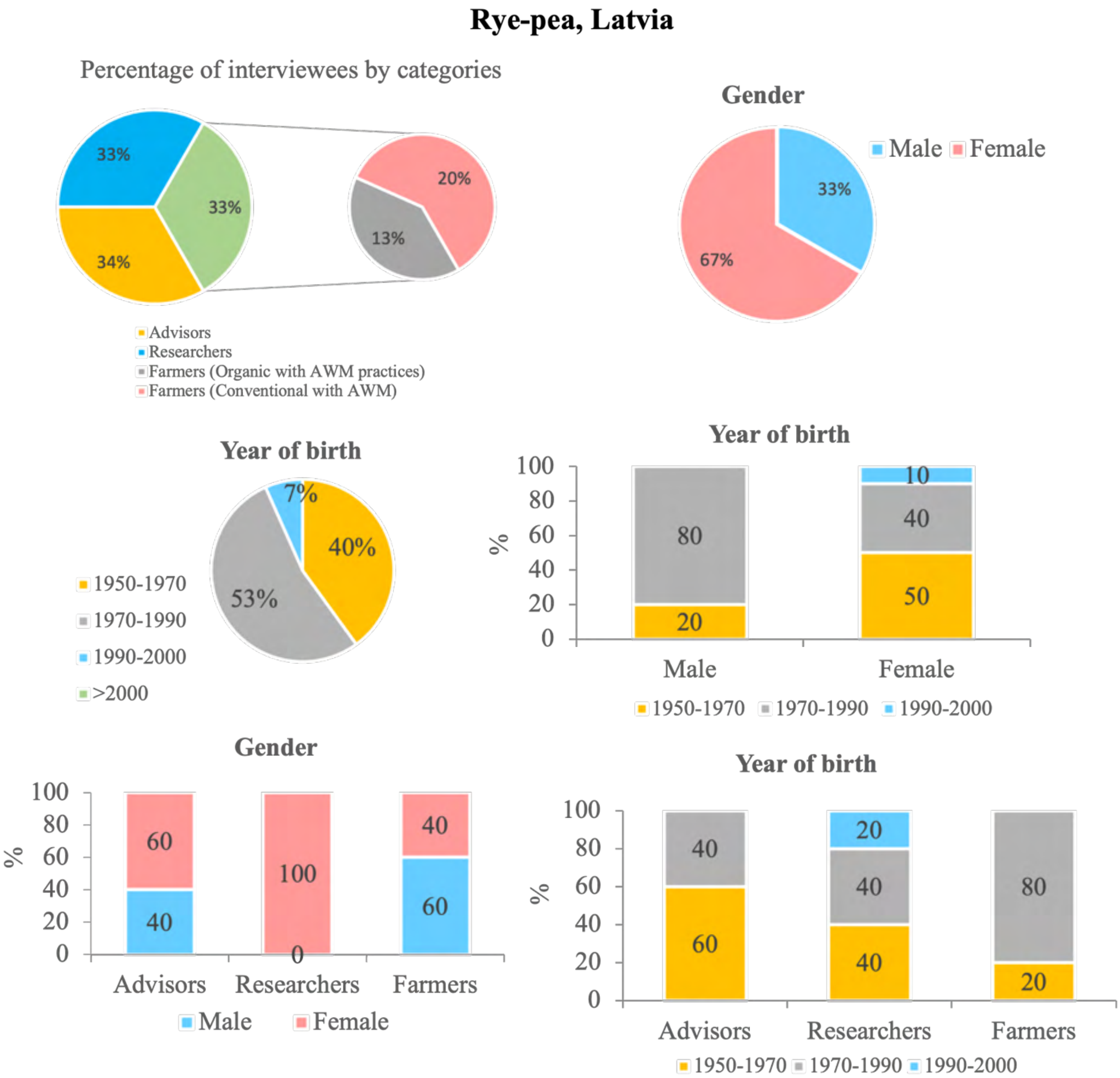

Figure 165. Interviewees description in the Rye-Pea Living Lab (Latvia)

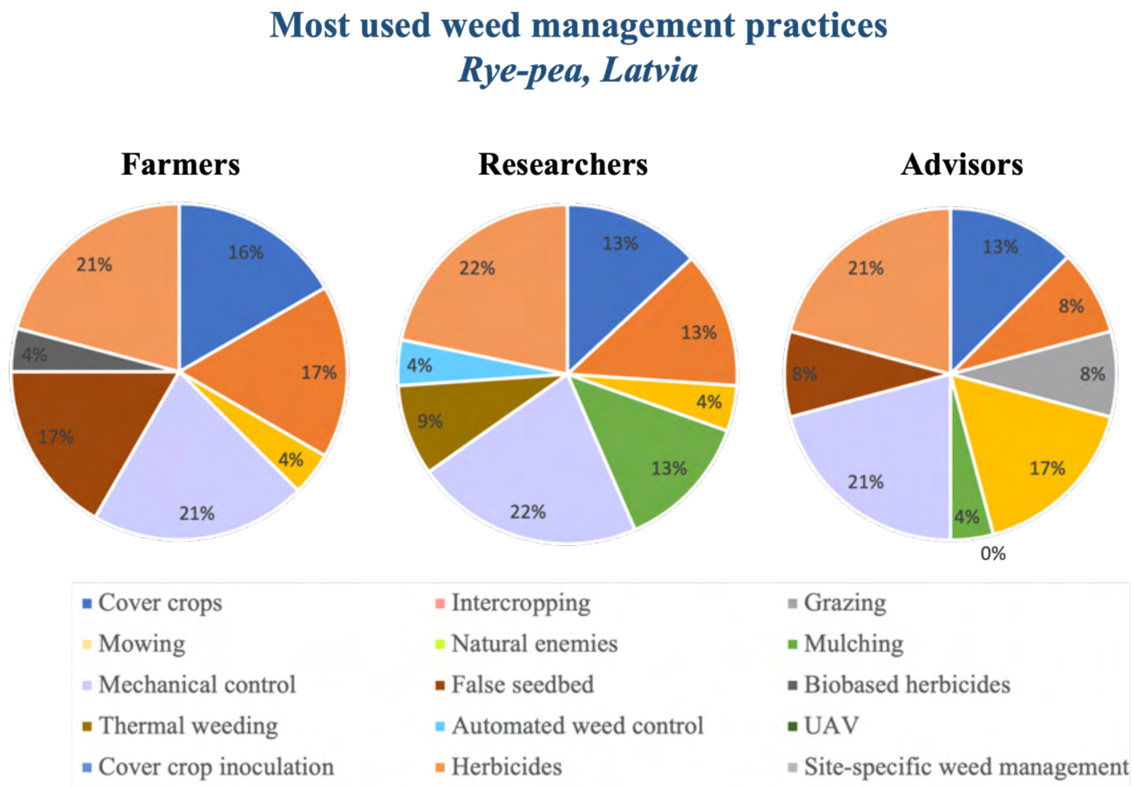

Figure 166. Most used weed management practices in the Rye-pea Living Lab (Latvia)

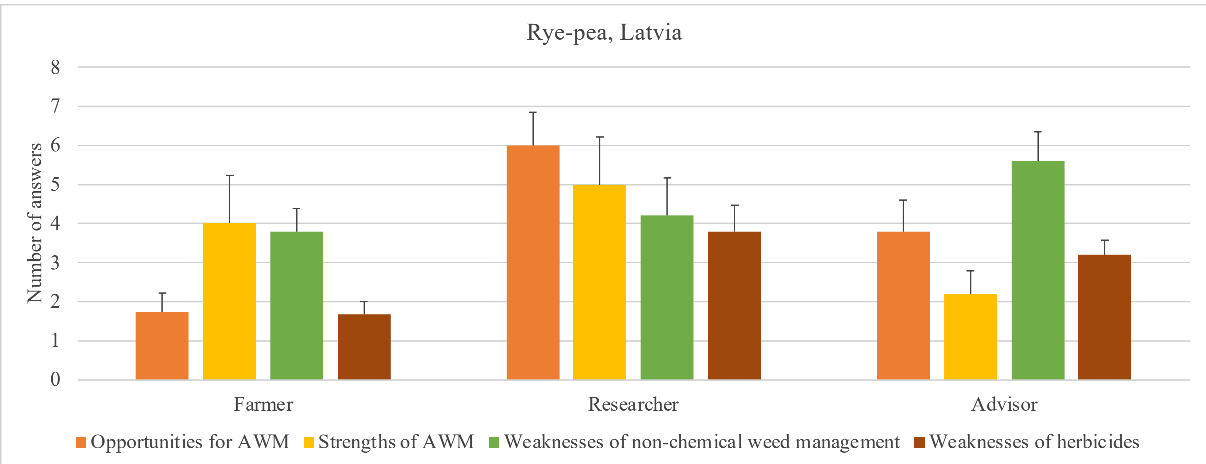

Figure 167. Mean number of answers (±se) per stakeholder group in the Rye-pea Living Lab (Latvia)

Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: Presented in the figure below.

THREATS: Only a few answers were collected and identified as threats for AWM by the Latvian interviewees. However, it is worth mentioning that a few farmers and researchers identified many threats. Specifically, EU policies, bureaucracy, uncertainty, inaccurate long-term planning and agricultural policy were mentioned by farmers. Researchers focused on climate change, invasive species, changes in weed flora and agricultural policy.

WEAKNESSES: Only a few weaknesses (lack of experience and knowledge, accessibility to knowledge, lack of labor) were identified by researchers.

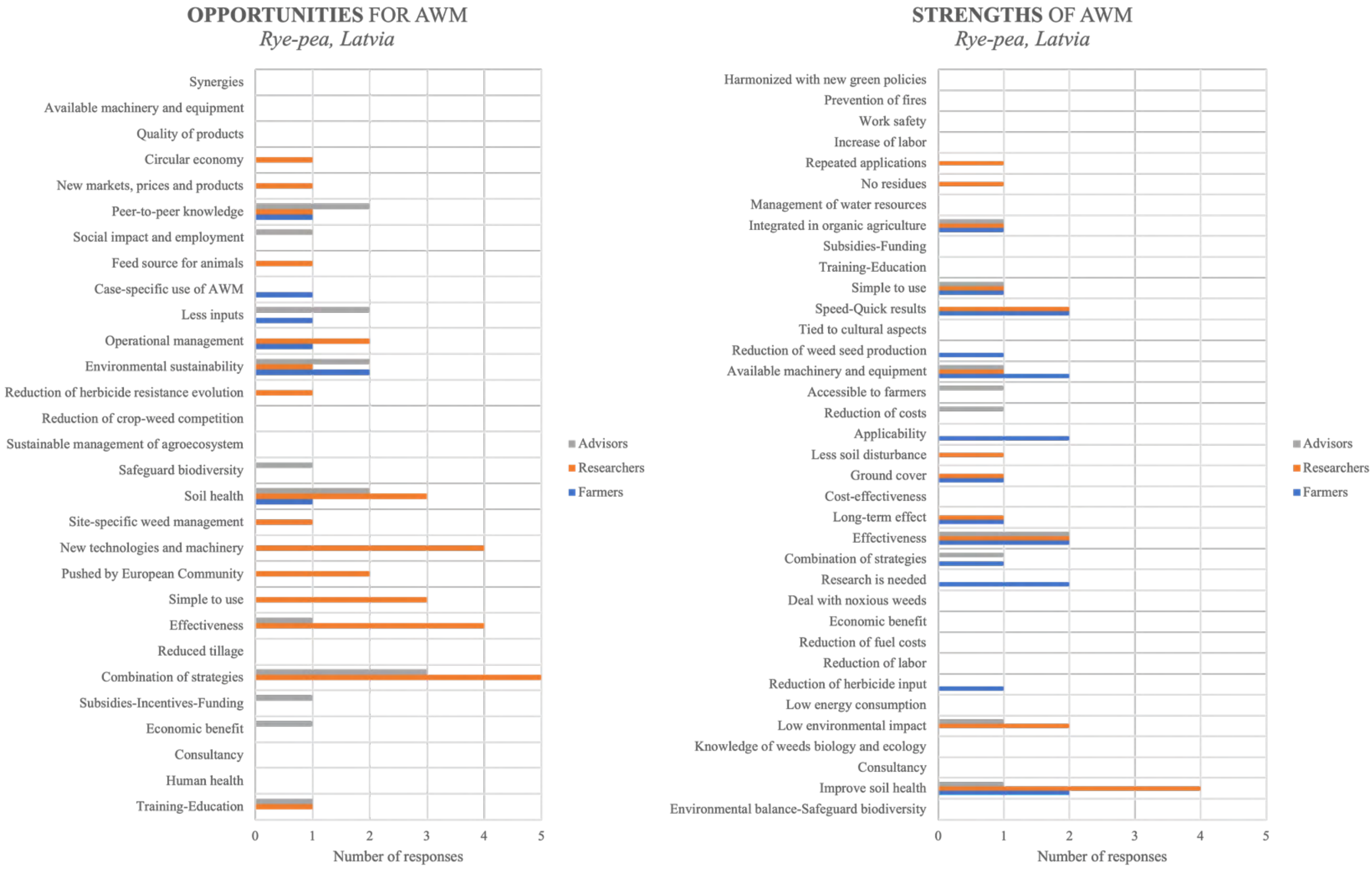

Figure 168. Opportunities and strengths of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: Climate and weather conditions is the major factor that determines the applicability and adoption of non-chemical weed management practices, as replied by all stakeholder groups. Additionally, other threats included the lack of recognition from markets, the energy sector and the agricultural policy.

WEAKNESSES: Presented in the figure below.

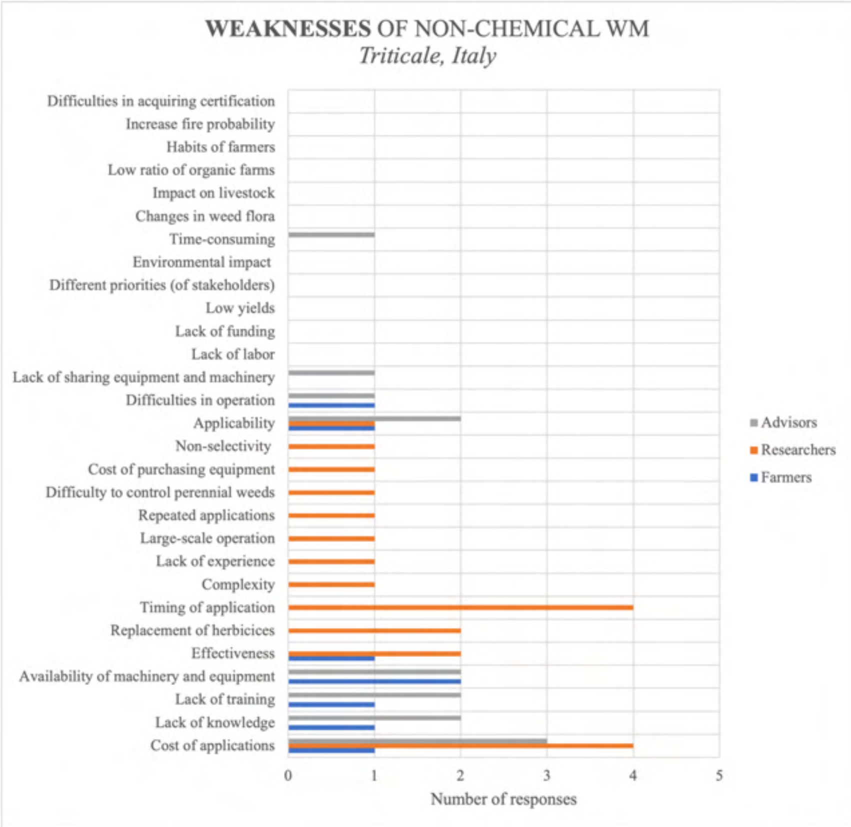

Figure 169. Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: Three responses from researchers focused on efficacy and quick results of herbicides. On the contrary, three responses from advisors included the optimized treatments. Besides these, a farmer mentioned the fast operation and less fuel consumption. A few answers included the broad spectrum of weeds, light machinery, reduction of crop-weed competition, available equipment, selectivity and low cost.

STRENGTHS: The efficacy of herbicides was mentioned by all stakeholder groups, along with the economic benefit and the simplicity to use herbicides. A few strengths referred to yields, reduction of crop-weed competition, broad spectrum of weeds, low cost and that herbicides are not labor intensive. However, three farmers praised the quick results which is really important for them.

THREATS: Only a few answers were identified about threats to herbicides and were mainly related to less subsidies, agricultural policy and pressure to reduce herbicides.

WEAKNESSES: Presented in the figure below.

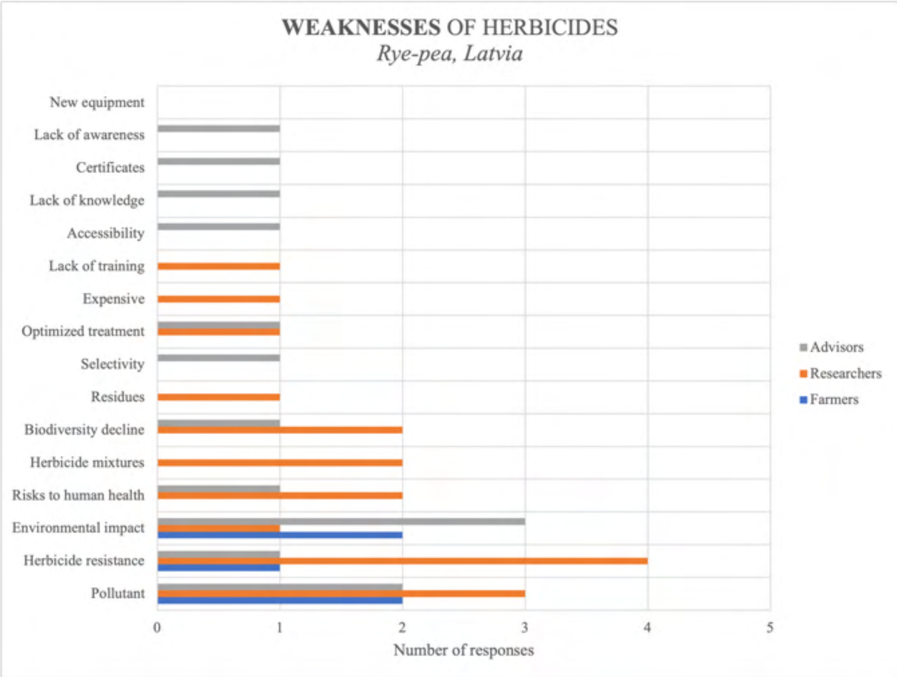

Figure 170. Weaknesses of herbicides.

SUMMARY OF THE INTERVIEWS – RYE/PEA, LATVIA
Most used weed management practices: Latvian farmers are using multiple methods to manage weeds. Among them, intercropping, the use of cover crops and false seedbed are cultural practices that aim to reduce chemical input. The window of growing season is short in Latvia (approx. 4 months) which means that the decision-making on weed management is really critical for the success or failure of crop yields. **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group**: Researchers identified more opportunities for AWM and weaknesses of herbicides than advisors and farmers. This demonstrates researchers' intention to conduct research on new areas of weed science that are not dependent only on herbicides. Advisors were able to identify many weaknesses of non-chemical weed management, a result that shows the concerns about applicability and effectiveness of alternative solutions to synthetic herbicides. **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: It is worth mentioning in the Latvian LL that researchers highlighted several opportunities for AWM, spanning from simplicity to use and effectiveness to new machinery and technologies and the fact that such practices are promoted by the European Union.

However, all researchers agreed that the combination of strategies is considered the most important opportunity for AWM. Several strengths were identified but there was no common ground on what strengths of AWM are the most important. Notably, quick results, effectiveness and improvement of soil health stand out.

Threats, and weaknesses for non-chemical weed management: Climate and weather conditions is the biggest threat for non-chemical weed management. In regard to the weaknesses, the costs and timing of applications were the most prevalent, followed by applicability, lack of training, effectiveness, and availability of machinery.

Opportunities, strengths, weaknesses, and threats for herbicides: The efficacy, simplicity to use and cost-effectiveness of herbicides were reported as their major strengths. However, there was also a recognition of their negative environmental impact and negative effect on biodiversity.

2.1.3.1.3 Living lab board meeting

The 1st LL board meeting took place in online platform Teams on 28th November 2023. The meeting was recorded and the agenda was: i) Opening Ceremony, ii) Introductions of participants to each other, iii) Presentation of the GOOD project, iv) Issues/tasks of the day.

The recommendations and advice obtained during the meeting were: i) As the country (Latvia) is so small we should look at production in the whole country, not separate regions, ii) Use the GOOD Project platform to promote rye because rye bread is a national product protected by a geographical indication, iii) Introducing the correct Latvian terms for agroecological methods, iv) Inclusion of Latgale on the Latvian map in the Project presentation. Why has Latgale been removed from the Latvian map?, v) After writing the minutes, send the notes to the Board members for approval, vi) A lot of research has been done in Latvia on agroecological weed control methods through other European projects. Somebody should compile these studies, vii) Is the project going to include a survey of farmers specifically on rye and pea production?, viii) Interviewing farmers in the light of their practical experience of growing these two crops. Project partners could benefit from targeted information on chosen crops using farmers practical experience, ix) Information on field days at the AREI institute. When the trials will be on view to start popularizing the project and spreading the word through Institute visitors? Moreover, during the LL board meeting, this information was also collected:

What are the market characteristics of rye/ pea?	1. How many farmers cultivate rye in the region (approx.)? Is it mostly monoculture or can rotations be made with other crops?
	According to statistics and observations, Rye is being grown less and less. We look at statistics for the whole territory of Latvia, without a regional breakdown The exact data can be found in the Organic Farming Statistics section. But the reason why rye is declining is market demand, which practically does not exist at the moment
	2. How many farmers cultivate peas in the region (approx.)? Is it mostly monoculture or can rotations be made with other crops?
	Peas are also currently being extensively studied in other EU projects. Europe legume, for example. Peas as a protein-rich product are currently being promoted in Europe. Yellow peas as a protein product. Grey peas as a continuation of national traditions.

	3. How many products are derived from the RYE? Are they important for the economy and/or food security?
	Rye bread is a national product protected by a geographical indication. Use of rye in agriculture as an intercrop for soil remediation, both in the field and in polytunels.
	3. How many products are derived from the PEAS? Are they important for the economy and/or food security?
	The national treasure is the grey pea. Yellow peas as a protein-rich product is becoming increasingly popular.
	4. Do you think that agroecological products could be promoted in local markets?
	Market prices are very low this year. Rye should definitely be promoted more.
	5. Do you believe that the region has a lack of technologies?
	Technology should not be an issue
	6. Is the regional agri-food value chain sustainable?
	In practice, farmers are unable to grow enough and varied food to feed schools, kindergartens and other social institutions.
What are the most common agricultural and weed management practices in rye/peas?	1. What are the most common agronomic practices in RYE?
	Terms. "Replace 'agronomic practices' by 'cultivation technologies'. This includes crop rotation, soil preparation, seed preparation and fertilization... All that is in this technology. Rye will mainly be a pre-crop. If rye is grown after grasses, the weed problem will be negligible. Rye on its own is good at suppressing weeds through its allelopathic properties. In organic systems, under-sowing is used. It is not very widespread, but there is a beginning and farmers are starting to use these methods. Harrowing is the most common cultivation technology used. It would be interesting to know whether row spacing in rye sowings is something that anybody has experimented with?
	2. What are the most common agronomic practices in PEAS?
	It is not very common at the moment, but peas can be sown in mixtures with cereals. With oats, spring wheat. Do whatever it takes to encourage the main crop to grow better. Leaf cover as a weed suppressant for effectiveness.

	Thickness of the crop in row spacing. Row spacing.
	3. What are the most common weed management practices in RYE?
	The terms in the LV language are not appropriate. We don't manage weeds. We control them. Harrowing is used.
	4. What are the most common weed management practices in PEAS?
	Harrowing is used.
What is the herbicide use in rye/ peas?	1. How many active ingredients there are available? How many different mode of actions?
	This is everyone's individual view of competences. Each of the participants has different levels of expertise on this issue. Most farmers themselves do not know what active ingredients are in the products. But in the experience of practicing agronomists, there are about 10 main active substances that are predominantly used in available products. Soil and foliar exposure. The choice of which to use will depend on the weeds present in the field. Herbicides are not a commodity product. The trader will keep the information on the active ingredients confidential as this is a trade secret.
	2. How many times do you spray in-season?
	Soil herbicides are predominantly used in peas. How often to spray depends on the problem to be solved. Of course, it would be cheaper to spray a less problematic field just once in the spring. Therefore, spraying several times with a combination of different active ingredients is practiced more often.
	3. Do you use pre-emergence, post-emergence or both herbicides?
	Glyphosate in rye before sowing. For those growing hybrid rye varieties, there could be some additional herbicides.
	4. Are herbicides efficient?
	AREI has carried out statistical research on herbicides comparing 100 different fields. The study does not single out individual crops on which herbicides have been used. Is it necessary to integrate the data from these studies into this project? The Institute has no right to share this information without approval.
	5. Do you think that alternatives to herbicides are equally efficient?

	Seasonality and a distinctly dry start to the growing season last year particulary reduced the impact of soil herbicides. Effectiveness is a scientific measurement used in research. Efficiency cannot be measured by the farmer. It is a subjective opinion. The farmer can assess whether or not he thinks the particular product had an effect on the weeds it has been applied on.
	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?
	Contamination to extent and resistance occur. That is why Europe is now putting forward an herbicide reduction plan.
	7. Do you believe that agriculture without herbicides is viable?
	Yes, it can. But it's hard. Yes, especially with the cultivation of rye. Even conventional growers in my region grow rye without herbicides. This question is cornered by the choice Yes or No. This question is incorrect in its essence. There are too many circumstances that should be taken into account when answering this. The key word is VIABLE. Of course, agriculture can be viable without herbicides, but it has to be PRODUCTIVE not viable. I also support organic farming, but I am not prepared to give a yes or no answer today. Of course, we need to move towards reducing herbicides, but that is going to be a huge problem in agriculture at the moment.
What are the needs and barriers to assist agroecological transitions & adopt agroecological weed management approaches?	1. What is needed to boost the uptake of agroecological practices?
	No farmer wants to harm his country. If the market situation stabilized, if income levels were such that people could buy these products. Logically, organic products must be more expensive if they are grown using agro-ecological methods. If the market stabilizes and there is demand, then there will be stabilization. Good practices should be promoted. Show farmers what can be achieved with these methods and what the contribution is.
	2. What are the barriers towards agroecology implementation?
	From the point of view of the farmers, whether they have sufficient knowledge on these matters. This could be a limiting factor because there is not this holistic view. He does not know any other option. Farmers don't know a lot of things. How effective these methods are, what they are. Most often there will be no result immediately. Also politically, will the consumer demand a

	product grown in this way? Why should producers change anything if there is no demand? Even if there is technological support, unlikely that everyone will be ready to change their technologies immediately. It is, however, a complex approach. An example would be the Sigulda Bioregion conference that took place recently. This problem is being addressed in a complex way through catering in schools and catering in hospitals. This is a comprehensive approach. If a farmer is struggling on his own and trying to compete in the market, there will be no result I also wanted to add that green public procurement is a tool for us to promote this. As specialists, we see that a comprehensive approach is needed here, while the farmer is struggling alone on his farm. If you give me money, I will do it; if you do not give me money, I will not do it. We must also be able to put ourselves in the farmer's shoes and look at the situation from his point of view. There would even be a demand, but peas are not grown in quantities needed to supply all schools.
	3. Should policies need be redefined to allow agroecological transitions?
	As for mechanical control options. Aggregates have evolved a lot. The question is their availability, then political influence.... There should be a clear policy to help farmers to buy these aggregates on preferential terms. If the availability is facilitated politically, then this segment of mechanical weed control methods would improve as a result. If it is done at such a primitive level, then the results will also be mediocre. Policy is important. Not only do we say that the objectives of the Green Deal must be achieved, but we are also given the tools to do it. Until the means are developed to promote these alternative methods, of course, those who use herbicides will be taking the easy way out. It is more convenient, it is cheaper... and business as usual will continue. The distribution of the financial pie should be different, but until it is, it is of course difficult for a farm to switch to a completely new method. No farmer is suicidal enough to go it alone and switch to these agro-ecological methods without money to cover it.
	4. How confident you feel about the adoption of agroecological weed management practices?
	Once there is enough practical evidence that they work, farmers will have no problem adopting these practices.

	The direction is already set, but what is needed is action, as Maris said. Political decisions are also important to motivate farmers. This Green Deal transition period could be the one that encourages the adoption of the practices if they are wisely guided to do so. But unfortunately, we are not going that smoothly with it.
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	What are the main drivers of weed dispersal?
	There have been projects on weed distribution in regions of Latvia. These issues are one of the cornerstones of my research. The information is there, the data is there, and the data needs to be compiled yet. Weeds can also serve as indicator species to determine agroecological background. But we cannot forget the main factor, which is the promotion of crop cultivation. If there is a strong crop with the right density, then weeds don't have a chance to withstand it. Also, the manure must be properly prepared for use to prevent the spread of weeds. This is correctly done composting. And this could also be one of the ways of increasing productivity. It is more than obvious that if there are 5 barley plants per m2 in a field, it is more than obvious that there will be a weed problem. These would be preventive weed control methods but the agroecological methods are already based on prevention.
	2. Which are the major and most noxious weeds in your area?
	The most ferocious weeds: couach grass, thistle, soft dandelion. As well as annual weeds, which cause a lot of pollution in the countryside.
	3. Are there any herbicide resistant weeds?
	The issue of resistant weeds is becoming increasingly important. Poa annua and Stellaria media.
	4. Do you know any invasive plants in your area?
	The Heracleum plant is recognized as an invasive plant in Latvia. The others are potentially invasive - *Impatiens grandulifera*, *Solidago chinensis*, etc. This is probably a problem in the countryside and country's landscapes rather than on farmland.
What do you think about the Living Lab?	1. Which proposals do you have for a good performance of the LL?
	The key word is to find willing hosts who have the technical know-how and who can meet the exact conditions of the pilot project. This is a huge part of the project's success. Farmers are practical, logical thinkers, so it would be important to make the trials as meaningful as possible.

	As a farmer, I can say that we have hundreds of jobs to do every day. And if you have to keep up with meeting the conditions of the project on time, then thAWM ere can be problems. So, thank you to the AREI Experimental Institute for carrying out this research.
	2. Would you like it to remain over time?
	This will depend on the results.

AGROECOLOGY FOR WEEDS

2.1.4 Horticulture

2.1.4.1 Onions (The Netherlands)

2.1.4.1.1 Questionnaires

Onion questionnaires provided insights with regard to six AWM techniques, including cover crops, false seedbed, herbicides, mechanical weeding, natural enemies, and site-specific spraying. Perspectives were provided by advisors, consumers, and researchers, as we did not gather enough responses from farmers, industry representatives and policy makers. A detailed breakdown of stakeholder participation in the questionnaires for each AWM practice is presented in Table 29.

Table 29. Number of responses for each AWM practice and stakeholder category in Onions.

	Advisor	Farmer	Consumer	Industry	Researcher	Policy maker
Automated weed control	1		1			
Biobased herbicides			2			
Cover crop inoculation to increase competitiveness						
Cover crops	**7**	1	**7**	1	2	
False seedbed	**4**	1		1	2	
Grazing			2			
Herbicides	**5**	1	**5**	2	**3**	
Intercropping	1		2			
Mechanical weeding	**5**	1	**3**	1	**3**	
Mowing	2		2		2	
Mulching	1					
Natural enemies	1		**3**			
Other			1			
Site-specific spraying	**5**		**3**			
Thermal weeding			2		1	
UAV	1					
n=29	9	1	11	2	3	0

2.1.4.1.1.1 Cover crops

2.1.4.1.1.1.1 Advisors

Advisors regard cover crops as a technique brimming with opportunities, with over 70% believing in its potential to foster IPM strategies and provide various ecosystem services, such as improving water quality, biodiversity, and soil health, while reducing farmers' reliance on herbicides. Additionally, more than half of the advisors foresee cover crops evolving into an important scientific discipline. Recognizing the significant necessities associated with cover crops, 57% of respondents prioritize practicing knowledge skills. Moreover, over 40% of advisors highlight regulatory changes, low method efficiency, management expertise, training, and timing reduction as essential requirements for successful cover crop implementation. While none of the queried barriers were deemed highly relevant by the majority, 43% of advisors identify method complexity and regulatory challenges as key impediments. Furthermore, no drawbacks were considered significant by the majority, but 43% of advisors cite low efficacy as a relevant disadvantage.

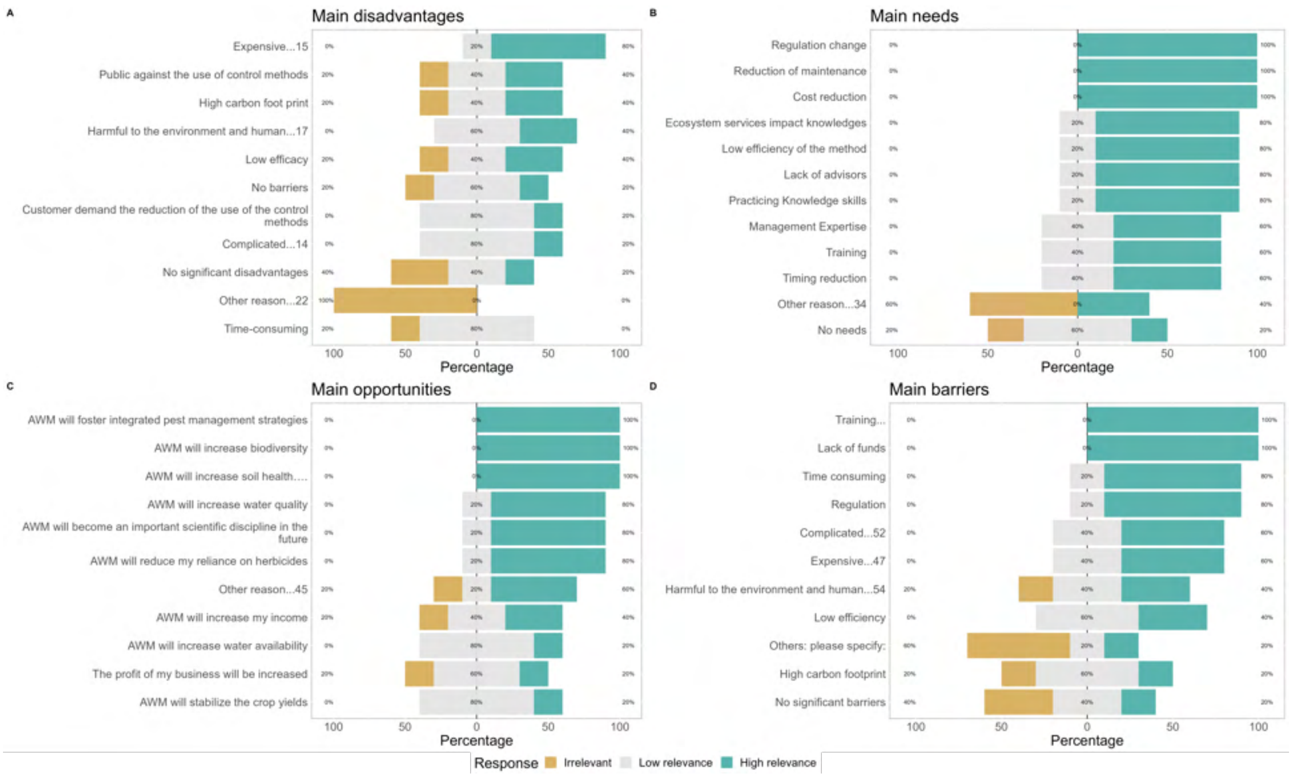

Figure 171. Main disadvantages, needs, barriers and opportunities for cover crops identified by advisors.

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2.1.4.1.1.1.2 Consumers

Consumers mainly shared a positive outlook regarding cover crops opportunities, yet they recognize key needs and some barriers and disadvantages for this practice implementation. More than half of the consumers considered that cover crop use will result in soil health increases while reducing farmers reliance on herbicides. Besides, 43% of respondents recognize that this technique will increase biodiversity and have potential to evolve into an important scientific discipline. Consumers recognize regulatory changes as the main requirement for cover crops, as stated by 86% of them. Besides, nearly sixty percent of consumers considered ecosystem services impact knowledge and practice knowledge skills as relevant needs. As the main barrier, consumers identify lack of funds (57%) and method's low efficiency (43%). Lastly 71% of consumers recognize that customers demand to reduce cover crops use as the main disadvantage for its use.

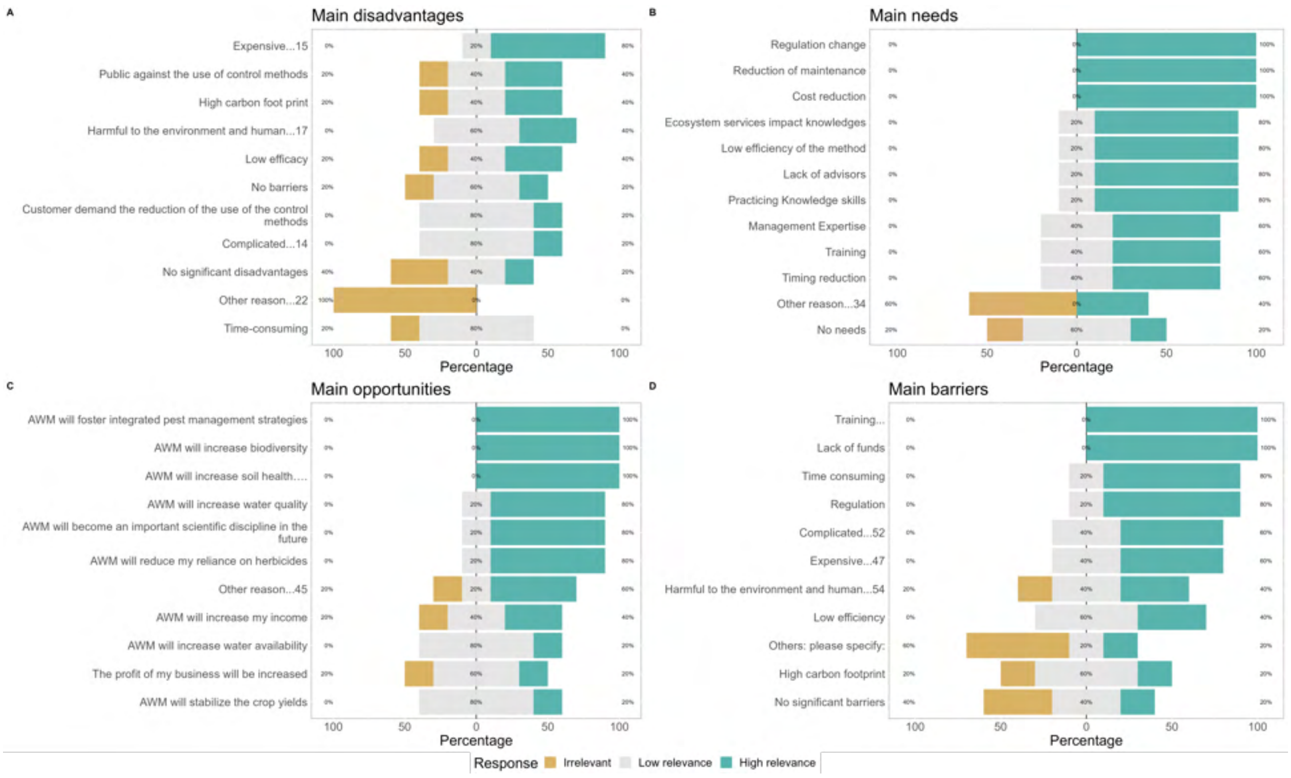


Figure 172. Main disadvantages, needs, barriers and opportunities for cover crops identified by consumers.

2.1.4.1.1.1.3 Conclusion

Advisors and consumers share a positive outlook regarding cover crops, both recognizing their potential to reduce herbicide reliance and provide ecosystem services. Advisors specifically highlight potential improvements in water quality, biodiversity, and soil health, while consumers focus on biodiversity increases and soil health enhancement. While advisors prioritize practicing knowledge skills as the main need for cover crops, consumers emphasize the importance of regulatory changes. Additionally, both groups highlight method efficiency, management expertise, training, timing reduction, and ecosystem services impact knowledge as essential requirements for successful implementation. Although consumers identify lack of funds (57%) as a significant impediment, the majority of advisors do not consider any of the queried barriers to be highly relevant. Similarly, no drawbacks were deemed significant by the majority of advisors, while 71% of consumers cite customer demands to reduce cover crop usage as the main disadvantage.

2.1.4.1.1.2 *False seedbed*

2.1.4.1.1.2.1 *Advisors*

Advisors perceive false seedbed as a technique with limited opportunities, disadvantages, and barriers, but with significant requirements. While half of the respondents believe it will reduce herbicide reliance, most other opportunities were considered low or irrelevant. Three-quarters of advisors prioritize practicing knowledge skills and training as primary needs for false seedbed implementation. Additionally, half of the respondents highlight regulatory changes, method efficiency, lack of advisors, and management expertise as relevant requirements. Regarding barriers, low efficiency and time consumption are the main concerns for half of the advisors. Notably, none of the queried disadvantages were considered relevant by more than half of the respondents.

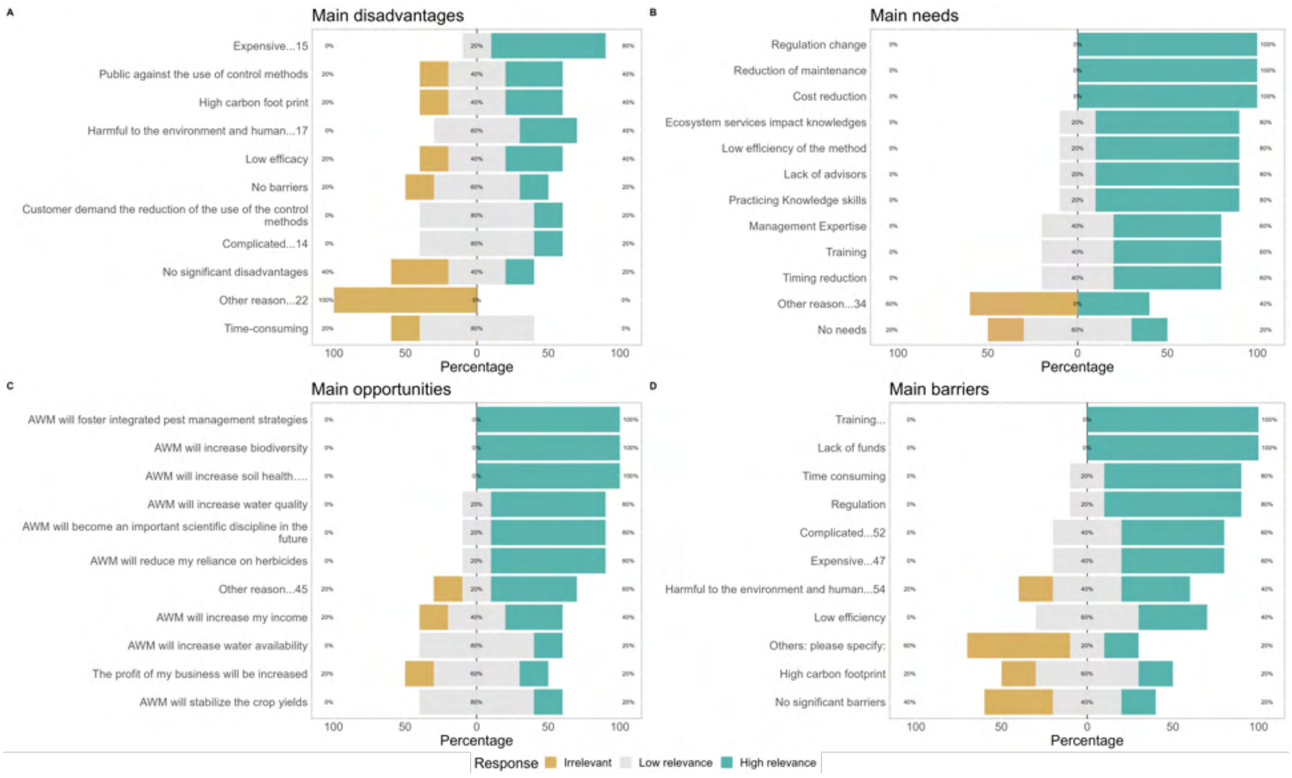


Figure 173. Main disadvantages, needs, barriers and opportunities for false seedbed identified by advisors.

2.1.4.1.1.2.2 *Conclusion*

Advisors view false seedbed as offering limited opportunities and facing significant barriers, with half acknowledging its potential to reduce herbicide reliance. The primary needs identified are practicing knowledge skills and training, while barriers include concerns about low efficiency and time consumption. Notably, none of the queried disadvantages were considered relevant by the majority of respondents.

2.1.4.1.1.3 Herbicides

2.1.4.1.1.3.1 Advisors

Advisors considered that herbicides offer some opportunities but also acknowledged significant needs, barriers, and disadvantages. Three-fifths of the respondents viewed herbicides positively, expecting economic benefits like increased business profitability, stabilized crop yields, and reduced herbicide reliance. Additionally, two out of five respondents recognized herbicides as providers of ecosystem services, anticipating improvements in water quality and soil health, with potential for scientific advancements. Advisors unanimously identified regulatory changes as a primary need, along with ecosystem services impact knowledge. Moreover, 80% of respondents considered training, cost reduction, and timing optimization as relevant necessities. Regulatory challenges were unanimously recognized as significant impediments to herbicide use, while 40% identified high carbon footprint, environmental and human harm, complexity of training, and expense as highly relevant barriers. Advisors unanimously acknowledged customer demands to reduce herbicide use as the most significant disadvantage, with 80% also recognizing environmental and human harm as a relevant drawback.

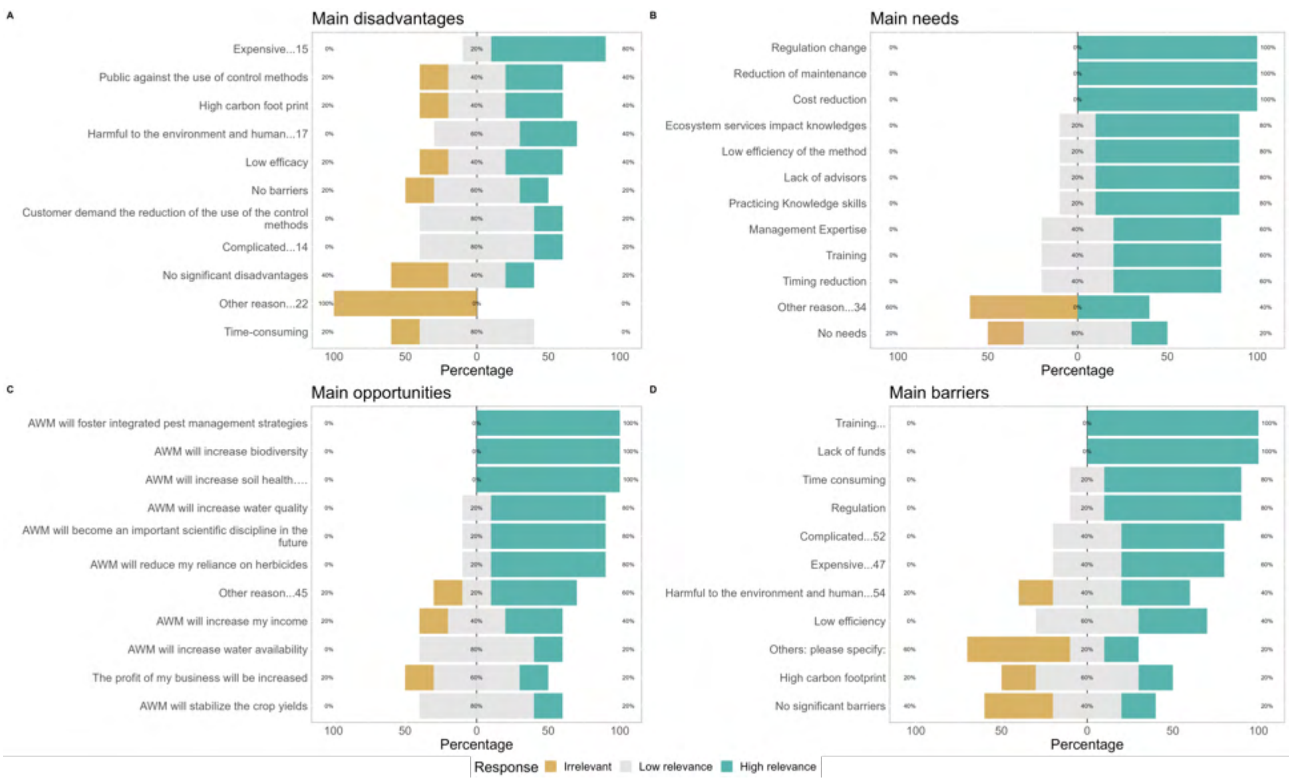


Figure 174. Main disadvantages, needs, barriers and opportunities for herbicides identified by advisors.

2.1.4.1.1.3.2 Consumers

Consumers hold a more pessimistic perspective regarding herbicide-related opportunities compared to advisors, acknowledging important needs and barriers to the method's implementation. However, they offer a balanced view on the method's disadvantages. Consumers prioritize economic-related opportunities, with 60% expecting herbicides to increase farmers' income and 40% anticipating benefits like increased business profitability, stabilized crop yields, and reduced herbicide reliance. Similarly to advisors, 80% of consumers identified regulatory changes as the primary need. Additionally, 60% of respondents viewed maintenance reduction as important, while 40% highlighted ecosystem services impact knowledge, practicing knowledge skills, training, cost reduction, and timing optimization as relevant requirements. Consistent with advisors, 80% of consumers recognized regulatory challenges as the most significant impediments to herbicide use. Furthermore, 60% of respondents cited environmental and human harm as key barriers. Finally, 60% of consumers identified customer demand to reduce herbicide use and environmental and human harm as relevant drawbacks. Moreover, 40% of respondents highlighted public concern to eliminate herbicide use and expense as significant disadvantages.

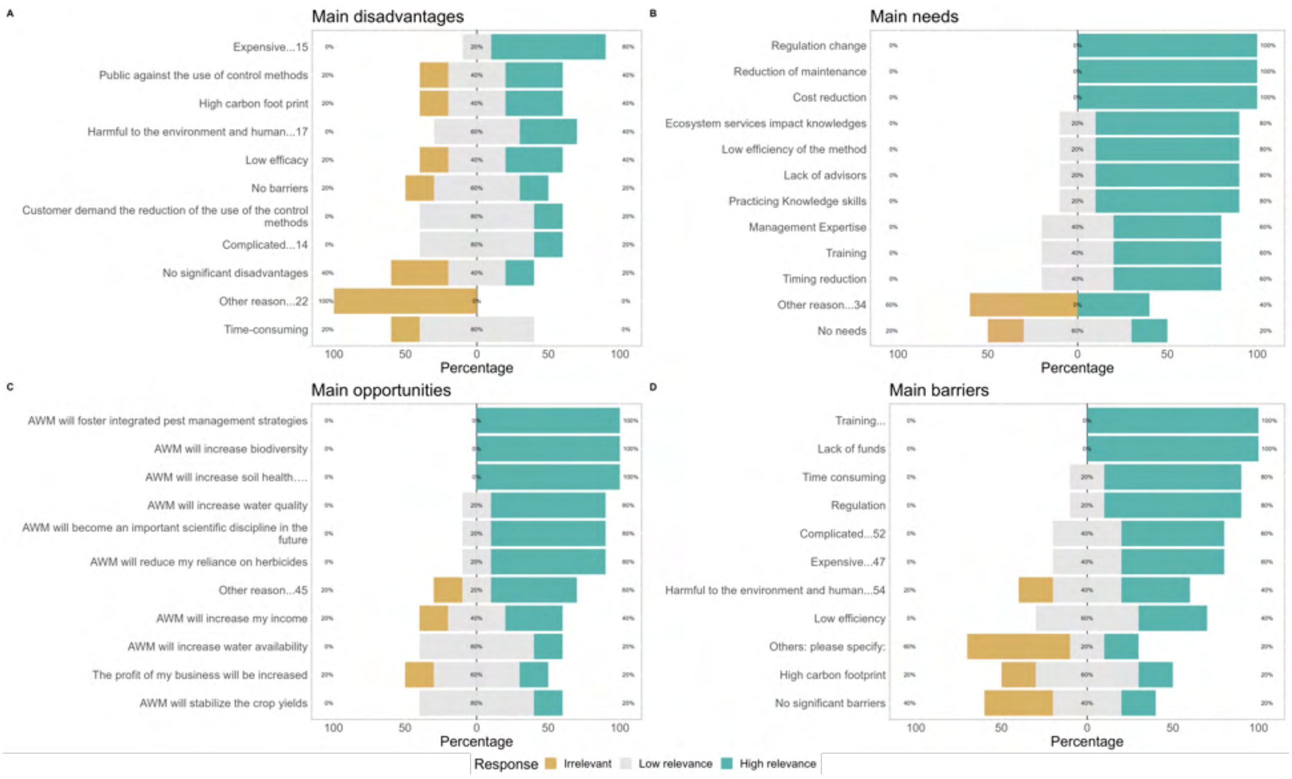


Figure 175. Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

2.1.4.1.1.3.3 Researcher

Researchers express a pessimistic outlook on herbicide opportunities in onion culture, with only one-third recognizing its potential to foster IPM strategies, stabilize crop yields, reduce herbicide reliance, and evolve into an important scientific discipline. Despite this, researchers unanimously identify key needs, including regulatory changes and cost and timing reduction. Additionally, practicing knowledge skills and management expertise were considered relevant needs by nearly 70% of respondents. Regulatory challenges are unanimously recognized as the most significant impediment to herbicide use, with expense highlighted as a barrier by 67% of respondents. Researchers are in strong agreement regarding the practice's disadvantages, with all considering expense and environmental and human harm as primary drawbacks. Furthermore, almost 70% cite customer demands to reduce herbicides and the complexity of application as additional concerns.

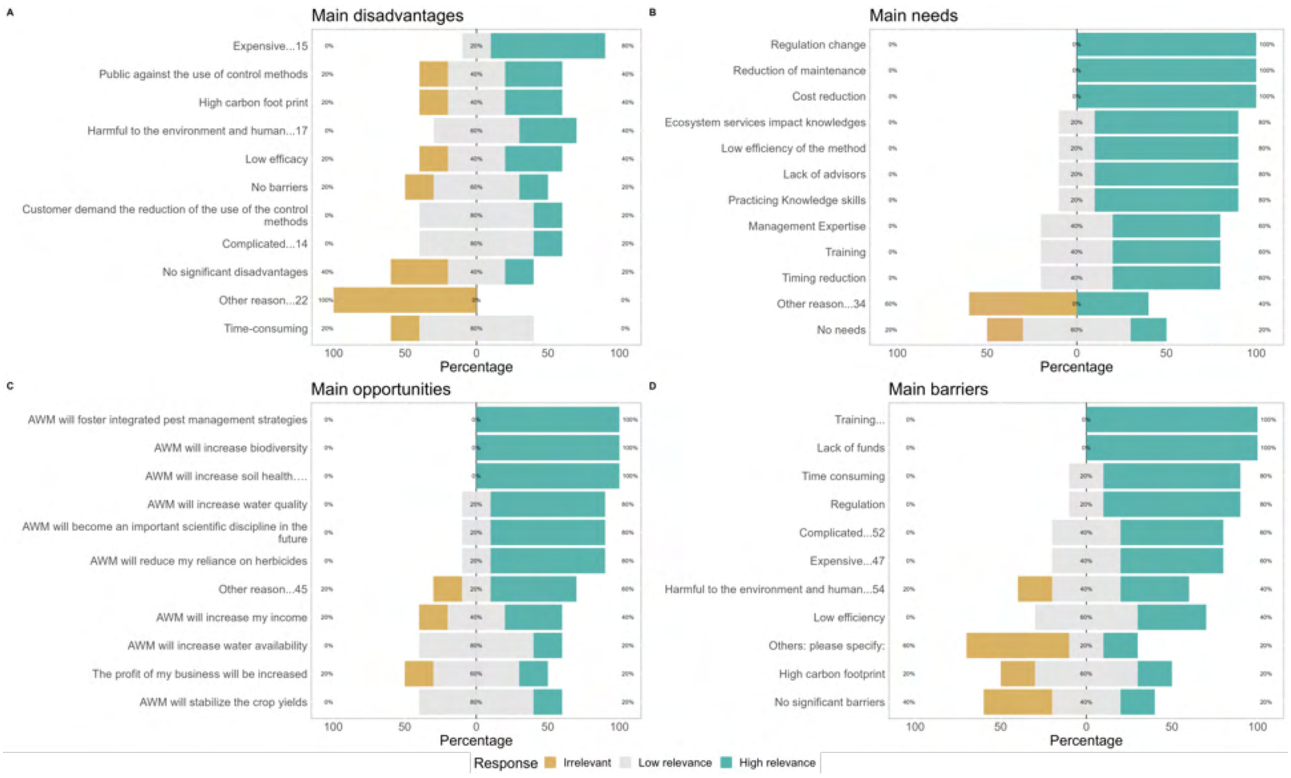


Figure 176. Main disadvantages, needs, barriers and opportunities for herbicides identified by researcher.

2.1.4.1.1.3.4 Conclusion

Advisors considered that herbicides offer some opportunities but also acknowledged significant needs, barriers, and disadvantages. Both consumers and researchers hold a more pessimistic perspective regarding herbicide-related opportunities compared to advisors, acknowledging important needs and barriers to the method's implementation. However, they offer a balanced view on the method's disadvantages. Both consumers and advisors prioritize economic-related opportunities, including increases in business profitability. Moreover, reduced herbicide reliance and stabilized crop yields were also considered as relevant by different proportions of all stakeholders. Advisors, consumers, and researchers considered regulatory changes as the primary need. Besides, while advisors and consumers considered ecosystem services impact knowledge as relevant, researchers highlighted cost and timing reduction. Akin to responses with regard to needs, all stakeholders considered regulatory challenges as paramount with regard to herbicide barriers. Environmental and human harm, and expense were also emphasized as relevant impediments. Customer demand to reduce herbicides use was considered as a relevant disadvantage by all stakeholders; besides, they highlighted environmental and human harm as relevant drawbacks.

2.1.4.1.1.4 Mechanical weeding

2.1.4.1.1.4.1 Advisors

Advisors perceive mechanical weeding as a technique with significant opportunities, needs, and barriers, yet presenting few disadvantages. They unanimously agree that it will reduce herbicide reliance, with 60% recognizing its potential to improve water quality. Additionally, 40% believe it will foster IPM strategies, enhance soil health, stabilize crop yields, and evolve into an important scientific discipline. Cost reduction is unanimously viewed as the primary need, with 60% emphasizing practicing knowledge skills and timing reduction, while 40% note the importance of addressing lack of advisors, management expertise, training, and maintenance reduction. The most significant barriers cited include complexity, time consumption, and expense, with 40% also noting high carbon footprint and low efficiency. Sixty percent of respondents see customer demand to reduce mechanical weeding as a relevant disadvantage, while 40% highlight expense and time consumption as notable drawbacks.

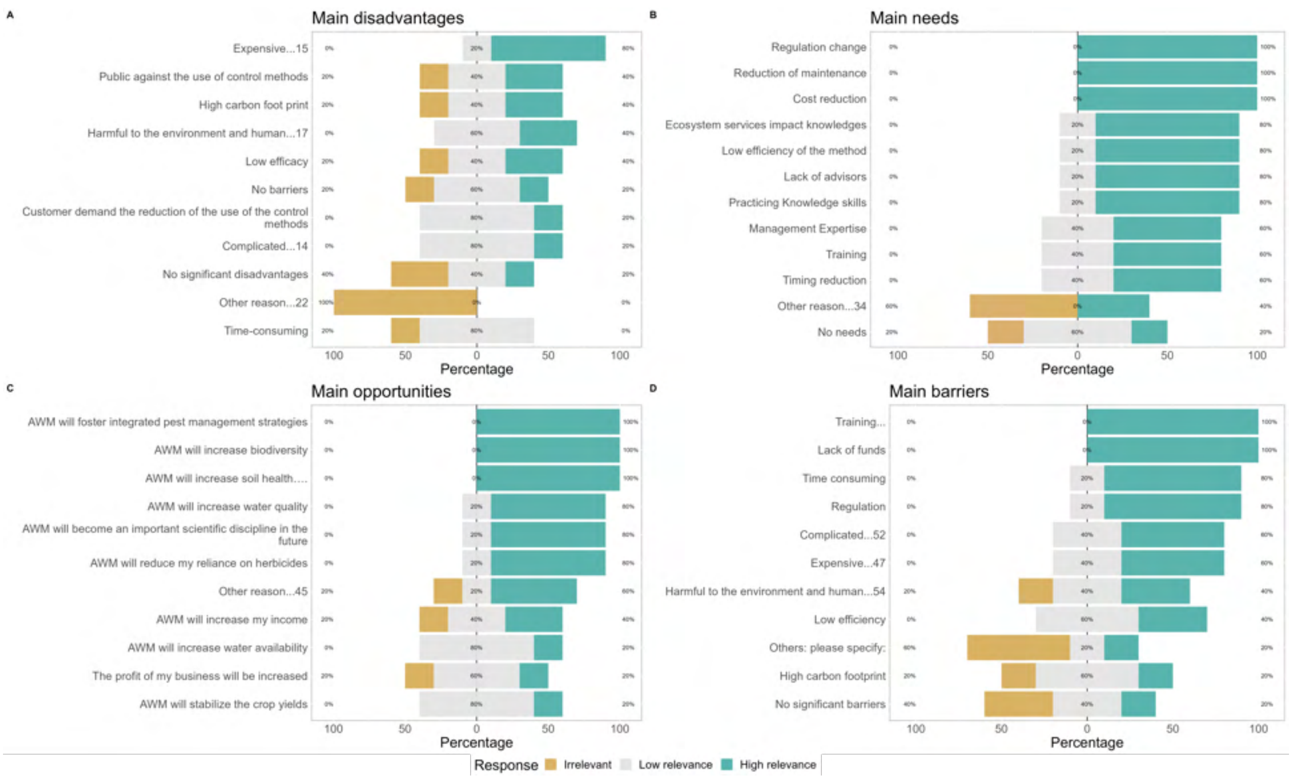


Figure 177. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by advisors.

2.1.4.1.1.4.2 Consumers

Consumers shared a cautious outlook with regard to mechanical weeding, with no factor in each category deemed highly relevant by over 70% of respondents. They identified the main opportunity as the reduction in herbicide reliance. Nearly 70% of consumers prioritized ecosystem services impact knowledge and regulatory changes as primary needs. Time consumption and regulatory challenges emerged as the most significant barriers for almost 70% of consumers. Similarly, the same proportion considered complexity and time consumption as the most relevant disadvantages. Notably, the remaining factors in each category were not deemed relevant by more than one-third of respondents.

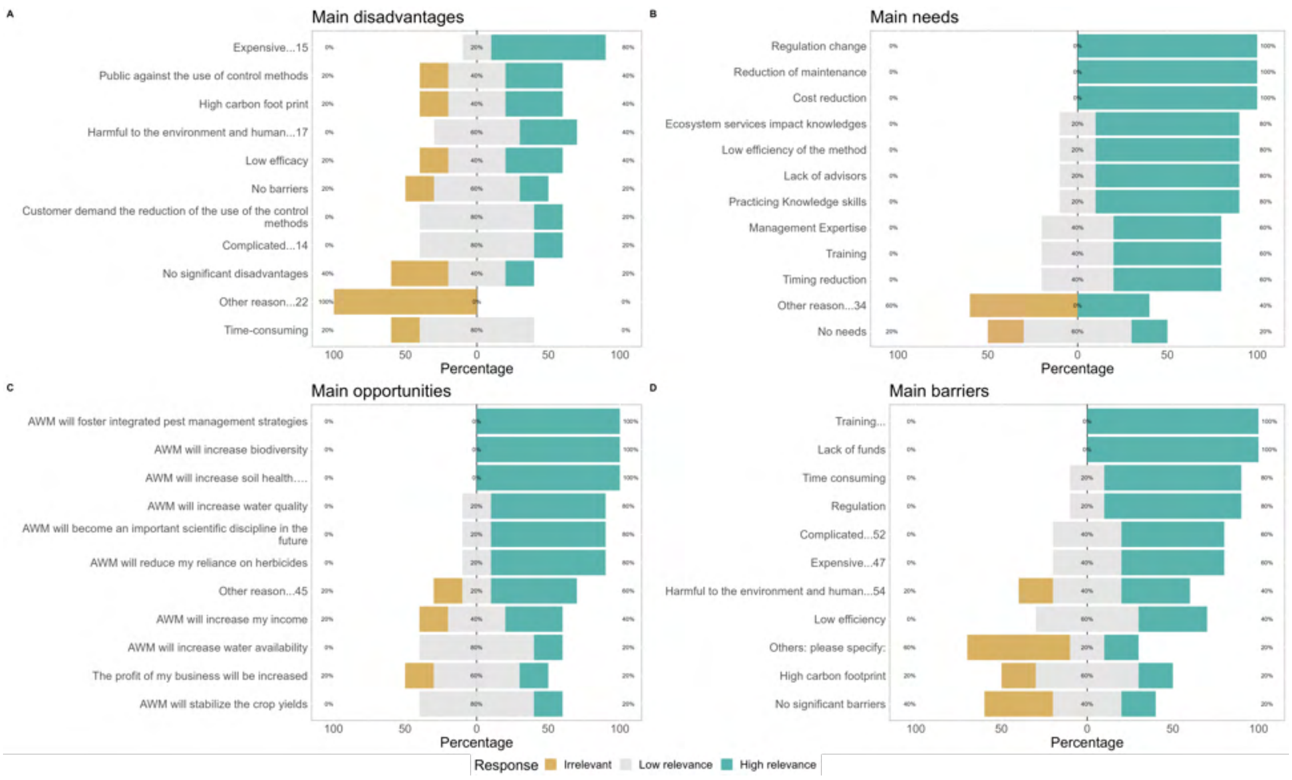


Figure 178. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by consumers.

2.1.4.1.1.4.3 Researcher

Researchers express a pessimistic view towards mechanical weeding, highlighting few opportunities and numerous needs, barriers, and disadvantages. Nearly 70% of respondents believe this practice will enhance water quality and reduce herbicide reliance. There is a strong consensus among researchers regarding primary needs, with unanimous agreement on the importance of practicing knowledge skills and management expertise. Moreover, approximately 70% of respondents deem regulatory changes, method efficiency, training, and cost and timing reduction as crucial necessities. Expense emerges as the most significant barrier, with unanimous agreement among respondents. Additionally, 70% of researchers identify time consumption and regulatory challenges as relevant impediments. Consensus also exists regarding the most relevant disadvantages, with complexity and time consumption unanimously acknowledged. Furthermore, nearly 70% of respondents highlight customer demand to reduce mechanical weeding, method efficacy, and expense as highly relevant disadvantages.

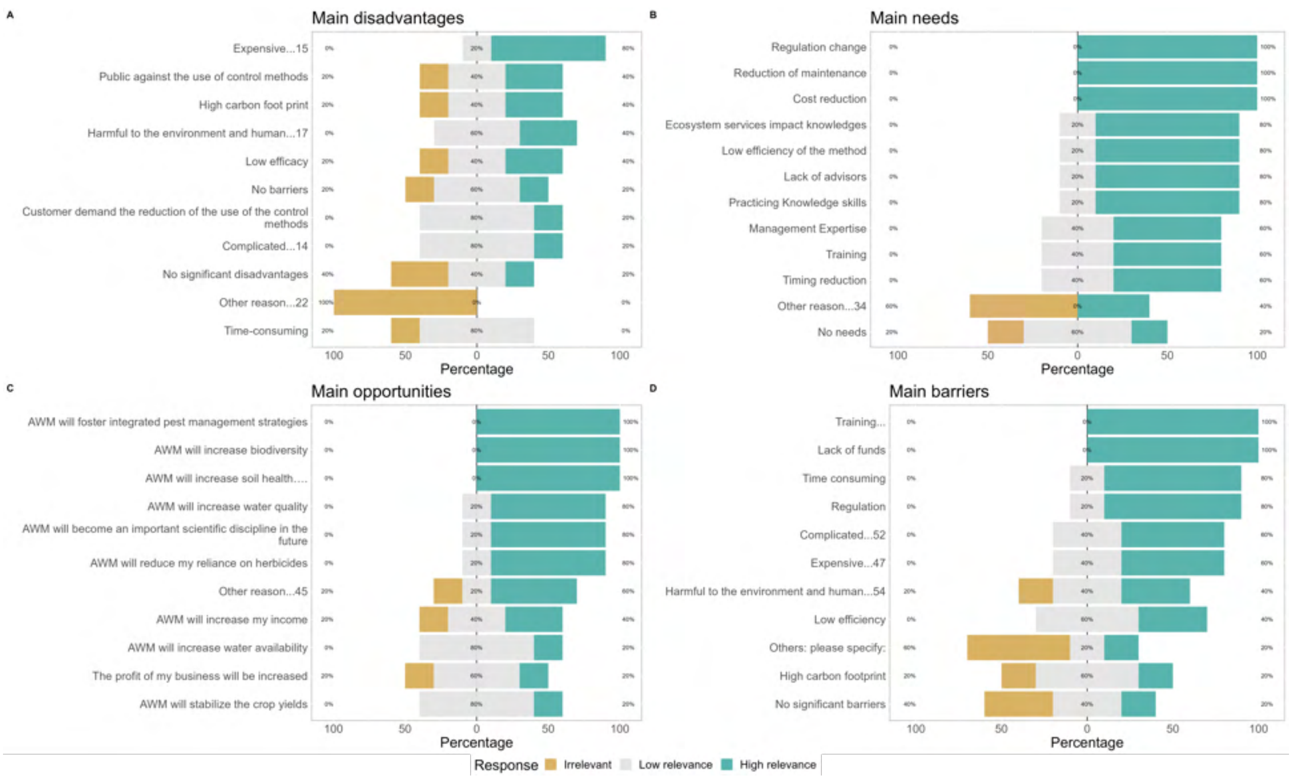


Figure 179. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by researchers.

2.1.4.1.1.4.4 Conclusion

Advisors regard mechanical weeding as a practice with substantial opportunities, needs, and barriers, while exhibiting minimal disadvantages. Conversely, consumers approach mechanical weeding with caution, with no factor in each category deemed highly relevant by over 70% of respondents. In contrast, researchers adopt a pessimistic stance towards mechanical weeding, emphasizing few opportunities alongside numerous needs, barriers, and disadvantages. All stakeholders concur on mechanical weeding's potential to reduce herbicide reliance, with both advisors and researchers acknowledging its capacity to enhance water quality. However, opinions diverge on the prioritization of needs, with advisors emphasizing cost reduction, consumers focusing on ecosystem services impact knowledge and regulatory changes, and researchers highlighting practicing knowledge skills and management expertise. Time consumption emerged as the most significant barrier, as stated unanimously by all stakeholders, followed by regulatory challenges noted by consumers and researchers. Additionally, expense was regarded as a relevant impediment by advisors and researchers. Furthermore, consumers and researchers perceive complexity and time consumption as significant drawbacks.

2.1.4.1.1.5 Natural enemies

2.1.4.1.1.5.1 Consumers

Consumers perceive natural enemies as a technique with both significant opportunities and disadvantages, alongside various needs and barriers. Nearly 70% of consumers acknowledge this practice as an ecosystem services provider, attributing benefits such as increased water availability and quality, biodiversity, and soil health. Similarly, the same proportion of respondents recognize natural enemies as a practice that can enhance business profitability, reduce herbicide reliance, and potentially evolve into an important scientific discipline. However, none of the queried needs were considered highly relevant by a majority of consumers; in fact, most of them were deemed irrelevant by respondents. Likewise, most consumers did not consider any of the main barriers highly relevant, although these categories were largely viewed as having low relevance. Regarding the main disadvantages, nearly 70% of consumers mentioned the high carbon footprint and expense as significant concerns.

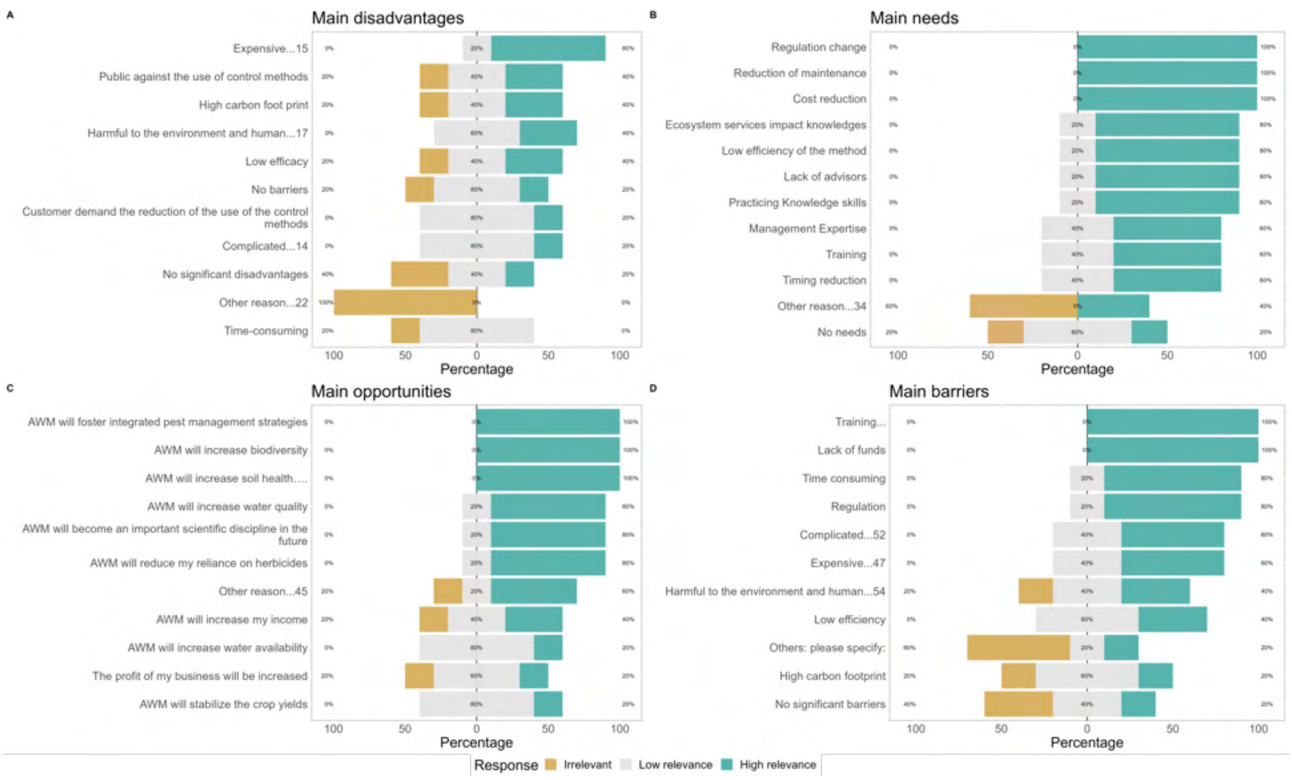


Figure 180. Main disadvantages, needs, barriers and opportunities for natural weeding identified by consumers.

2.1.4.1.1.5.2 Conclusion

Consumers recognize natural enemies as offering significant benefits such as improved ecosystem services and potential economic advantages. However, they do not consider most of the identified needs and barriers as highly relevant, with many being deemed irrelevant. Despite this, concerns about the high carbon footprint and expense remain prominent among consumers. Overall, while consumers acknowledge the potential of natural enemies, their perception of its implementation is tempered by concerns about its practicality and cost.

2.1.4.1.1.6 *Site-specific spraying*

2.1.4.1.1.6.1 *Advisors*

Advisors express a pessimistic view regarding site-specific spraying, identifying few opportunities alongside numerous needs, barriers, and some relevant disadvantages. None of the queried opportunities were deemed highly relevant by more than half of the respondents. However, 40% of advisors highlighted increases in business profitability, crop yield stabilization, farmers' income increases, and reduction in herbicide reliance as highly relevant opportunities. Regulatory changes, practicing knowledge skills, and timing reduction were unanimously identified as highly relevant necessities by 80% of advisors, with training also recognized as a relevant need by 60% of them. Regarding barriers, 80% of advisors considered training and expense highly relevant, with regulatory challenges cited by 60% as a significant impediment. Customer demand to reduce site-specific spraying and the practice's expense were cited as the most relevant disadvantages, while the rest of the queried disadvantages were regarded as low or irrelevant by most respondents.

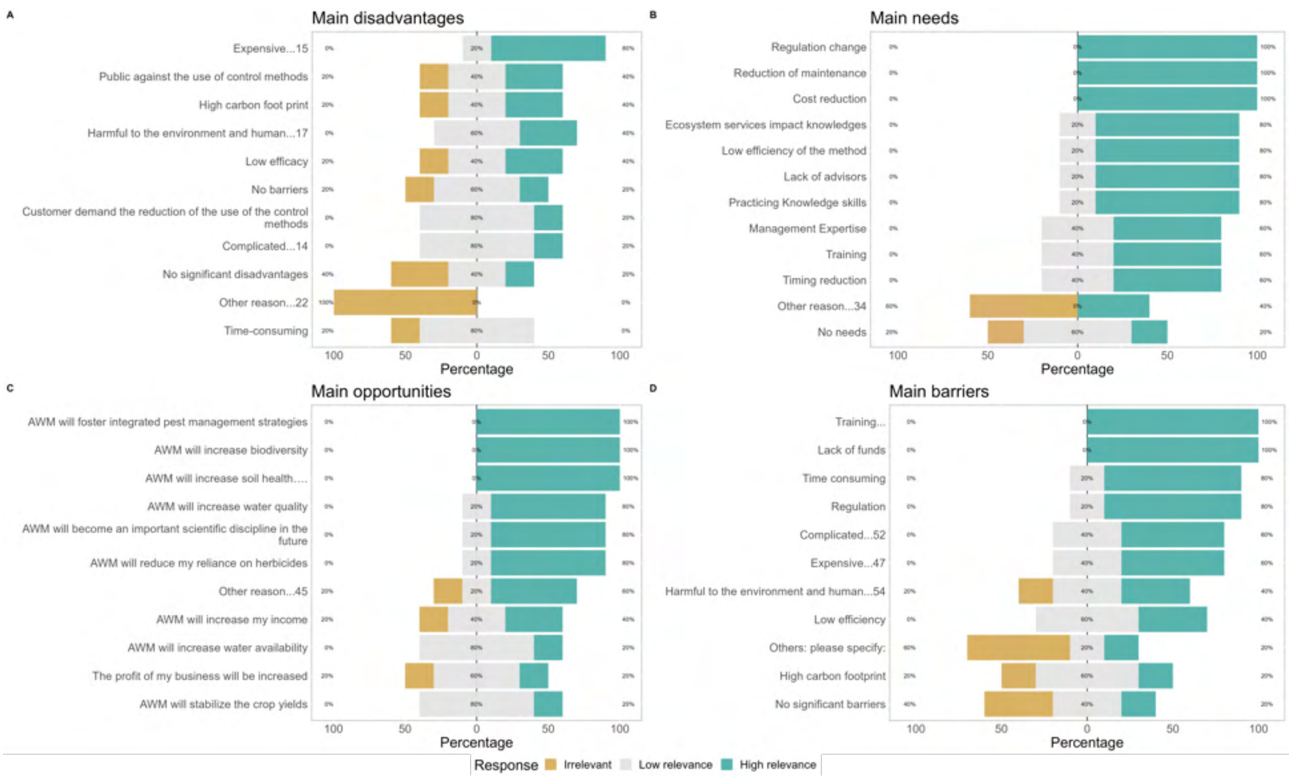


Figure 181. Main disadvantages, needs, barriers and opportunities for site-specific spraying identified by advisors.

2.1.4.1.1.6.2 Consumers

Consumers hold a positive perspective on site-specific spraying, recognizing its significant opportunities for onion culture while acknowledging its associated needs, barriers, and disadvantages. They unanimously believe that implementing site-specific spraying will stabilize crop yields and reduce herbicide reliance. Nearly 70% also see it as fostering IPM strategies and providing ecosystem services such as enhancing water availability and quality, biodiversity, soil health, and business profitability. Ecosystem services impact knowledge, regulatory changes, and training are deemed the most critical necessities by all consumers. Additionally, two-thirds of respondents identify lack of advisors, practicing knowledge skills, management expertise, and cost, timing, and maintenance reductions as key needs. Consumers unanimously highlight high carbon footprint, environmental and human harm, and expense as significant barriers. Moreover, almost 70% of consumers consider factors like complexity, time consumption, training, and regulation as relevant impediments. They unanimously view environmental and human harm as main disadvantages, with 70% also citing customer demand to reduce its use and its high carbon footprint as significant drawbacks.

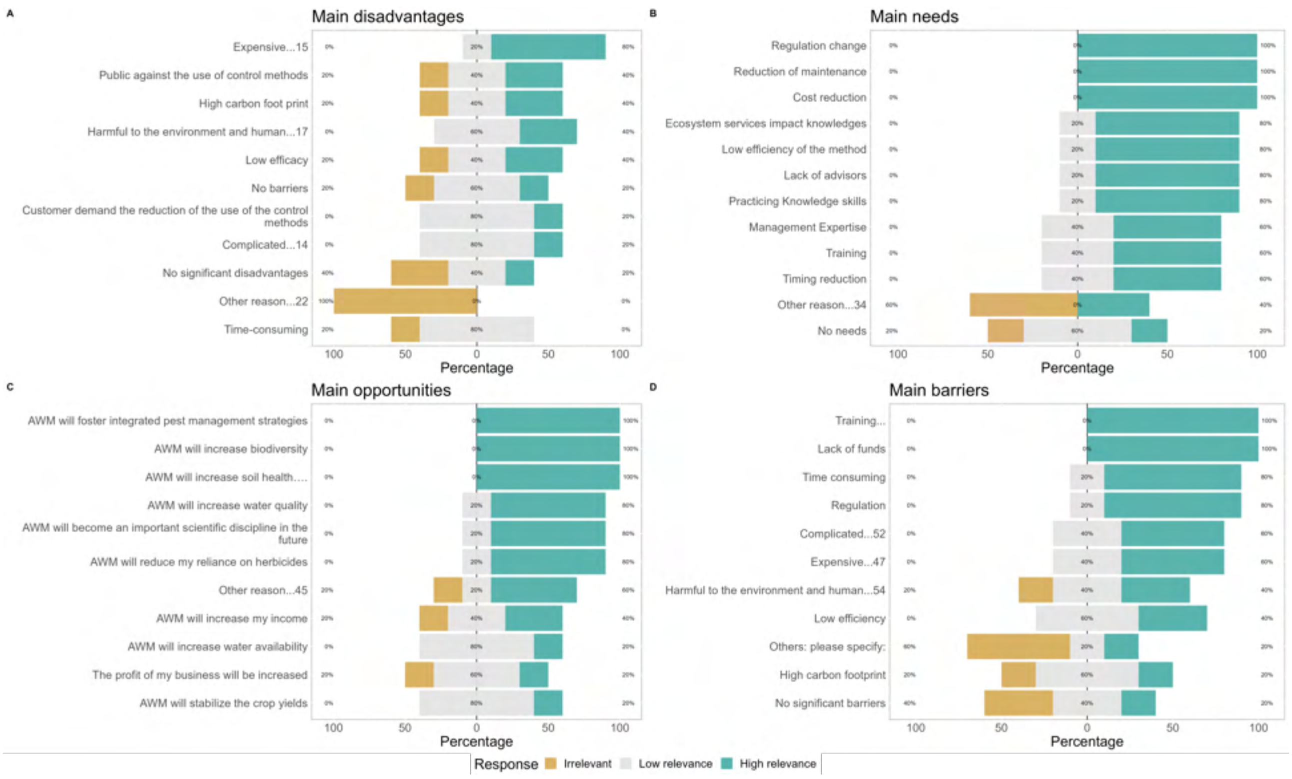


Figure 182. Main disadvantages, needs, barriers and opportunities for site-specific spraying identified by consumers.

2.1.4.1.1.6.3 Conclusion

Advisors express a pessimistic view toward site-specific spraying, noting limited opportunities alongside numerous needs, barriers, and some relevant disadvantages. Conversely, consumers maintain a positive outlook, recognizing its significant potential for onion culture while acknowledging associated needs, barriers, and disadvantages. Consumers unanimously regard site-specific spraying as conducive to crop yield stabilization and a reduction in herbicide reliance, viewpoints echoed by 40% of advisors. Additionally, consumers emphasize its capacity to foster IPM and provide ecosystem services like improving water availability and quality, biodiversity, soil health, and business profitability. Both advisors and consumers prioritize regulatory changes, timing reduction, practicing knowledge skills, and training as highly relevant necessities. Moreover, consumers highlight lack of advisors, management expertise, and cost and maintenance reduction. Regarding barriers, both groups emphasize expense and training. Advisors focus on regulatory challenges, while consumers underscore high carbon footprint, environmental and human harm. Finally, both advisors and consumers consider customer demands to reduce site-specific spraying as a relevant disadvantage, with advisors particularly emphasizing expense, while consumers also highlight environmental and human harm and high carbon footprint.

2.1.4.1.2 Surveys

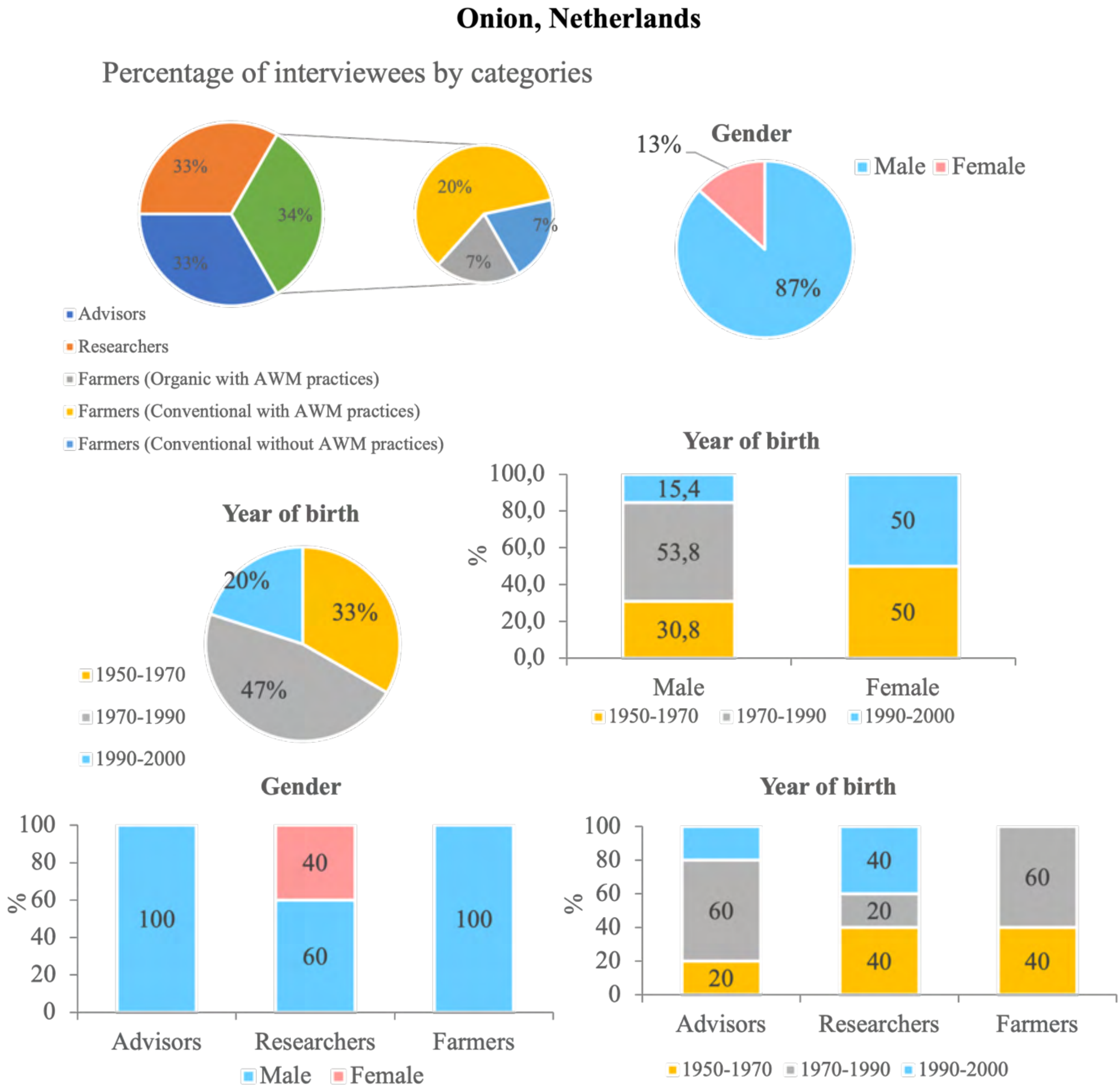


Figure 183. Interviewees description in the Onion Living Lab (Netherlands)

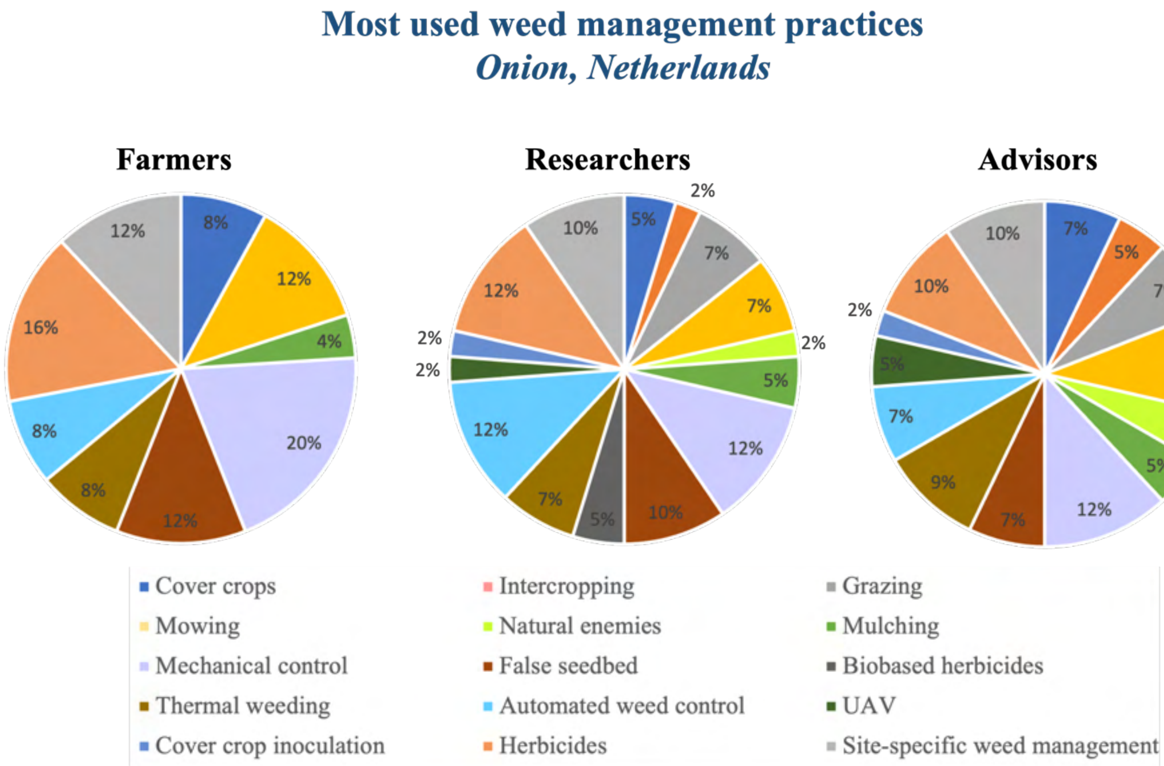


Figure 184. Most used weed management practices in the Onion Living Lab (Netherlands)

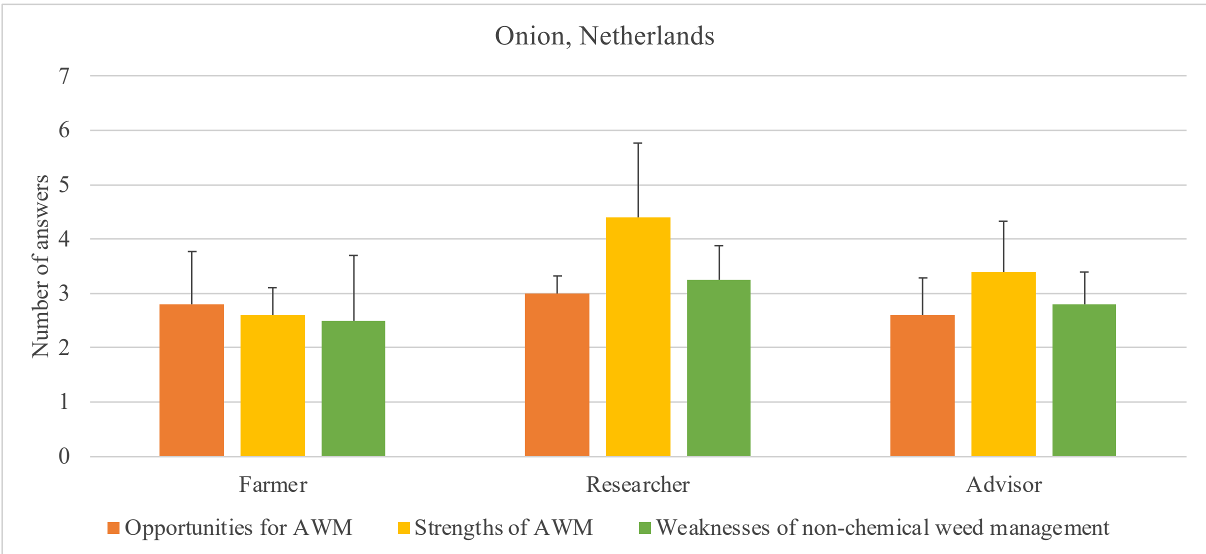


Figure 185. Mean number of answers (±se) per stakeholder group in the Onion Living Lab (Netherlands)

Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: Presented in the figure below.

THREATS: None.

WEAKNESSES: There were several answers from the farmers' group. Farmers mentioned the cost of applications, difficulties in operation, lack of technical assistance, effectiveness, timing of application, cost of purchasing equipment, non-selectivity and lack of labor as weaknesses of AWM practices.

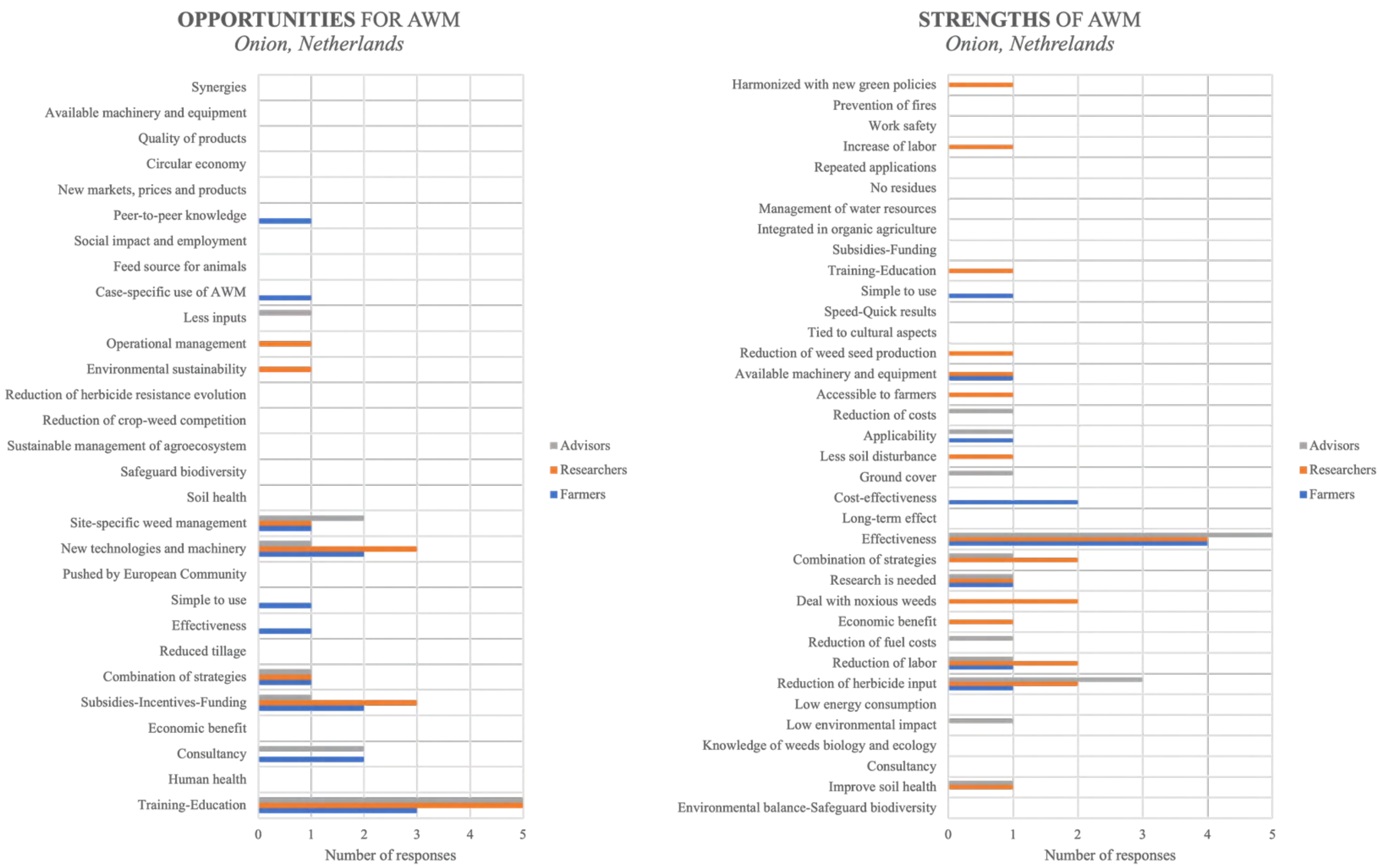


Figure 186. Opportunities and strengths of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: Climate and weather conditions was considered the major threats for non-chemical weed management by all stakeholder groups.

WEAKNESSES: Presented in the figure below.

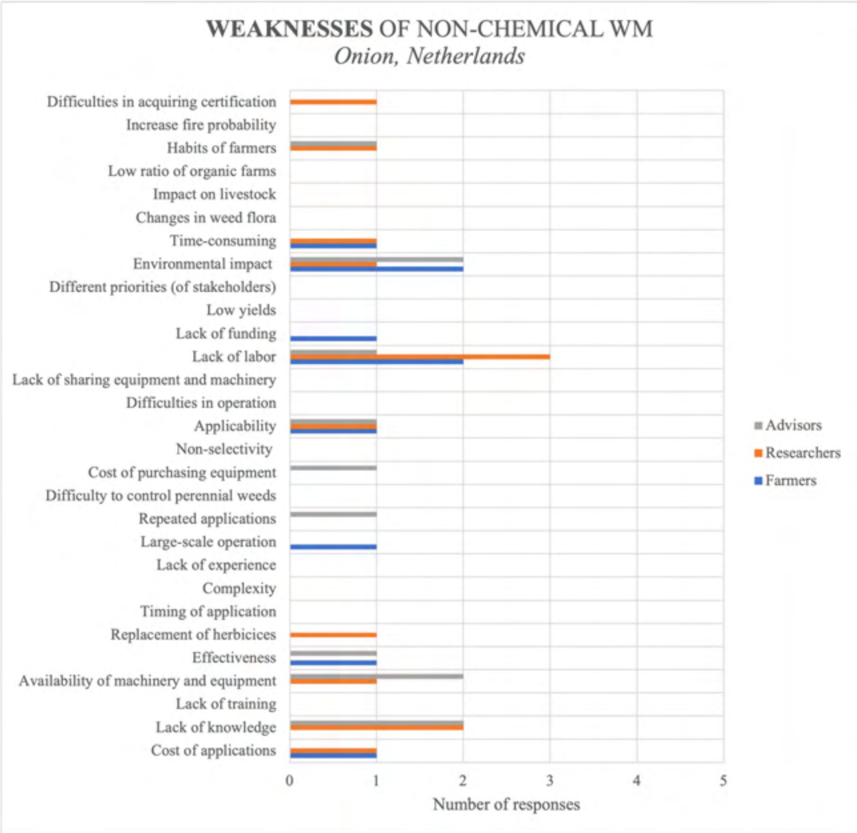


Figure 187. Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: Only a few answers referred to opportunities for herbicides. Among them, efficacy, quick results, available equipment, and low cost were mentioned by farmers and advisors.

STRENGTHS: The biggest strength of herbicides is the efficacy according to all stakeholder groups in the *onion LL* in the Netherlands. It is noteworthy that all advisors agree that efficacy is a strength of herbicides. Besides that, quick results, simplicity to use, low cost and availability of herbicides on markets anytime are also strengths.

THREATS: The lack of new herbicides, the withdrawal of herbicides and the pressure to reduce them, along with the markets, are threats for herbicides for some Dutch interviewees.

WEAKNESSES: Presented in the figure below.

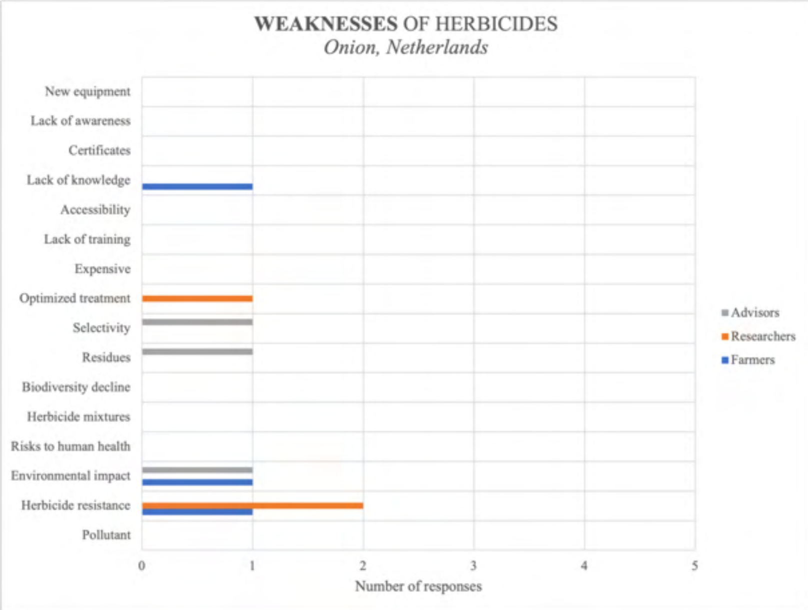


Figure 188. Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – ONION, NETHERLANDS
Most used weed management practices: The onion LL in the Netherlands was the most diverse in terms of responses, and in fact, the most advanced in contrast to other crops and LLs. Common weed management practices included automatic weed control, UAV, site-specific weed management and thermal weeding among others. These practices are expensive and require a sufficient level of knowledge, training and consultancy to be adopted and implemented. As it is widely known, the extension services in the Netherlands are very good and accessible to farmers. In addition, researchers work close to farmers bringing innovations to the fields. **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group**: The identified strengths of AWM were more than the opportunities of AWM and the weaknesses of herbicides. Researchers were able to identify more compared to the other stakeholder groups. **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: The opportunities for AWM are mainly related to training and education, subsidies and funding, and new machinery and equipment. The strengths of AWM are clearly tied to the effectiveness, the reduction of labour and the reduction of herbicide input. Weaknesses of AWM come only from the farmers' side who mentioned the cost of

applications, difficulties in operation, lack of technical assistance, effectiveness, timing of application, cost of purchasing equipment, non-selectivity and lack of labour.

Threats, and weaknesses for non-chemical weed management: The most important threat for non-chemical weed management is climate and weather conditions (i.e., affecting the effectiveness or applicability of non-chemical weed management strategies). Among a few weaknesses of non-chemical weed management which were identified, the most notable were the lack of knowledge, lack of labour, availability of machinery, and potential environmental impact.

Opportunities, strengths, weaknesses, and threats for herbicides: In line with other LLs, efficacy of herbicides is considered their major strength. Besides that, quick results, simplicity to use, low cost and availability of herbicides on markets anytime are also strengths. The threats for herbicides are related to lack of new herbicides, the withdrawal of herbicides and the pressure to reduce them. Only a few weaknesses of herbicides were reported. The most notable was the evolution of herbicide resistance.

2.1.4.1.3 Living lab board meeting

In total 8 persons participated in the online meeting which was held on 11th December 2023. We had a short introduction to the project and the LL. Afterwards, brainstorm and discussion on the theme AWM and the experiment in the LL. The results of the discussion were that onions are an important crop for Dutch growers. It is a cash crop. It is a contract-free crop. The grower is in control of the trade. The LL is located in the province of Zeeland. The cultivation of onions is declining here partly due to a lack of fresh water and disease pressure on the crop. The cultivation of onions is specific. Cultivation is very delicate and has to be done precisely. So it is not a crop that you as a grower can simply include in your cropping plan. Soil diseases are becoming an increasing problem in cultivation. To tackle this problem, however, new genetics/robust varieties are increasingly being looked at. Better support for diseases and pests in the form of decision support systems is desirable, though. The problem here is that the whole region would have to participate. Growers need reliable information. And a long-term vision from the government. There is no (financial) room for growers to experiment/innovate. Moreover, during the LL board meeting, this information was also collected:

What are the market	1. How many farmers cultivate onion in the region (approx.)? Is it mostly monoculture or can rotations be made with other crops?

characteristics of onions?	Seed onions 29.322ha total in NL 3.030ha in the province of Zeeland Plant onions 5498ha total in NL 2.174ha in the province of Zeeland Province of Zeeland has 13 municipalities. Total area 2934km^2 317 farms with planting onions in 2022 438 farms with seed onions in 2022 Always in crop rotation.
	2. How many products are derived from onions? Are they important for the economy and/or food security?
	Over 52% of exported onions find their outlet in African destinations. Followed by European (27%) and Asian destinations (12%). To destinations on the South American (5%) and North American (4%) continent, less is exported.
	3. Do you think that agroecological products could be promoted in local markets?
	Yes, local markets already exists where farmer selling directly to consumers and local supermarkets. National studies show that markets exist, but is limited.
	4. Do you believe that the region has a lack of technologies?
	Dutch agriculture is known for its innovative character. In arable farming and seed/plant onions, too, progress is being made towards new technologies to increase the sustainability of the sector.
	5. Is the regional agri-food value chain sustainable?
	In the province of Zeeland, onion acreage is in significant decline. This is mainly due to the increasing shortage of fresh water availability and pest and disease stress in the region.
What are the most common agricultural and weed management practices in onions?	1. What are the most common agronomic practices in onion?
	Tillage, fertilisation, sowing/planting, irrigation, crop protection, weed control, harvesting, processing
	2. What are the most common weed management practices in onions?
	Chemicals

What is the herbicide use in onions?	1. How many active ingredients there are available? How many different mode of actions?	
	There are some products, but year by year they are being reduced in the market	
	2. How many times do you spray in-season?	
	3-6 times depending on weather conditions. For organic farmers 0.	
	3. Do you use pre-emergence, post-emergence or both herbicides?	
	In conventional farming 100% of the farmers use both types of herbicides in onion.	
	4. Are herbicides efficient?	
	Yes	
	5. Do you think that alternatives to herbicides are equally efficient?	
	For alternatives, you need the right time and weather conditions. However, there are good alternatives to herbicides as this can also be done mechanically. An important thing is an inexpensive alternative.	
	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?	
	Because of the impact to environment, there is strict monitoring of chemical use. Much of it is already restricted. In addition, growers maintain buffer zones and there are increasing technical possibilities to apply spot-specific sprays.	
	7. Do you believe that agriculture without herbicides is viable?	
	The organic sector show that it is possible. The question should be if the market is ready.	
What are the needs and barriers to assist agroecological transitions & adopt agroecological weed	1. What is needed to boost the uptake of agroecological practices?	
	Government should be able to make arrangement for farm-level experiments. Business model for Dutch grower does not allow for experiments now.	
	2. What are the barriers towards agroecology implementation?	
	Government's short-term vision. There needs to be a long-term vision. And the rest of EU/world needs to follow as well. NL cannot do this alone. It has to come from the market, it needs acceptance and sales.	
	3. Should policies need be redefined to allow agroecological transitions?	

management approaches?	See above	
	4. How confident you feel about the adoption of agroecological weed management practices?	
	Many growers are already exploring ways to reduce chemicals. However, it appears that something only happens when it is driven by the government. Tighter rules alone also create resistance.	
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	1. What are the main drivers of weed dispersal?	
	Machines that have not been adequately cleaned. Organic fertilisers. Tilling of soil by ploughing etc. Less frequently: via sprinkling with surface water, moving soil.	
	2. Which are the major and most noxious weeds in your area?	
	Chamomile, milkweed, pigweed, jacobs weed. Cleavers, black nightshade.	
	3. Are there any herbicide resistant weeds?	
	No no herbicide resistance. Thanks to diversity in cropping plans.	
	4. Do you know any invasive plants in your area?	
	No. Thorn apple was long gone, but has been on the rise again in the last 2 years unfortunately. (*Datura stramonium*)	
What do you think about the Living Lab?	1. Which proposals do you have for a good performance of the LL?	
	LL should have an access to policymakers. They should also be involved in the LL. Show realistic view (so also what is not going well) LL must be known within the sector.	
	2. Would you like it to remain over time?	
	Certainly, it is an experimentation opportunity for the sector. Good would be to form a study club of growers around the LL.	

3 ANNEX III – QUESTIONNAIRES, SURVEYS AND LL ANALYSIS FOR PERMANENT CROPS

3.1 Olive

3.1.1 Portugal

3.1.1.1 Questionnaires

Olive questionnaires provided insights with regard to four AWM techniques, including grazing, herbicides, mechanical weeding and site-specific spraying. Respondents included advisors, consumers policy makers and researchers, not enough responses were garnered from farmers and industry representatives. A detailed breakdown of stakeholder participation in the questionnaires for each AWM practice is presented in Table 30.

Table 30. Number of responses for each AWM practice and stakeholder category in Olives (Portugal).

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control					1	
Biobased herbicides						1
Cover crop inoculation to increase competitiveness						1
Cover crops	1	1			1	2
False seedbed					1	
Grazing	**4**	1				2
Herbicides	**6**	**5**	1	1	**3**	**9**
Intercropping					2	2
Mechanical weeding	**7**	**3**	1	1	**3**	**8**
Mowing	1				1	
Mulching					1	
Natural enemies						1
Other					1	
Site-specific spraying	2		1		1	**3**
Thermal weeding						
UAV						
n=28	7	6	1	1	3	9

3.1.1.1.1 Grazing

3.1.1.1.1.1 Advisors

Advisors regard grazing as a technique with several opportunities and relevant needs and barriers but no significant disadvantages. They unanimously believe that this technique will foster IPM strategies, while mostly recognizing its potential in providing ecosystem services, including increases in water availability and quality, biodiversity, and soil health amelioration. Advisors mainly consider that grazing will evolve into an important scientific discipline and will reduce farmers' herbicide reliance. Practicing knowledge skills were considered a primary need by all respondents, followed by lack of advisors and management expertise, which were regarded as relevant necessities by 75% of advisors. Complexity, time consumption, training, and lack of funds were considered the most relevant impediments, as stated by 75% of respondents. Expense was cited as a relevant impediment by half of our sample. As the main disadvantages, 50% of advisors cited customers' demand to reduce grazing and high carbon footprint as relevant.

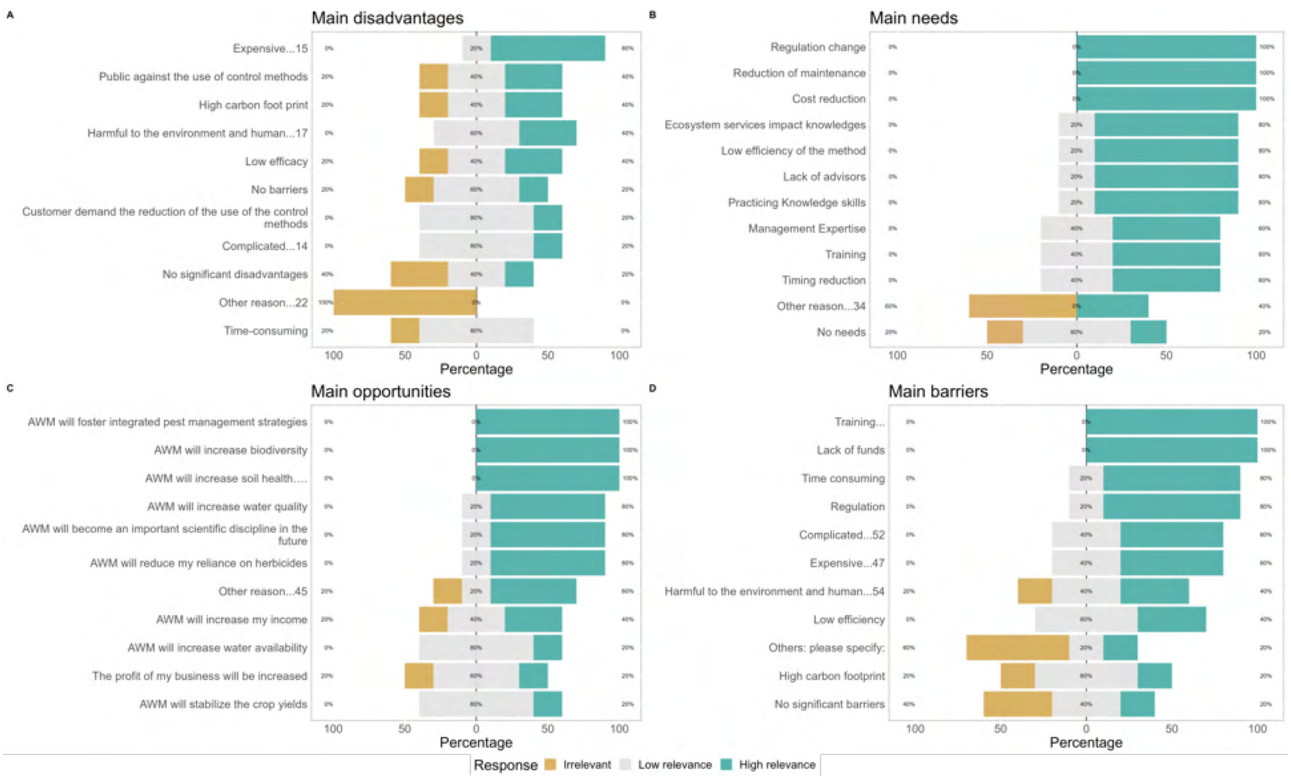


Figure 189. Main disadvantages, needs, barriers and opportunities for grazing identified by advisors.

3.1.1.1.1.2 Conclusion

Advisors perceive grazing as a technique with promising opportunities for IPM strategies and ecosystem services provision, alongside significant needs like practicing knowledge skills and management expertise. While they acknowledge barriers such as complexity and time consumption, they find few significant disadvantages, except for concerns over customer demand to reduce grazing and its high carbon footprint.

3.1.1.1.2 Herbicides

3.1.1.1.2.1 Advisors

Advisors considered herbicides as a technique with limited opportunities, entailing relevant needs, barriers, and disadvantages. Half of the respondents viewed herbicides as potentially fostering IPM strategies and evolving into an important scientific discipline. Notably, they acknowledge the potential for herbicides to reduce farmers' reliance on them. Advisors showed relative consensus when determining the practice necessities, with 83% of respondents considering ecosystem services impact knowledge, lack of advisors, practicing knowledge skills, management expertise, and training as highly relevant. Additionally, half of our sample emphasized the importance of regulatory challenges and the reduction of maintenance and cost. Environmental and human harm, as well as training, were unanimously considered main barriers by advisors. Furthermore, almost 70% of respondents recognized high carbon footprint and expense as relevant impediments to herbicide implementation. Advisors unanimously considered environmental and human harm as the main disadvantage of herbicide implementation. More than 80% of them acknowledged customer demand to reduce or eliminate herbicide use and expense as relevant drawbacks.

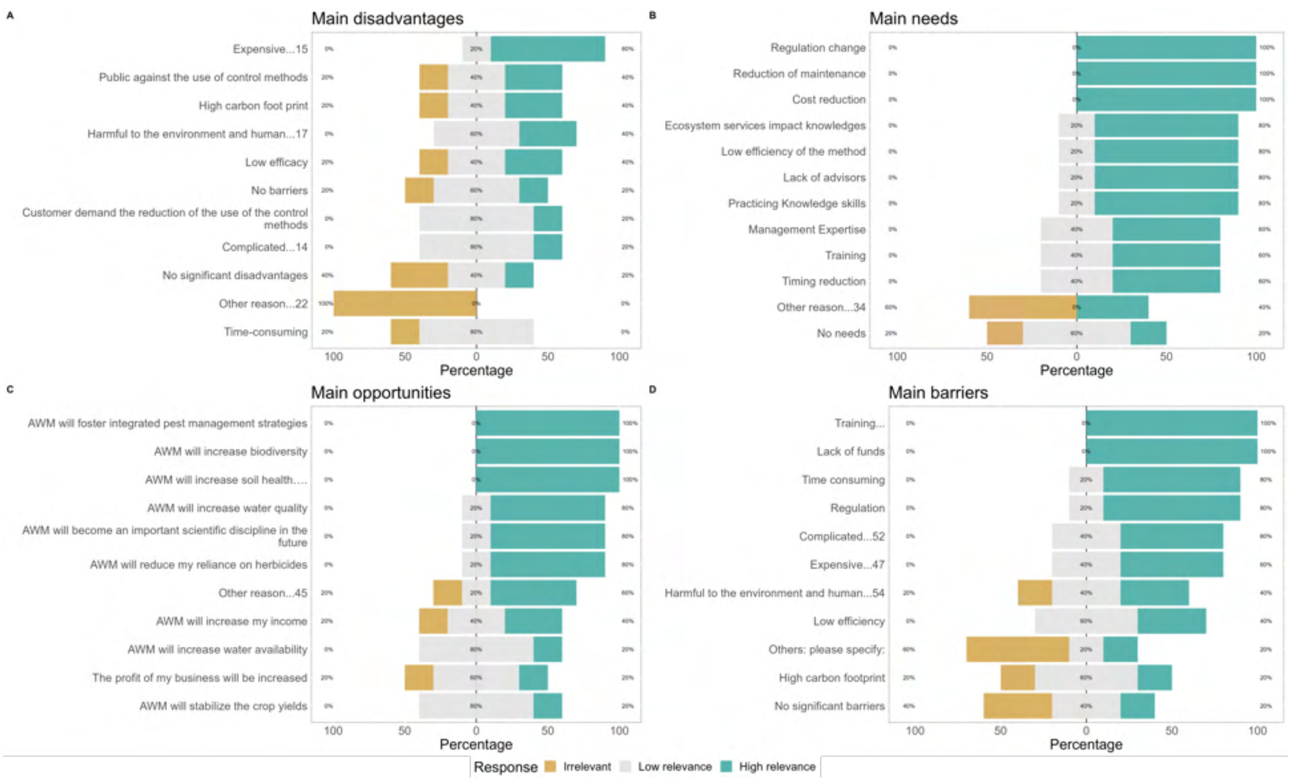


Figure 190. Main disadvantages, needs, barriers and opportunities for herbicides identified by advisors.

3.1.1.1.2.2 Consumers

Consumers share a similar perspective with advisors regarding herbicides, viewing the technique as offering limited opportunities alongside relevant needs, barriers, and disadvantages. While none of the queried opportunities were considered highly relevant by over half of the respondents, 40% of consumers recognized herbicides as potential providers of various ecosystem services. In line with advisors' sentiments, consumers unanimously identified ecosystem services impact knowledge as the primary need. Additionally, eighty percent of consumers recognized regulatory changes, practicing knowledge skills, and training as key necessities. Main barriers, as acknowledged by consumers, included training, regulation, and expense. Moreover, sixty percent of consumers perceived environmental and human harm and lack of funds as relevant challenges to herbicide implementation. Consistent with advisors, consumers considered environmental and human harm as the most significant disadvantages, emphasizing customer demands to reduce or eliminate herbicide use, their high carbon footprint, and expense as relevant factors.

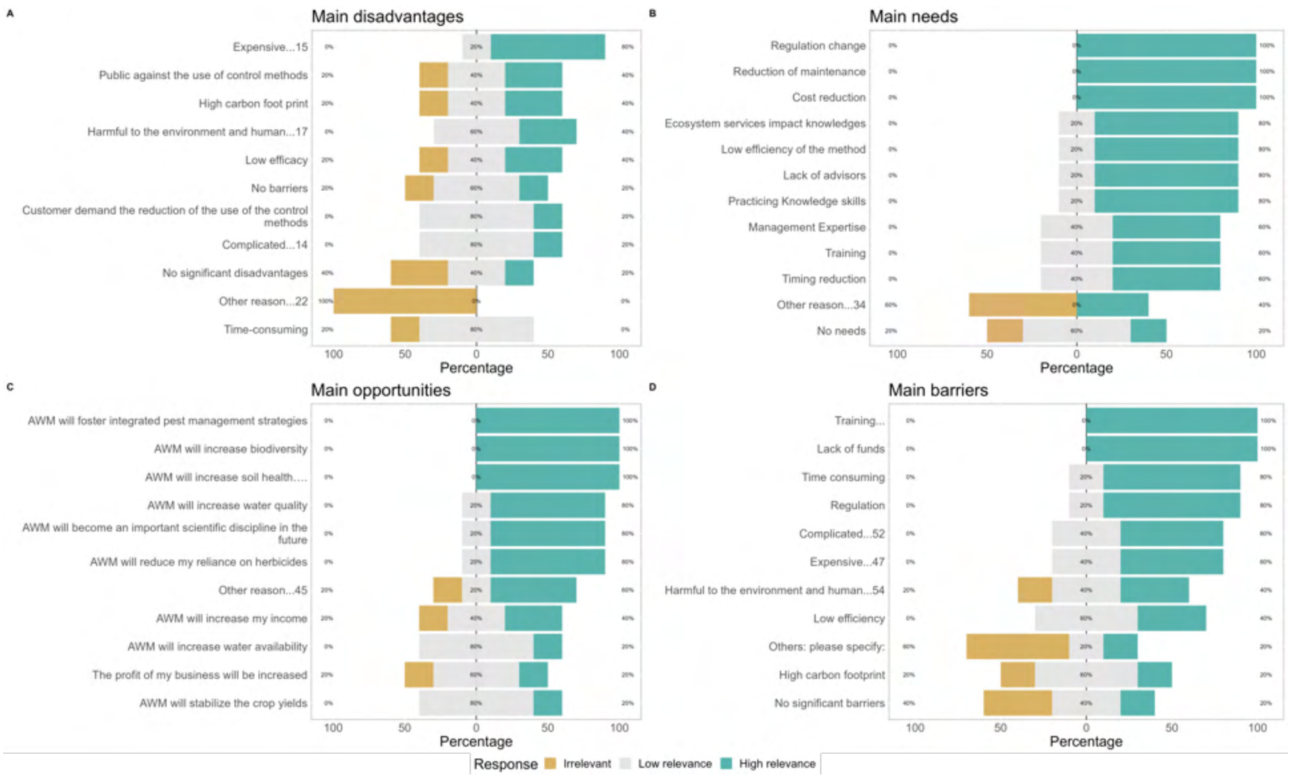


Figure 191. Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

3.1.1.1.2.3 Policy makers

Policy makers hold a distinct general perspective on herbicides compared to consumers and advisors, recognizing both significant opportunities and important needs, barriers, and disadvantages associated with their use. They unanimously acknowledge that herbicides play a role in fostering IPM strategies and providing ecosystem services, such as improving water quality, biodiversity, and soil health. Additionally, policy makers foresee herbicides evolving into an important scientific discipline and reducing farmers' reliance on them. They identify several crucial necessities for herbicide use, unanimously emphasizing the need for practicing knowledge skills, training, and reducing costs, timing, and maintenance. Furthermore, nearly 70% of respondents highlight ecosystem services impact knowledge, lack of advisors, and management expertise as highly important impediments. The most prominent barriers identified by policy makers are the high carbon footprint, environmental and human harm, and the need for training. Moreover, two-thirds of respondents view regulatory challenges and expenses as key obstacles. Consistently, policy makers, like consumers and advisors, unanimously consider customer concerns to reduce or eliminate herbicide use, alongside high carbon footprint and environmental and human harm, as critical disadvantages.

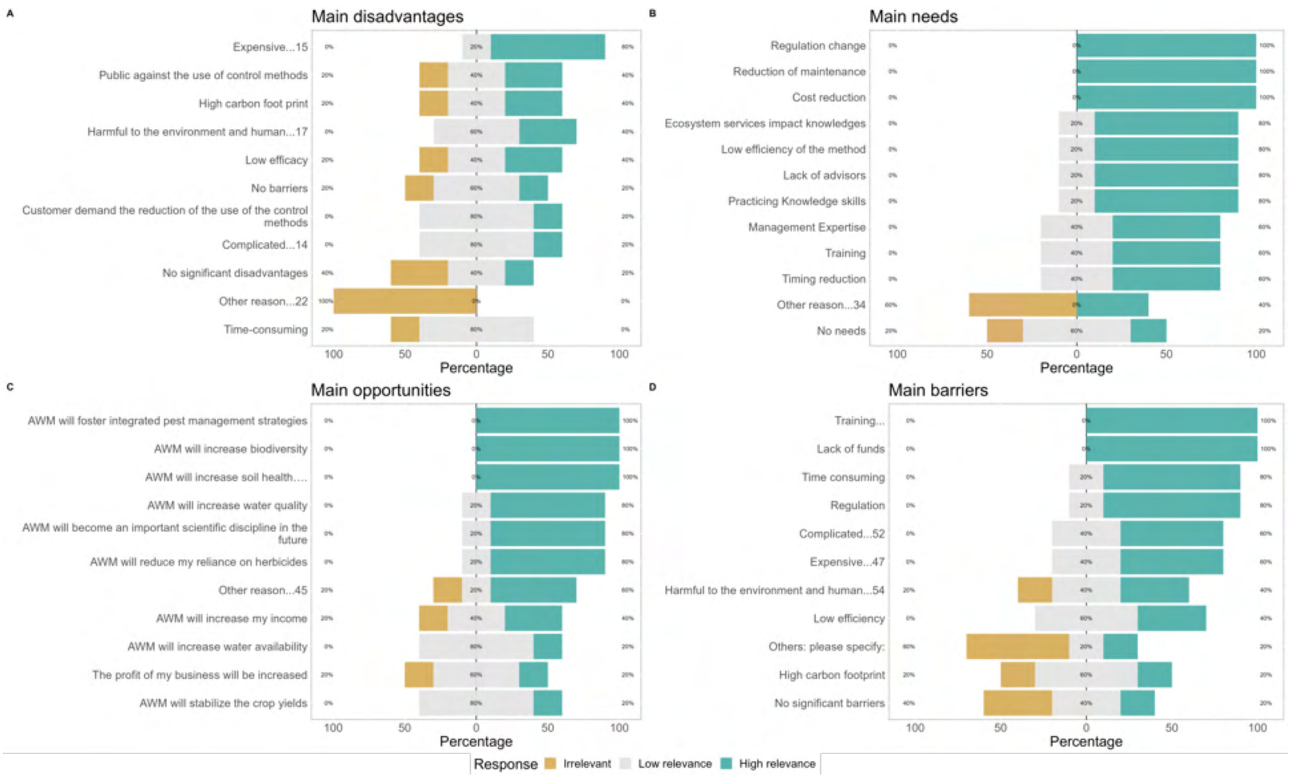


Figure 192. Main disadvantages, needs, barriers and opportunities for herbicides identified by policy makers.

3.1.1.1.2.4 Researchers

Researchers' overall perspective on herbicides aligns with advisors and consumers, recognizing few opportunities and relevant needs, barriers, and disadvantages associated with their use. While 56% of respondents identified opportunities such as the potential for herbicides to become an important scientific discipline and their role in reducing herbicide reliance, the rest of the queried categories were deemed of low or irrelevant importance in olive culture. Researchers unanimously emphasize the significance of ecosystem services impact knowledge and training, with almost 90% recognizing the importance of lack of advisors, practicing knowledge skills, and management expertise. Additionally, nearly 80% emphasize the importance of regulatory changes and cost reduction as key requirements for herbicide use. Regulation emerges as the most relevant barrier, cited by 78% of researchers, while environmental and human harm, alongside training, are regarded as pressing impediments by two-thirds of the sample. Consistent with other stakeholders, researchers also regard customer demand to reduce or eliminate herbicides and potential environmental and human harm as the most pressing disadvantages.

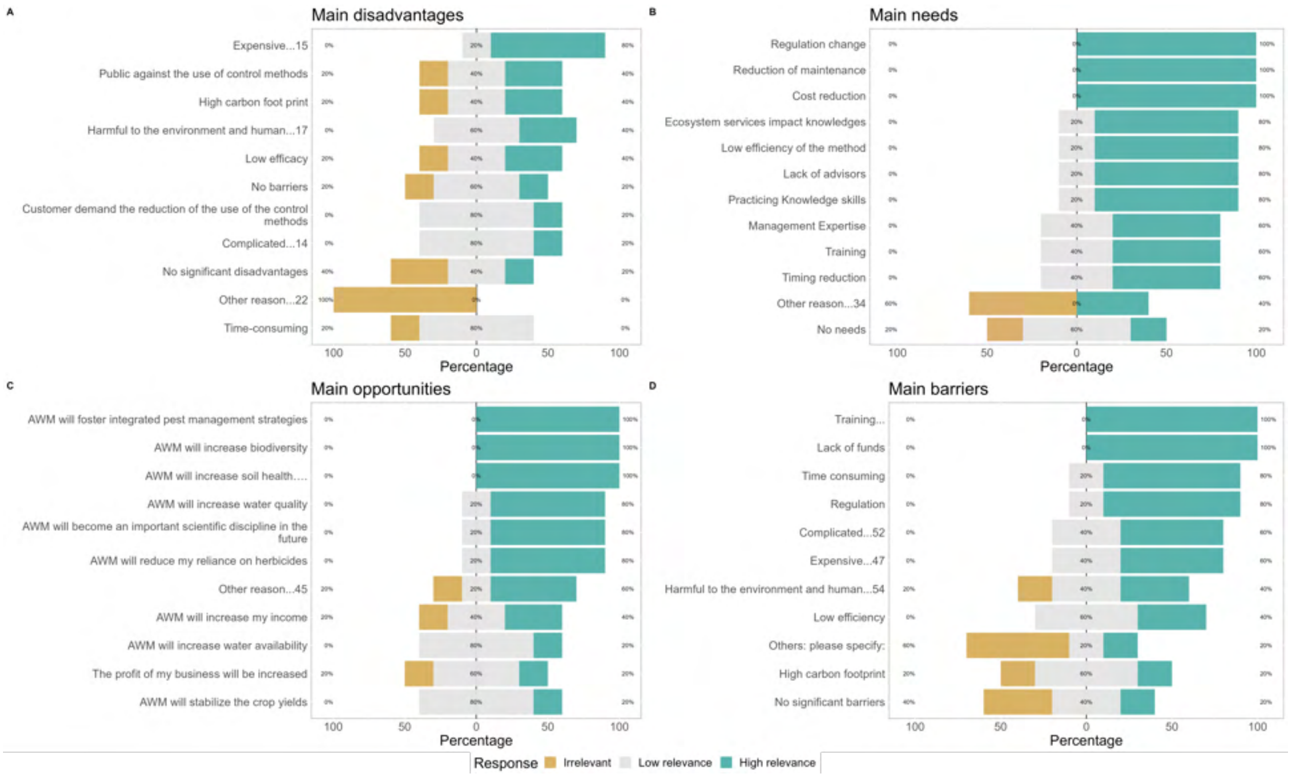


Figure 193. Main disadvantages, needs, barriers and opportunities for herbicides identified by researchers.

3.1.1.1.2.5 Conclusion

Advisors, consumers, and researchers considered herbicides as a technique with limited opportunities, entailing relevant needs, barriers, and disadvantages. In contrast, policy makers hold a distinct general perspective on herbicides compared to consumers and advisors, recognizing both significant opportunities and important needs, barriers, and disadvantages associated with their use. Policy makers unanimously identify herbicides as fosterers of IPM strategies and providers of several ecosystem services, whereas the other stakeholders did not massively recognize those attributes. Stakeholders view the potential for herbicides to become an important scientific discipline. All stakeholders considered that herbicides present relevant needs, barriers, and disadvantages. Ecosystem services impact knowledge, training, lack of advisors, and practicing knowledge skills, among other crucial issues, were regarded as highly relevant necessities across stakeholders. Environmental and human harm, high carbon footprint, regulation, as well as training and expense were regarded as relevant impediments by surveyed stakeholders. All stakeholders considered environmental and human harm as well as customer demand to reduce or eliminate herbicide use as the most relevant disadvantages.

3.1.1.1.3 Mechanical weeding

3.1.1.1.3.1 Advisors

Advisors expressed optimism regarding the use of mechanical weeding in olives, while acknowledging its associated needs, barriers, and limited disadvantages. They believe mechanical weeding will promote IPM strategies, increase farmers' income, and reduce herbicide reliance. Additionally, 71% of respondents recognize its potential to enhance biodiversity and soil health, boost business profitability, and become a vital scientific discipline. About 51% perceive opportunities related to water quality improvement and crop yield stabilization. Over eighty percent of advisors prioritize the need for ecosystem services impact knowledge in implementing mechanical weeding. They also identify crucial requirements such as lack of advisors, knowledge skills, expense, and cost reduction. The main barriers, highlighted by over 70% of respondents, include training, financial constraints, and expenses. Interestingly, 71% consider expense as the most significant disadvantage, while an equal proportion believe the technique lacks notable drawbacks.

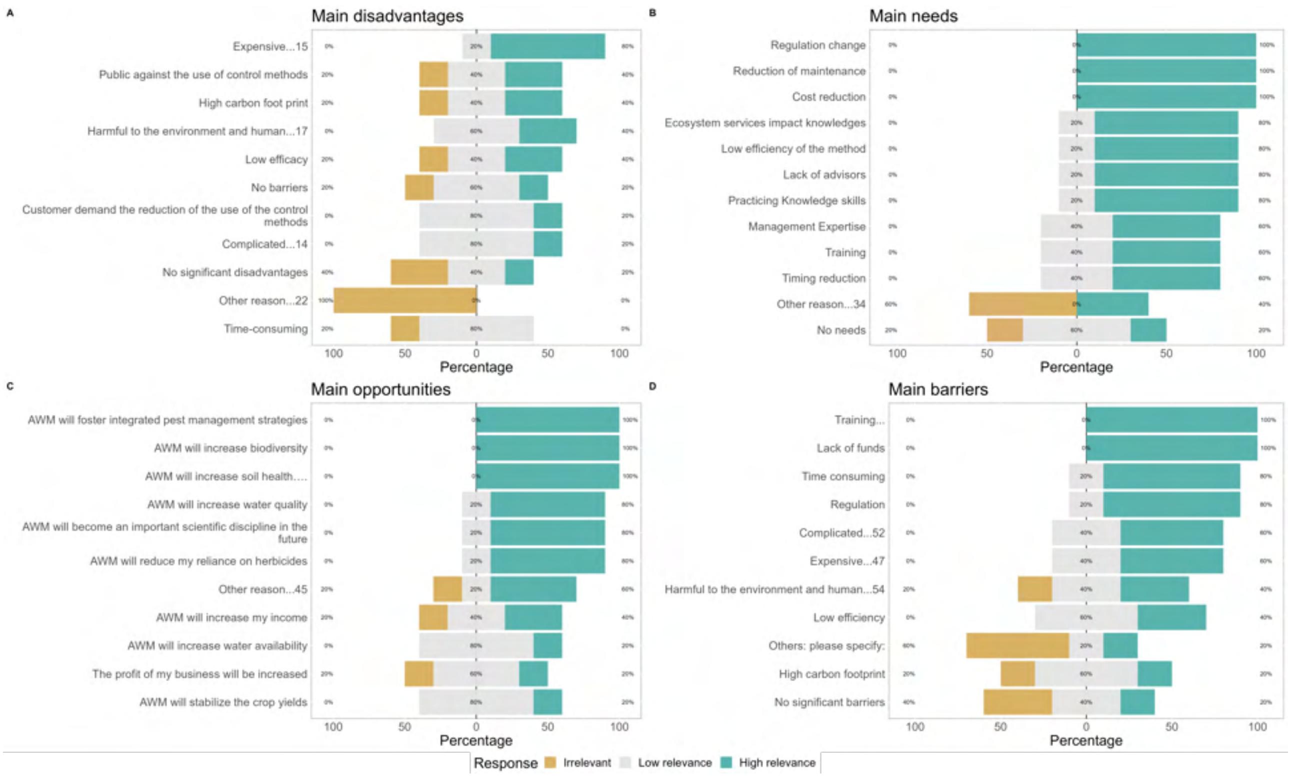


Figure 194. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by advisors.

3.1.1.1.3.2 Consumer

Nearly seventy percent of consumers recognized its potential to improve soil health and reduce herbicide reliance. Among the primary needs, 67% emphasized the importance of ecosystem services impact knowledge, lack of advisors, knowledge skills, training, and cost reduction. Conversely, none of the queried barriers was deemed as of significant relevance, being mostly deemed of low importance for mechanical weeding implementation. Almost seventy percent of respondents identified high carbon footprint and expense as relevant disadvantages. Notably, the same proportion believed that mechanical weeding lacks significant drawbacks.

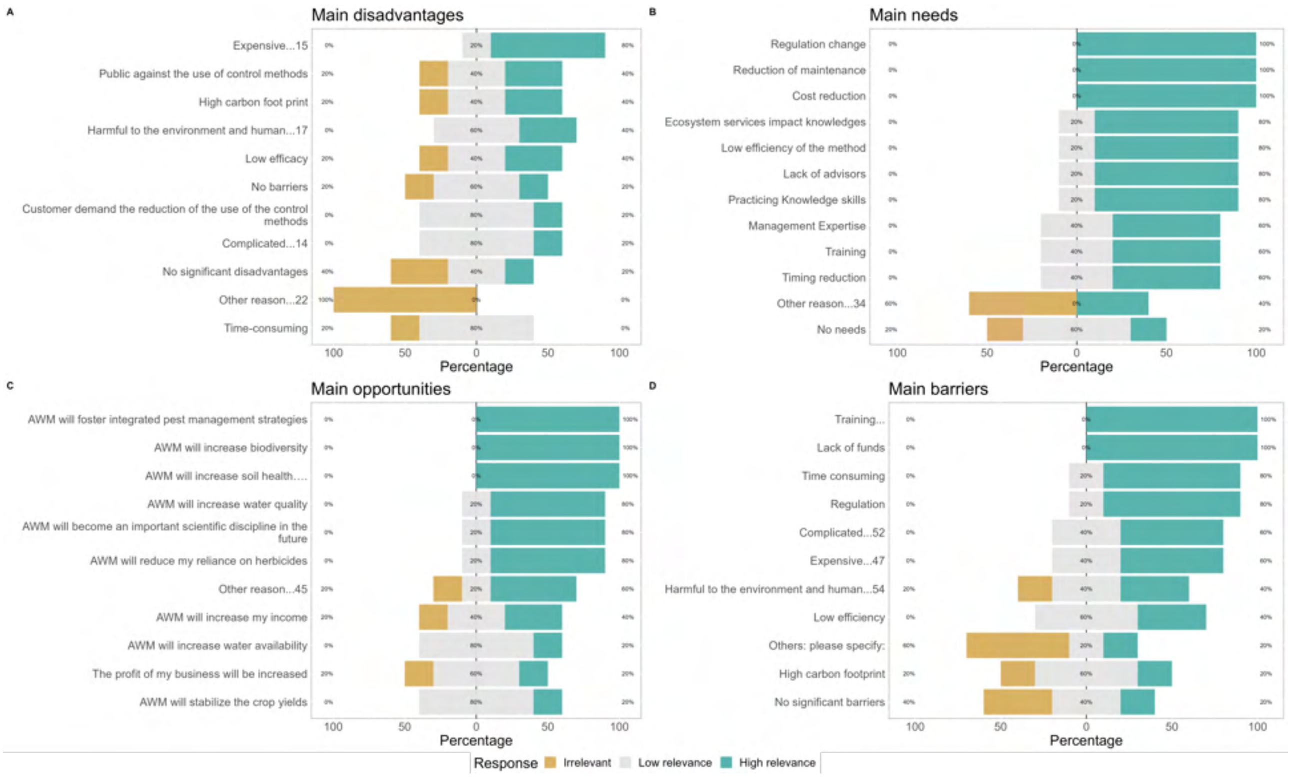


Figure 195. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by consumers.

3.1.1.1.3.3 Policy makers

Policy makers recognize mechanical weeding as an AWM practice offering significant opportunities and needs, with minimal barriers and some relevant disadvantages. They unanimously agree on its positive impact on soil health and its potential to evolve into an important scientific discipline. Moreover, nearly 70% consider it a facilitator of IPM strategies and a provider of essential ecosystem services, such as improving water quality and biodiversity, while also reducing herbicide reliance. All policy makers prioritize practicing knowledge skills and training as highly relevant needs. Additionally, almost 70% recognize other pertinent needs, including knowledge of ecosystem services impact, lack of advisors, and cost and timing reduction. There is consensus among respondents regarding the main barrier to mechanical weeding, with all of them highlighting training, while 67% also view expense as significant. Expense is unanimously considered the most relevant disadvantage, with almost 70% emphasizing the method's high carbon footprint as an important drawback.

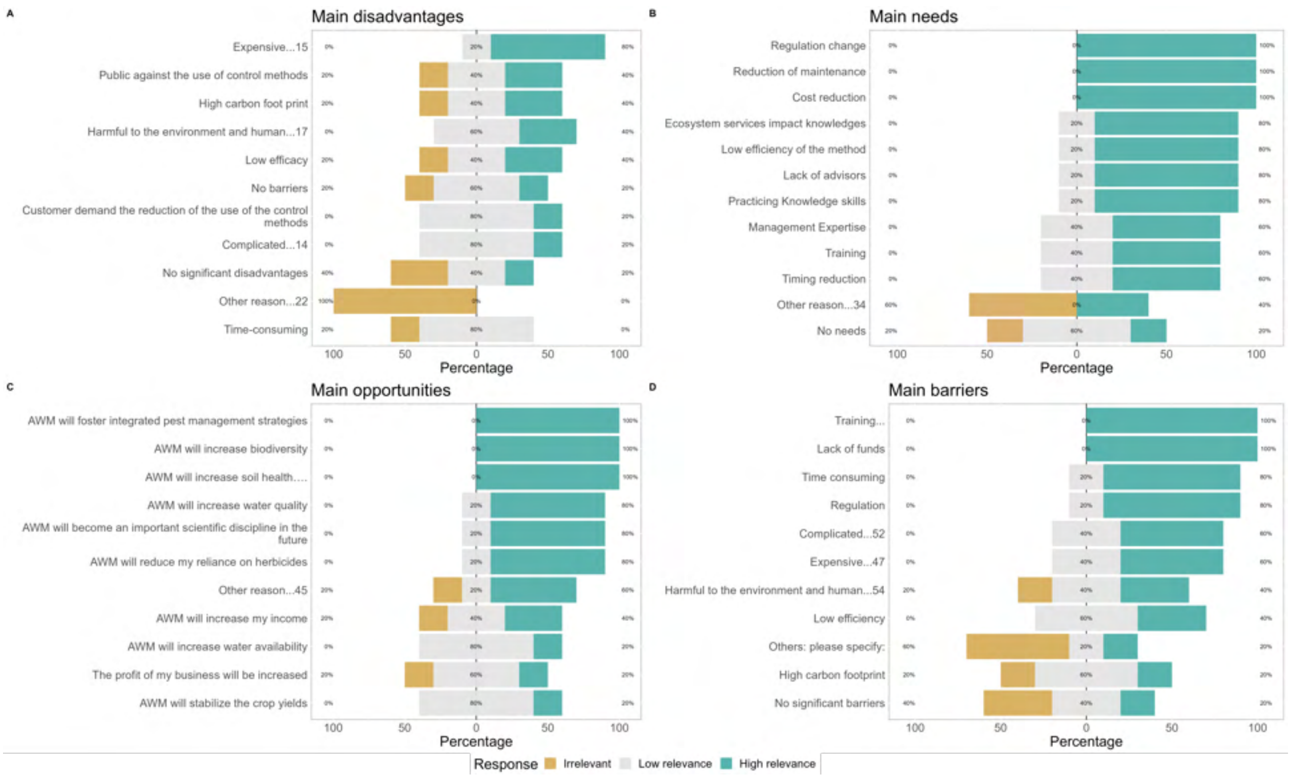


Figure 196. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by policy makers.

3.1.1.1.3.4 *Researchers*

Researchers, much like other stakeholders, recognize that mechanical weeding offers significant opportunities, needs, and disadvantages, while encountering minimal barriers. Seventy-five percent of them believe that mechanical weeding will reduce herbicide reliance, with half emphasizing its potential to foster IPM strategies, improve water quality, biodiversity, and soil health, and possibly evolve into a significant scientific discipline. Cost reduction was unanimously considered the primary need, with nearly 90% emphasizing maintenance reduction and three-quarters highlighting practicing knowledge skills, timing reduction, and ecosystem services impact knowledge. Training was deemed the most relevant barrier by 62% of researchers, with half also noting lack of funds and expense. Expense was overwhelmingly regarded as the most significant disadvantage by 88% of respondents, followed by environmental and human harm and low efficacy, which half of them considered significant drawbacks.

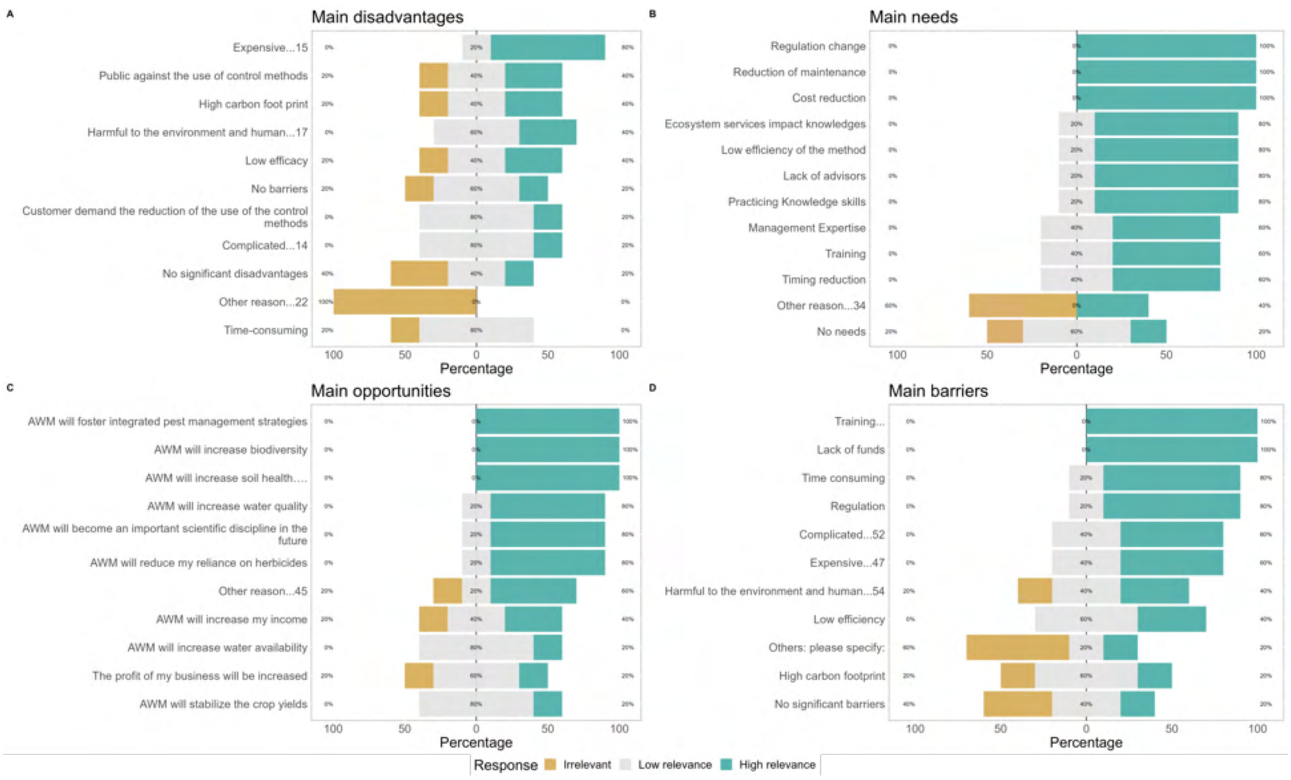


Figure 197. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by researchers.

3.1.1.1.3.5 Conclusion

Advisors, policymakers, and researchers express an optimistic perspective toward the use of mechanical weeding in olive culture, acknowledging its relevant opportunities and few disadvantages, while identifying significant needs and barriers. In contrast, consumers adopt a neutral stance, emphasizing relevant requirements but considering few opportunities. Stakeholders recognize the technique's potential to provide essential ecosystem services, such as enhancing soil health. Advisors, policymakers, and researchers believe that mechanical weeding fosters IPM strategies and holds the potential to become an important scientific discipline. While advisors and consumers prioritize ecosystem services impact knowledge as the primary need, policymakers and researchers opt for practicing knowledge skills and training, and cost reduction, respectively. Other emphasized requirements include lack of advisors, expense, and maintenance reduction, among others. Advisors, policymakers, and researchers unanimously identify training as the most relevant barrier, with lack of funds and expense also considered significant impediments. Conversely, consumers do not consider any queried barriers as relevant, mostly deeming them as low or irrelevant. Expense emerges as the most significant disadvantage for all stakeholders. While a significant proportion of advisors and consumers perceive mechanical weeding as lacking significant disadvantages, policymakers highlight its high carbon footprint, and researchers emphasize environmental and human harm, as well as low efficacy, as significant drawbacks.

3.1.1.1.4 Site-specific spraying

3.1.1.1.4.1 Researcher

Researchers express a pessimistic view toward site-specific spraying, recognizing few opportunities alongside relevant needs, barriers, and disadvantages. While nearly 60% of respondents believe this practice could evolve into an important scientific discipline and reduce herbicide reliance, other opportunities were not widely regarded as relevant. There was consensus among researchers regarding the primary needs, with ecosystem services impact knowledge and training unanimously considered crucial. Additionally, lack of advisors, practicing knowledge skills, and management expertise were highly emphasized. Regulatory changes and cost reduction were also seen as important requirements by nearly 80% of researchers. Regulatory challenges were highlighted as the main barriers by 78% of respondents, with environmental and human harm, and training also identified as significant impediments. The main disadvantages identified by researchers included public demands to eliminate site-specific spraying, environmental and human harm, as well as concerns about consumer demand to reduce its use and the expense involved, which were highlighted by a majority of respondents.

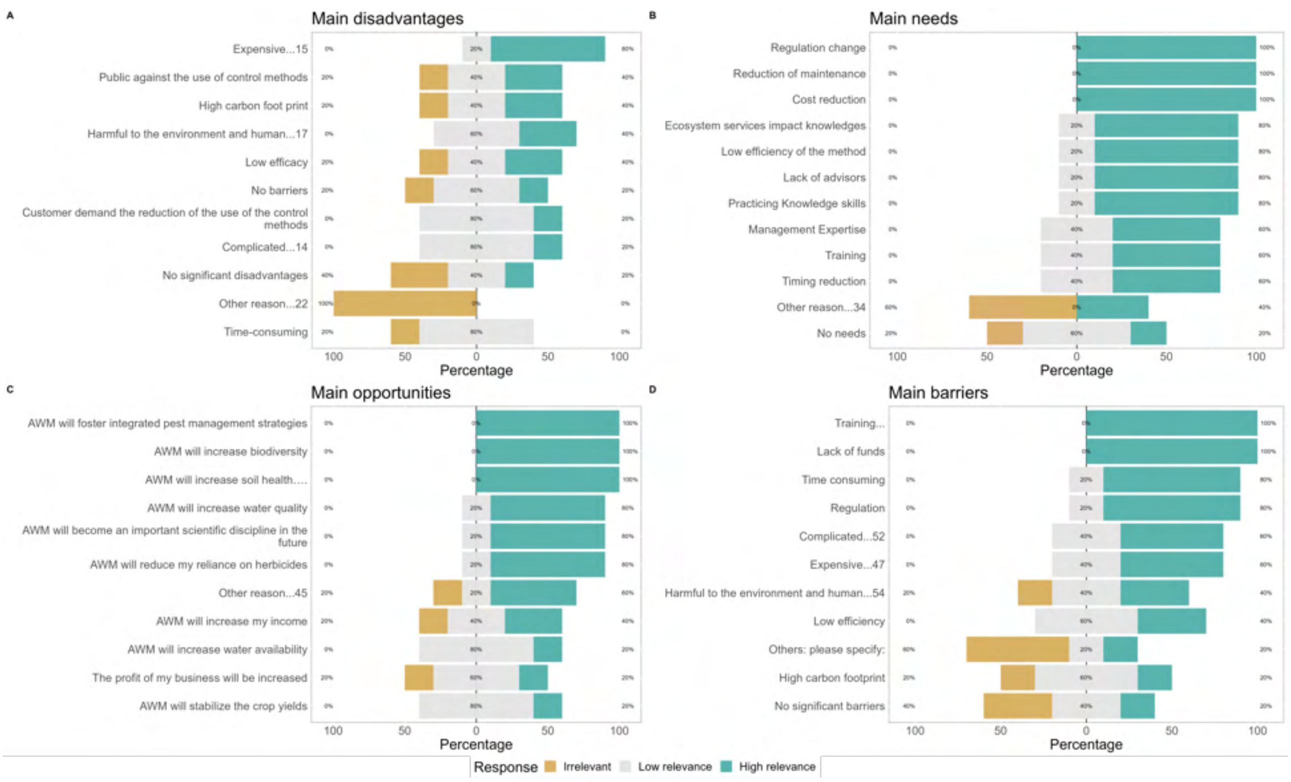


Figure 198. Main disadvantages, needs, barriers and opportunities for site-specific spraying identified by researchers.

3.1.1.1.4.2 Conclusion

Researchers express a cautious stance regarding site-specific spraying, acknowledging its potential to evolve into a significant scientific discipline and reduce herbicide reliance. They emphasize the critical importance of ecosystem services impact knowledge and training, underscoring the need regulatory adjustments. However, concerns about regulatory hurdles, environmental and human harm, and the financial burden associated with the practice remain prominent. While site-specific spraying holds promise for agricultural innovation, addressing these concerns will be essential for its successful implementation and acceptance within the farming community.

3.1.1.2 Surveys

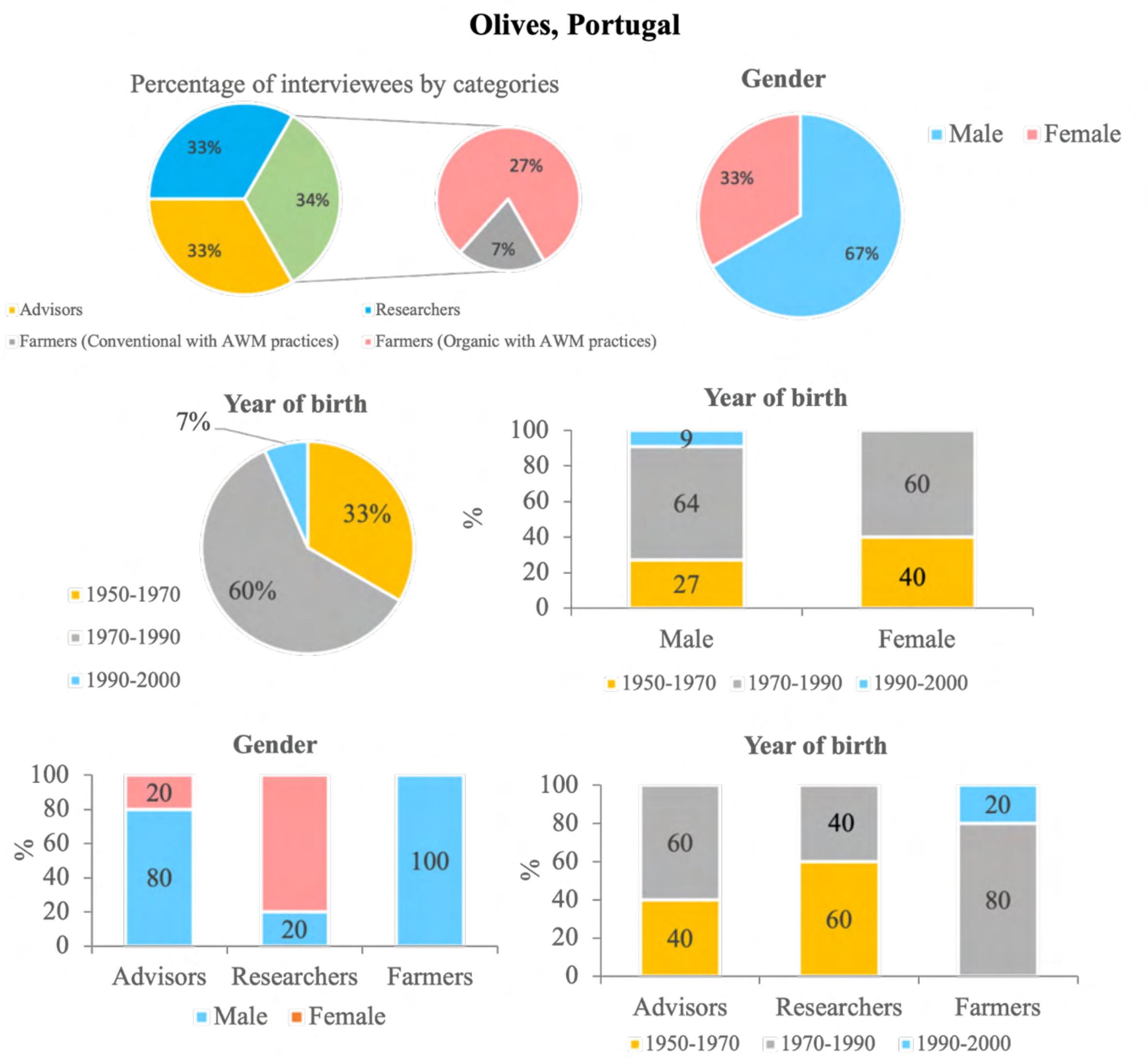


Figure 199. Interviewees description in the Olives Living Lab (Portugal)

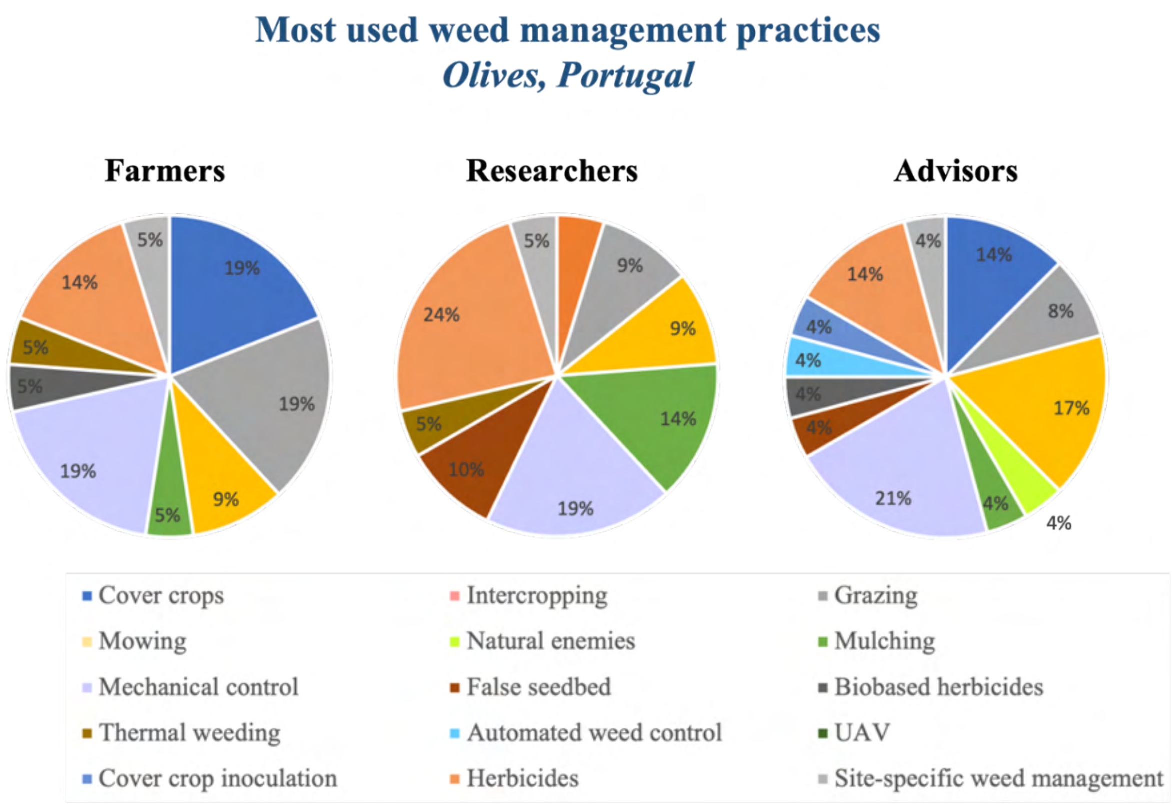


Figure 200. Most used weed management practices in the Olives Living Lab (Portugal)

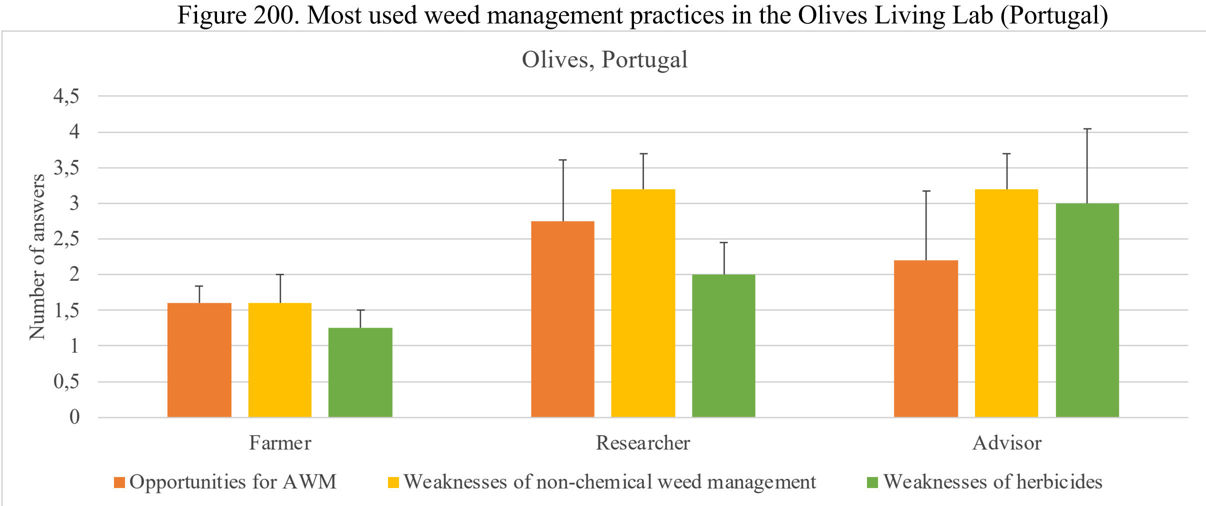


Figure 201. Mean number of answers (±se) per stakeholder group in the Olives Living Lab (Portugal)

Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: Presented in the figure below.

THREATS: None.

WEAKNESSES: Only a farmer mentioned difficulties in operation and effectiveness as weaknesses of certain AWM practices.

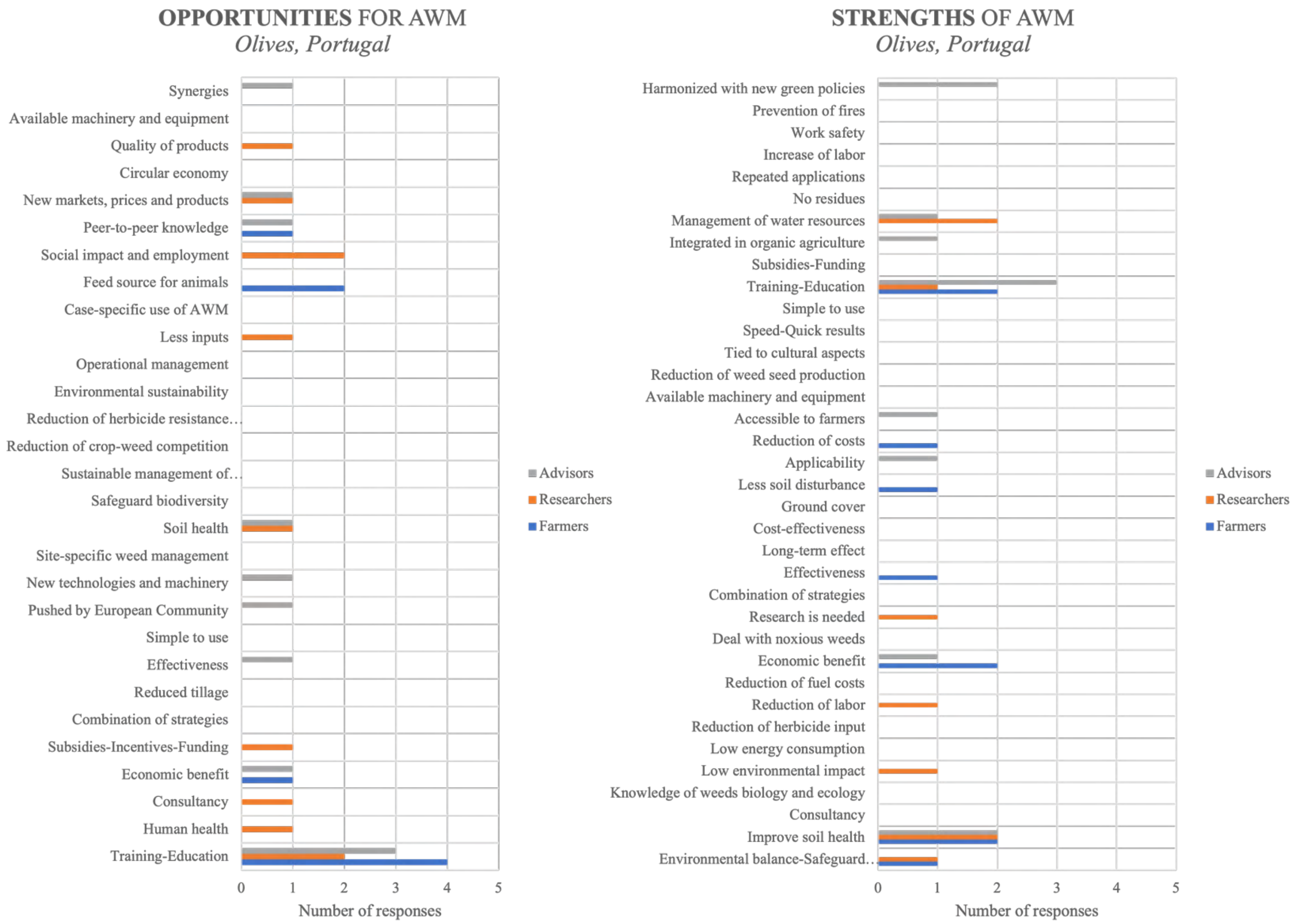


Figure 202. Opportunities and strengths of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: A few answers identified threats for non-chemical weed management in the olives LL in Portugal. Climate and weather conditions, markets and lack of recognition from them were mentioned.

WEAKNESSES: Presented in the figure below.

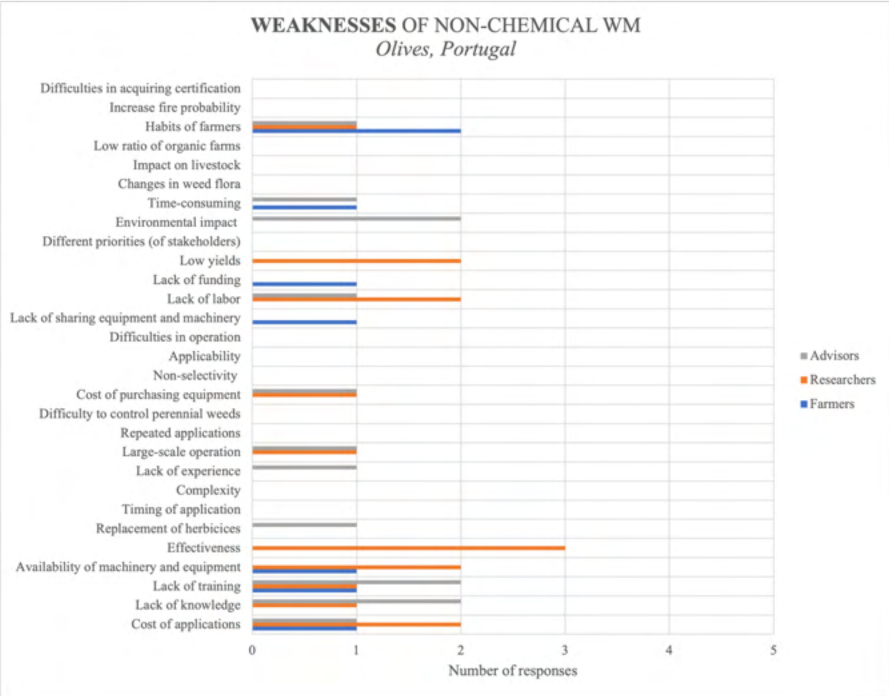


Figure 203. Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: None.

STRENGTHS: None.

THREATS: Only two answers were identified to relate to threats for herbicides. Those referred to agricultural policy and markets.

WEAKNESSES: Presented in the figure below.

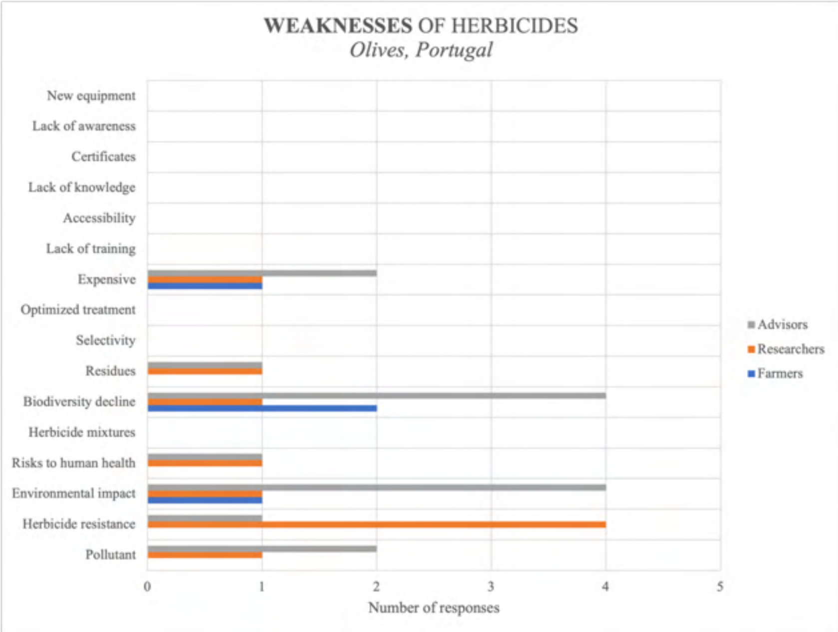


Figure 204. Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – OLIVES, PORTUGAL
Most used weed management practices: The olive LL in Portugal gave similar results to the cowpea LL in terms of the diversity of AWM strategies that are currently used for weed management. The use of animals for grazing is recognized and it is noteworthy that there are attempts for site-specific weed management and more use of UAV. **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group**: Advisors and researchers were more willing to identify opportunities for AWM, weaknesses of non-chemical weed management and herbicides compared to farmers. **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: The most important opportunity for AWM, identified by all stakeholder groups, was the training and education on agroecology and AWM. Training-education was considered a strength at the same time because new knowledge requires peer-to-peer knowledge. Management of water resources and improvement of soil health were also considered as strengths of AWM practices. **Threats, and weaknesses for non-chemical weed management**: Climate and weather conditions was the most prevalent threat for non-chemical weed management in the olive LL

in Portugal. Lack of labour and knowledge, and the cost of applications and costs for purchasing new equipment are tied to weaknesses of non-chemical weed management. However, the most important is the uncertainty regarding the effectiveness, as many researchers mentioned that. It was commonly agreed by all stakeholder groups that the old generation of farmers is not willing to easily change their habits and it is imperative to bring back youth.

Opportunities, strengths, weaknesses, and threats for herbicides: Herbicides are expensive, lead to biodiversity decline, have an environmental impact and they are pollutants. These were the most common answers regarding the weaknesses of herbicides. In addition, herbicide resistance is another factor to consider as a weakness.

3.1.1.3 Living lab board meeting

See section 2.1.2.1 Cowpea (Portugal) (page 309)

3.1.2 Cyprus

3.1.2.1 Questionnaires

Olive questionnaires provided insights with regard to six AWM techniques, including grazing, herbicides, intercropping, mechanical weeding, mowing, and site-specific spraying. We garnered responses from all stakeholders, namely advisors, consumers, farmers, industry, policy makers and researchers. A detailed breakdown of stakeholder participation in the questionnaires for each AWM practice is presented in Table 31.

Table 31. Number of responses for each AWM practice and stakeholder category in Olives (Cyprus).

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control						
Biobased herbicides		1	1			1
Cover crop inoculation to increase competitiveness						
Cover crops			1			1
False seedbed						
Grazing		1	3			2
Herbicides	6	7	18	1	4	5

Intercropping	1	1	4	1	1	1
Mechanical weeding	6	2	12	3	2	5
Mowing	3		8		3	5
Mulching	1					
Natural enemies		1				
Other						
Site-specific spraying	2	2	3			2
Thermal weeding						
UAV			1			
n=56	7	9	26	4	4	6

3.1.2.1.1 Grazing

3.1.2.1.1.1 Farmers

Farmers view grazing as a technique with few yet significant opportunities, accompanied by essential needs, minimal barriers, and few disadvantages. They unanimously acknowledge grazing's role in providing ecosystem services, particularly in increasing biodiversity and improving soil health. However, other opportunities were deemed relevant by only a third of respondents. Farmers unanimously prioritize lack of advisors, practicing knowledge skills, and cost reduction as primary needs for grazing implementation. Additionally, nearly 70% consider management expertise, training, and maintenance reduction crucial. Training is unanimously recognized as the most significant barrier, while two-thirds also identify complexity, time consumption, and lack of funds as relevant impediments. Notably, none of the queried disadvantages were deemed significant by a significant proportion of respondents, with only a third mentioning grazing's low efficacy, expense, and time consumption.

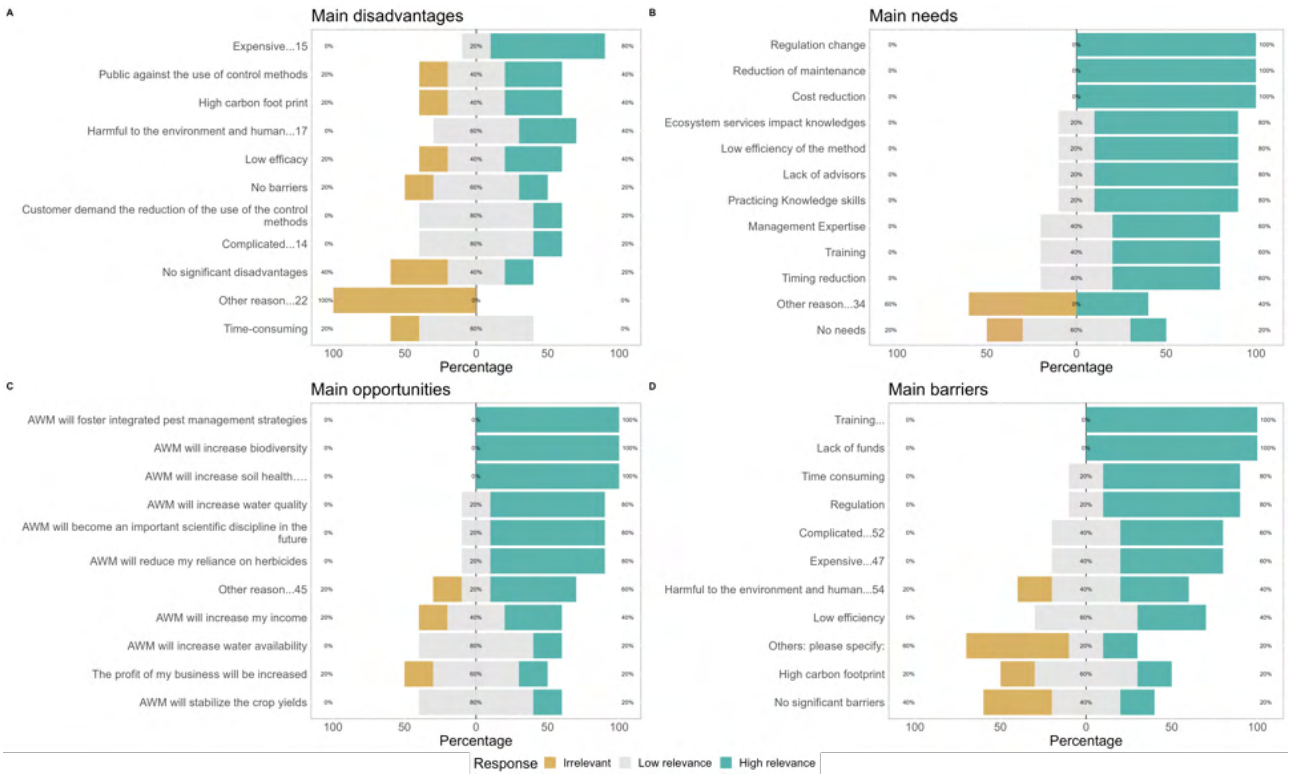


Figure 205. Main disadvantages, needs, barriers and opportunities for grazing identified by farmers.

3.1.2.1.1.2 Conclusion

Farmers perceive grazing as a technique with promising opportunities for enhancing biodiversity and soil health, despite facing notable challenges such as the need for training and addressing complexity. The majority of respondents prioritize crucial needs like knowledge enhancement and cost reduction, concerns about grazing's efficacy and expense remain relatively low. Farmers did not recognize major drawbacks as a result of grazing implementation.

3.1.2.1.2 Herbicides

3.1.2.1.2.1 Advisors

Advisors express a pessimistic perspective toward herbicides, with none of the queried opportunities deemed highly relevant by more than one-third of respondents. Regarding the most critical needs, nearly 70% of advisors prioritize timing reduction. Additionally, half of the respondents identify ecosystem services impact knowledge and lack of advisors as relevant necessities. Half of the advisors perceive training and regulatory challenges as the primary barriers to herbicide implementation in olives. Nearly 70% of respondents consider environmental and human harm as the most significant disadvantage, with half of them stating that herbicides do not present any significant drawbacks.

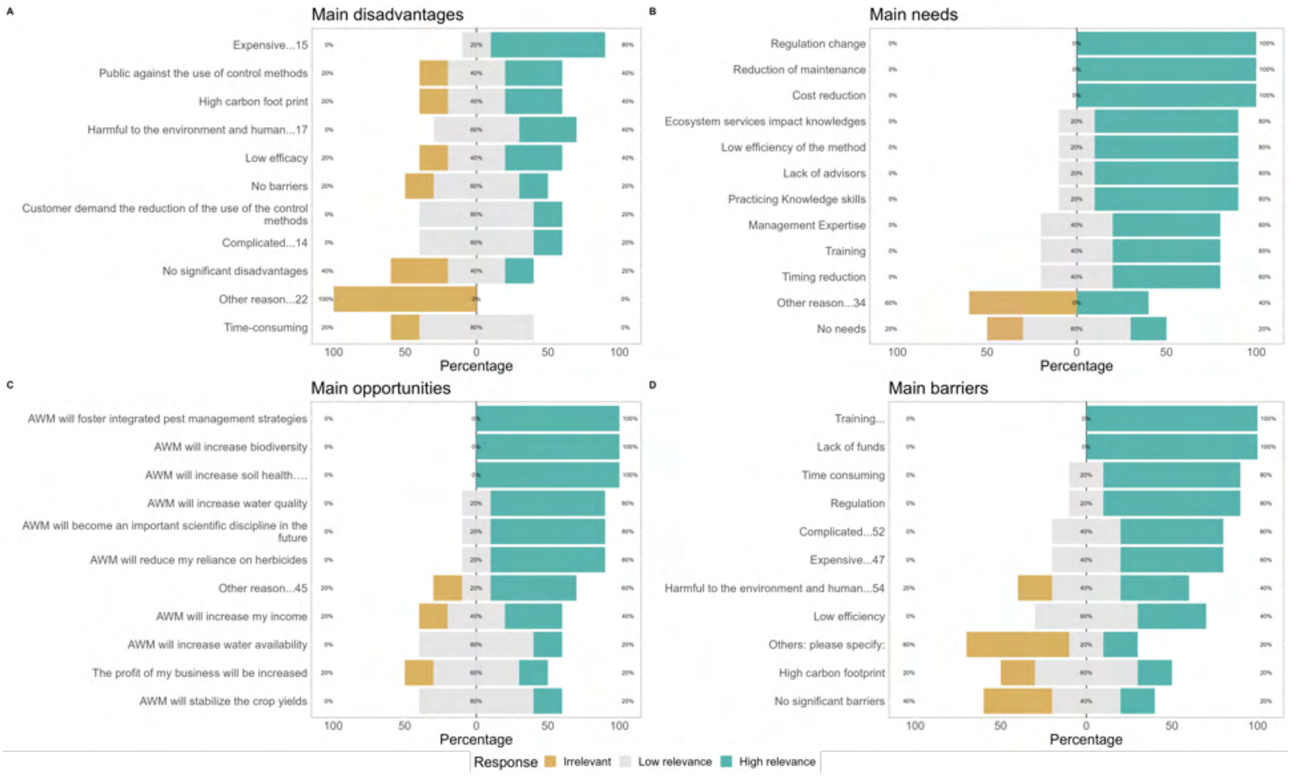


Figure 206. Main disadvantages, needs, barriers and opportunities for herbicides identified by farmers.

3.1.2.1.2.2 Consumers

Consumers, aligning with the general sentiment of advisors, perceive herbicides as offering few relevant opportunities. Notably, consumers recognize more needs, barriers, and disadvantages associated with herbicide use compared to advisors. Regarding main opportunities, 43% of consumers believe herbicide use will enhance biodiversity and soil health. Regulatory changes, lack of advisors, management expertise, and cost reduction were identified as relevant necessities by 86% of respondents. Additionally, ecosystem services impact knowledge (71%), practicing knowledge skills and training (57%) were considered relevant. Nearly 90% of consumers view training as the most significant barrier, with 71% also citing environmental and human harm, along with regulatory challenges, as important impediments. Consumers largely agree on the most relevant disadvantage, unanimously considering environmental and human harm as highly significant. Moreover, high carbon footprint and expense were highlighted as relevant drawbacks.

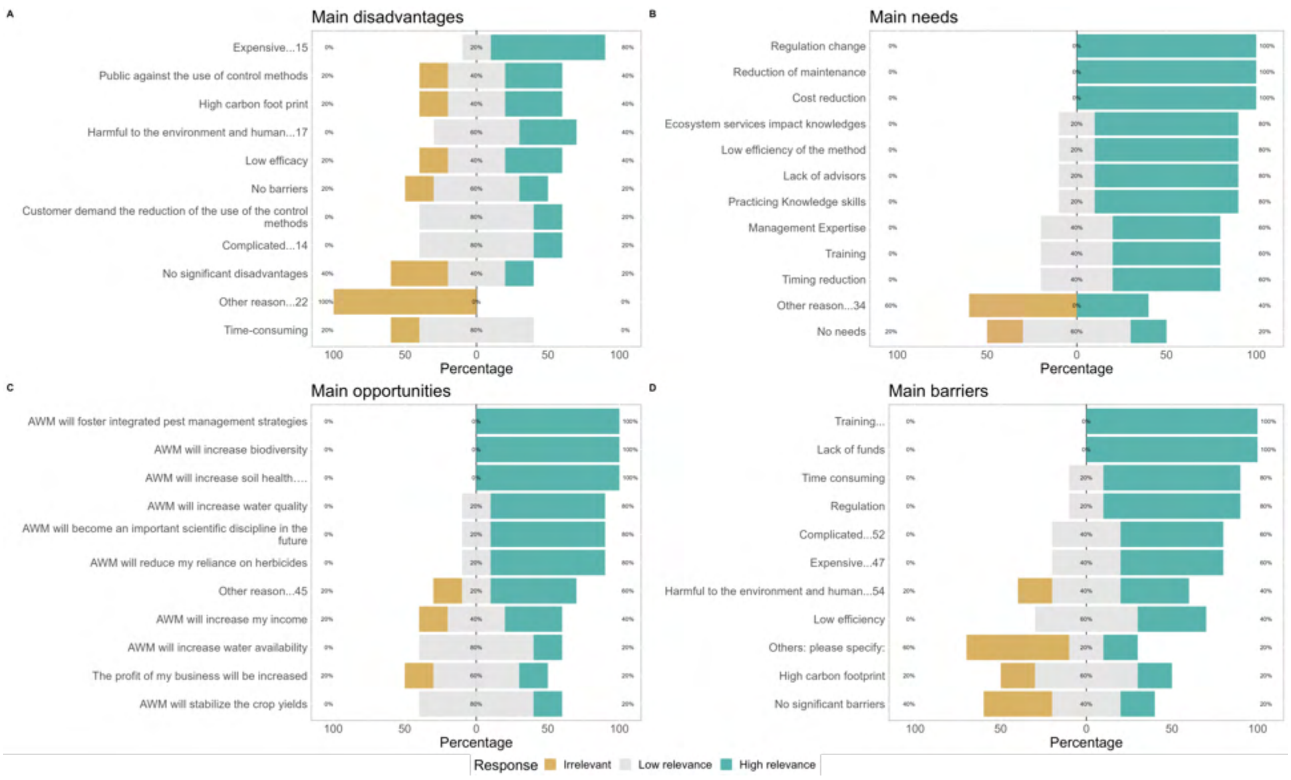


Figure 207. Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

3.1.2.1.2.3 Farmers

Farmers' perception of herbicides aligns with the sentiments of advisors and consumers, as they identify few opportunities and recognize several needs, barriers, and disadvantages. Notably, farmers did not predominantly consider any of the queried disadvantages as highly relevant, similarly, none of the queried needs were regarded as relevant by more than half of the respondents. Two-thirds of respondents deemed environmental and human harm, as well as the lack of funds, as the most relevant barriers. Additionally, expense was considered highly relevant by more than half of the respondents. Consistent with these barriers, practically 90% of farmers identified environmental and human harm as the most relevant disadvantage. Moreover, two-thirds of respondents emphasized the public's opposition to herbicides and expense as the most relevant disadvantages.

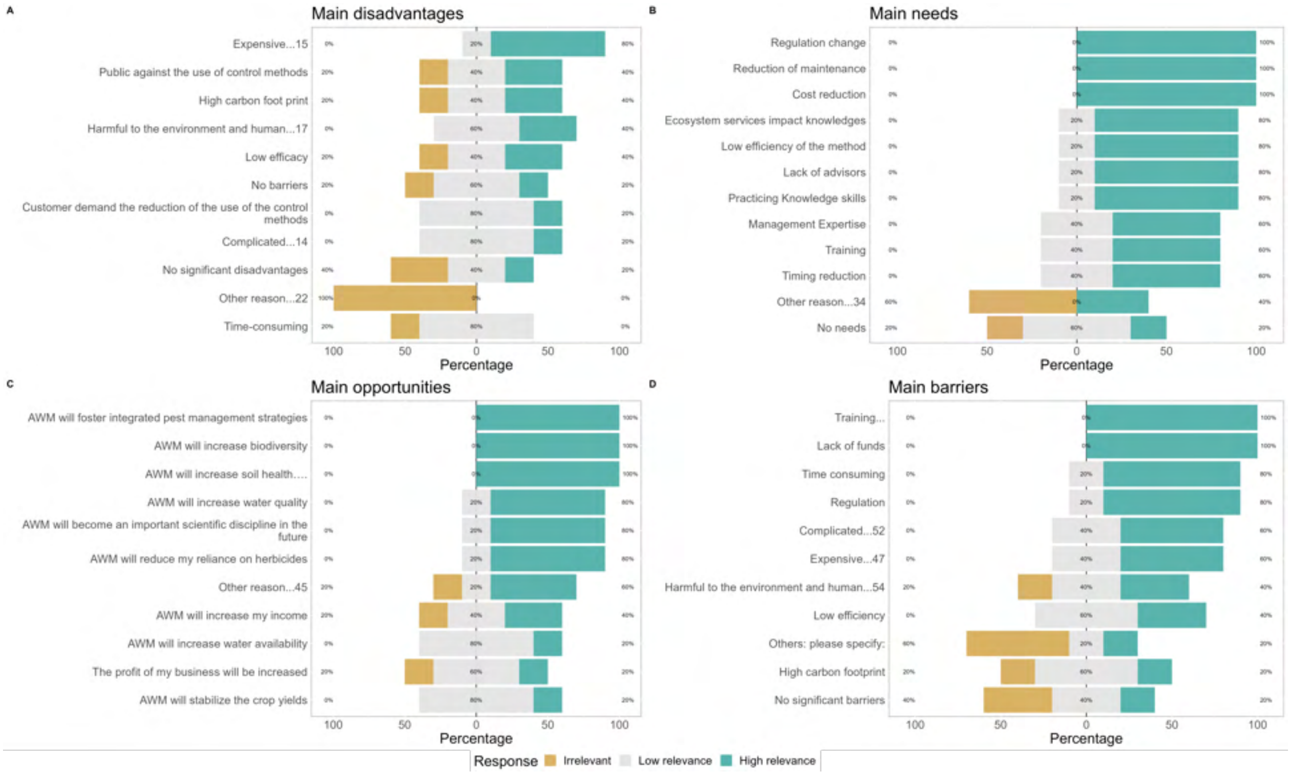


Figure 208. Main disadvantages, needs, barriers and opportunities for herbicides identified by farmers.

3.1.2.1.2.4 Policy makers

Policy makers, in line with the rest of the stakeholders, have a negative view of herbicides. They considered that herbicide use does not present crucial opportunities and identified that it entails relevant needs, barriers, and some important disadvantages. None of the queried opportunities were regarded as relevant by more than one quarter of the policy makers. Policy makers unanimously view management expertise, as well as maintenance and cost reduction as the primary needs. Moreover, seventy-five percent of the respondents considered practicing knowledge skills, training, and timing reduction as paramount requirements. As for the main barriers, seventy-five percent of the respondents emphasize environmental and human harm, as well as training. Policy makers unanimously considered public opposition to herbicide use and potential harm to the environment and humans as relevant disadvantages.

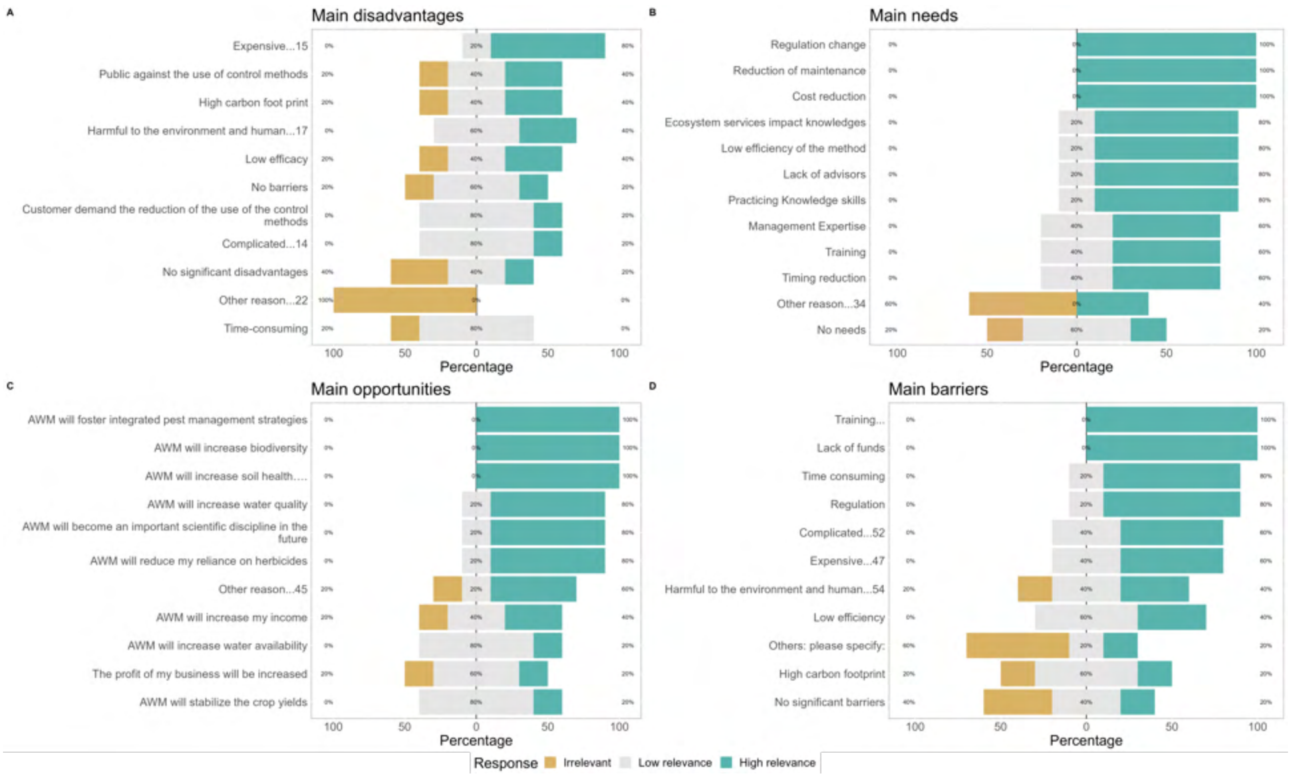


Figure 209. Main disadvantages, needs, barriers and opportunities for herbicides identified by policy makers.

3.1.2.1.2.5 *Researchers*

Researchers, like the other stakeholders, perceive herbicides as lacking significant opportunities while recognizing important needs, barriers, and disadvantages. None of the opportunities queried were deemed highly relevant. Sixty percent of respondents emphasized the necessity of management expertise and cost reduction. Environmental and human harm, along with regulatory challenges, were identified as primary barriers by 60% of researchers. Moreover, eighty percent of respondents highlighted public opposition to herbicides and environmental and human harm as the main disadvantages. Additionally, 60% emphasized customer demand to reduce herbicide use and expense as significant drawbacks.

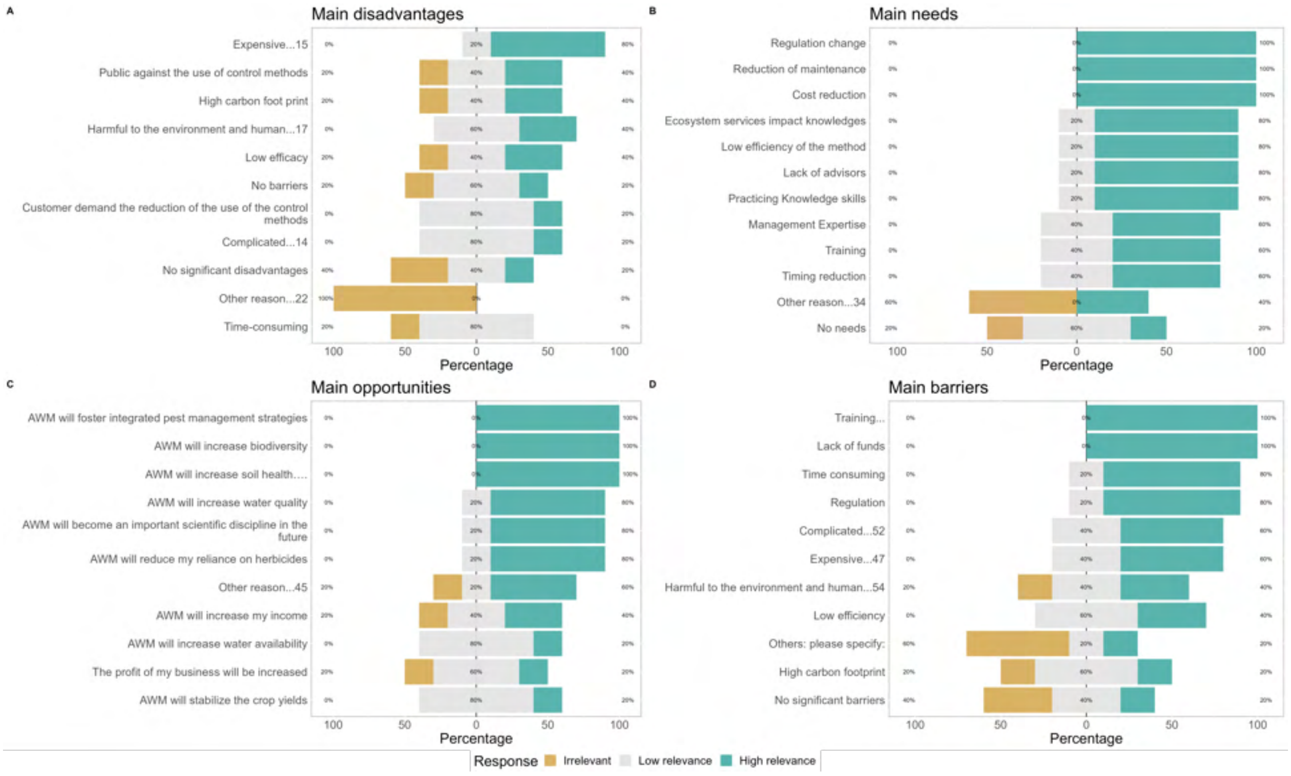


Figure 210. Main disadvantages, needs, barriers and opportunities for herbicides identified by researchers.

3.1.2.1.2.6 Conclusion

Stakeholders hold a negative perspective on herbicide use, as none of the groups deemed any of the queried opportunities as highly relevant. The overview suggests that herbicides are not commonly utilized as an AWM technique in olives. Advisors prioritize timing reduction as critical needs, while consumers and researchers emphasize regulatory changes, lack of advisors, management expertise, and cost reduction. Policy makers prioritize management expertise, maintenance, and cost reduction as primary needs. Notably, farmers did not consider any of the queried needs as highly relevant by more than half of the respondents. Advisors and consumers identified training as the most relevant barrier, while farmers, policy makers, and researchers highlighted environmental and human harm as significant impediments. Additionally, all stakeholders underscored regulatory challenges as relevant. Environmental and human harm were unanimously considered the most relevant disadvantage, followed by public opposition to the practice, expense, and high carbon footprint as relevant drawbacks.

3.1.2.1.3 Intercropping

3.1.2.1.3.1 Farmers

Farmers hold a positive view of intercropping, seeing it as a practice with promising opportunities despite needing to address certain barriers and needs. Notably, farmers did not consider any of the queried disadvantages as highly significant. They acknowledge intercropping's potential to foster IPM strategies and provide ecosystem services, such as enhancing biodiversity and soil health while reducing herbicide reliance. Among the primary needs, farmers prioritize ecosystem services impact knowledge, lack of advisors, and practicing knowledge skills. Time consumption emerges as the most significant barrier. While no single disadvantage stands out, fifty percent of respondents consider factors like low efficacy, expense, and time consumption as relevant challenges.

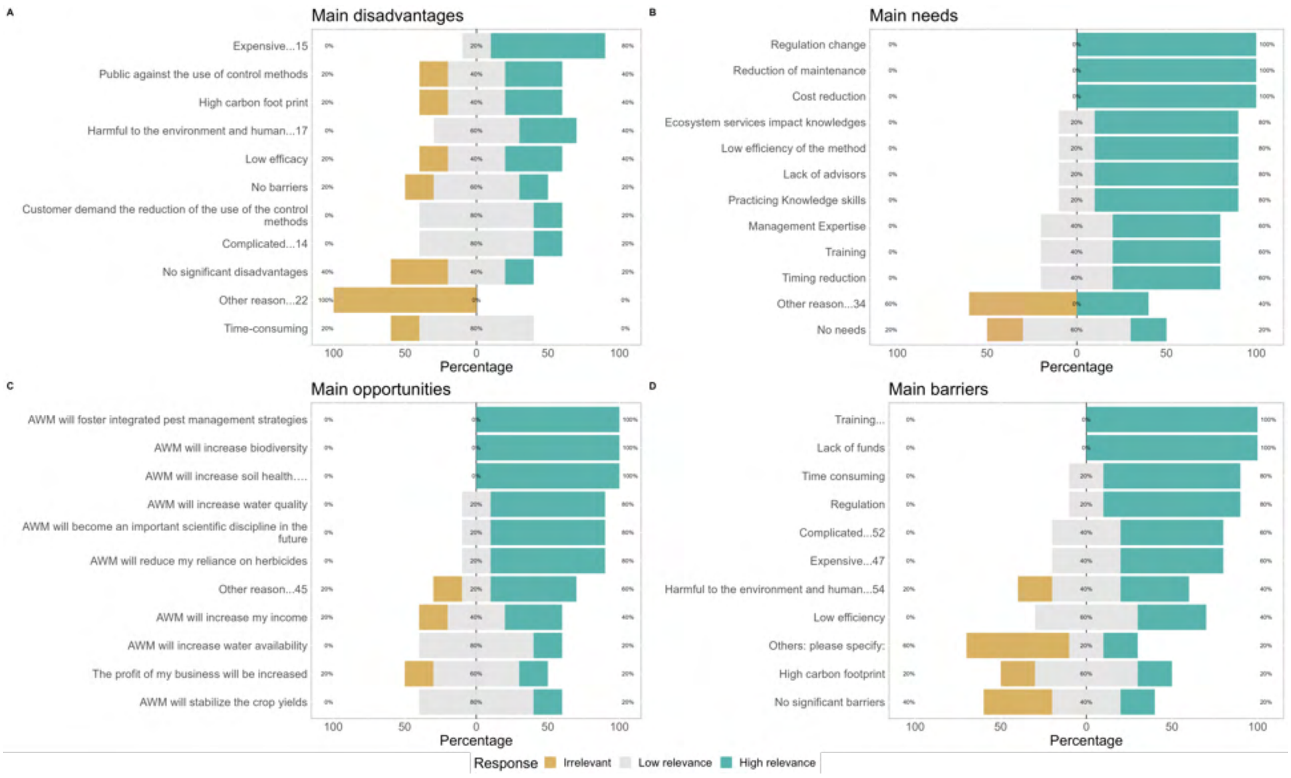


Figure 211. Main disadvantages, needs, barriers and opportunities for intercropping identified by farmers.

3.1.2.1.3.2 Conclusion

Farmers' positive perspective on intercropping underscores its potential as a beneficial AWM. While recognizing its promising opportunities, they also acknowledge the need to address certain requirements and obstacles. Notably, farmers did not perceive any of the queried disadvantages as highly significant. As they continue to explore and implement intercropping, addressing challenges such as time consumption and ensuring efficacy will be essential. Overall, farmers' embrace of intercropping highlights its importance as a sustainable farming strategy with potential benefits for both crop yield and environmental health.

3.1.2.1.4 Mechanical weeding

3.1.2.1.4.1 Advisors

Advisors hold an optimistic perspective on mechanical weeding, perceiving numerous opportunities and few needs, barriers, or disadvantages. Around two-thirds of respondents view this technique as conducive to IPM strategies and enhancing ecosystem services like water quality improvement, while also acknowledging its potential to reduce reliance on herbicides. Moreover, half of the advisors recognize its capacity to provide other ecosystem services such as increasing water availability, biodiversity, and soil health, and foresee its role as an emerging scientific discipline. Interestingly, a majority of advisors do not see mechanical weeding as presenting significant needs, with only half considering ecosystem services impact knowledge, practicing knowledge skills, and management expertise as pertinent requirements. Similarly, only 50% of respondents regard time consumption as a noteworthy barrier. Furthermore, none of the queried disadvantages are deemed significant by at least half of the surveyed advisors; only one-third consider high carbon footprint and expense as relevant drawbacks.

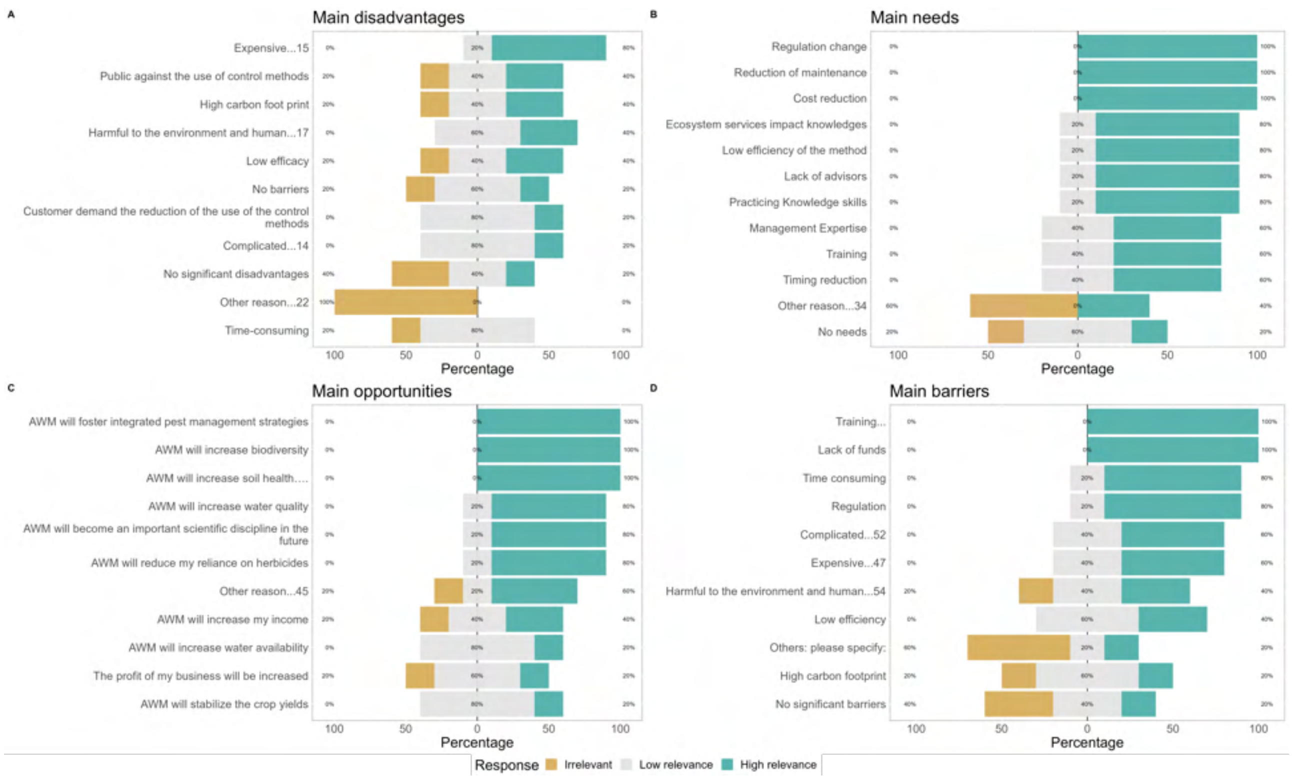


Figure 212. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by advisors

3.1.2.1.4.2 Farmers

Farmers, aligning with advisors, view mechanical weeding as a promising technique, acknowledging almost all of the queried opportunities as relevant while recognizing some needs and barriers, and virtually none as disadvantages. Over 90% of respondents believe that mechanical weeding will foster IPM strategies and provide essential ecosystem services such as improved water quality, biodiversity, and soil health. Additionally, 83% of farmers see its potential to increase water availability and reduce herbicide reliance, with three-quarters anticipating its evolution into an important scientific discipline. More than half of the respondents also perceive benefits such as crop yield stabilization and increased business profitability upon its implementation. Timing reduction is unanimously regarded as the primary need by nearly 70% of respondents, with the same proportion indicating that this practice faces no significant barriers. Similarly, farmers do not view any relevant disadvantages associated with its use.

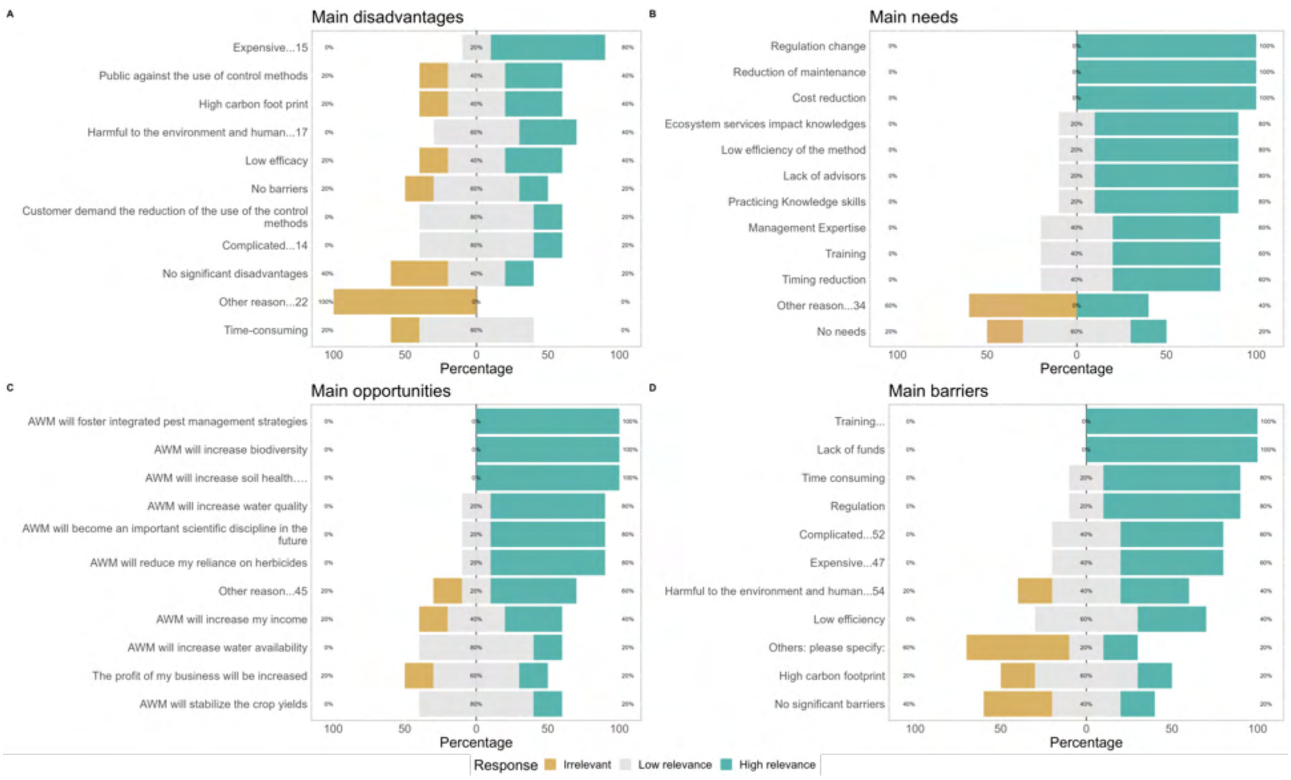


Figure 213. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by farmers.

3.1.2.1.4.3 Industry

Industry representatives, as farmers and advisors, considered mechanical weeding as a promising AWM practice, as they identify several opportunities related to its use, yet they recognize relevant needs and barriers and few disadvantages to its implementation. They unanimously acknowledge its potential to foster IPM strategies, provide various ecosystem services such as enhancing biodiversity and soil health, and even foresee its evolution into a significant scientific discipline. Additionally, nearly 70% of respondents believe that mechanical weeding will enhance water quality and reduce reliance on herbicides. Among the main needs identified by industry representatives are practicing knowledge skills, management expertise, and reducing costs and timing, while barriers include complexity, time consumption, training, regulatory challenges, and lack of funds. Interestingly, industry representatives highlight time consumption as the most significant disadvantage associated with mechanical weeding.

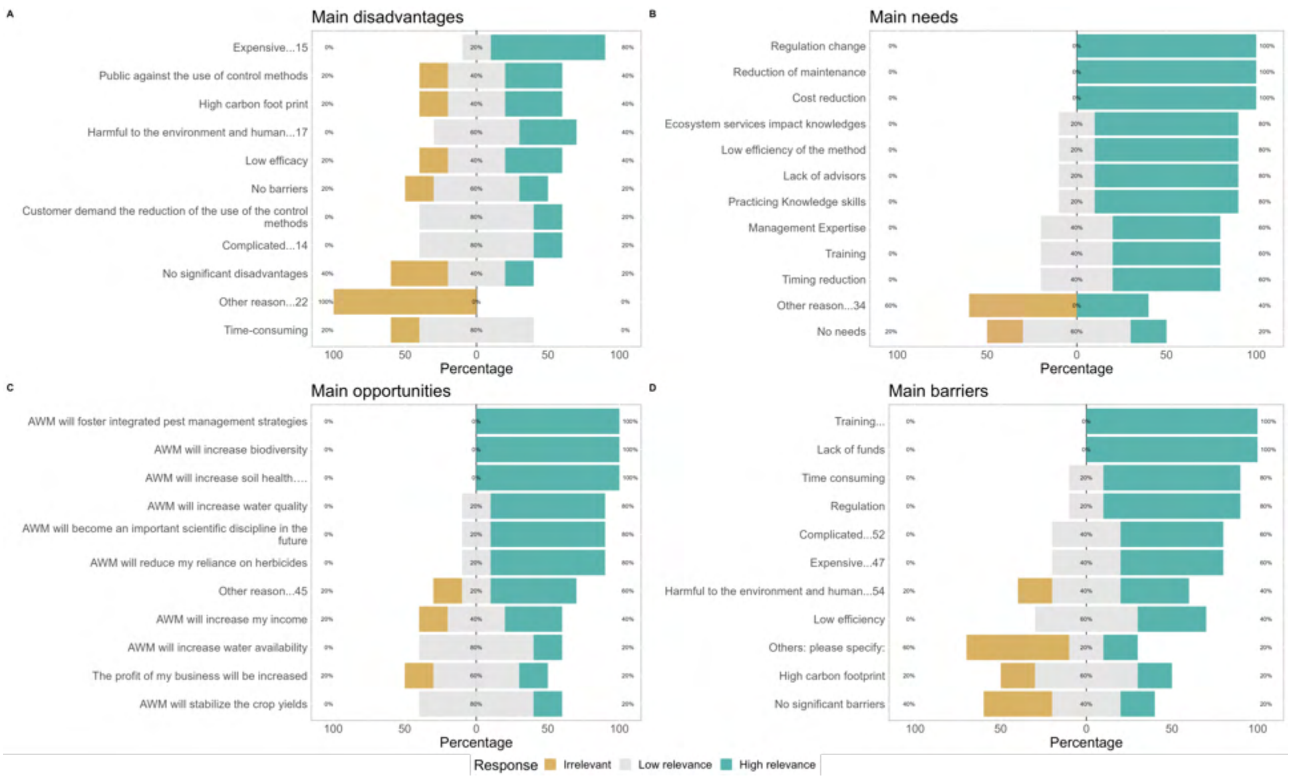


Figure 214. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by industry.

3.1.2.1.4.4 *Researchers*

Researchers held a more conservative perspective on mechanical weeding compared to other stakeholders, as they did not widely regard any of the queried opportunities, needs, barriers, or disadvantages as highly relevant for this practice. Among the main opportunities, 60% of researchers highlighted its potential to reduce herbicide reliance, while 40% emphasized its capacity to evolve into a significant scientific discipline and its role in stabilizing crop yields. In terms of needs, researchers did not identify any single requirement as paramount; rather, 40% of respondents cited lack of advisors, practicing knowledge skills, and cost and timing reduction as relevant necessities. Similarly, only 40% of respondents viewed training as the primary barrier, with high carbon footprint identified as the main disadvantage for implementing mechanical weeding.

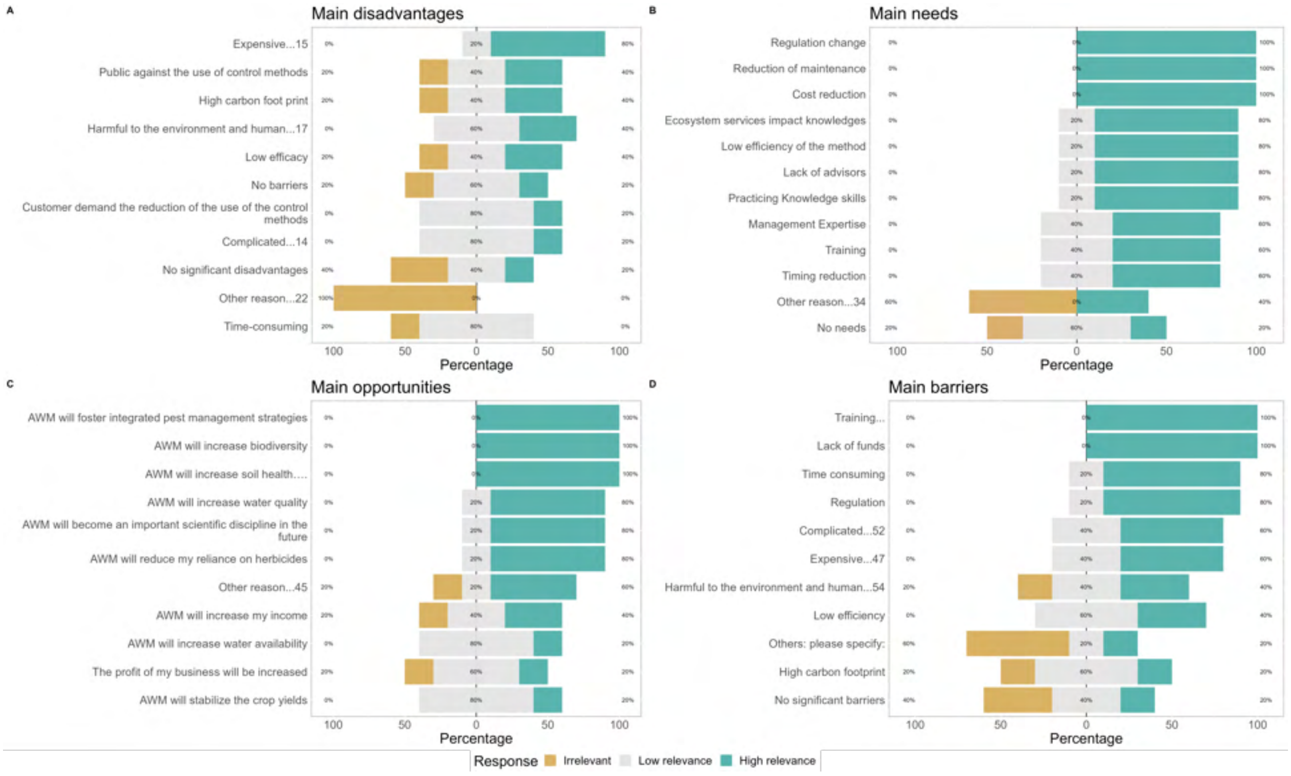


Figure 215. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by researchers.

3.1.2.1.4.5 Conclusion

Advisors, farmers, and industry representatives view mechanical weeding as a promising AWM practice, citing numerous opportunities and minimal needs, barriers, and disadvantages. In contrast, researchers did not widely recognize any of the queried aspects as significant for mechanical weeding. The stakeholders highlighted the potential of this technique to foster IPM strategies and provide essential ecosystem services like improved biodiversity, water quality, and soil health. They also anticipate its role in reducing herbicide reliance and foresee its evolution into a crucial scientific discipline. Farmers, in particular, expressed the most optimism regarding mechanical weeding.

Stakeholders did not identify numerous needs for mechanical weeding. Advisors stressed the importance of ecosystem services impact knowledge, while farmers emphasized timing reduction. Industry representatives and researchers cited practicing knowledge skills, and cost and timing reduction as crucial needs. None of the queried barriers were widely regarded as significant across stakeholder groups. Time consumption was highlighted by advisors and industry representatives, while training was considered important by researchers. Remarkably, farmers did not perceive any significant barriers to mechanical weeding. Similarly, none of the disadvantages were considered significant by a sufficient proportion of respondents in each stakeholder category. Advisors mentioned high carbon footprint and expense, industry representatives pointed out time consumption, and researchers highlighted high carbon footprint. Once again, farmers did not identify any significant disadvantages associated with its use.

3.1.2.1.5 Mowing

3.1.2.1.5.1 Advisors

Advisors considered mowing a promising practice, emphasizing numerous opportunities while recognizing relevant needs and few barriers and disadvantages for its implementation. Two-thirds of the respondents believed that mowing fosters IPM strategies, provides essential ecosystem services, including increases in biodiversity, has the potential to become a key scientific discipline in the future, increases business profitability, and stabilizes crop yields. Regarding primary needs, nearly 70% identified ecosystem services impact knowledge, practicing knowledge skills, and cost reduction as highly relevant. Additionally, one-third of the respondents considered cost reduction, low efficiency of the method, and lack of advisors, among others, as relevant requirements. Training was deemed a relevant barrier by 67% of respondents, while low efficiency of the method, time consumption, lack of funds, and regulatory challenges were considered relevant by 33% of them. None of the queried disadvantages was considered significant by more than half of the respondents. One-third of them viewed customer demand to reduce or eliminate its use, expense, and time consumption as relevant. Notably, the same proportion of respondents regarded mowing as having no barriers and no significant disadvantages.

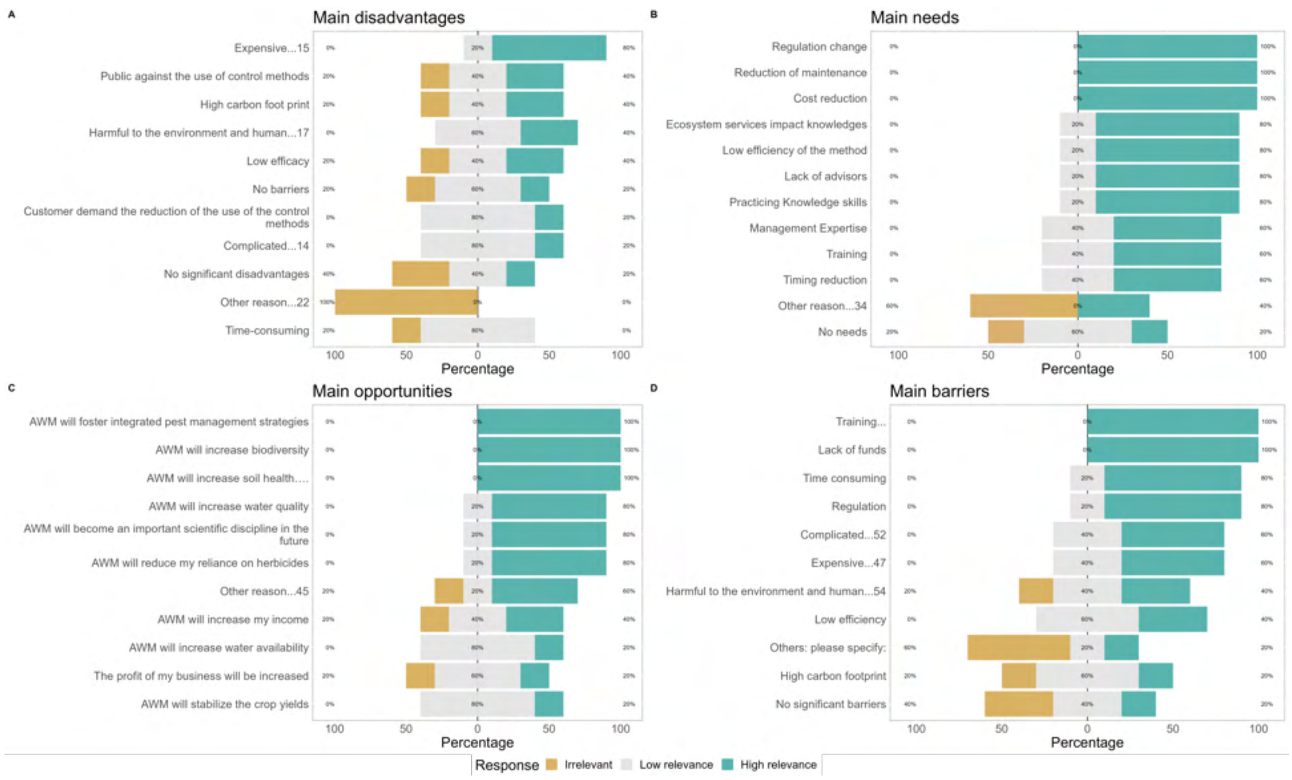


Figure 216. Main disadvantages, needs, barriers and opportunities for mowing identified by advisors.

3.1.2.1.5.2 Farmers

Farmers express a positive perspective regarding mowing, recognizing numerous opportunities and presenting few relevant necessities and virtually no disadvantages or barriers of importance. They view mowing as an ecosystem services provider, improving soil health (88%), biodiversity (75%), and increasing water quality (62%) and availability (50%). Moreover, nearly 90% of respondents recognize its potential to evolve into an important scientific discipline, while 75% believe it will reduce herbicide reliance and 62% consider it will foster IPM strategies. Regarding main needs, 62% of farmers consider practicing knowledge skills and timing reduction as highly relevant, with 38% emphasizing cost reduction as an important requirement. None of the queried barriers was considered significant by a relevant proportion of respondents; according to 38% of respondents, the most relevant factor was that the method faces no significant barrier. Similarly, 38% of farmers considered that mowing entails no significant disadvantages.

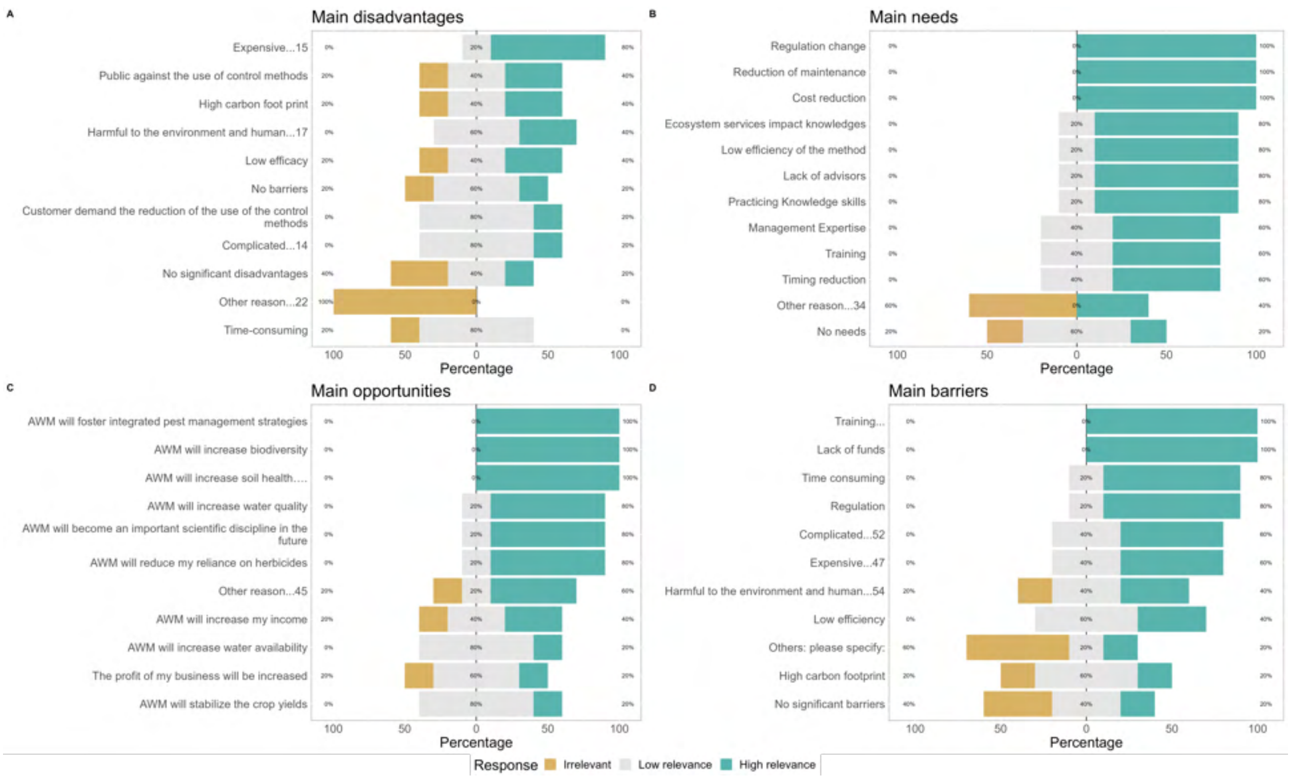


Figure 217. Main disadvantages, needs, barriers and opportunities for mowing identified by farmers.

3.1.2.1.5.3 *Policy makers*

Policy makers' perspective on mowing was more conservative compared to that of other stakeholders. Despite acknowledging numerous opportunities, they recognize relevant needs and face some important barriers while considering the method free of considerable disadvantages. Policy makers view mowing as an ecosystem services provider, with three-quarters believing it will enhance water quality, biodiversity, and soil health. Similarly, the same proportion of respondents anticipates a reduction in herbicide reliance with its implementation. Timing reduction was deemed the primary need by 67% of respondents, while virtually, the remaining requirements were considered highly relevant by 33%. Nearly 70% of policy makers identified time consumption and lack of funds as the most relevant barriers, yet the same proportion believed the technique faces no significant barriers. None of the queried disadvantages was deemed relevant by a sufficient proportion of policy makers, with only one-third expressing concerns about customer demands to reduce mowing use, high carbon footprint, method's low efficacy, expense, and time consumption.

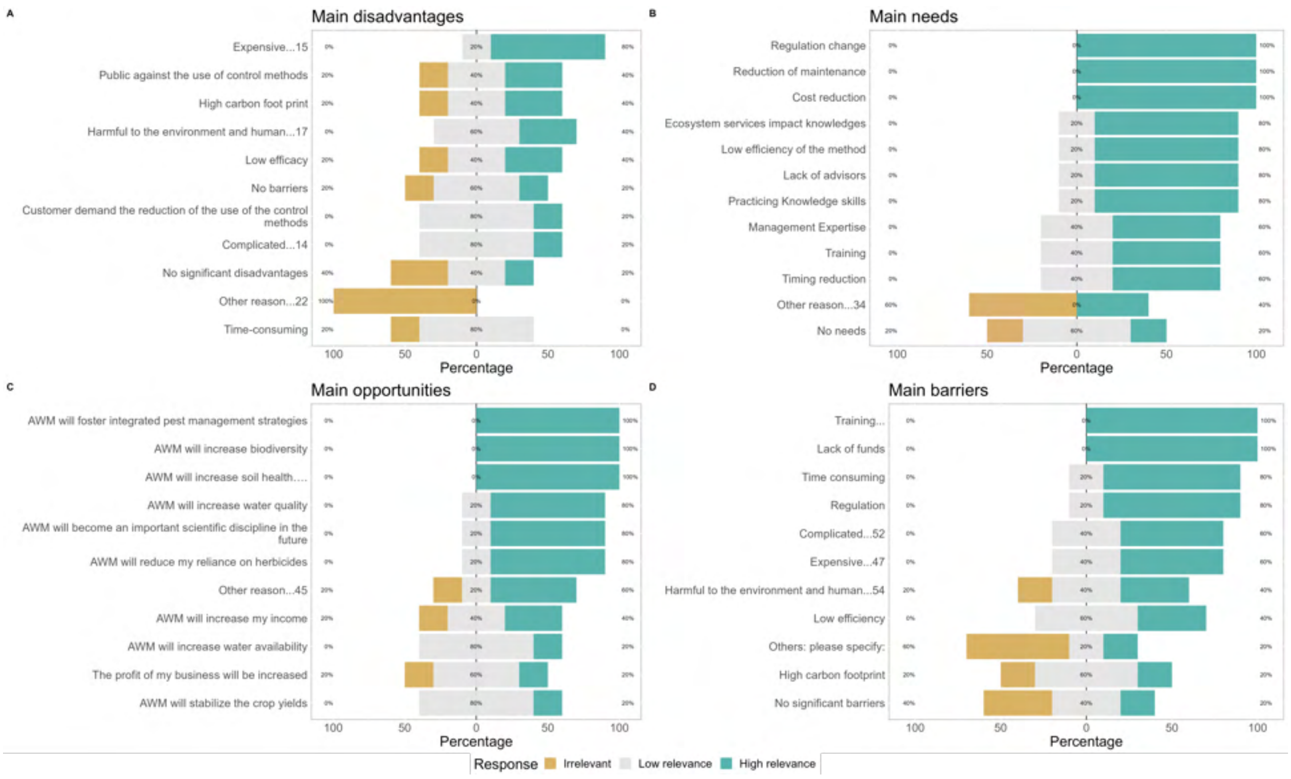


Figure 218. Main disadvantages, needs, barriers and opportunities for mowing identified by policy makers.

3.1.2.1.5.4 Researcher

Researchers, similar to policy makers, adopt a cautious stance towards mowing, recognizing some relevant opportunities while acknowledging that the method faces few but relatively significant needs, barriers, and some disadvantages. Sixty percent of respondents acknowledge that mowing improves soil health and reduces herbicide reliance, while forty percent consider it beneficial for increasing water quality, biodiversity, and its potential as a scientific discipline. Lack of advisors (60%) is highlighted as the primary need, followed by 40% of respondents who identify low efficiency, cost, and timing reduction as relevant needs. Time consumption emerges as the main barrier for 60% of respondents, aligning with the expressed needs, while low efficiency is also considered significant. Similarly, sixty percent of respondents identify low efficacy as the main disadvantage.

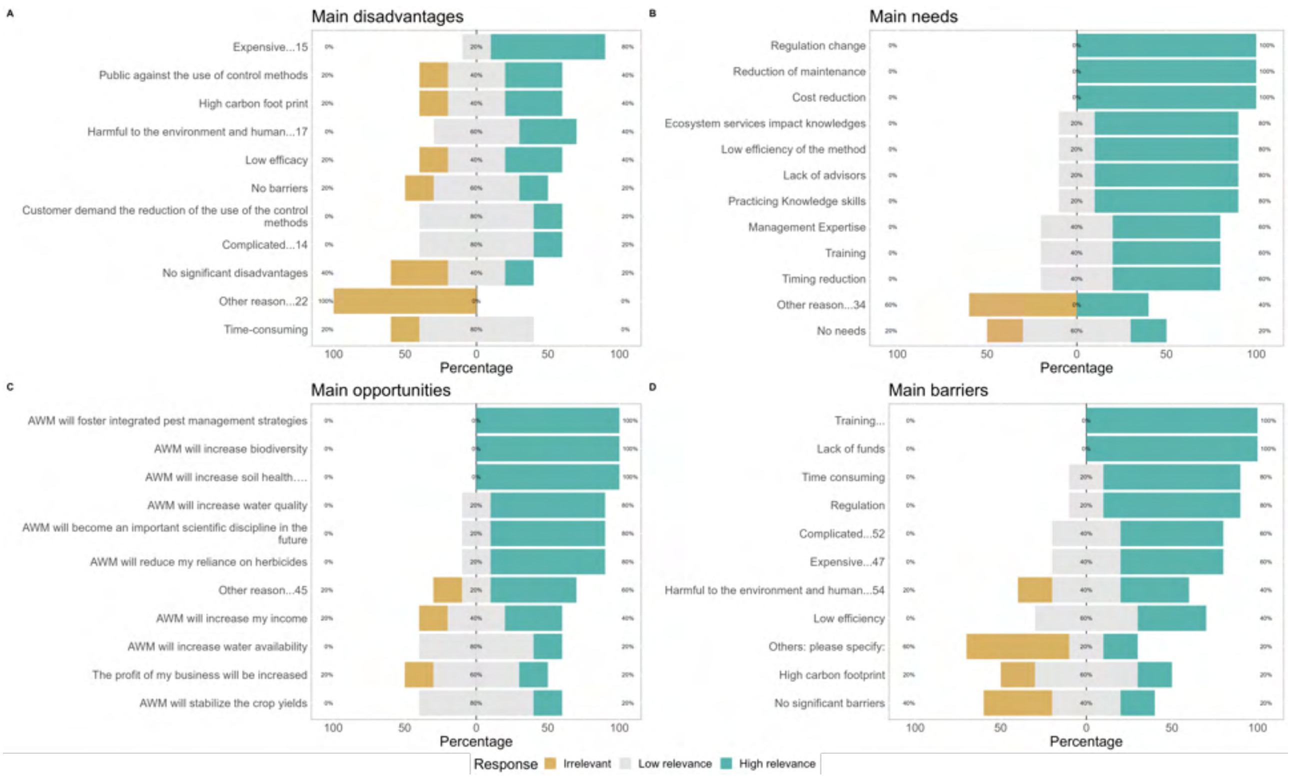


Figure 219. Main disadvantages, needs, barriers and opportunities for mowing identified by researchers.

3.1.2.1.5.5 Conclusion

Advisors and farmers view mowing as a promising practice, highlighting its numerous opportunities while recognizing few but relevant necessities and virtually no disadvantages or barriers to implementation. In contrast, policy makers and researchers take a more cautious stance toward mowing, acknowledging some opportunities but emphasizing significant needs, barriers, and virtually no disadvantages. Both advisors and farmers believe that mowing fosters IPM strategies and provides essential ecosystem services, such as increased biodiversity, with potential for further development into a scientific discipline. Policy makers acknowledge the provision of ecosystem services, particularly improvements in soil health, and emphasize the opportunity to reduce herbicide reliance. Advisors prioritize ecosystem services impact knowledge as a relevant need, while practicing knowledge skills and cost reduction are important for both advisors and farmers. Timing reduction emerges as a relevant need across all stakeholder groups, with farmers, policy makers, and researchers emphasizing its importance. Advisors identify training as the most significant barrier, while policy makers emphasize time consumption, lack of funds, and regulatory challenges. Researchers highlight time consumption as the primary impediment. Additionally, researchers are unique in considering low efficiency as a significant drawback, with less than 40% of respondents from each stakeholder group considering other categories as relevant, such as expense, time consumption, and customer demand to reduce mowing use.

3.1.2.1.6 Site-specific spraying

3.1.2.1.6.1 Farmers

Farmers hold an optimistic view of site-specific spraying, recognizing abundant opportunities and minimal disadvantages while identifying key needs and barriers. Two-thirds of respondents believe that site-specific spraying fosters IPM strategies and acts as an ecosystem services provider, enhancing soil health, biodiversity, and water quality and availability. Nearly 70% of farmers prioritize ecosystem services impact knowledge and training as essential needs. However, they also acknowledge regulatory challenges and expense issues as primary barriers. Consistently, farmers unanimously agree that expense is the main disadvantage associated with the method.

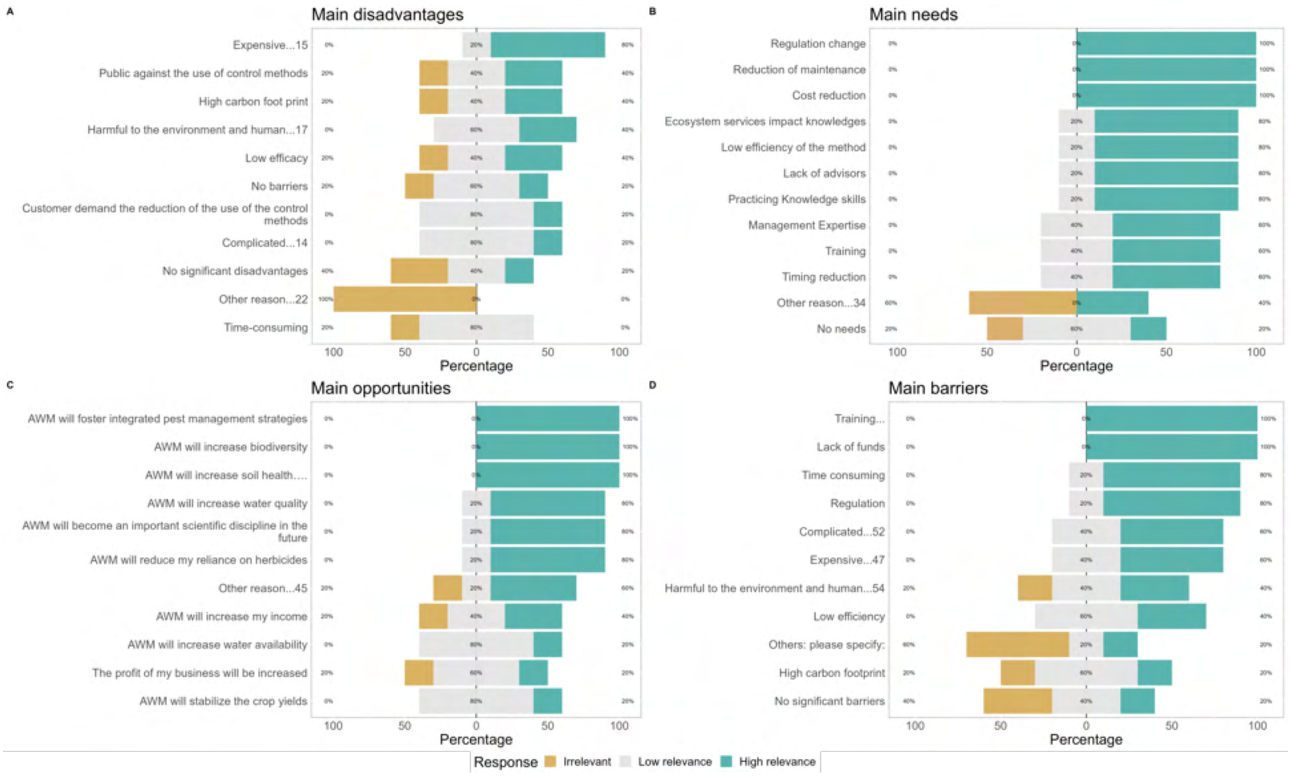


Figure 220. Main disadvantages, needs, barriers and opportunities for site-specific spraying identified by farmers.

3.1.2.1.6.2 Conclusion

Farmers express optimism about site-specific spraying, they prioritize ecosystem knowledge and training while recognizing regulatory and expense challenges. Overall, they unanimously agree on expense as the main disadvantage.

3.1.2.2 *Surveys*

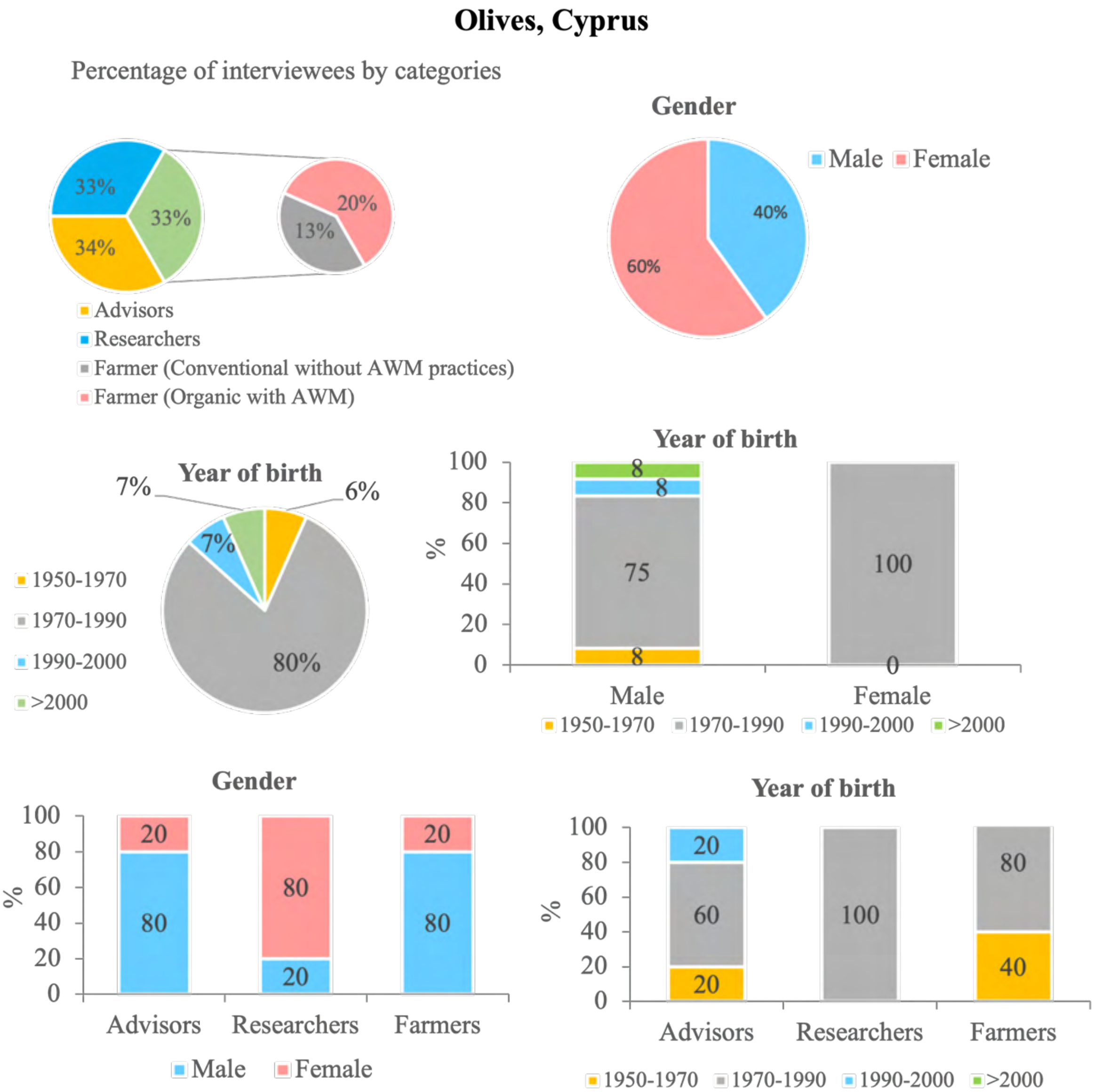


Figure 221. Interviewees description in the Olives Living Lab (Cyprus)

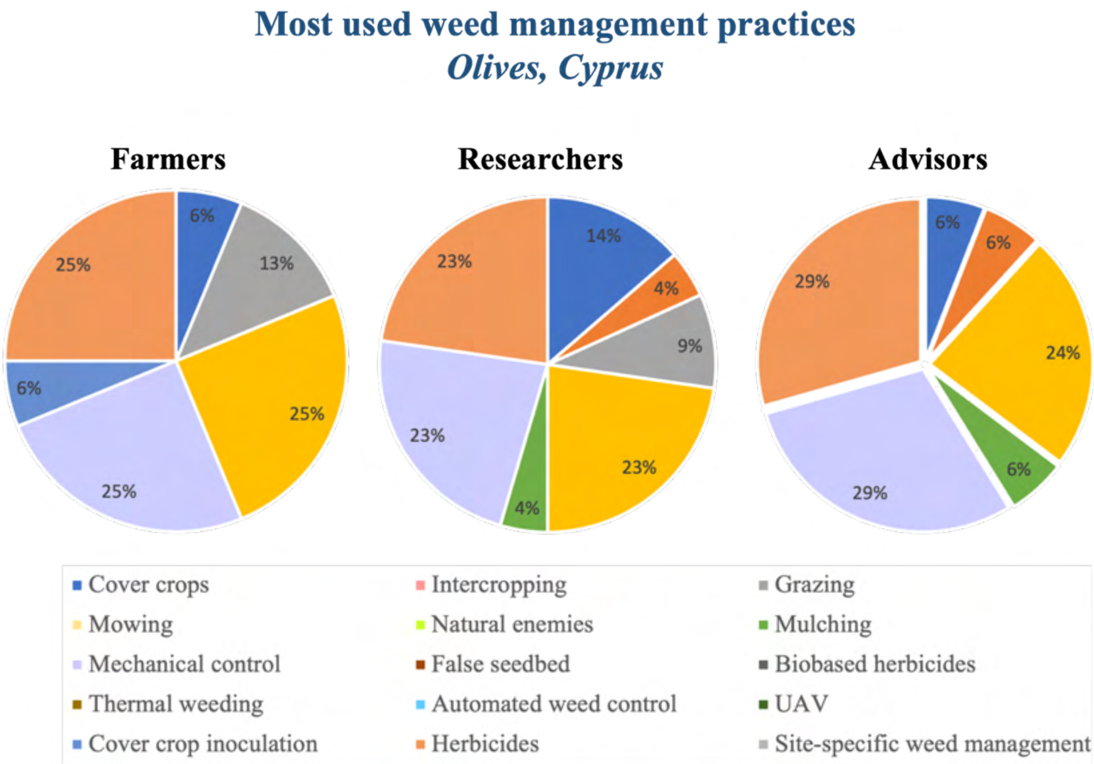


Figure 222. Most used weed management practices in the Olives Living Lab (Cyprus)

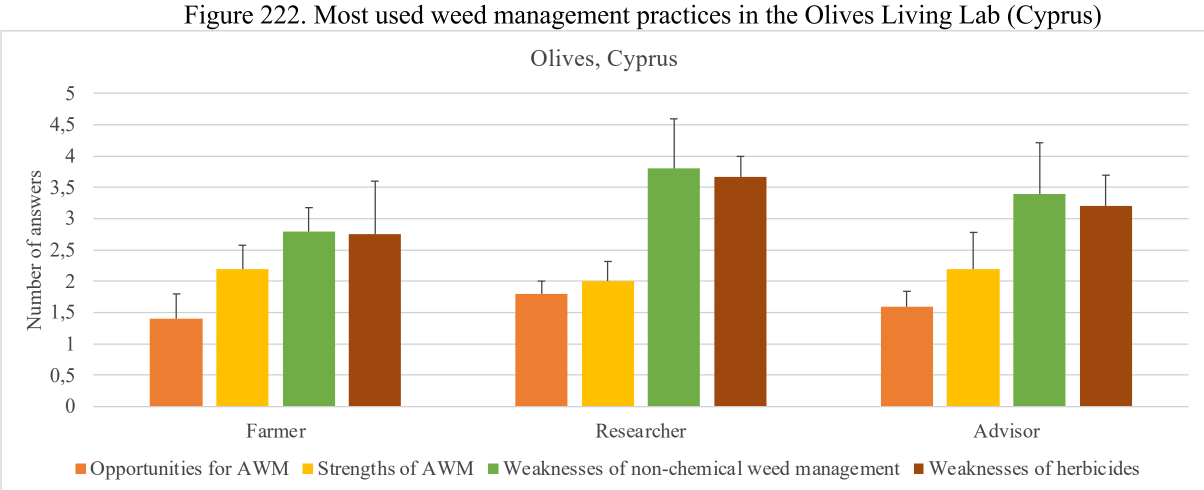


Figure 223. Mean number of answers (±se) per stakeholder group in the Olives Living Lab (Cyprus)

Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: Presented in the figure below.

THREATS: None.

WEAKNESSES: None.

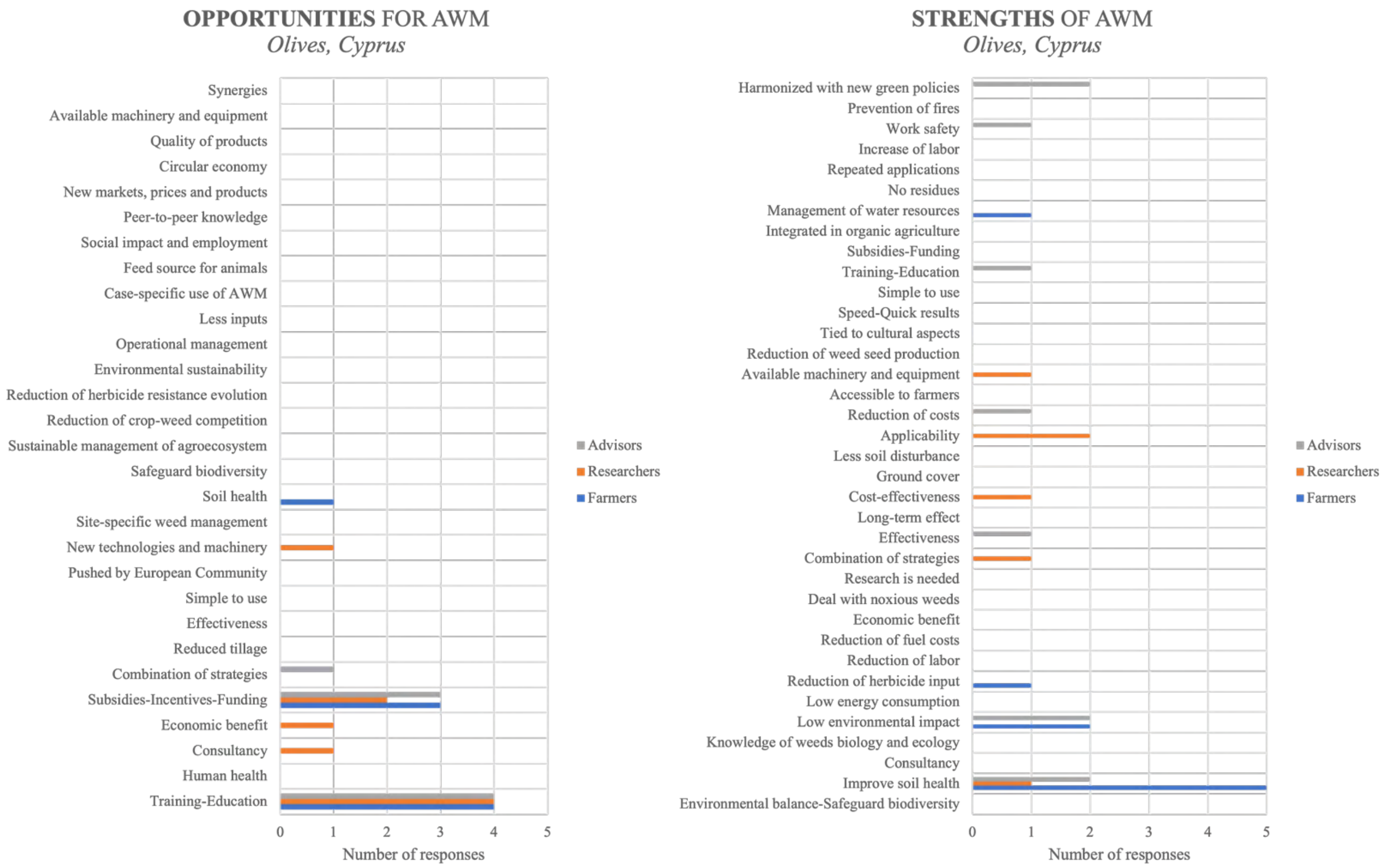


Figure 224. Opportunities and strengths of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: Only one farmer mentioned climate change and weather conditions.

WEAKNESSES: Presented in the figure below.

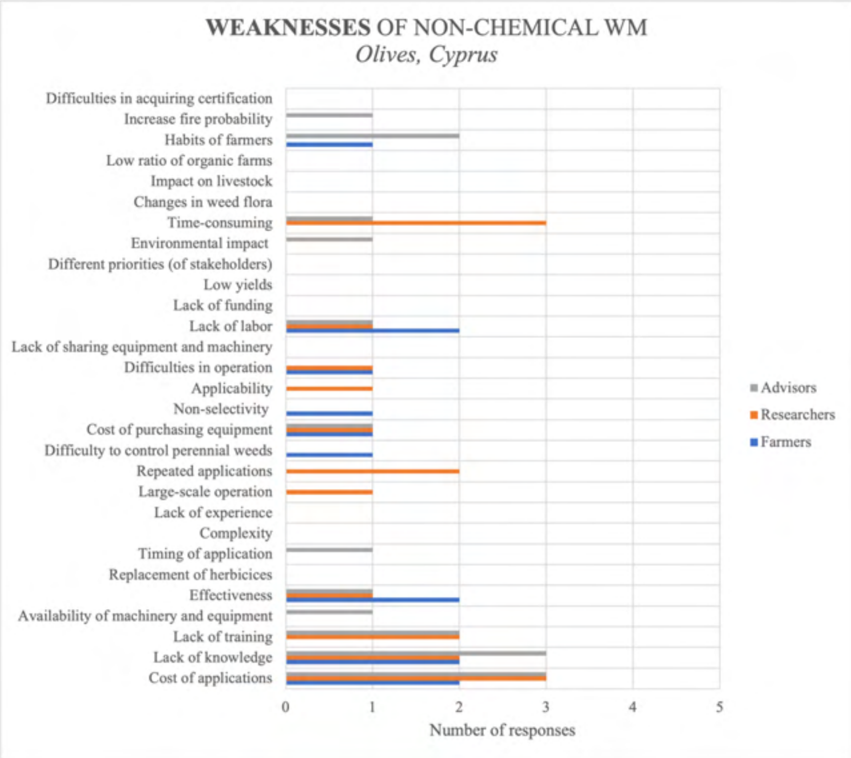


Figure 225. Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: None.

STRENGTHS: There were a few answers, though, covering several strengths. Quick results, not labour intensive, simple to use, low cost, optimized treatment and selectivity were among them.

THREATS: Researchers identified the markets and lack of new herbicides and the withdrawal of existing active ingredients are threats for herbicides.

WEAKNESSES: Presented in the figure below.

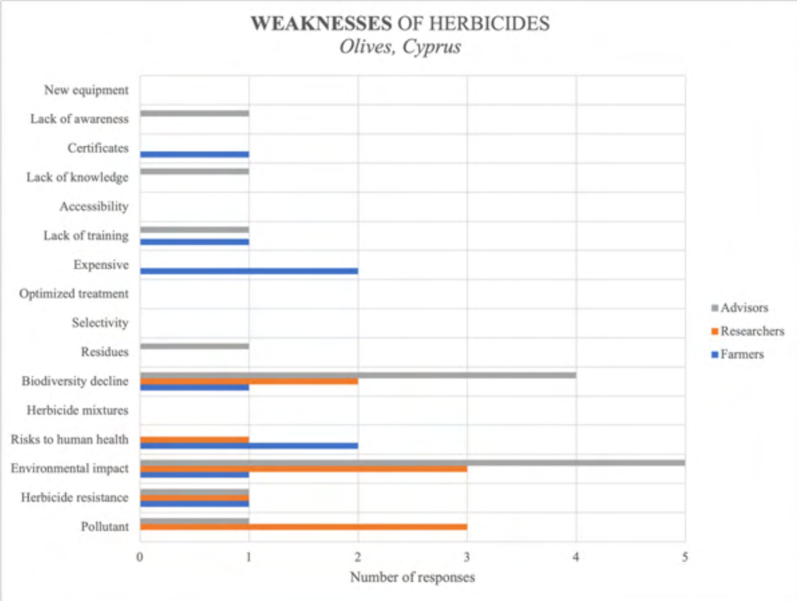


Figure 226: Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – OLIVES, CYPRUS
Most used weed management practices: Weed management in olive cultivation in Cyprus is mainly done by mechanical means, mowing and herbicides. There is an increase in the use of grazing. The use of cover crops, especially during the summer months, remains operationally difficult as it increases the complexity of decision making and also involves fire risks due to the high dry matter. **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group:** All three types of stakeholders provided about the same number of responses. An important point is the highlighting of several weaknesses of herbicides, which shows both the awareness around their use, but also the weaknesses of non-chemical herbicides, suggesting that research and further knowledge is needed to justify this transition. **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: It was widely accepted that agroecology and agroecological weed management combine and improve education and training around new practices and approaches. Education, primarily of producers and advisors, is an opportunity for the primary sector as it is combined with a radical transformation of the agri-food sector based on agroecological principles. In addition, the adoption of agroecological practices goes hand in hand with a reform of financial support and can lead to an increase in subsidies and financial

incentives. The greatest strength for AWM is considered the improvement of soil health. No weaknesses and threats were identified.

Threats, and weaknesses for non-chemical weed management: The weaknesses of non-chemical weed management mainly revolve around lack of education and training, lack of knowledge, and lack of workers. At the operational level, effectiveness, the time-consuming nature of some practices, and the cost of applications are negative factors.

Opportunities, strengths, weaknesses, and threats for herbicides: Herbicides have been identified as pollutants, leading to a decline in biodiversity and having a significant negative environmental impact. However, a few responses also highlighted that their use brings quick results, they are selective and do not require much labour. Risks to herbicides were only identified by researchers who highlighted the removal of active ingredients from the market and the lack of new herbicides.

3.1.2.3 Living lab board meeting

The first annual virtual meeting with the LL Board took place on Tuesday 28th November 2023 at 5:00 pm at the Cyprus University of Technology. The meeting was attended by 13 Board Members. All Board Members expressed their interest, concerns and expectations about the Living Labs. Agroecological products can be promoted in local markets after proper training and information to stakeholders. GOOD project implementation is the first case of agroecological management methods application, and the expected information dissemination and trainings are needed. The regional agri-food value chain could be sustainable if citizens are educated at an early age about the importance of agroecological practices. Chemical herbicides are applied twice a year, mostly post-emergence in olive orchards in Cyprus. While some herbicides are effective, they pose a risk to human health and the environment. Alternatives to herbicides are equally effective, especially in integrated crop management systems. However, herbicides interfere with natural environment functions, reducing biodiversity and polluting groundwater. The Board of the Living Lab in Cyprus has discussed the needs and barriers to agroecological transition and adopting agroecological weed management practices. They suggested informing all stakeholders, providing financial incentives for farmers to purchase necessary equipment, organizing workshops and conferences to educate farmers about the benefits of agroecological practices, and providing certification for farmers who apply these practices. Barriers to agroecological implementation include the lack of appropriate machinery, farmers refusal to implement new practices, and the absence of demonstration sites to prove the effectiveness of agroecological practices. They also suggested a redefinition of policies to prioritize these agroecological approaches. The Board Members feel confident in adopting agroecological weed management practices, as they have been successful in organic olive farming. They also discussed the main drivers of weed dispersal, major weeds per cropping scenario and herbicide-resistant weeds in their area. They proposed the sustainability of the Living Labs and the continued positive results of agroecological weed management practices. During the LL board meeting, this information was also collected:

What are the market characteristics of olives?	1. How many farmers cultivate olives in the region Sia-Kornos and Klavdia? Is it mostly monoculture or can rotations be made with other crops?
	In the region of Klavdia there are 3 large-scale olive growers. The olive orchards in Cyprus are about 13.500 hectares and constitute approximately 37% of the permanent crops. It is mainly monoculture but can be intercropped. For example, some cover crops, such as vetch, can be sown between the lines.
	2. How many products are derived from the olives? Are they important for the economy and/or food security?
	Multiple olive products are produced in Cyprus that have an important socioeconomic impact. The most important products are olive oil, table olives of various varieties and processing types and olive paste. In addition, several cosmetic and therapeutic products, such as soaps and creams, are also produced from olives. In addition, olive pomace, after processing and removal of the pomace oil, can be used as a biofuel and potentially as biofertiliser (not yet available).
	3. Do you think that agroecological products could be promoted in local markets?
	Agroecological products could be promoted on local markets after the appropriate training and information of all stakeholders. It is very important to ensure that consumers are properly informed about the importance of agroecological products.
	4. Do you believe that the region has a lack of technologies?
	In Cyprus there is a lack of agroecological management methods. However, after proper information and training of producers, they can be easily applied in olive orchards. The GOOD project is a great start for all stakeholders to see the important effects of agroecological practices on the economy, the environment and society.
	5. Is the regional agri-food value chain sustainable?

	The regional agri-food value chain could be sustainable if we start the education/information of citizens at an early age, e.g. secondary school.
What are the most common agricultural and weed management practices in olives?	1. What are the most common agronomic practices in olives?
	The most common agronomic practices are pruning, irrigation, insecticides and olive harvesting. Recently applications of CaCO3 are becoming a tendency to combat high temperatures and UV irradiation on plants and drupes. Also, mineral nutrition of olive orchards is applied, i.e. fertilization. Various plant protection products are used to manage mainly pests (insects). In addition, weeds are managed chemically or mechanically.
	2. What are the most common weed management practices in olives?
	The most common weed management practices for olive trees in Cyprus are the use of chemical herbicides, tillage, mowing and mulching. One member proposed the use of aromatic plants within the rows of Olive orchards. All members agreed with the use of legumes within the rows.
What is the herbicide use in olives?	1. How many active ingredients there are available? How many different mode of actions?
	The active ingredients that are available and applied in Cyprus for the control of weeds in olive orchards are the following: 5 - glyphosate, glyphosate + MCPA, oxyfluorfen, pyraflufen-ethyl, tribenuron. There are 7 different mode of actions.
	2. How many times do you spray in-season?
	In conventional olive groves, chemical herbicides are applied twice a year.
	3. Do you use pre-emergence, post-emergence or both herbicides?
	Mainly post-emergence herbicides are used.
	4. Are herbicides efficient?
	Some chemical herbicides are effective if used correctly and according to label instructions. However, they remain a hazard to human health and the environment.
	5. Do you think that alternatives to herbicides are equally efficient?
	Alternatives to herbicides are equally effective, especially in olive trees, and can effectively participate in the integrated crop management system. One of the members expressed the opinion that herbicides are economically preferable, but the other members managed to oppose his opinion and the AWM prevailed.

	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?
	Herbicides belong to the category of agrochemical formulations and are agents that interfere with physiological functions of the natural environment. Therefore, their use to any level has an impact on the natural environment, reduces biodiversity, pollutes groundwater, and reduces soil microbiota.
	7. Do you believe that agriculture without herbicides is viable?
	All board members agree that agriculture without herbicides is viable if all farmers adopt agroecological approaches. Two members are already using the AWM and manage to convince all members for AWM benefits.
What are the needs and barriers to assist agroecological transitions & adopt agroecological weed management approaches?	1. What is needed to boost the uptake of agroecological practices?
	Inform, discuss and co-operation of all stakeholders (producers, researchers, policy makers, consultants and industry workers) about agroecological management practices. Also, the State could help in the adoption of agroecological management practices if financial incentives are provided to farmers to purchase the necessary equipment. In addition, the Department of Agriculture could help by organizing workshops and conferences to inform and educate farmers about the benefits of agroecological practices. Also, through the Living Labs, farmers would see in practice the positive results of agroecological management practices, and it would be easier to implement them. Moreover, it would be right for farmers who apply agroecological management practices to be provided with some kind of certification (label) on their products to help them to be supported by consumers.
	2. What are the barriers towards agroecology implementation?
	The barriers to the implementation of agroecological practices in Cyprus are mainly the lack of appropriate machinery and the refusal of farmers to implement and be trained in alternative practices. Also, an important barrier is the lack of living labs to prove the effectiveness of agroecological practices. Moreover, more labor hours will be needed to implement agroecological management practices.
	3. Should policies need be redefined to allow agroecological transitions?
	Yes, policies need to be redefined in a way that prioritizes the agroecological approaches that are suitable for the Cyprus climatic conditions, soil properties and weeds occurrences.

	4. How confident you feel about the adoption of agroecological weed management practices?
	All the members of the Board feel confident in adopting agroecological weed management practices, because in organic olive farming, where some agroecological practices have already been applied, they have been highly effective.
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	1. What are the main drivers of weed dispersal?
	The main drivers of weed dispersal are agricultural machinery, animals (e.g. birds) and wind.
	2. Which are the major and most noxious weeds in your area?
	The major and most noxious weeds in the areas where the Living Labs are located are perennial and grassy weeds. Some examples are below: *Solanum nigrum, Solanum villosum, Sinapis arvensis, Conyza sp., Amaranthus blitoides, Amaranthus powellii, Juncus effusus, Ecballium elaterium, Portulaca oleracea.*
	3. Are there any herbicide resistant weeds?
	There are several weeds that have developed resistance due to incorrect and indiscriminate use of herbicides on crops in previous years. One typical example of herbicide resistant weed is the *Conyza sp.*
	4. Do you know any invasive plants in your area?
	No, there are no invasive plants in the areas where the Living Labs are located.
What do you think about the Living Lab?	1. Which proposals do you have for a good performance of the LL?
	Some suggestions presented by all the members of the Board for the good performance of the Living Labs were: • Faithful implementation of agroecological practices and involvement of all stakeholders • To be informed of the insects that exist and will exist during the 4 years of the project, insect population, harmful and beneficial insects. • To create more Living Labs in different areas of Cyprus, from the coast to mountain regions. • To keep in constant touch with all stakeholders and especially with farmers.
	2. Would you like it to remain over time?

	Over time, all members wish for the Living Lab to continue to exist. All menders look forward to seeing the positive results of agroecological weed management practices

3.1.3 Europe

3.1.3.1 Questionnaires

Cypriot and Portuguese stakeholders provided insights regarding AWM in olive culture their respective regions. We considered two practices identified as relevant by enough respondents in at least two countries, herbicides and mechanical weeding. However, we did not gather enough responses from farmers nor industry representatives in any of the practices for both countries. Table 32 presents the types of stakeholders who answered the questionnaires associated with different AWM practices and the number of respondents in each category.

Table 32 Number of responses for each AWM practice and stakeholder category in Olives (Cyprus and Portugal).

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control					1	
Biobased herbicides		1	1			2
Cover crop inoculation to increase competitiveness						1
Cover crops	1	1	1		1	3
False seedbed					1	
Grazing	4	2	3			4
Herbicides	**12**	**12**	19	2	**7**	**14**
Intercropping	1	1	4	1	3	3
Mechanical weeding	**14**	5	13	4	5	**13**
Mowing	4		8		4	5
Mulching	1				1	
Natural enemies		1				1
Other						
Site-specific spraying	4	2	4		1	5
Thermal weeding						1
UAV			1			
n=83	14	15	27	5	7	15

3.1.3.1.1 Herbicides

3.1.3.1.1.1 Advisors

Advisors from Portugal and Cyprus regard herbicides as a relevant AWM practice for olives, recognizing its essential needs, barriers, and disadvantages, while identifying limited opportunities. Among the listed opportunities, none were deemed highly relevant by more than half of the respondents. However, one-third of them perceive herbicides as fostering IPM strategies and potentially reducing herbicide reliance with effective management. Regarding primary needs, nearly seventy percent of respondents collectively from both regions prioritize ecosystem services impact knowledge and access to advisors. Moreover, approximately sixty percent of them highlight the importance of practicing knowledge skills, management expertise, and training, alongside fifty percent who recognize the significance of timing reduction. The principal barrier identified by seventy-five percent of respondents is training, with 67% expressing concerns about environmental and human harm associated with herbicide use. Half of the respondents also consider high carbon footprint and regulatory concerns as notable barriers. The primary disadvantage, according to 83% of respondents, is the potential environmental and human harm caused by herbicide use. Additionally, nearly sixty percent emphasize public demand to reduce or eliminate herbicides as a significant drawback. Interestingly, the same proportion of advisors consider that the practice presents no significant disadvantages.

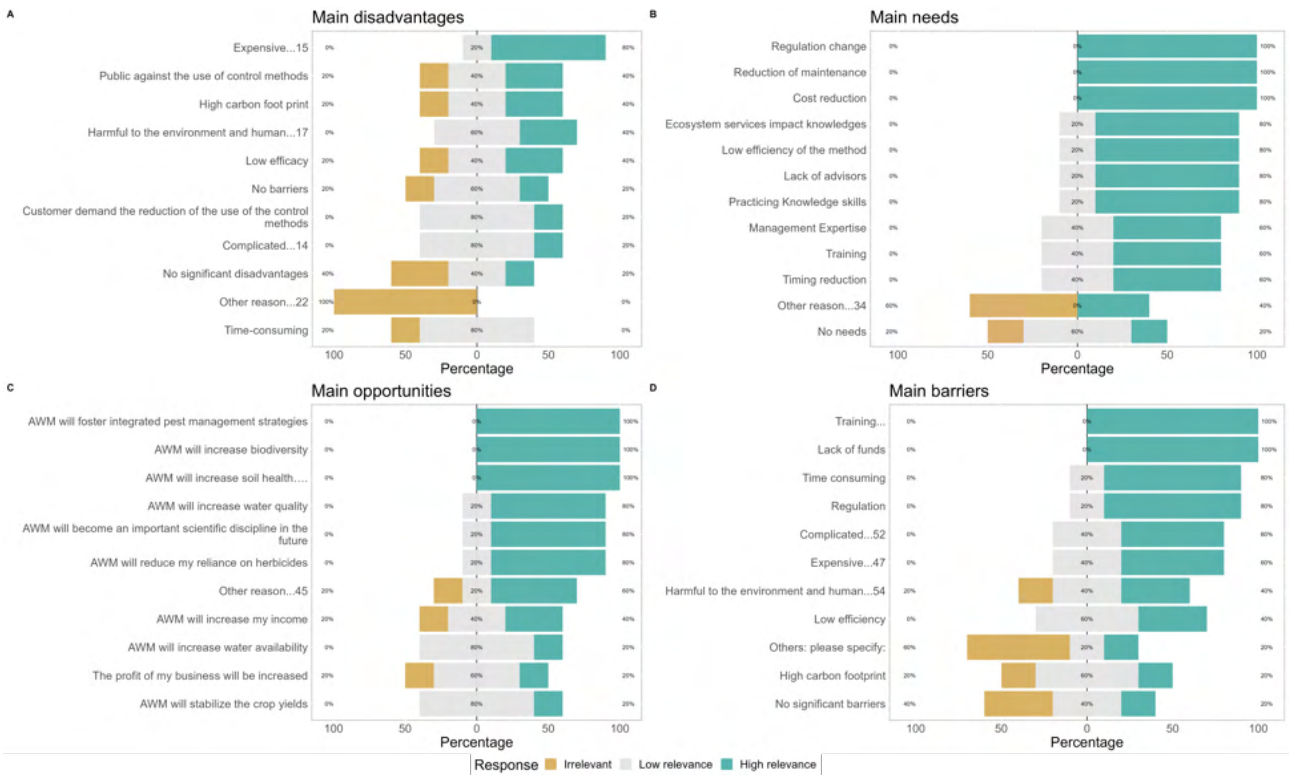


Figure 227 Main disadvantages, needs, barriers and opportunities for herbicides identified by advisors.

3.1.3.1.1.1.1 By country

Advisors from Portugal and Cyprus perceive herbicides as offering limited opportunities. In Portugal, half of the respondents highlight the reduction of herbicide reliance as the primary opportunity, whereas seventeen percent of their counterparts in Cyprus share this perspective. Conversely, one-third of advisors from Cyprus consider increases in biodiversity and water quality as the most relevant opportunities, while the same proportion of Portuguese respondents prioritize economic factors such as increases in income, business profitability, and stabilization of crop yields.

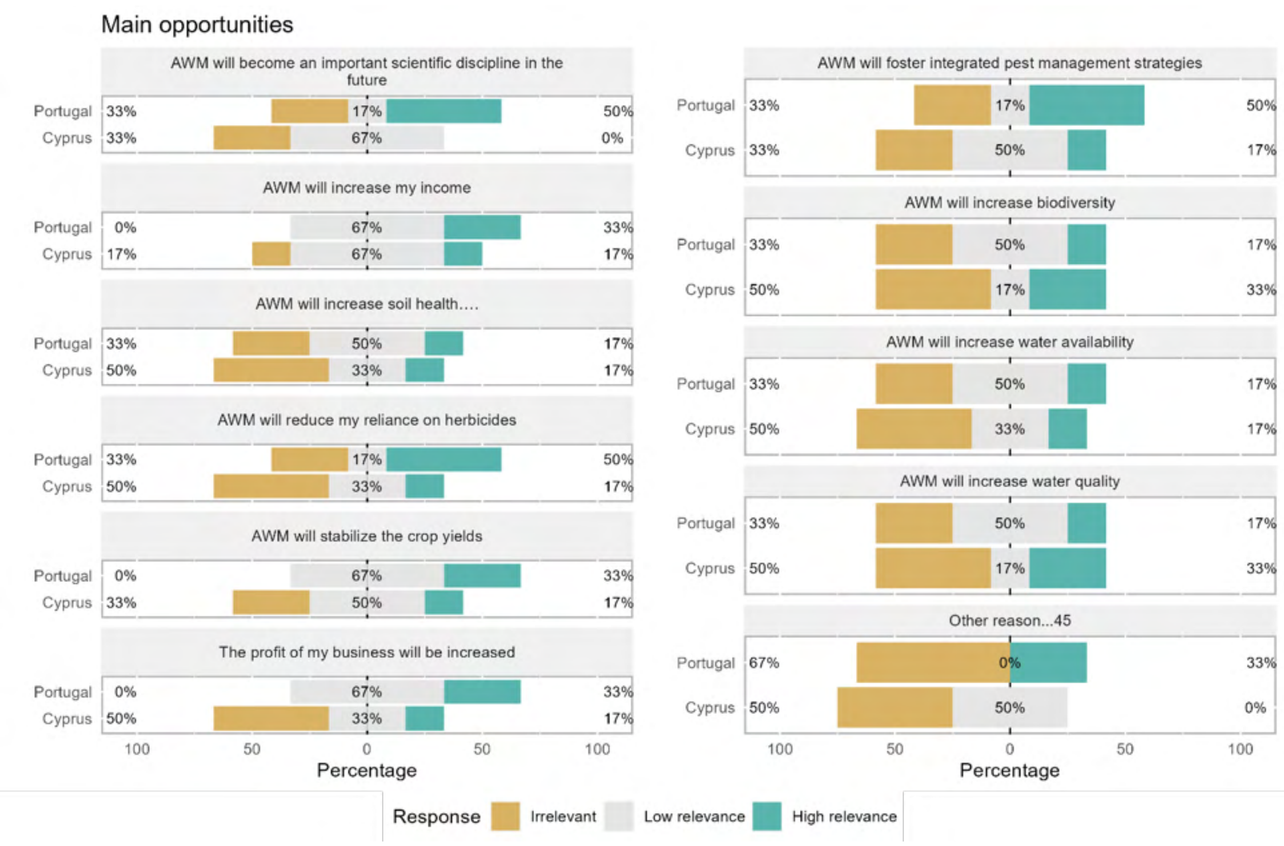


Figure 228. Main opportunities for herbicides identified by advisors.

Advisors from Portugal and Cyprus share a consensus regarding the significant necessities associated with herbicide use, yet they prioritize these factors differently. While nearly seventy percent of Cypriot respondents emphasize timing reduction as the primary need, over eighty percent of Portuguese respondents highlight management expertise, practicing knowledge skills, training, ecosystem services impact knowledge, and lack of advisors as primary needs. In contrast, only 33% and 50% of Cypriot respondents respectively consider these factors as relevant.

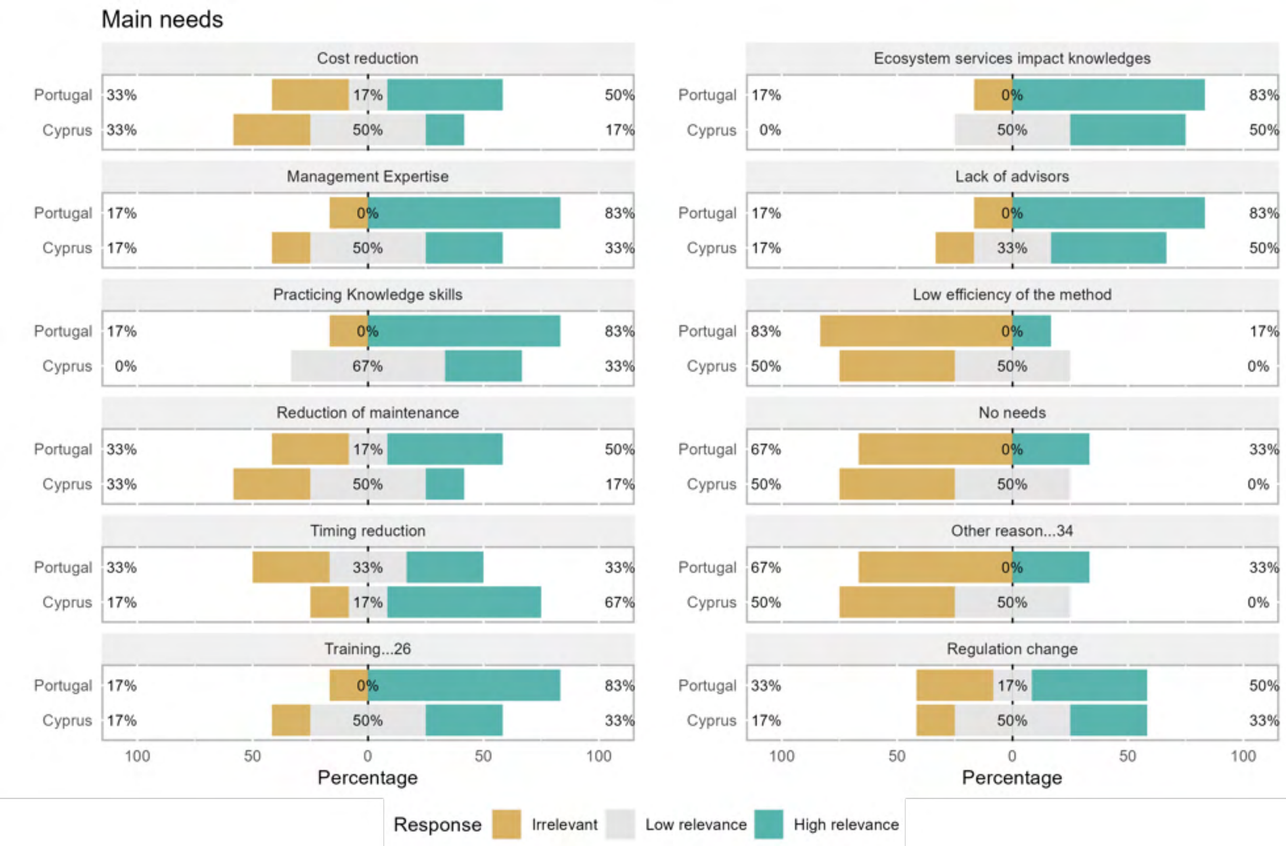


Figure 229. Main needs for herbicides identified by advisors.

Portuguese advisors perceive herbicides as facing more barriers compared to their Cypriot colleagues. All advisors from Portugal unanimously consider training barriers and potential environmental and human harm as the most relevant disadvantages. In contrast, only half of their Cypriot counterparts share concerns regarding training, and one third of them consider environmental and human harm as a relevant hurdle. Regulatory challenges were considered as an important barrier by half of the advisors from each region. Additionally, one third of the advisors from Cyprus believe that a high carbon footprint is a principal concern, while two thirds of the Portuguese respondents hold the same view.

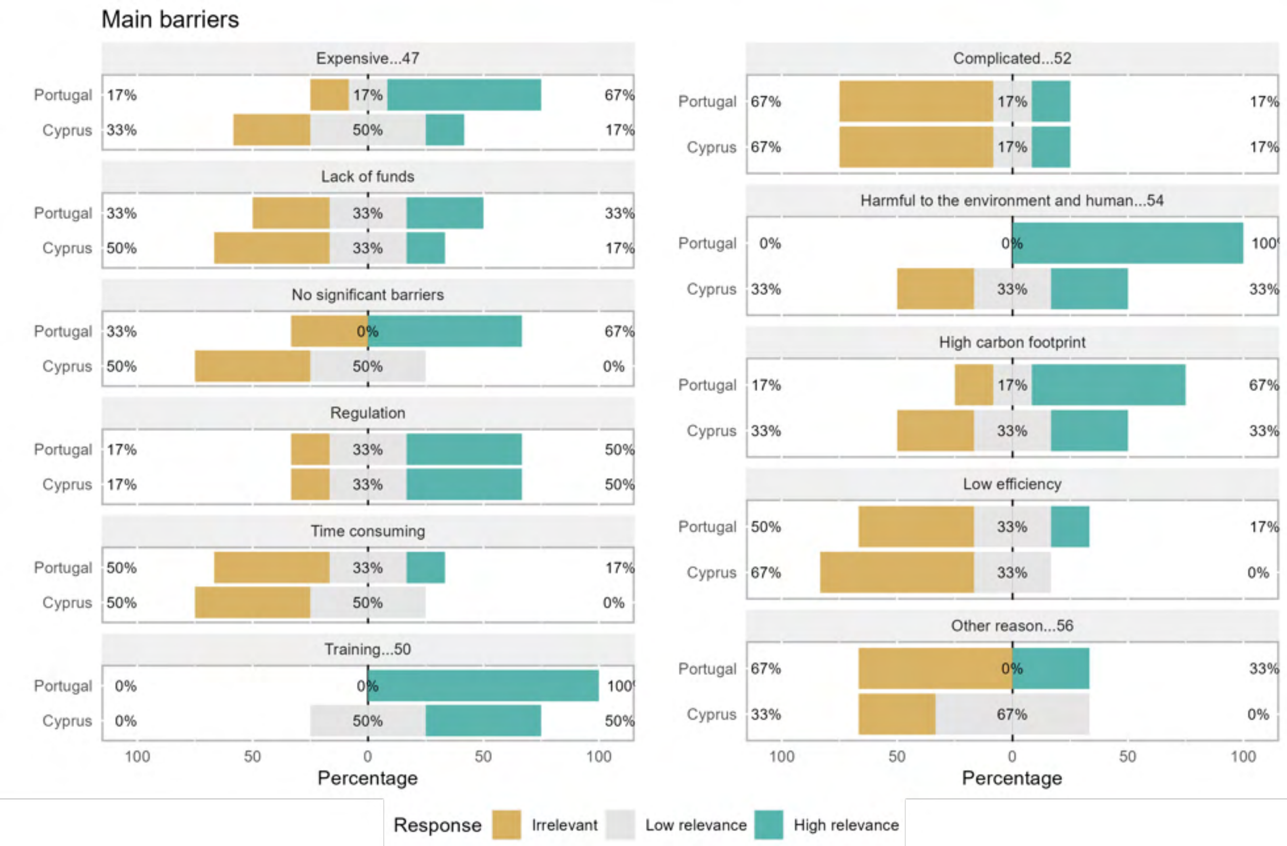


Figure 230. Main barriers for herbicides identified by advisors.

Advisors from both studied regions consider that herbicides present important disadvantages. All respondents from Portugal and two thirds of the advisors from Cyprus emphasize environmental and human harm as the most relevant disadvantage. Over eighty percent of the Portuguese respondents, as well as 33% and 50% of the respondents from Cyprus, consider customer demand to reduce herbicides and public opposition to their use as relevant disadvantages. Additionally, Portuguese respondents considered expense as a noteworthy disadvantage of herbicides. Lastly, 50% of Cypriots and 67% of Portuguese respondents view herbicides as having no significant disadvantages.

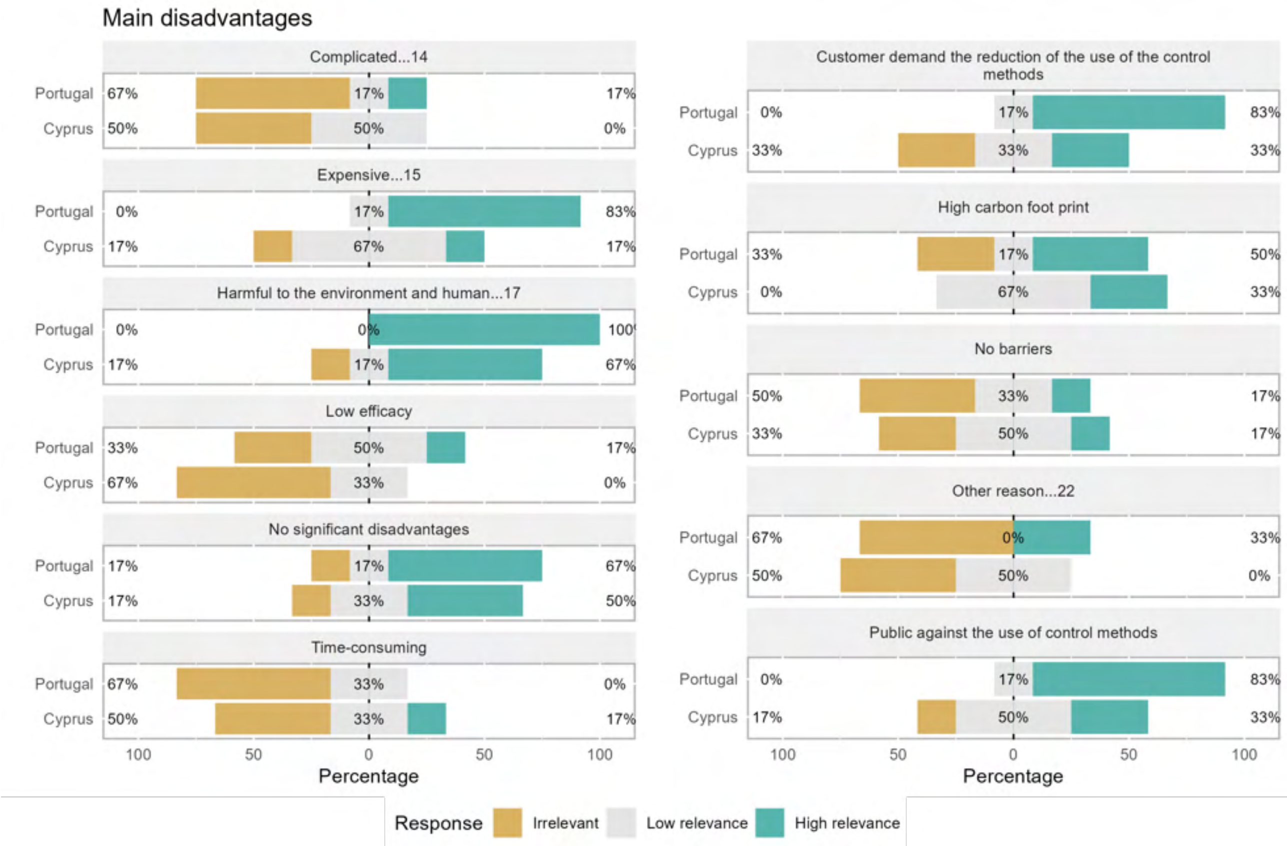


Figure 231. Main disadvantages for herbicides identified by advisors.

3.1.3.1.1.2 Consumers

Consumers from both Cyprus and Portugal consider that herbicides present limited opportunities, while recognizing important needs, barriers, and disadvantages. None of the queried opportunities were considered as relevant by more than half of the respondents from either of the studied countries. Collectively, approximately forty percent of the respondents view herbicides as ecosystem services providers, as they recognize increases in biodiversity and soil health as potential outcomes of implementing herbicides. Over eighty percent of the consumers from Portugal and Cyprus consider knowledge regarding ecosystem services impact, as well as regulatory changes, as herbicides' primary needs. Besides, two-thirds of the respondents recognized the need for lack of advisors, practicing knowledge skills, management expertise, training, and cost reduction as important needs. Training was considered as the most relevant need by over eighty percent of the respondents, along with three-quarters of consumers who believe regulatory challenges are important impediments. Two-thirds of respondents view environmental and human harm, as well as expense, as relevant barriers. Consumers from Portugal and Greece consider environmental and human harm as the most relevant disadvantage. Besides, nearly seventy percent of them consider the practice expense and its high carbon footprint as relevant drawbacks. Additionally, customer demand to reduce herbicides, as well as public opposition to the practice, were recognized as important disadvantages by one in every two respondents.

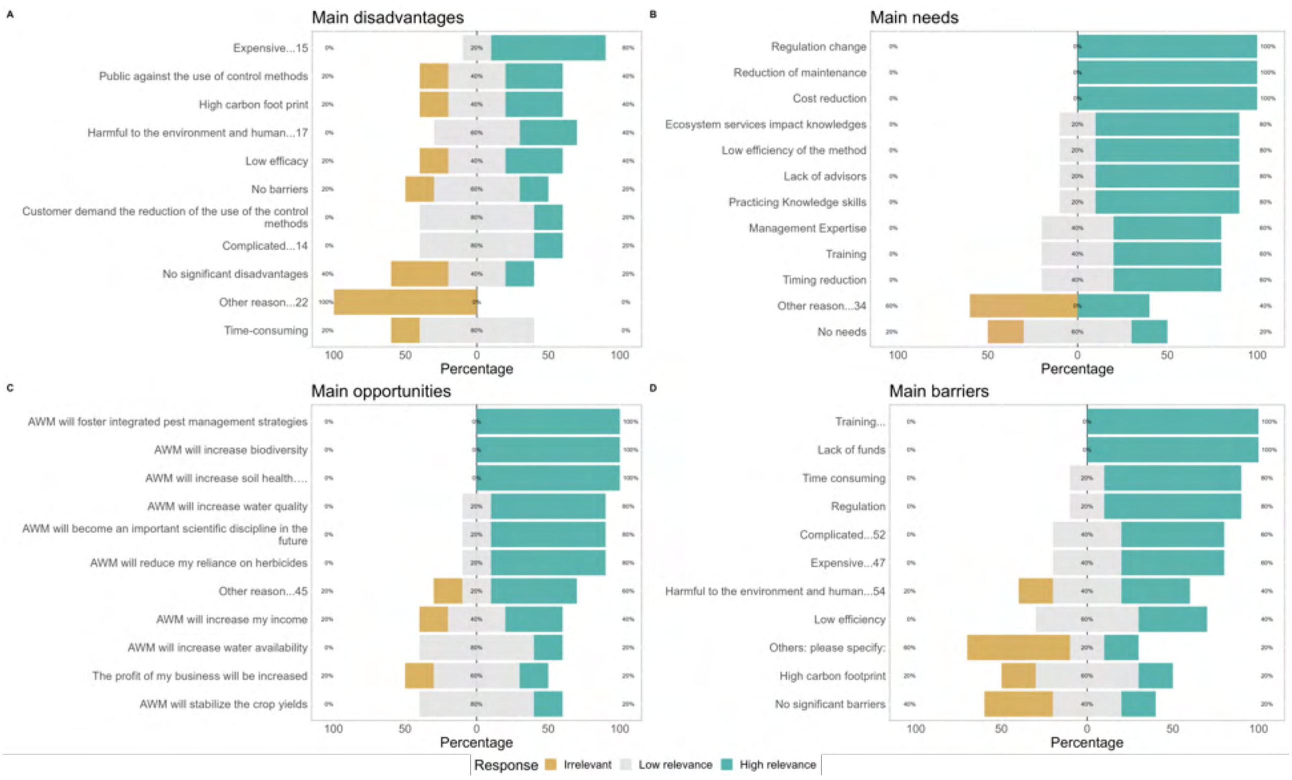


Figure 232. Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

3.1.3.1.1.2.1 By country

Consumers from Portugal and Cyprus did not perceive herbicides as presenting significant opportunities, as none of the queried factors were considered highly relevant by most respondents from either of the studied countries. Over forty percent of the Cypriot respondents believe that herbicides improve soil health and increase biodiversity, along with forty percent of the Portuguese respondents, who also consider that this practice will reduce herbicide reliance, enhance water quality, and have the potential to evolve into an important scientific discipline. These factors were also considered relevant by less than 30% of the consumers from Cyprus.

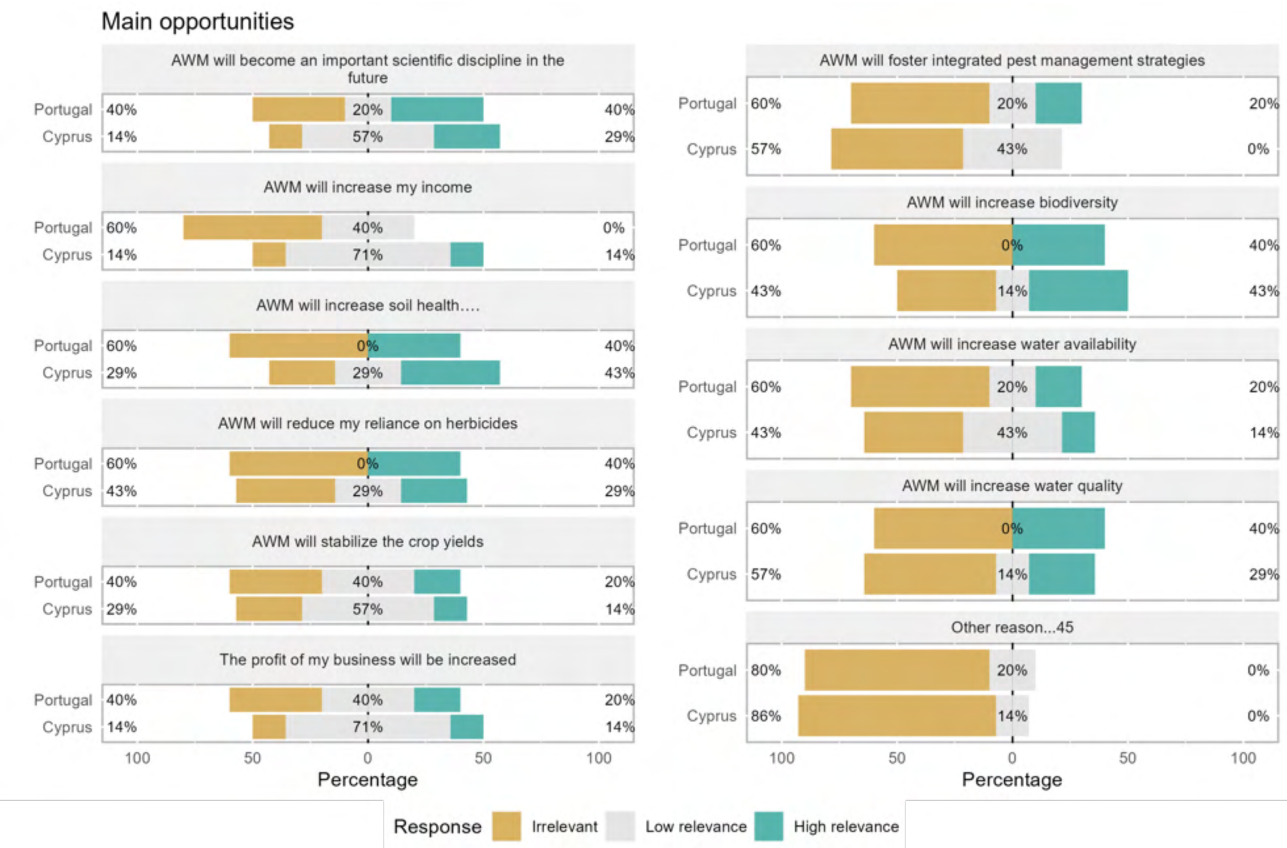


Figure 233. Main opportunities for herbicides identified by consumers.

Cypriot and Portuguese consumers acknowledge several important needs associated with herbicides. Portuguese consumers unanimously prioritize increasing knowledge of ecosystem services impact as the primary need, a sentiment shared by over seventy percent of respondents in Cyprus. Additionally, over eighty percent of Cypriot respondents prioritize cost reduction, management expertise, lack of advisors, and regulatory challenges as primary needs. These factors were also considered relevant requirements by a considerable proportion of Portuguese respondents.

Figure 234. Main needs for herbicides identified by consumers.

Training emerged as a unanimous concern among respondents from Cyprus and Portugal, recognized as a principal barrier to herbicide use. Additionally, eighty percent of Portuguese consumers highlighted expense and regulatory challenges, while 57% and 71% of Cypriot respondents respectively shared similar concerns. Moreover, consumers from both regions identified lack of funds, as well as environmental and human harm, as significant hurdles to herbicide use.

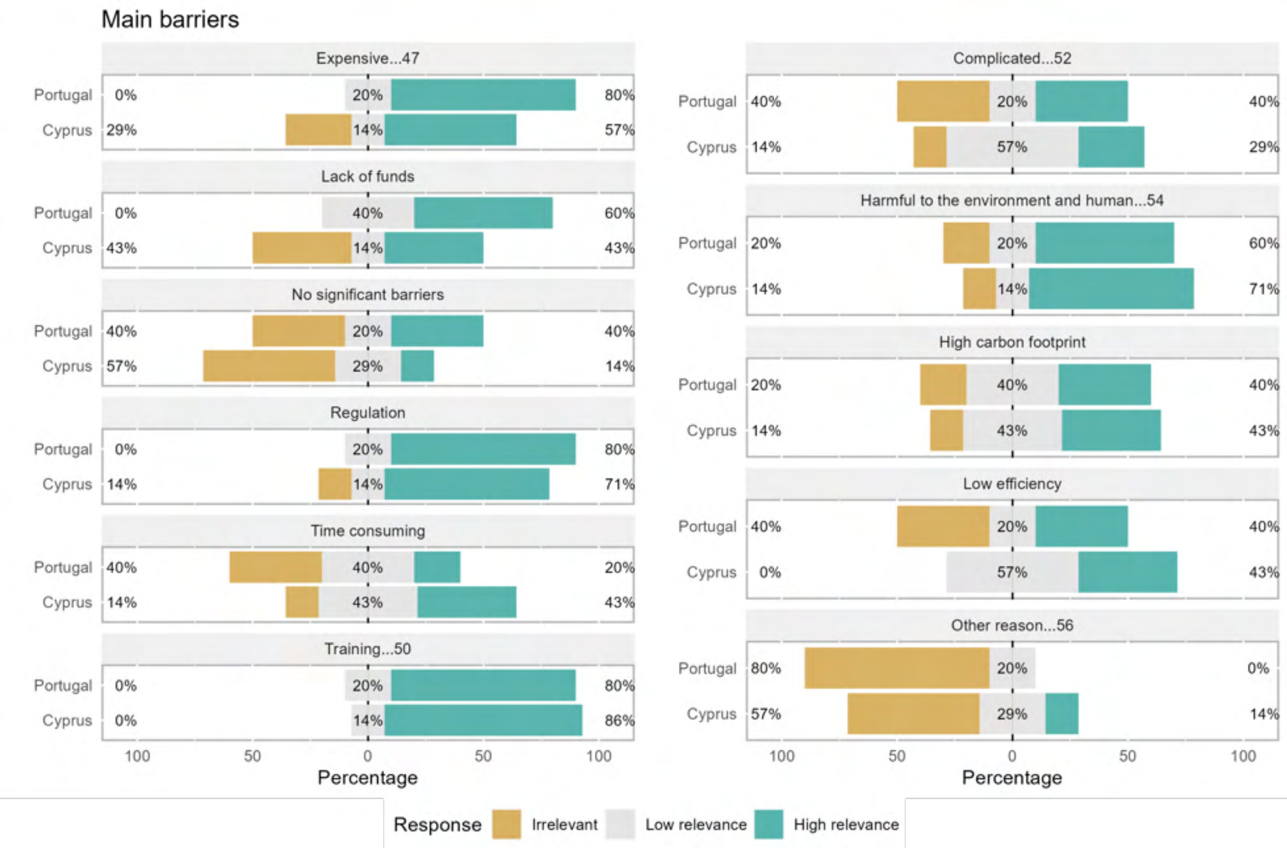


Figure 235. Main barriers for herbicides identified by consumers.

Consumers from Cyprus and Portugal unanimously identified environmental and human harm as the most significant disadvantage associated with herbicide use. While both groups acknowledged other disadvantages, their relative importance differed. Eighty percent of Portuguese consumers expressed concern about customer demand to reduce herbicides, compared to less than thirty percent of Cypriot consumers. Additionally, sixty percent of Portuguese respondents considered expense and high carbon footprint as relevant disadvantages, whereas over seventy percent of Cypriot respondents shared this perspective. Lastly, respondents from both countries expressed concerns about public opposition to herbicides, with sixty percent of Portuguese and over forty percent of Cypriot consumers sharing this sentiment.

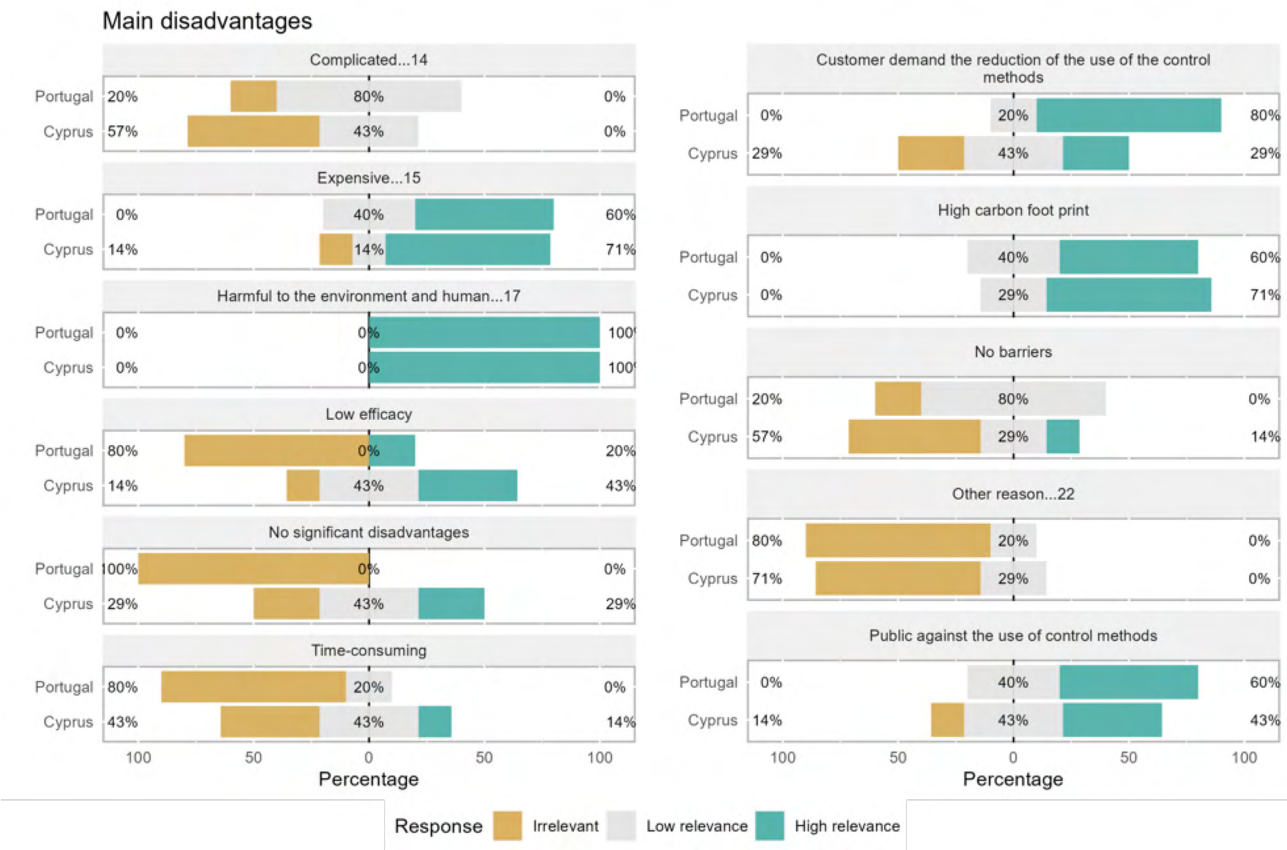


Figure 236. Main disadvantages for herbicides identified by consumers.

3.1.3.1.1.3 Policy makers

Policy makers from Cyprus and Portugal recognize that herbicides offer significant opportunities but also come with important needs, barriers, and disadvantages. Nearly sixty percent of respondents from both countries see herbicides as beneficial for fostering IPM strategies, enhancing biodiversity, improving water quality, and promoting soil health. They also believe in the potential for herbicide use to evolve into an important scientific discipline and reduce reliance on herbicides. Policy makers unanimously prioritize the reduction of cost and maintenance as primary needs for herbicide use. Additionally, nearly ninety percent of consumers highlight practicing knowledge skills, management expertise, training, and timing reduction as important necessities for effective herbicide implementation. Regarding the main barriers to herbicide use, nearly ninety percent of respondents point to environmental and human harm and training as significant impediments. Moreover, over seventy percent emphasize the high carbon footprint of herbicides, while 57% cite regulatory challenges and expense as relevant barriers. Policy makers unanimously recognize public opposition to herbicides and environmental and human harm as relevant disadvantages. Additionally, over seventy percent share concerns about customer demand to reduce herbicides, while 57% consider expense and high carbon footprint as important disadvantages.

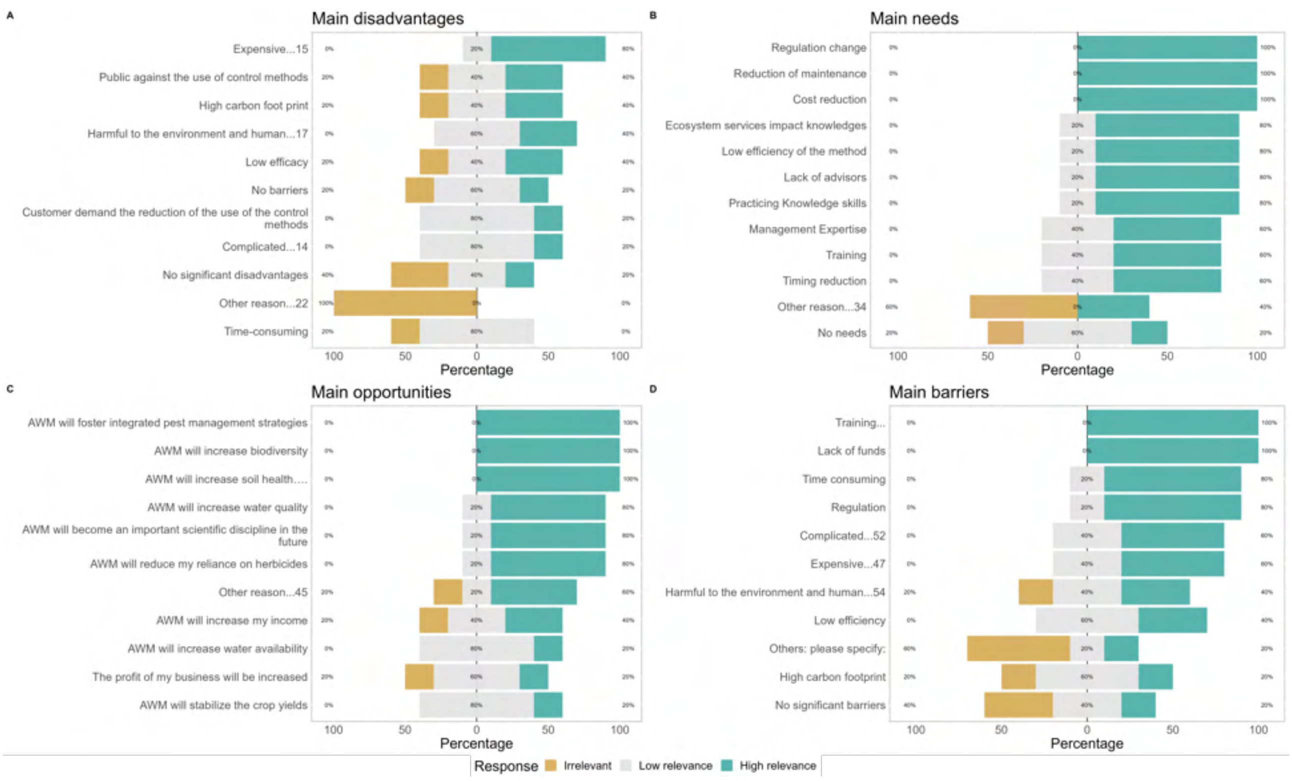


Figure 237. Main disadvantages, needs, barriers and opportunities for herbicides identified by policy makers.

3.1.3.1.1.3.1 By country

Policymakers from Portugal and Cyprus hold contrasting views on herbicides. Portuguese policymakers regard herbicides as presenting significant opportunities. They unanimously believe that herbicide use could evolve into a crucial scientific discipline and offer various ecosystem benefits, such as enhancing soil health, biodiversity, and water quality. Furthermore, they unanimously view herbicides as fostering IPM strategies and reducing reliance on herbicides. Additionally, two-thirds of Portuguese respondents see herbicides as potentially increasing water availability, while another third believes in their potential to increase farmers' income. In contrast, only a quarter of Cypriot policymakers find these aspects relevant.

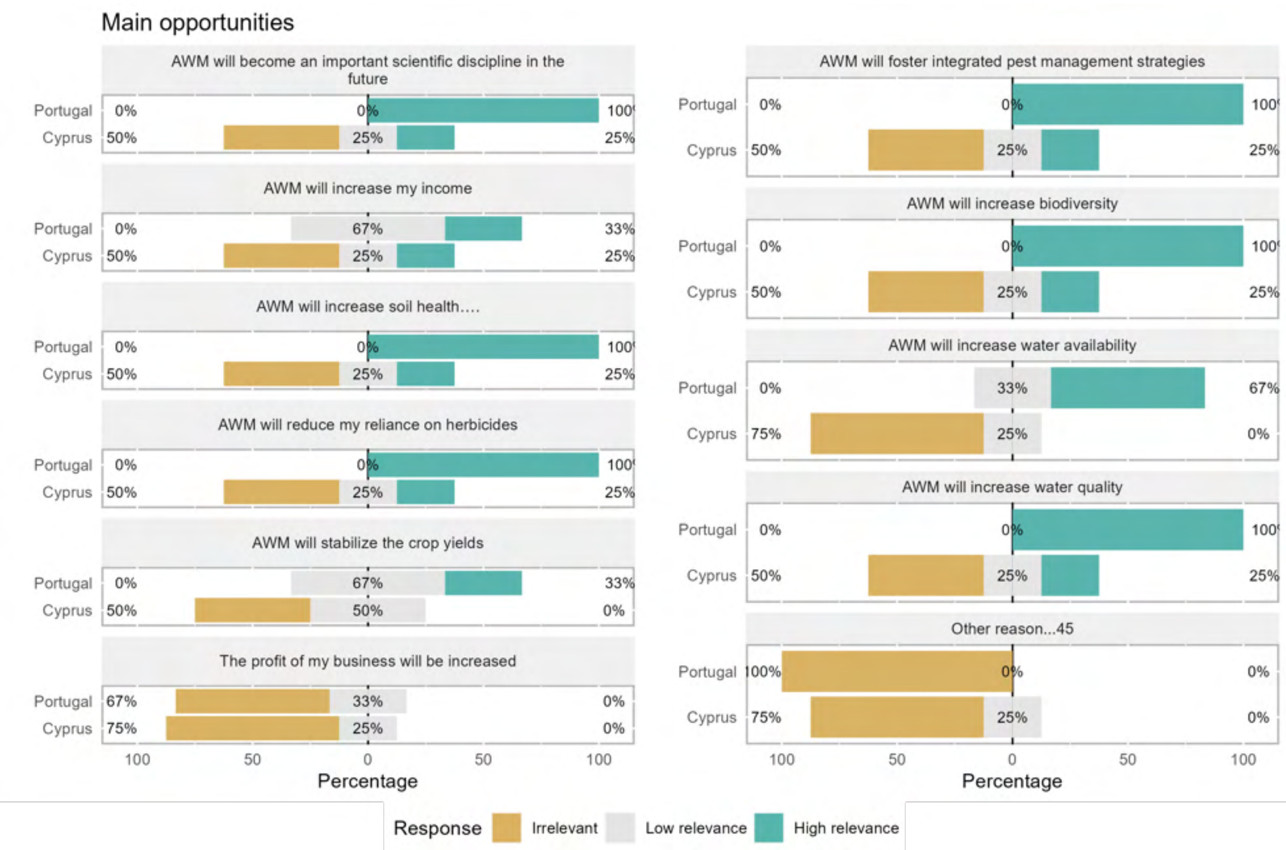


Figure 238. Main opportunities for herbicides identified by policy makers.

Policymakers from Cyprus and Portugal consider herbicides as presenting numerous relevant needs. Both groups unanimously regard cost and maintenance reduction as the foremost requirement. Additionally, policymakers from Portugal unanimously identify the need for practicing knowledge skills, timing reduction, and training as primary concerns, while 75% of those from Cyprus also find these aspects relevant. Conversely, Cypriot respondents unanimously prioritize improvements in management expertise, a concern deemed relevant by only two-thirds of Portuguese respondents.

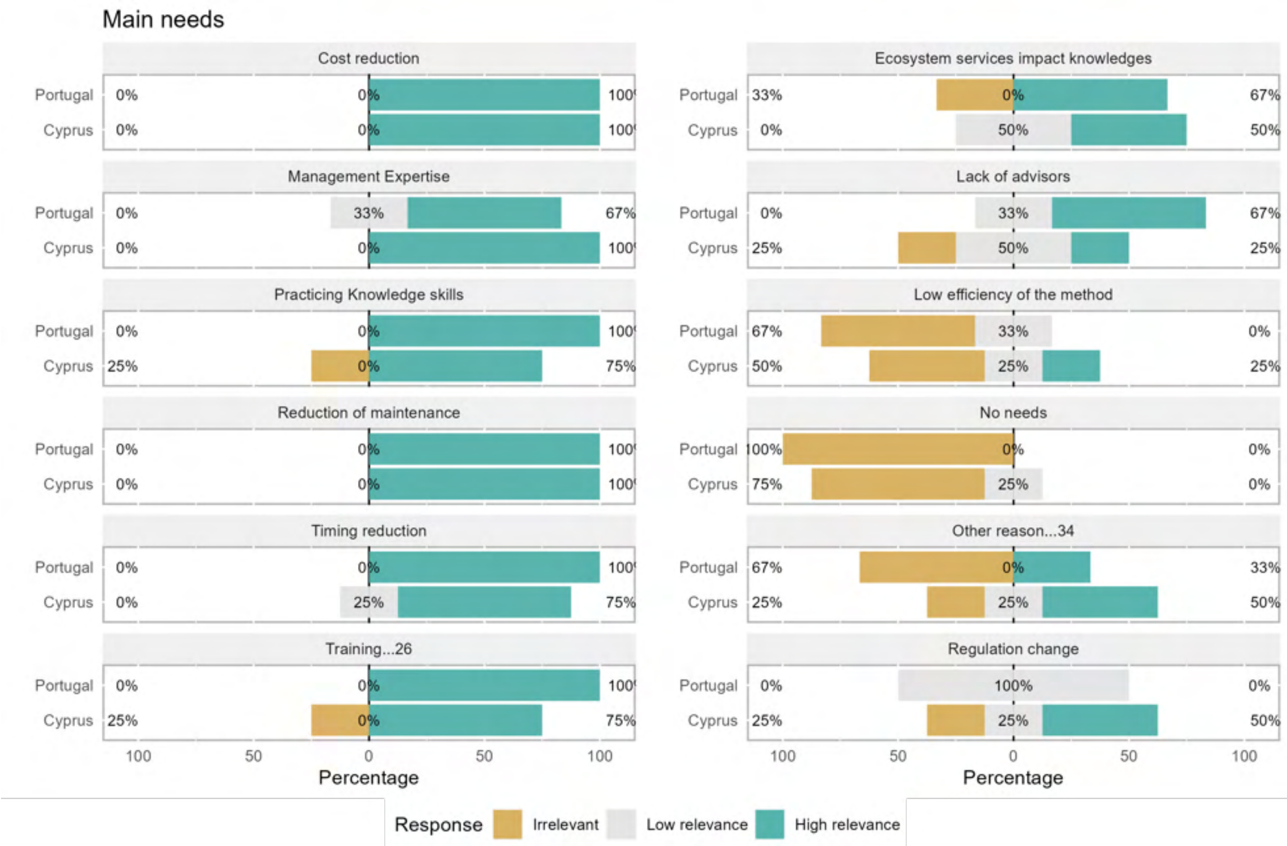


Figure 239. Main needs for herbicides identified by policy makers.

Policy makers from the studied regions consider that herbicides face relevant barriers, yet they differ on the relative importance of each category. Training and environmental and human harm were considered as the primary barriers in both regions, yet these factors were unanimously considered as relevant by all Portuguese respondents, while they were deemed so by 75% of Cypriot policymakers. In addition to these aspects, Portuguese respondents emphasize the high carbon footprint of herbicide use as a unanimously relevant barrier, with two-thirds of them perceiving that herbicides also face regulatory challenges and expense concerns, whereas only half of the policymakers from Cyprus contemplated this factor.

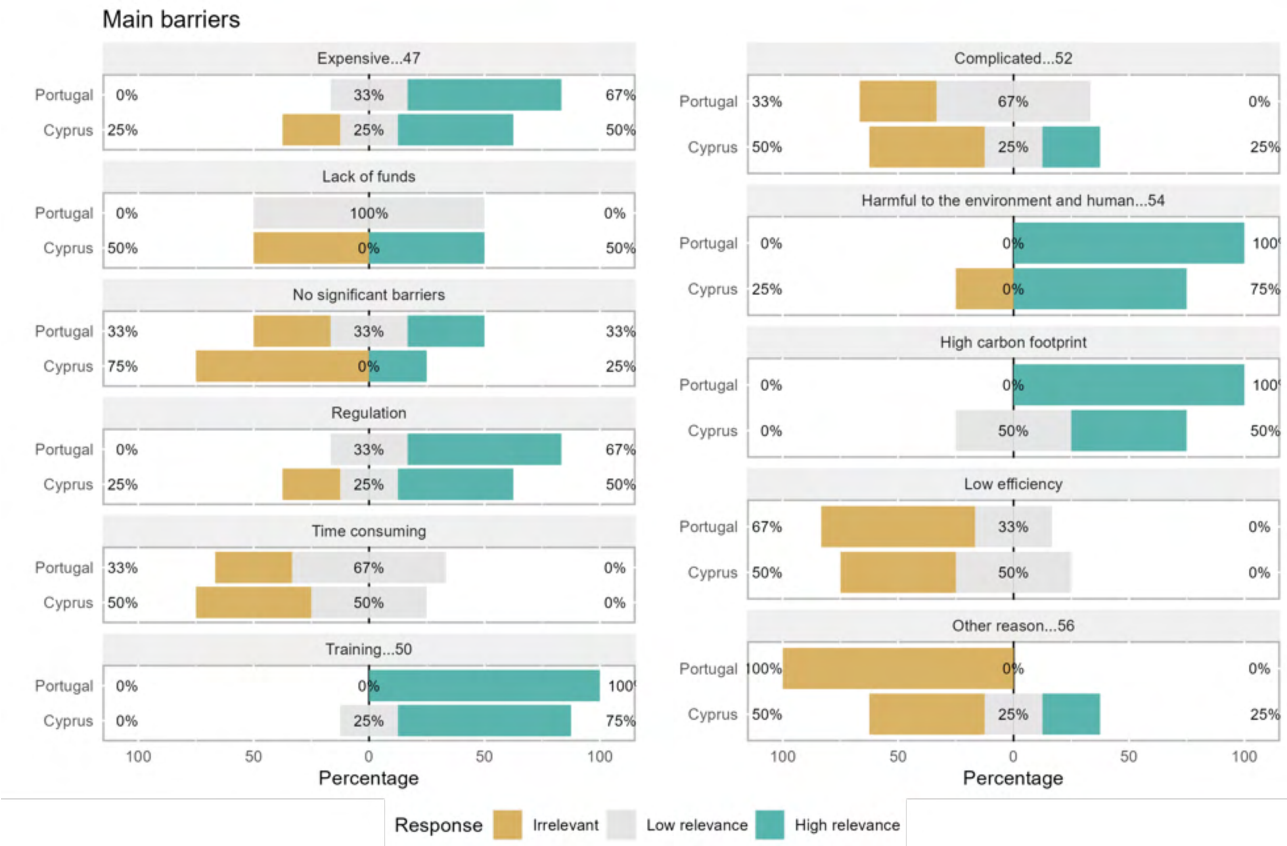


Figure 240. Main barriers for herbicides identified by policy makers.

Policy makers from Portugal and Cyprus considered that herbicides present numerous relevant disadvantages. They unanimously regarded environmental and human harm, as well as public opposition to the practice, as the most significant drawbacks. Respondents from Portugal unanimously emphasized customer demand to reduce herbicides, as well as the high carbon footprint, as relevant drawbacks. Additionally, two-thirds of the respondents considered method complexity and expense as important disadvantages. In contrast, these factors were deemed relevant by either 50% or 25% of policymakers from Cyprus. Notably, two-thirds of the respondents from Portugal stated that herbicides present no significant disadvantages and no significant barriers.

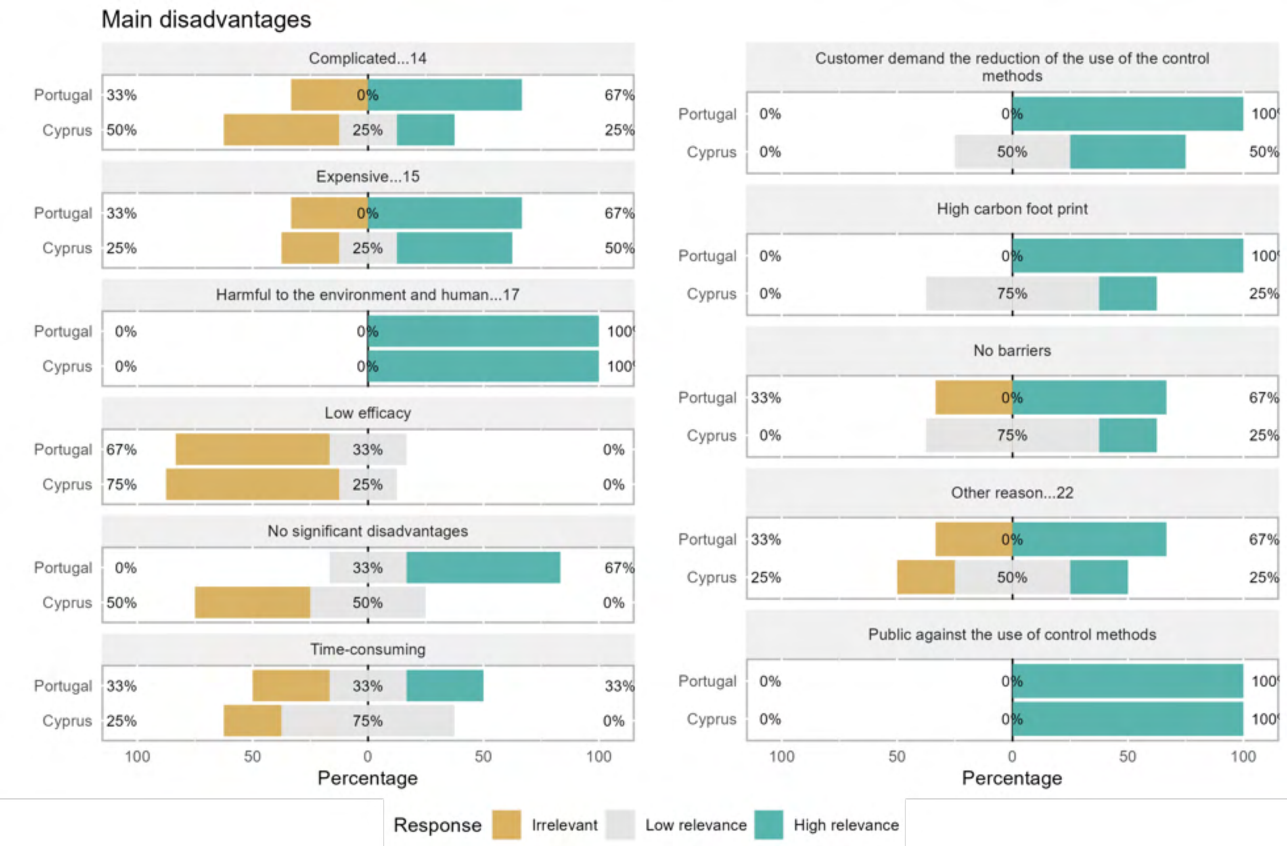


Figure 241. Main disadvantages for herbicides identified by policy makers.

3.1.3.1.1.4 Researchers

Researchers from Cyprus and Portugal collectively consider herbicides to entail important needs, barriers, and disadvantages, while not perceiving significant opportunities associated with their use, as indicated by the responses of a majority of respondents. However, over forty percent of the surveyed researchers anticipate that herbicides will evolve into an important scientific discipline. Additionally, 36% emphasize the practice as fostering IPM strategies and reducing reliance on herbicides. Nearly eighty percent of researchers from both regions identify increased knowledge of ecosystem services' impact, management expertise, and general training as primary needs for herbicide use. Moreover, over seventy percent of respondents prioritize practicing knowledge skills and cost reduction, with 64% acknowledging regulatory concerns and 57% citing the lack of advisors as important necessities. Regarding herbicides' main barriers, over seventy percent of researchers cite regulatory challenges, while 64% recognize the potential for environmental and human harm. Furthermore, half of the respondents identify training and expense as significant impediments to implementing herbicide practices. Researchers agree on the significant disadvantages associated with herbicide use, with over ninety percent highlighting environmental and human harm, as well as public opposition to its use. Additionally, nearly eighty percent acknowledge customer demand to reduce herbicide usage, while 64% cite expense as an important disadvantage. Interestingly, over half of the respondents believe that herbicides present no significant barriers despite the recognized challenges and disadvantages.

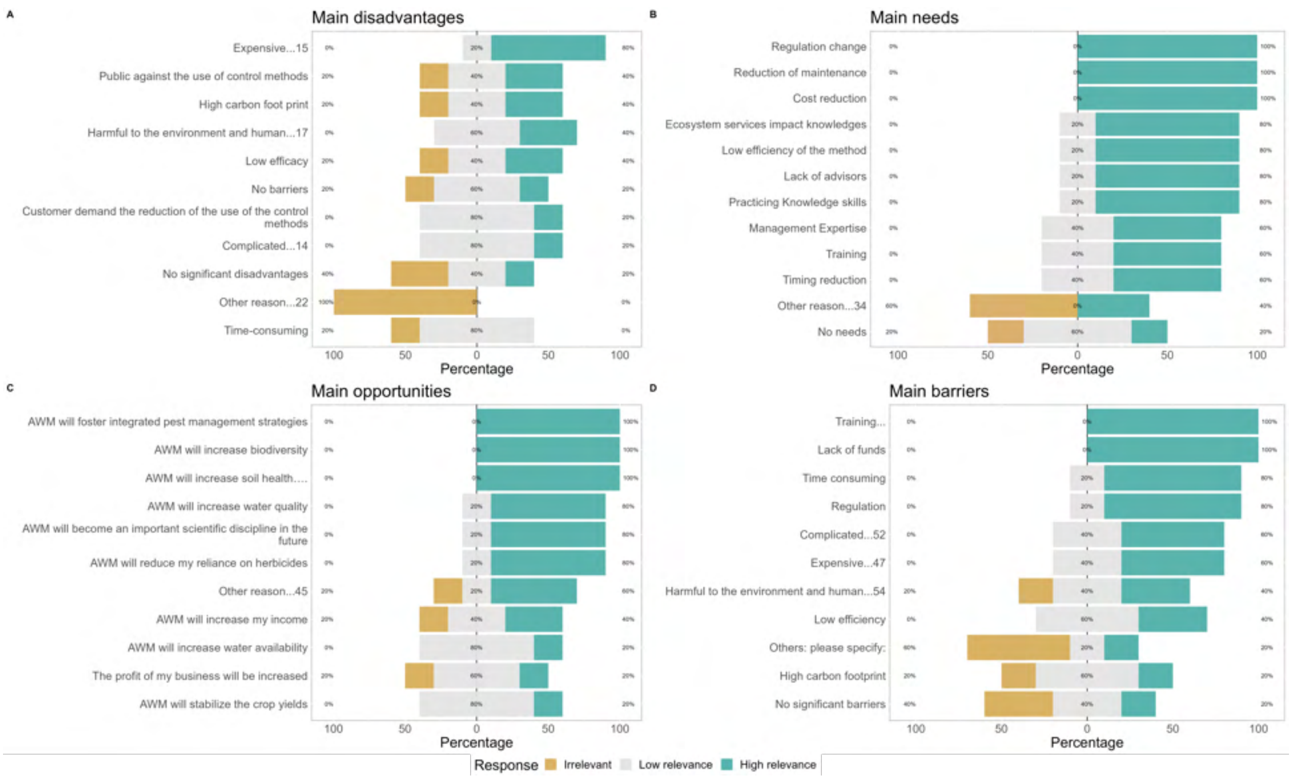


Figure 242. Main disadvantages, needs, barriers and opportunities for herbicides identified by researchers.

3.1.3.1.1.4.1 By country

Portuguese and Cypriot respondents hold distinct views on herbicide-related opportunities. A majority of respondents from Portugal believe that herbicides have the potential to evolve into an important scientific discipline. Additionally, over 50% recognize their role in reducing herbicide reliance, while 44% acknowledge their potential to improve soil health and water quality, as well as to foster IPM strategies. In contrast, most researchers from Cyprus do not perceive herbicides as presenting significant opportunities. Only twenty percent of the respondents from Cyprus acknowledge their academic potential and role in fostering IPM strategies. However, they do recognize some potential benefits, such as increasing farmers' income, stabilizing crop yields, and enhancing business profitability.

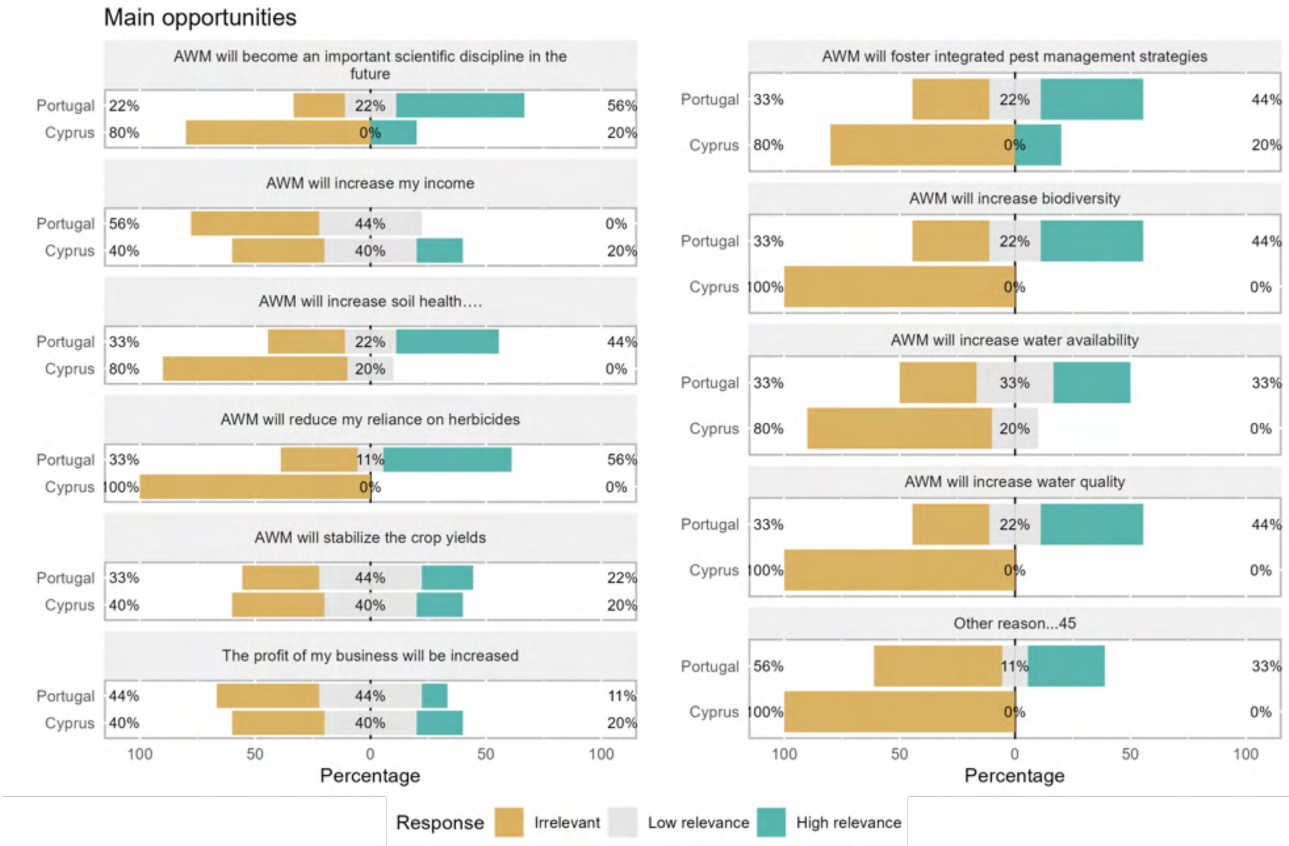


Figure 243. Main opportunities for herbicides identified by researchers.

Portuguese researchers perceive herbicide implementation as requiring more comprehensive measures compared to their Cypriot counterparts. They emphasize the necessity for increased knowledge, with unanimous agreement on the importance of training and understanding the impact on ecosystem services. Additionally, nearly ninety percent of Portuguese researchers prioritize management expertise, practicing knowledge skills, and the availability of advisors, along with a significant portion acknowledging the importance of cost reduction and regulatory changes. In contrast, Cypriot researchers view herbicide implementation with a different lens. While they also recognize the need for cost reduction and management expertise, these factors are not as prioritized. Sixty percent of respondents from Cyprus emphasize the importance of cost reduction and management expertise as primary needs for herbicide implementation.

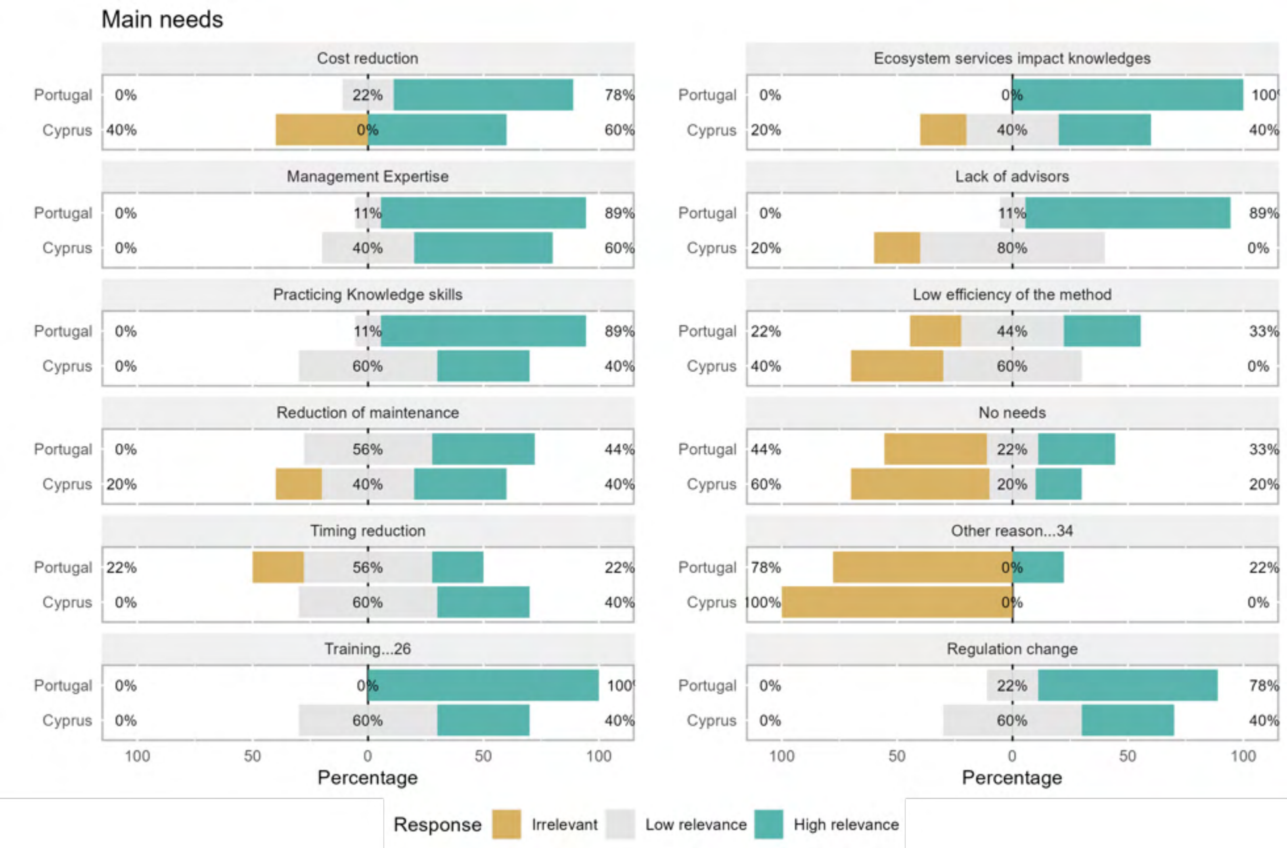


Figure 244. Main needs for herbicides identified by researchers.

Both Cypriot and Portuguese researchers recognize significant barriers to herbicide implementation. Regulatory challenges emerge as the foremost impediment, with nearly eighty percent of Portuguese and sixty percent of Cypriot researchers highlighting its importance. Additionally, both groups identify potential environmental and human harm, as well as expense, as relevant barriers. However, Portuguese researchers uniquely emphasize the importance of training as an impediment to herbicide implementation, suggesting a broader perspective on the challenges associated with herbicides

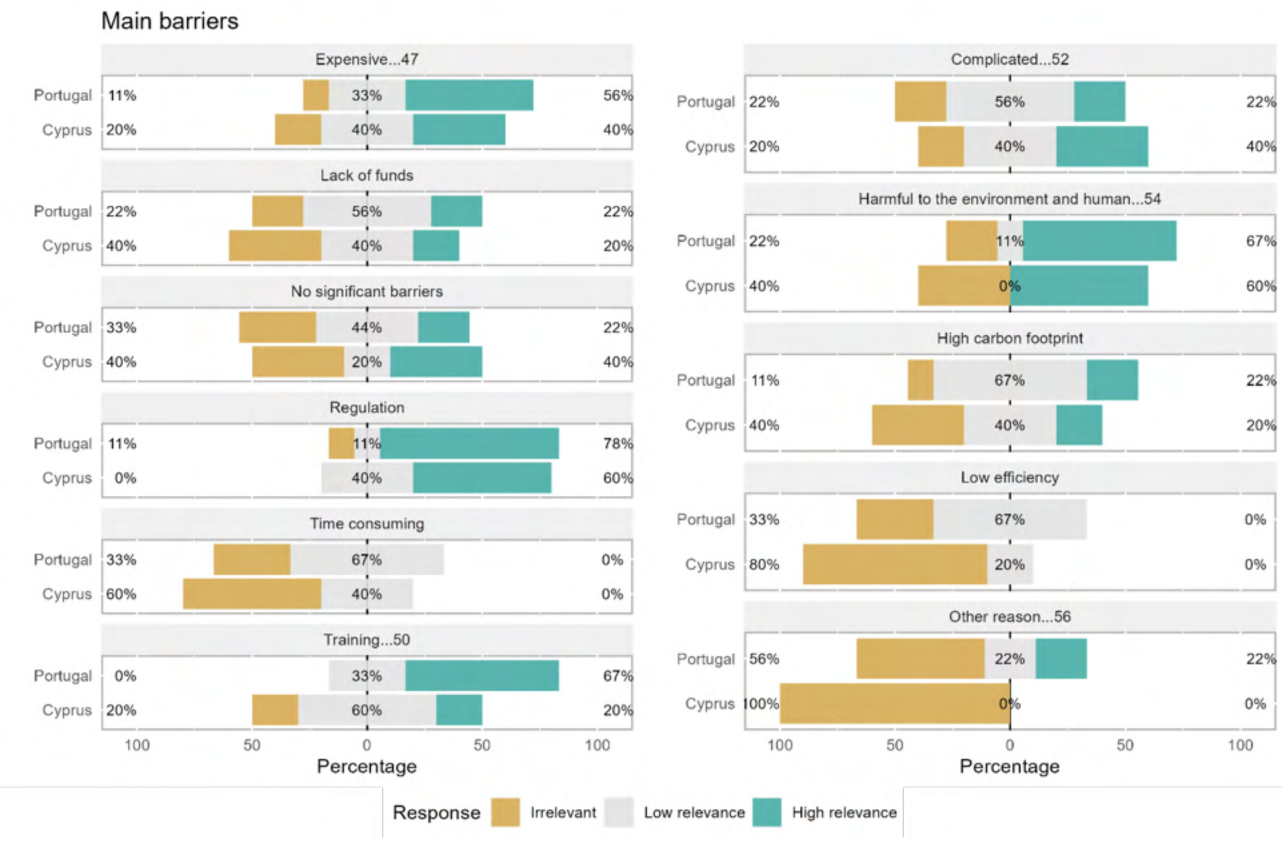


Figure 245. Main barriers for herbicides identified by researchers.

Researchers from both Portugal and Cyprus identify significant disadvantages associated with herbicide use. Environmental and human harm, along with public opposition to implementation, emerge as key concerns, unanimously recognized by Portuguese respondents and emphasized by eighty percent of their Cypriot counterparts. Moreover, nearly ninety percent of Portuguese researchers highlight customer demand to reduce herbicides as a major disadvantage, compared to sixty percent of Cypriot researchers. Regarding expense, sixty percent of Cypriot respondents and nearly seventy percent of Portuguese researchers view it as an important drawback. Interestingly, while two-thirds of Portuguese researchers and sixty percent of their Cypriot counterparts believe that herbicides pose no barriers to implementation.

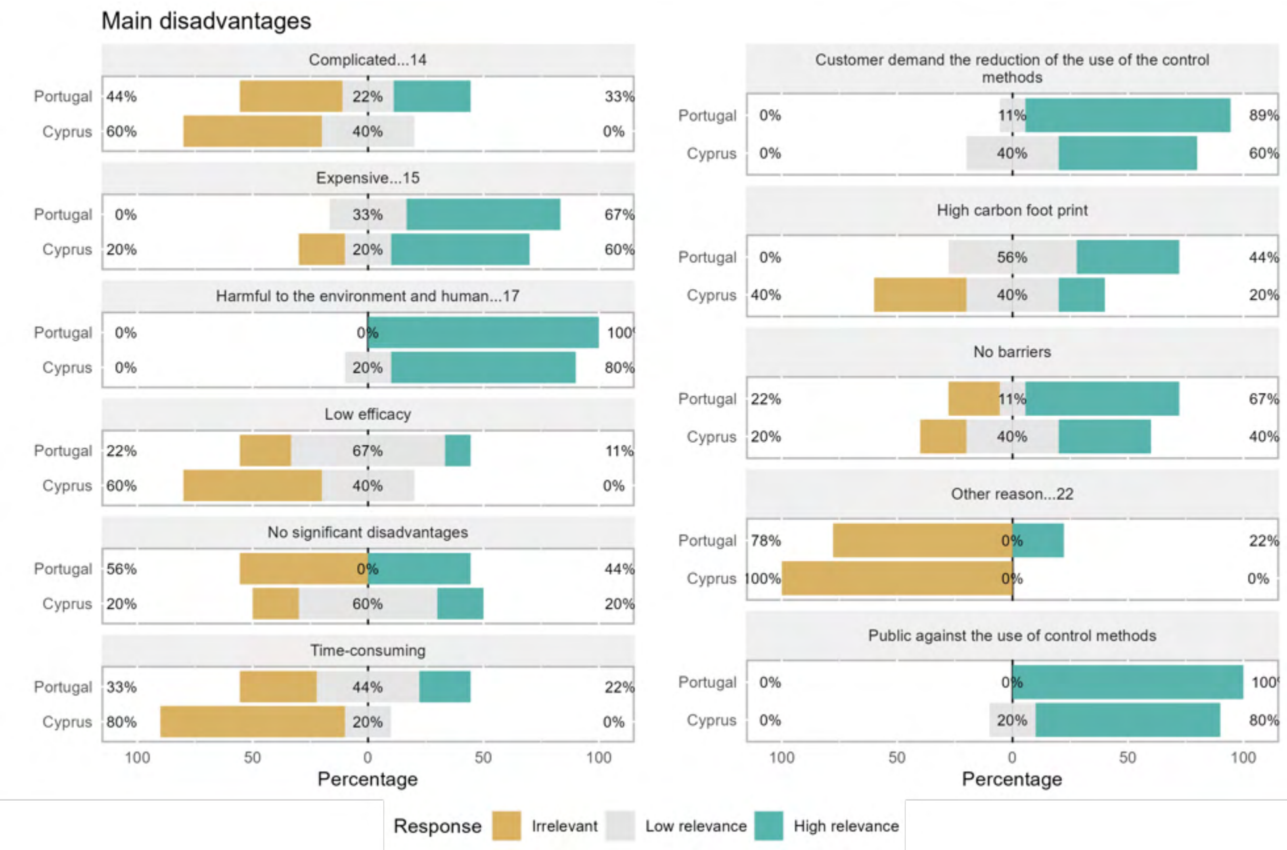


Figure 246. Main disadvantages for herbicides identified by researchers.

3.1.3.1.1.5 Conclusion

Stakeholders from Cyprus and Portugal exhibit contrasting perspectives on herbicide use in olives. While the majority of advisors, consumers, and researchers from both countries view opportunities related to herbicide use as low or irrelevant, policymakers from Portugal see herbicides as facilitators of IPM strategies and providers of ecosystem services. In contrast, most policymakers in Cyprus do not perceive herbicides as offering significant opportunities.

Despite this disparity, stakeholders from both countries agree on the relevant needs associated with herbicide use, particularly emphasizing training, knowledge of practicing skills, management, and understanding the impact on ecosystem services. Moreover, stakeholders highlight the need for regulatory changes and technical improvements to reduce maintenance, costs, and timing. However, stakeholders identify several barriers to herbicide use, with potential environmental and human harm topping the list, recognized unanimously across all stakeholder categories. Training and regulatory challenges are also seen as significant barriers, with policymakers highlighting the high carbon footprint of herbicides as a notable impediment.

In terms of disadvantages, stakeholders express concerns about environmental and human harm, public opposition, customer demand for reduced herbicide use, and expense. These concerns are consistent across all stakeholder groups and are deemed highly relevant by a majority of respondents.

3.1.3.1.2 Mechanical weeding

3.1.3.1.2.1 Advisors

Advisors from Cyprus and Portugal shared a positive regard toward herbicides, they emphasize numerous and relevant opportunities associated to the practice, some important needs, and few barriers and disadvantages. Nearly eighty percent of the surveyed advisors consider that this practice fosters IPM strategies and herbicide reliance. Additionally, over sixty percent of them recognize that mechanical weeding provides relevant ecosystem services, including increases in water quality and biodiversity as well as improved soil health, along with the perception that this practice will evolve into a relevant scientific discipline. Nearly seventy percent of the surveyed advisors from both countries consider that there is not enough knowledge with regard to the impact of mechanical weeding in ecosystem services and consider this factor as the practice primary need. Besides, over sixty percent of the respondents emphasize training and management expertise as relevant necessities as well as timing reduction. Advisors mainly consider that mechanical weeding faces no relevant barriers, and 46% of them considered training and lack of fund as relevant impediments. Expense was the most relevant disadvantage as stated by 54% of the respondents, followed by 46% of the surveyed advisors which stated that mechanical weeding presents no significant disadvantages.

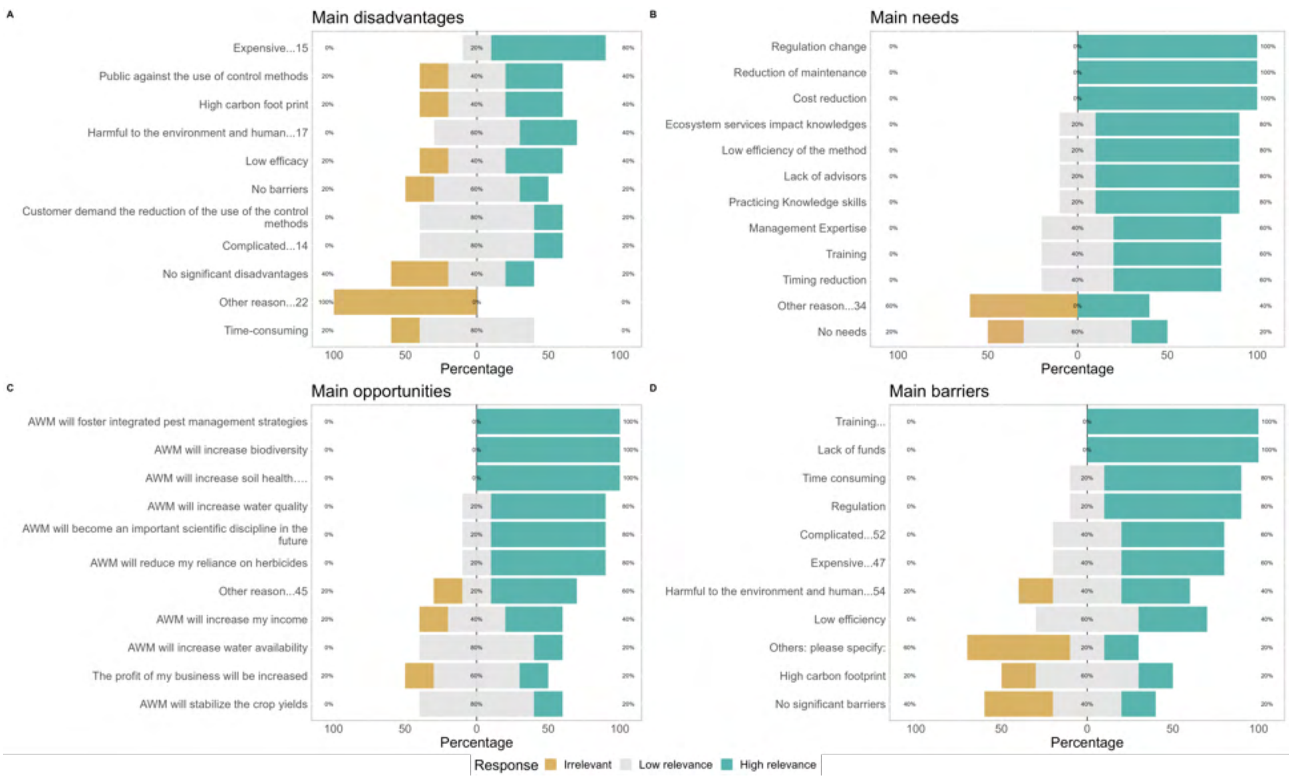


Figure 247. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by advisors.

3.1.3.1.2.1.1 By country

Advisors from both regions recognize mechanical weeding as a practice with several pertinent needs, though with a more optimistic outlook from Portuguese respondents compared to their Cypriot counterparts. Over eighty percent of Portuguese respondents and two-thirds of those from Cyprus perceive mechanical weeding as a fosterer for IPM strategies, anticipating a reduction in herbicide reliance with its implementation. Moreover, 85% of Portuguese advisors highlight the potential for increased income, while over seventy percent underscore improvements in soil health and biodiversity. In contrast, these factors are regarded as relevant by only half of the Cypriot advisors. Advisors from both regions emphasized increases in water quality and availability as a result of mechanical weeding implementation.

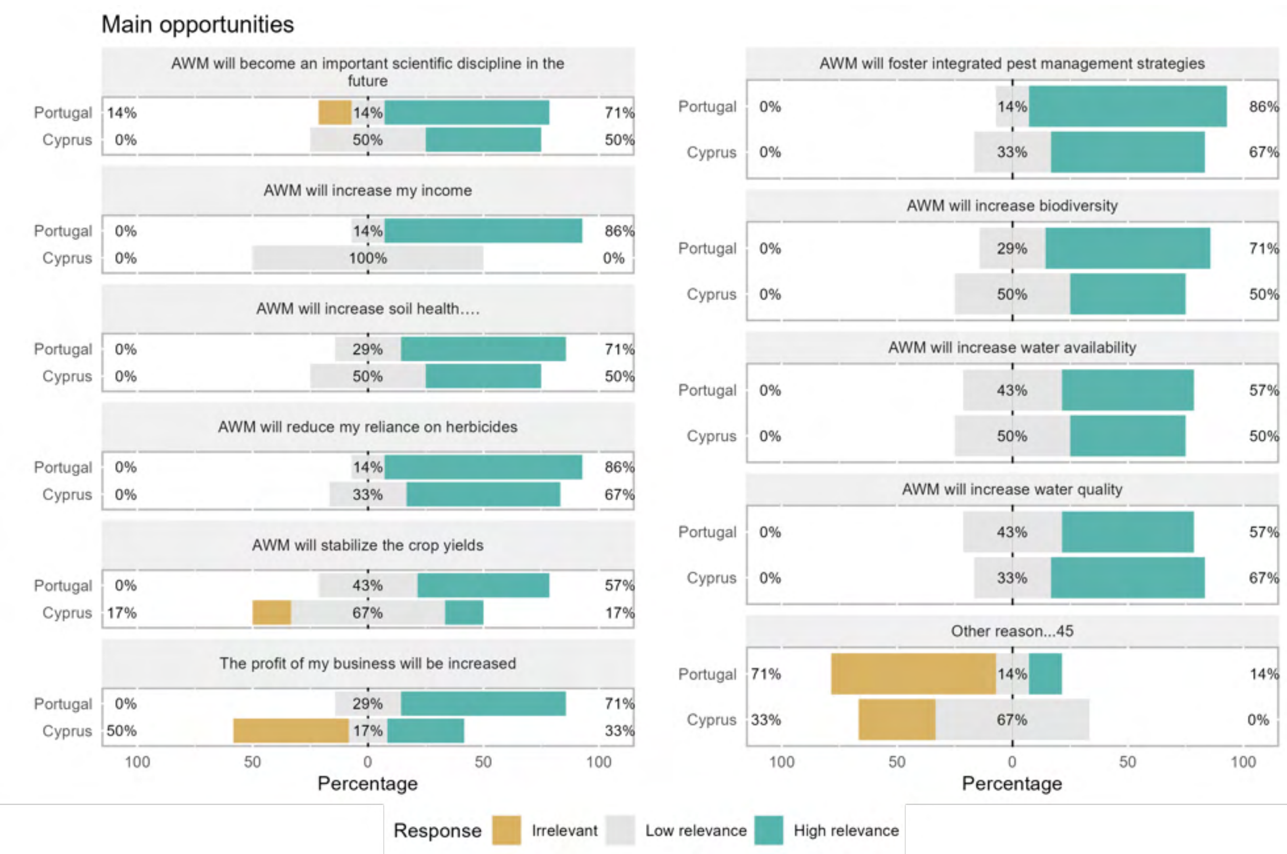


Figure 248. Main opportunities for mechanical weeding identified by advisors.

Portuguese advisors perceive mechanical weeding as presenting several significant needs, whereas their Cypriot counterparts view this practice as requiring fewer necessities. Almost ninety percent of Portuguese respondents deem knowledge about ecosystem services impact as crucial, while only half of their Cypriot peers share this perspective. Moreover, over seventy percent of Portuguese advisors, along with half of those from Cyprus, consider increasing knowledge, encompassing concerns about management expertise and practical skills, as pertinent. Portuguese respondents also highlight educational factors such as the lack of training and advisors, as well as technical considerations like cost reduction, timing, and maintenance, as important.

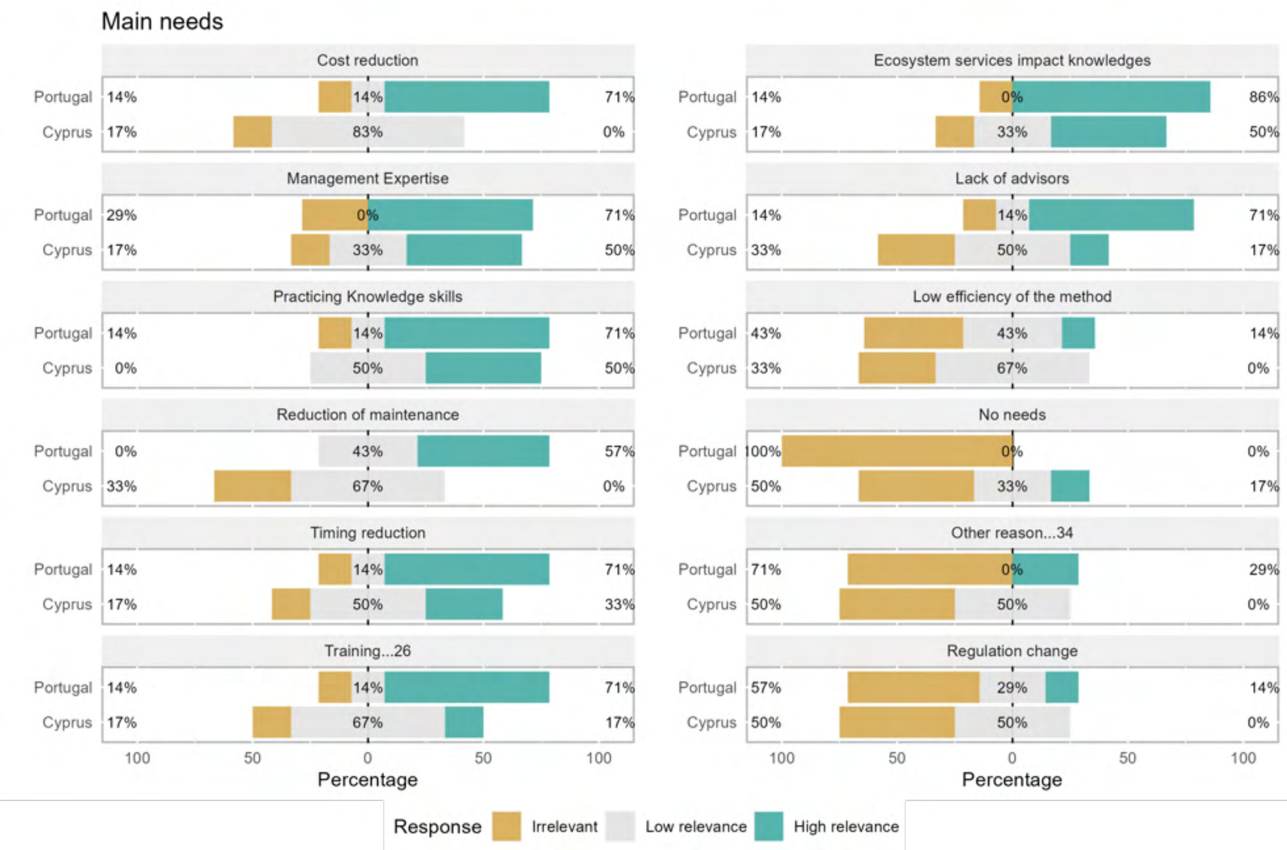


Figure 249. Main needs for mechanical weeding identified by advisors.

Portuguese advisors perceive mechanical weeding as encountering more significant barriers compared to their Cypriot counterparts. While half of the advisors from Cyprus identify time consumption as the most relevant barrier, over seventy percent of respondents from Portugal consider expense as paramount. Additionally, factors such as lack of funds and training are regarded as relevant impediments by 17% of advisors from Cyprus, while they are emphasized by 71% of Portuguese respondents.

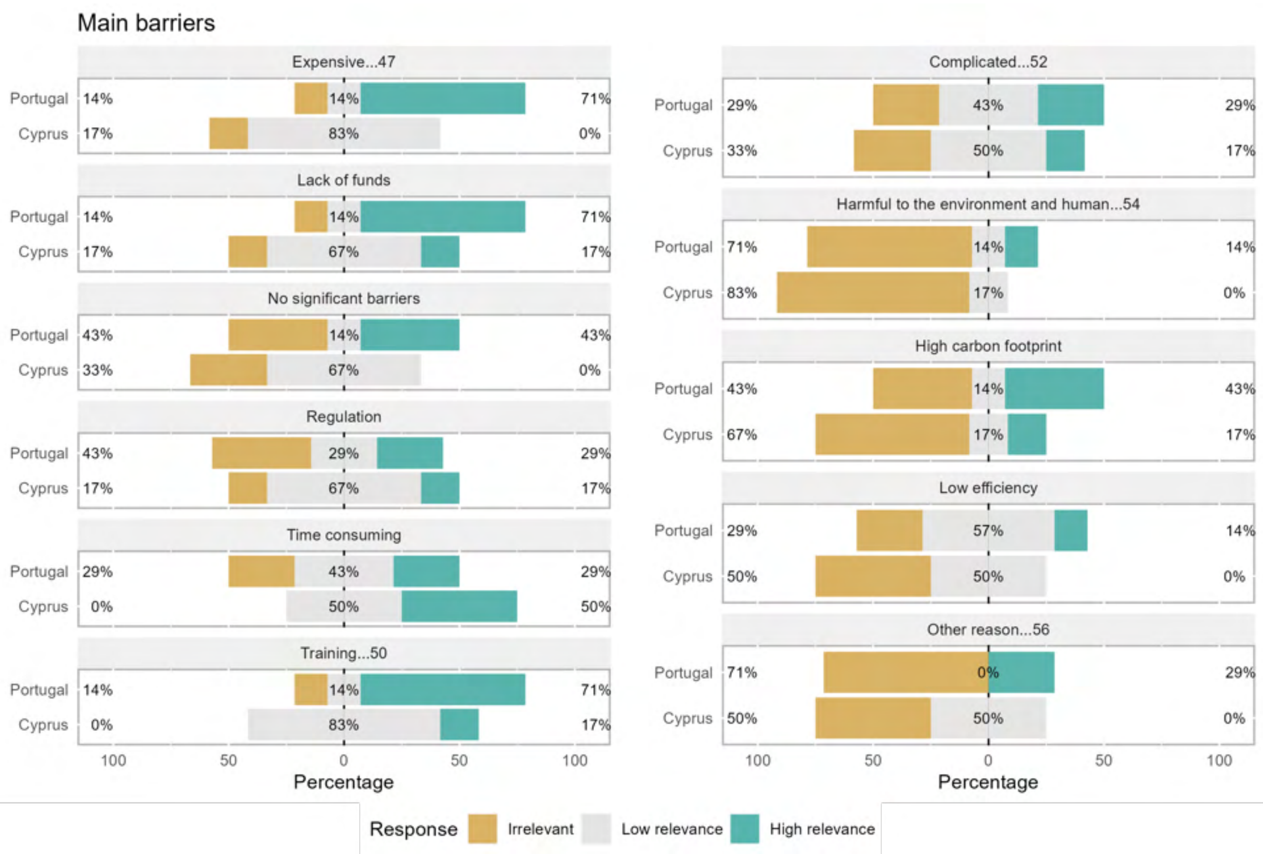


Figure 250. Main barriers for mechanical weeding identified by advisors.

Perceived disadvantages followed the trend observed in barriers and needs, with Portuguese respondents viewing mechanical weeding as presenting significant drawbacks, whereas none of the queried factors was considered relevant by more than half of the respondents. Over seventy percent of advisors from Portugal considered expense as the most relevant disadvantage. Interestingly, the same proportion of respondents also believed that the practice presents no significant disadvantages. In contrast, these factors were regarded as relevant by 33% and 17% of their Cypriot counterparts, respectively.

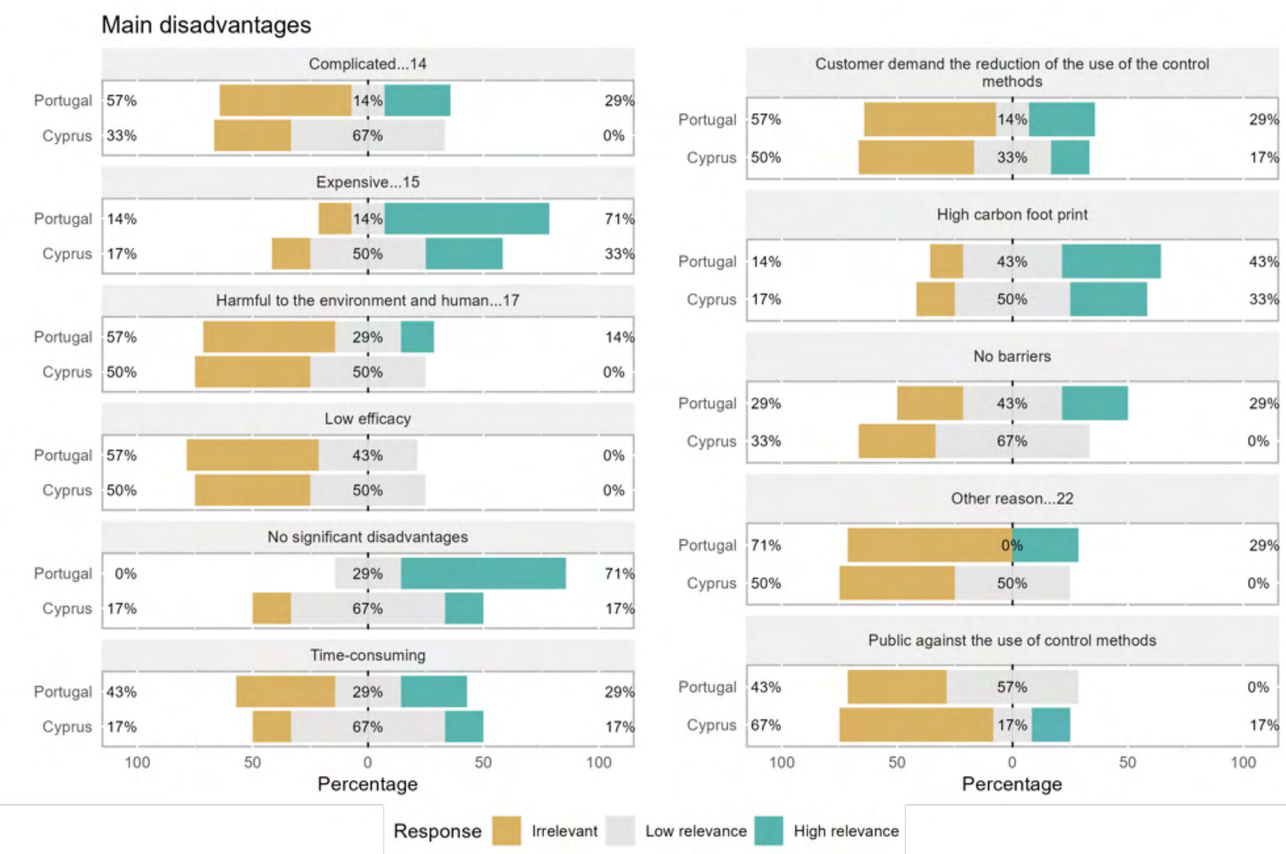


Figure 251. Main disadvantages for mechanical weeding identified by advisors.

3.1.3.1.2.2 Researchers

Researchers from Cyprus and Portugal perceive mechanical weeding as a practice entailing important needs, along with some opportunities, barriers, and disadvantages. Nearly seventy percent of respondents from both regions believe that this practice reduces reliance on herbicides. Additionally, 46% of them foresee mechanical weeding evolving into an important scientific discipline, while 38% emphasize its provision of crucial ecosystem services, such as increased water quality, improved biodiversity, and soil health. Cost reduction is unanimously regarded as the primary necessity for mechanical weeding, with over sixty percent of respondents also highlighting technical aspects like maintenance and timing reduction and expressing concerns about practicing knowledge skills. Additionally, 38% of researchers recognize the need for increasing knowledge about the practice's impact on ecosystem services and the lack of advisors. Training is considered the most relevant barrier by over fifty percent of respondents, with over thirty percent also citing lack of funds and expense as significant impediments to mechanical weeding implementation. In line with these barriers, 62% of researchers consider expense as the most relevant disadvantage of the practice. Moreover, nearly 40% of them identify a high carbon footprint, environmental and human harm as important drawbacks associated with mechanical weeding implementation.

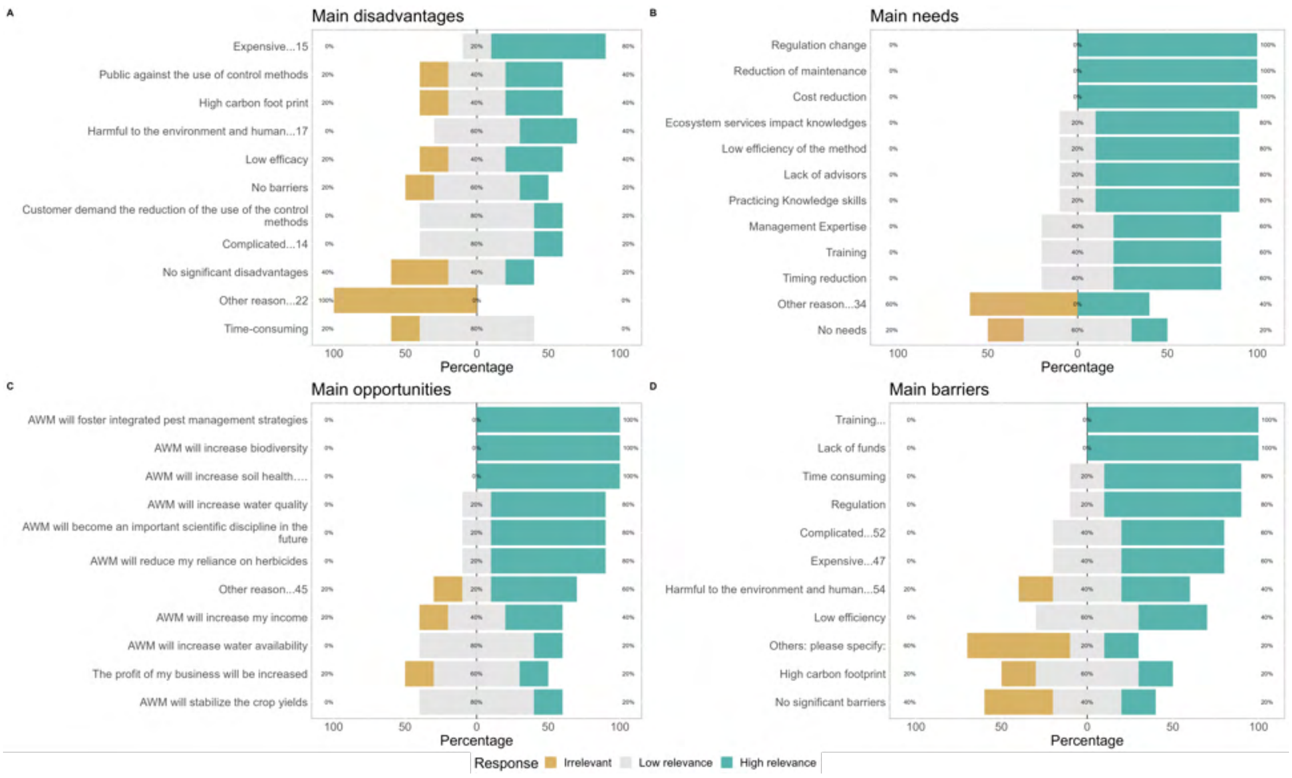


Figure 252. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by researchers.

3.1.3.1.2.2.1 By country

Portuguese researchers view mechanical weeding as a practice with significant opportunities, reflecting a more positive outlook compared to their Cypriot counterparts. Seventy-five percent of Portuguese respondents and sixty percent of their Cypriot peers perceive the reduction in herbicide reliance as the most relevant opportunity associated with mechanical weeding implementation. Additionally, half of the Portuguese respondents consider the technique's potential to evolve into an important scientific discipline as relevant, a viewpoint shared by forty percent of the respondents from Cyprus. Furthermore, one in two Portuguese researchers regard mechanical weeding as a provider of ecosystem services, including improvements in soil health, biodiversity, and water quality, and they consider this practice as fostering IPM strategies.

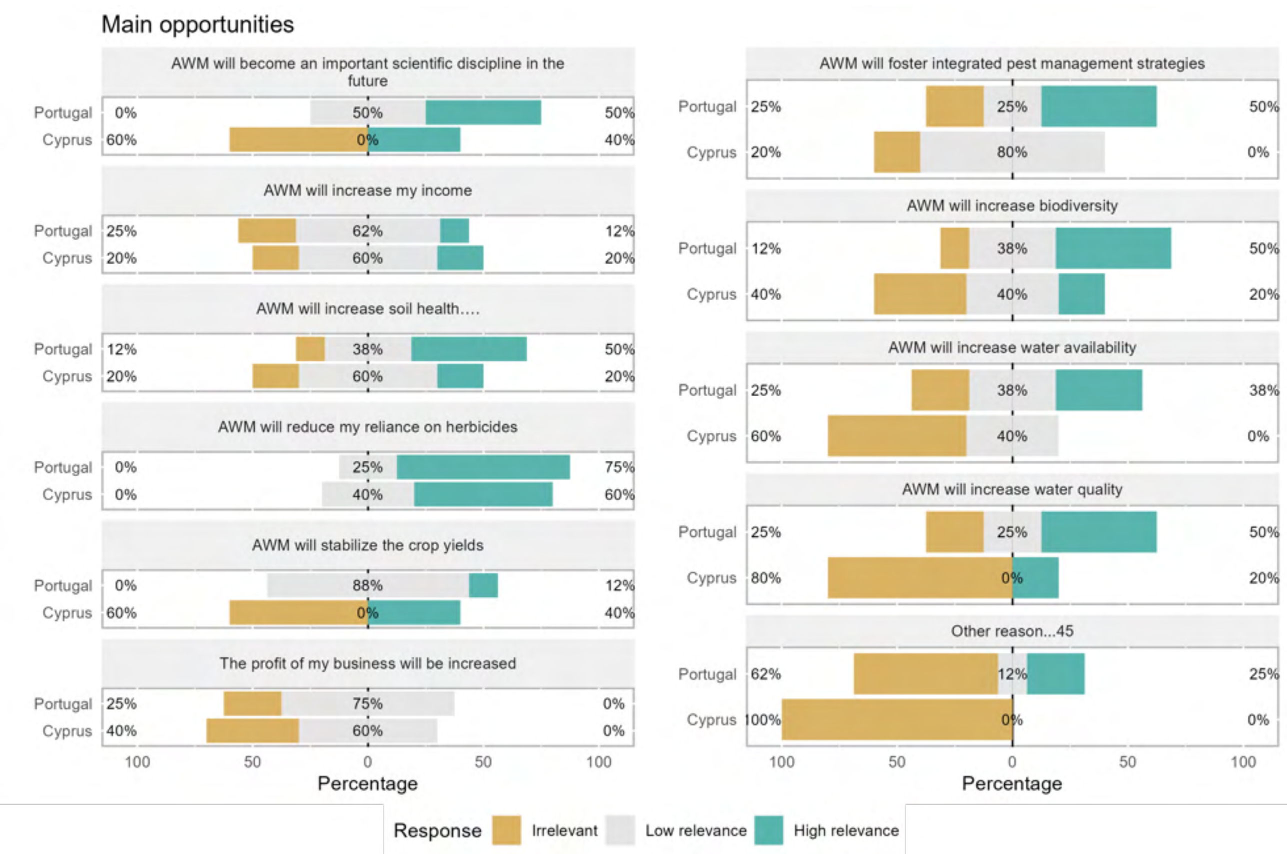


Figure 253. Main opportunities for mechanical weeding identified by researchers.

Portuguese respondents perceive mechanical weeding as presenting important needs compared to their Cypriot counterparts, who did not mainly consider any of the queried needs as relevant. Portuguese researchers unanimously regard cost reduction as the primary need, while this factor was deemed relevant by only 40% of the respondents from Cyprus. Nearly ninety percent of the Portuguese researchers consider maintenance reduction as relevant, whereas only 20% of their Cypriot peers share this view. Practicing knowledge skills and timing reduction were considered relevant by 75% of Portuguese researchers and 40% of Cypriots. Lastly, over sixty percent of the surveyed respondents regard ecosystem services impact knowledge as a highly relevant need.

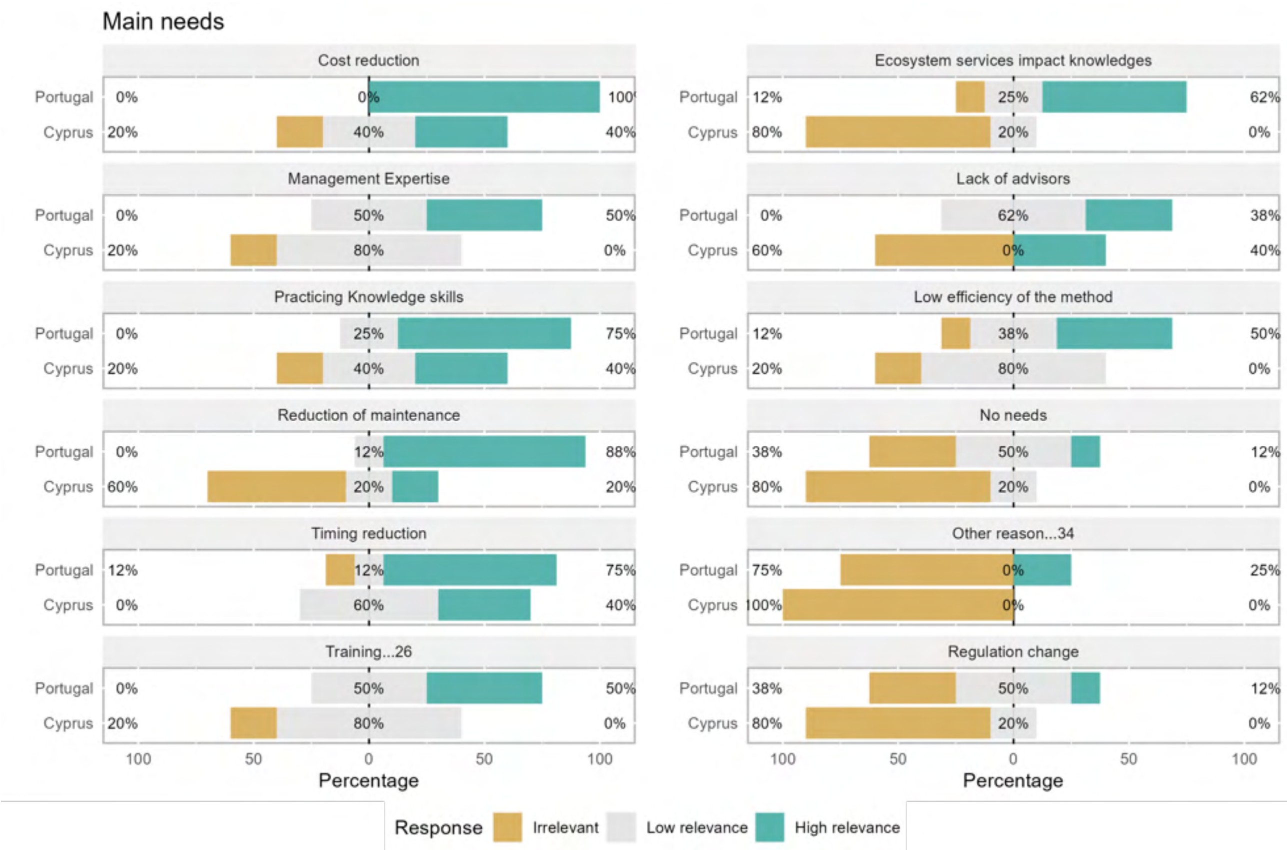


Figure 254. Main needs for mechanical weeding identified by researchers.

Once more, none of the queried barriers were considered relevant by over half of the respondents from Cyprus. In contrast, 62% of their Portuguese peers regarded training as an important impediment for mechanical weeding implementation, compared to 40% of the researchers from Cyprus. Additionally, half of the Portuguese respondents identified expense and lack of funds as additional barriers, while only 20% of their Cypriot colleagues shared this perspective.

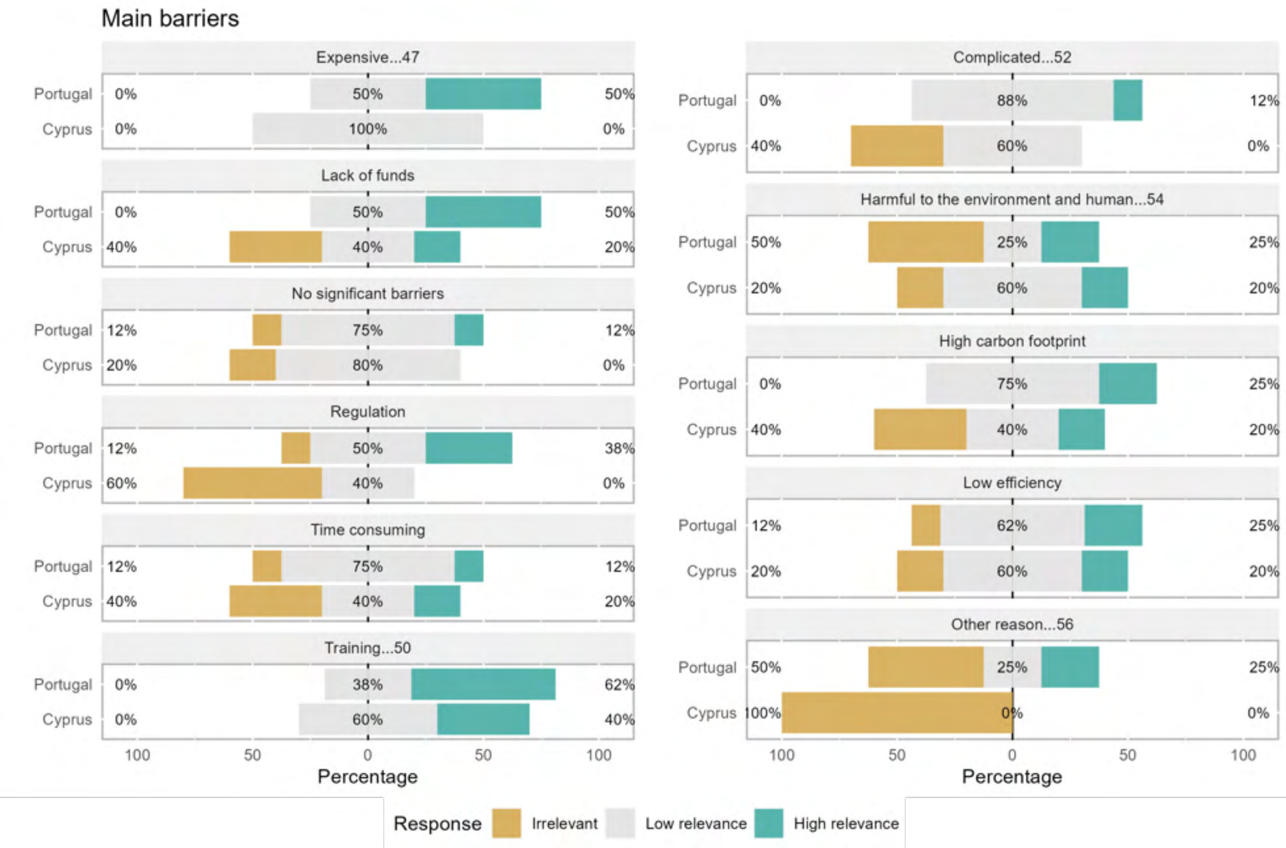


Figure 255. Main barriers for mechanical weeding identified by researchers.

Similarly, none of the queried disadvantages were regarded as highly relevant by more than half of the respondents from Cyprus. In contrast, Portuguese researchers recognized that mechanical weeding presents significant disadvantages. Nearly ninety percent of the respondents considered expense as the most relevant drawback, whereas only 20% identified this factor as important. Additionally, half of the respondents emphasized environmental and human harm, as well as the method's low efficiency, as important weaknesses of mechanical weeding.

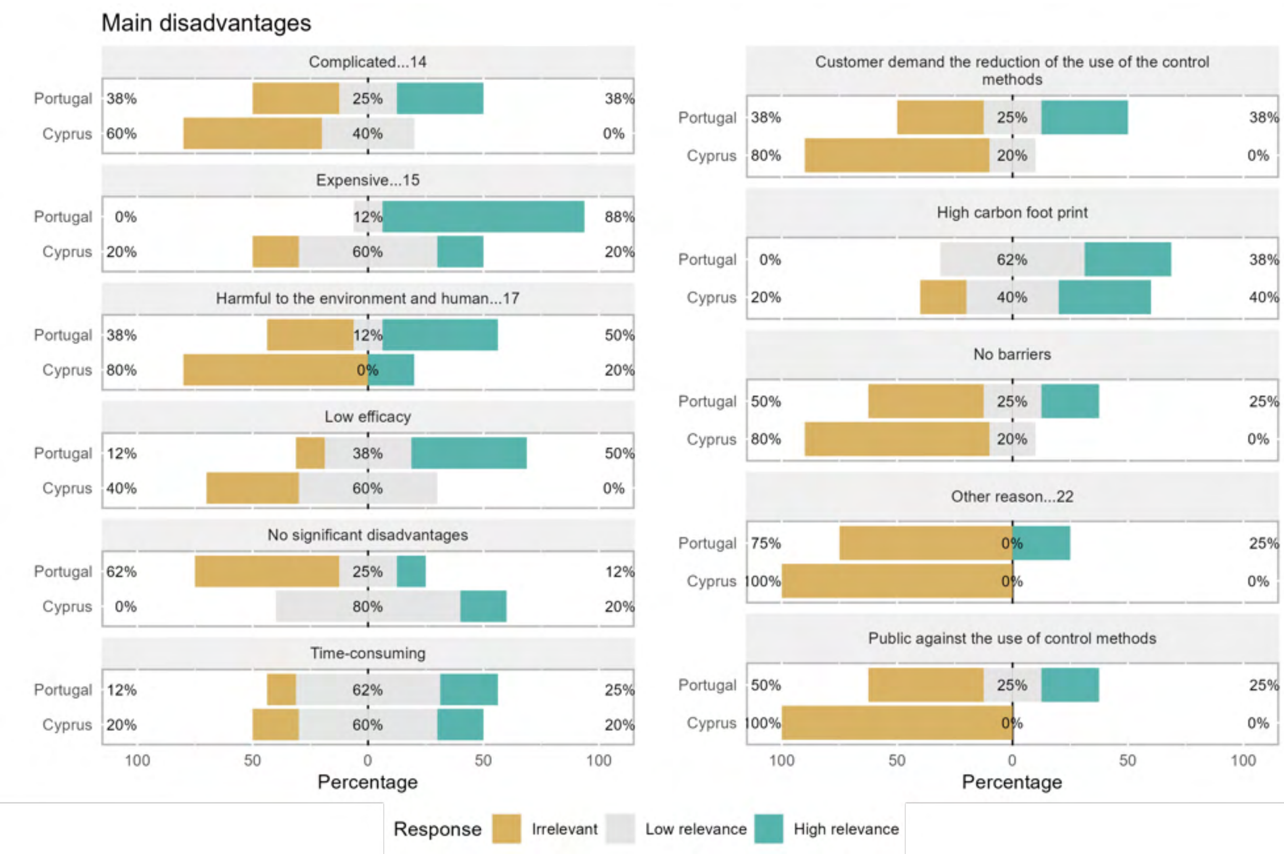


Figure 256. Main disadvantages for mechanical weeding identified by researchers.

3.1.3.1.2.3 Conclusion

Stakeholders from Cyprus and Portugal shared similar insight with regard to mechanical weeding use in olive cropping, a relevant proportion of advisors and researchers emphasized the reduction in herbicide reliance. Advisors from Portugal considered income increase, fostering of IPM strategies and reduction in herbicide reliance as the most relevant, while the latter was the sole category considered as relevant by more than half of Portuguese researchers. Both advisors and researchers from Cyprus considered reduction of herbicide reliance as the most important opportunity related to mechanical weeding.

Portuguese advisors consider ecosystem services impact knowledges as relevant, and researchers recognize that mechanical weeding faces relevant opportunities, including reduction of cost, maintenance and timing as well as a lack of practicing knowledge skills, whereas their Cypriot peers did not mainly consider any of the listed categories as of relevance. Training was considered as the most important overall barrier by half of the advisors and researchers alike. Similarly, both groups considered expense as the most important disadvantage.

3.2 Cherry

3.2.1 Spain

3.2.1.1 Questionnaires

Cherry questionnaires provided insights of 2 AWM techniques, regarding the perception of their main opportunities, needs, barriers and disadvantages. Advisors and consumers shared their perspective with regard to herbicides, and mowing was considered by advisors. A detailed breakdown of stakeholder participation in the questionnaires for each AWM practice is presented in Table 33.

Table 33 Number of responses for each AWM practice and stakeholder category in Cherry (Spain).

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control						
Biobased herbicides						
Cover crop inoculation to increase competitiveness						
Cover crops	1	1	1			1
False seedbed						
Grazing	2	1	1		1	
Herbicides	**4**	**7**	1		1	2
Intercrop	1				1	
Mechanical weeding	2		1		1	1
Mowing	**3**		1	1		1
Mulching						1
Natural enemies						
Other						
Site-specific spraying	2					1
Thermal weeding						
UAV						
n=17	5	7	1	1	1	2

3.2.1.1.1 Herbicides

3.2.1.1.1.1 Advisors

Advisors shared an optimistic perspective with regard to herbicides, noting numerous opportunities alongside relevant needs and barriers, as well as some disadvantages. 80% of them acknowledge improvements in water quality and soil health. Sixty percent believe in herbicides fostering IPM and biodiversity. Main needs include regulatory changes, maintenance, and timing reduction, alongside ecosystem knowledge and cost reduction, cited by 60% of respondents. Advisors unanimously highlight time consumption, lack of funds, and expense as main barriers, while 60% identify environmental and human harm, low efficiency, training, and regulatory challenges. Notably, 80% see public opposition to herbicides as the primary disadvantage, with 60% citing environmental and human harm.

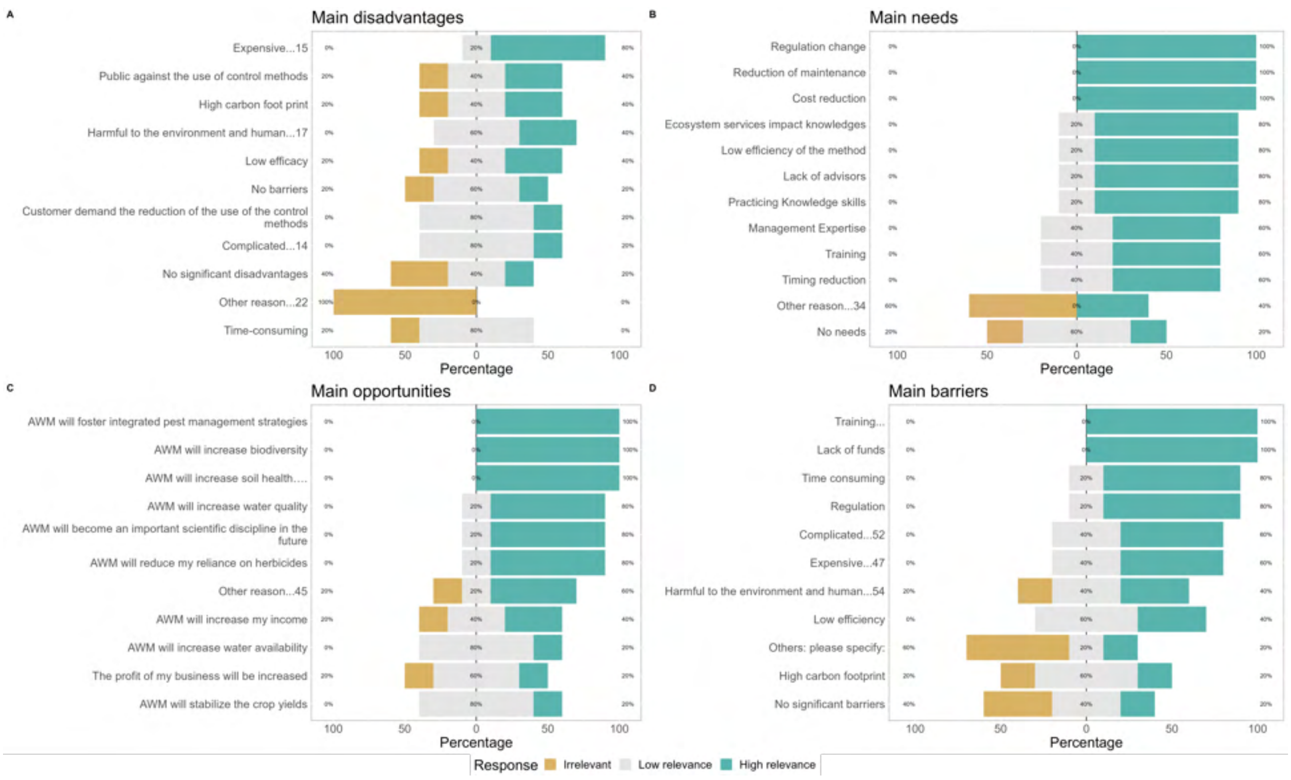


Figure 257. Main disadvantages, needs, barriers and opportunities for herbicides identified by advisors.

3.2.1.1.1.2 Consumer

Consumers perceive herbicides as offering significant opportunities while also presenting important needs, disadvantages, and some barriers. Over 70% believe herbicide use can improve water quality and stabilize crop yields, with nearly 60% noting benefits to water availability, biodiversity, and soil health. Ecosystem services impact knowledge is seen as the primary need by 86% of respondents, while 71% highlight method efficiency. Regulatory changes, lack of advisors, and training are also considered important by nearly 60% of respondents. Training is identified as a key barrier by 86% of respondents, while environmental and human harm concerns are shared by nearly 60%. Interestingly, the same proportion of respondents believe herbicides face no relevant barriers. Environmental and human harm is unanimously considered the main disadvantage, though 71% believe there are no significant disadvantages. Furthermore, nearly 70% express concerns about public opposition to herbicides, and almost 60% note worries about customer demand to reduce herbicide use and high carbon footprint.

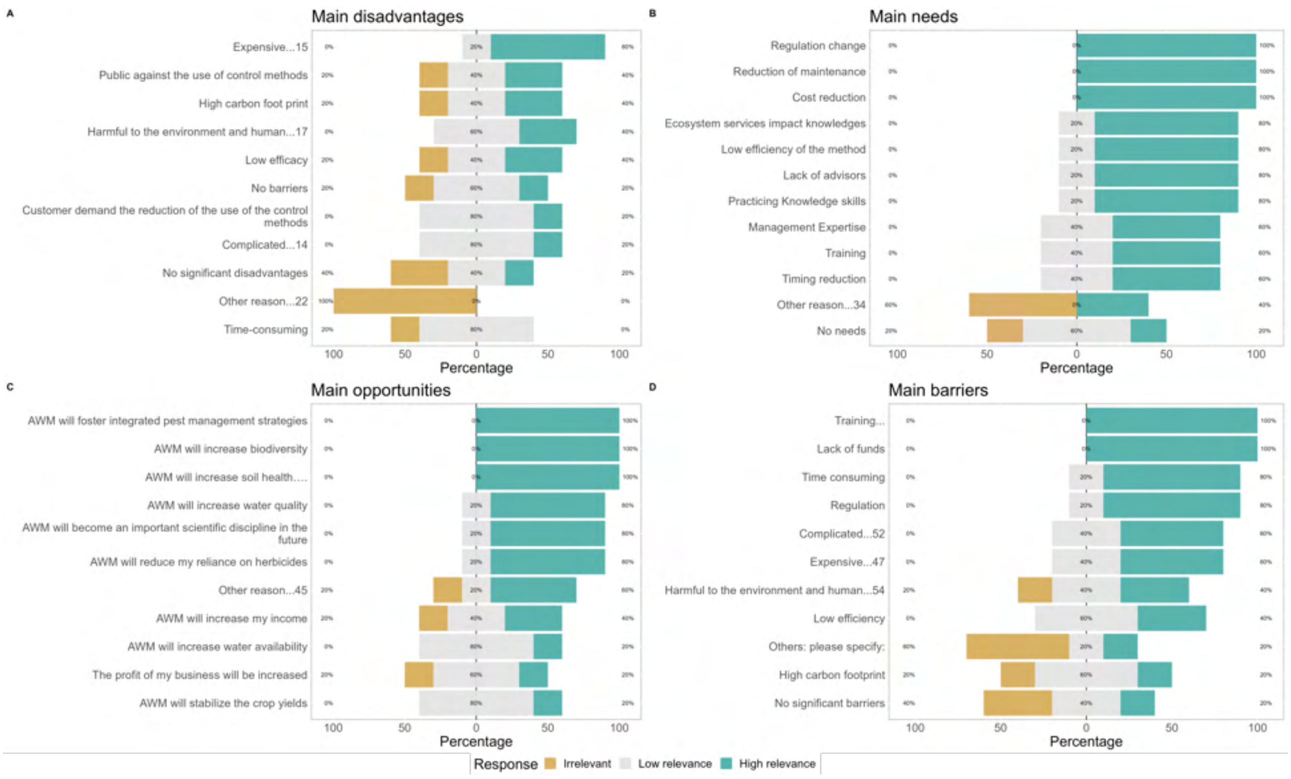


Figure 258. Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

3.2.1.1.1.3 Conclusion

Advisors and consumers consider herbicides as a method that offers relevant opportunities while presenting significant needs, barriers, and disadvantages. A significant proportion of both stakeholders believe that herbicide use results in improvements in water quality and soil health. Consumers recognize herbicides as providers of other ecosystem services, including increased water availability and biodiversity. Both stakeholders also see potential for reduced herbicide reliance. Advisors prioritize regulatory changes, maintenance, and timing reduction as primary needs, while consumers identify ecosystem services impact knowledge as the most relevant necessity. Advisors unanimously recognize time consumption, lack of funds, and expense as main barriers, whereas consumers consider training as the most relevant impediment. Both groups emphasize environmental and human harm as highly relevant barriers. Advisors identify public opposition to herbicide use as the main disadvantage, a concern shared by consumers who unanimously consider environmental and human harm as the most relevant drawback

3.2.1.1.2 Mowing

3.2.1.1.2.1 Advisors

Advisors express an optimistic outlook on mowing, identifying significant opportunities and barriers while acknowledging few needs and virtually no disadvantages. They unanimously view mowing as an ecosystem services provider, improving water quality and soil health, and reducing herbicide reliance. Nearly 70% believe it fosters IPM strategies, increases water availability and biodiversity, and will evolve into an important scientific discipline, stabilizing crop yields. As primary needs, nearly 70% prioritize cost and maintenance reduction, with other necessities not deemed relevant by a significant proportion. Advisors unanimously cite low efficiency and time consumption as main barriers, while complexity, training, and expense are emphasized by nearly 70% as relevant. Two-thirds consider time consumption the main disadvantage, with other drawbacks not considered significant by a significant proportion of respondents.

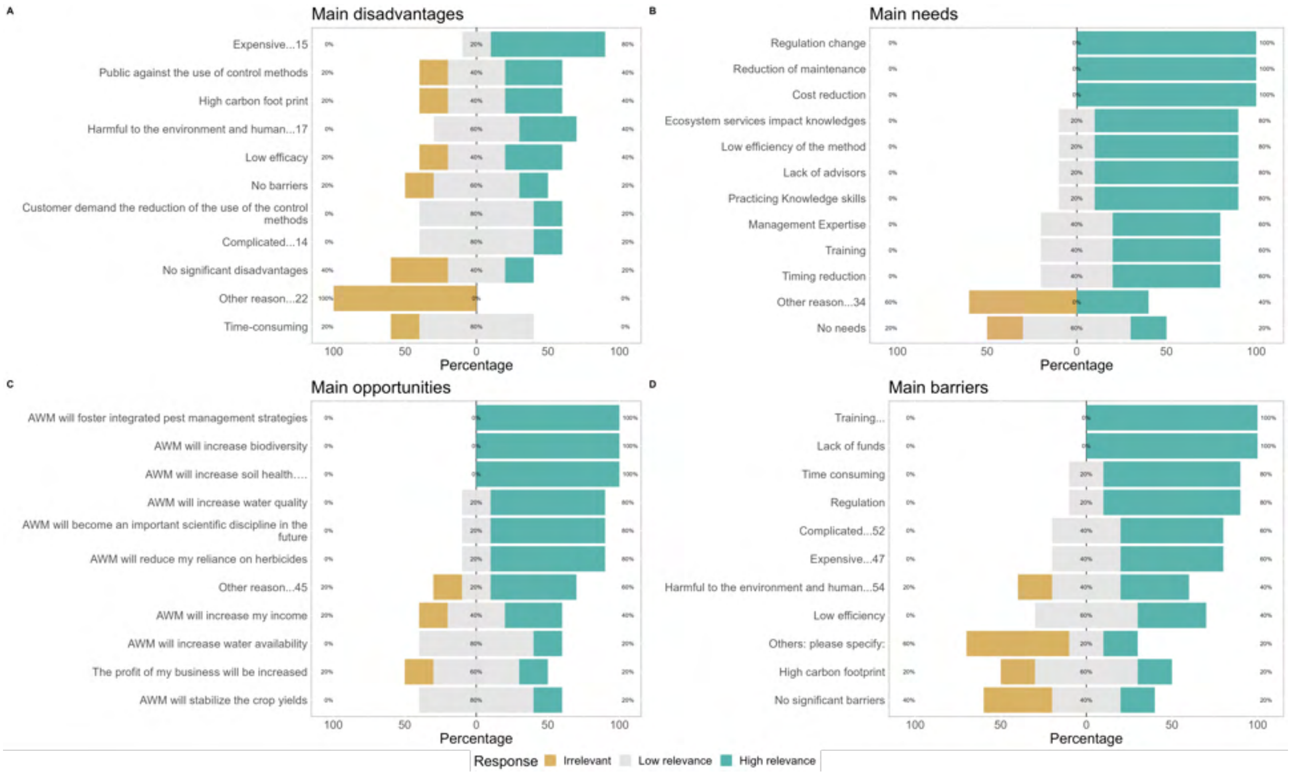


Figure 259. Main disadvantages, needs, barriers and opportunities for mowing identified by advisors.

3.2.1.1.2.2 Conclusion

Advisors exhibit an optimistic perspective on mowing, recognizing its potential to provide numerous benefits while facing limited barriers and needs. They unanimously acknowledge its role as an ecosystem services provider, foreseeing positive impacts on water quality, soil health, and herbicide reliance reduction. While certain challenges such as low efficiency and time consumption are recognized, the overall sentiment remains positive, highlighting mowing as a promising approach for sustainable agricultural practices.

3.2.1.2 *Surveys*

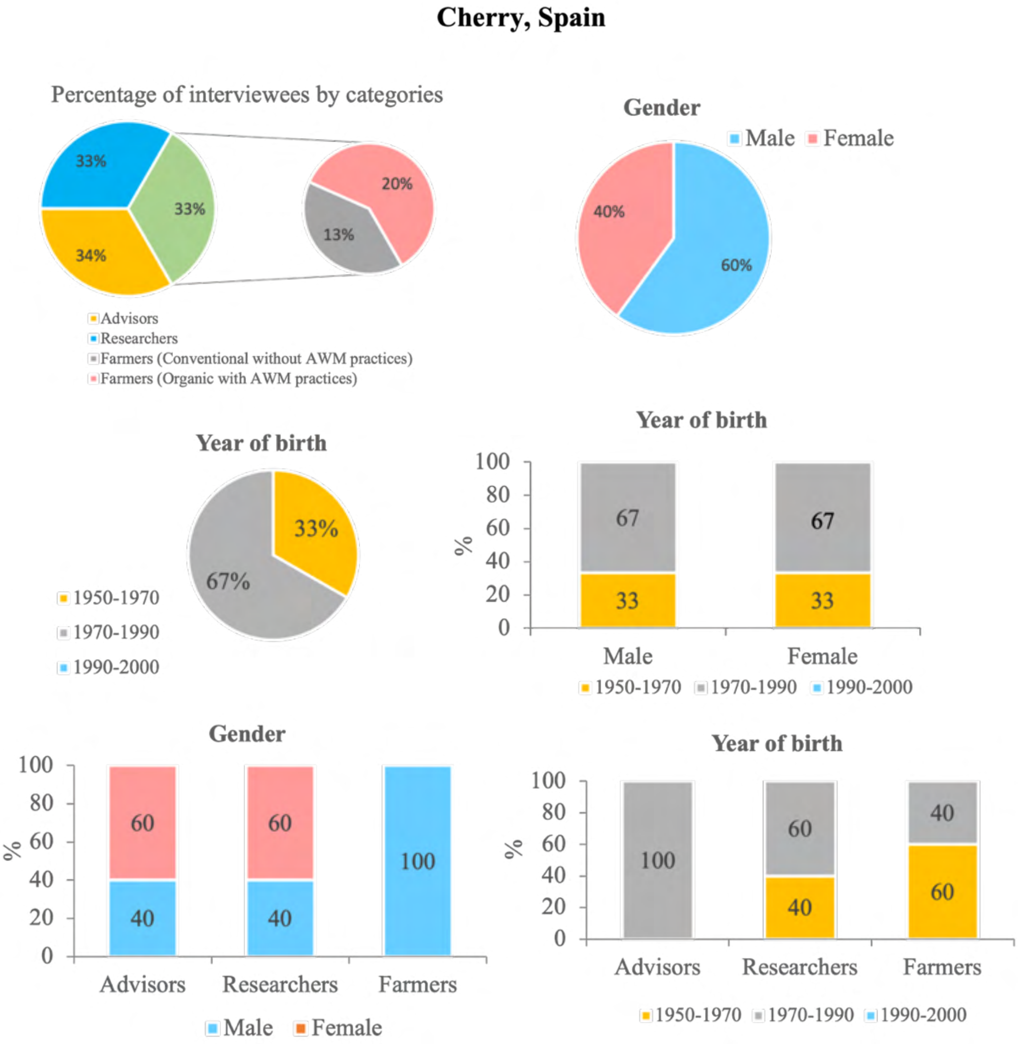


Figure 260. Interviewees description in the Cherry Living Lab (Spain)

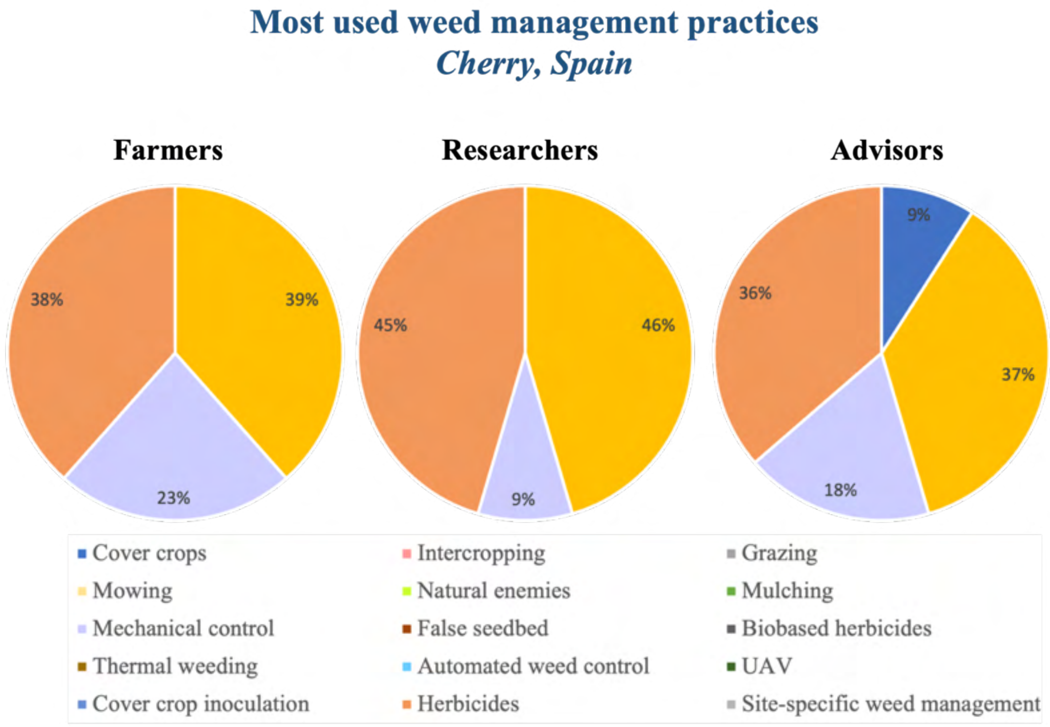


Figure 261. Most used weed management practices in the Cherry Living Lab (Spain)

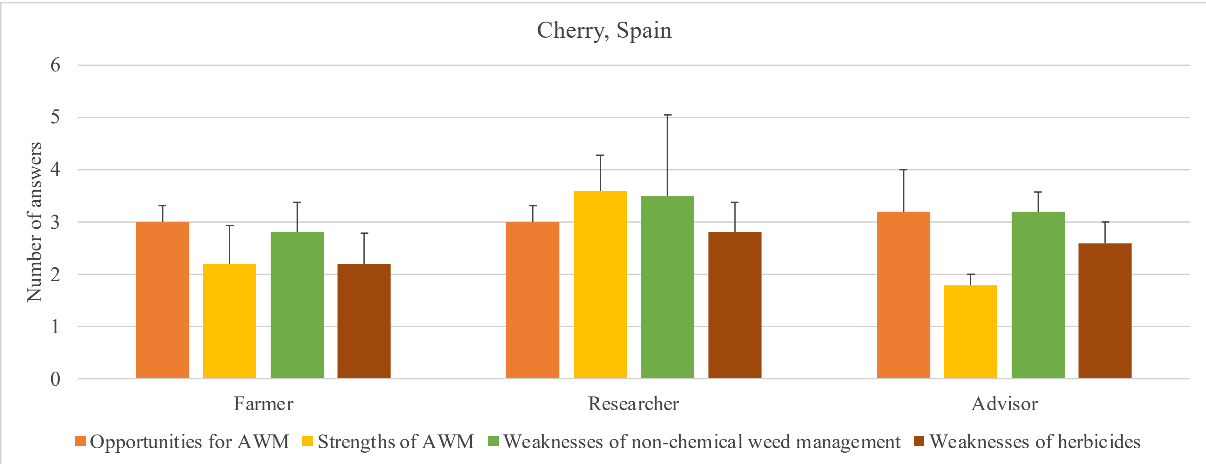


Figure 262. Mean number of answers (±se) per stakeholder group in the Cherry Living Lab (Spain)

Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: Presented in the figure below.

THREATS: Only invasive species and changes in weed flora were related to threats for AWM practices.

WEAKNESSES: Since there is no experience in many of the available AWM practices in Extremadura, the weaknesses tied to them included only a few answers (cost of applications, lack of technical assistance, lack of training, limitation for large-scale operation).

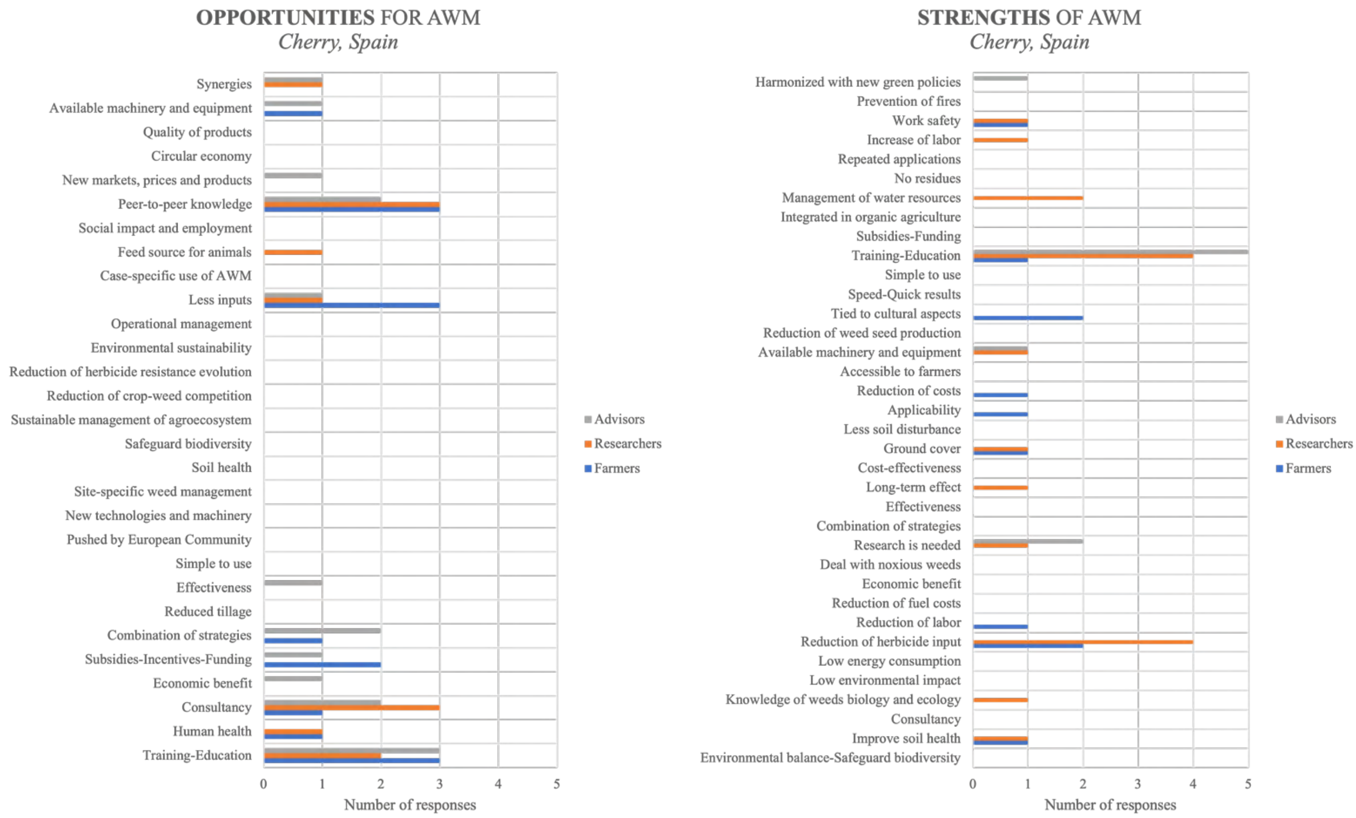


Figure 263. Opportunities and strengths of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: Lack of recognition from markets and the structure of market were identified as threats for non-chemical weed management by all stakeholder groups.

WEAKNESSES: Presented in the figure below.

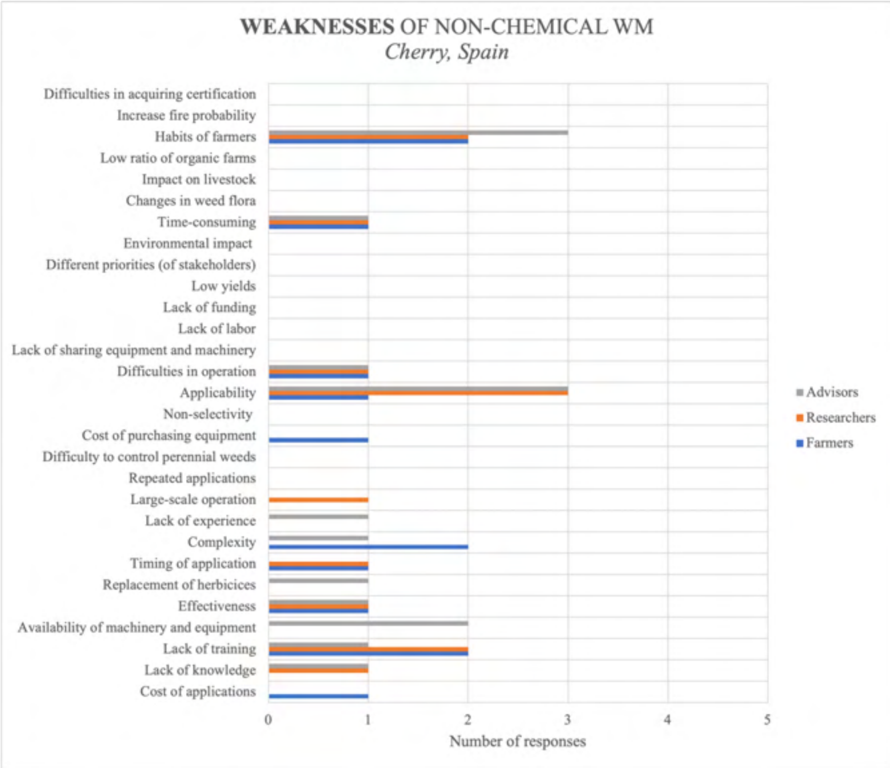


Figure 264. Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: None.

STRENGTHS: None.

THREATS: A farmer thinks that the market is a threat for herbicides.

WEAKNESSES: Presented in the figure below.

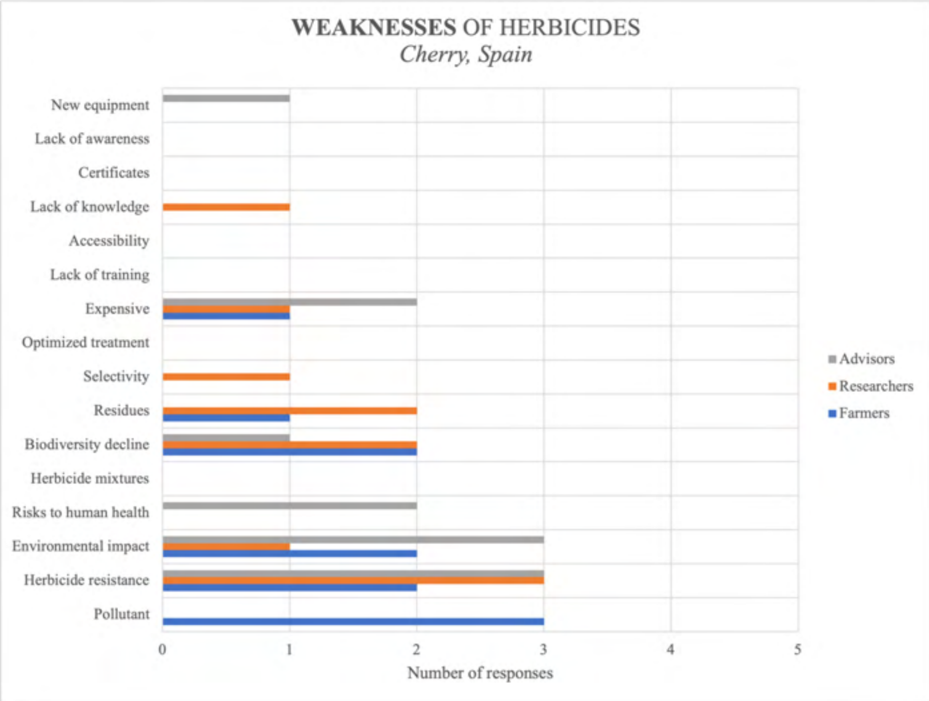


Figure 265. Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – CHERRY, SPAIN
Most used weed management practices: The results from the Extremadura area and the cherry crop in terms of weed management were enlightening and showed that only mechanical means, mowing and herbicides are used. Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group: The number of responses from stakeholders indicated that researchers could identify more strengths of agroecological weed management than producers and advisors. Another important result was the finding of more weaknesses of non-chemical than chemical weed management, suggesting a reliance on chemical herbicides for this crop. **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: For the region of Extremadura, training and education, less inputs, consultancy and peer-to-peer knowledge are highlighted as opportunities around agroecological weed management. This effect is even more evident in the strengths of agroecological weed management where it is recognised as offering and requiring more education and training, and can lead to a reduction in chemical inputs.

Threats, and weaknesses for non-chemical weed management: The major weaknesses of non-chemical weed management in Extremadura and cherry crop are identified as farmers' habits, applicability and lack of training, compounded by the complexity of these practices. Lack of recognition from markets and the structure of market were identified as threats for non-chemical weed management by all stakeholder groups.

Opportunities, strengths, weaknesses, and threats for herbicides: Farmers, advisors and researchers recognized that herbicide resistance, environmental impact, biodiversity decline and residues are major weaknesses of herbicides. In addition, they are also considered expensive by some respondents.

3.2.1.3 . Living lab board meeting

The Cherry LL meeting was held in person at the Centre for Organic and Mountain Agriculture CAEM (30/11/2023 from 9.30h to 11.30h). It was attended by 15 people (6 researchers, 1 company, 3 farmers, 1 policy maker, 1 consumer organization, 2 advisors). Two other policy makers and 2 companies that are part of the LL could not attend but are interested. Consent forms to participate in the LL board were collected from all attendees. We keep the records for the incidences that could arise on the part of the European Commission, as a sample of the conformation of the LL and the constitution with these members present. The multi-stakeholder conformation of the driving group is to make the debate more diverse and to see if the methodologies are appropriate or not.

The GOOD partner conducted the meeting and presented the project and the activities carried out so far. In Casas del Castañar (Cáceres province), one plot is managed organically, which is the experimental farm of the Agrupación de Cooperativas, and another plot is managed in a traditional-conventional way. In the two experimental plots, 4 types of cover crops have been sown and will remain throughout the project. Serradela, which is a leguminous plant. Mixture of leguminous plants and low-growing grasses. Mixture of low grasses and Subterranean clover. All of them are self-seeding species. The management will be applied at a certain time, the aim is to encourage the establishment of the cover crop to prosper. The last clearing applied to the cover crop is done when the plants have completed their cycle.

We will study the cover crop's ability to establish itself in the first year and compare it with the usual management methods used by farmers, which in the case of conventional crops is usually one or two applications of herbicide and then weeding, and in the case of organic crops only weeding.

The following year, the best cover crop (inoculated and non-inoculated) will also be planted. Microorganisms theoretically benefit the implantation and development of this cover crop. These are AMF that make the cover crop plant better to see if we see any difference in competition. Research team from Pisa University is in charge of identifying the micro-organisms in each site to multiply (en masse) and isolate the micro-organisms that most interest us in order to inoculate them.

In addition to these plots, water monitoring will be carried out in one of them to see the water competition between the cover crop and the main crop. In another organic farm with a good spontaneous cover crop, management recommendations will be made to ensure that the most interesting weeds proliferate.

Afterwards, the attendees discussed and answered questions about the cherry sector and weed management issues. The weed control techniques at the tree line will be introduced through discussion. It has been seen which things are feasible and which are not. The next steps in this direction are aimed at holding a specific meeting to work on this issue and to finalize which possible strategies would be interesting.

There is a great interest in the project and the group is very dynamic and diverse. It has been decided that we will identify concrete issues to work on in order to better define weed management strategies for cherry growing in mountain systems.

During the next year at least two discussion and co-creation workshops will be held on: (1) the different cherry production models and possible control alternatives to be applied in years 2 and 3 of the project; (2) discussion on the results of ground covers. In addition, a field visit will be made in spring to the experimental plots to see the development of cover crops.

We intend to carry out many transfer actions and materials will be published, creating digital tools within this AWM network so that they are accessible to producers, technicians, to any entity, and over the next four years the LL will be attentive to decision-making. That is why we have invited representatives of all profiles to participate. In addition, for it to make sense to include new (agroecological) techniques, there must be the normative and regulatory stakeholders, the companies, and the cooperatives Agrupación de Cooperativa del Campo (Navaconcejo), Cooperativa Agroecológica de Montaña and Ecojerte, and on the consumer side, there is Ecocomedores de Extremadura /Agroecoteca, which is always important to be also in the Living Labs and can be a good ally in the project for the whole issue of dissemination. It is proposed to integrate more conventional farmers into the LL Board. During the LL board meeting, this information was also collected:

<table>
<tr><td rowspan="10">What are the market characteristics of [crop]?</td><td>1. How many farmers cultivate [crop] in the region (approx.)? Is it mostly monoculture or can rotations be made with other crops?</td></tr>
<tr><td>5000 (including three valleys in Cáceres province: Jerte, la Vera, el Ambroz...). The Jerte Valley is mainly conducted in monoculture. In La Vera there is an association with chestnut and plum trees. No inter-cropping, but there are several productions because they are larger farms. The smaller and more homogeneous plots are cultivated in monoculture. But sometimes, for economic reasons, there is a diversification of crops: in El Cabrero and El Torno there are olive trees, chestnut trees, plum trees. La Vera has more diverse production, and the plots are larger than in Jerte.</td></tr>
<tr><td>2. How many products are derived from the [crop]? Are they important for the economy and/or food security?</td></tr>
<tr><td>Fresh fruit is the principal. There are also jams, wine and liqueurs, but representing a little
importance (residual).</td></tr>
<tr><td>3. Do you think that agroecological products could be promoted in local markets?</td></tr>
<tr><td>Yes, in ECOCOMEDORES, a regional project aimed at supplying organic food in school
canteens (caterings from Extremadura used to bring cherries when they were from Catalonia!!)
The local market is more than covered with the production we already have in organic production. If we understand Madrid as a nearby destiny, everything is distributed. The problem is the price for the organic cherry. Due to transport and commercial intermediaries.</td></tr>
<tr><td>4. Do you believe that the region has a lack of technologies?</td></tr>
<tr><td>Novel sprayers are available, there is sensorisation applied to water saving and fertilisation (but little and expensive, company investments).</td></tr>
<tr><td>5. Is the regional agri-food value chain sustainable?</td></tr>
<tr><td>Depends on production inputs, the profitability limit depends on the season and the climatic situation.
Economic SUSTAINABILITY (relative) due to the prices of inputs: fertilisers, herbicides, pesticides. And FUEL in organic farming for weeding.</td></tr>
</table>

	Tilling is practically not done as it damages the roots of the trees, the soil is usually covered all year round, so we start from a situation that is a little better environmentally speaking in terms of weed management than in other areas. IPM criteria are always recommended by local advisors. It is basically a question of trying ideal management and in those places where herbicides can be reduced. SOCIAL SUSTAINABILITY (except Navaconcejo and Cabezuela del Valle villages) - There is no generational renewal or sufficient human labour - In 10 years it will be difficult to find people who want to come to this type of cultivation - It will depend on the location and the economic profitability of the crops. ECONOMIC SUSTAINABILITY There are more and more difficulties, the last few years in cherry growing have been a real disaster and those who do not have a cushion and cannot devote themselves to something else have to give it up. There is no prospect that is economically viable over time (no attractive for young people). One strategy to attract them would be the whole issue of technology and digitalisation because it is always associated with agriculture as something hard. In addition, the diversification of crops could be a positive point of view to help young beginners, as the disadvantages are that in the new incorporations of young farmers, they have to start with a minimum of 4.5 hectares and a young farmer does not have enough economic capacity if he does not have a family that has farms before. Public incentives will be encouraged in order to more young farmers entry into the sector.
What are the most common agricultural and weed management practices in [crop]?	1. What are the most common agronomic practices in [crop]? FERTILISATION MANAGEMENT Conventional fertilisation: bottom dressing (February) + limestone (or dolomite, which is the most common) + organic + top dressing (NAC) // ECO: organic (Natuvigor, Amicote, Fertiplus) + limestone + foliar (nettle slurry). In organic farming, organic fertiliser is applied now when the tree is dormant, giving it time to

	mineralise in winter or when conditions are more favourable due to the temperature, and one type of fertiliser or another will be applied depending on the maturity of the manure. Or compost if it is available closer to spring. The aim is to make soil, and thus improve the structure of these acid soils. Ploughing: it is worse for the trees. PESTS A lot of work is done on the basis of integrated production, which serves as a reference although it is not certified. MOWING Many people do mowing, but it would be interesting to know how often it is done and with what criteria. Integrated production leaves cover soil from NOVEMBER to FEBRUARY.In El Cabrero, some people plough the land 2 or 3 times a year in the years of planting. One of the farmers, two or three years ago, left the natural cover and let it complete its full cycle and then weeded it when it was already summer when we finished picking the cherries in July, and what he achieved with that was that both the plant and the roots developed as much as possible and created a structure in the soil with the properties and a mulch with all the dry matter. This line of work is very important because depending on the moment when this cover is cleared, we will obtain a different composition of plants and more N or C for the soil. Based on the needs of the farm and the soil analyses or the time of the cherry crop cycle.
	2. What are the most common weed management practices in [crop]?
	Herbicides (1-2 treatments) +mowing in conventional. Only mowing in organic farming. Mowing is done 2 or 3 -times in spring. No intervention from November to February.

	1. How many active ingredients there are available? How many different mode of actions?
	Glyphosate (contact) POST-emergence/MCPA systemic (contact) POST emergence/Oxifluorfen- residual, in PRE.
	2. How many times do you spray in-season?
	Treatments: 2 herbicide treatments: one in April-May (spring) and one now (autumn).
	3. Do you use pre-emergence, post-emergence or both herbicides?
	Both
	4. Are herbicides efficient?
	The conventional producer says yes, except when they are already resistant.
	5. Do you think that alternatives to herbicides are equally efficient?
What is the herbicide use in [crop]?	If progress is made in the organic regulation with grazing, yes. There is an operative group for the use of weeding with the introduction of the "blue" hen (local breed). There are limitations to the introduction of goats, which is more common in mountain areas. One thing is to make a calendar to see on what dates the animals are there and for how long, and that for six animals or three animals that you can have or if they belong to someone who comes from someone who is not so organic, you have problems with the official documents and requirements (you need to be in the animal breeders register…) The documents required are adapted to extensive farms, but not to small and diversified ones: we give them some guidelines (says the local government representative in the board) that are so that the use is not really for sheep, but for cultivation. They have found areas of overgrazed slopes and this is not acceptable in organic farming. But if we see that the crop is fine and that there is no erosion or that there is no damage to the crop, it is allowed.

	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?
	HERBICIDE PROBLEMS 1. lack of biodiversity 2. fewer insects 3. enhancing soil compaction and contamination 4. diminishing soil microbiology The life cycle of the different alternatives that are going to be proposed (ecological impact and footprint), the biophysical costs so to speak and on the other hand the economic balance we have to look at it to take it into account in a more holistic way.
	7. Do you believe that agriculture without herbicides is viable?
	Organic farmers say yes. Conventional ones say that it depends on the market price (does it will support the over-costs of agroecological strategies?)
What are the needs and barriers to assist agroecological transitions & adopt agroecological weed management approaches?	1. What is needed to boost the uptake of agroecological practices?
	Incentives. The climate change that we are suffering, the pollution that we are experiencing. We are all paying for it in some way, and those who generate pollution, such as industries, are paying more and more for it. We, for example, are working and trying to do things better than them, but we are being increasingly hindered and impeded. We, organic farms are the ones who improve the environment: we have to pay those who produce oxygen and we are going to give those who are polluting the obstacles and incentives to accompany those who do it well.
	2. What are the barriers towards agroecology implementation?
	Economic innovation strategies need to be put in place to value the ecosystem services that organic farming promotes. Be aware of carbon markets (one of the practices that is rewarded is the establishment of cover crops and organic farming).
	3. Should policies need be redefined to allow agroecological transitions?

	Of course, this is a key point for the transition. Public support Good practices, and transfer processes for information to flow. A more professionalized sector in agroecological systems is essential.	
	4. How confident you feel about the adoption of agroecological weed management practices?	
	It is not because we have more cultural tools that we will know what we are doing or where we want to go; we should not only measure ourselves in terms of production or productivity, but in many other ways. Where we are going and the necessary change of mentality. What management possibilities will we have on this type of farm? - mechanical clearing - manual clearing - to influence collaborative processes to try to fill those gaps because you don't have your own capacity... Creating synergies between livestock farmers and cherry producers, service enterprises for mowing, …	
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	1. What are the main drivers of weed dispersal?	
	All of them: machinery, manure, farmers walks…	
	2. Which are the major and most noxious weeds in your area?	
	Lolium rigidum	
	3. Are there any herbicide resistant weeds?	
	Lolium is getting resistant in this area	
	4. Do you know any invasive plants in your area?	
	No	
What do you think about the Living Lab?	1. Which proposals do you have for a good performance of the LL?	
	We aim to create a working environment that will last beyond this project. We want to be able	

	to see what we needs still have in the cultivation of cherry trees or in mountain crops and to be able to continue working throughout the project and after it.
	2. Would you like it to remain over time?
	Of course.

3.3 Apple

3.3.1 Spain

3.3.1.1 Questionnaires

Apple questionnaires provided insights of 8 AWM practices with regard to the perception of their main disadvantages, needs, barriers and opportunities. The main evaluated techniques were grazing, mowing and mulching answered by all types of stakeholders (advisors, consumers, farmers, industry, policy makers and researchers, while automated weed control was only answered by the consumers Table 34 shows the type of stakeholder that answered the questionnaires associated with the different AWM practices.

Table 34 Number of responses for each AWM practice and stakeholder category in Apple (Spain).

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control		1				
Biobased herbicides		**3**	1	1	1	
Cover crop inoculation to increase competitiveness						
Cover crops	1	**5**	2			2
False seedbed						
Grazing	**3**	**6**	**1**	1	**3**	2
Herbicides	2	**9**	**8**		**3**	**5**
Intercropping		1	**3**			
Mechanical weeding	**5**	**6**	**1**	2	**3**	**3**
Mowing	**4**	**4**	**9**	**4**	1	**3**
Mulching	1	**3**	**3**	1		1
Natural enemies	1					
Other			1			
Site-specific spraying		1	1			
Thermal weeding						
UAV						
n=49	6	10	18	5	4	6

3.3.1.1.1 Biobased herbicides

3.3.1.1.1.1 Consumers

Consumers unanimously believe that biobased herbicides will evolve into an important scientific discipline and significantly contribute to IPM strategies, soil health improvement, increased profitability, and reduced herbicide reliance. Regarding key needs, consumers unanimously prioritize ecosystem services impact knowledge, lack of advisors, practicing knowledge skills, management expertise, training, and cost reduction. Additionally, two-thirds of consumers highlight the importance of regulatory changes, method efficiency, and timing and maintenance reduction. However, consensus among consumers is lower when identifying relevant impediments, with 67% citing time consumption, training, lack of funds, and expense as significant barriers. Similarly, expense and complexity are considered relevant drawbacks by the same proportion of respondents.

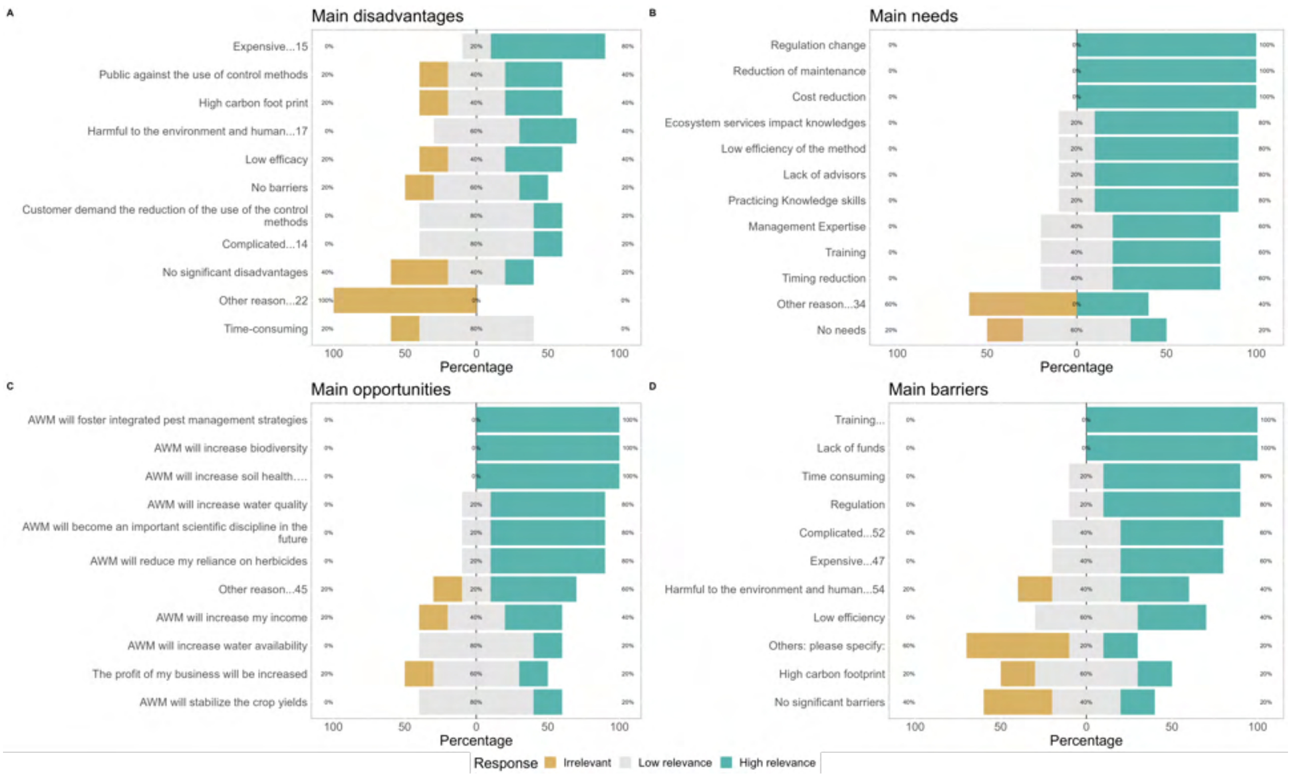


Figure 266. Main disadvantages, needs, barriers and opportunities for Biobased herbicides identified by consumers.

3.3.1.1.1.2 Conclusion

Consumers view biobased herbicides optimistically, recognizing their potential for evolving into a relevant scientific discipline, while acknowledging various needs, including the necessity for increasing the knowledge on ecosystem services impact, training, and cost reduction. Additionally, they recognize time consumption as a relevant barrier and expense as a disadvantage.

3.3.1.1.2 Cover crops

3.3.1.1.2.1 Consumer

Cover crops are considered a relevant AWM technique by a sufficient number of consumers, who perceive it as promising due to the numerous opportunities it presents. However, they also recognize that this method entails relevant necessities while presenting few barriers and disadvantages. Consumers unanimously believe that cover crops can reduce reliance on herbicides, with 80% of them stating that it improves water security, biodiversity, and soil health, while fewer respondents, below 60%, see the rest of the ecosystem services as main opportunities. However, only 20% of consumers consider cover crops as a way to foster IPM or stabilize crop yields. Regarding the main needs, around 60% of surveyed consumers found the need for knowledge and knowledge transfer highly relevant, but only 20% think there is a need for knowledge on ecosystem services impact, regulation changes, or lack of advisors. This discrepancy may be because they are less familiar with the use of cover crop techniques at the field level. Consumers perceive time consumption as the main barrier, but do not identify the rest of the options as relevant. Time consumption is the most significant disadvantage of the cover crop AWM technique perceived by just 40% of consumers.

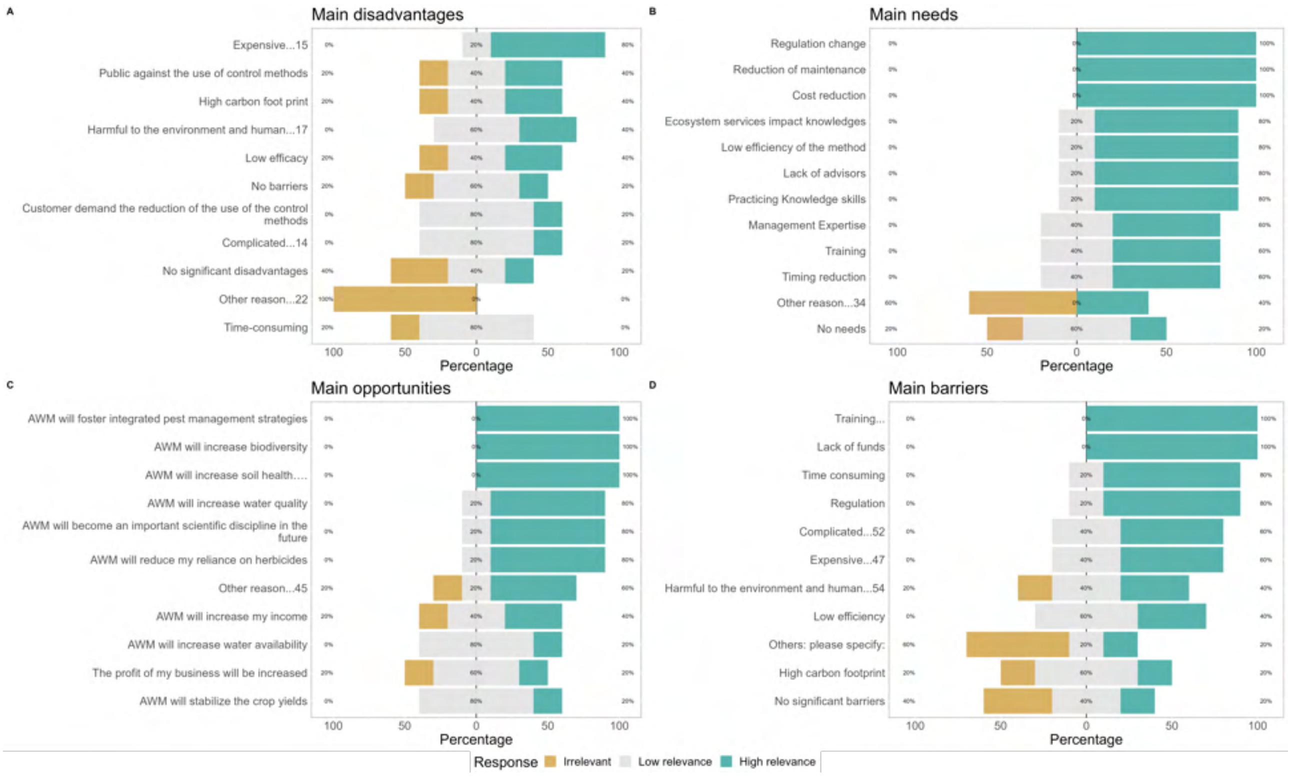


Figure 267. Main disadvantages, needs, barriers and opportunities for cover crops identified by consumers.

3.3.1.1.2.2 Conclusion

Consumers view cover crops as a promising AWM technique, recognizing its potential to reduce herbicide reliance and improve water availability, biodiversity, and soil health. However, they also acknowledge the need for greater practicing knowledge skills and identify time consumption as the main barrier.

3.3.1.1.3 Grazing

3.3.1.1.3.1 Advisor

Advisors considered grazing as a AWM practice that entails relevant opportunities, faces important needs and barriers and presents virtually no disadvantages. Two-thirds of respondents recognize its potential to foster IPM strategies and offer valuable ecosystem services, such as enhancing water availability and quality, and improving soil health. They also acknowledge its potential to reduce herbicide reliance and become a relevant scientific discipline. None of the queried opportunities was considered as irrelevant by advisors. However, advisors identify numerous critical needs associated with grazing. Nearly 70% emphasize the importance of regulatory changes, the method's low efficiency, and the need for practicing knowledge skills and management expertise, maintenance, and cost reduction. Additionally, they highlight time consumption, lack of funds, and regulatory challenges as significant barriers. Aligning with these concerns, they perceive time consumption as the most noteworthy drawback, although a third also express concerns about customer demand to reduce grazing, its high carbon footprint, and associated expenses.

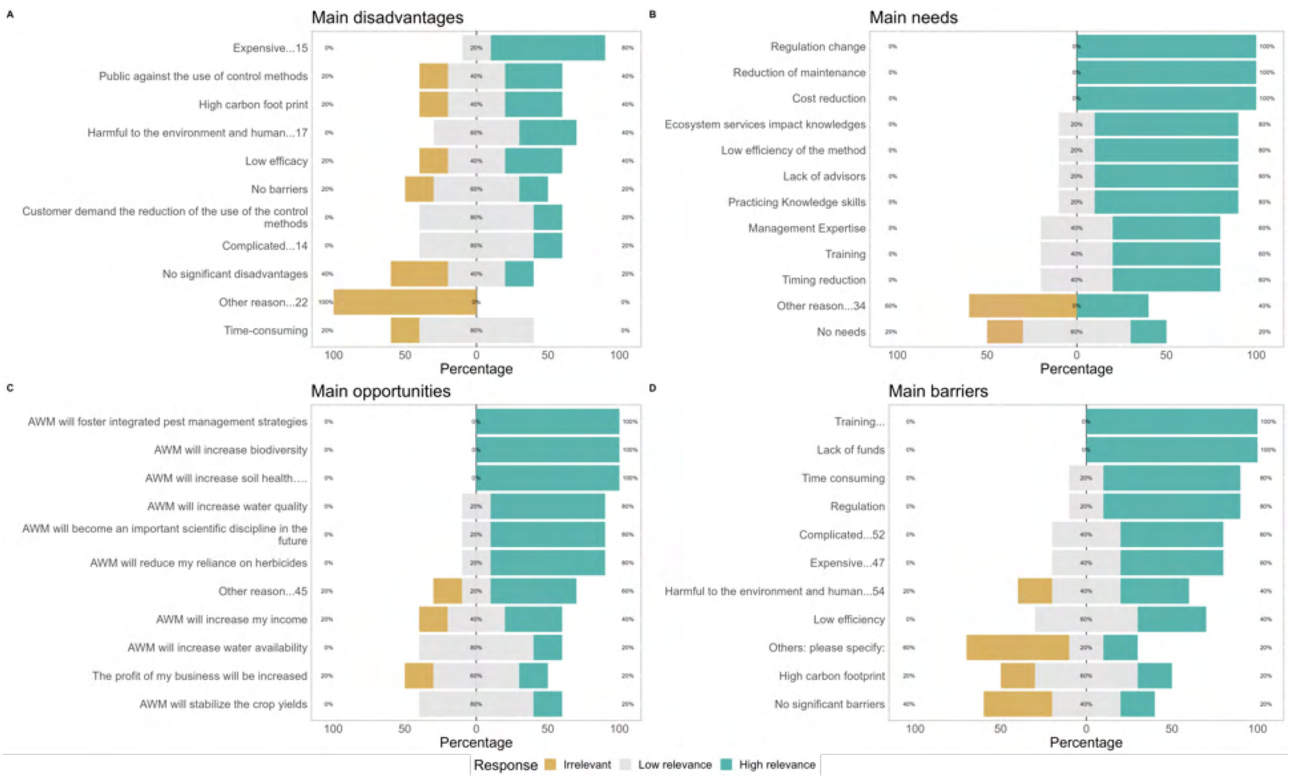


Figure 268. Main disadvantages, needs, barriers and opportunities for grazing identified by advisors.

3.3.1.1.3.2 Consumers

Consumers unanimously believe that grazing will lead to reduced herbicide reliance. Moreover, over eighty percent of respondents view it as an ecosystem services provider, contributing to increased biodiversity and soil health, as well as enhancing business profitability and farmers' income. As for primary needs, two-thirds of respondents prioritize cost and maintenance reduction, while 50% emphasize the importance of ecosystem services impact knowledge. One-third of consumers also recognize the relevance of factors such as lack of advisors, practicing knowledge skills, and timing reduction. However, none of the queried barriers garnered majority agreement among consumers; only one-third considered training, lack of funds, regulatory challenges, and expense as significant obstacles. Similarly, only 33% of consumers regarded low efficacy, complexity, and time consumption as relevant disadvantages.

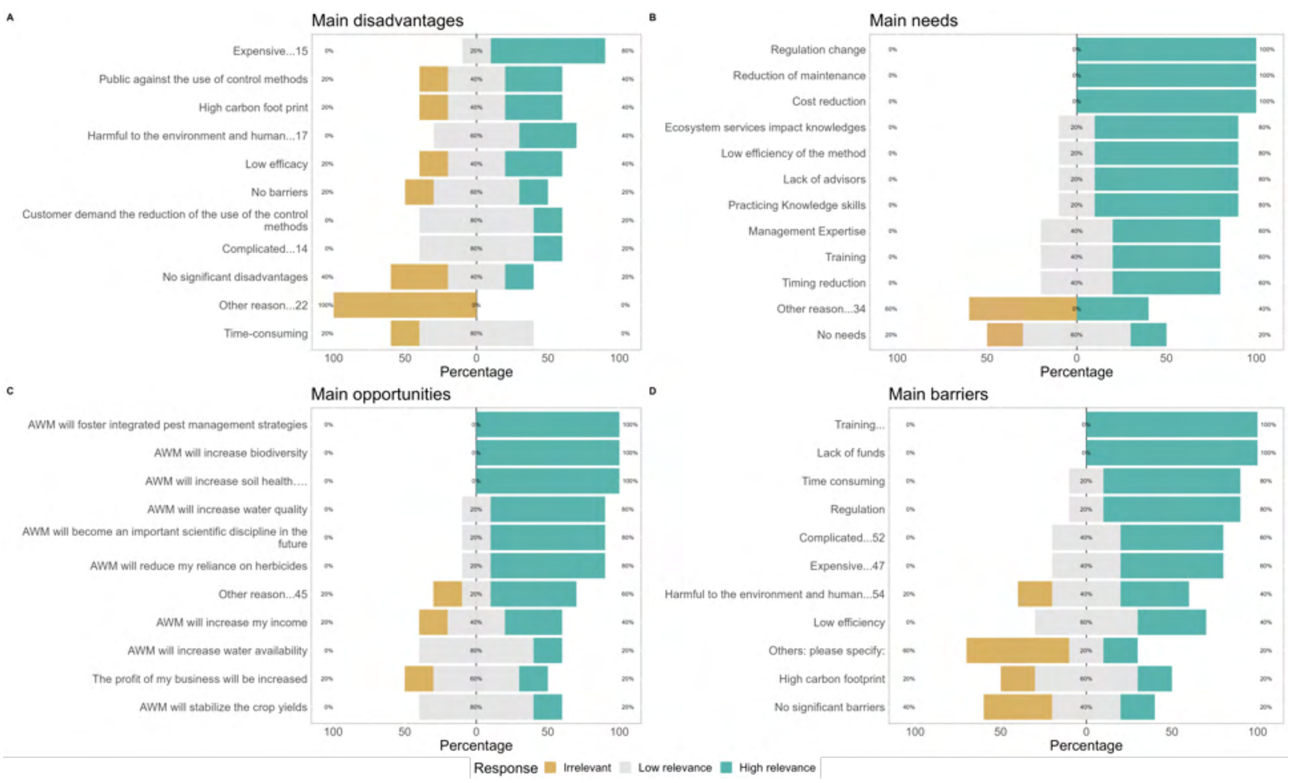


Figure 269. Main disadvantages, needs, barriers and opportunities for grazing identified by consumers.

3.3.1.1.3.3 Farmers

Farmers, like advisors and consumers, perceive grazing as a practice abundant in opportunities and needs. Additionally, they do not view grazing as burdened by significant barriers or disadvantages. Seventy percent of farmers acknowledge grazing as an ecosystem service provider, recognizing its positive impact on water quality, biodiversity, and soil health. Moreover, sixty percent of them see grazing as fostering IPM strategies, increasing water availability, reducing herbicide reliance, and potentially evolving into an important scientific discipline. For farmers, the primary needs revolve around timing (80%) and cost (70%) reduction, with fifty percent also emphasizing the importance of training and maintenance reduction. As per the main barriers, fifty percent of farmers appointed time consumption and regulatory challenges as relevant impediments. Like other stakeholder groups, the majority of farmers do not perceive any of the queried disadvantages as relevant. However, similar to advisors, 40% of farmers consider time consumption as the most significant drawback.

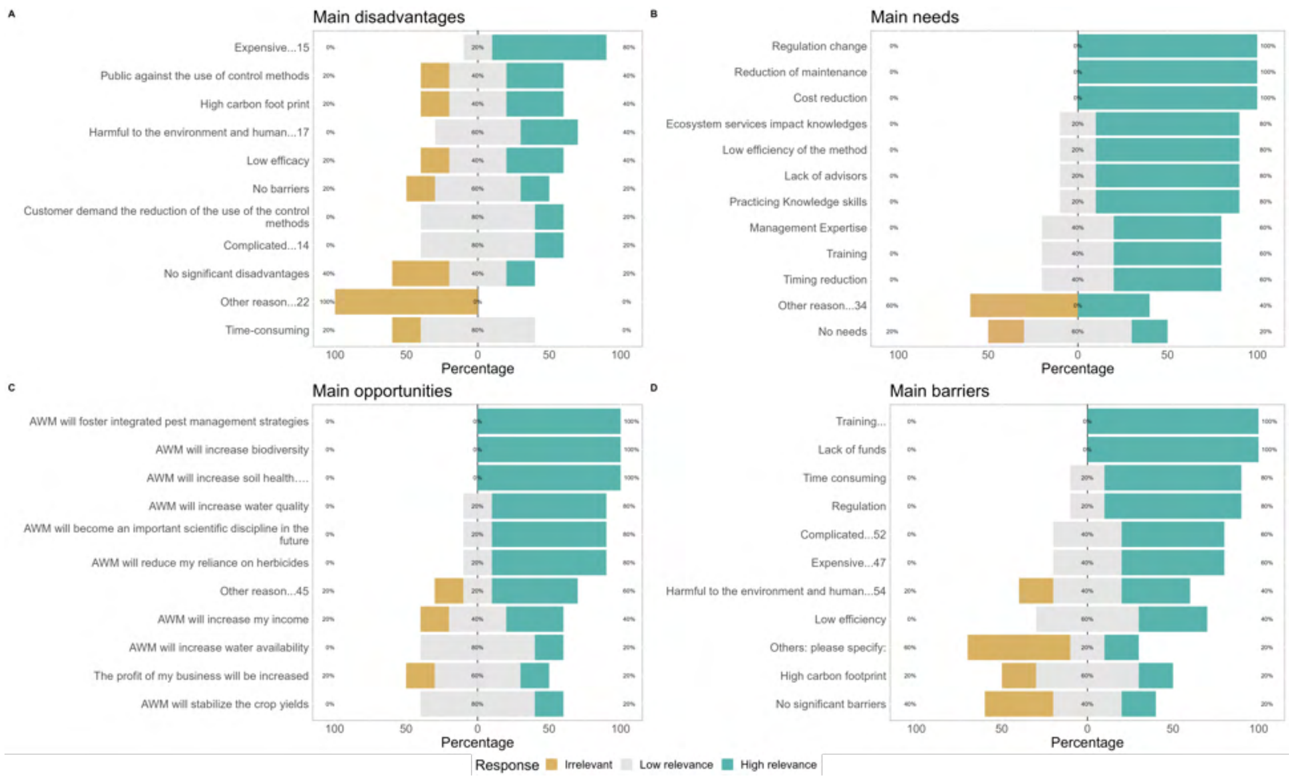


Figure 270. Main disadvantages, needs, barriers and opportunities for grazing identified by farmers.

3.3.1.1.3.4 *Policy maker*

Policy makers share a positive outlook on grazing, aligning with other stakeholders in recognizing its significant opportunities and identifying relevant needs and barriers. Like other groups, policy makers see grazing as lacking significant disadvantages and unanimously regard it as an ecosystem service provider, enhancing biodiversity and soil health. Moreover, two-thirds of respondents highlight grazing's role in fostering IPM strategies, improving water quality, reducing herbicide reliance, and potentially evolving into a crucial scientific discipline. Policy makers unanimously prioritize the need for ecosystem services impact knowledge, with nearly 70% also emphasizing the importance of practicing knowledge skills, management expertise, and training. Lack of funds stands out as the most significant barrier according to all respondents, with 67% also recognizing complexity, time consumption, training, and expense as noteworthy challenges. Notably, policy makers unanimously believe that grazing does not present any significant disadvantages, with many of the queried drawbacks considered low or irrelevant in this context.

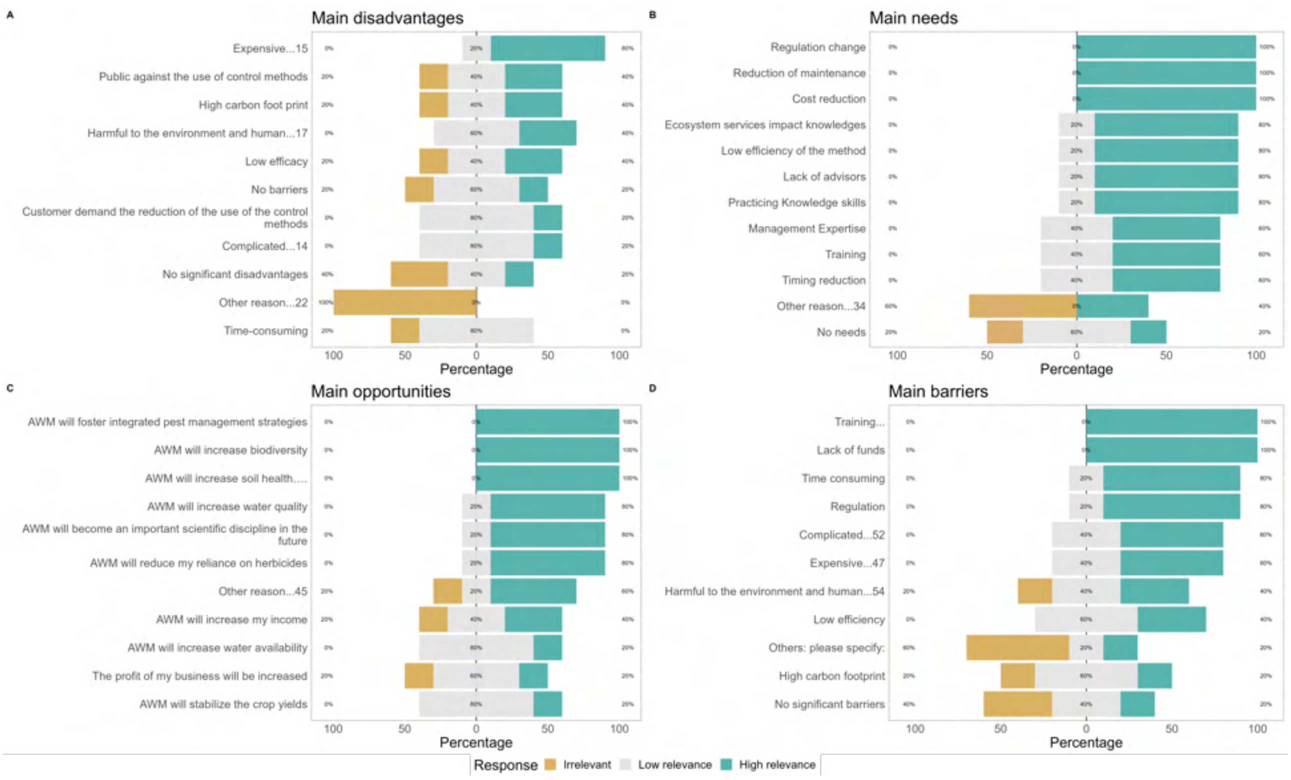


Figure 271. Main disadvantages, needs, barriers and opportunities for grazing identified by policy makers.

3.3.1.1.3.5 Conclusion

Grazing was perceived similarly by advisors, consumers, and policymakers as a technique rich in opportunities and virtually devoid of disadvantages. However, while advisors, farmers, and policymakers believed that this practice presented significant needs, consumers held the opposite sentiment. Only advisors perceived relevant barriers to implementation. The positive sentiment toward the technique varied among stakeholders, with each group ranking the queried categories differently. Advisors, farmers, and policymakers highlighted grazing's potential to foster IPM strategies and provide valuable ecosystem services, such as enhancing water availability and quality and improving soil health. In contrast, consumers unanimously considered reduced herbicide reliance essential and emphasized other ecosystem services, particularly increased biodiversity. Advisors identified regulatory changes, method inefficiency, and the need to improve practical knowledge skills as primary needs. Consumers focused on cost and maintenance reduction and understanding ecosystem service impacts. Farmers emphasized timing and cost reduction, alongside the need for training and maintenance reduction. Similarly, policymakers prioritized the need for ecosystem service impact knowledge, along with other categories like practical knowledge skills and management expertise. The lack of funds was deemed a significant barrier by advisors, consumers, and policymakers, with other identified impediments including time consumption, which was highlighted by advisors, farmers, and policymakers, and expense, which was identified as a notable challenge. Time consumption emerged as a relevant drawback according to advisors, consumers, and farmers. Moreover, the other queried disadvantages were deemed minor or irrelevant by stakeholders in this context.

3.3.1.1.4 Herbicides

3.3.1.1.4.1 Consumer

Consumers expressed a negative perspective on herbicide use, mainly considering the opportunities as irrelevant while emphasizing the method's needs, barriers, and disadvantages. Only 44% of them deemed increased soil health, business profitability, and stabilized crop yields as relevant opportunities. The same proportion of consumers recognize herbicides potential to evolve into an important scientific discipline. Regarding needs, consumers unanimously considered training as the most crucial. Additionally, almost 80% of respondents emphasized ecosystem services impact knowledge, practical knowledge skills, and management expertise as key necessities. Lack of advisors, cost, and timing reduction were seen as relevant needs by nearly 70% of respondents, while 56% viewed regulatory changes and maintenance reduction as key requirements. Consumers identified environmental and human harm as the most significant barriers (89%). Almost eighty percent of respondents viewed high carbon footprint, training, lack of funds, and expense as important impediments, while time consumption and regulatory concerns were regarded as significant barriers by 67%. Aligned with these barriers, nearly 90% of consumers considered environmental and human harm as the most relevant disadvantages. Moreover, eighty percent of respondents regarded public opposition to herbicides and high carbon footprint as relevant, while nearly two-thirds cited expense as important drawbacks.

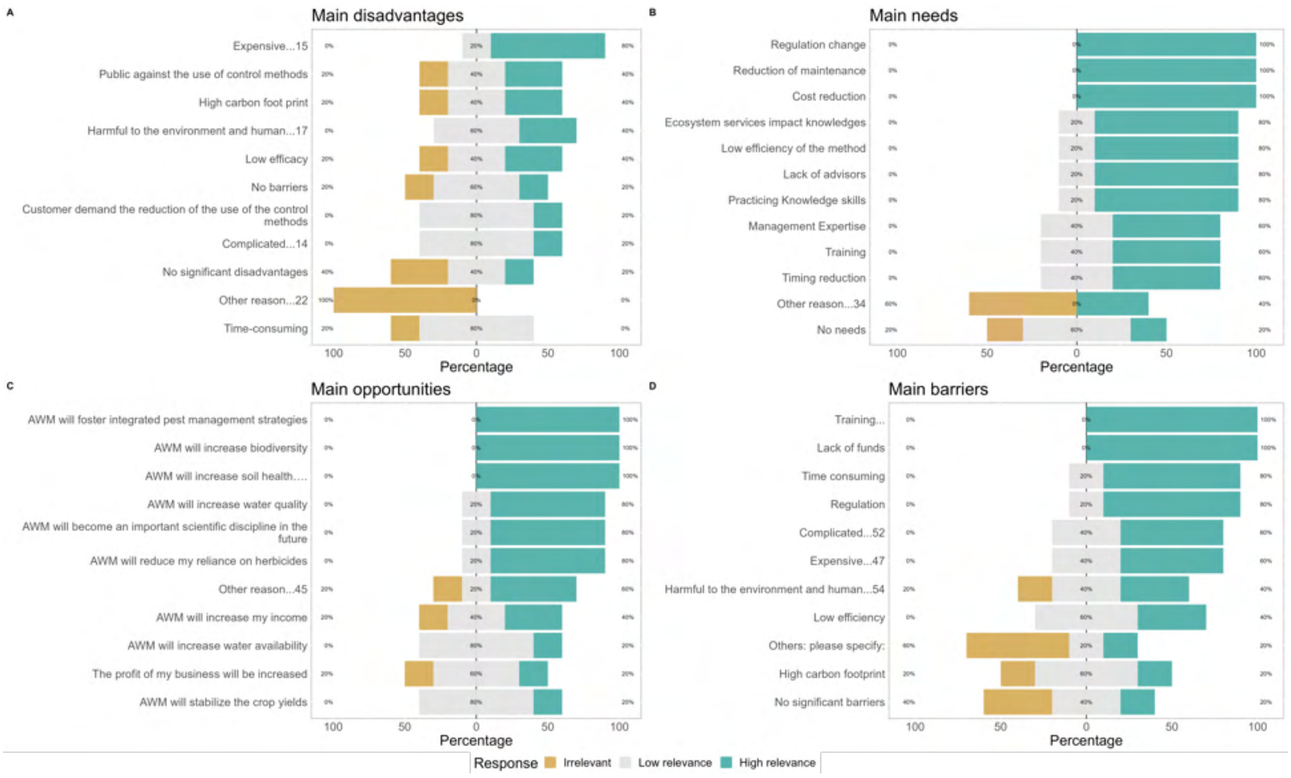


Figure 272. Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

3.3.1.1.4.2 Farmer

Farmers expressed a more neutral perspective on herbicides, as they did not consider this practice to offer significant opportunities, recognizing instead numerous needs, barriers, and disadvantages. Regarding opportunities, half of the respondents saw herbicides rational use as fostering IPM strategies and reducing herbicide reliance. Three-quarters of farmers identified regulatory changes and cost reduction as primary needs, while more than sixty percent acknowledged the importance of ecosystem services impact knowledge and the reduction of timing and maintenance. The main barriers, as identified by farmers, were lack of funds and regulatory challenges. Additionally, half of the respondents viewed high carbon footprint, environmental and human harm, expense, and training as relevant barriers. Three-quarters of farmers identified environmental and human harm and expense as relevant disadvantages. More than 60% acknowledged customer demand to reduce its use, while 50% recognized public opposition to herbicides and high carbon footprint as relevant drawbacks.

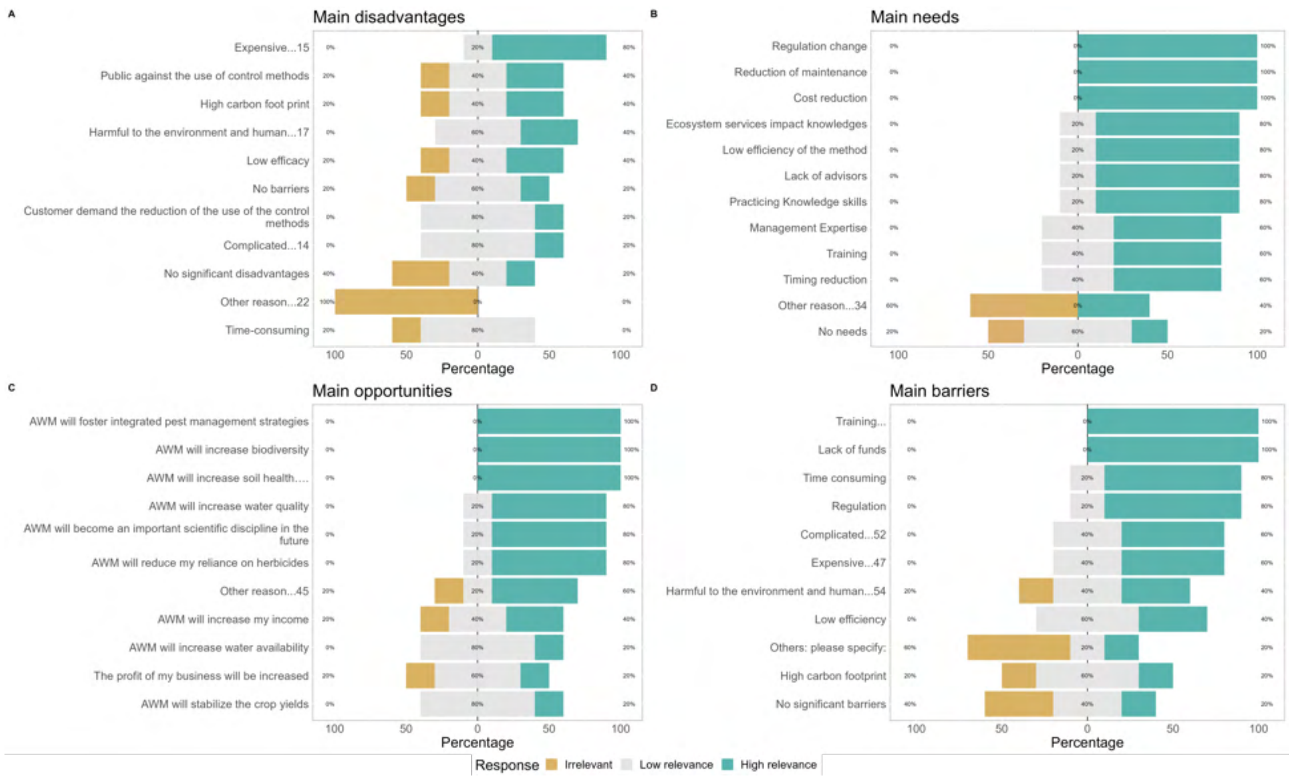


Figure 273. Main disadvantages, needs, barriers and opportunities for herbicides identified by farmers.

3.3.1.1.4.3 Policy maker

Policy makers hold a negative perspective on herbicides, perceiving few opportunities and acknowledging relevant needs, barriers, and disadvantages associated with their use. None of the queried opportunities were deemed highly relevant by most respondents; only one third considered herbicides as fostering IPM strategies, increasing biodiversity and soil health, and potentially evolving into an important scientific discipline in the future. Policy makers unanimously identified training as the primary need for herbicide use. Additionally, nearly seventy percent viewed ecosystem services impact knowledge, management expertise, and cost reduction as highly relevant necessities. As for the main barriers, policy makers unanimously cited its high carbon footprint, along with environmental and human harm, as primary impediments. Moreover, two thirds of respondents deemed complexity, time consumption, regulatory challenges, and expense as relevant barriers. According to 67% of policy makers, customer demand to reduce or eliminate herbicides, high carbon footprint, environmental and human harm, and expense are the most relevant disadvantages. Notably, the same proportion of respondents considered that herbicides present no significant disadvantages.

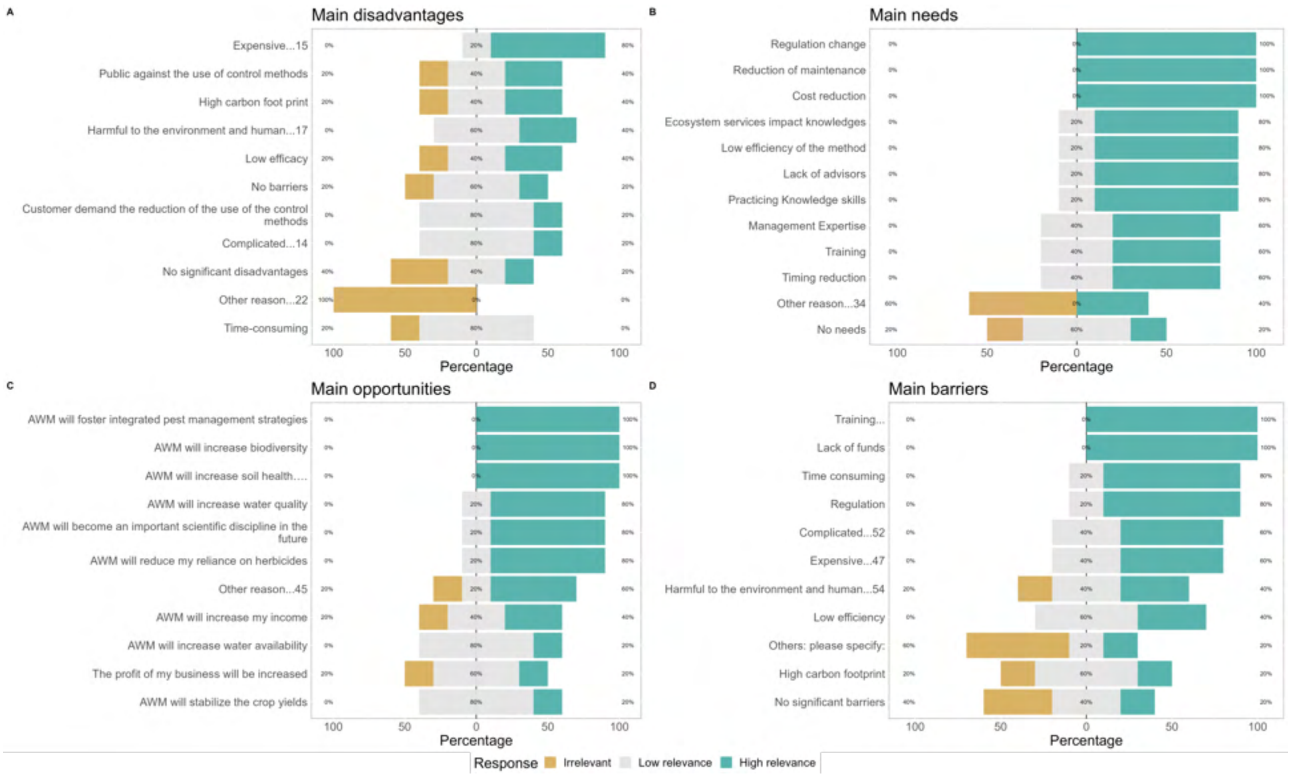


Figure 274. Main disadvantages, needs, barriers and opportunities for herbicides identified by policy makers.

3.3.1.1.4.4 Researchers

Researchers hold a notably positive perspective on herbicide use compared to other stakeholders, seeing it as offering significant opportunities but also acknowledging pertinent needs, barriers, and disadvantages. Over eighty percent of respondents recognize herbicides as providers of ecosystem services, promoting increased water quality, biodiversity, and soil health, while also noting their potential to evolve into an important scientific discipline. Additionally, two-thirds believe that herbicides will foster IPM strategies, increase water availability, and reduce reliance on herbicides, as their integration with other AWM practices and rational use are implemented. Researchers prioritize ecosystem services impact knowledge, regulatory changes, and training as primary needs. Management expertise and timing reduction are seen as crucial necessities by nearly seventy percent of respondents, while half of them consider lack of advisors, practicing knowledge skills, and cost and maintenance reduction as highly relevant requirements. Over eighty percent identify environmental and human harm, along with regulatory challenges, as significant barriers. Furthermore, two-thirds of researchers view the high carbon footprint as a relevant barrier yet note that herbicides face no significant barriers. However, half of them see training as a relevant impediment. Like other stakeholders, researchers consider public opposition to herbicides, environmental and human harm, and customer demand to reduce their use as relevant disadvantages. Notably, sixty percent of researchers believe that herbicides present no significant disadvantages.

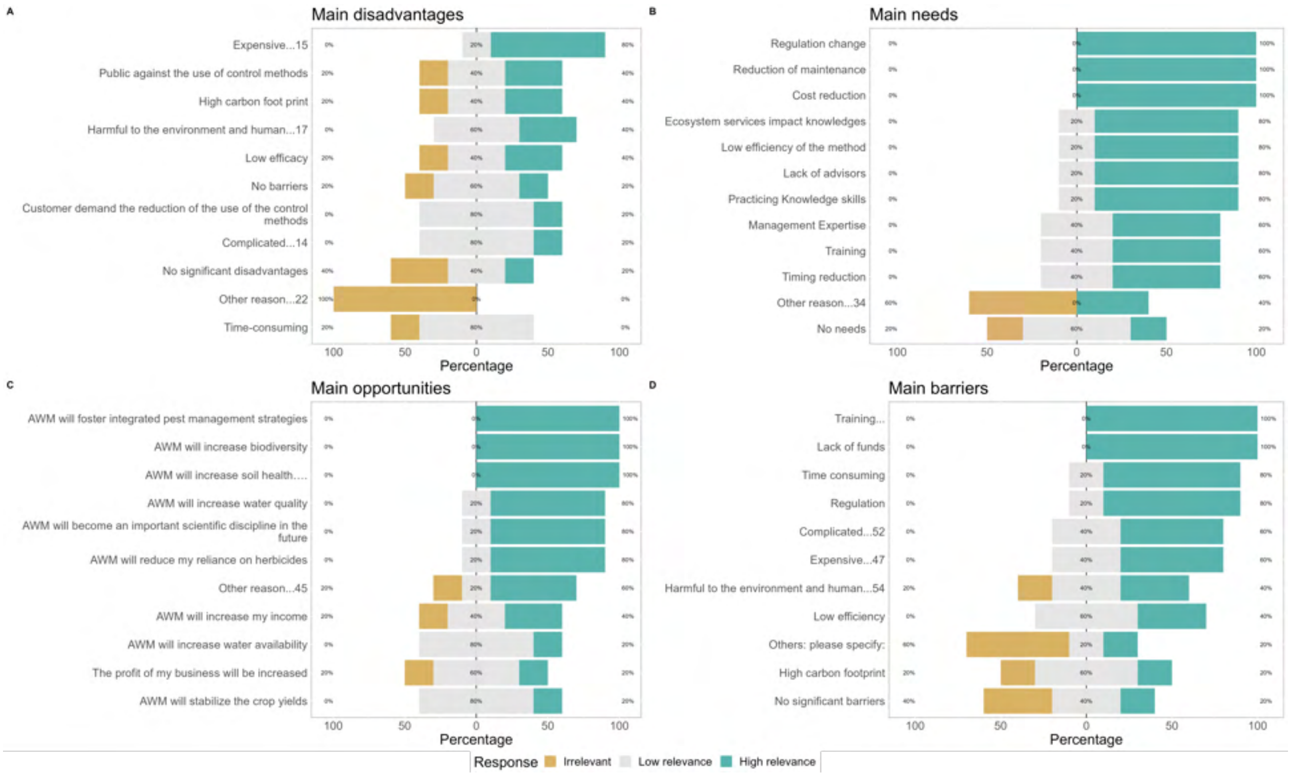


Figure 275. Main disadvantages, needs, barriers and opportunities for herbicides identified by researchers.

3.3.1.1.4.5 Conclusion

Consumers and policy makers shared a negative perspective toward herbicides, while farmers expressed a more neutral perception, and researchers held a positive insight. All stakeholders emphasized the needs, barriers, and disadvantages associated with herbicide use. While consumers, policy makers, and farmers did not primarily consider any of the queried opportunities as highly relevant, over eighty percent of researchers recognized herbicides as providers of ecosystem services, promoting IPM strategies, among others. All stakeholders considered herbicides to have highly relevant needs: consumers and policy makers prioritized training as the primary need, while farmers emphasized regulatory changes and cost reduction, and researchers prioritized ecosystem services impact knowledge and regulatory changes, alongside training. The rest of the queried needs were regarded as highly relevant by different yet significant proportions of respondents across the different stakeholder groups. Regarding the most significant barriers, environmental and human health were regarded as the most relevant impediments by consumers, policy makers, and researchers. Other recognized barriers across all stakeholders included high carbon footprints, expense, and complexity, among others. Consistent with the cited barriers, environmental and human harm, as well as public demand to reduce or eliminate the practice, were prioritized as relevant by all stakeholders. Moreover, high carbon footprint and expense were also highlighted across various groups. Notably, 67% of respondents and 60% of researchers stated that herbicides present no significant disadvantages.

3.3.1.1.5 Intercropping

3.3.1.1.5.1 Farmer

Farmers unanimously deemed most queried opportunities as highly relevant, highlighting intercropping's potential to foster IPM strategies, act as an ecosystem services provider (enhancing water quality and availability, biodiversity, and soil health), and evolve into an important scientific discipline. Additionally, 100% of farmers recognized intercropping's significant economic benefits, including stabilized crop yields, increased income, as well as reduced herbicide reliance. As unanimously noted by farmers, primary necessities included practicing knowledge skills, management expertise, training, and reduction of maintenance. Moreover, two-thirds of respondents considered regulatory changes and method efficiency as highly relevant. Main barriers, as identified by nearly 70% of farmers, included time consumption and training, with the remaining queried impediments not deemed highly relevant by a significant number of respondents. Farmers did not primarily view any of the queried disadvantages as highly relevant; one-third considered intercropping to face no significant disadvantages or barriers. However, the same proportion expressed concerns about customer demand to reduce its use, environmental and human harm, and time consumption.

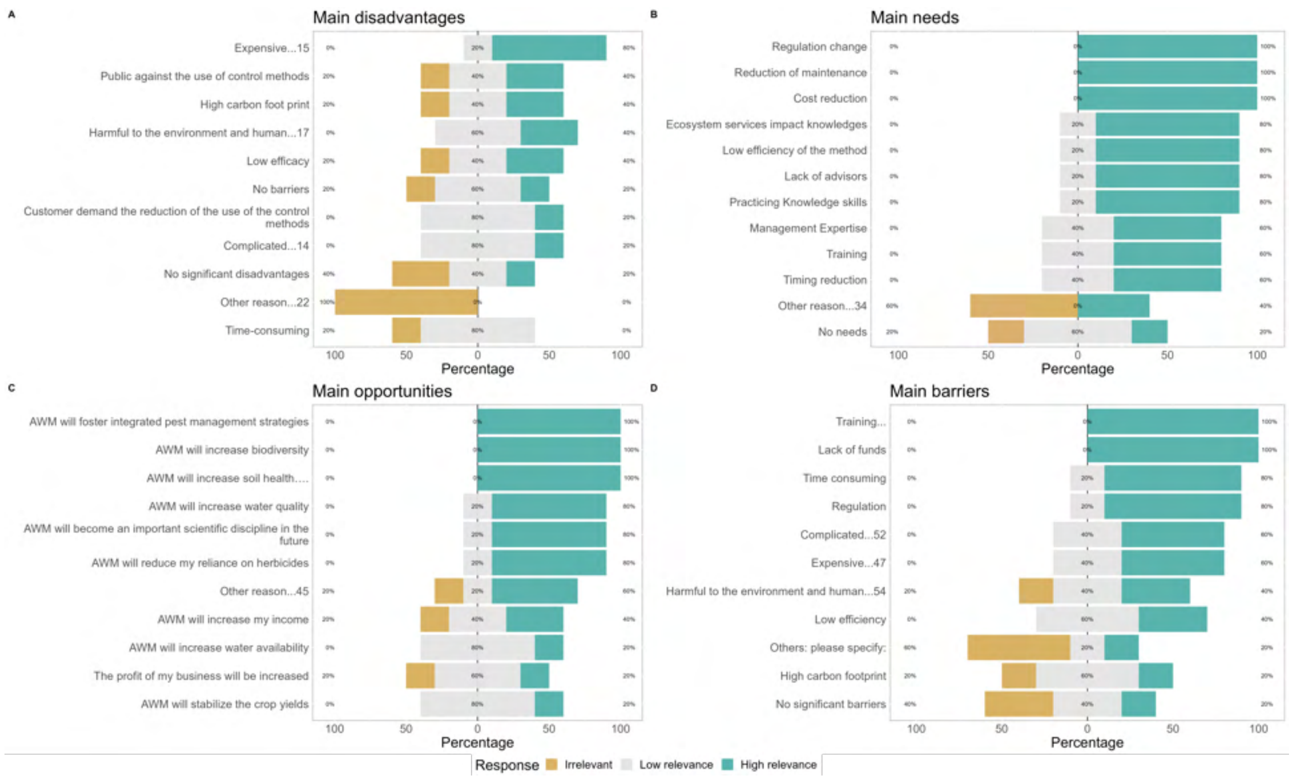


Figure 276. Main disadvantages, needs, barriers and opportunities for intercropping identified by farmers.

3.3.1.1.5.2 Conclusion

Farmers hold a positive view of intercropping, recognizing its significant opportunities such as fostering IPM strategies, enhancing ecosystem services, and providing economic benefits. They identify needs like knowledge skills, management expertise, and training, while perceiving few significant barriers or disadvantages.

3.3.1.1.6 Mechanical weeding

3.3.1.1.6.1 Advisor

Advisors view mechanical weeding as a technique with numerous opportunities, while also acknowledging significant needs and some barriers. A majority (80%) of advisors recognize its potential to reduce reliance on herbicides. Additionally, 60% emphasize its role in providing ecosystem services such as improved water quality, biodiversity, and soil health. Forty percent also foresee benefits like increased water availability and business profitability, as well as its potential to become a significant scientific discipline in the future. Advisors identify cost and timing reduction as primary needs for mechanical weeding. Furthermore, 60% emphasize the importance of training and maintenance reduction. Sixty percent of advisors see time consumption and training as the main impediments. Additionally, 40% view low efficiency, complexity, lack of funds, regulatory challenges, and expense as relevant. Similarly, advisors do not see many disadvantages with mechanical weeding, but cite expense (80%) and time consumption (60%) were considered as relevant disadvantages.

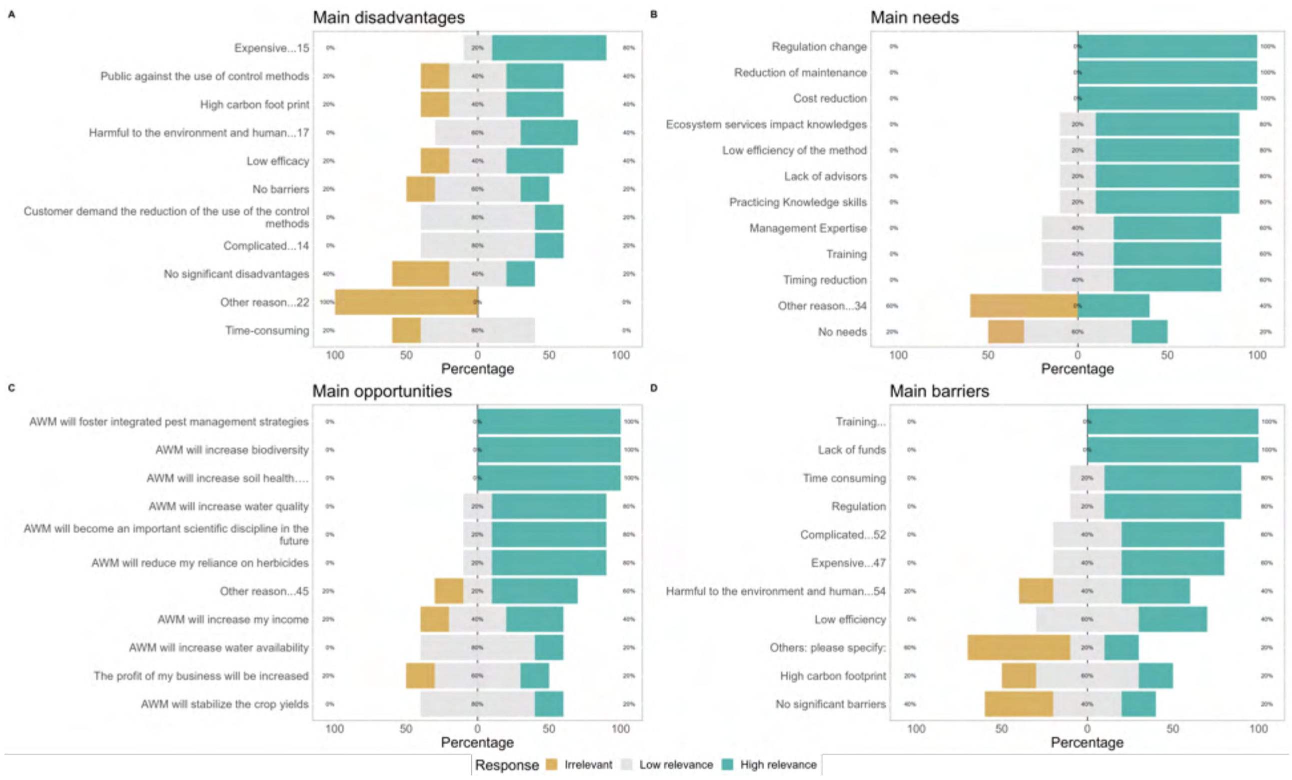


Figure 277. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by advisors.

3.3.1.1.6.2 Consumers

Consumers, much like advisors, share a positive outlook on the opportunities presented by mechanical weeding, recognizing its potential while also acknowledging the relevant needs, barriers, and disadvantages associated with it. Two-thirds of consumers believe that mechanical weeding can increase water availability and reduce reliance on herbicides. Additionally, half of the respondents see it as a way to foster IPM strategies and improve water quality, biodiversity, and soil health, acknowledging its potential to become a significant scientific discipline. Concerning needs, half of the consumers prioritize lack of advisors, practicing knowledge skills, management expertise, and timing reduction. In terms of barriers, two-thirds of consumers highlight time consumption and expense, with half emphasizing the importance of adequate training. Notably, almost seventy percent of consumers see the method's high carbon footprint as the most significant drawback.

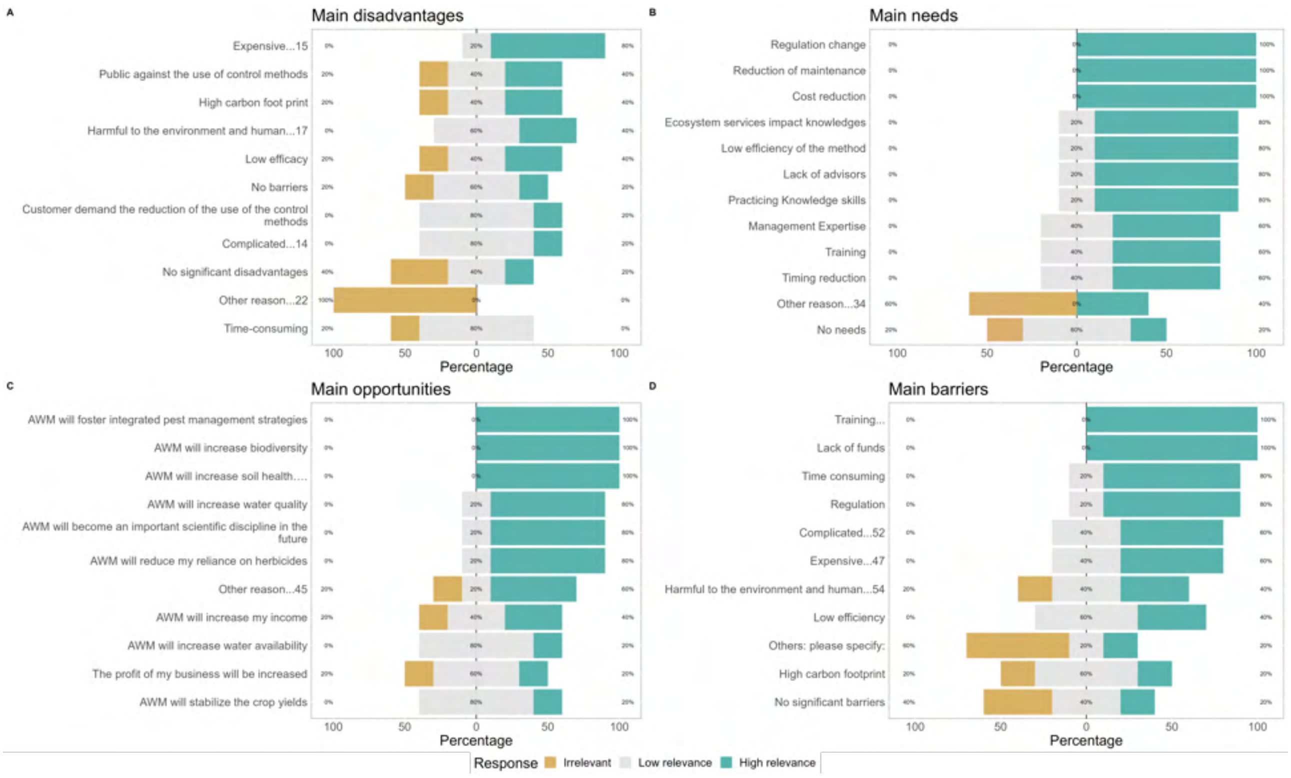


Figure 278. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by consumers.

3.3.1.1.6.3 Farmer

Farmers held a more conservative perception towards mechanical weeding, cautiously recognizing few opportunities as relevant while acknowledging significant needs and barriers. Sixty percent of respondents identified reducing herbicide reliance as a main opportunity. Primary needs revolved around timing (70%) and cost (60%) reduction, with half of the respondents also considering training and maintenance reduction as relevant necessities. Regarding barriers, seventy percent of farmers cited expense, while fifty percent mentioned time consumption and lack of funds as significant impediments. Consistent with identified needs and barriers, farmers viewed expense as the most notable drawback in implementing mechanical weeding.

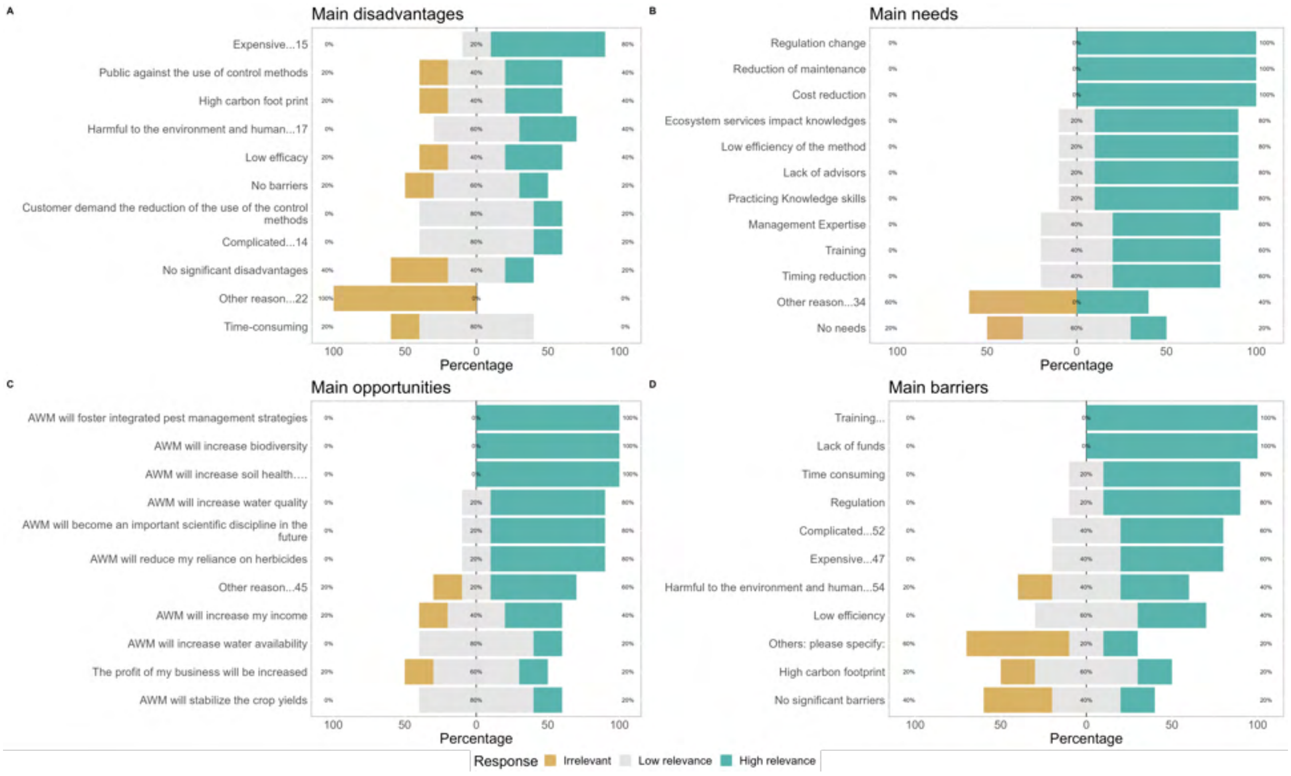


Figure 279. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by farmers.

3.3.1.1.6.4 Policy maker

Policy makers' perspective on mechanical weeding, akin to farmers' views, was more cautious compared to advisors and consumers. Nearly 70% of policy makers believed that mechanical weeding improves soil health and reduces herbicide reliance, expressing confidence in its potential to become an important scientific discipline. Notably, one third of respondents perceived most of the queried opportunities as highly relevant. Regarding the main needs of the method, two thirds of policy makers emphasized the importance of ecosystem services impact knowledge, along with reduction of cost, timing, and maintenance. As for the main barriers, none were considered relevant by a majority of respondents; only one third viewed high carbon footprint, training, lack of funds, regulatory challenges, and expense as impediments. Nearly seventy percent of policy makers considered high carbon footprint and time consumption as the most relevant drawbacks, while one third regarded environmental and human harm, as well as complexity, as relevant concerns.

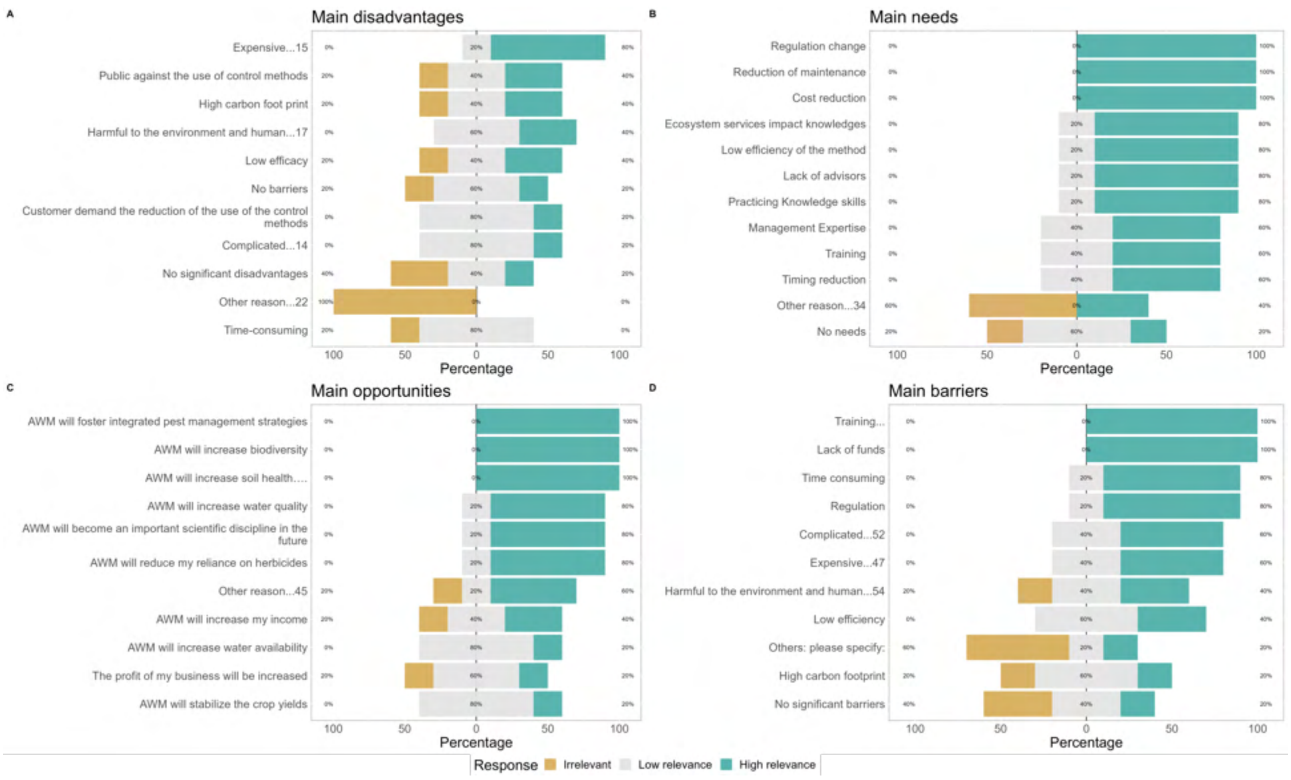


Figure 280. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by policy makers.

3.3.1.1.6.5 Researchers

Researchers shared a positive perspective toward mechanical weeding. They unanimously considered this practice as an ecosystem services provider, recognizing increases in water quality, biodiversity, soil health, as well as a reduction in herbicide reliance. Moreover, two thirds of the respondents considered that it fosters IPM strategies, increases water availability, and presents the potential to evolve into an important scientific discipline. As primary needs, nearly seventy percent of researchers deemed ecosystem services impact knowledge, low efficiency of the method, reduction of cost, and maintenance. Researchers also considered high carbon footprint as an important drawback and barrier of mechanical weeding.

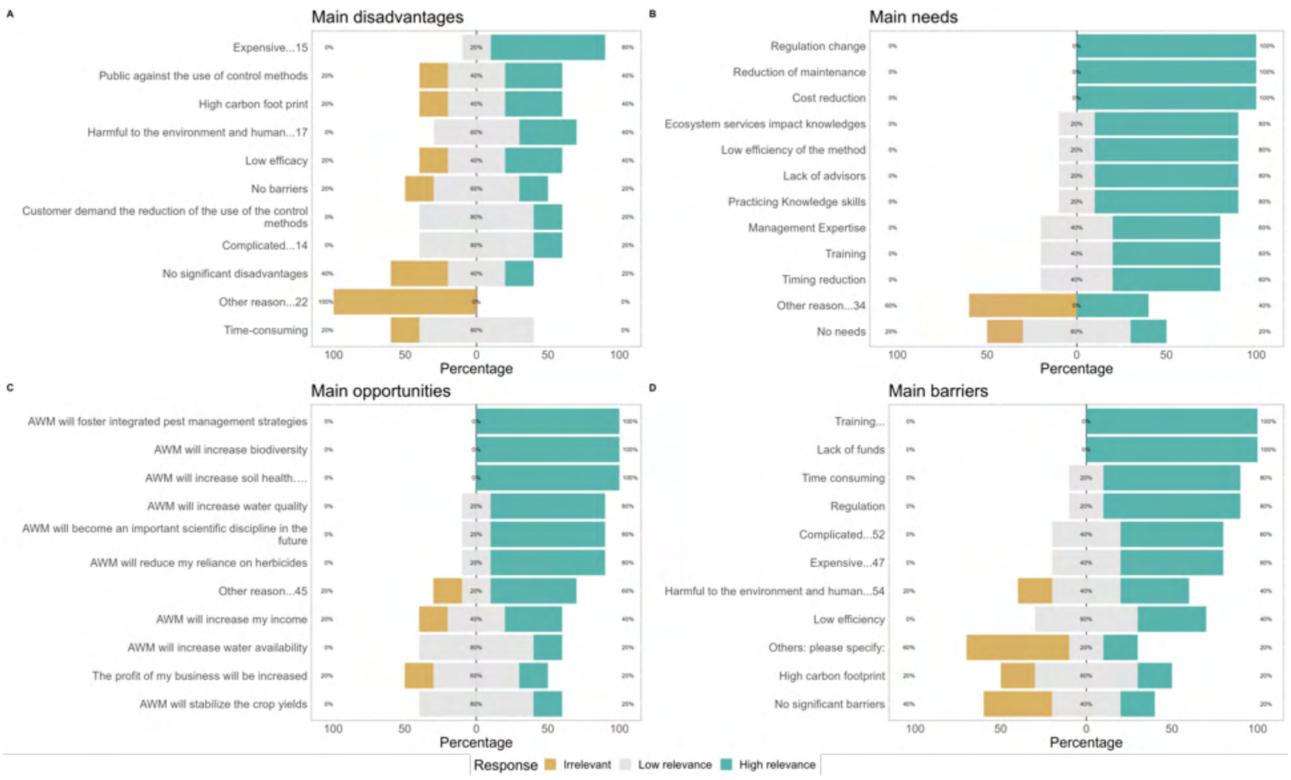


Figure 281. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by researchers.

3.3.1.1.6.6 Conclusion

Stakeholders held diverse perspectives toward mechanical weeding, with advisors, consumers, and researchers viewing it positively, while farmers and policymakers took a more neutral point of view. Despite this diversity, there was consensus among stakeholders regarding certain aspects. For instance, all stakeholders agreed on the role of mechanical weeding in reducing herbicide reliance. Additionally, there was widespread recognition of its potential contribution to ecosystem services, such as improving water quality, biodiversity, and soil health. Primary needs for mechanical weeding, including cost, timing, and maintenance reduction, were identified across all stakeholder groups. Training and knowledge acquisition were also emphasized as important necessities. While stakeholders did not perceive mechanical weeding as presenting significant barriers, time consumption emerged as a concern across various groups. Additionally, expense, training, and high carbon footprint were identified as relevant barriers by different proportions of stakeholders. Similarly, most stakeholders did not view mechanical weeding as having many drawbacks. However, concerns about expense, time consumption, and high carbon footprint were acknowledged to varying degrees among different stakeholder groups.

3.3.1.1.7 Mowing

3.3.1.1.7.1 Advisor

Advisors shared a balanced perspective on mowing opportunities. Three-quarters of the respondents considered it would reduce reliance on herbicides. Additionally, half of the respondents viewed mowing as fostering IPM strategies and recognized its potential in ecosystem services provision. This includes improvements in water availability and quality, biodiversity, and soil health, highlighting its potential to become an important scientific discipline and enhance business profitability. Regarding primary needs, 75% of advisors prioritized training and cost reduction. Half of the respondents emphasized the importance of knowledge about ecosystem services impact, regulatory changes, method efficiency, advisor availability, practical skills, and timing and maintenance reduction. None of the queried barriers was selected as highly relevant by more than half of the respondents. However, consistent with expressed needs, 50% of advisors highlighted time consumption, training, and expenses as significant concerns. Similarly, expenses were considered the main disadvantage by half of the surveyed advisors.

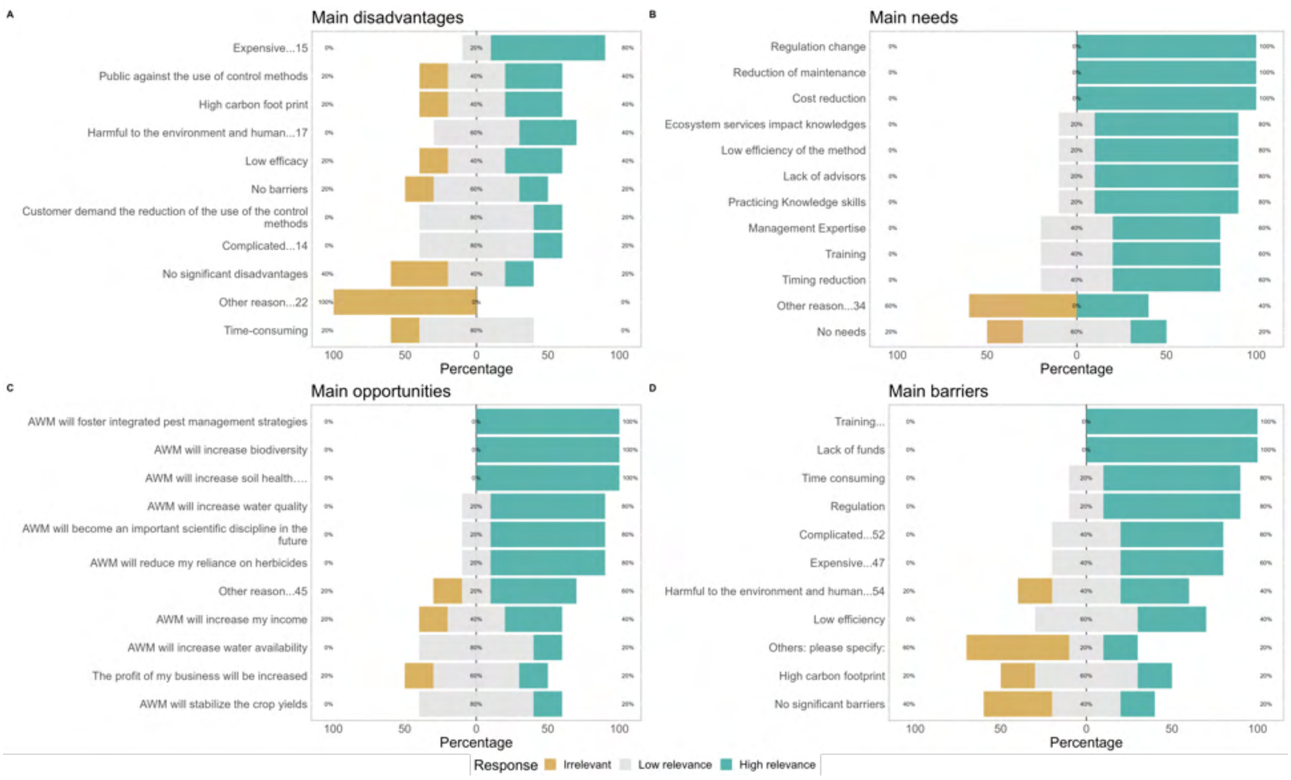


Figure 282. Main disadvantages, needs, barriers and opportunities for mowing identified by advisors.

3.3.1.1.7.2 Consumer

Consumers shared a more cautious perspective on mowing, with virtually none of the queried factors considered relevant by more than half of the respondents. Seventy-five percent of the respondents emphasized that it would reduce reliance on herbicides, while the rest of the opportunities were not considered relevant by more than one quarter of the respondents. Half of the consumers identified cost and timing reduction as the main needs. Accordingly, time consumption and expense were considered the most relevant impediments by half of the respondents. Lastly, mowing's high carbon footprint was regarded as a relevant disadvantage by half of the consumers.

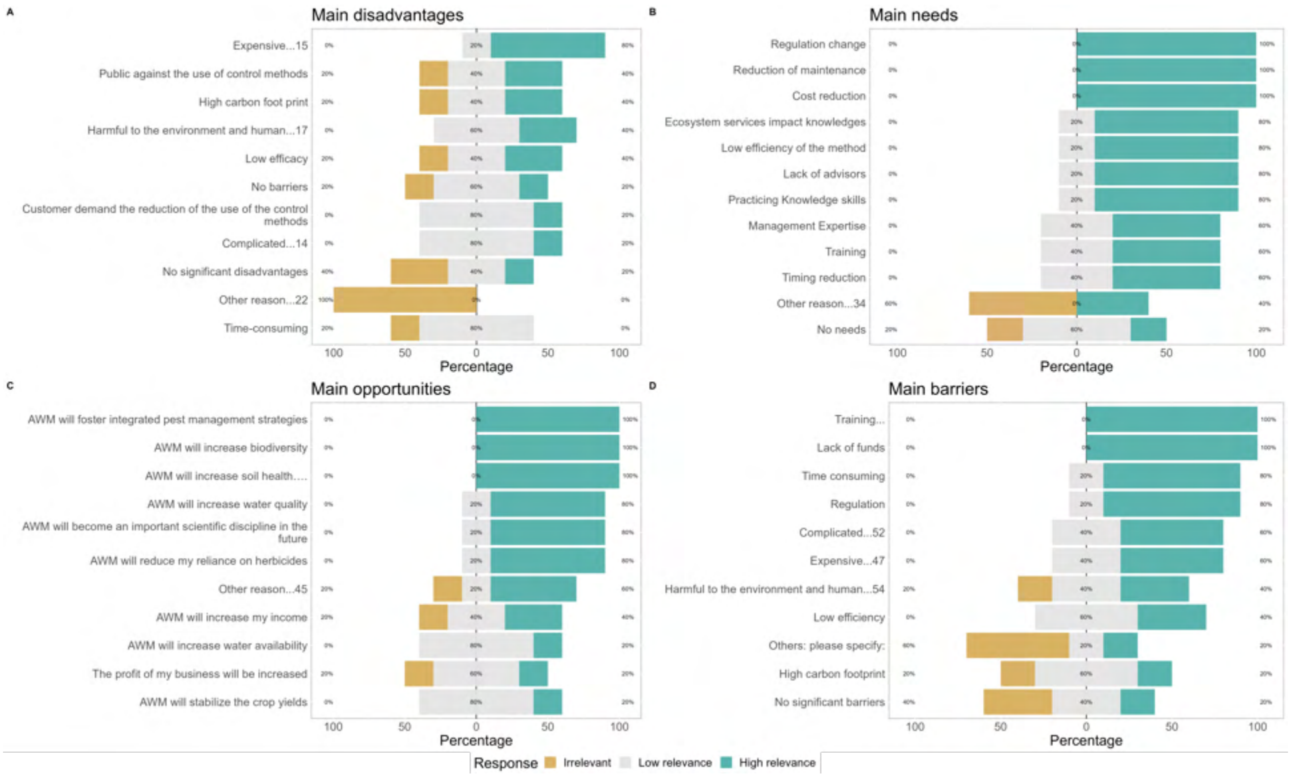


Figure 283. Main disadvantages, needs, barriers and opportunities for mowing identified by consumers.

3.3.1.1.7.3 Farmers

Farmers shared a more positive regard toward mowing compared to advisors and consumers, as over half of them acknowledge mowing as an IPM fosterer; an ecosystem services provider, including improved water quality, biodiversity, and soil health; and reduced herbicide reliance. None of the queried needs was considered as relevant by more than half of the surveyed farmers, over forty percent of them considered method's low efficiency, practicing knowledge skills, management expertise as well as reduction of maintenance, cost, and timing as relevant necessities. As per the methods main barriers, two thirds of the respondents appointed to expense, and over fifty percent of them view time consumption and 44% recognize low efficiency and lack of funds as the method's main barriers. Similarly, over fifty percent of the farmers acknowledge expense, complexity and time consumption as the most relevant drawbacks, besides, 44% considered that mowing presents no significant disadvantages.

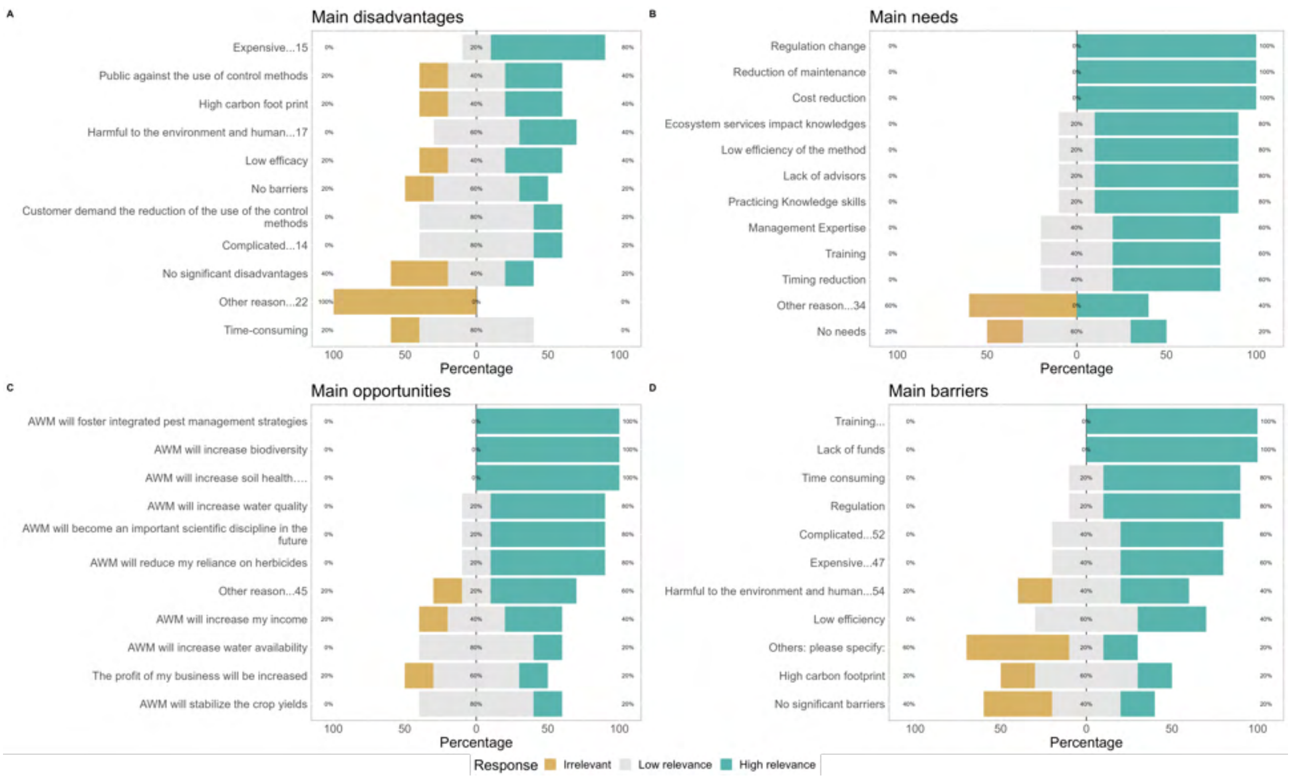


Figure 284. Main disadvantages, needs, barriers and opportunities for mowing identified by farmers.

3.3.1.1.7.4 Industry

Industry representatives recognize mowing as a method with numerous opportunities and have identified relevant needs associated with it. They considered that it involves no significant barriers or important disadvantages. Industry representatives unanimously view mowing as an ecosystem services provider, contributing to increased water quality and soil health improvements. Additionally, three quarters of the respondents believe that mowing fosters IPM strategies, enhances water availability, and promotes biodiversity. They also recognize its potential to evolve into an important scientific discipline in the future. Furthermore, they emphasize various economic opportunities related to mowing implementation, including increased business profitability, income, and stabilization of crop yields. Management expertise was unanimously identified as the primary need for mowing, with seventy-five percent recognizing the importance of addressing issues such as lack of advisors, training, and cost reduction. None of the queried barriers were considered mainly relevant by a sufficient number of respondents. However, 25% cited time consumption and expense as relevant impediments. All industry representatives noted that "other reasons" were the most relevant disadvantage, while one-third of the respondents considered the method's low efficacy as an important drawback.

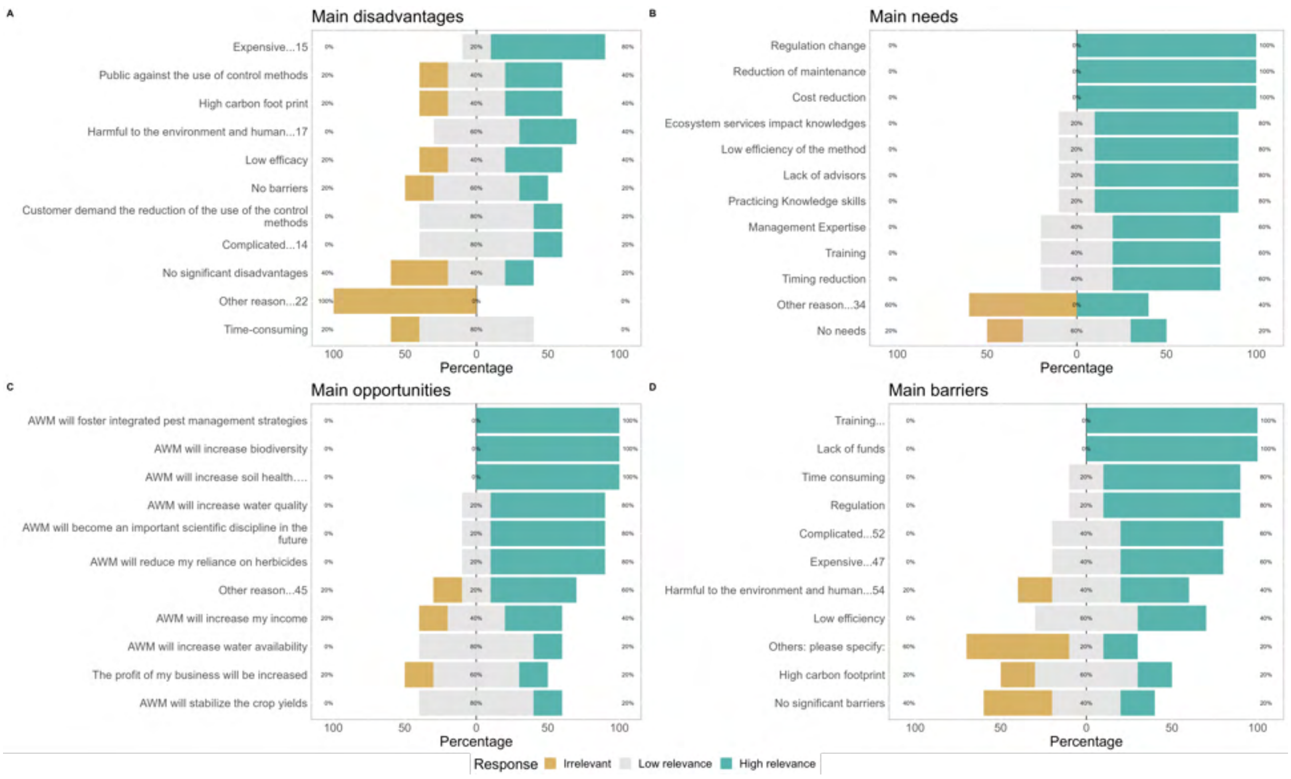


Figure 285. Main disadvantages, needs, barriers and opportunities for mowing identified by researchers.

3.3.1.1.7.5 Researchers

Researchers, similar to industry representatives, regard mowing as a technique with significant opportunities. Seventy-five percent of them view this practice as fostering IPM strategies and recognize its role as an ecosystem services provider, including enhancements in water quality and availability, biodiversity, and improved soil health. Additionally, they acknowledge that mowing results in a reduction in herbicide reliance. Half of the researchers believe that mowing will evolve into an important scientific discipline. Regarding primary needs, three-quarters of surveyed researchers consider ecosystem services impact knowledge and regulatory changes as relevant, while half of them acknowledge the lack of advisors as a key requirement for mowing implementation. Seventy-five percent of the respondents stated that mowing faces no relevant barriers to its implementation, and nearly seventy percent considered that it does not present any significant disadvantages either.

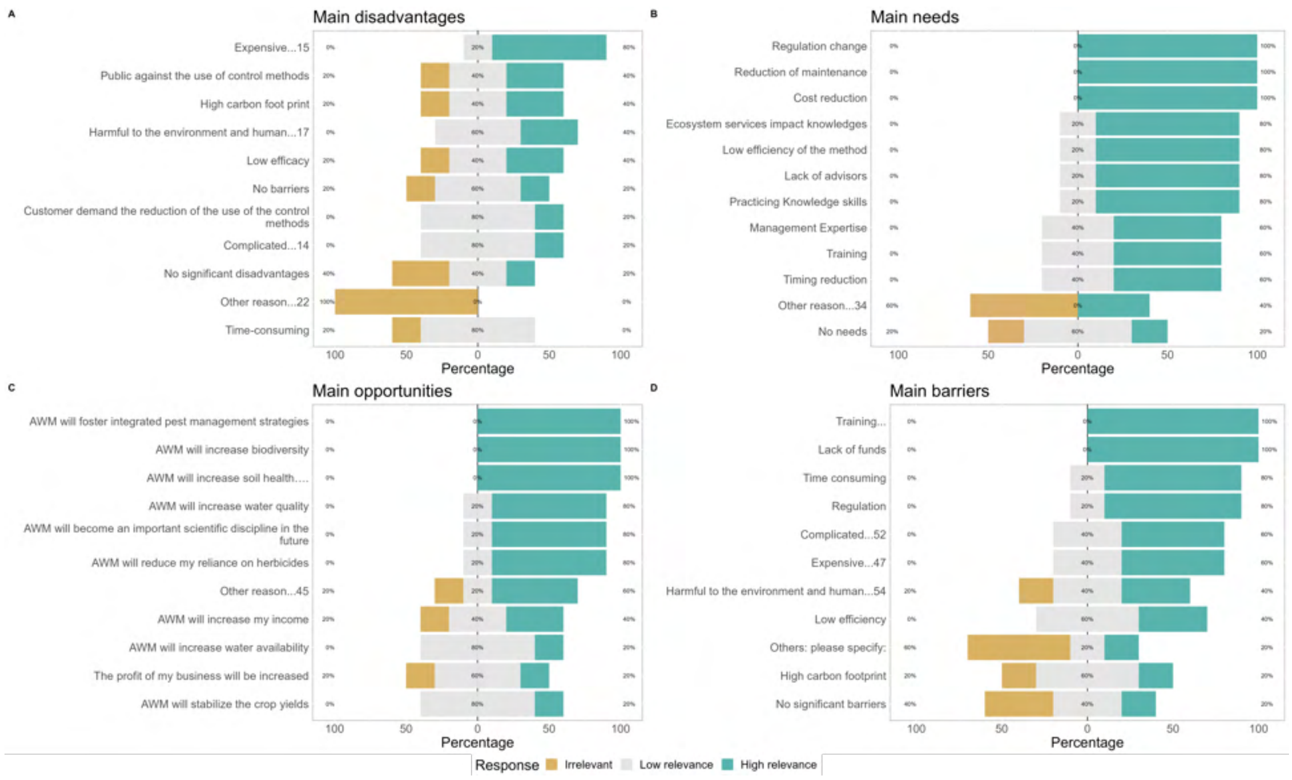


Figure 286. Main disadvantages, needs, barriers and opportunities for mowing identified by researchers.

3.3.1.1.7.6 Conclusion

Stakeholders hold diverse perspectives on mowing; advisors and consumers express relatively cautious views, while farmers, industry representatives, and researchers believe that mowing offers numerous opportunities. Across various stakeholders, including advisors, farmers, industry representatives, and researchers, mowing is seen as fostering IPM strategies and providing ecosystem services. Advisors, consumers, farmers, and researchers emphasize that mowing can reduce reliance on herbicides. Additionally, industry representatives and researchers highlight its potential to evolve into an important scientific discipline. Primary needs vary: advisors prioritize training and cost reduction, consumers stress cost and timing reduction, industry representatives identify a lack of advisor availability, training, and cost reduction, while researchers prioritize knowledge of ecosystem services impacts and regulatory changes. Farmers do not primarily consider any of the queried necessities as relevant. Time consumption and expense are significant concerns across stakeholders, with varying degrees of emphasis from advisors, consumers, farmers, and industry representatives. Researchers, however, believe that mowing faces no significant barriers. Expense, carbon footprint, and time consumption are regarded as relevant disadvantages across stakeholders. As in the case of barriers, researchers do not consider mowing to present any significant drawbacks.

3.3.1.1.8 Mulching

3.3.1.1.8.1 Consumer

Consumers generally held a neutral view toward mulching, as they did not perceive significant opportunities or identify relevant needs, barriers, or disadvantages associated with the method. Seventy-five percent of consumers believed that mulching could reduce reliance on herbicides, but other potential benefits were not deemed significant by more than half of the respondents. Among the main needs cited by consumers, half of the respondents mentioned cost and timing reduction. Additionally, half of the consumers considered time consumption and expense to be relevant impediments. Finally, an equal proportion of respondents identified a high carbon footprint as the most significant disadvantage.

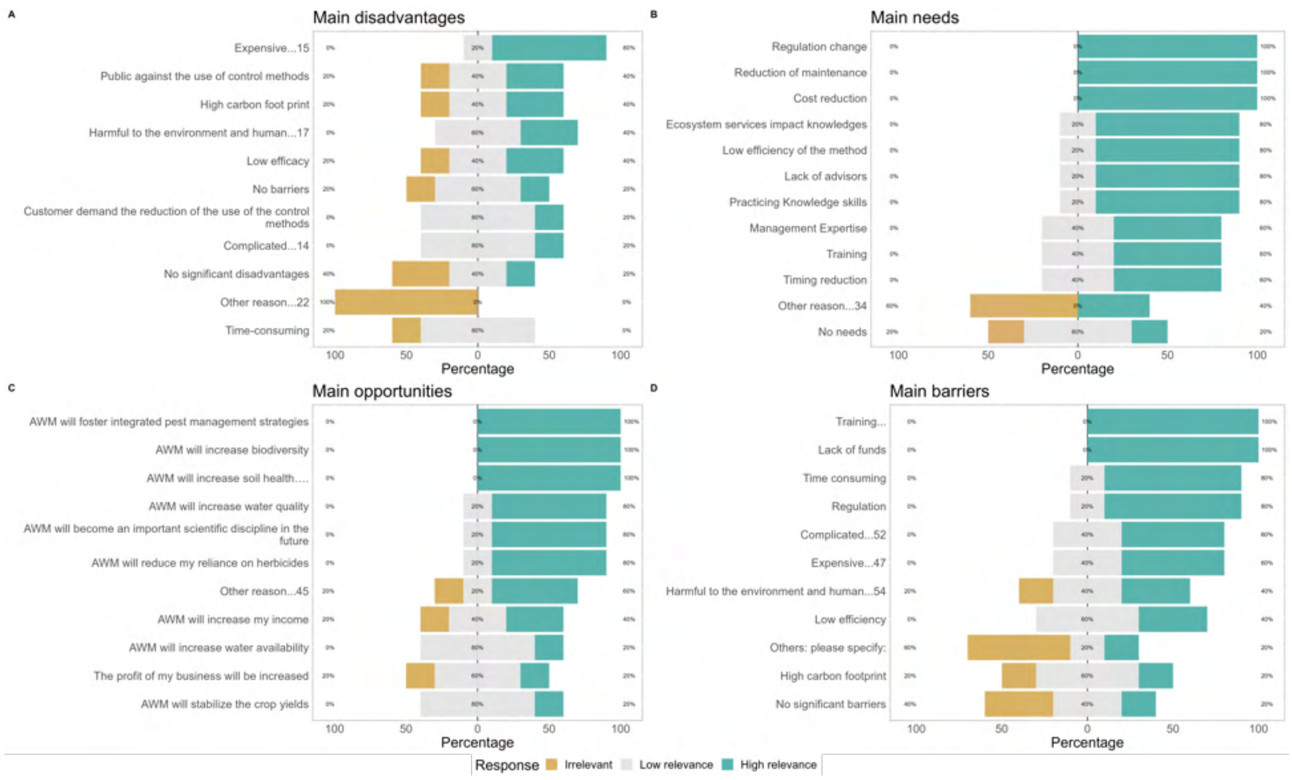


Figure 287. Main disadvantages, needs, barriers and opportunities for mulching identified by consumer.

3.3.1.1.8.2 Farmer

Farmers expressed a balanced perspective on mulching compared to consumers, acknowledging both its potential opportunities and challenges. Over half of the respondents believed that mulching supports IPM strategies and serves as an ecosystem services provider, contributing to improved water quality, biodiversity, and soil health. They also recognized its potential to reduce reliance on herbicides. Regarding the main needs associated with mulching, none of the queried factors were considered significant by more than half of the respondents. However, 44% of farmers cited factors such as low efficiency, required knowledge and skills, management expertise, and the need for timing, cost, and maintenance reduction as relevant necessities. Among the main barriers identified by farmers, two-thirds of the respondents emphasized expense, while over fifty percent mentioned time consumption. Similarly, 56% of farmers identified expense, complexity, and time consumption as highly relevant disadvantages associated with mulching.

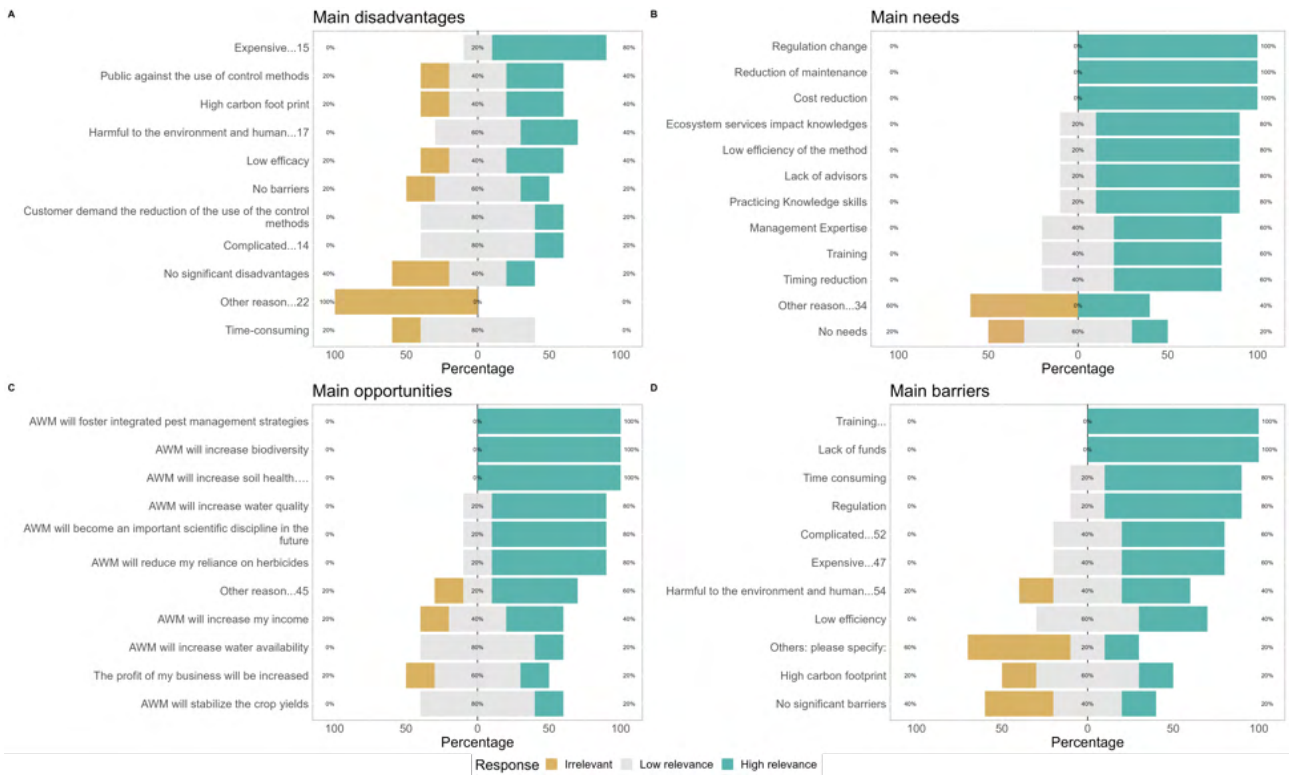


Figure 288. Main disadvantages, needs, barriers and opportunities for mulching identified by farmers.

3.3.1.1.8.3 Conclusion

Consumers and farmers held a neutral view toward mulching, although farmers expressed a slightly more positive perspective by acknowledging some potential opportunities, needs, barriers, and disadvantages associated with the practice. Both consumers and farmers highlighted the potential of mulching to reduce reliance on herbicides. However, farmers alone recognized mulching as fostering IPM strategies and providing ecosystem services. Cost and timing reduction were seen as relatively important needs by both stakeholders, although farmers did not consider any of the queried factors as primarily relevant. Time consumption and expense were identified as the most significant barriers by both farmers and consumers. While consumers considered a high carbon footprint as the most relevant disadvantage, farmers highlighted expense, complexity, and time consumption as the primary concerns associated with mulching.

3.3.1.2 Surveys

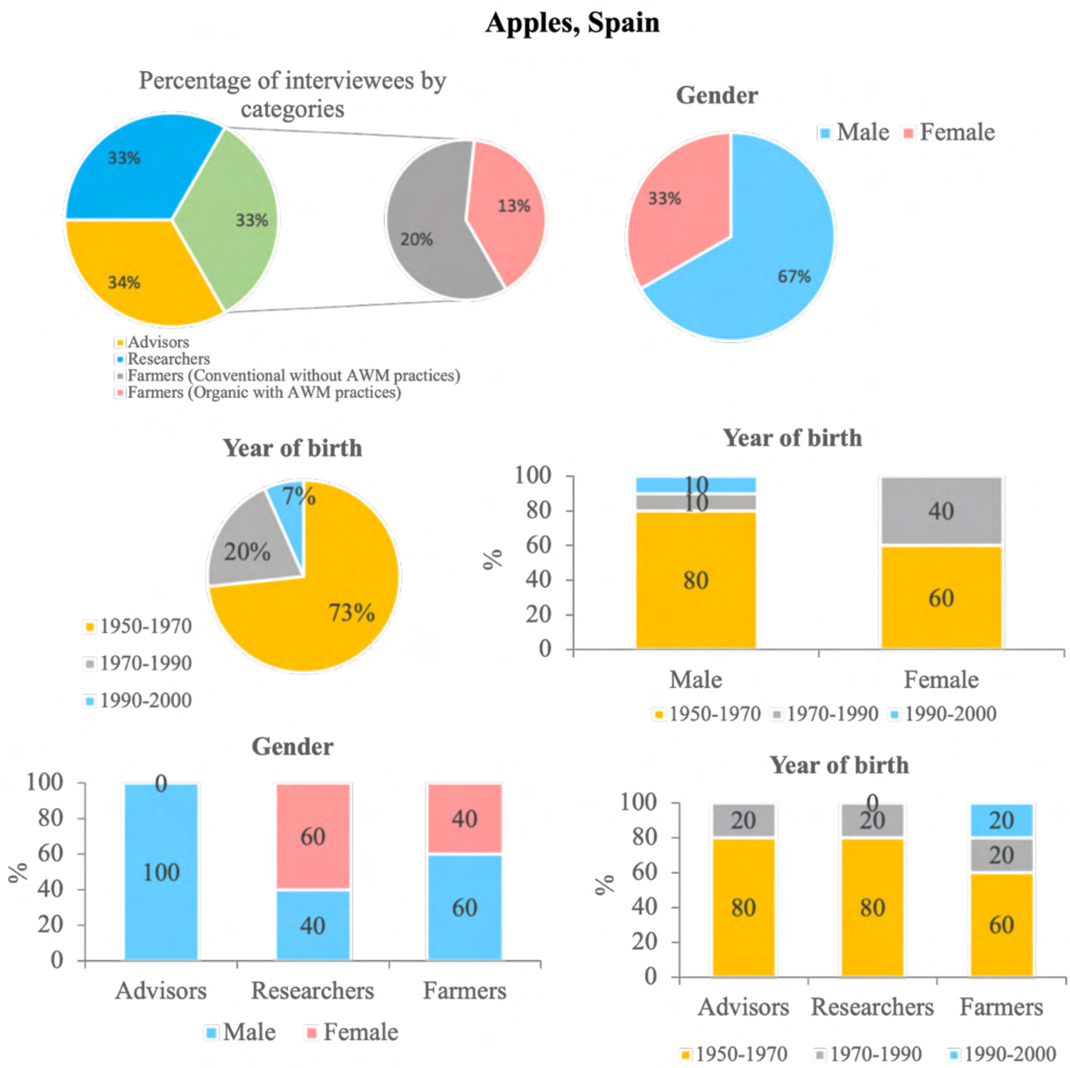


Figure 289. Interviewees description in the Apple Living Lab (Spain)

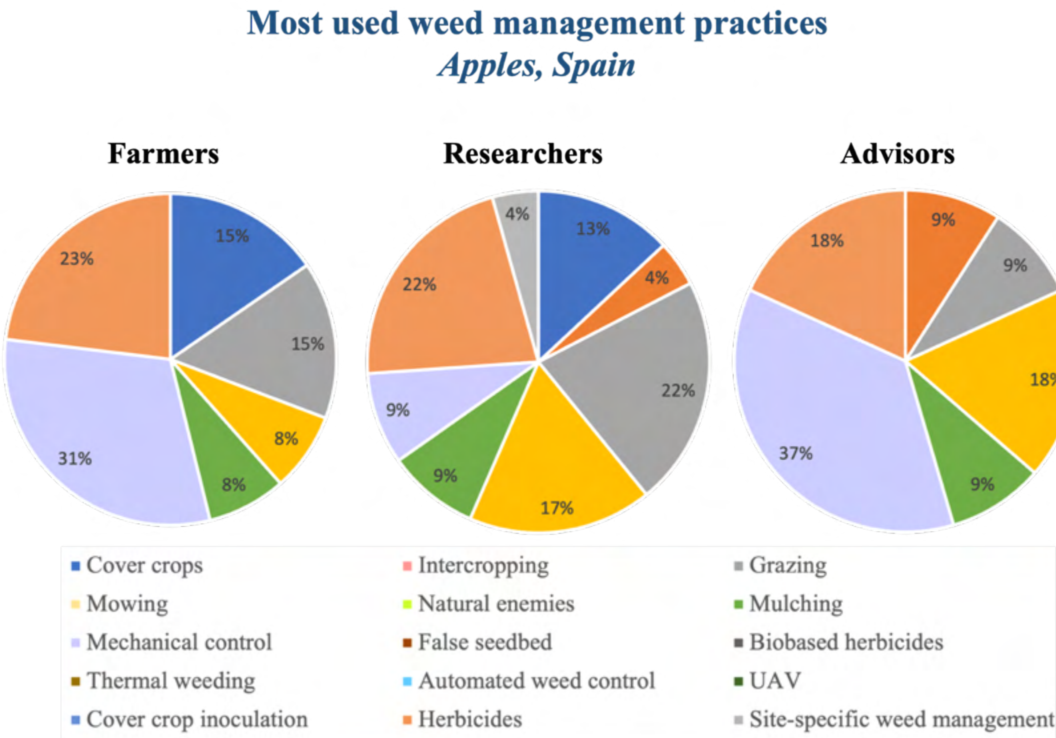


Figure 290. Most used weed management practices in the Apple Living Lab (Spain)

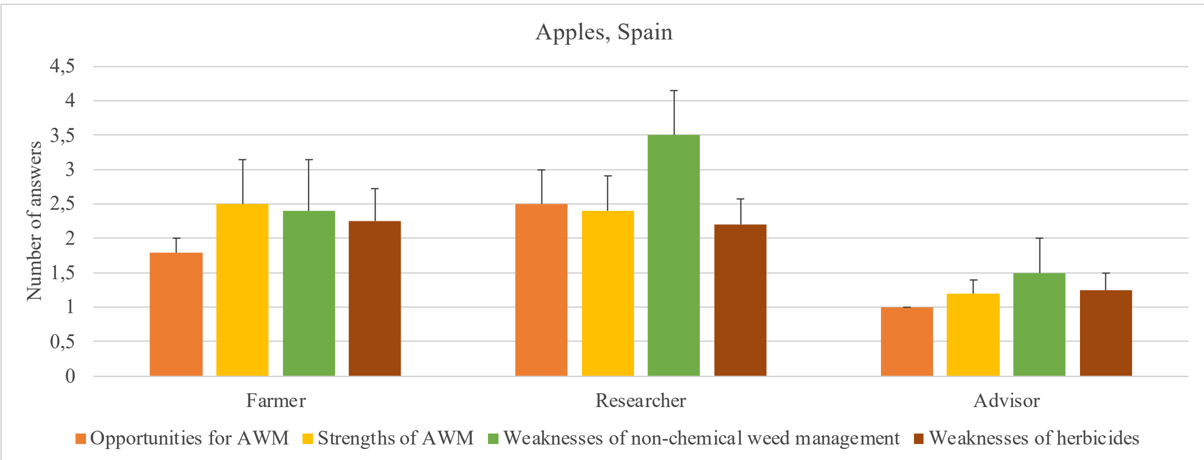


Figure 291. Mean number of answers (±se) per stakeholder group in the Apple Living Lab (Spain)

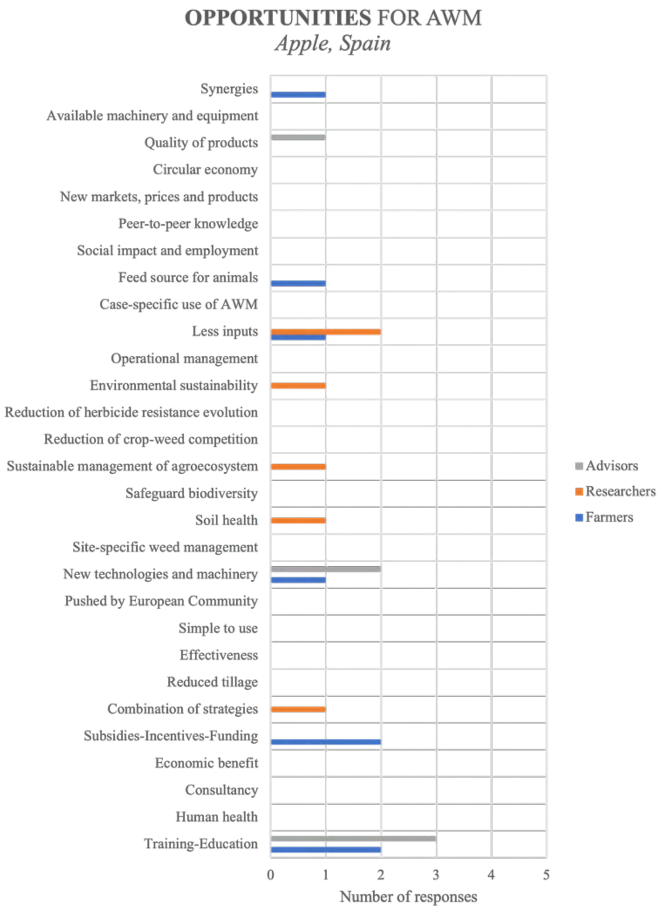
Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: Presented in the figure below.

THREATS: None.

WEAKNESSES: Only a few answers were related to more commitment, limitations on large-scale operations and lack of labor.



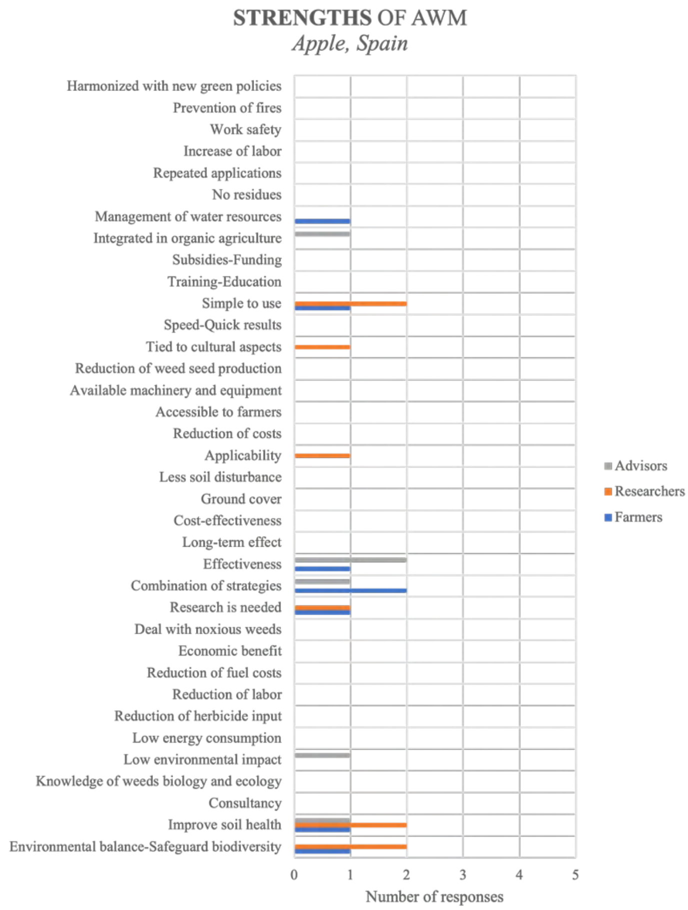


Figure 292. Opportunities and strengths of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: Lack of recognition from markets was identified by a farmer and a researcher.

WEAKNESSES: Presented in the figure below.

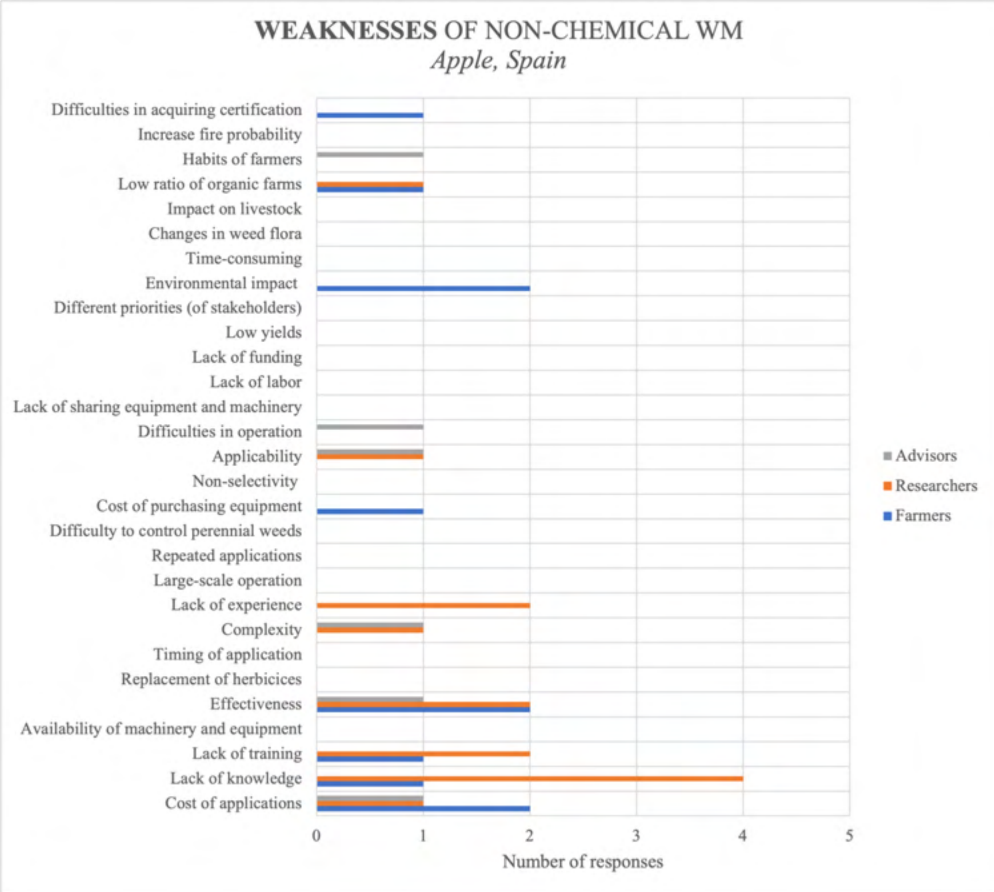


Figure 293. Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: For three researchers, the availability of equipment is an opportunity for herbicides.

STRENGTHS: For two researchers the availability of herbicides is a strength and for a farmer the simplicity to use herbicides.

THREATS: Researchers identified the markets, the pressure to reduce herbicides, as well as the lack of new and withdrawal of existing herbicides as threats.

WEAKNESSES: Presented in the figure below.

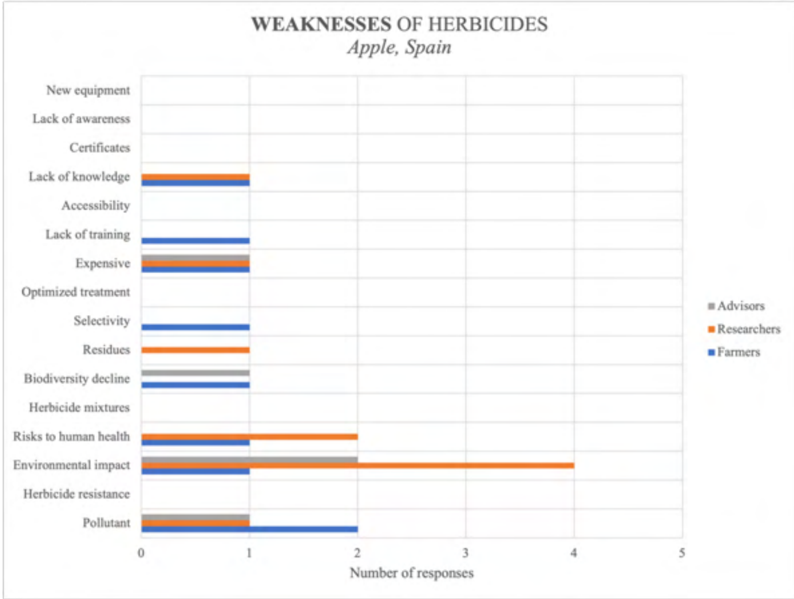


Figure 294. Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – APPLE, SPAIN
Most used weed management practices: The most common weed management practices in apple orchards in the Living Lab area include mechanical control and herbicides, followed by the use of cover crops and grazing. However, it is observed that stakeholders (farmers, researchers, advisors) have different views on which practices are more and less applied. For example, advisors consider that cover crops are not applied, and grazing is not a widespread practice. **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group**: In this Living Lab, it is observed that farmers and researchers have much more to say than the advisors, which is evident from the number of responses they gave on the opportunities and strengths of agroecological weed management, and the weaknesses of chemical and non-chemical weed management. Specifically, the interviewed researchers found the most weaknesses in non-chemical weed management which suggests that research is being conducted on alternative practices that reduce chemical use and efforts are being made to improve or better align them with the capabilities of the farmers and the region. **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: Although a few opportunities around agroecological weed management were identified, the most important were education and training, reduced inputs and the ability to

invest in new equipment and machinery. Strengths of the practices incorporated their effectiveness, ease of use, the fact that they improve soil health and protect biodiversity.

Threats, and weaknesses for non-chemical weed management: Lack of knowledge, education and experience are barriers to adoption and weaknesses of non-chemical weed management. In some cases, ineffectiveness, high operational costs and complexity of applications make non-chemical weed management weak compared to chemical weed management.

Opportunities, strengths, weaknesses, and threats for herbicides: The environmental impact, pollution and risks to human health are the main weaknesses of herbicides. Although, the presence of herbicides in markets is considered a strength, but there is an ever increasing pressure to reduce their use.

3.3.1.3 Living lab board meeting

The first LL board meeting was an online meeting held on 21st December 2023 at 16:00 hours (CEST). In total 13 people participated in the meeting (2 GOOD partners, 5 farmers, 2 advisors, 2 researchers, 1 consumer, 1 policy maker) and two companies that are part of the LL could not attend but they are interested. Consent forms to participate in the LL board were collected from all attendees. The agenda of the LL board meeting was: i) Presentation of the GOOD project (10 min), ii) Presentation of the Galician Living Lab (LL) (10 min), iii) Discussion (60 min) and iv) Conclusions (10 minutes). During the discussion, the participants in the meeting talked about the next activities of the Galician LL and agroecological weed management. In Galicia, in the case of the apple trees, the production is generally an agroecology production. Moreover, weed control is not a problem in apple tree plantations, but when it is necessary, the most common weed management practices are the use of herbicides (chemical weed control), mulching, compost or bark in the lines. In the corridors, the grass is cut or grazed. Regarding the cover crops, due to the Galicia climate, the soil is always covered with spontaneous vegetation. In any case, participants in the meeting think that it is necessary to organise activities to show the results of the GOOD project such as webinars, visits to demonstration plots or training courses to increase the adoption of agroecology practices in the sector by farmers. During the LL board meeting, this information was also collected:

	1. How many farmers cultivate apple trees in the region (approx.)?

What are the market characteristics of apples?	The number of farmers is not known but in Galicia the area occupied by apple trees was 4.395 hectares in 2022.
	2. How many products are derived from the apple trees?
	The products derived from the apple trees are mainly apple juice, marmalade, confiture, cider, vinegar and cider liqueur.
	3. Do you think that agroecological products could be promoted in local markets?
	Yes, but it is necessary to promote the agroecological products.
	4. Do you believe that the region has a lack of technologies?
	Yes, there is technology for recollection and transformation of the product but in Galicia, that technology is not used.
	5. Is the regional agri-food value chain sustainable?
	Participants in the LL board meeting think that the value chain is not sustainable.
What are the most common agricultural and weed management practices in apple trees?	1. What are the most common agronomic practices in apple trees?
	The most common agronomic practices are the annual grass-cutting or grazing and pruning of the trees every 2, 3 or 4 years. Additionally, pest and disease control are necessary practices but these management practices are generally not carried out.
	2. What are the most common weed management practices in apple trees?
	The most common weed management practices are the use of herbicides (chemical weed control), mulching, compost or bark in the lines. In the corridors, the grass is cut or grazed. Regarding the cover crops, due to the Galicia climate, the soil is always covered with spontaneous vegetation. However, it is important to take into account that in most of the cases, weeds are not a problem in apple tree plantations.
	1. How many active ingredients there are available? How many different mode of actions?

What is the herbicide use in apple trees?	Herbicides are not generally used in the plantations of apple trees. Sometimes, copper is applied.
	2. How many times do you spray in-season?
	Herbicides are not generally used in the plantations of apple trees.
	3. Do you use pre-emergence, post-emergence or both herbicides?
	Herbicides are not generally used in the plantations of apple trees.
	4. Are herbicides efficient?
	Herbicides are not generally used in the plantations of apple trees
	5. Do you think that alternatives to herbicides are equally efficient?
	Herbicides are not generally used in the plantations of apple trees
	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?
	Herbicides are not generally used in the plantations of apple trees
	7. Do you believe that agriculture without herbicides is viable?
	Yes. In Galicia, agriculture without herbicides could be viable due to the Galician traditions.
What are the needs and barriers to assist agroecological transitions & adopt agroecological weed management approaches?	1. What is needed to boost the uptake of agroecological practices?
	In the case of the plantation of apple trees in Galicia agroecology is implemented mainly because the sector is not professionalised. In any case, agroecology should be promoted through the training of farmers with the help of the Administration.
	2. What are the barriers towards agroecology implementation?
	In the case of the plantations of apple trees in Galicia agroecology is implemented.
	3. Should policies need be redefined to allow agroecological transitions?
	In the case of the plantations of apple trees in Galicia agroecology is implemented
	4. How confident you feel about the adoption of agroecological weed management practices?

GOOD AGROECOLOGY FOR WEEDS

	In the case of the plantations of apple trees in Galicia agroecology is implemented
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	1. What are the main drivers of weed dispersal?
	The main cause of weed spread is related to the soil clearing and pasture sowing that encourages the appearance of weeds such as *Rumex obtusifolius*.
	2. Which are the major and most noxious weeds in your area?
	The major and most noxious weed is *Convolvulus arvensis,* but in general, weeds are not a problem in the plantations of apple trees.
	3. Are there any herbicide resistant weeds?
	Not relevant in the case of the plantations of apple trees.
	4. Do you know any invasive plants in your area?
	Not relevant in the case of the plantations of apple trees.
What do you think about the Living Lab?	1. Which proposals do you have for a good performance of the LL?
	In general, participants in the LL board meeting have a good opinion about the LL activities. Participants asked about the grazing treatment which will be established next year. GOOD partners explained that grazing can be combined with the production of apple trees with the use of shepherds or virtual fences. Participants in the meeting think that it is necessary to organise activities to show the results such as webinars, visits to demonstration plots or training courses.
	2. Would you like it to remain over time?
	All participants in the first LL board meeting are interested in being part of the LL board.

3.3.2 France

French LL had previously conducted their own study with regard to stakeholders perception to AWM practices and investigate issues and perspectives for weed management in established orchards, young plantations and berry crops, as well as regulatory changes, through a big survey on weed management in fruit crops. The summary of this survey is given below. For more information and the documents please contact maria-martha.fernandez@ctifl.fr . Links to French versions: link1, link2

Based on the contributions and limits of available surveys on crop and phytosanitary tree growing practices, the CTIFL drafted a detailed inventory of weed control practices, for each species and for the entire region covered, aiming to evaluate priorities in relation to using alternatives to glyphosate. This complementary survey aims to obtain detailed quantified data on extra growing costs, number of interventions, weed control methods and equipment used, amounts invested and depreciation periods. Given the wide range of situations and types of fruit growing, it was essential to avoid the risk of using non-representative examples as references. The survey was organised on-line from 26 August to 9 October 2019 with growers in each of the fruit growing sectors (fruit trees, berries, table grapes). The aim was to identify the alternative methods used in the field, to obtain economic reference data and, finally, to highlight obstacles and impasses. The 959 farms studied covered a total surface area of 19,938 hectares used for fruit growing, i.e. 12.1% of French orchards. The survey covered 27 of the main fruit species grown in mainland France. According to the main conclusions of this survey, weed control is a key factor in the competitiveness of fruit crops. If weeds are not efficiently controlled, they will spread to the detriment of tree growth, with a direct impact on yield and regular crops. 98% of herbicide strategies used for fruit crops revolve around glyphosate. Grass is left to grow in plantation interrows, therefore only 25% to 50% of surface areas are treated with herbicide. It is also apparent that orchards managed according to Integrated Fruit Production (IFP) practices are already globally run using techniques which reduce the use of herbicides: 20% of farms already integrate alternative methods in their weed control strategies and 18% have totally excluded herbicide use. Nonetheless, the integration of alternative weed control practices currently varies widely depending on the species due to technical impasses faced with certain types of fruit growing. Only two of the wide range of alternative methods described as easy to transfer are actually implemented in the field. The first method involves mowing plantation rows, and the second method involves mechanical weed removal from the ground. These alternative methods have consequences on crop performance and increase the workload of growers. This extra cost will vary depending on the sector and market segments. These methods are not technically feasible in some sectors. Current equipment and qualified labour are two points which limit this approach for the time being.

3.4 Grapes

3.4.1 Spain

3.4.1.1 Questionnaires

Grape's questionaries in Spain provided insights of 7 AWM practices regarding the perception of their main disadvantages, needs, barriers, and opportunities. Some practices were exclusively considered by a single stakeholder category; for instance, biobased herbicides were solely evaluated by consumers. None of the techniques were assessed by more than three respondents across all stakeholder categories. Table 35 presents the types of stakeholders who answered the questionnaires associated with different AWM practices and the number of respondents in each category.

Table 35 Number of responses for each AWM practice and stakeholder category in Grapes (Spain).

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automates weed control	1	1				
Biobased herbicides		**4**	1			
Cover crop inoculation to increase competitiveness	1					
Cover crops		2	**3**	2		1
False seedbed		1				
Grazing		**5**	2	1		1
Herbicides	**3**	**1**	**5**	**3**	2	**4**
Intercropping		1	1			
Mechanical weeding	1	**6**	**5**	**3**	2	**3**
Mowing	2	**3**	**4**	2	1	**3**
Mulching		**4**	**3**			2
Natural enemies						
Other				1		
Site-specific spraying	1	1	1			
Thermal weeding						
UAV						
n=41	4	11	9	6	5	6

3.4.1.1.1 Biobased herbicides

3.4.1.1.1.1 Consumers

Consumers unanimously agree on the opportunities associated with the use of biobased herbicides. Seventy-five percent of them emphasize its capacity to foster IPM and state the potential of this AWM technique to evolve into a significant scientific discipline in the future. Additionally, consumers highlight the stabilization of crop yields due to the utilization of biobased herbicides. Half of the surveyed consumers believe that this practice will increase farmers' income and the profitability of businesses. However, responses were evenly split when consumers were asked whether biobased herbicides would reduce reliance on traditional herbicides. There is less consensus regarding the provision of ecosystem services, as only 25% of consumers believe that this practice will enhance water quality and availability, biodiversity, and soil health. Most respondents consider these categories to have low relevance. Consumers unanimously agree on the identified needs for implementing this technique. One hundred percent of respondents list an increase in knowledge about ecosystem services, training and practicing skills, regulatory changes, lack of advisors, and management expertise as the main needs associated with biobased herbicides use. Moreover, 75% of the respondents' state that reducing costs and simplifying maintenance are key needs for its practical implementation. Consumers show high rates of consensus regarding the barriers, listing low efficiency, complexity, lack of training, expensive costs, and regulatory problems. Consumers perceive biobased herbicides as an expensive, inefficient, complicated, and time-consuming as the main disadvantages of this practice.

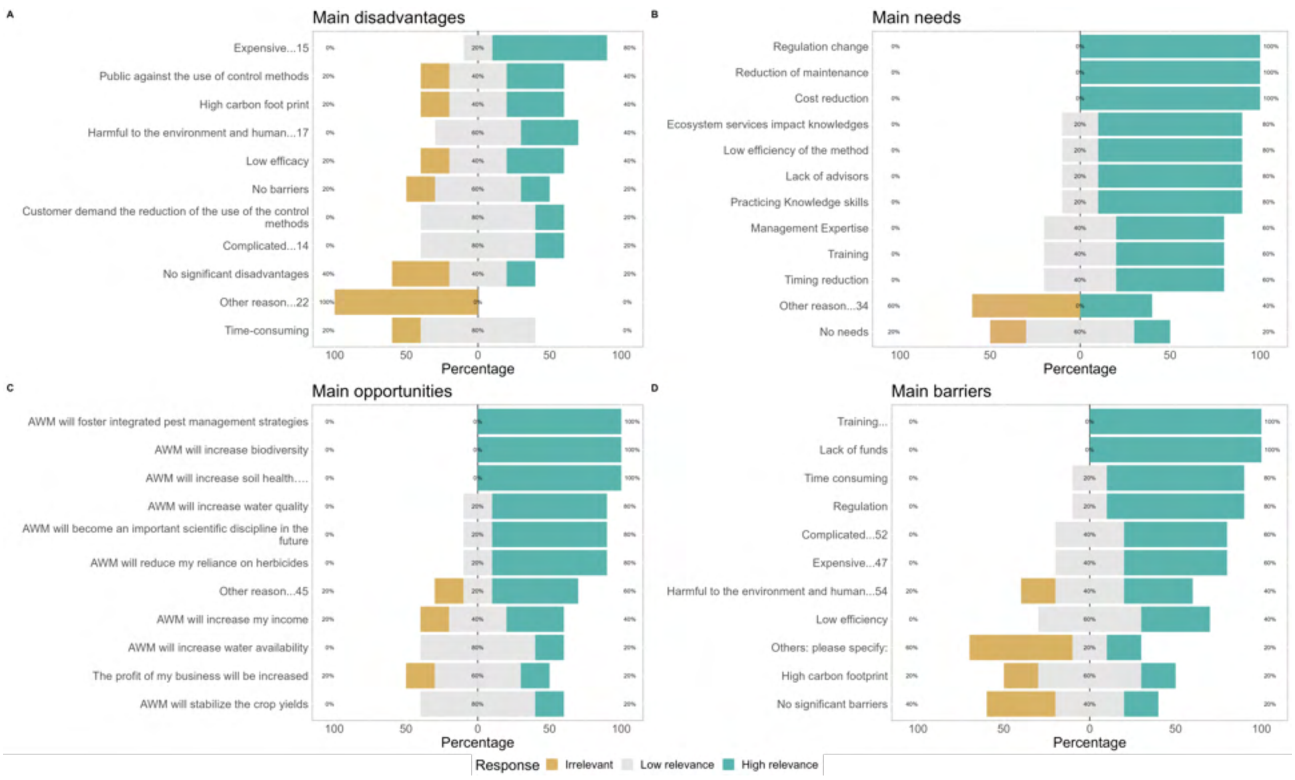


Figure 295. Main disadvantages, needs, barriers and opportunities for biobased herbicides identified by consumers.

3.4.1.1.1.2 Conclusion

Consumers emphasize the role of biobased herbicides in the implementation of IPM strategies, stating that it may stabilize crop yields. According to consumers, the potential of biobased herbicides may be hindered due to the high price of biobased herbicides and its inefficiency.

3.4.1.1.2 Cover crops

3.4.1.1.2.1 Farmers

Farmers acknowledge the potential of cover crops to provide ecosystem services, with 100% of respondents associating this technique with IPM, improved water quality, increased biodiversity, and enhanced soil health. All respondents believe that incorporating cover crops in AWM leads to stabilized crop yields. Sixty-seven percent of farmers anticipate increased profitability through this practice, along with reduced reliance on herbicides, highlighting the growing significance of cover cropping in future scientific disciplines. There is unanimity among farmers regarding the needs for implementing cover crops, with enhanced knowledge of ecosystem services and reduced maintenance recognized as essential by all respondents. Despite the positive outlook, all farmers (100%) identify price as the primary barrier, followed by concerns about its carbon footprint and potential environmental and human health impacts, as noted by 67% of respondents. The scarcity of advisors, skills, and the need for time efficiency are emphasized by most respondents, with 67% of farmers agreeing that these factors are highly relevant. Finally, 67% of farmers find cover cropping time-consuming, while 50% state that this AWM technique does not present significant disadvantages.

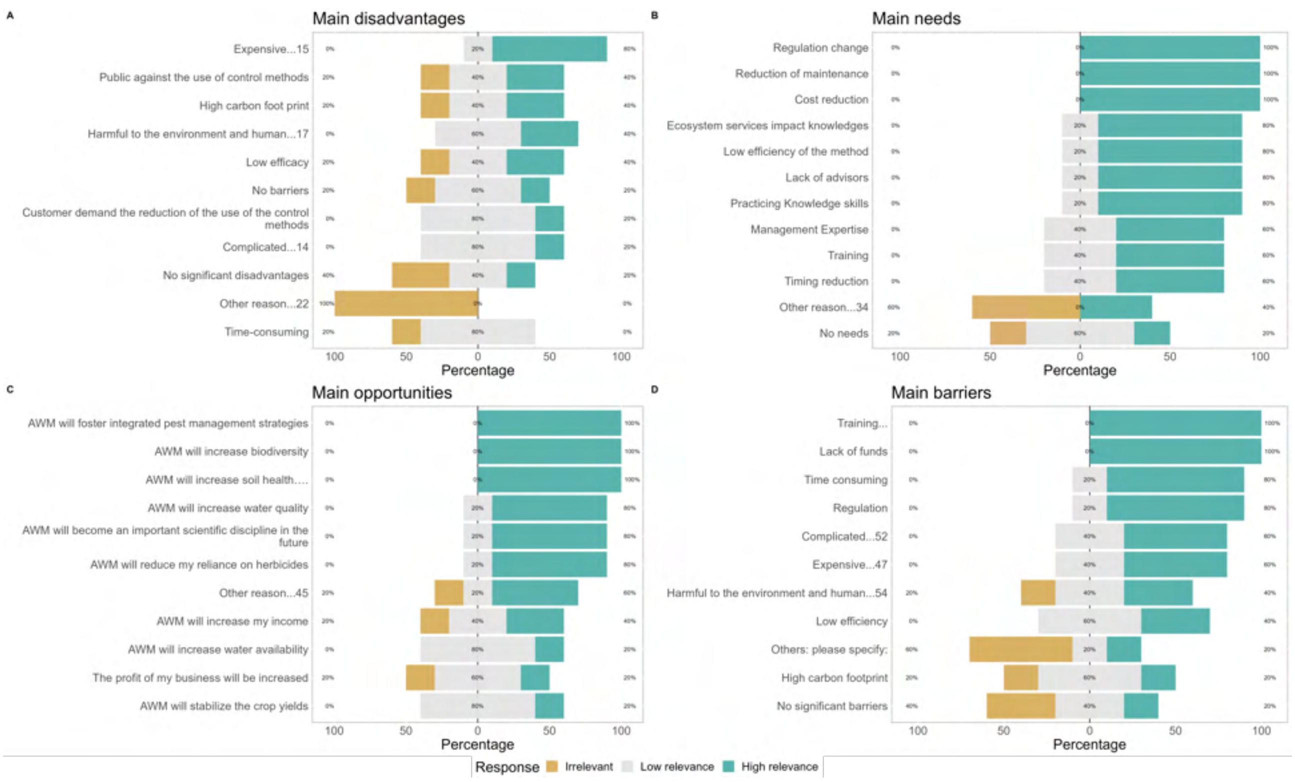


Figure 296. Main disadvantages, needs, barriers and opportunities for cover crops identified by farmers.

3.4.1.1.2.2 Conclusion

Farmers unanimously recognize the potential of cover crops, associating them with various ecosystem services and the stabilization of crop yields. They anticipate increased profitability and reduced reliance on herbicides, indicating the growing importance of the practice. There is unanimous agreement on the essential needs for implementing cover crops, although all farmers identify price as the primary barrier. Concerns about environmental impacts and the scarcity of advisors and skills are noted by respondents. Most respondents find cover cropping time-consuming, while half of them believe it lacks significant disadvantages.

3.4.1.1.3 Grazing

3.4.1.1.3.1 Consumers

Consumers recognize all categories of opportunities associated with grazing as highly important. They emphasize improvements in soil health, reduction in herbicide use, and economic aspects such as increased profitability, income, and the stabilization of crop yields. A significant 80% of consumers highlight the ecosystem service-related opportunities, including the IPM fostering, increased water availability and quality, and an anticipation that grazing will evolve into an important scientific discipline. Consumers agree regarding the necessities of implementing grazing, with 80% stating that knowledge, skills, training, and reduction of maintenance are key factors. Additionally, factors like ecosystems impact knowledge, regulatory changes, lack of advisors, management, cost, and timing reduction are recognized as crucial requirements for successful grazing implementation. All consumers identify training as the main barrier, 60% of respondents express concerns about the practice being time-consuming, lack of funds, or regulatory problems. Notably, 40% of respondents perceive grazing as either complicated or having no significant barriers. This divergence in responses suggests potential differences within the key informant group. Furthermore, a noteworthy 20% of respondents express concerns about grazing, citing a high carbon footprint, environmental and human health harm, efficiency concerns, and implementation cost. Overall, customers do not perceive grazing as having significant disadvantages, mentioning only that it is time-consuming and expensive.

It is noteworthy that 20% of consumers either oppose or believe that the public opposes the use of grazing.

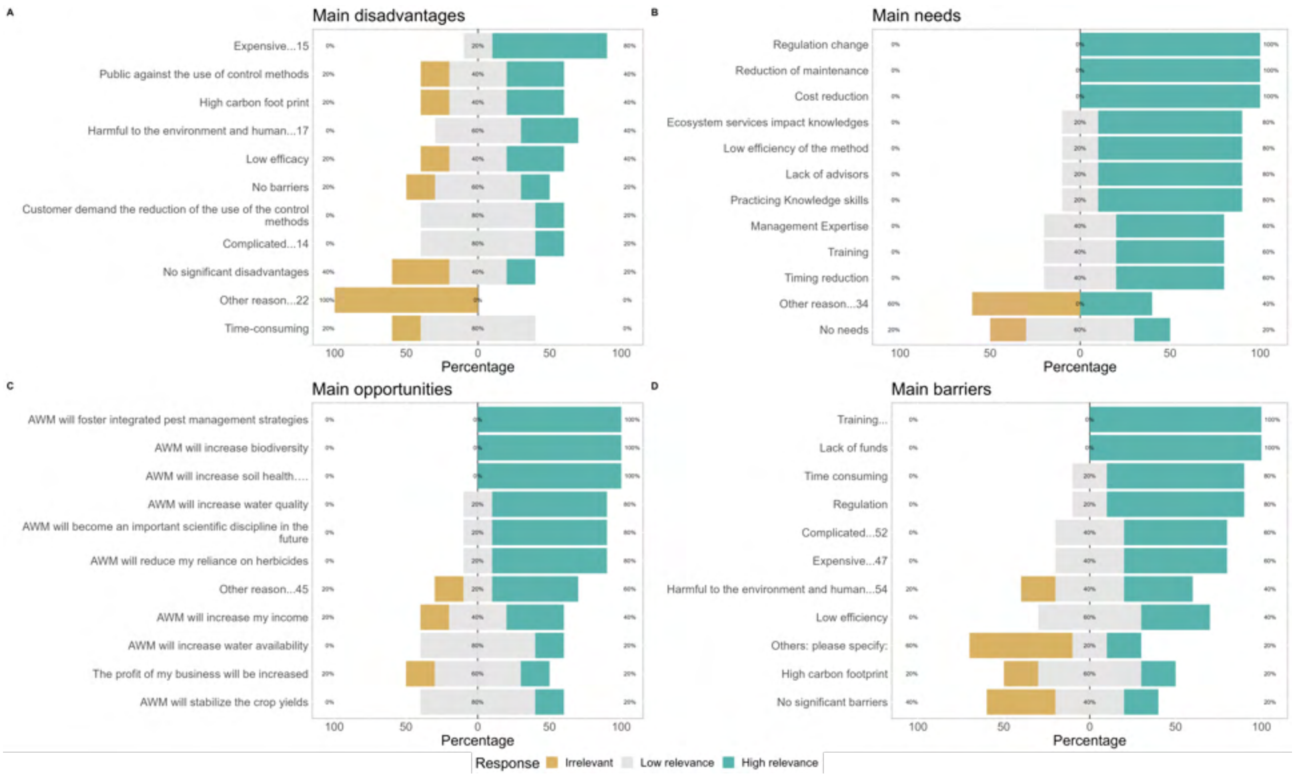


Figure 297. Main disadvantages, needs, barriers and opportunities for grazing identified by consumers.

3.4.1.1.3.2 Conclusion

In conclusion, consumers accentuate the substantial opportunities of grazing, emphasizing improvements in soil health, reduced herbicide use, and economic benefits. The alignment on key ecosystem service-related opportunities reflects a shared perspective on needs, including knowledge, training, and maintenance reduction. All respondents stated training as the main barrier in grazing. However, diverse perceptions the ease of its implementation highlight potential variations within the respondent group. It is important to note that consumers were the sole group with enough respondents.

3.4.1.1.4 Herbicides

3.4.1.1.4.1 Advisors

Advisors' views on herbicide-related opportunities are diverse, evenly distributed across three categories—irrelevant, of low relevance, and of high relevance. Particularly notable are opportunities related to fostering IPM and increasing water availability. One-third of respondents underscore the role of herbicides in ecosystem services, including improvements in water quality, biodiversity, and soil health. They highlight that herbicides may evolve into an important scientific discipline, while 67% consider these opportunities of low relevance. This distribution among advisors indicates that 33% view all categories as relevant opportunities except for yield stabilization. Respondents demonstrate consensus when identifying the main needs for herbicide use, categorizing the following as highly relevant: ecosystem service impact knowledge, regulatory changes, reduction of maintenance, costs, and timing. Advisors unanimously agree that the main barrier to herbicides is regulatory, yet they do not consider any significant barriers for herbicides. The remaining queried categories exhibit heterogeneity, with 33% of respondents assigning high relevance to factors such as herbicide carbon footprint and its potential harm to the environment and human health, mirroring the pattern observed in opportunities. Advisors unanimously identify customers and the public as the primary deterrents to herbicide use, as all of them believe that these groups oppose its usage. Again, 33% of respondents assert that herbicides have no significant barriers, despite acknowledging a high carbon footprint and potential harm to the environment and human health.

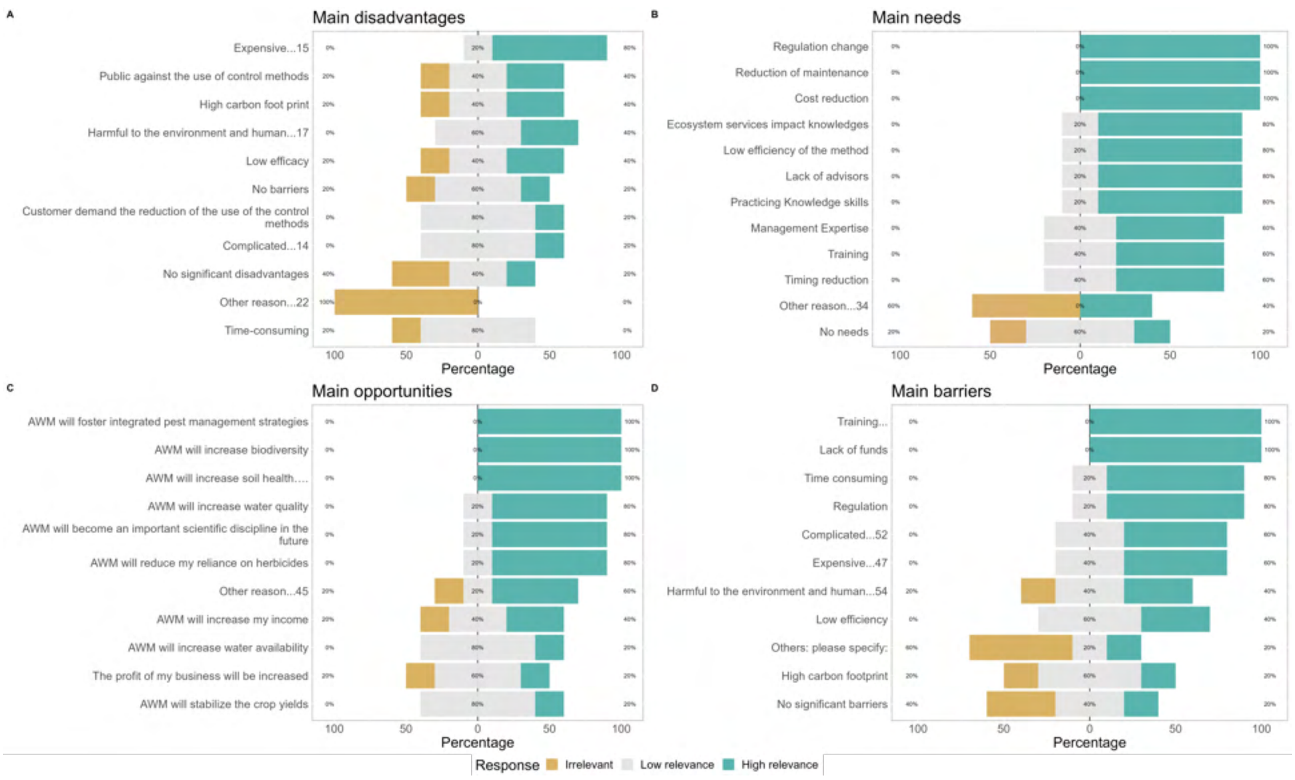


Figure 298. Main disadvantages, needs, barriers and opportunities for herbicides identified by advisors.

3.4.1.1.4.2 Consumers

Consumers predominantly perceive the presented opportunities for herbicide use as irrelevant or of low relevance. Notably, economic aspects, such as income increase, herbicide reduction, and business profitability, were the highest-ranked categories among consumers. However, 50% of them find herbicide use irrelevant in ecosystem services-related categories like water quality, availability, biodiversity, and soil health. Consumers unanimously agree on key needs, emphasizing the necessity for increased knowledge about ecosystem services impact, regulatory changes, lack of advisors, skills training, management expertise, and maintenance reduction, with 80% considering these highly relevant. Primary barriers identified by consumers for herbicide use include concerns about potential harm to the environment and humans, a high carbon footprint, and regulatory issues, as noted by more than 80% of respondents. A substantial proportion of consumers perceive significant barriers to herbicide implementation. Lastly, all consumers express a belief that herbicides pose a threat to the environment or humans, with 90% of them concurring with advisors that the public demands a reduction and is against herbicide use.

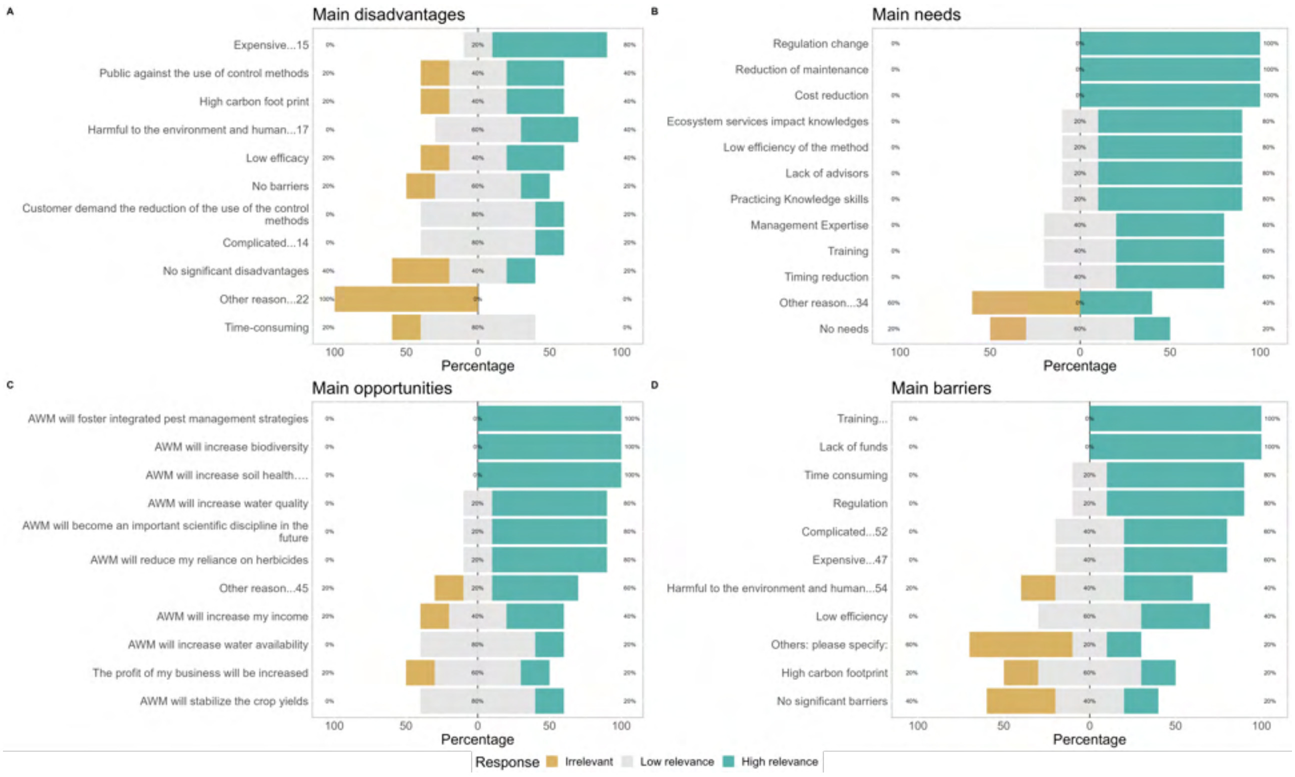


Figure 299. Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

3.4.1.1.4.3 Farmers

Farmers views on herbicides related opportunities differ with customers opinions but show higher similarities to advisors 'response distribution. Forty percent of farmers state that herbicides will foster IPM and view this practice as a full provider of ecosystem systems, including there the increase of water availability and quality, biodiversity, and better soil health. Notably, as in the case of advisors the other 60% of respondents find that herbicides are irrelevant providers of ecosystem services. Eighty percent of farmers agree that practicing knowledge skills, reduction of maintenance and timing reduction as the main needs when implementing this technique. The latter categories were also considered as relevant by advisors and consumers. Notably, only 60% of farmers find that knowledge regarding ecosystem services impact compared to 100% of advisors and 80% of consumers. Notably, all farmers state that the main barrier to herbicide use is its potential harm to the environment and humans, its high carbon footprint, lack of training and regulatory problems, these concerns are shared with consumers. The main disadvantages of herbicide use according to farmers agree with consumers and advisors, as most of them find that the public demands either a reduction or its directly against its use. Note the difference between the proportions, as 90-100% of consumers an advisors agree that this category is highly relevant while only 3 out of 5 farmers agree with the relevance of these statements, this may indicate that advisors may be closer to consumer concerns. Lastly, 60% of farmers state that herbicides have a high carbon footprint and may be harmful to the environment and human.

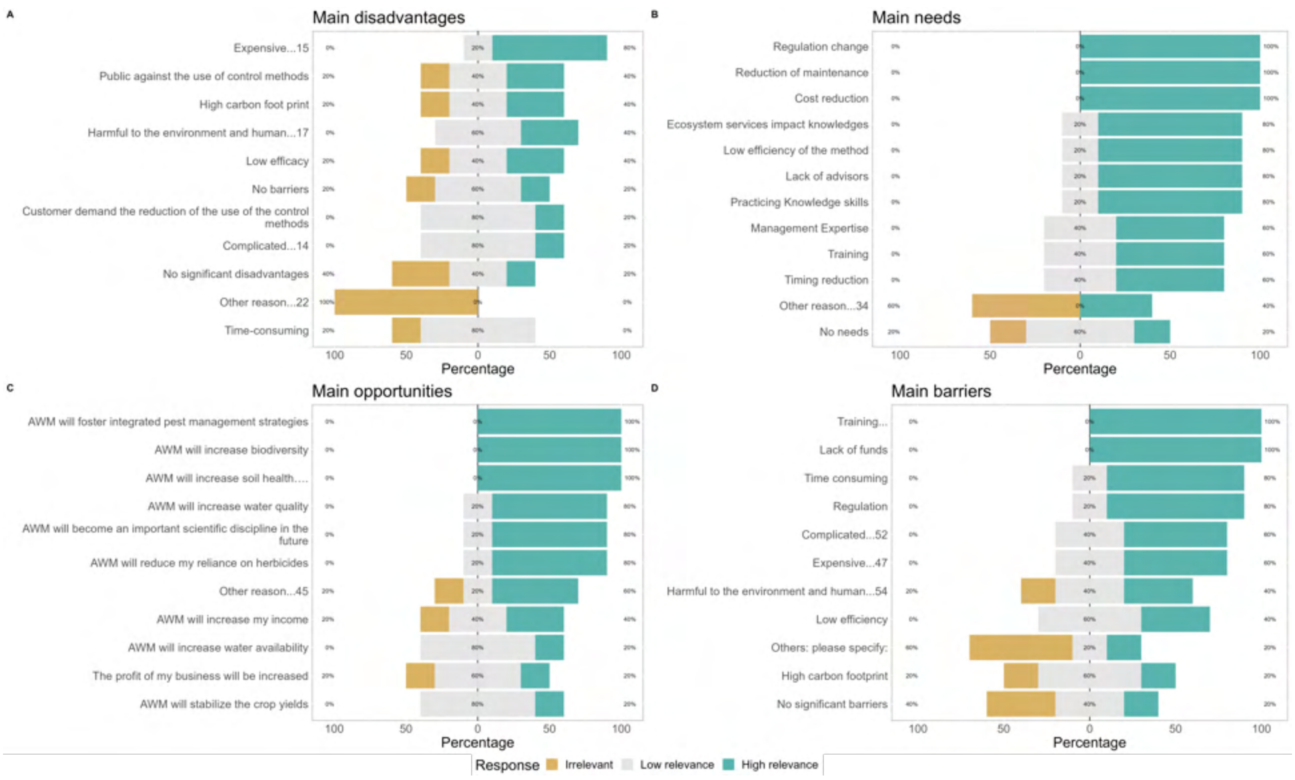


Figure 300. Main disadvantages, needs, barriers and opportunities for herbicides identified by farmers.

3.4.1.1.4.4 Industry

Industry stakeholders align with farmers on herbicide opportunities, recognizing them as providers of ecosystem services and contributors to IPM. Notably, industry representatives share common ground with consumers and advisors on the primary needs of this practice, especially emphasizing the importance of understanding the impact on ecosystem services. Consensus prevails among industry representatives regarding herbicide barriers, with 67% expressing concerns about potential harm to the environment and humans, difficulties in usage, time consumption, insufficient training, funding limitations, and perceived expense. Industry representatives stand out as the stakeholder group that perceives fewer barriers to herbicide use. Finally, the main drawbacks, according to industry views, are the potential harm to the environment and humans. It is noteworthy that while more than half of this group views herbicides as providers of ecosystem services, all of them unanimously agree on their potential harm. Additionally, 67% of this group believes the public opposes herbicide use, whereas, according to the respondents, only 33% of customers demand a reduction in its use as a control method.

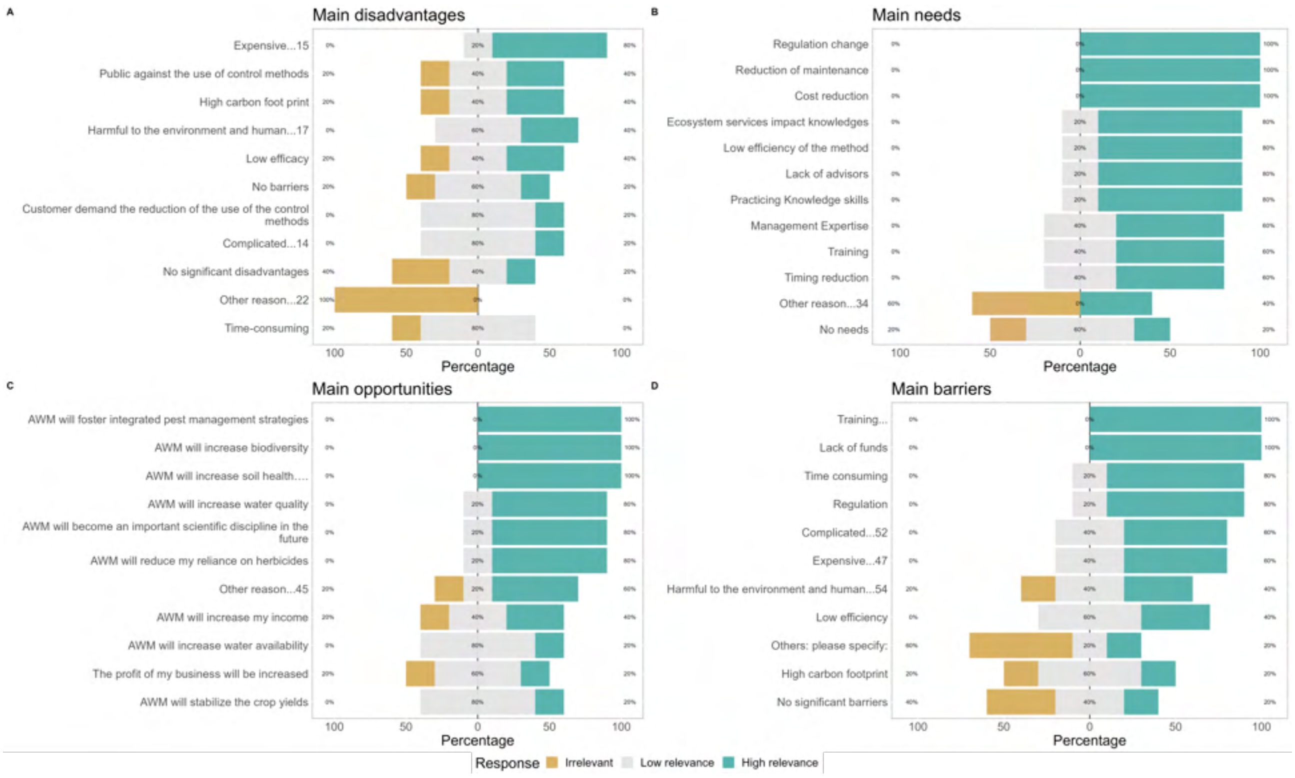


Figure 301. Main disadvantages, needs, barriers and opportunities for herbicides identified by industry

3.4.1.1.4.5 Researchers

Three-fourths of researchers assert that herbicides improve soil health and will emerge as a significant scientific discipline in the future. Half of the respondents perceive herbicides as contributors to ecosystem services and enablers of IPM. Researchers underscore economic factors, with half of them stating that herbicides enhance profitability and farmers' income, this viewpoint is shared by farmers and industry representatives. All researchers unanimously agree that the use of herbicides necessitates regulatory changes, and 75% align with other stakeholders (including advisors, consumers, and industry) in emphasizing the need for increased knowledge about the impact on ecosystem services. Most researchers stress the importance of management expertise and training. All stakeholder groups acknowledge numerous necessities associated with herbicide use. As primary barriers, researchers unanimously agree that herbicides may pose harm to the environment and humans, and three-thirds of respondents highlight their high carbon footprint. These two categories are also deemed highly relevant by other stakeholders. Researchers, in agreement with advisors and consumers, unanimously identify the public's demand for reduction or opposition to herbicides as the main disadvantages. Researchers recognize the potential harm to the environment and humans due to the implementation of this practice, citing high carbon footprint and cost as additional primary disadvantages in herbicide use.

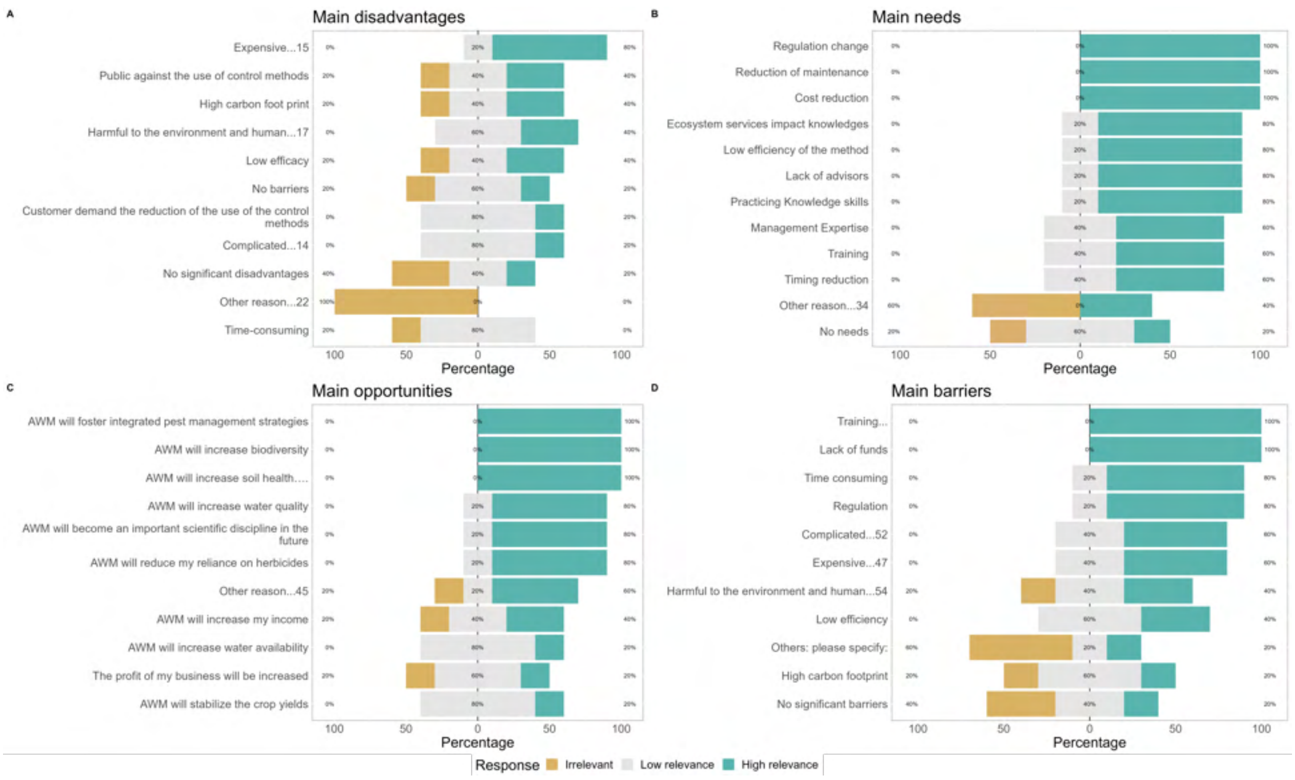


Figure 302. Main disadvantages, needs, barriers and opportunities for herbicides identified by researchers.

3.4.1.1.4.6 Conclusion

The divergent viewpoints among stakeholders regarding herbicide-related considerations delineate a nuanced panorama. Advisors underscore opportunities such as facilitating IPM and augmenting water availability, with consumers placing primacy on economic considerations. Farmers exhibit a spectrum of opinions concerning the role of herbicides in IPM and ecosystem services. Industry stakeholders align closely with farmers, acknowledging herbicides as contributors to ecosystem services. Researchers uniformly underscore the pivotal role of herbicides in enhancing soil health and propelling scientific disciplines. A confluence of perspectives emerges between advisors, consumers, industry and researchers concerning the practice needs, notably the imperative of comprehending the impact on ecosystem services and navigating regulatory changes. Most farmers echo these sentiments, underscoring the importance of knowledge skills and streamlined maintenance. While advisors unanimously identify regulatory hurdles as the primary barrier, consumers spotlight additional concerns, encompassing potential harm to environment and human and a high carbon footprint. Farmers and industry representatives express a spectrum of concerns, ranging from potential harm and operational complexities to knowledge gaps, financial constraints, and perceived costs. Researchers unanimously emphasize potential harm, a high carbon footprint, and regulatory intricacies. Stakeholders coincide identifying customers and the public as principal deterrents to herbicide use. Furthermore, researchers, advisors, and consumers uniformly point to the public's demand for reduction or opposition as the principal disadvantages. Industry representatives, alongside farmers and consumers, recognize potential harm as the primary drawback. Researchers emphasize potential harm, a high carbon footprint, and cost as the primary disadvantages, thereby offering an intricate and comprehensive portrayal across diverse stakeholder groups.

3.4.1.1.5 Mechanical weeding

3.4.1.1.5.1 Consumers

Consumers held a moderate perspective toward mechanical weeding, recognizing it as offering few relevant opportunities, barriers, and disadvantages while identifying important necessities. Two-thirds of respondents believed that mechanical weeding would reduce reliance on herbicides, with one-third perceiving it as fostering IPM practices and providing ecosystem services. The primary need identified by nearly 70% of consumers was the lack of advisors. Additionally, half of them cited the need for knowledge about ecosystem services impact, practicing knowledge and skills, management expertise, training, and cost reduction as relevant necessities. Half of the consumers considered the high carbon footprint and the potential for environmental and human harm as the main barriers to mechanical weeding. Furthermore, one-third of consumers cited time consumption and the need for training as relevant impediments. Nearly 70% of respondents considered the high carbon footprint as the most significant disadvantage of mechanical weeding. Moreover, over 30% identified low efficacy, expense, and time consumption as highly important drawbacks.

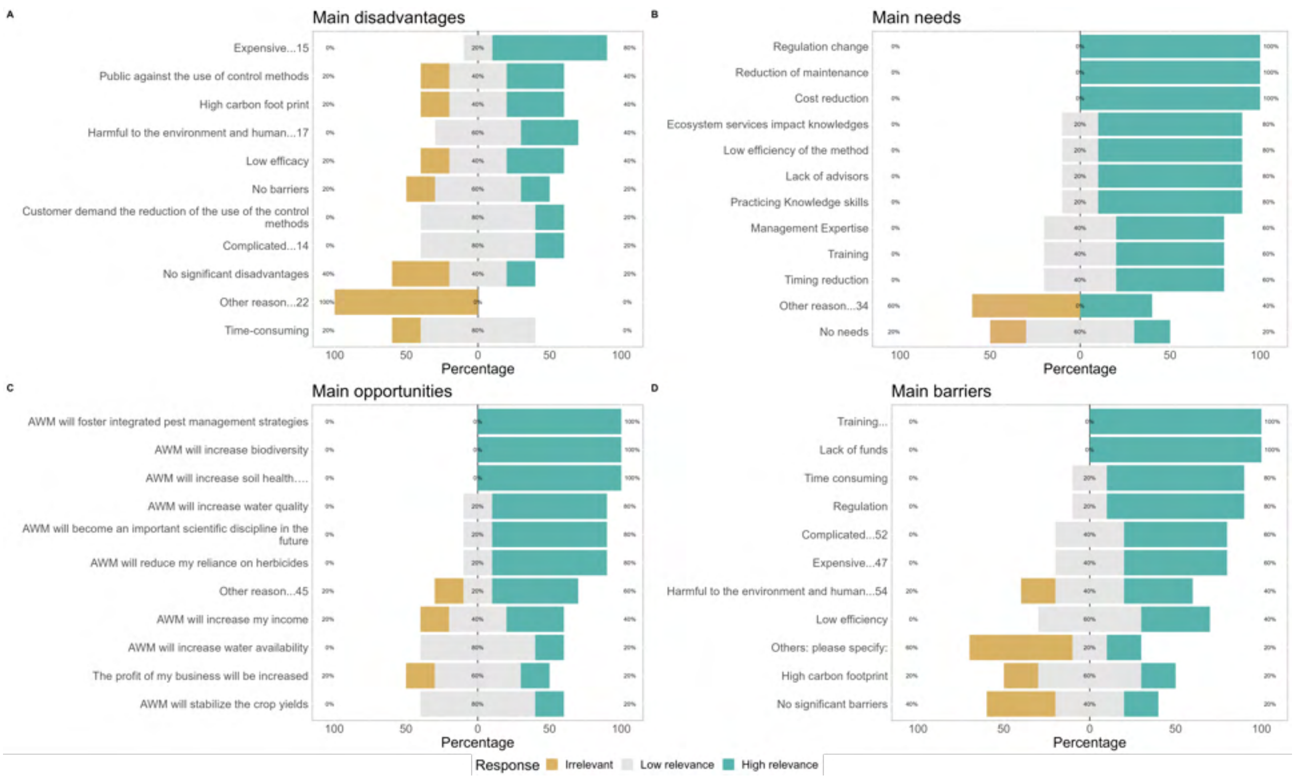


Figure 303. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by consumers.

3.4.1.1.5.2 Farmers

Farmers held a more optimistic view toward mechanical weeding, considering it to present relevant opportunities while recognizing significant needs and barriers and virtually no disadvantages. They unanimously perceived mechanical weeding as a practice that reduces reliance on herbicides. Moreover, sixty percent of them believed that this practice improves water quality, enhances soil health, and stabilizes crop yields. Additionally, 40% of respondents viewed mechanical weeding as fostering IPM, providing other ecosystem services, and increasing business profitability and farmers' income. Timing reduction was considered the primary need of mechanical weeding by 80% of farmers, with 60% of them regarding cost and maintenance reduction as highly relevant necessities. Additionally, forty percent of farmers considered practicing knowledge skills and training as relevant requirements. Sixty percent of respondents cited high carbon footprint, time consumption, and expense as the main barriers to mechanical weeding. Environmental and human harm, complexity, and lack of funds were regarded as relevant barriers by 40% of surveyed farmers. None of the queried disadvantages was considered relevant by the majority of respondents; however, 40% of them cited expense, complexity, and time consumption as relevant drawbacks.

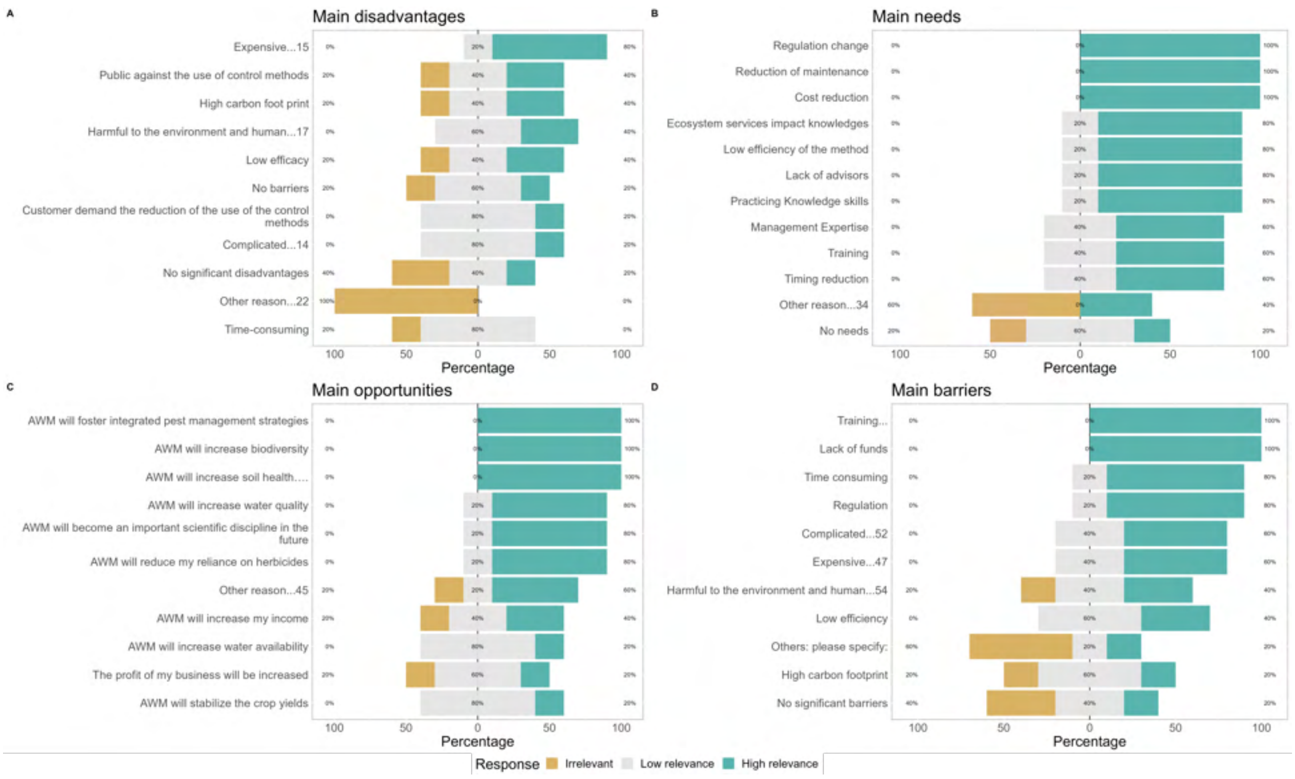


Figure 304. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by farmers.

3.4.1.1.5.3 Industry

Industry representatives considered mechanical weeding as a technique that presents relevant opportunities, few barriers, as well as disadvantages, and virtually no necessities. They unanimously perceived this practice as an ecosystem services provider, including increased water quality, biodiversity, and soil health, emphasizing that its use would result in a reduction in herbicide reliance. Additionally, nearly 70% of the respondents viewed mechanical weeding as fostering IPM strategies and recognized that its use would result in increased water availability. Regarding the primary need, none of the queried factors was regarded as relevant by a majority of respondents; just one-third of the industry representatives cited practicing knowledge skills as relevant. Expense was considered the principal barrier by all respondents, and two-thirds regarded time consumption as a relevant impediment. In accordance with expressed barriers, industry representatives unanimously identified expense and time consumption as relevant disadvantages. Moreover, lack of funds was considered as a relevant disadvantage by half of the industry representatives. The rest of the queried factors were considered as low or irrelevant by most of the surveyed industry representatives.

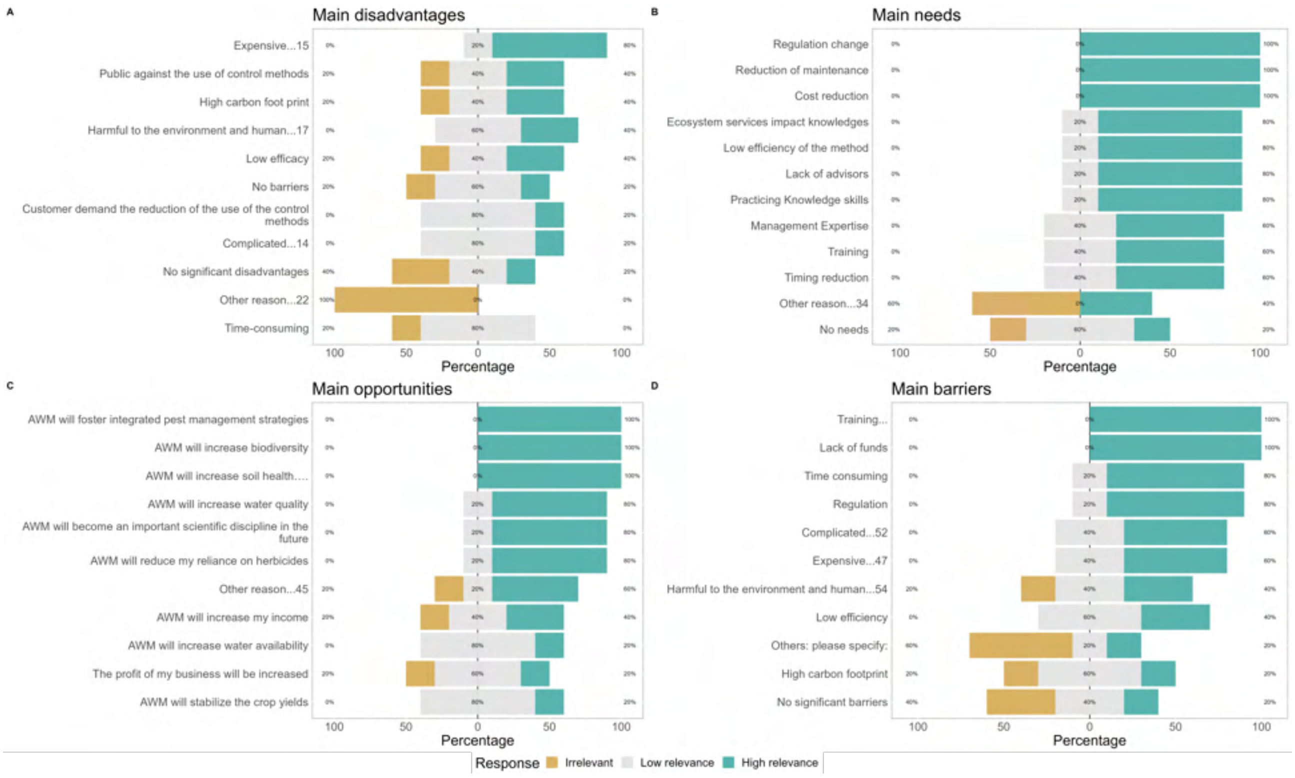


Figure 305. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by industry.

3.4.1.1.5.4 Researchers

Researchers, like the majority of stakeholders, held an optimistic view of mechanical weeding; they considered this practice to present relevant opportunities, important needs, and barriers, and few disadvantages. They unanimously regarded mechanical weeding as a method that will evolve into an important scientific discipline. Additionally, two-thirds of them believed that this practice would foster IPM strategies and serve as a provider of ecosystem services, including increased water quality, improved biodiversity, enhanced soil health, and reduced herbicide reliance. As for the main needs, nearly seventy percent of the researchers considered knowledge of ecosystem services impact, proficiency in practical skills, and cost and maintenance reduction to be important. One-third of them perceived regulatory challenges, low efficiency of methods, lack of advisors, and training as additional needs. High carbon footprint and expense were considered relevant barriers by nearly seventy percent of the respondents. Moreover, over thirty percent of the researchers regarded environmental and human harm, low efficiency, training, lack of funds, and regulatory challenges as significant barriers. Researchers identified time consumption as the most relevant drawback, with two-thirds of respondents expressing this concern. Additionally, one-third of the respondents considered high carbon footprint, environmental and human harm, and expense to be important drawbacks.

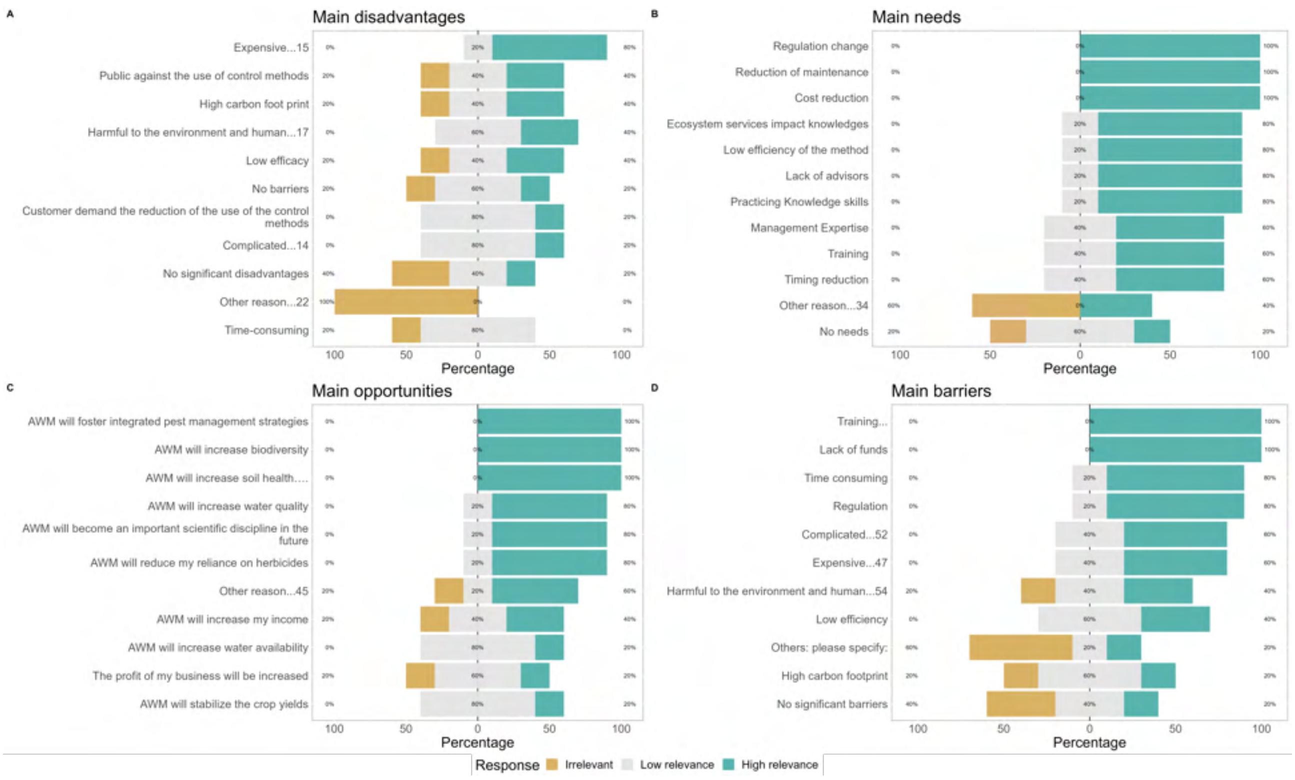


Figure 306. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by researchers.

3.4.1.1.5.5 Conclusion

Farmers and researchers, along with industry representatives to a lesser extent, shared a positive perception of mechanical weeding, emphasizing various opportunities and differing views on the needs, barriers, and disadvantages associated with the practice. In contrast, consumers held a more cautious view, recognizing few opportunities related to the practice. All stakeholders perceived mechanical weeding as a method that would reduce reliance on herbicides, foster IPM strategies, and provide ecosystem services, including improvements in water quality, soil health, and biodiversity increases. Researchers particularly highlighted the potential for mechanical weeding to become an important scientific discipline. There was no consensus among stakeholders regarding the primary need associated with the practice. Consumers cited a lack of advisors, farmers emphasized the importance of timing reduction, and industry representatives mentioned the need for proficiency in practical skills. Researchers highlighted the importance of understanding the impact on ecosystem services, proficiency in practical skills, and cost and maintenance reduction. Consumers, farmers, and researchers identified the method's high carbon footprint as a relevant barrier. Researchers and industry representatives emphasized the importance of expense as a significant barrier to implementing mechanical weeding. Other central barriers included environmental and human harm, time consumption, complexity, method efficiency, and lack of training, among others. Expense and time consumption were considered relevant disadvantages across all stakeholders. Additionally, consumers and researchers highlighted the method's high carbon footprint, while farmers cited complexity, and industry representatives mentioned a lack of funds as highly significant drawbacks.

3.4.1.1.6 Mowing

3.4.1.1.6.1 Consumers

Consumers expressed an optimistic view toward mowing, highlighting numerous opportunities, needs, and some relevant barriers and disadvantages associated with the practice. They unanimously believed that using mowing would lead to a reduction in reliance on herbicides. Moreover, two-thirds of respondents considered mowing as an ecosystem services provider, anticipating increases in water availability and quality, improved biodiversity, and soil health. Additionally, they saw mowing as having the potential to evolve into an important scientific discipline and increase business profitability, farmers' income, and stabilize crop yields. Consumers unanimously identified knowledge of ecosystem services impact as the primary requirement for implementing mowing. Two-thirds of consumers viewed regulatory changes, the method's low efficiency, proficiency in practical skills, management expertise, training, and reduction of maintenance as relevant needs for using mowing. Regarding the most relevant barriers to mowing practice, two-thirds of respondents cited its low efficiency, concerns about training, lack of funds, and regulatory challenges. Consistent with these barriers, consumers unanimously identified the method's low efficacy as the primary disadvantage. Moreover, nearly 70% of them expressed concerns about mowing's high carbon footprint, while expense was also considered a relevant drawback by the majority of respondents.

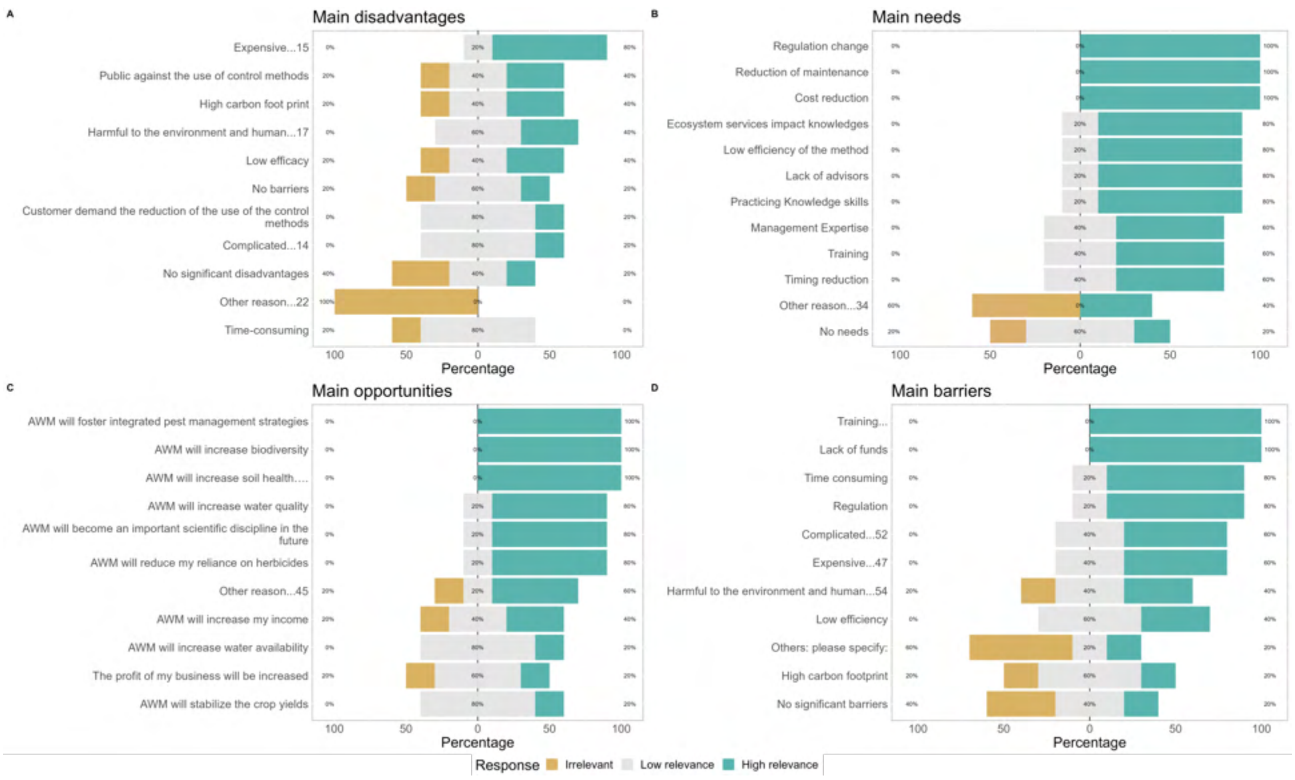


Figure 307. Main disadvantages, needs, barriers and opportunities for mowing identified by consumers.

3.4.1.1.6.2 Farmers

Farmers, much like consumers, view mowing positively, recognizing numerous opportunities associated with the practice. However, they also acknowledge significant barriers, disadvantages, and some needs. They unanimously agree that mowing leads to reduced reliance on herbicides and improves water quality. Additionally, three-quarters of surveyed farmers highlight mowing as fostering IPM strategies and providing other ecosystem services, such as increasing water availability, biodiversity, and soil health. Furthermore, they acknowledge that implementing mowing stabilizes crop yields. Half of the farmers consider training, maintenance reduction, cost, and timing as relevant necessities. Regarding the main barriers to mowing, three-quarters of respondents emphasize the importance of time consumption, while 50% of farmers cite high carbon footprint, environmental and human harm, and expense as significant impediments. Consistent with these barriers, farmers consider time consumption as an important drawback. Moreover, fifty percent of them regard expense as a significant disadvantage.

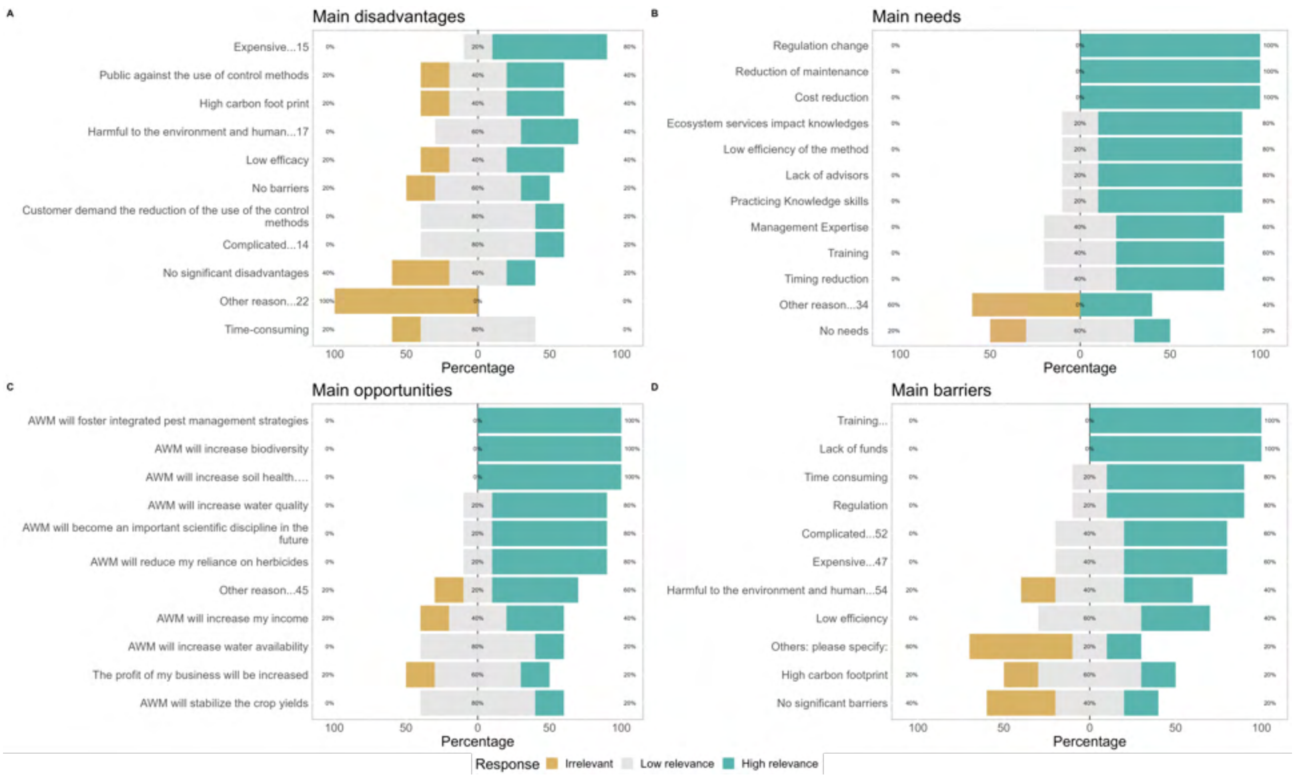


Figure 308. Main disadvantages, needs, barriers and opportunities for mowing identified by farmers.

3.4.1.1.6.3 Researchers

Similar to the consumers and farmers, researchers share a positive perception of mowing, emphasizing its significant opportunities while recognizing some needs and disadvantages and virtually no barriers. Researchers unanimously consider mowing as fostering IPM strategies, providing ecosystem services such as improvements in water quality, biodiversity, and soil health, and acknowledge its role in reducing herbicide reliance. Additionally, nearly seventy percent of respondents cite increased water availability, the potential for mowing to become an important scientific discipline, and its ability to stabilize crop yields as highly relevant opportunities. Regarding primary needs, researchers highlight the reduction of maintenance and cost. The remaining queried needs were not considered relevant by a majority of respondents. One third of respondents consider the practice's high carbon footprint, low efficiency, and time consumption as highly relevant barriers. Consistent with expressed needs, two-thirds of respondents acknowledge expense and time consumption as relevant disadvantages. Finally, one third of surveyed researchers highlight the method's high carbon footprint, low efficacy, and complexity as important drawbacks.

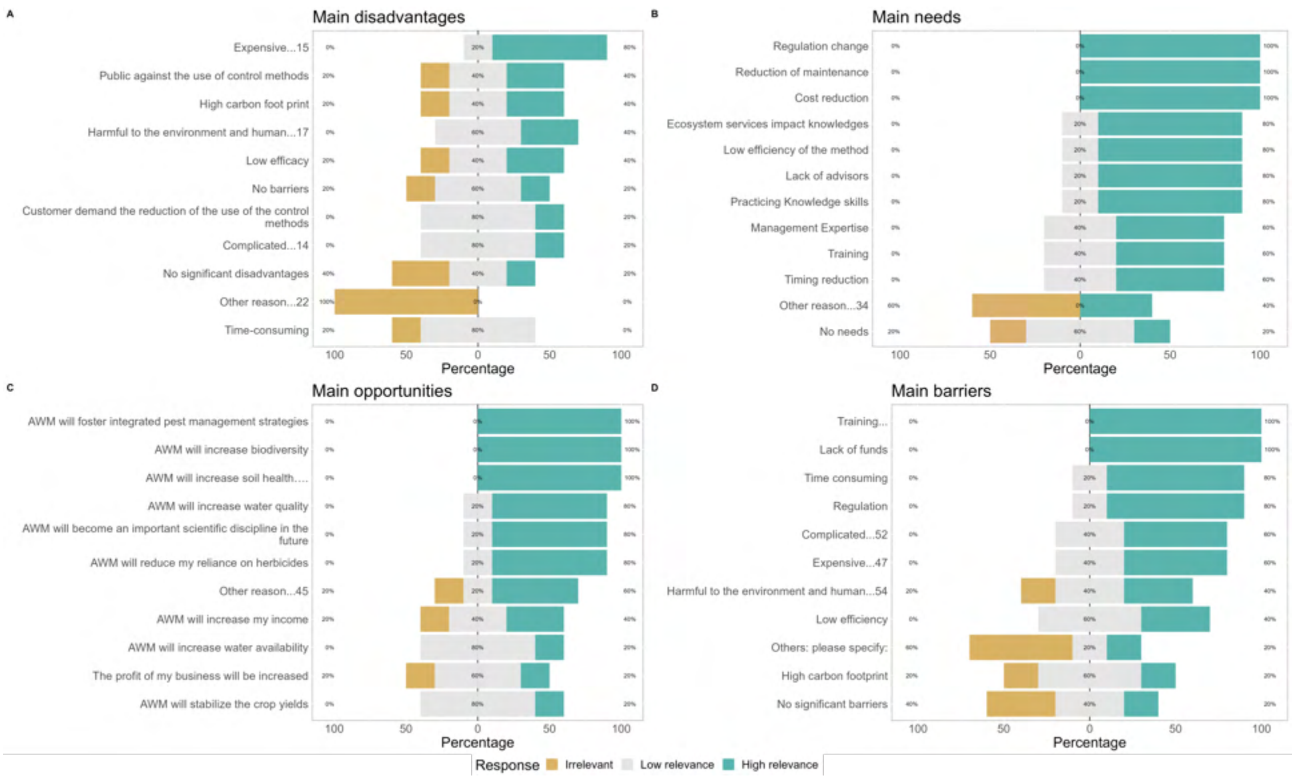


Figure 309. Main disadvantages, needs, barriers and opportunities for mowing identified by researchers.

3.4.1.1.6.4 Conclusion

Stakeholders considered mowing as an outstanding AWM practice, recognizing its significant opportunities. They emphasize its role in reducing herbicide reliance and consider it a provider of ecosystem services, fostering IPM strategies, among others. Notably, most of the highlighted opportunities were deemed highly relevant by a majority of respondents.

Stakeholders did not showed consensus with regard to the practice most relevant needs, consumers emphasize ecosystem services impact, farmers highlighted the importance of training and agree with researchers acknowledgement of maintenance and cost reduction. Consumers considered mowing as a low efficient method and shared concerns with regard to training, lack of funds, and regulatory challenges; while farmers considered time consumption, environmental and human harm, and expense as relevant, these concerns were shared by one third of researchers, who did not regarded any of the queried impediments as relevant by a majority of respondents.

In line with expressed barriers, consumers and farmers considered the method's low efficacy and time consumption, respectively, as the most significant drawbacks. Conversely, industry representatives acknowledged expense and time consumption as relevant disadvantages, consistent with perceived needs.

3.4.1.1.7 Mulching

3.4.1.1.7.1 Consumers

Consumers view mulching as a valuable AWM practice in grapevine culture, highlighting numerous opportunities while acknowledging important necessities and virtually no barriers or disadvantages. They unanimously recognize mulching as a means to reduce herbicide reliance. Moreover, three-quarters of consumers identify it as an ecosystem services provider, contributing to increased water quality and soil health improvements. Half of the surveyed consumers acknowledge that mulching fosters IPM strategies and results in increased water availability and biodiversity. Regarding the main needs associated with the method, consumers unanimously identify the lack of advisors, proficiency in practical skills, and management expertise as primary requirements. Additionally, over seventy percent of respondents consider training important, with half of them also citing knowledge of ecosystem services impact and the method's low efficiency as relevant needs. None of the queried barriers or disadvantages are considered highly relevant by a majority of respondents, with only 25% citing the method's low efficiency, complexity, time consumption, and training as important barriers.

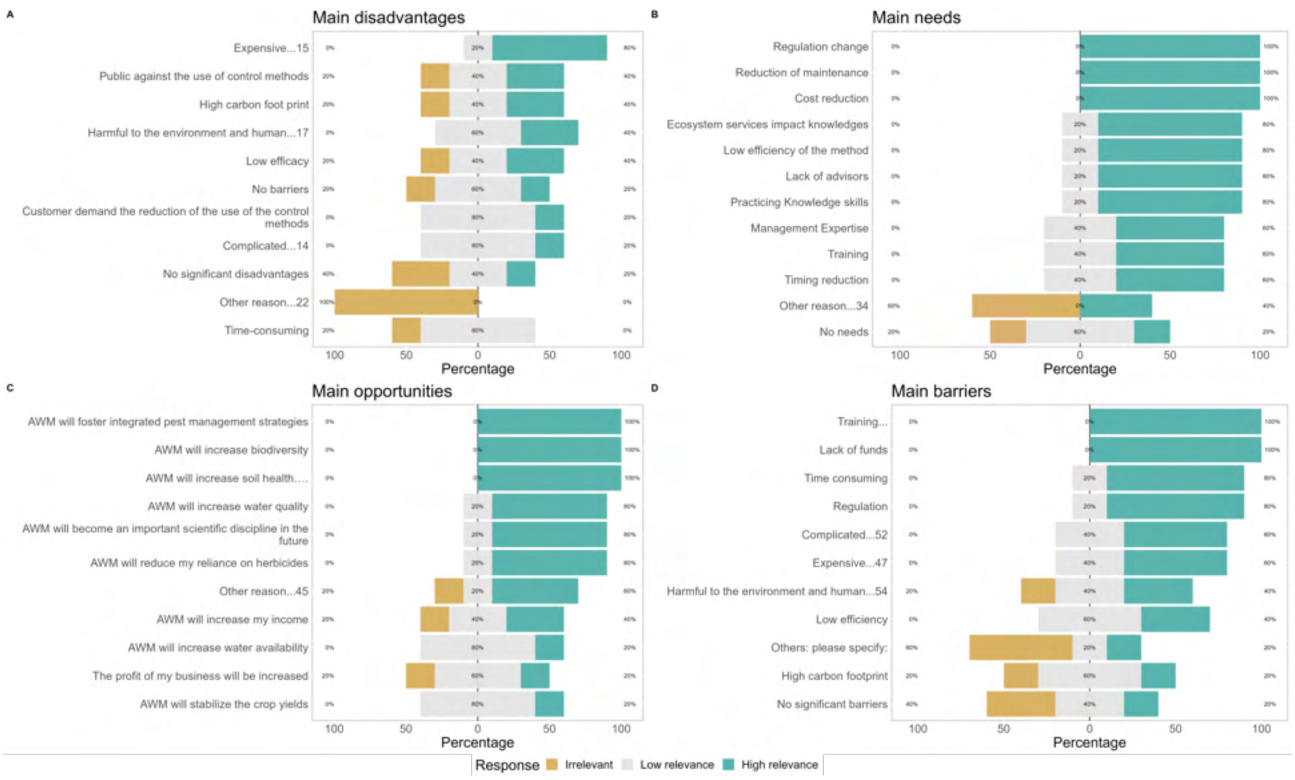


Figure 310. Main disadvantages, needs, barriers and opportunities for mulching identified by consumers.

3.4.1.1.7.2 Farmers

Farmers hold an optimistic view of mulching, recognizing numerous opportunities while acknowledging relevant needs, barriers, and a few but significant disadvantages associated with this practice. They unanimously regard mulching as an ecosystem services provider, contributing to increased water quality and enhancements in soil health. Moreover, nearly seventy percent of respondents believe it improves water availability and biodiversity, while also reducing herbicide reliance. Regarding primary needs, farmers prioritize proficiency in practical skills, management expertise, training, and reduction of maintenance. One third of respondents also highlight the importance of regulatory changes, the lack of advisors, and cost and timing reduction. Farmers unanimously consider time consumption as the primary impediment. Additionally, two-thirds of respondents recognize complexity, training, lack of funds, and expense as relevant barriers. Regarding the main disadvantages of the practice, nearly seventy percent of respondents cite expense and the method's complexity.

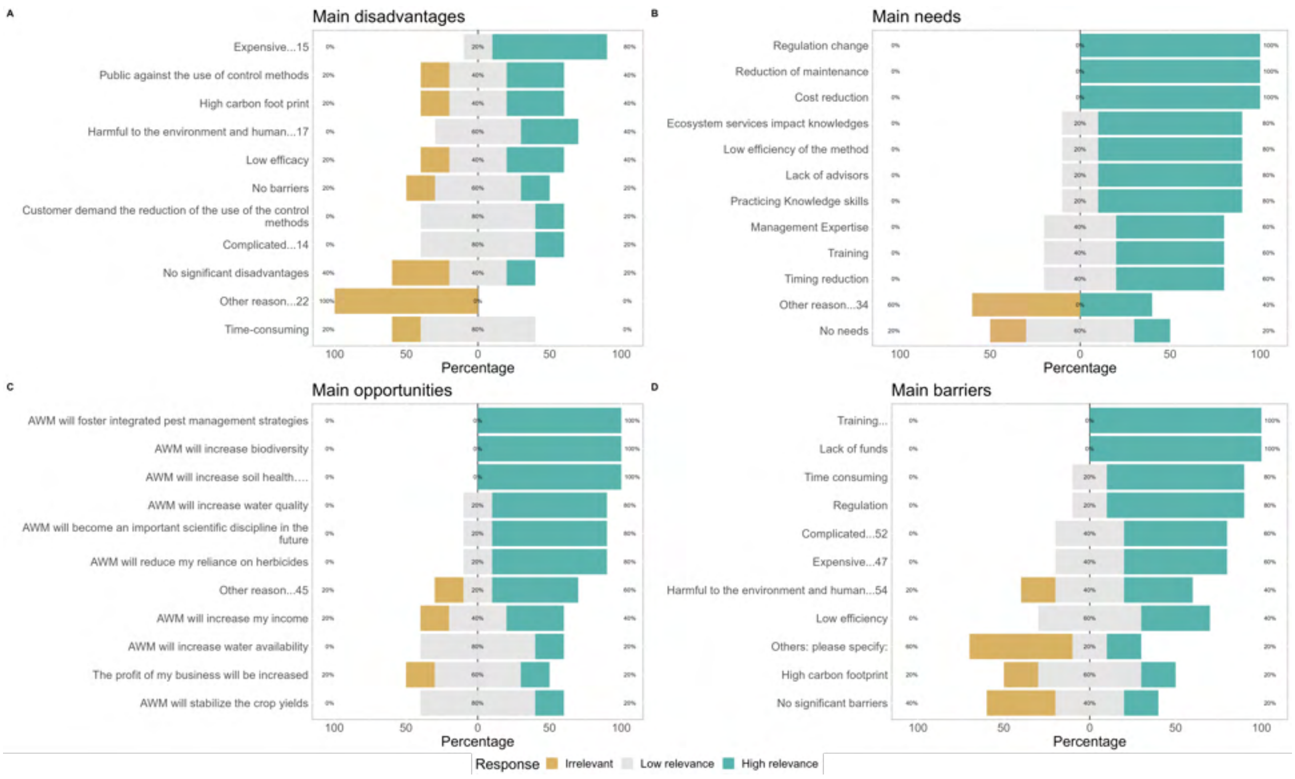


Figure 311. Main disadvantages, needs, barriers and opportunities for mulching identified by farmers.

3.4.1.1.7.3 Conclusion

Consumers and farmers alike hold a positive view of mulching, recognizing its relevant opportunities when implemented in grapevine systems as an AWM practice, while also acknowledging important needs. Farmers emphasize the significant needs associated with this method, while consumers did not identify any notable impediments, and both groups consider that this method has virtually no disadvantages. Both stakeholders considered the same factors as relevant opportunities in mulching implementation, but they differ in their relative importance. Consumers emphasize mulching as a means to reduce herbicide reliance, while farmers prioritize the technique as an ecosystem services provider. However, both groups recognize that its use results in increased water quality and soil health. Farmers and consumers agree when assigning primary needs to the method, as both groups consider practicing knowledge skills and management expertise to be of high relevance. Additionally, both groups share concerns regarding training, lack of advisors, and regulatory changes, among other factors. Farmers unanimously consider time consumption as the primary barrier, emphasizing method complexity, lack of funds and training, as well as expense, as relevant barriers. In contrast, consumers did not mainly regard any of these factors as relevant, with only 25% of them, in agreement with farmers, considering low efficiency, complexity, time consumption, and lack of training as relevant. Regarding the main disadvantages of the method, farmers emphasize expense and complexity, while none of the queried drawbacks were considered relevant by consumers.

3.4.1.2 Surveys

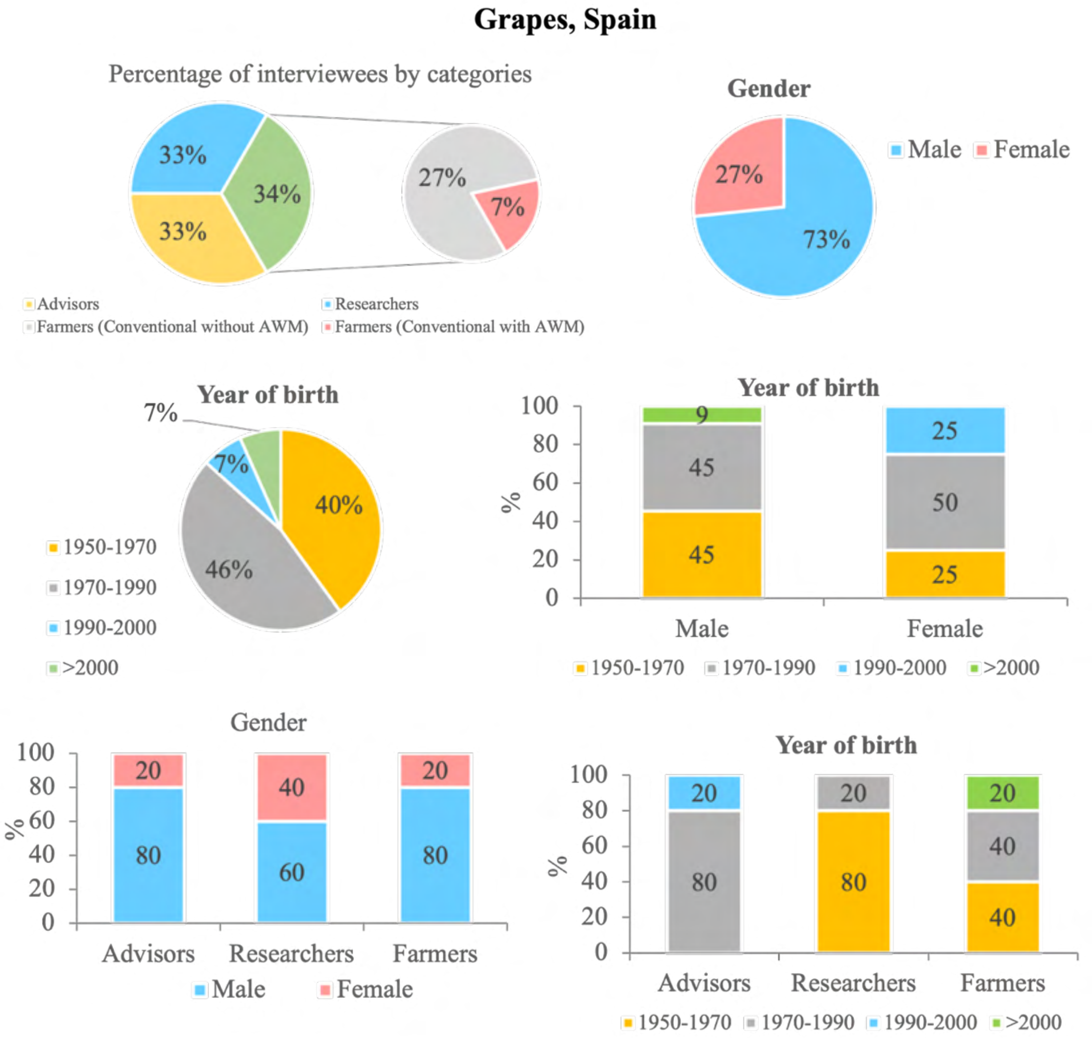


Figure 312. Interviewees description in the Grapes Living Lab (Spain)

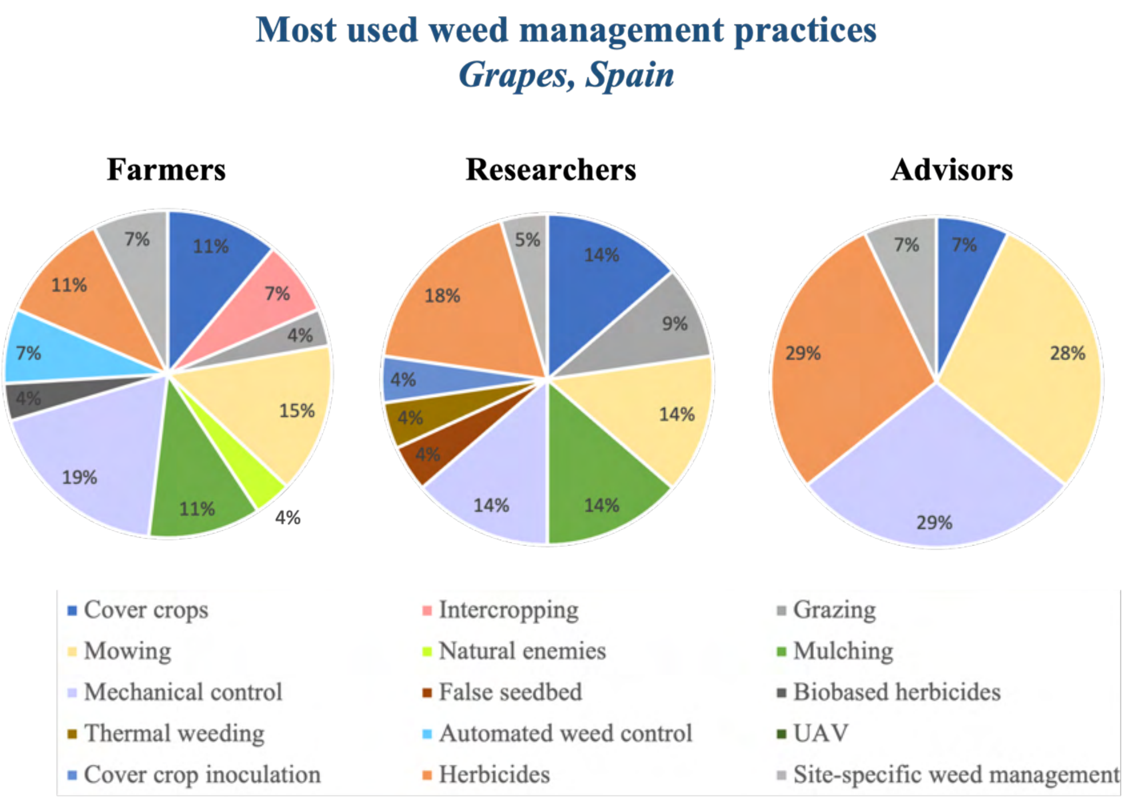


Figure 313. Most used weed management practices in the Grapes Living Lab (Spain)

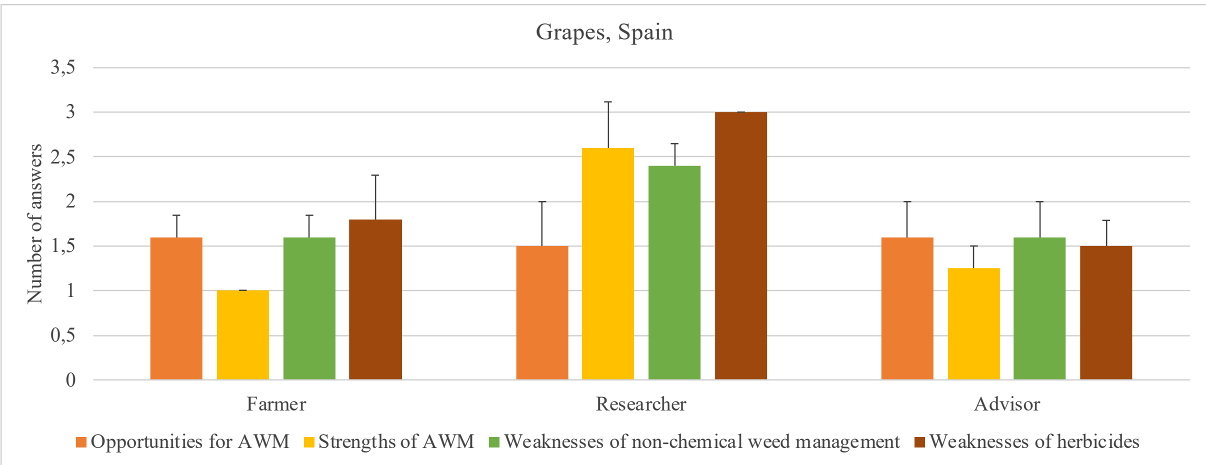


Figure 314. Mean number of answers (±se) per stakeholder group in the Grapes Living Lab (Spain)

Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the Figure below.

STRENGTHS: Presented in the Figure below.

THREATS: None.

WEAKNESSES: None.

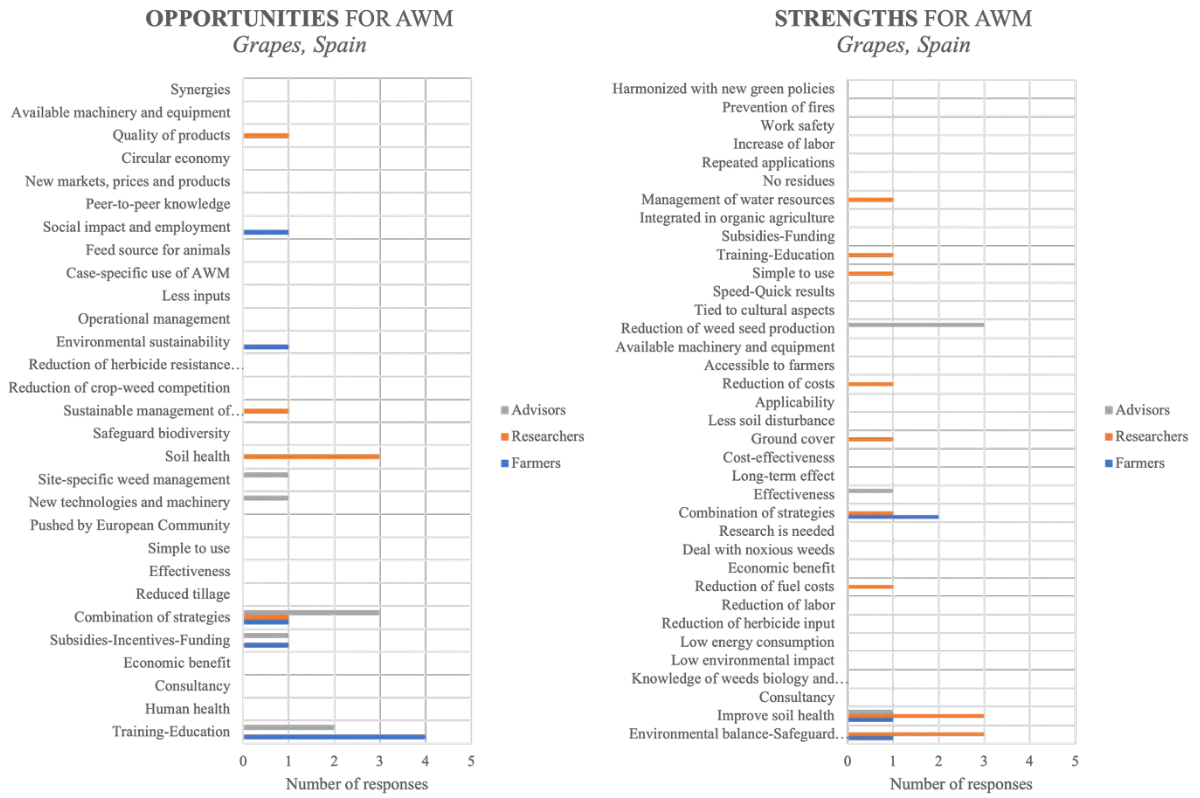


Figure 315. Opportunities and strengths of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: Only one researcher mentioned the weather conditions and the climate change, as well as lack of recognition from markets.

WEAKNESSES: Presented in the Figure below.

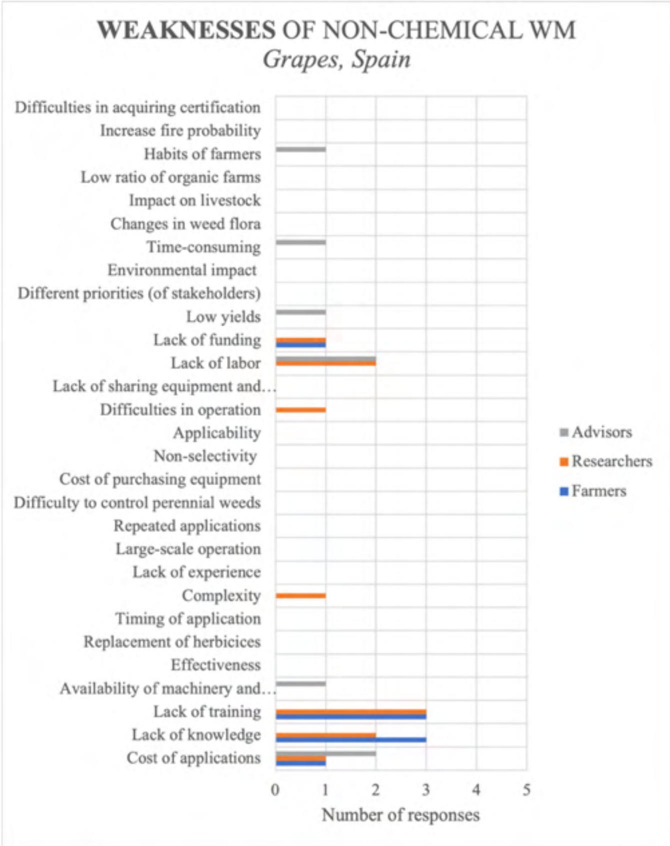


Figure 316. Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: There were only a few opportunities for herbicides identified. They were related to efficacy, available equipment, and their low cost.

STRENGTHS: Several strengths were reported by the interviewees. Farmers referred to efficacy and low cost. Researchers mentioned the efficacy of herbicides, saying that they are cheap, easy to use, not labor intensive and present cost-effectiveness. Advisors mentioned the economic benefit, the efficacy and the facts that herbicides are cheap and easy to use.

THREATS: Only two threats were identified, the markets and the withdrawal of herbicides.

WEAKNESSES: Presented in the Figure below.

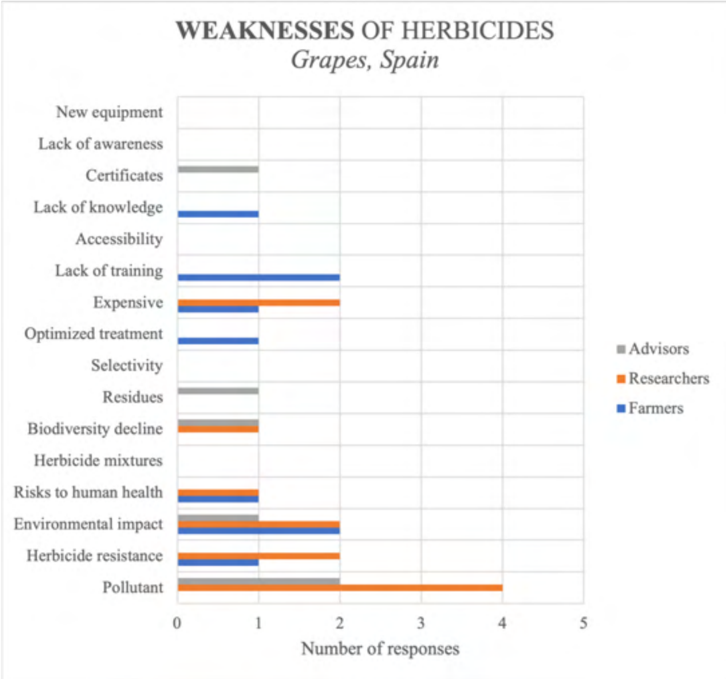


Figure 317. Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – GRAPES, SPAIN
Most used weed management practices: The results of the interviews in Spain and in the grapes showed that farmers have access to and use different practices for weed management. Importantly, the use of other practices such as cover crops and mulching was mentioned. Although the researchers believe and suggest the same diversified set of weed management practices, the same is not believed by the advisors who consider that weed management is mainly done with herbicides, mechanical means and mowing. **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group:** The researchers gave more answers about the strengths of agroecological weed management in relation to farmers and advisors. The identified weaknesses of non-chemical and chemical weed management were also significantly more in the researcher category. It appears from the number and style of responses that farmers and advisors had roughly the same views on agroecological, non-chemical and chemical weed management. **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: Although there were few responses about the opportunities surrounding

agroecological weed management, the most important one in this Living Lab was also about education and training. Researchers perceived that soil health is combined with these practices, and some across all stakeholder categories mentioned the opportunity of combining strategies. Improving soil health, protecting biodiversity and reducing the seed-producing potential of weeds were identified as strengths of agroecological weed management.

Threats, and weaknesses for non-chemical weed management: Non-chemical weeding in grape cultivation in Spain carries few but significant weaknesses according to stakeholders interviewed in the Living Lab. In particular, the lack of training and knowledge, the lack of labour and funding, and the cost of applications were mentioned.

Opportunities, strengths, weaknesses, and threats for herbicides: Several strengths were reported by the interviewees. Farmers referred to efficacy and low cost. Researchers mentioned the efficacy of herbicides, saying that they are cheap, easy to use, not labor intensive and present cost-effectiveness. Advisors mentioned the economic benefit, the efficacy and the facts that herbicides are cheap and easy to use. However, herbicides were identified as pollutants bearing an environmental impact. The lack of training in their use, the herbicide resistance and the fact that they are expensive are also considered weaknesses.

3.4.1.3 Living lab board meeting

The first LL board meeting was an online meeting held on 30th November 2023 at 16:00 hours (CEST). In total 11 people participated in the meeting (1 GOOD partner, 2 farmers, 2 advisors, 2 researchers, 2 consumers, 1 policy maker and 1 industry) and two other companies that are part of the LL could not attend but they are interested. Consent forms to participate in the LL board were collected from all attendees. The agenda of the LL board meeting was: i) Presentation of the GOOD project (10 min), ii) Presentation of the Galician Living Lab (LL) (10 min), iii) Discussion (60 min) and iv) Conclusions (10 minutes). During the discussion, the participants in the meeting talked about the next activities of the Galician LL and agroecological weed management. In the case of wine production, there is interest in agroecological approaches mainly when weed management is considered but, in our region, there are not many projects like the GOOD project which implies a lack of knowledge on agroecological weed management. Moreover, agroecological weed practices are generally expensive compared to herbicides. In any case, in Galicia, the most common weed management practice is the combination of herbicides (chemical weed control) in the lines with cover crops in the corridors and the participants in the LL board meeting think that it is very interesting to evaluate new cover crops. In this context, some participants in the meeting said that maybe other cover crops not included in the Galician LL could be studied such as a combination of grass species. Moreover, winegrowers also think that the technology is limited in our region to apply agroecological weed practices. Finally, it is important to take into account that to strengthen agroecological practices, workshops and demonstrations could be organized to show farmers the results of these practices and convince them to adopt such practices in Galicia. During the LL board meeting, this information was also collected:

<table>
<tr><td rowspan="10">What are the market characteristics of vine?</td><td>1. How many farmers cultivate vine in the region (approx.)?</td></tr>
<tr><td>The number of farmers is not known but in Galicia the area occupied by vineyard was 25041 hectares in 2022.</td></tr>
<tr><td>2. How many products are derived from the vine?</td></tr>
<tr><td>The products derived from the vine are mainly grapes, wine and schnapps. Moreover, the subproducts can also be used as compost and vine leaves to extract antocian, which is used in the pharmaceutical industry due to its antioxidant capacity.</td></tr>
<tr><td>3. Do you think that agroecological products could be promoted in local markets?</td></tr>
<tr><td>Yes, agroecology has to always be connected to local markets.</td></tr>
<tr><td>4. Do you believe that the region has a lack of technologies?</td></tr>
<tr><td>The winegrowers think that technology is ready for weed control through chemicals, but in the case of agroecological practices, the technology is limited. Moreover, it is necessary to adapt the machine available to the characteristics of the different areas</td></tr>
<tr><td>5. Is the regional agri-food value chain sustainable?</td></tr>
<tr><td>Some winegrowers think that the value chain is sustainable but other winegrowers think that the value chain is not sustainable because the vine production is not based on the agroecological principles.</td></tr>
<tr><td rowspan="2">What are the most common agricultural and</td><td>1. What are the most common agronomic practices in vine?</td></tr>
<tr><td>The most common agronomic practices are pruning, tillage (for mechanical weed control and soil aeration and moisture) and harvest.</td></tr>
</table>

weed management practices in vine?	
	2. What are the most common weed management practices in vine?
	The most common weed management practice is the combination of herbicides (chemical weed control) in the lines with cover crops in the corridors.
What is the herbicide use in vine?	1. How many active ingredients there are available? How many different mode of actions?
	There are 7 active ingredients available and only 4 modes of action.
	2. How many times do you spray in-season?
	They spray 1 time within a season.
	3. Do you use pre-emergence, post-emergence or both herbicides?
	The majority uses both kinds of herbicides, while a few farmers use only post-emergence herbicides.
	4. Are herbicides efficient?
	Herbicides are efficient, mainly in the big plots.
	5. Do you think that alternatives to herbicides are equally efficient?
	In some dry areas alternatives to herbicides can be used such as soil tillage in the lines. However, it is important to take into account that in general agroecological practices are expensive compared to herbicides and there is a lack of knowledge of the use of agroecological practices.
	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?
	Herbicides pollute soil and water, reduce biodiversity and are harmful to humans and animals.
	7. Do you believe that agriculture without herbicides is viable?
	Yes. In vine, agriculture without herbicides could be viable.
	1. What is needed to boost the uptake of agroecological practices?

What are the needs and barriers to assist agroecological transitions & adopt agroecological weed management approaches?	To strengthen agroecological practices, workshops and demonstrations could be organized to show farmers the results of these practices and convince them to adopt such practices. Moreover, a change in the legislation is needed and the farmers using agroecological practices should be rewarded for it.
	2. What are the barriers towards agroecology implementation?
	Agroecology increases costs considerably.
	3. Should policies need be redefined to allow agroecological transitions?
	Yes, eco schemes that integrate agro-ecological management of crops have to be developed.
	4. How confident you feel about the adoption of agroecological weed management practices?
	The majority sees such practices in a positive way. Many farmers and vineyard owners are turning (or want to turn) to alternative methods of weed control.
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	1. What are the main drivers of weed dispersal?
	The main cause of weed spread is related to crop management. For example, sometimes weed dispersion is carried out by applying organic fertilisers that have seed weeds.
	2. Which are the major and most noxious weeds in your area?
	The major and most noxious weeds are *Conyza canadensis, Cynodon dactylon, Solanum nigrum, Rumex obtusifolius.*
	3. Are there any herbicide resistant weeds?
	Yes, there are herbicide-resistant weeds.
	4. Do you know any invasive plants in your area?
	There are invasive plants in the area such as *Arctotheca calendula* or *Phytolacca americana.*
	1. Which proposals do you have for a good performance of the LL?

What do you think about the Living Lab?	In general, participants in the LL board meeting have a good opinion about the LL activities. For the next year, some participants propose to increase the experimental surface and and carry out the sowing of the cover crops earlier than this year.
	2. Would you like it to remain over time?
	All participants in the first LL board meeting are interested in being part of the LL board because the GOOD project is an opportunity for the sector.

3.4.2 Italy

3.4.2.1 Questionnaires

Grape's questionaries in Italy provided insights of 4 AWM practices regarding the perception of their main disadvantages, needs, barriers, and opportunities. These practices include grazing, mechanical weeding, mowing, and mulching. Most AWM practices were evaluated by multiple stakeholder groups. However, mowing was the only category considered by advisors, farmers, industry representatives, and policy makers. Table 36 presents the types of stakeholders who answered the questionnaires associated with different AWM practices and the number of respondents in each category.

Table 36. Number of responses for each AWM practice and stakeholder category in Grapes (Italy).

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control						
Biobased herbicides			1			1
Cover crop inoculation to increase competitiveness						
Cover crops		2		1		
False seedbed				1		
Grazing		**3**	2	1	2	2
Herbicides		1	2	1	1	2
Intercropping						
Mechanical weeding	2	2	1	**3**	1	2
Mowing	**3**	2	**3**	**3**	**4**	2
Mulching		**3**	2			1
Natural enemies						
Other						
Site-specific spraying				1	1	
Thermal weeding		1				
UAV						
n=28	4	9	3	4	4	4

3.4.2.1.1 Grazing

3.4.2.1.1.1 Consumers

Consumers hold a positive view of grazing, recognizing its numerous opportunities while acknowledging the important needs, barriers, and disadvantages associated with it. They unanimously believe that grazing will promote IPM strategies and serve as an ecosystem services provider, enhancing water quality, availability, soil health, and biodiversity, and facilitating a reduction in herbicide reliance. Moreover, two-thirds of consumers see grazing as contributing to increased business profitability, stabilized crop yields, and enhanced farmers' income. Consumers unanimously prioritize the reduction of maintenance, cost, and timing as the primary needs for grazing. Additionally, nearly 70% emphasize the importance of ecosystem services impact knowledge, practicing knowledge skills, management expertise, and training. Regarding barriers, two-thirds of consumers highlight concerns about the high carbon footprint, environmental and human harm, as well as expenses associated with grazing. They also note customer demands to reduce grazing and time consumption as significant disadvantages. However, it's noteworthy that consumers also perceive grazing as presenting no barriers and no significant disadvantages overall.

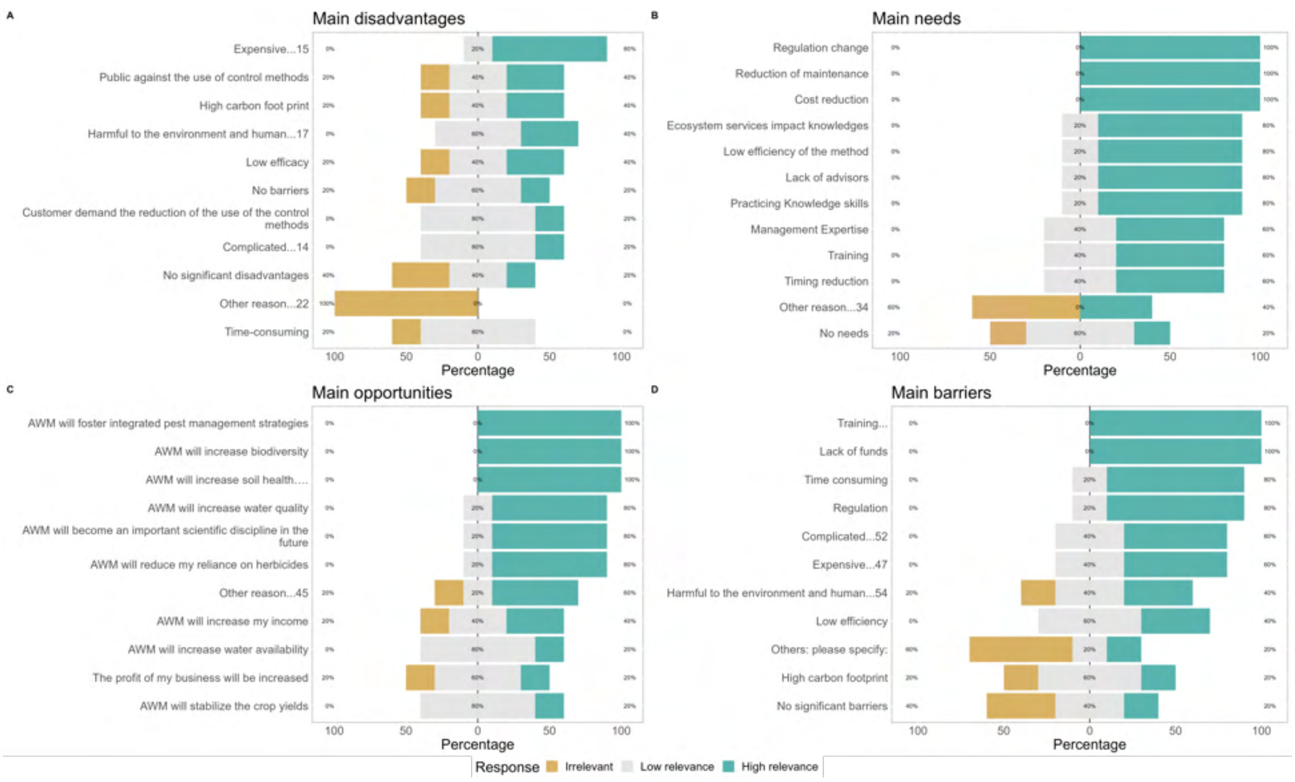


Figure 318. Main disadvantages, needs, barriers and opportunities for grazing identified by consumers.

3.4.2.1.1.2 Conclusion

Consumers view grazing favourably, recognizing its potential for promoting IPM practices and ecosystem services, despite acknowledging various challenges such as high carbon footprints. They prioritize reducing maintenance, timing and costs while emphasizing the importance of knowledge and training for successful implementation.

3.4.2.1.2 Mechanical weeding

3.4.2.1.2.1 Industry

Industry representatives consider mechanical weeding a technique with numerous opportunities, while acknowledging its important needs, barriers, and disadvantages. They unanimously perceive that it fosters IPM strategies and reduces reliance on herbicides. Additionally, two-thirds of the respondents view this practice as a provider of ecosystem services, contributing to improved biodiversity and soil health. Training, cost reduction, and maintenance were identified as the main needs of the method. Moreover, two-thirds of the respondents highlighted the lack of advisors, practical knowledge skills, and management expertise as highly relevant necessities. Aligned with the expressed needs, industry representatives unanimously regard training and lack of funds as significant barriers. Furthermore, complexity, time consumption, regulatory challenges, and expense were considered important impediments by two-thirds of the respondents. In terms of the main disadvantages of the method, industry representatives cited expense (100%), time consumption, and complexity (67%), consistent with the expressed needs and barriers.

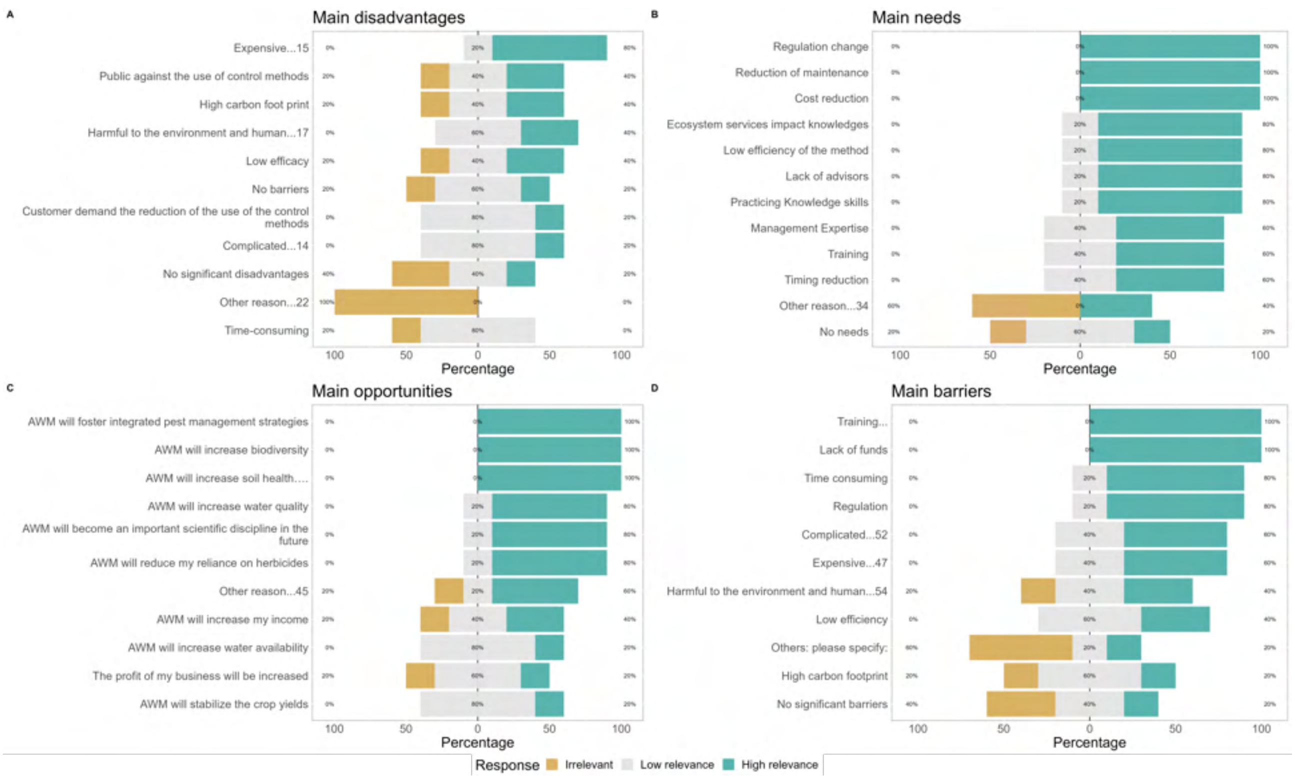


Figure 319. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by industry

3.4.2.1.2.2 Conclusion

Industry representatives view mechanical weeding as a promising AWM practice because it promotes IPM strategies and reduces reliance on herbicides. However, significant barriers and numerous needs, such as lack of training, high costs, and regulatory challenges hinder its widespread adoption.

3.4.2.1.3 Mowing

3.4.2.1.3.1 Advisors

Advisors view mowing as an AWM practice with significant opportunities, although they acknowledge its important needs, barriers, and a few disadvantages. They unanimously believe that mowing fosters IPM strategies and reduces reliance on herbicides. Additionally, two-thirds of the respondents see this practice as a provider of ecosystem services, contributing to increases in biodiversity and soil health, and anticipate its evolution into an important scientific discipline. They unanimously identify training, reduction of maintenance, and cost as the primary needs of the practice. Moreover, nearly seventy percent of the surveyed advisors consider the lack of advisors, practical knowledge skills, and management expertise as important necessities. Regarding the main barriers to the practice, in line with perceived needs, 100% of the advisors emphasize the importance of training and the lack of funds. Additionally, two-thirds of the respondents highlight complexity, time consumption, regulatory challenges, and expense as important impediments for mowing implementation. Consistent with expressed needs and barriers, advisors unanimously consider expense as a relevant disadvantage, with 67% of them also perceiving complexity and time consumption as important disadvantages.

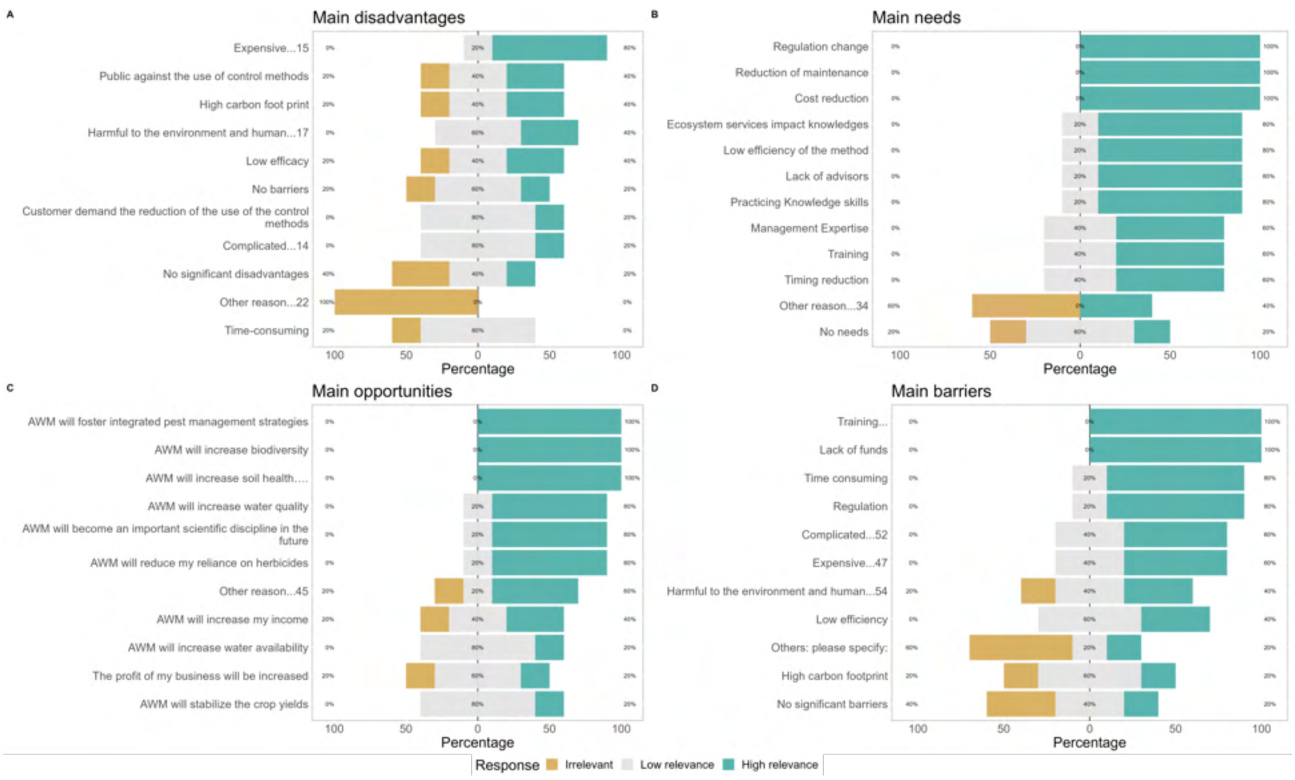


Figure 320. Main disadvantages, needs, barriers and opportunities for mowing identified by advisors.

3.4.2.1.3.2 Farmers

Farmers adopt a more conservative stance toward mowing, recognizing its relevant opportunities and needs while highlighting significant barriers and a few but noteworthy disadvantages. Nearly seventy percent of the surveyed farmers perceive mowing as fostering IPM strategies and recognize its provision of important ecosystem services, such as increased water availability and biodiversity, as well as its role in reducing herbicide reliance. Two-thirds of the farmers consider the impact on ecosystem services knowledge and practicing knowledge skills as the primary needs of mowing. Regarding the main barriers to the method, farmers unanimously identify time consumption, training, and lack of funds as highly important impediments. Additionally, two-thirds of the respondents view the method's low efficiency, complexity, and expense as relevant hurdles in mowing implementation. Consistent with perceived barriers, 100% of the surveyed farmers consider time consumption as the most relevant disadvantage related to mowing use. Moreover, nearly 70% of them cite expense as a relevant factor when considering mowing implementation.

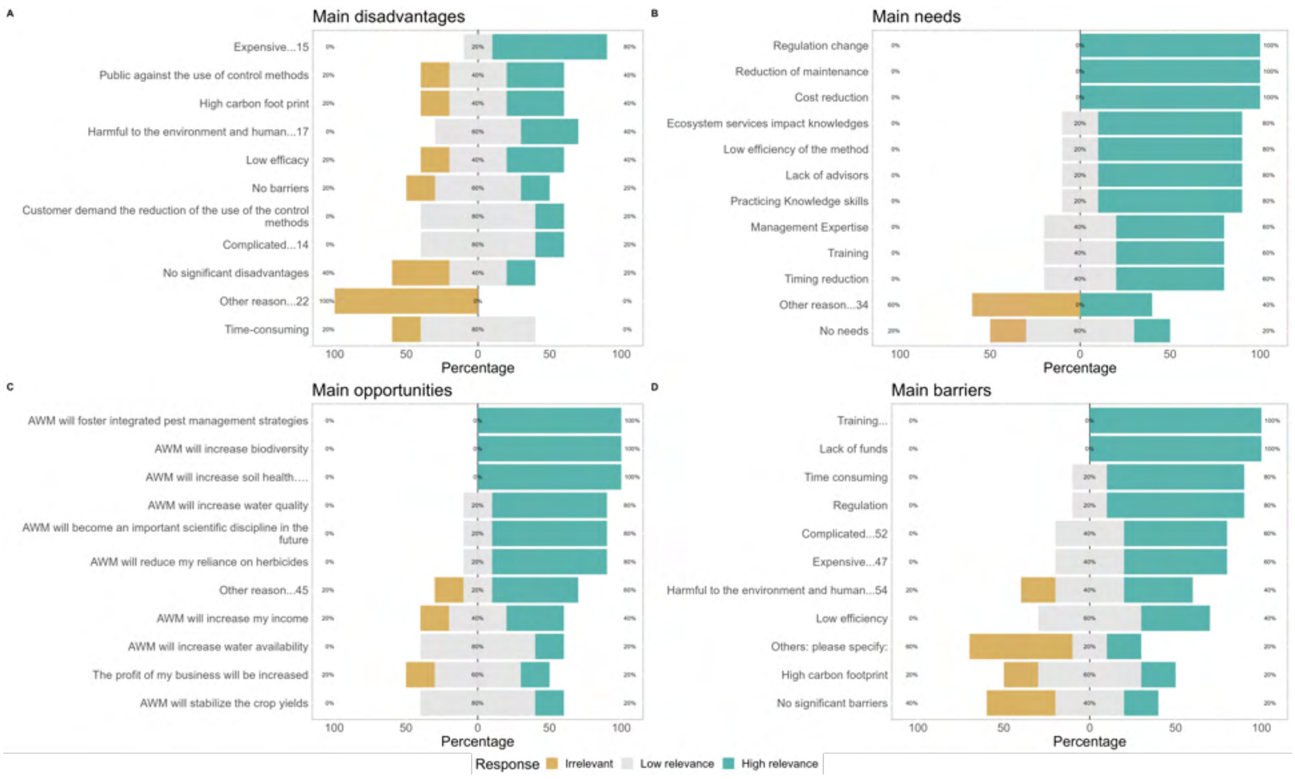


Figure 321. Main disadvantages, needs, barriers and opportunities for mowing identified by farmers.

3.4.2.1.3.3 *Industry*

Industry representatives unanimously believe that mowing will foster IPM strategies and reduce reliance on herbicides. Two-thirds of the respondents consider mowing as a provider of ecosystem services, including improvements in biodiversity and soil health, with the potential to become an important scientific discipline in the future. Primary needs, as unanimously noted by industry representatives, include training, reduction of maintenance, and cost. Additionally, nearly 70% of the respondents consider the lack of advisors, practical knowledge skills, and management expertise as relevant needs. Regarding the main barriers to the method, industry representatives, in agreement with farmers, emphasize training and lack of funds. Moreover, time consumption, regulation, and expense are considered as relevant impediments by nearly 70% of the respondents. Expense is unanimously regarded as the most relevant drawback by industry representatives, with two-thirds of the respondents also regarding complexity and time consumption as important disadvantages.

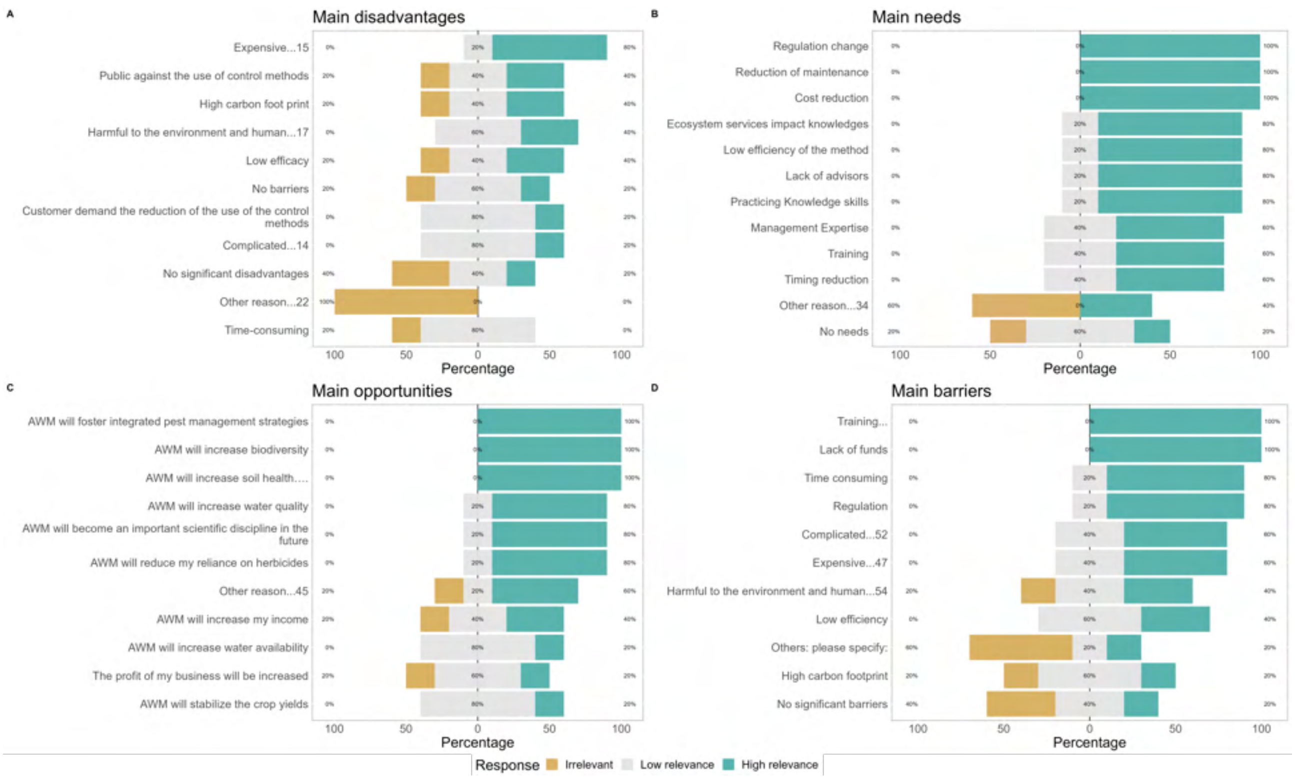


Figure 322. Main disadvantages, needs, barriers and opportunities for mowing identified by industry.

3.4.2.1.3.4 *Policy maker*

Policy makers adopt a more conservative stance toward mowing, despite recognizing significant opportunities; they acknowledge important necessities, barriers, and a few but relevant disadvantages. Nearly eighty percent of the respondents consider that mowing increases soil health and reduces herbicide reliance. Moreover, sixty percent of them regard it as fostering IPM strategies and providing other ecosystem services, including improvements in water availability and biodiversity. Policy makers believe that mowing will evolve into an important scientific discipline in the future. Practicing knowledge skills and cost reduction were considered as the main necessities of the method by 80% of respondents. Management expertise, training, and reduction of maintenance were regarded as important necessities by sixty percent of the respondents. Training, unanimously considered the most relevant impediment to mowing implementation by other stakeholders, was also emphasized by policy makers. Additionally, eighty percent of the respondents consider lack of funds and expense as important barriers. Time consumption was regarded as the most relevant disadvantage, as stated by all surveyed policy makers. Moreover, eighty percent of the respondents emphasize expense as a relevant drawback of mowing implementation.

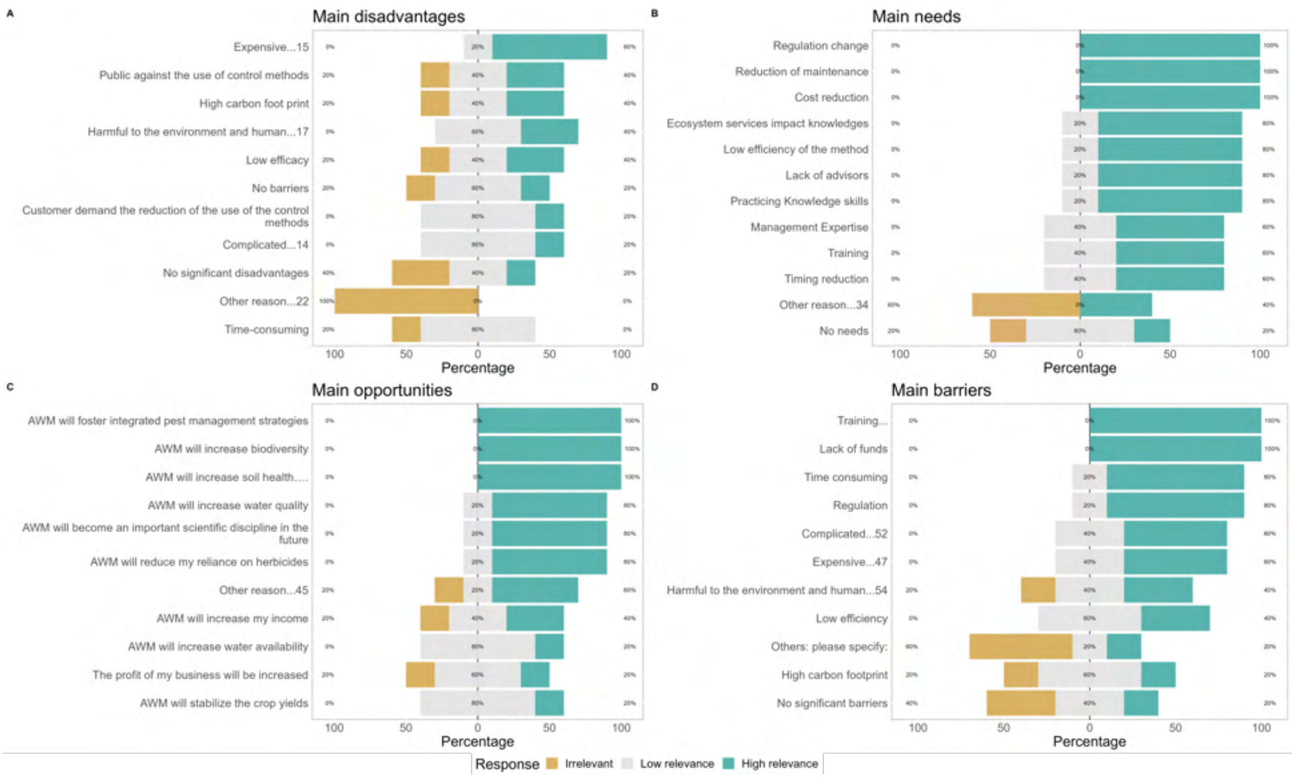


Figure 323. Main disadvantages, needs, barriers and opportunities for mowing identified by policy makers.

3.4.2.1.3.5 Conclusion

Advisors and industry representatives share an optimistic perception regarding mowing, as they emphasize important opportunities while acknowledging needs, barriers, and few disadvantages. Conversely, farmers and policymakers adopt a more conservative stance towards the practice, recognizing opportunities but emphasizing important barriers, needs, and relevant disadvantages. All stakeholders agree on the significant opportunities presented by mowing, as they consider it fosters IPM strategies and reduces herbicide reliance to different degrees. They also acknowledge that mowing is a provider of ecosystem services. Advisors, industry representatives, and policymakers anticipate its evolution into an important scientific discipline. Training was considered a primary need by advisors and industry representatives, while farmers emphasized ecosystem services knowledge and researchers considered practicing knowledge skills and cost reduction as paramount. Training was unanimously considered a relevant barrier across all stakeholders. Besides, advisors, farmers, and industry representatives emphasized lack of funds as an important impediment. Stakeholders showed high rates of consensus when selecting the practice's primary needs, as they all consider expense and time consumption as relevant concerns.

3.4.2.1.4 Mulching

3.4.2.1.4.1 Consumers

Consumers share a positive perception toward mulching, emphasizing numerous opportunities while recognizing important needs, barriers, and disadvantages. Eighty percent of respondents believe that mulching improves soil health and reduces herbicide reliance, while sixty percent consider that it fosters IPM strategies, increases farmers' income, presents potential to evolve into an important scientific discipline, and provides other ecosystem services, such as increases in water availability and biodiversity. Improvements in practicing knowledge skills and cost reduction were considered primary needs by eighty percent of the consumers. Besides, sixty percent of them emphasized management expertise, training, and reduction of maintenance as relevant necessities. Consumers unanimously considered training as the most relevant impediment to mulching implementation. Additionally, eighty percent of the surveyed consumers considered lack of funds and expense as relevant barriers, while sixty percent of them regarded time consumption as important. In line with expressed barriers, time consumption was unanimously considered the main disadvantage by consumers, along with expense, which was regarded as a relevant drawback by 80%.

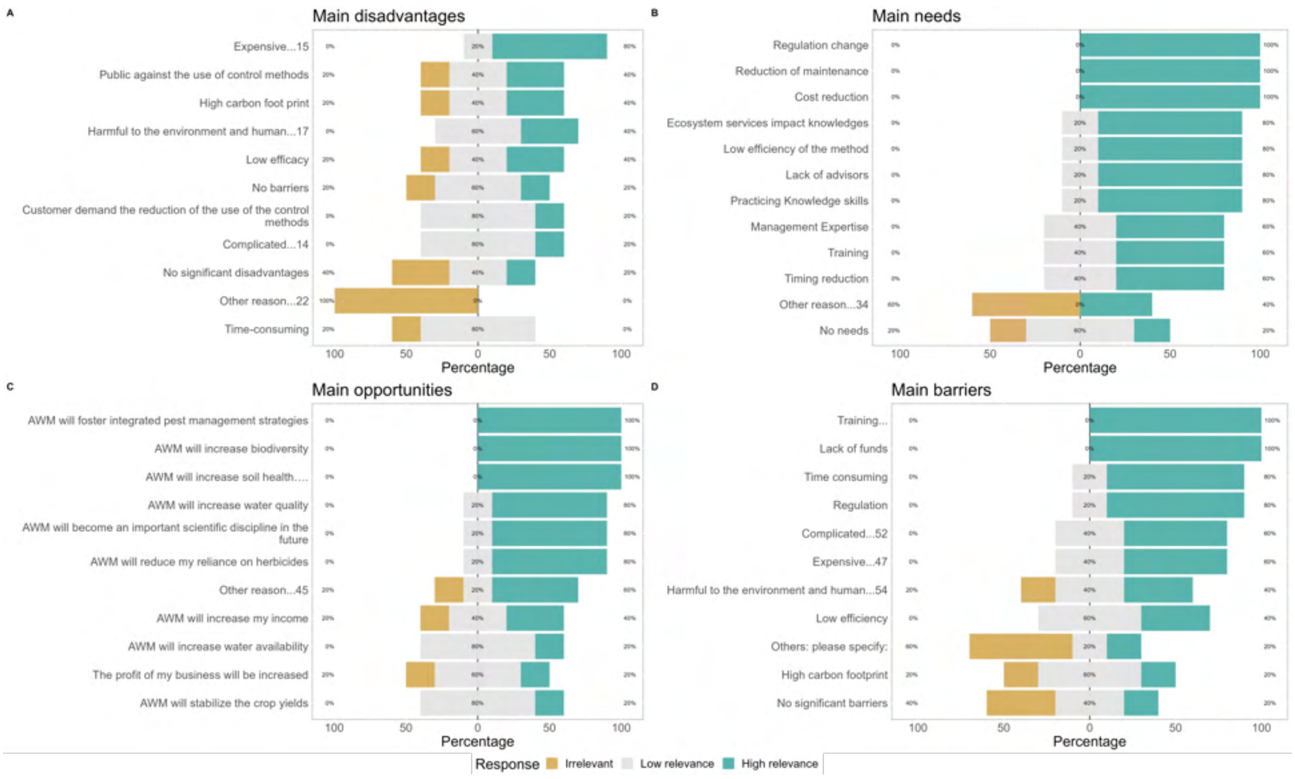


Figure 324. Main disadvantages, needs, barriers and opportunities for mulching identified by consumers.

3.4.2.1.4.2 Conclusion

Consumers hold a positive view of mulching, citing benefits such as improved soil health and reduced herbicide reliance. However, addressing needs like improved knowledge and cost reduction, alongside barriers such as lack of training and financial constraints, is essential for wider adoption. Time consumption and expense remain significant concerns.

3.4.2.2 Surveys

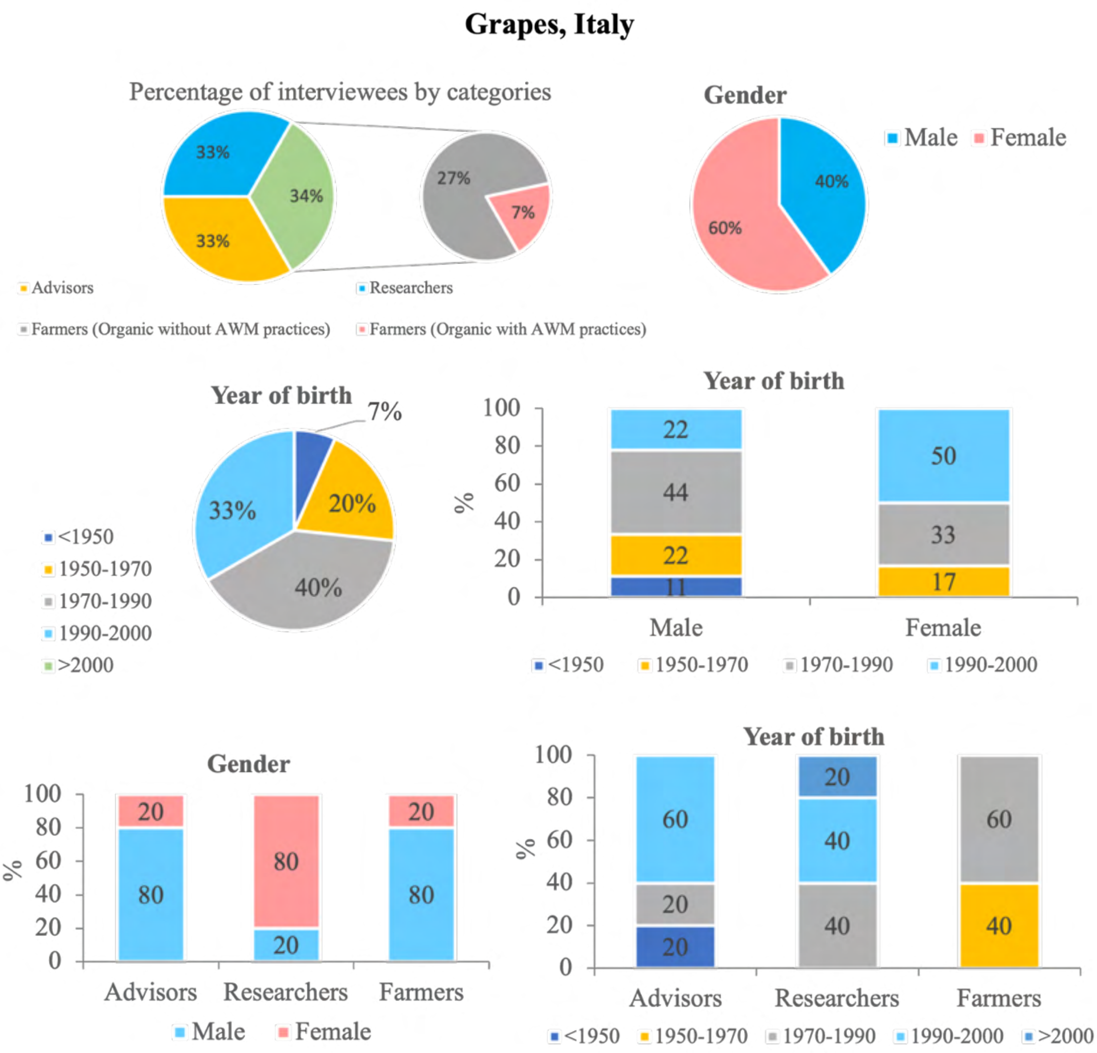


Figure 325. Interviewees description in the Grapes Living Lab (Italy)

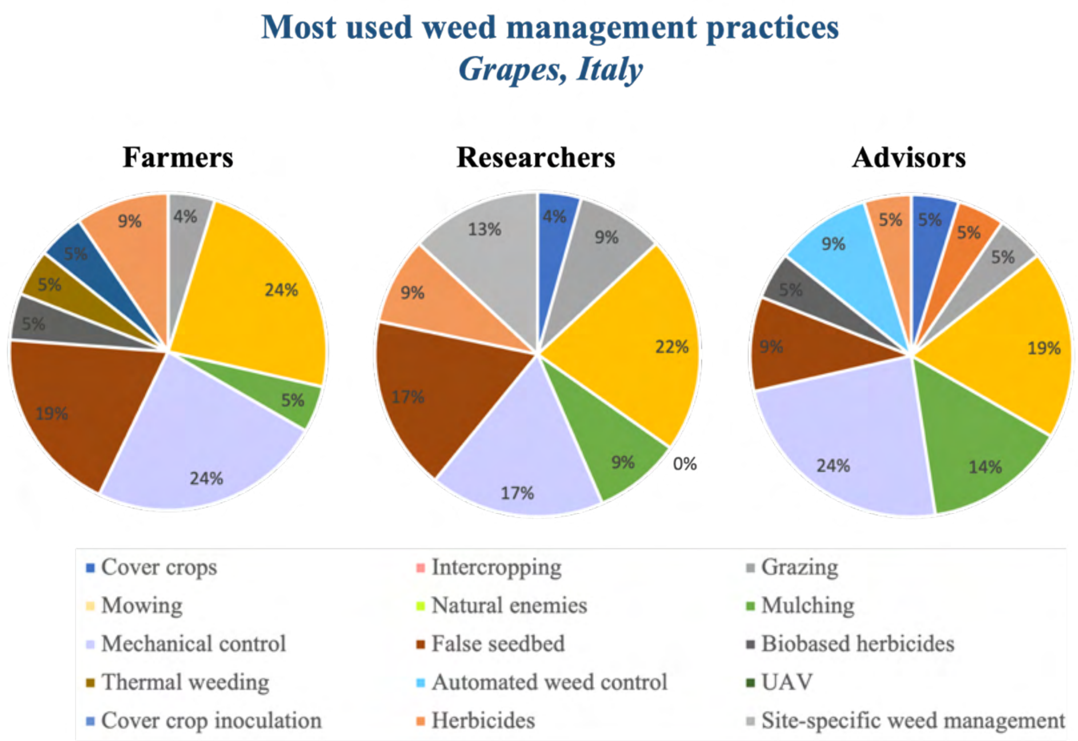


Figure 326. Most used weed management practices in the Grapes Living Lab (Italy)

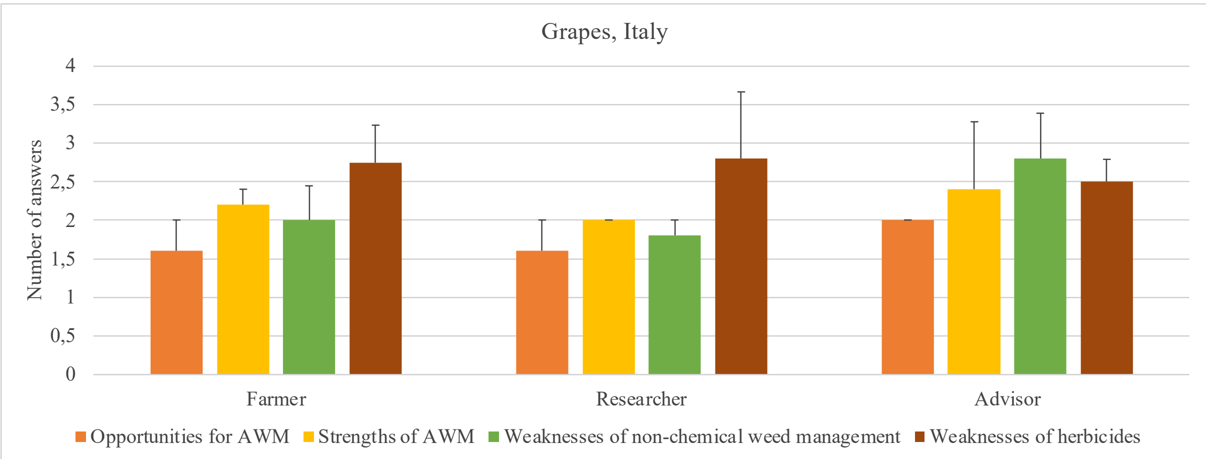


Figure 327. Mean number of answers (±se) per stakeholder group in the Grapes Living Lab (Italy)

Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the Figure below.

STRENGTHS: Presented in the Figure below.

THREATS: No significant threats for AWM were identified. Only one farmer mentioned that the agricultural policies could be potentially a threat.

WEAKNESSES: Only a few responses were collected about weaknesses of AWM. Four responses came from farmers and referred to cost of applications, environmental impact, soil disturbance and risks to human health. One advisor sees a weakness related to environmental impact of AWM practices.

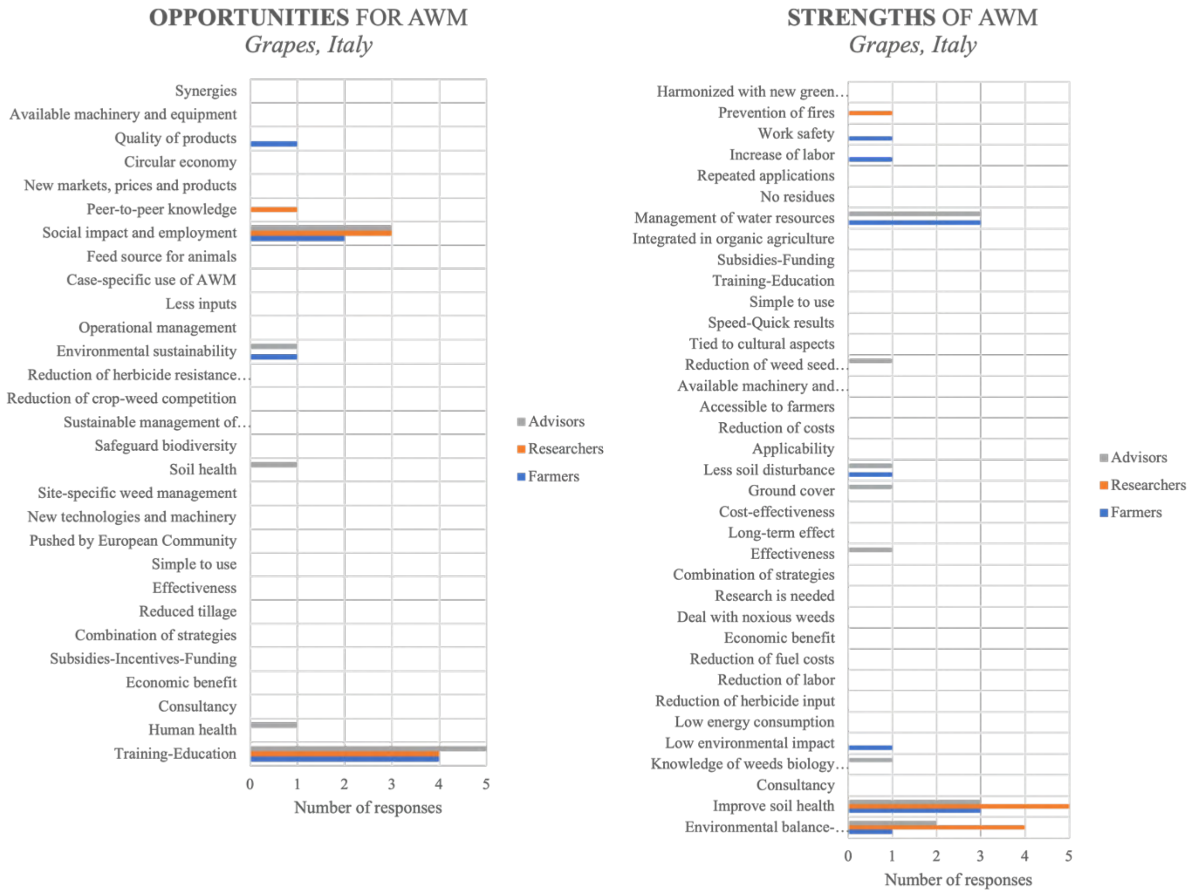


Figure 328. Opportunities and strengths of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: No threats for non-chemical weed management were identified in Italian grapes.

WEAKNESSES: The weaknesses of non-chemical weed management are presented in the figure below.

Figure 329. Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: None.

STRENGTHS: None.

THREATS: None.

WEAKNESSES: Several weaknesses are presented in the figure below.

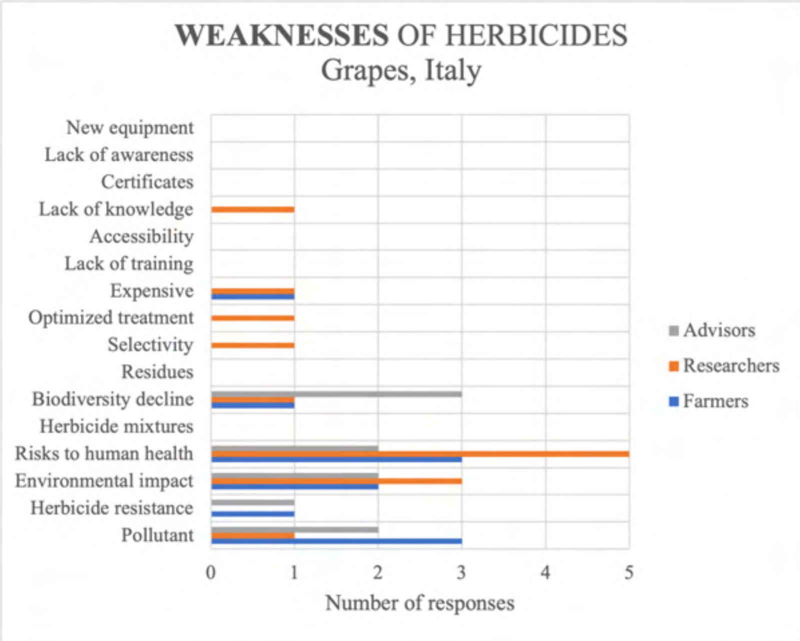


Figure 330. Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – GRAPES, ITALYs
Most used weed management practices: Weed management in vineyards in Italy appears as one of the most practice-rich crops in the project. In particular, mechanical weed control combined with false seeding receives a significant share in the typical weed management practices of farmers. Several practices such as the use of automatic machinery and vegetative cover crops are beginning to be implemented. **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group:** The various stakeholders interviewed gave an almost similar number of responses on weaknesses of non-chemical and chemical weed management, and opportunities and strengths of agroecological weed management. This result suggests that all sides are on the same page in terms of adopting agroecological practices in weed management and reducing chemical inputs. Most responses were given on the weaknesses of herbicides. **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: Training and education, as well as social impact and employment are considered widely accepted opportunities tied to agroecological weed management. The improvement of soil health and the environmental balance that AWM practices can bring, safeguarding biodiversity, are identified as the main strengths of them. A few responses about

weaknesses of AWM came from farmers and referred to cost of applications, environmental impact, soil disturbance and risks to human health.

Threats, and weaknesses for non-chemical weed management: Non-chemical weed management appeared to have several weaknesses but only a few respondents came to the same conclusions. Interviewees from all stakeholder groups identified the cost of applications as the major constraint for adopting non-chemical alternatives for weed management.

Opportunities, strengths, weaknesses, and threats for herbicides: The interviewees in the grape Living Lab in Italy were opinionated against the use of synthetic herbicides highlighting several negative repercussions they bring to people, farms and ecosystems. Among them, risks to human health, environmental impact and the recognition of herbicides as pollutants were the most prevalent responses.

3.4.2.3 Living lab board meeting

The committee meeting was held online on 22nd November 2023 and opened with the presentation of the participants. The GOOD partner introduced the 10 participants present, describing the motivation for which they were contacted to be part of the project committee. Joining the committee were 10 people (1 GOOD Partner Facilitator, 2 farmers, 2 Consultants, 2 researchers, 1 Consumer, 1 Public Administrator and 1 Supply Chain Entrepreneur). Once the presentations were over, the project activity with aims and objectives were presented. In introducing the GOOD project, a brief presentation of all the partners describing the project strategies, specifying that the operational partners for the LL was made. Grapes_24 activities are AIAB, UNICT and UNIPISA. The GOOD partner specifies the objective of the committee and why it is important to have a committee to monitor the project activities through an annual meeting and also to participate in the various project activities, especially those related to territorial information. Then, the research activities activated in the LL were introduced by illustrating the objectives, and reminding the committee that the project activities have a duration of 48 months. In describing the activities in the field, the committee was informed that what has been done in the first year will be preparatory for the activities of other WPs coordinated and implemented by other partners, particularly regarding research on mycorrhizae application. The most important aspects of agroecology and how it includes not only the agricultural component but also the various management, economic and social aspects of an area were also introduced. The choices made for the realization of the experimental fields were described and justified, introducing the agronomic aspects and motivating the choice of cover crops species selected. In introducing the 2 LL on Grapevine (one in an organic farm and one in a conventional farm), the agro-ecological strategies and the role that LL can have in the agro-ecological management of farms combined with the importance of reducing the use of synthetic chemical agents in line with the objectives of Green Deal were defined. A presentation of the experimental fields and the farms involved was made, explaining why 15 experimental plots were made on an organically managed farm and 21 on a conventional one. Under organic farming 3 cover crops treatments (field bean, berseem clover and hairy vetchoats mix) are compared with 1 untreated plot, left with spontaneous flora, and 1 plot managed with the usual tillage practices for the farm. Under conventional farming, the plots are joined by other two plots where herbicides will be used for monitoring purposes, with one plot sprayed at the label rate, and the other at half the rate. Each plot will be replicated three times on the same farm, fruits will be collected for monitoring yield responses to the proposed treatments and for lab qualitative analysis of the grapes raw material, in order also to compare (if possible) the results with the incomes of other farm areas. The second part of the meeting, which involves all the participants in the committee, was presented in order to have more information on the management, agronomic and economic activities on the cultivation of grapes, useful for possible project actions and future organization and information programming. A general overview of vine cultivation was done, explaining how grape cultivation has a regional economic role and how Calabria is important in the Italian production of quality wines. Moreover, it was also indicated how over the years the number of farmers and wineries has increased in the area, given the great interest that wines are arousing in this historical period, and how in Calabria many young entrepreneurs have set up in wineries, also changing what was the management structure of the family business. All in all, the wine sector is fairly well established and creates an important economy for the region. Farmers' interest in increasingly innovative practices that focus on agroecology was also highlighted, with particular reference to organic management. In this context, research projects, such as GOOD, can be very important and above all how it could represent a unique opportunity for companies to innovate and improve the management and qualitative aspects of production; politics can do a lot in increasing these actions with CAP and PNRR (National Recovery and Resilience Plan) among all. In conclusion, the problem of water, which persists in many of the areas cultivated with vines, can be an obstacle to the success of agroecological practices. Moreover, a participant in the meeting indicated that this type of research can also be useful for companies to correctly monitor unnecessary expenses, also in relation to water savings. The drought aspect is creating a major problem in recent years in agronomic management and disease control. This summer, given the accentuated drought, farmers had to intervene more consistently in the fight against downy mildew than in previous years. Among the most frequently used operations mowing and mechanical control are often done on a calendar basis, while for soil fertility green manure is used. Another participant in the meeting explains, in line with the project's activities and objectives, how the market for agroecological products, especially certified organic, is growing and is increasingly attracting the interest of consumers. A farmer involved in the LL board meeting justified his own and his partners' decision to actively participate in the project, making part of the vineyard available for the creation of the experimental plots, and how this choice could be optimal and important for the future planning of the company, which is now in its third generation, but has only started bottling in recent years. In conclusion, he emphasizes how important it is to plan and manage the vineyard correctly to obtain quality grapes that will be transformed into wine. As it was the first meeting, there were no further suggestions or proposals for the LL, but all the members approved the planned activities. In conclusion, GOOD partner takes the floor on behalf of the AIAB partner, reminding how sensitive AIAB is to these issues and how it is involved in scientific research in several areas. AIAB's project activities also foresee the realization of other actions in other WPs related to the dissemination of data, collection of interviews and sending of questionnaires involving companies, consumers, industries, political representatives, technicians and researchers. She also explains that a copy of the signed documents, regarding the expression of consensus to be part of the committee board, will be kept for five years at AIAB head office.

During the LL board meeting, this information was also collected:

What are the market characteristics of vine?	1. How many farmers cultivate vine in the region (approx.)?
	In the Calabria Region are grown about 10000 ha of vineyards. Most of the grape varieties are black skinned and account for about 80% of the production: Gaglioppo, Nerello Mascalese, Nerello Capuccio and Greco Nero among the main ones. The white grape varieties are instead: Greco Bianco, Pecorello, Montonico and Guernaccia. The number of wineries is about 150, 500 considering also the small ones. There is no crop rotation.
	2. How many products are derived from the vine?
	Wine is a relevant product for the regional farmers, and for the landscape too.
	3. Do you think that agroecological products could be promoted in local markets?
	Yes, for wine they are a marketing lever.

	4. Do you believe that the region has a lack of technologies?
	In the area, not all wineries are well structured for cultivation, although most wineries are better equipped for processing. In smaller wineries, there is a lack of equipment, and more than half of the wineries in the sector use subcontractors for ordinary processing, while harvesting is very often carried out with family labor.
	5. Is the regional agri-food value chain sustainable?
	For the organic vineyard, yes, it is sustainable. For other products not always so.
What are the most common agricultural and weed management practices in vine?	1. What are the most common agronomic practices in vine?
	Pruning, soil tillage, flail mowing, fertilization with both pelleted and foliar fertilizers, fertilization with manure, irrigation but not in all vineyards. Pruning is carried out in winter, green pruning in spring/summer. Plant protection.
	2. What are the most common weed management practices in vine?
	Flail mowing, soil tillage.
What is the herbicide use in vine?	1. How many active ingredients there are available? How many different mode of actions?
	More than ten ingredients are registered, in all of the main action modes (burn-down, preemergence, post-emergence).
	2. How many times do you spray in-season?
	None in the farms involved in the LL board, but in the farms where chemical weeding is carried out, 2-3 times per year.
	3. Do you use pre-emergence, post-emergence or both herbicides?
	None in the farms involved in the LL board.
	4. Are herbicides efficient?
	It depends on several factors, usually yes.
	5. Do you think that alternatives to herbicides are equally efficient?
	In the regional realities yes, but more time consuming.
	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?

	They can impact in many ways, they are used not only in growing vines, it is a trade-off not yet well perceived by the public.
	7. Do you believe that agriculture without herbicides is viable?
	Yes, although, especially on small family farms, there is not enough time to dedicate to alternative practices.
What are the needs and barriers to assist agroecological transitions & adopt agroecological weed management approaches?	1. What is needed to boost the uptake of agroecological practices?
	More field demonstration activities, as well adequate training of farmers and farm workers.
	2. What are the barriers towards agroecology implementation?
	There is often a fear of the new management techniques, which is mainly related to costs and production risks.
	3. Should policies need be redefined to allow agroecological transitions?
	In the discussion emerged the need for a financial planning to protect farmers above all from the risk of loosing production in terms of quantity but also in terms of quality, i.e. grapes not diminished in their quality by fungi or other pests. Agroecological transition is perceived as knowledge intensive, so the need of more how to information.
	4. How confident you feel about the adoption of agroecological weed management practices?
	It will take several years, but the feeling is that those practices will be adopted out of necessity.
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per	1. What are the main drivers of weed dispersal?
	Soil tillage not carried out at right times, over-fertilization that is very often done without previous soil analysis, and climatic changes that set the stage for other weeds.
	2. Which are the major and most noxious weeds in your area?
	Cynodon sp., *Elytrigia* sp.
	3. Are there any herbicide resistant weeds?
	Probably not yet or in any case there is no perception on that.
	4. Do you know any invasive plants in your area?
	No, farmers do not report species that will be considered invasive.

cropping scenario?		
What do you think about the Living Lab?	1. Which proposals do you have for a good performance of the LL?	
	There is consensus on keeping AWM solutions adoptable also by average, not hi-tech, farms.	
	2. Would you like it to remain over time?	
	Probably yes if there will be a network where useful information on AWM can be shared.	

3.4.3 Greece

3.4.3.1 Questionnaires

Grape's questionnaires in Greece provided insights with regard to four AWM techniques, including herbicides, mechanical weeding and mowing. None of the techniques was considered as relevant by a sufficient number of respondents across all stakeholders types, and we did not receive enough responses from farmers and policymakers. Table 37 presents the types of stakeholders who answered the questionnaires associated with different AWM practices and the number of respondents in each category.

Table 37. Number of responses for each AWM practice and stakeholder category in Grapes (Greece).

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control						
Biobased herbicides		1			1	
Cover crop inoculation to increase competitiveness						
Cover crops						
False seedbed						
Grazing						
Herbicides	**8**	**9**		**3**	2	**5**
Intercropping						
Mechanical weeding	**6**	**3**		**3**	2	2
Mowing	**4**	**3**		1		
Mulching						
Natural enemies						
Other						
Site-specific spraying					2	
Thermal weeding						
UAV						1
n=29	8	10	0	3	3	5

3.4.3.1.1 Herbicides

3.4.3.1.1.1 Advisors

Advisors hold a conservative perception toward herbicides, considering this practice to have important needs while acknowledging few opportunities, barriers, and some disadvantages. Over sixty percent of the respondents recognize that herbicides foster IPM strategies, and nearly 40% emphasize that this practice provides relevant ecosystem services, including increases in water quality, biodiversity, and soil health, among other potential benefits. Nearly ninety percent of the surveyed advisors highlight the reduction of maintenance as the most relevant necessity. Besides, over sixty percent of them highlight regulatory changes, as well as cost reduction, with half of the respondents emphasizing the importance of ecosystem services impact knowledge as important requirements, along with nearly forty percent highlight the lack of advisors, training, and timing reduction among others. Regarding the main barriers to the method, over sixty percent of the advisors highlight regulatory challenges, with half of them emphasizing expense, as well as environmental and human harm, which were considered important barriers by 38% of the surveyed advisors. In line with expressed barriers, half of the respondents highlight environmental and human harm as the main disadvantages of the method. Additionally, over thirty percent consider expense as a relevant disadvantage.

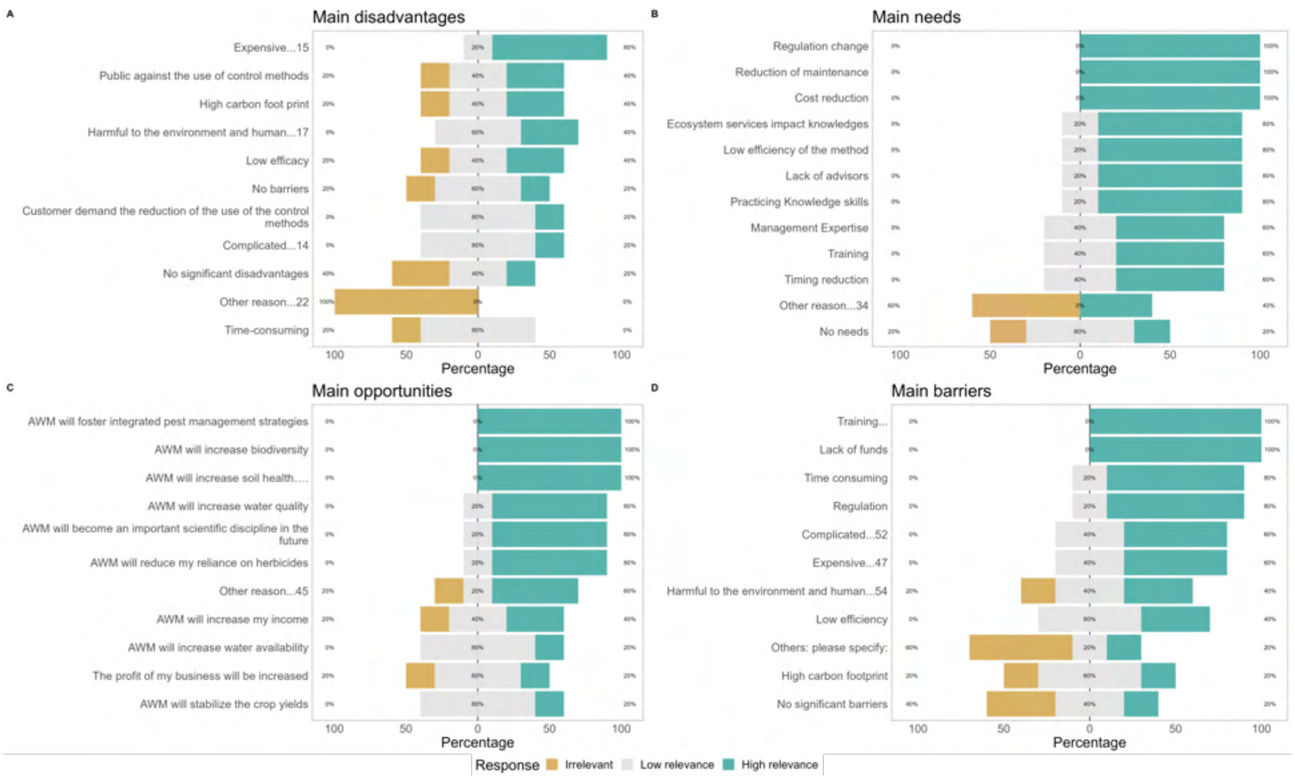


Figure 331. Main disadvantages, needs, barriers and opportunities for herbicides identified by advisors.

3.4.3.1.1.2 Consumers

Consumers, similar to advisors, view herbicides as a technique with few relevant opportunities, while recognizing important needs, barriers, and some disadvantages. None of the queried opportunities were regarded as highly relevant by more than half of the respondents. One-third of the consumers consider herbicides as ecosystem service providers, including increases in water quality and availability, as well as improvements in business profitability and crop yield stabilization. Regarding the main needs of the practice, nearly seventy percent of consumers emphasize regulatory changes, alongside practicing knowledge skills, training, reduction of maintenance, cost, and timing, which were considered relevant by nearly sixty percent of the respondents. Additionally, over forty percent of the respondents consider ecosystem services impact knowledge, as well as management expertise, as important requirements. Nearly seventy percent of the respondents share regulatory concerns as highly relevant barriers. Besides, 56% of the surveyed consumers emphasize environmental and human harm, training, and expense as important impediments to herbicide implementation. In line with expressed barriers and advisors' opinions, over half of the consumers consider environment and human harm, as well as expense, as the most relevant disadvantages.

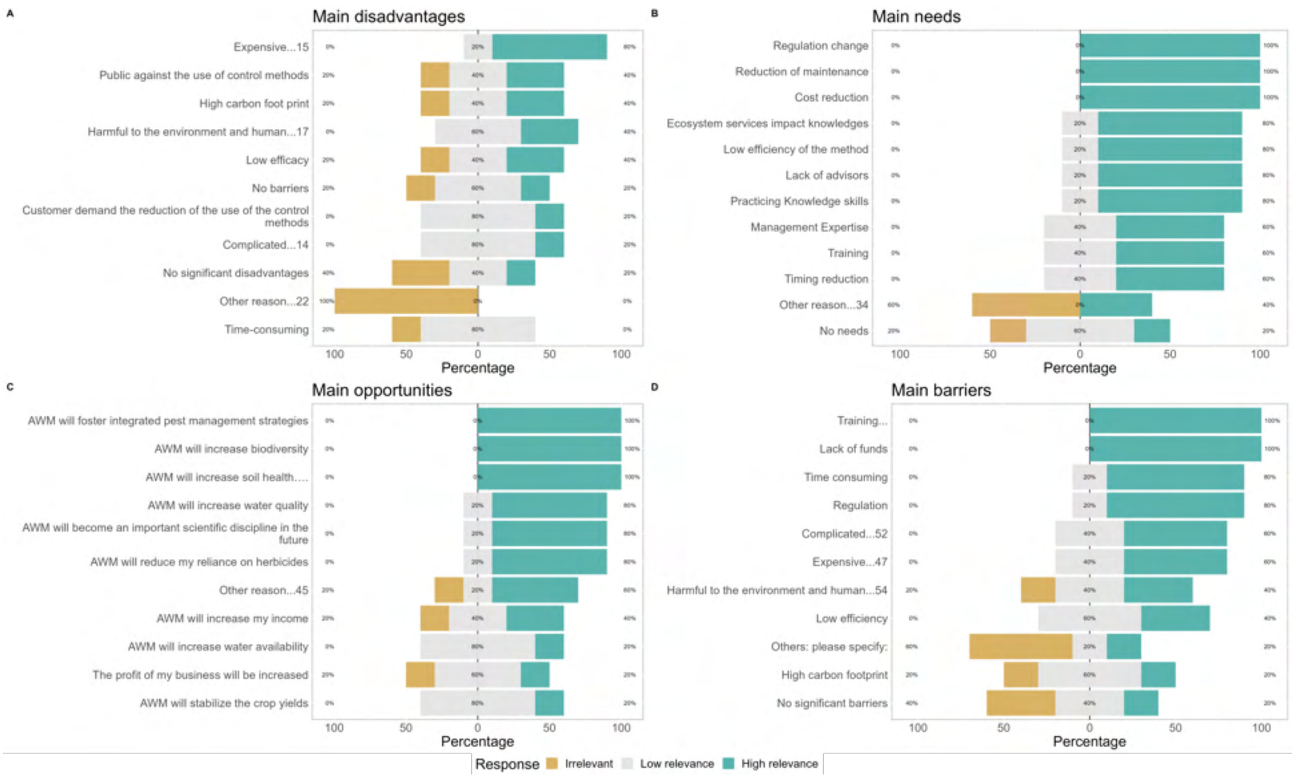


Figure 332. Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

3.4.3.1.1.3 Industry

Industry representatives adopt a neutral stance toward herbicides, recognizing important opportunities but virtually no relevant needs, barriers, or disadvantages. Nearly seventy percent of the respondents acknowledge that herbicide implementation results in increases in business profitability, and they stabilize crop yields. One third of them consider that its use increases their income. However, the rest of the queried opportunities were not regarded as highly relevant by a significant majority of the respondents. Regarding the main needs, just one third of the respondents consider ecosystem services impact knowledge, regulatory changes, as well as cost, timing, and maintenance reduction as important. Industry representatives consider that herbicide use presents no significant barriers or important disadvantages derived from its implementation.

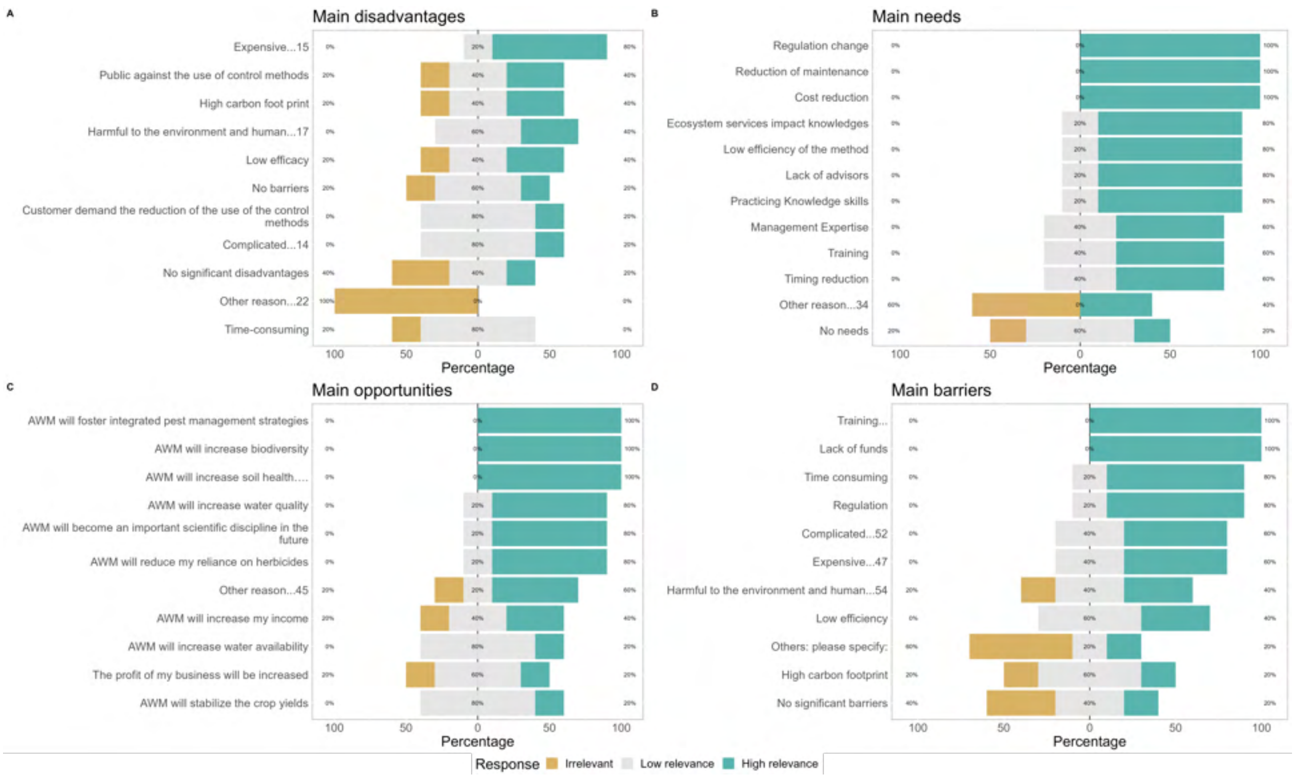


Figure 333. Main disadvantages, needs, barriers and opportunities for herbicides identified by industry.

3.4.3.1.1.4 Researchers

Researchers perspective with regard to herbicides was similar to what was expressed by advisors and consumers, as they considered that the practice entails important needs while presenting few barriers, opportunities as well as some disadvantages. None of the queried opportunities were considered as highly relevant by more than half of the respondents, forty percent of them considered that herbicides will evolve into an important scientific discipline in the future, that their use will increase business profitability and that it will stabilize crop yields. Eighty percent of the surveyed researcher regarded cost reduction as the primary need in herbicide implementation. Moreover, sixty percent of them included ecosystem services impact knowledge and reduction of maintenance as important necessities, along with forty percent that emphasize regulatory changes, lack of advisors and training, as well as other factors as important needs. As in the case of opportunities, researchers considered that none of the barriers were regarded as relevant by more than half of the respondents; yet forty percent of the respondents considered training, lack of funds as well as regulatory challenges as important barriers. As per the method main disadvantages sixty percent of the respondents considered environmental and human harm as important disadvantages, and forty percent of them emphasized public opposition and customer demand to reduce herbicides as relevant drawbacks.

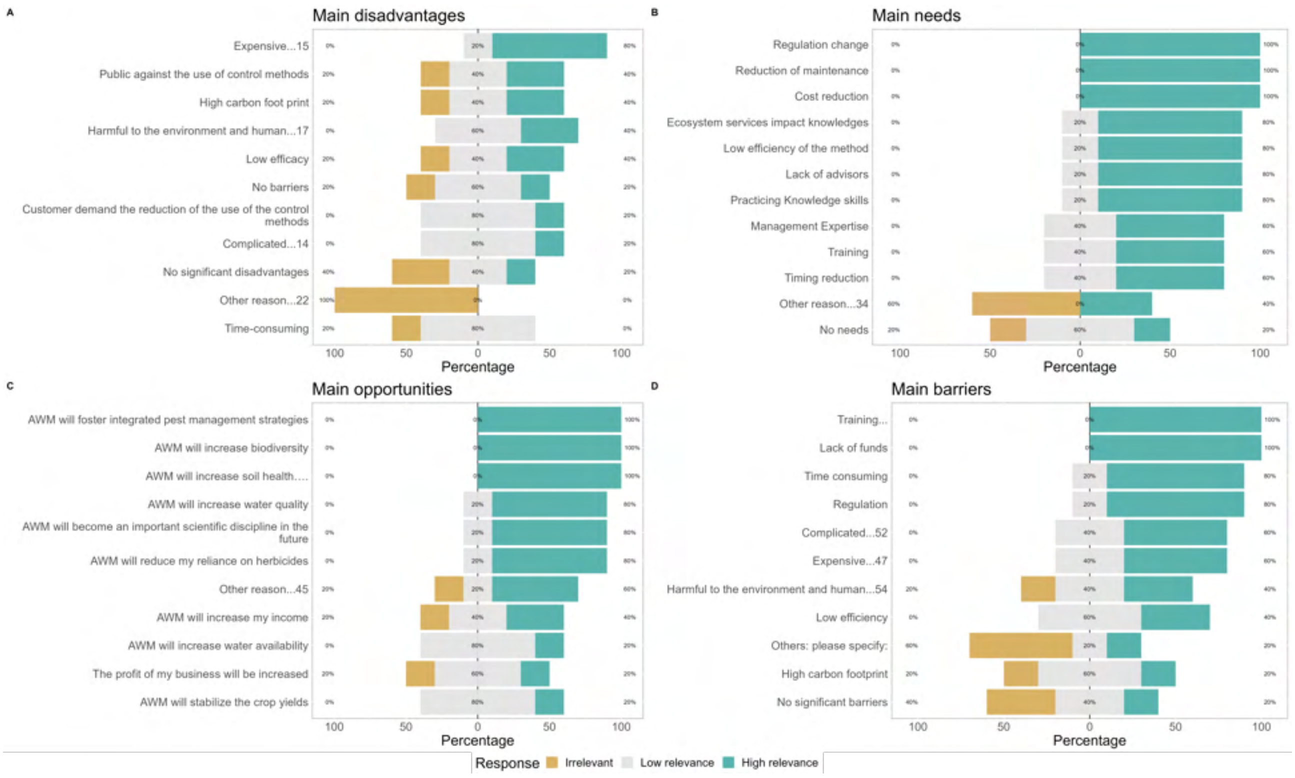


Figure 334. Main disadvantages, needs, barriers and opportunities for herbicides identified by researchers.

3.4.3.1.1.5 Conclusion

Stakeholders share a conservative perspective toward herbicides, recognizing their use in grape weed management, but generally considering this practice to entail important needs, with few opportunities, barriers, and some disadvantages. Advisors perceive herbicides as fostering IPM strategies, while industry representatives emphasize improvements in business profitability and crop yield stabilization as relevant opportunities. None of the queried opportunities were regarded as highly relevant by a majority of consumers or researchers. Regarding primary needs, advisors prioritize reduction of maintenance, researchers emphasize cost reduction, and consumers identify regulatory changes. However, industry representatives did not mainly consider any of the queried necessities as highly relevant. Regulatory challenges were considered the most relevant barriers by advisors, consumers, and researchers, while industry representatives considered that herbicides face no significant barriers. Environmental and human harm were considered as relevant barriers by advisors, consumers, and researchers, while industry representatives considered that the practice faces no relevant barriers.

3.4.3.1.2 Mechanical weeding

3.4.3.1.2.1 Advisors

Advisors regard mechanical weeding as a method with numerous opportunities while acknowledging limited but relevant needs, barriers, and disadvantages. Over eighty percent of the surveyed advisors consider that this practice improves biodiversity, while nearly seventy percent acknowledge its role as a fosterer of IPM strategies and recognize its potential to increase water quality and potential to evolve into an important scientific discipline. Additionally, half of the respondents highlight that its use increases soil health and reduces herbicide reliance. According to advisors, cost reduction is the primary need of the method, along with half of them emphasizing timing and maintenance reduction. In agreement with perceived necessities, nearly seventy percent of the surveyed advisors highlight time consumption as relevant barrier. Moreover, they emphasize high carbon footprint and expense as important impediments. Time consumption is considered a relevant disadvantage by nearly 70% of the respondents, and in agreement with expressed barriers, half of the respondents consider a high carbon footprint as an important drawback.

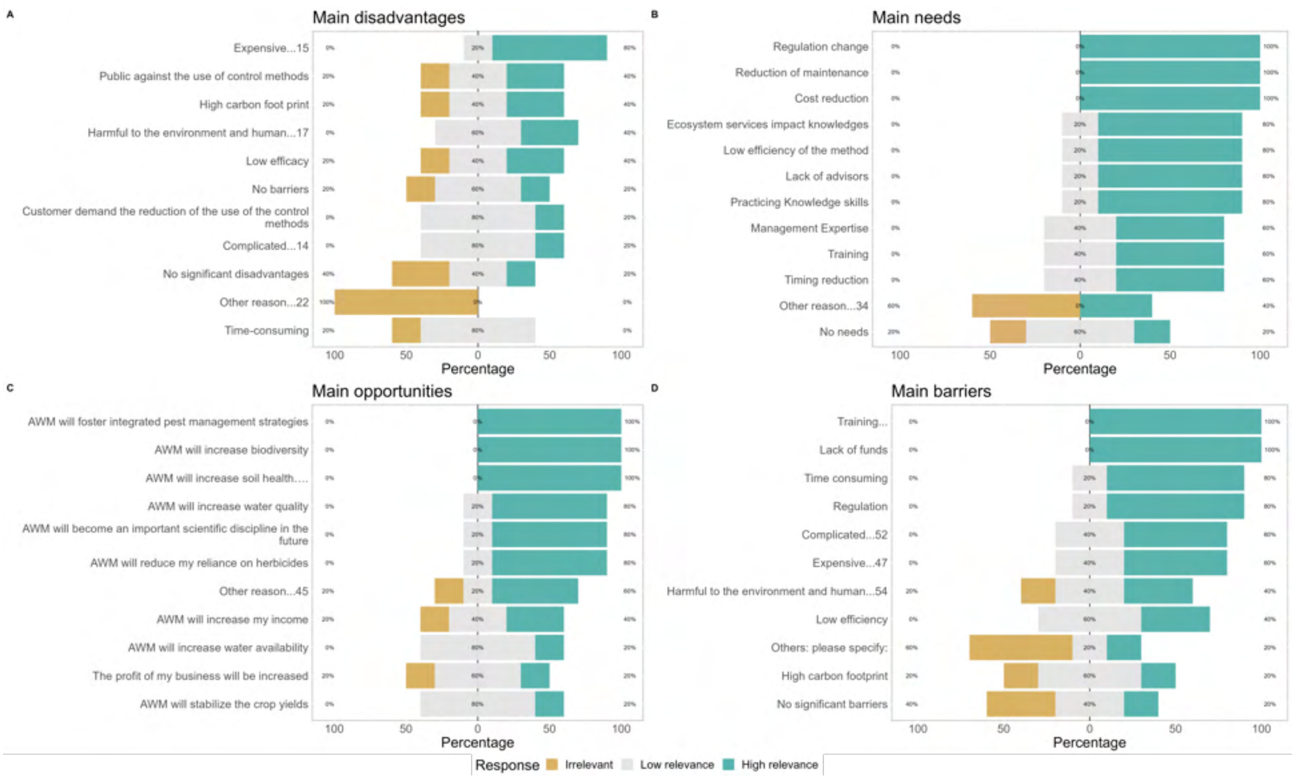


Figure 335. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by advisors.

3.4.3.1.2.2 Consumers

Consumers, similar to advisors, consider mechanical weeding as a practice with important opportunities that entails few but relevant needs and barriers, but virtually no disadvantages. They unanimously agree that mechanical weeding will reduce herbicide reliance, with nearly 70% of the respondents considering that its use will foster IPM strategies. Timing reduction is considered the primary need by nearly seventy percent of the respondents, while the rest of the queried necessities were considered as low or irrelevant by most respondents. Like advisors, nearly seventy percent of consumers perceive that time consumption is the most relevant barrier. None of the queried disadvantages were considered as highly relevant by a significant proportion of respondents, with just one third of them emphasizing time consumption as an important drawback.

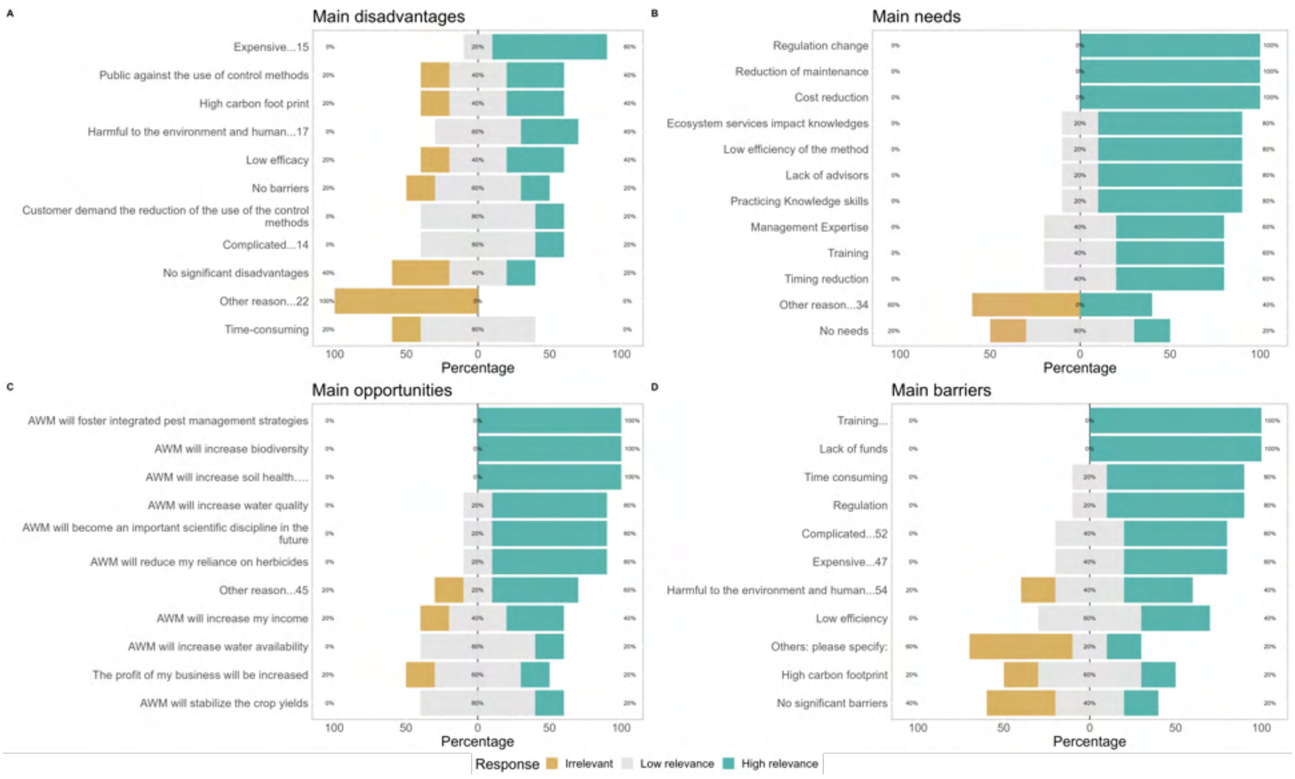


Figure 336. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by consumers.

3.4.3.1.2.3 Industry

Industry representatives hold a different perspective toward mechanical weeding compared to advisors and consumers, as the majority of the respondents perceive that the practice presents no relevant opportunities nor disadvantages but that it entails few but relevant needs and barriers. None of the queried opportunities was considered as relevant by more than half of the respondents; one third of them emphasize mechanical weeding's role as an ecosystem services provider, including improvements in water quality and availability, biodiversity, and enhancements in soil health along with reduction in herbicide reliance. As a primary need, nearly seventy percent of the respondents highlighted cost reduction, with one third of them considering timing reduction as a highly relevant requirement. Industry representatives unanimously considered a high carbon footprint as an important barrier. Besides, one third of them highlighted time consumption as an important impediment. None of the queried disadvantages were considered as highly relevant by more than half of the respondents and, in line with expressed barriers, one third of the surveyed industry representatives regarded the method's high carbon footprint and time consumption as relevant drawbacks.

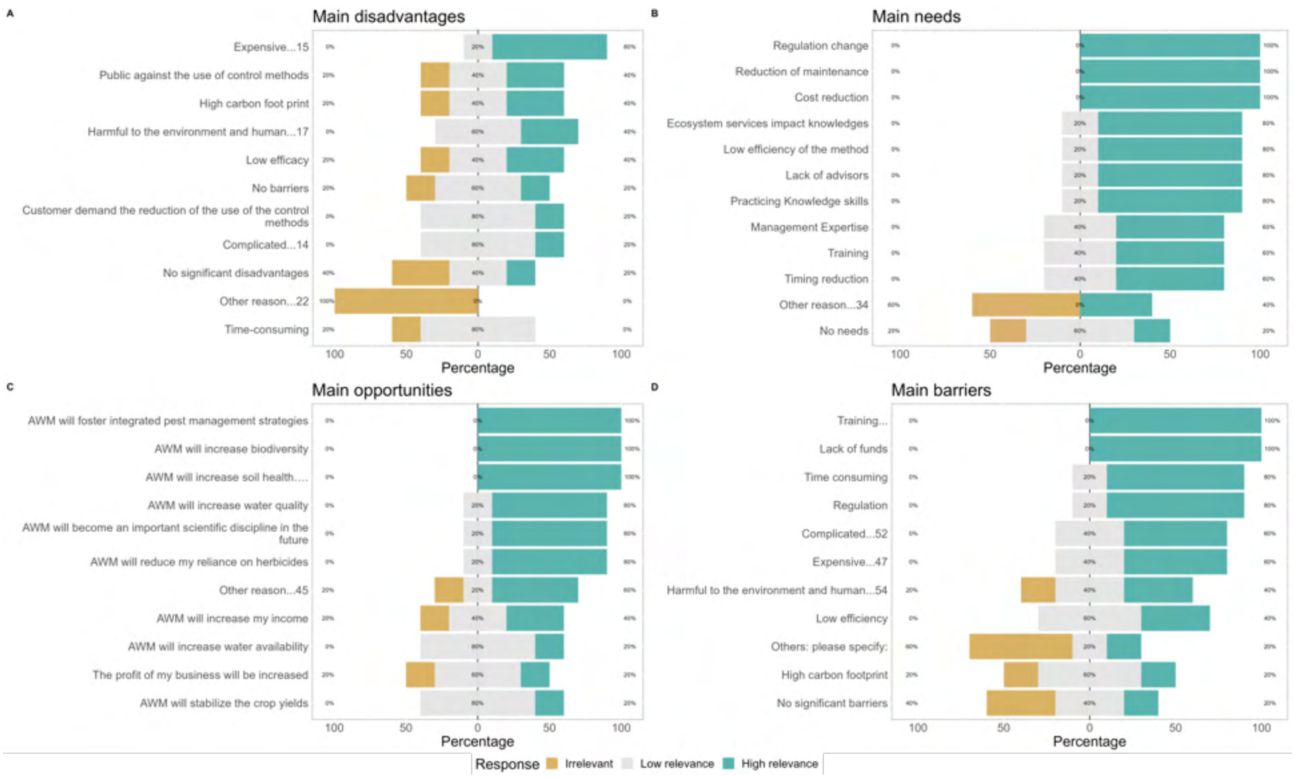


Figure 337. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by industry.

3.4.3.1.2.4 Conclusion

Advisors and consumers view mechanical weeding as a practice with relevant opportunities, presenting few but significant needs, barriers, and disadvantages. Advisors perceive it as a provider of ecosystem services, including improvements in biodiversity and water quality. Consumers believe it will reduce herbicide reliance and foster IPM strategies. In contrast, industry representatives perceive mechanical weeding as an AWM practice that does not present relevant opportunities. Advisors and industry representatives consider cost reduction as the primary need, while consumers believe that timing reduction is the most relevant requirement for mechanical weeding. Time consumption and high carbon footprint are considered the most relevant barriers and disadvantages across all stakeholder’s categories.

3.4.3.1.3 Mowing

3.4.3.1.3.1 Advisors

Advisors view mowing as an AWM practice that presents few but relevant opportunities, as well as important needs, with virtually no barriers or disadvantages. Three quarters of the respondents believe that mowing fosters IPM strategies, along with half of them emphasizing the practice as an ecosystem services provider, implying improvements in water availability, quality, biodiversity, and enhancements in soil health. Advisors unanimously consider timing reduction as the primary need, with half of them acknowledging that cost reduction is a relevant requirement. Time consumption is considered a relevant barrier and disadvantage by half of the respondents.

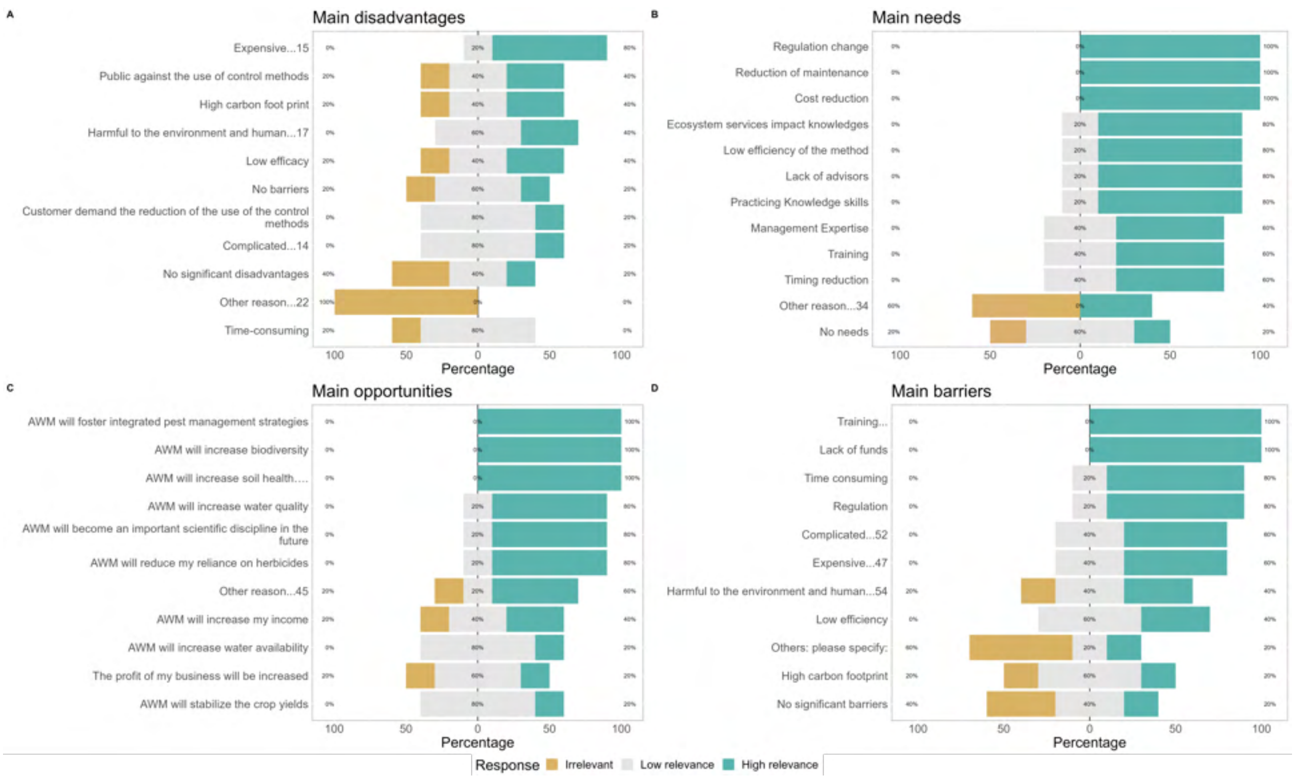


Figure 338. Main disadvantages, needs, barriers and opportunities for mowing identified by advisors.

3.4.3.1.3.2 Consumers

Consumers' perception of mowing was similar to what was expressed by advisors, as they perceive few opportunities, relevant needs and disadvantages, as well as virtually no barriers. As main opportunities, two-thirds of the surveyed consumers identify mowing as an ecosystem services provider, including increased soil health as well as a reduction in herbicide reliance. As primary needs, nearly seventy percent of them emphasize ecosystem services impact knowledge, practicing knowledge skills, and management expertise. None of the queried barriers was considered as relevant by most respondents, and time consumption was considered as a relevant disadvantage by two thirds of the respondents.

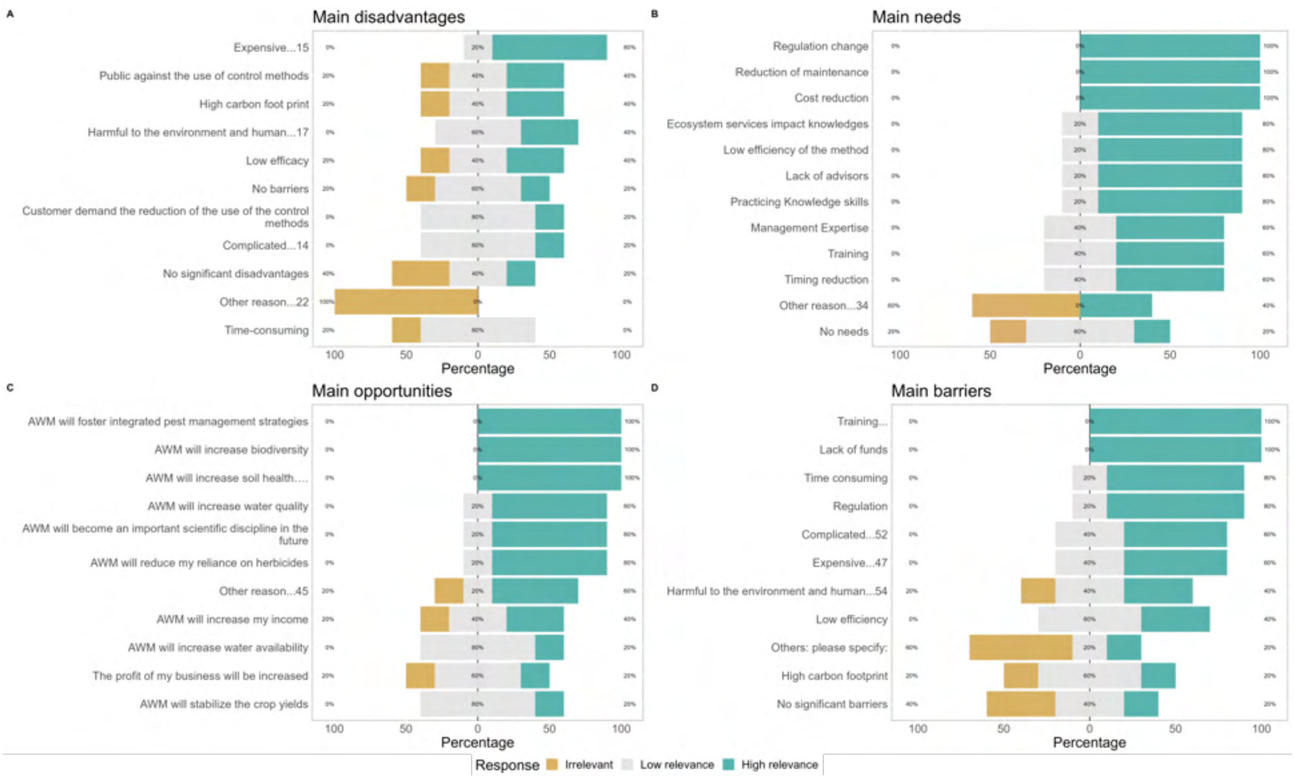


Figure 339. Main disadvantages, needs, barriers and opportunities for mowing identified by consumers.

3.4.3.1.3.3 Conclusion

Stakeholders consider mowing as a practice that presents few opportunities, with both groups emphasizing its important needs and virtually no barriers or disadvantages. Advisors believe that mowing fosters IPM strategies, while consumers identify that its implementation reduces herbicide reliance. Both groups also emphasize the practice as an ecosystem services provider, including increases in soil health. While advisors identify timing reduction as a primary need, consumers acknowledge ecosystem services impact knowledge as an important requirement. Time consumption was considered as a relevant barrier and disadvantage by advisors, while this factor was only regarded as a relevant drawback by consumers.

3.4.3.2 *Surveys*

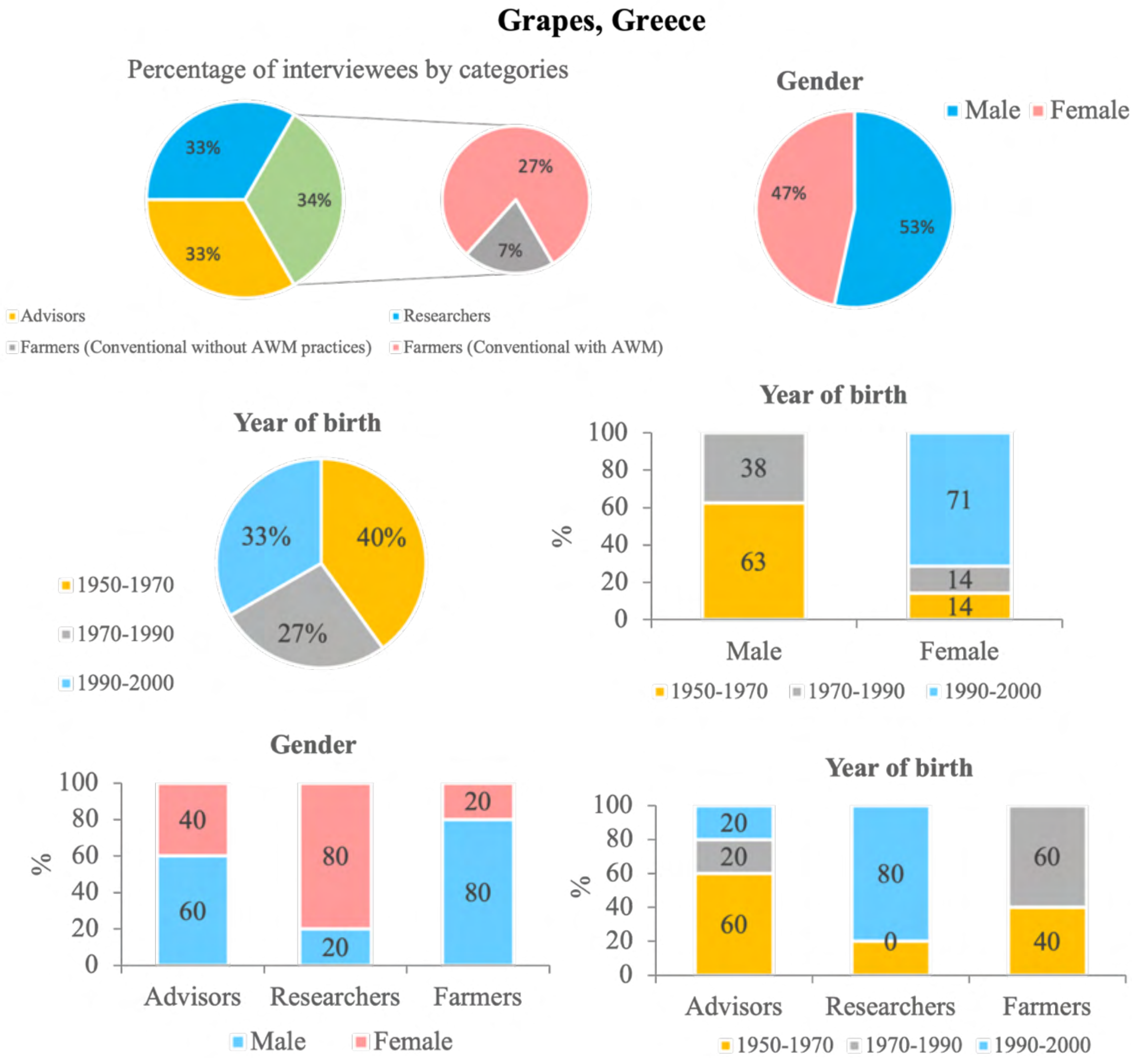


Figure 340. Interviewees description in the Grapes Living Lab (Greece)

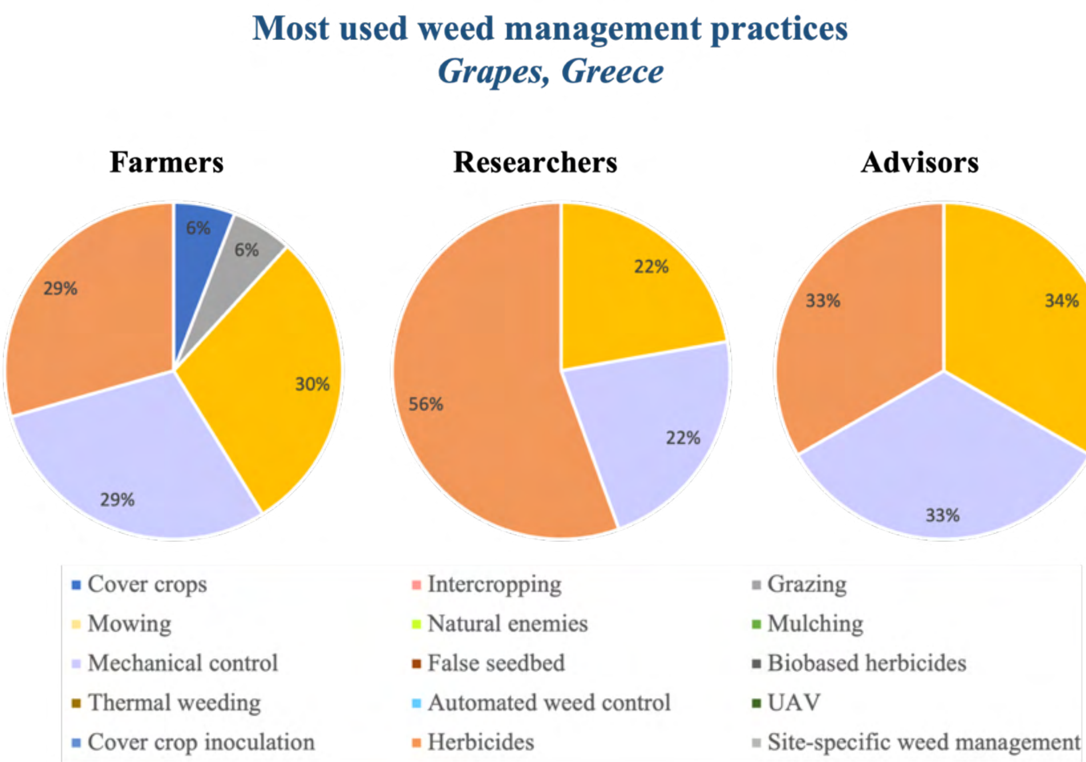


Figure 341. Most used weed management practices in the Grapes Living Lab (Greece)

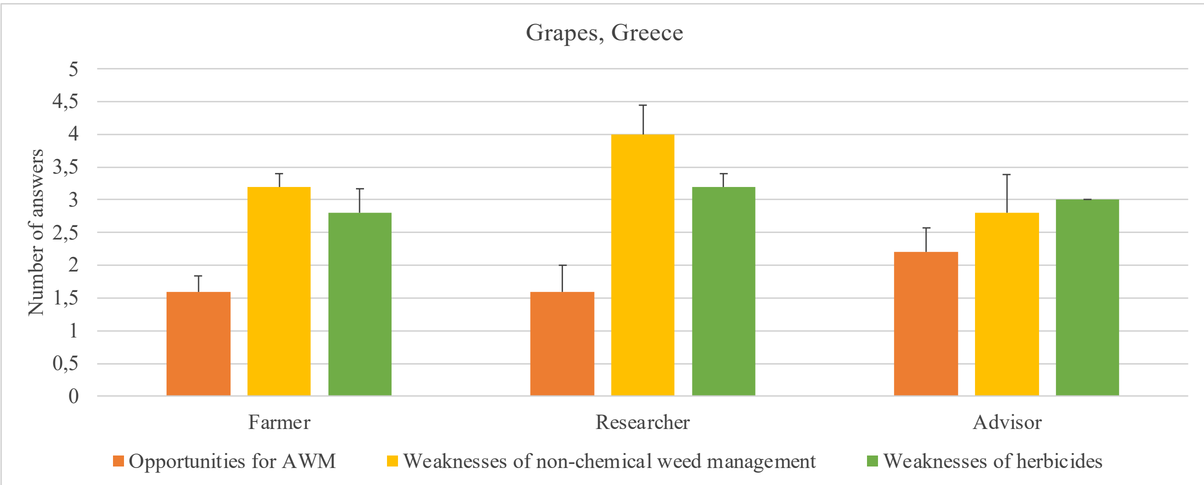


Figure 342. Mean number of answers (±se) per stakeholder group in the Grapes Living Lab (Greece)

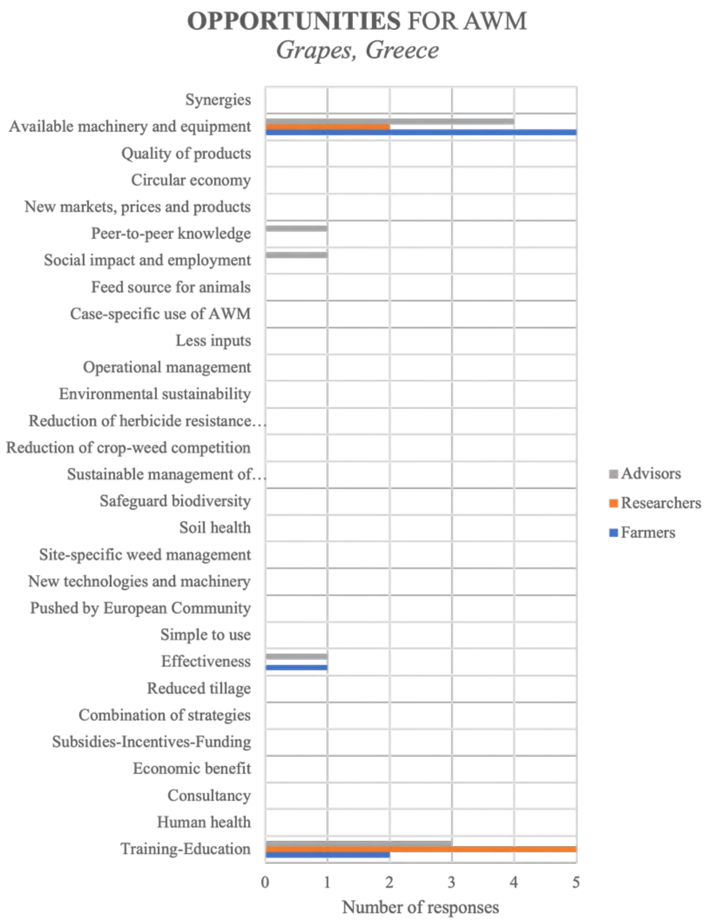
Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: Presented in the figure below.

THREATS: None.

WEAKNESSES: None.



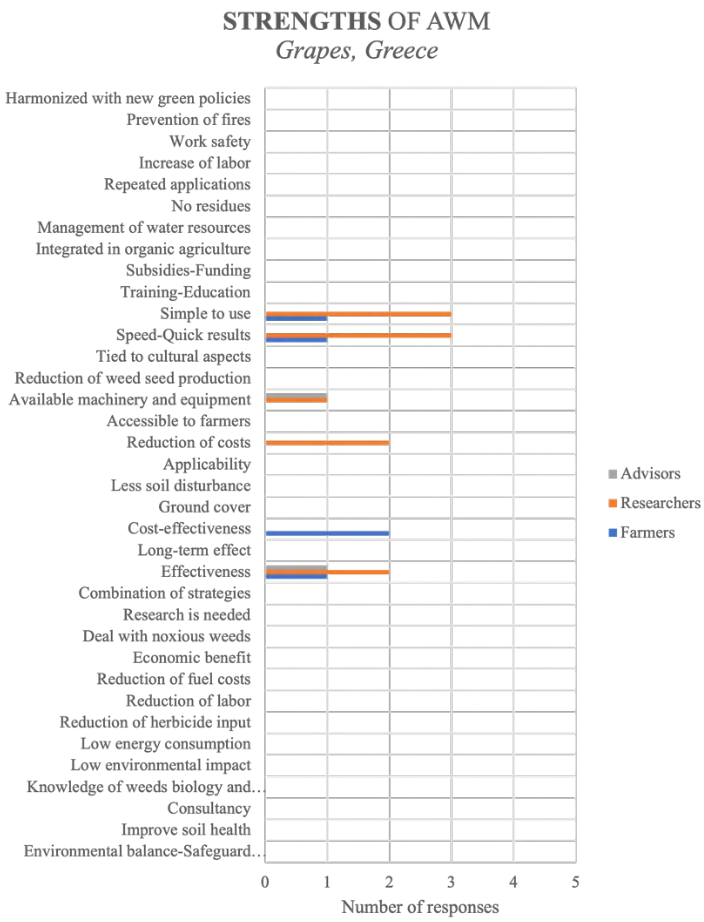


Figure 343. Opportunities and strengths of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: None.

WEAKNESSES: Presented in the figure below.

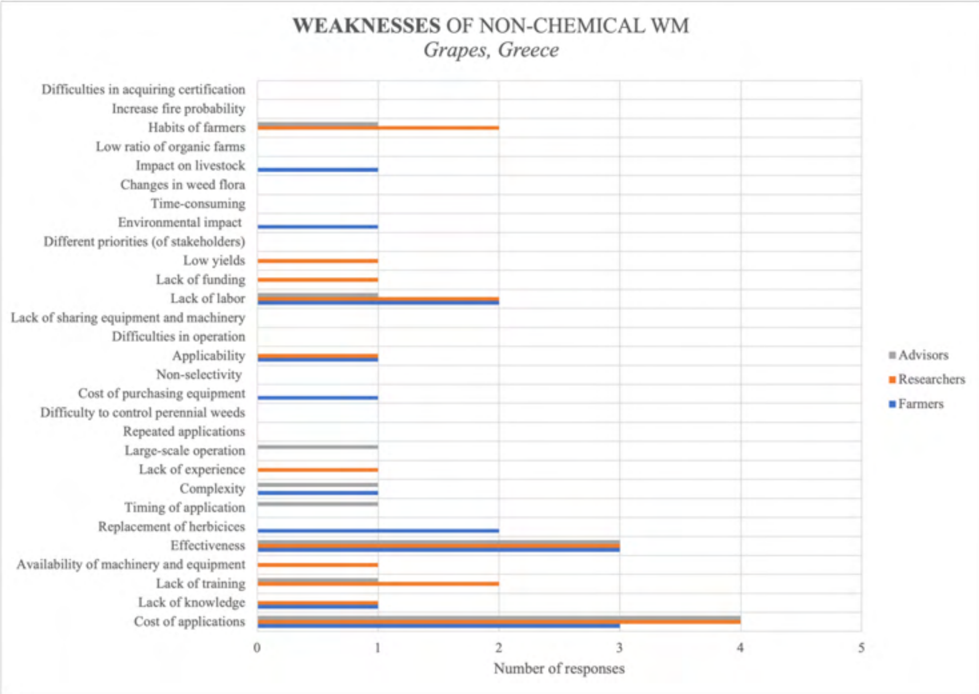


Figure 344. Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: None.

STRENGTHS: All stakeholder groups identified strengths of herbicides. Specifically, farmers mentioned the quick results, the efficacy and the cost-effectiveness. Researchers talked about efficacy, simplicity to use, optimized treatments and available equipment. Lastly, advisors highlighted the quick results, efficacy and how simple is to use herbicides.

THREATS: None.

WEAKNESSES: Presented in the figure below.

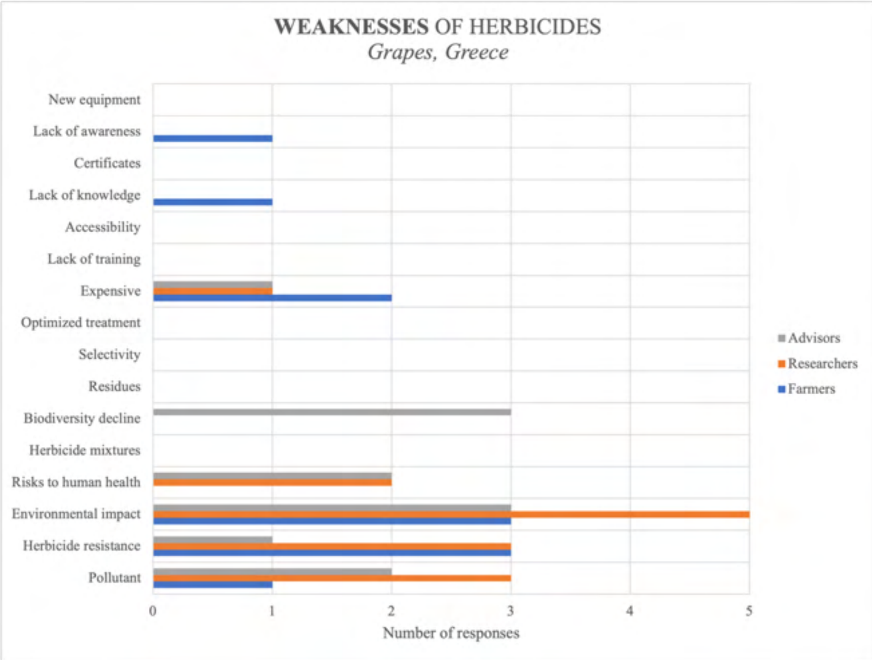


Figure 345. Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – GRAPES, GREECE
Most used weed management practices: According to the interviewees, weed management in grapes in Greece is almost entirely done with three practices: herbicides, mechanical control and mowing. **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group**: Participants showed a bias towards the effectiveness and ease of transition to non-herbicide systems, and this was reflected in the number of responses given to the weaknesses of non-chemical weed management, which was higher than the identified weaknesses of herbicides for farmers and researchers. **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: Agroecological weed management in grapes in Greece is strongly linked to training and education opportunities, as well as the availability of machinery and equipment. Some practices are considered easy to use and simple but the majority needs to be further tested in real field conditions. **Threats, and weaknesses for non-chemical weed management**: The lack of labor, knowledge, training and the habits of farmers are quite important weaknesses of non-

chemical weed management for Greek vineyards. If these are accompanied with the high cost of applications and the low effectiveness in some cases, then non-chemical weed management is still under further evaluation in this specific crop and area of the Living Lab. **Opportunities, strengths, weaknesses, and threats for herbicides**: All stakeholder groups identified strengths of herbicides. Specifically, farmers mentioned the quick results, the efficacy and the cost-effectiveness. Researchers talked about efficacy, simplicity to use, optimized treatments and available equipment. Lastly, advisors highlighted the quick results, efficacy and how simple it is to use herbicides. However, the environmental impact, the pollution and the risks to human health were identified as key weaknesses of herbicides by all interviewee groups. Herbicide resistance is also a factor that makes herbicides less attractive for weed management in grapes.

3.4.3.3 Living lab board meeting

The living lab board meeting was an online meeting held on 13th November 2023. The total number of participants in the meeting was 11 people. During the meeting, the GOOD project, LL, and the technical details - interventions were presented. There are more than 20 wineries in the Nemea region. There is interest in organic wine production and consequently in agroecological approaches. As far as weeds are concerned, mechanical cultivation is widely used in organic farming, but it is costly and carries the risk of erosion on very sloppy vineyards. Winegrowers are ready for smart farming approaches (drones, remote sensing, etc.) as part of their culture. As for the policy aspect is concerned, cover crops are already included in Annex 6 of good practices (mulching from November to March), but also in the intervention- eco-schemes (31.3). In the LL board meeting, this information was also collected:

What are the market characteristics of vine?	1. How many farmers cultivate vine in the region (approx.)?
	There are 20-25 wineries in the area with more than 100 farmers.
	2. How many products are derived from the vine?
	The products of the vine are mainly wine, raisins, vinegar and table grapes.
	3. Do you think that agroecological products could be promoted in local markets?

	There is an opportunity to bring the product to the market because people are willing to pay more for an organic- agroecological product.
	4. Do you believe that the region has a lack of technologies?
	Winegrowers are ready for smart farming (drones, remote sensing, etc.); this is already a part of their culture but is not yet a common practice.
What are the most common agricultural and weed management practices in vine?	1. What are the most common agronomic practices in vine?
	The most common agronomic practices are pruning, tillage (for mechanical weed control and soil aeration and moisture) and harvest
	2. What are the most common weed management practices in vine?
	The most common weed management practice is the combination of herbicides (chemical weed control) and mechanical control.
What is the herbicide use in vine?	1. How many active ingredients there are available? How many different mode of actions?
	There are 7 active ingredients available and only 4 modes of action.
	2. How many times do you spray in-season?
	They spray 1 to 2 times within a season.
	3. Do you use pre-emergence, post-emergence or both herbicides?
	The majority uses both kinds of herbicides, while a few farmers use only post-emergence herbicides.
	4. Are herbicides efficient?
	They are efficient except in some cases of weed resistance.
	5. Do you think that alternatives to herbicides are equally efficient?
	Agroecological practices have not been adequately tested and some of them seem less effective than herbicides but with pressure from the European Union to reduce chemicals we will be forced to switch to new methods.
	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?
	Herbicides pollute soil and water, reduce biodiversity and are harmful to humans and animals. However, if there is a limited number of applications and in full accordance to the registration (label), then the negative impact is minimum.

	7. Do you believe that agriculture without herbicides is viable?
	Yes. In vine, agriculture without herbicides could be viable.
What are the needs and barriers to assist agroecological transitions & adopt agroecological weed management approaches?	1. What is needed to boost the uptake of agroecological practices?
	To strengthen agroecological practices, workshops and demonstrations could be organized to show farmers the results of these practices and convince them to adopt such practices.
	2. What are the barriers towards agroecology implementation?
	Agroecology increases costs considerably, vine is a crop where heavy machinery cannot be used and there is a shortage of labor.
	3. Should policies need be redefined to allow agroecological transitions?
	Eco schemes that integrate agro-ecological management of crops could be developed.
	4. How confident you feel about the adoption of agroecological weed management practices?
	The majority sees such practices in a positive way. Many farmers and vineyard owners are turning (or want to turn) to alternative methods of weed control.
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	1. What are the main drivers of weed dispersal?
	The main causes of weed spread are rain, the transfer of weed seeds by uncertified seeds and mainly the transfer of weed seeds (and rhizomes-tubers) from one field to another by farmers' machinery.
	2. Which are the major and most noxious weeds in your area?
	The major and most noxious weeds are *Convolvulus arvensis* and *Sorghum halepense*.
	3. Are there any herbicide resistant weeds?
	Yes, there are herbicide-resistant weeds such as *Conyza canadensis*.
	4. Do you know any invasive plants in your area?
	There are invasive plants in the area such as *Conyza* species.
What do you think about the Living Lab?	1. Which proposals do you have for a good performance of the LL?
	Good communication during the implementation of agroecological practices, field days and visits

	2. Would you like it to remain over time?
	The aim is to maintain the living lab for the next years so that it can become a new tool for more sustainable solutions for weed control and integrated crop management.

3.4.4 Europe

3.4.4.1 Questionnaires

Greek, Spanish, and Italian stakeholders provided insights regarding AWM in grapes culture their respective regions. We considered five practices identified as relevant by enough respondents in at least two countries. These practices include grazing, herbicides, mechanical weeding, mowing, and mulching. However, we did not gather enough responses from policymakers in any of the practices. Table 38 presents the types of stakeholders who answered the questionnaires associated with different AWM practices and the number of respondents in each category.

Table 38 Number of responses for each AWM practice and stakeholder category in Grapes (Spain, Italy, Greece).

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control	1	1				
Biobased herbicides		5	2		1	1
Cover crop inoculation to increase competitiveness	1					
Cover crops		4	3	3		1
False seedbed		1		1		
Grazing		**8**	4	2	2	3
Herbicides	11	**2**	7	**7**	5	**11**
Intercropping		1	1			
Mechanical weeding	9	**11**	6	**9**	5	7
Mowing	**9**	**8**	7	6	5	5
Mulching		**7**	5			3
Natural enemies						
Other				1		
Site-specific spraying	1	1	1	1	3	
Thermal weeding		1				
UAV						1
n=98	16	30	12	13	12	15

3.4.4.1.1 Grazing

3.4.4.1.1.1 Consumers

Grazing was considered a relevant practice by consumers in both Spain and Italy. They unanimously believe that its implementation will enhance soil health and reduce reliance on herbicides. Additionally, nearly ninety percent of consumers in both countries agree that grazing fosters IPM and provides ecosystem services, such as increasing water availability and improving water quality. They also anticipate that grazing will evolve into an important scientific discipline, while also boosting business profitability, farmers' income, and stabilizing crop yields. Moreover, seventy-five percent of surveyed consumers emphasize the potential for grazing to increase biodiversity. In addition to the opportunities, consumers from both countries recognize that grazing presents numerous necessities. Nearly ninety percent of the consumers identify reduction of maintenance as a relevant need, while seventy percent emphasize practicing knowledge skills, training, and cost reduction as important necessities. Moreover, over sixty percent of them consider ecosystem services impact knowledge, management expertise, and timing reduction as important requirements for grazing implementation. However, consumers' perspectives regarding the barriers and disadvantages of grazing differ between Spain and Italy. Collectively, over sixty percent of the surveyed consumers from both countries consider training as the most relevant barrier. Additionally, half of them regard time consumption, lack of funds, and regulatory challenges as important impediments. Similarly, consumers' perspectives regarding grazing disadvantages differ between the two countries. Together, fifty percent of them consider time consumption, while the rest of the queried disadvantages were considered relevant by more than half of the respondents.

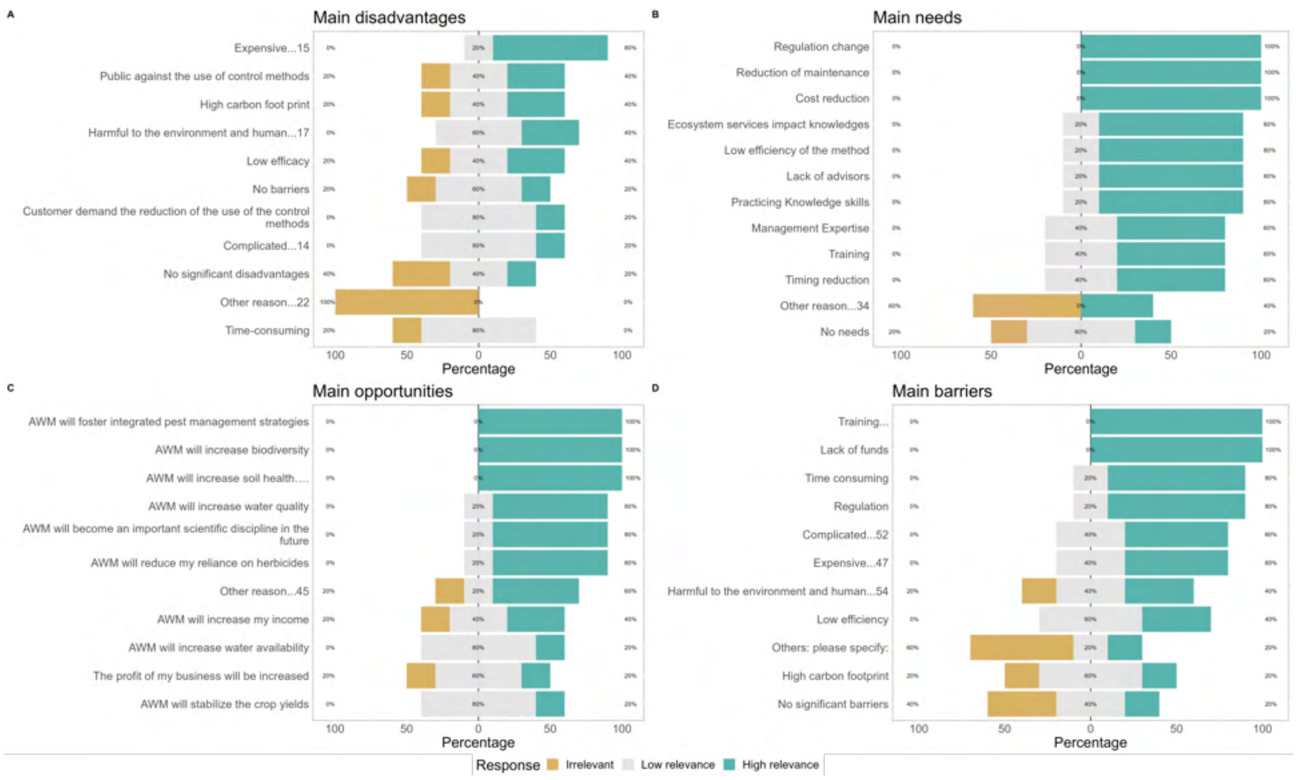


Figure 346. Main disadvantages, needs, barriers and opportunities for grazing identified by consumers.

3.4.4.1.1.1.1 By country

Consumers from both Spain and Italy share a positive outlook regarding grazing. In both regions, soil health and reduced herbicide reliance were considered relevant opportunities derived from grazing by all surveyed consumers. Italian consumers unanimously regard grazing as an ecosystem services provider, including benefits such as increased biodiversity, water availability, and improved water quality. They also unanimously recognize the potential for grazing to become an important scientific discipline. Most of these factors were similarly regarded as relevant by eighty percent of Spanish consumers, except for biodiversity increase, which was considered relevant by 60% of them. Additionally, Spanish consumers unanimously emphasize increases in income and business profitability, as well as crop yield stabilization, which were regarded as relevant by two-thirds of Italian consumers.

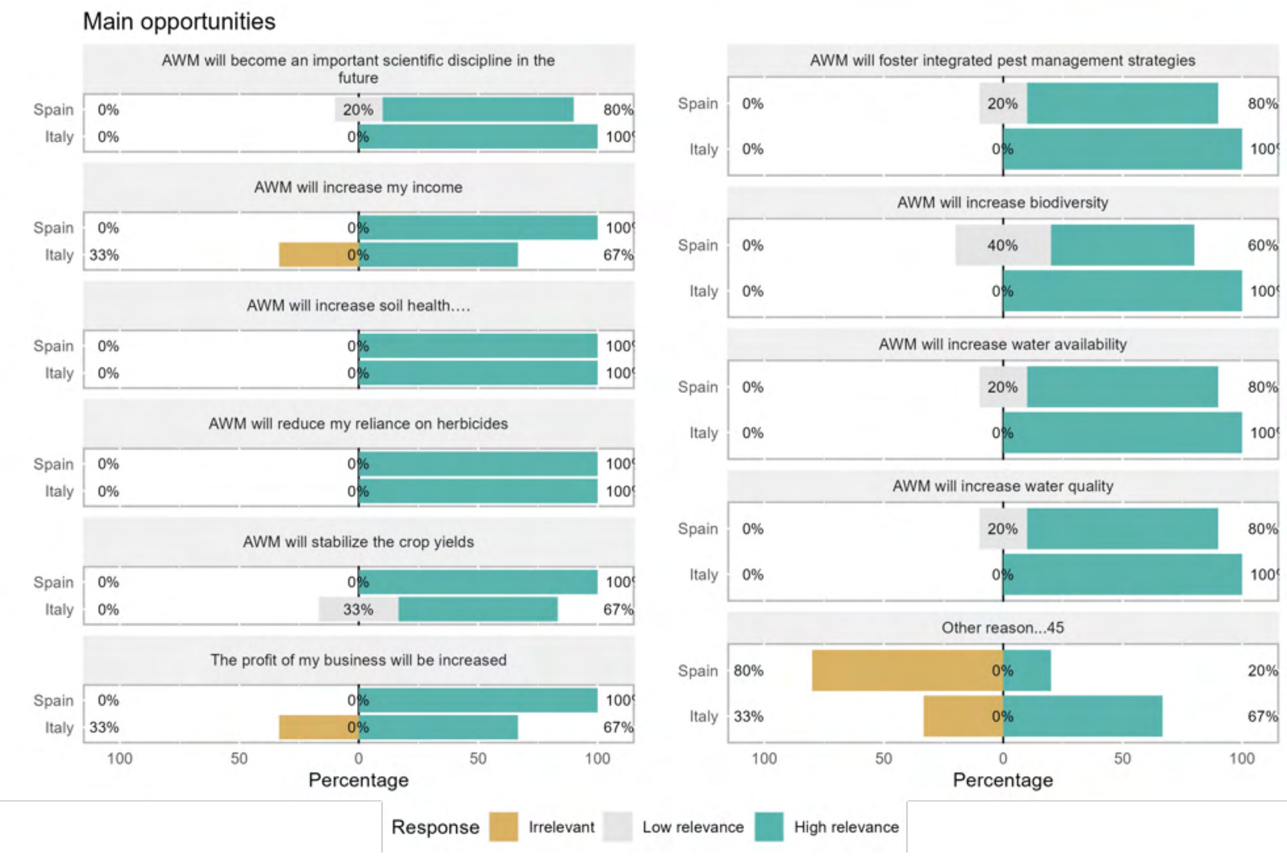


Figure 347. Main opportunities for grazing identified by consumers.

Italian consumers identified more relevant needs associated with grazing compared to the perspective in Spain. Both groups consider maintenance reduction as a primary need. Additionally, Italian consumers emphasize cost and timing reduction, while Spaniards prioritize practicing knowledge skills and training. Sixty percent of Spanish consumers and 67% of Italian consumers perceive management expertise and ecosystem services impact knowledge as relevant requirements.

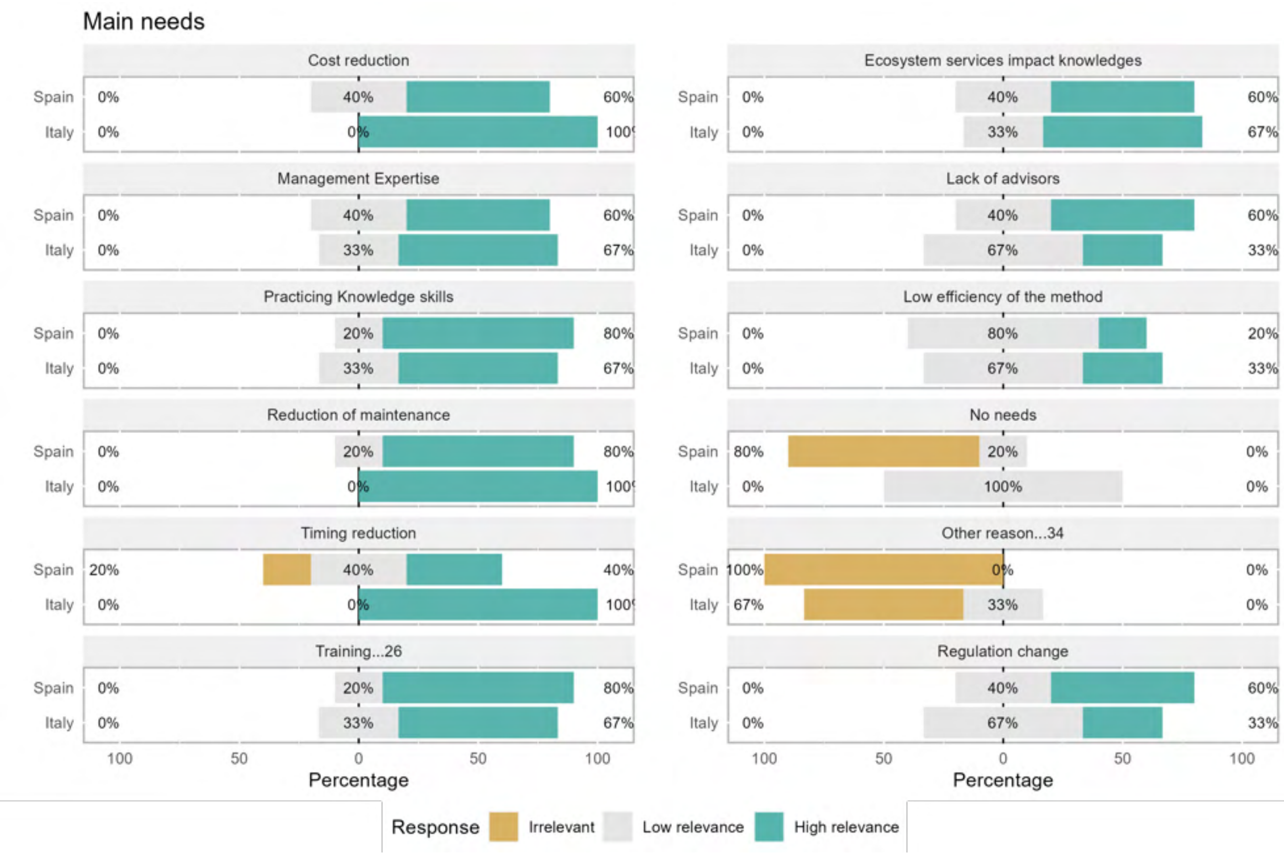


Figure 348. Main needs for grazing identified by consumers.

Consumers from Spain and Italy did not perceive the same factors as relevant barriers to grazing implementation. While training was unanimously considered the most relevant barrier by Spanish consumers, two-thirds of surveyed Italians emphasized expense, environmental and human harm, and high carbon footprint. Notably, the other queried barriers were not considered relevant by at least half of the Italian respondents. Additionally, sixty percent of Spanish consumers perceive lack of funds, regulatory challenges, and time consumption as significant barriers.

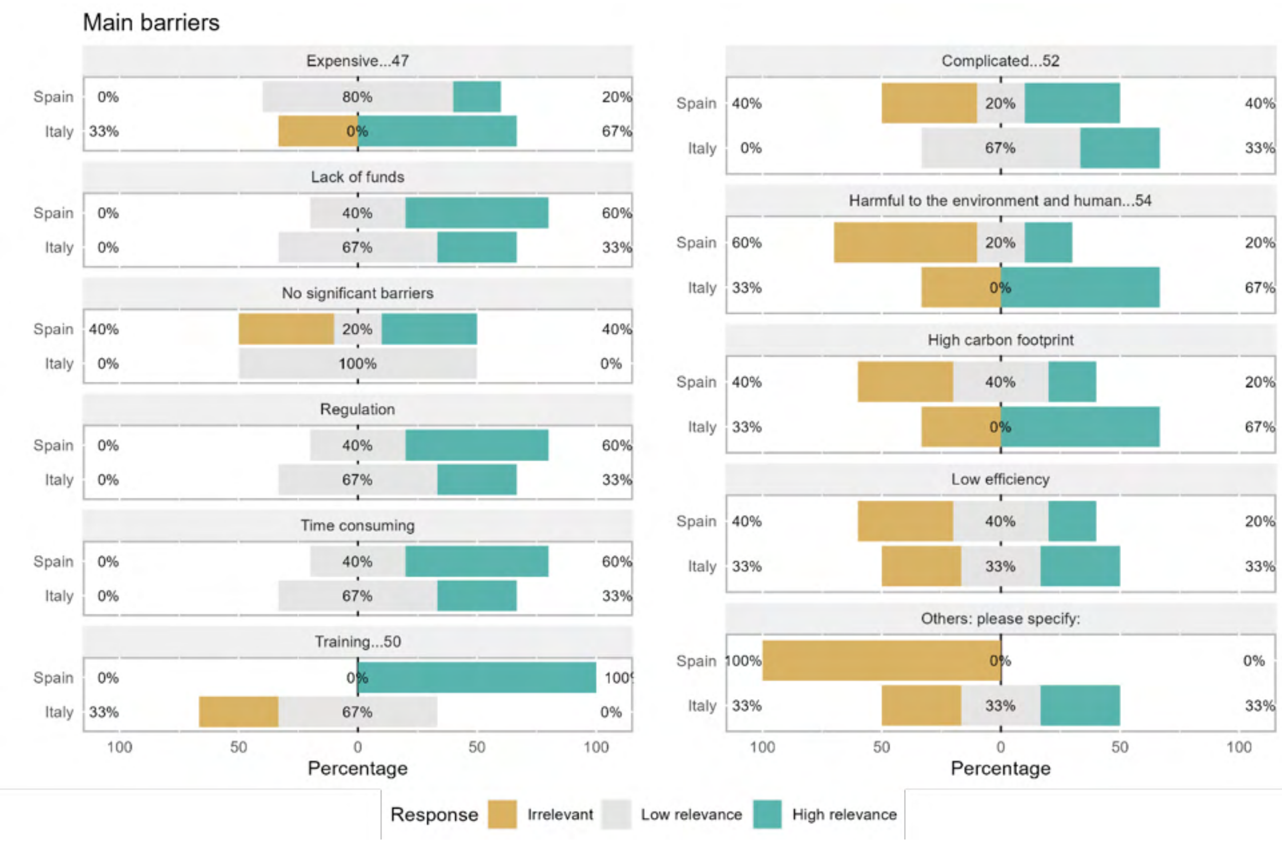


Figure 349. Main barriers for grazing identified by consumers.

Spanish consumers did not primarily consider any of the queried disadvantages as relevant. However, two-thirds of Italian consumers considered customer demand to reduce its use and time consumption as significant drawbacks. In comparison, only 40% of Spanish respondents regarded time consumption as a relevant drawback.

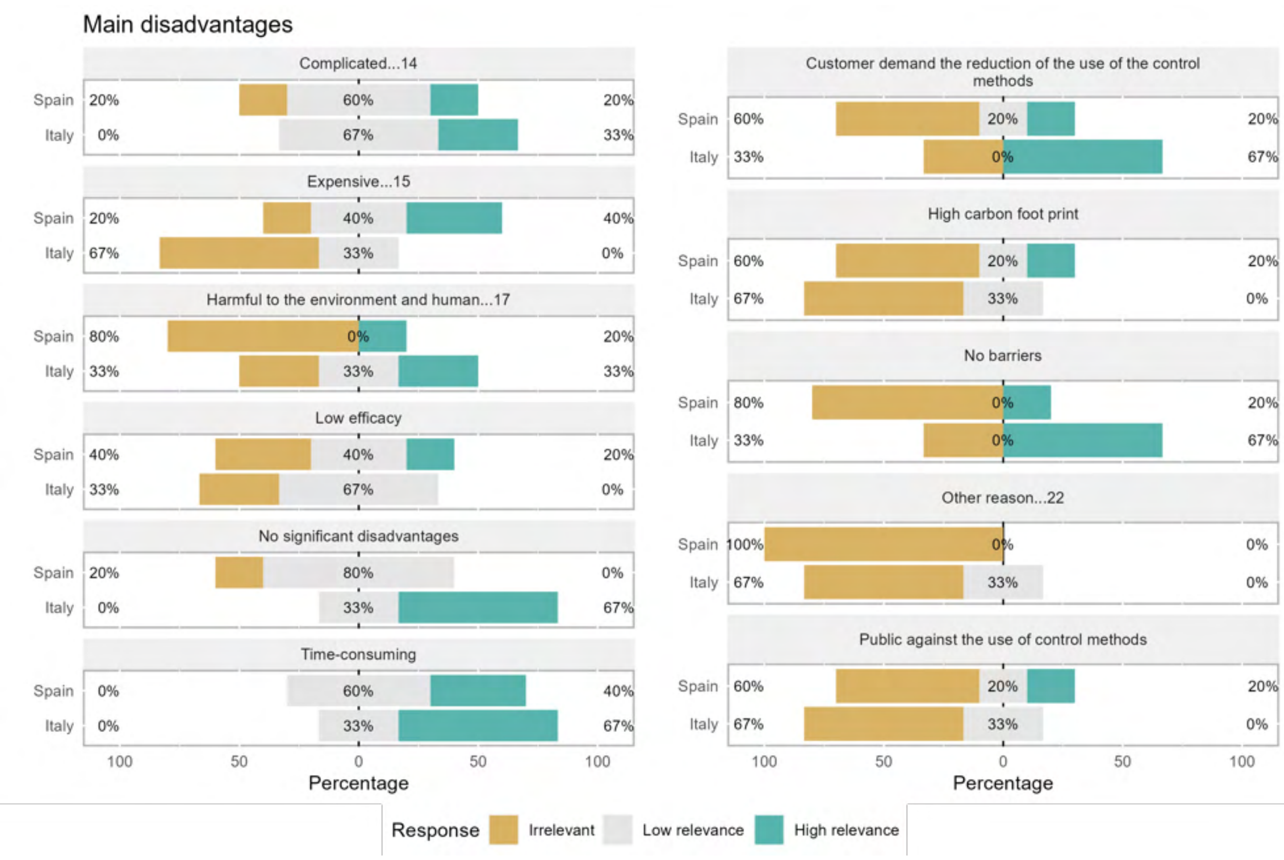


Figure 350. Main disadvantages for grazing identified by consumers.

3.4.4.1.1.2 Conclusion

Grazing was regarded as a practice with significant opportunities by both Spanish and Italian consumers. When analysing the data as a whole, they unanimously highlighted enhanced soil health and reduced herbicide reliance as the most important opportunities. Besides, Italian consumers unanimously emphasized grazing as an ecosystem services provider, including benefits such as increased biodiversity, water availability, and improved water quality, while also foreseeing its evolution into an important scientific discipline. Although most of these factors were deemed relevant by eighty percent of the Spanish respondents, this group emphasized increases in income and business profitability, as well as crop yield stabilization, which were considered relevant by two-thirds of Italian consumers.

Regarding the necessities associated with grazing, both groups collectively emphasized the reduction of maintenance as a key need. However, Italians also prioritized the reduction of cost and time, while Spaniards focused on practicing knowledge skills and training as primary needs. Training emerged as the most significant barrier unanimously among Spaniards, whereas two-thirds of Italian consumers highlighted expense, environmental and human harm, and high carbon footprint as major barriers.

Considering the responses from Spanish consumers collectively, over sixty percent identified training as the most significant barrier. Both Spanish and Italian consumers perceived grazing as a practice with few drawbacks. While two-thirds of Italians considered customer demand to reduce grazing and time consumption as important disadvantages, 40% of Spanish respondents regarded time consumption as a relevant drawback.

3.4.4.1.2 Herbicides

3.4.4.1.2.1 Advisors

Advisors in Greece and Spain considered herbicides as a relevant AWM practice. They perceive it as offering few opportunities and disadvantages, while entailing numerous needs and few but relevant barriers. Over half of the surveyed advisors collectively believe that herbicides foster IPM strategies. Additionally, 36% of them consider that the practice provides relevant ecosystem services and will increase farmers' income.

Advisors from both countries recognize that the practice presents relevant needs, with over ninety percent of them considering reduction of maintenance as the primary requirement. Moreover, 73% of the advisors consider regulatory changes and cost reduction as relevant necessities, along with 63% emphasizing ecosystem services and 55% considering timing reduction as relevant.

Regarding practice barriers, over seventy percent of the respondents believe that herbicides face regulatory challenges. None of the other factors were considered as relevant by more than half of the respondents. Similarly, none of the queried disadvantages were considered relevant by more than half of the respondents. However, 45% of the respondents considered customer demand to reduce or eliminate herbicides and environmental and human harm as relevant drawbacks.

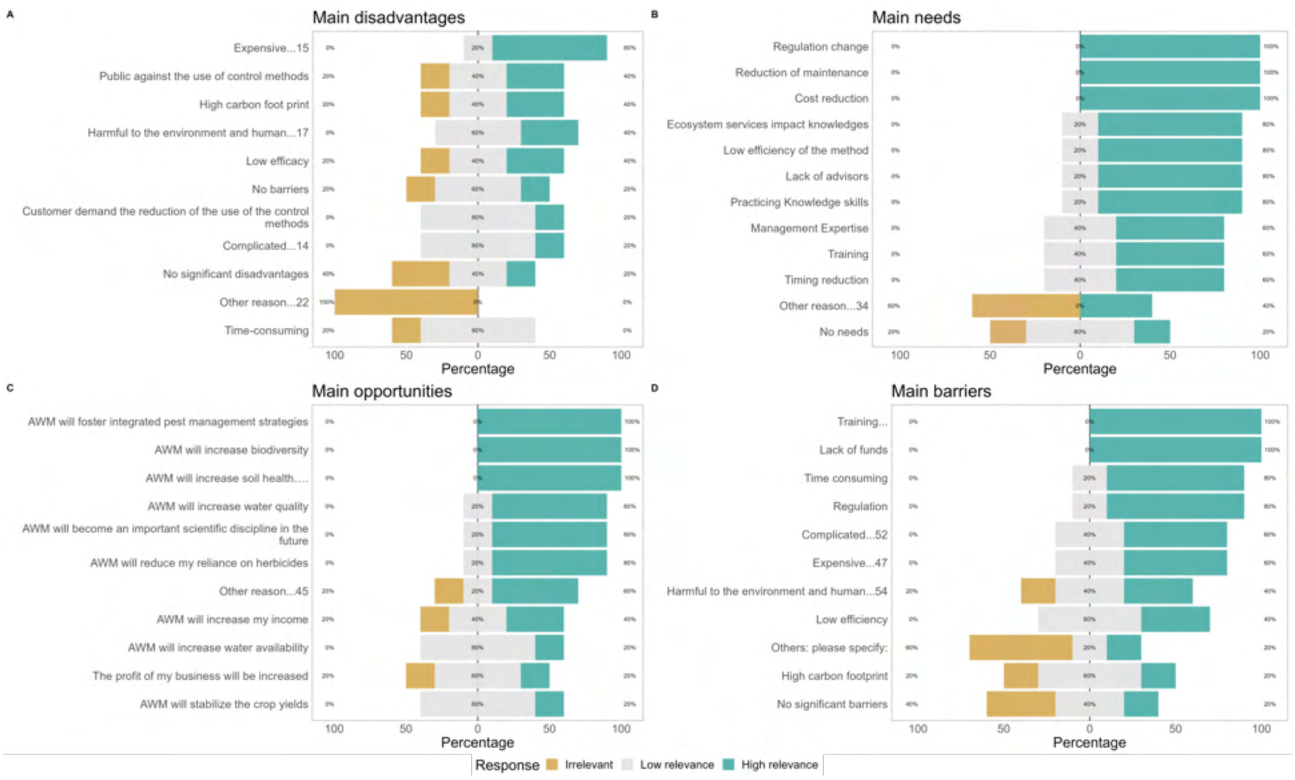


Figure 351. Main disadvantages, needs, barriers and opportunities for herbicides identified by advisors.

3.4.4.1.2.1.1 By country

In line with the collective perception of herbicides, advisors from Greece and Spain do not consider this AWM practice to present relevant opportunities. Over sixty percent of Greek advisors believe that it fosters IPM strategies, while one third of Spanish advisors share this view. Additionally, 38% of the respondents from Greece and 33% from Spain recognize that herbicides can potentially increase income, soil health, and water quality, among other benefits. They also identify that herbicides have the potential to evolve into an important scientific discipline.

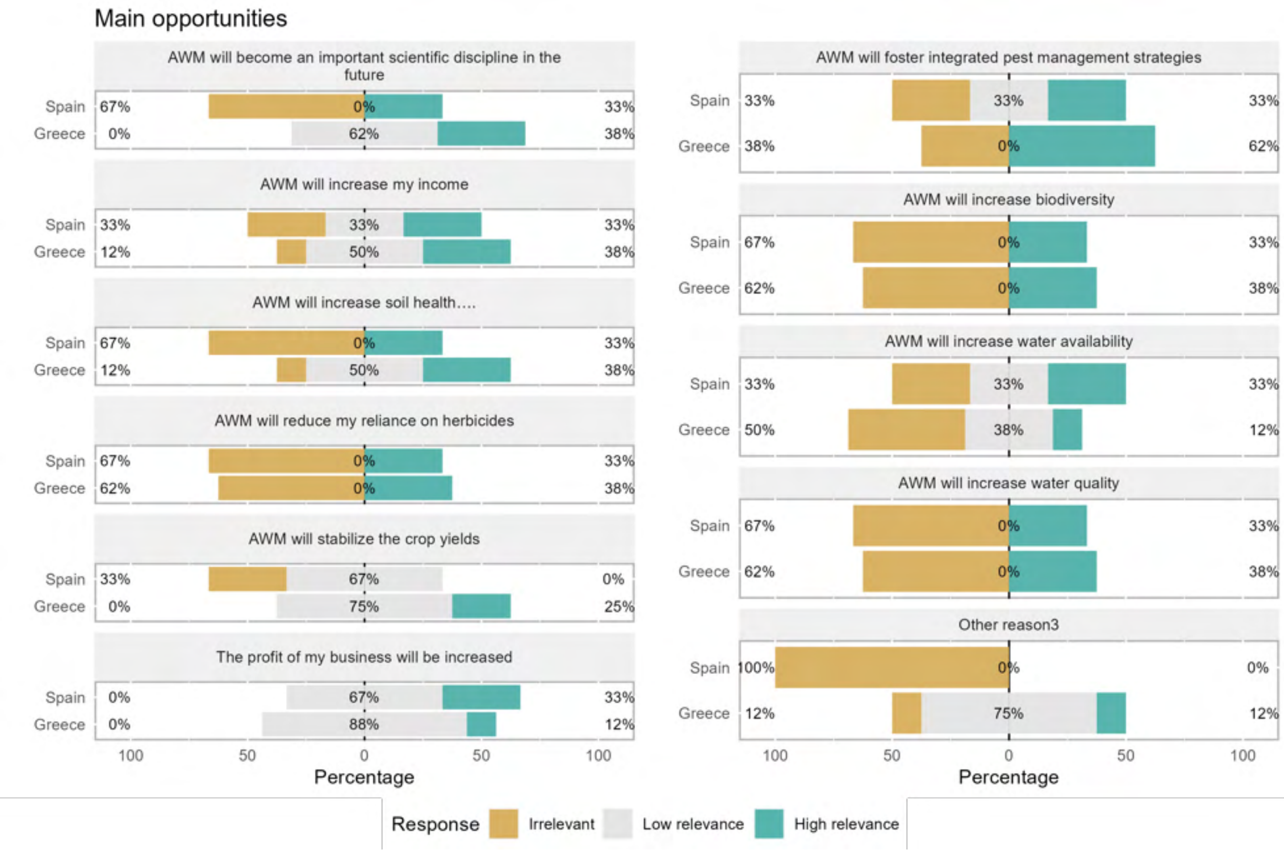


Figure 352. Main opportunities for herbicides identified by advisors.

Spaniards perceive herbicides as a practice with numerous relevant opportunities, while Greek advisors acknowledge some of them. Advisors from Spain unanimously consider maintenance, cost and timing reduction, regulatory changes as well as ecosystem services impact as primary needs. Besides, two thirds of the surveyed advisors in Spain emphasize management expertise, practicing knowledge skills, training and lack of advisors as relevant necessities. Maintenance (88%) and cost reduction as well as regulatory changes (62%) were also considered as relevant requirements by the surveyed advisors from Greece. Besides half of the Greek respondents acknowledge ecosystem services impact knowledge as relevant needs.

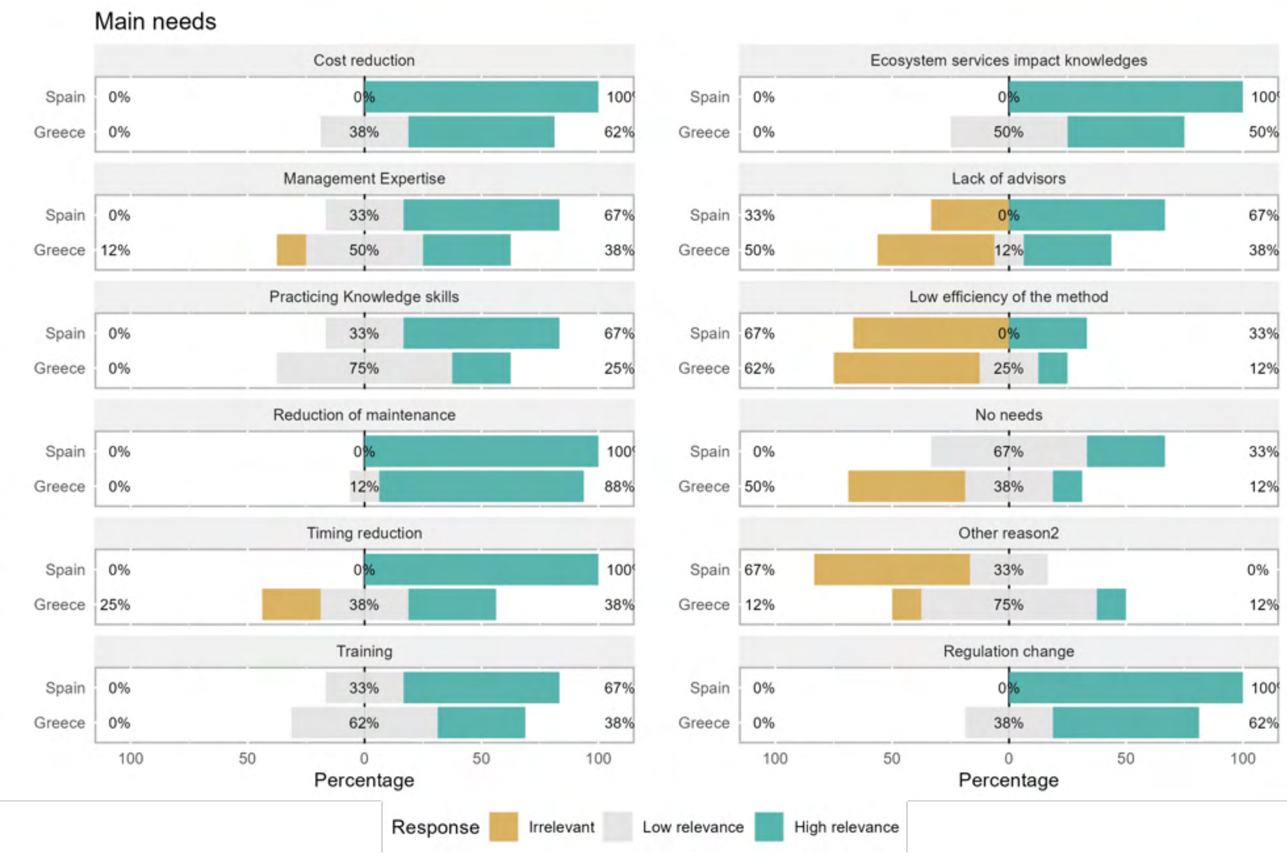


Figure 353. Main needs for herbicides identified by advisors.

The perspective of advisors regarding herbicide barriers differs across the studied regions. Regulatory challenges were considered as the most relevant barrier by all Spanish respondents and by over sixty percent of the Greek advisors, who also cited expense as a relevant impediment. Additionally, all Spaniards unanimously acknowledged that herbicide use does not present significant barriers. Correspondingly, the rest of the barriers considered highly relevant were cited by only one-third of the respondents.

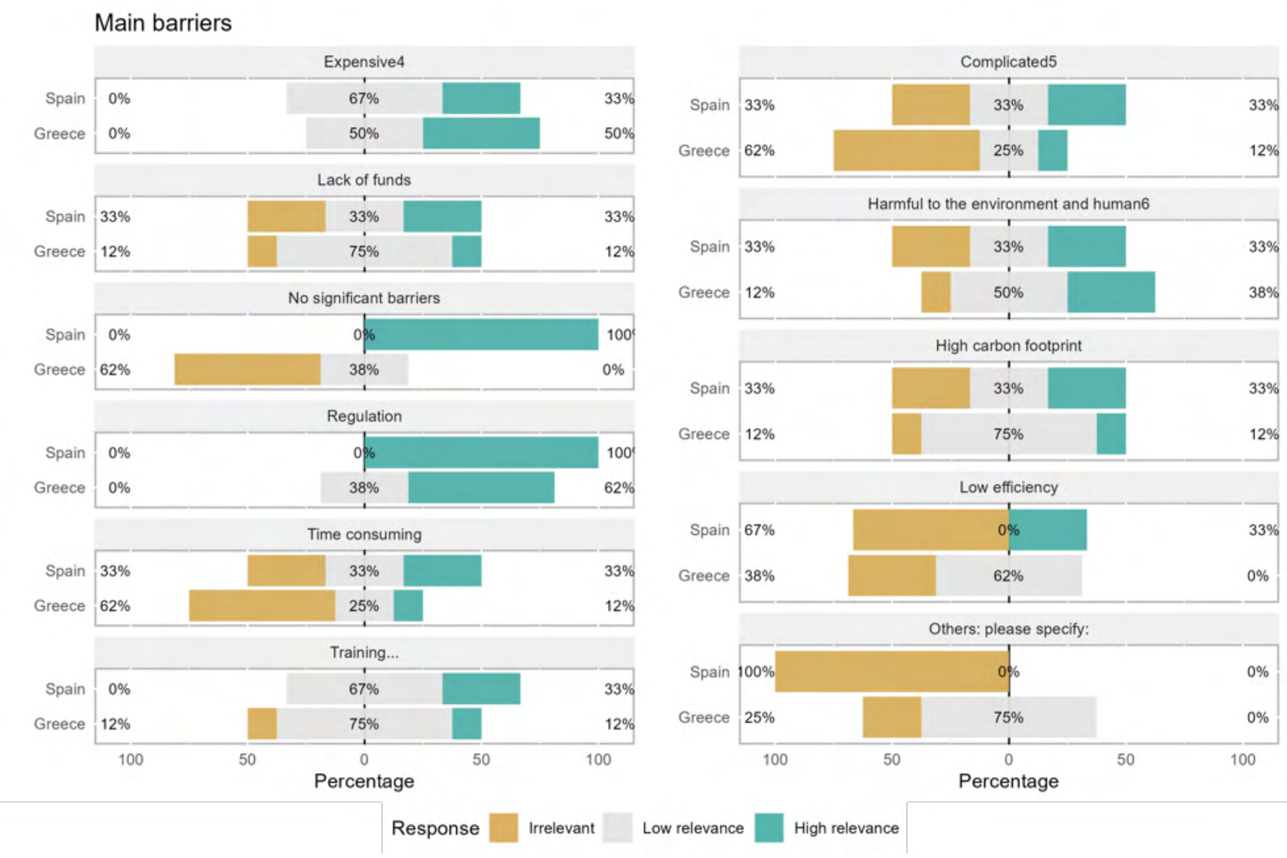


Figure 354. Main barriers for herbicides identified by advisors.

The perception of herbicide disadvantages varied across the studied regions. While collectively advisors consider herbicides as a practice with few opportunities, all Spanish advisors regarded public demand to either reduce or eliminate herbicides as the most relevant disadvantage. Conversely, this factor was considered relevant by only one quarter of the Greek advisors. Additionally, potential environmental and human harm were deemed relevant by half of the Greek respondents, while just one third of the Spanish respondents considered it highly relevant. The rest of the queried disadvantages were not considered as relevant by a significant proportion of respondents.

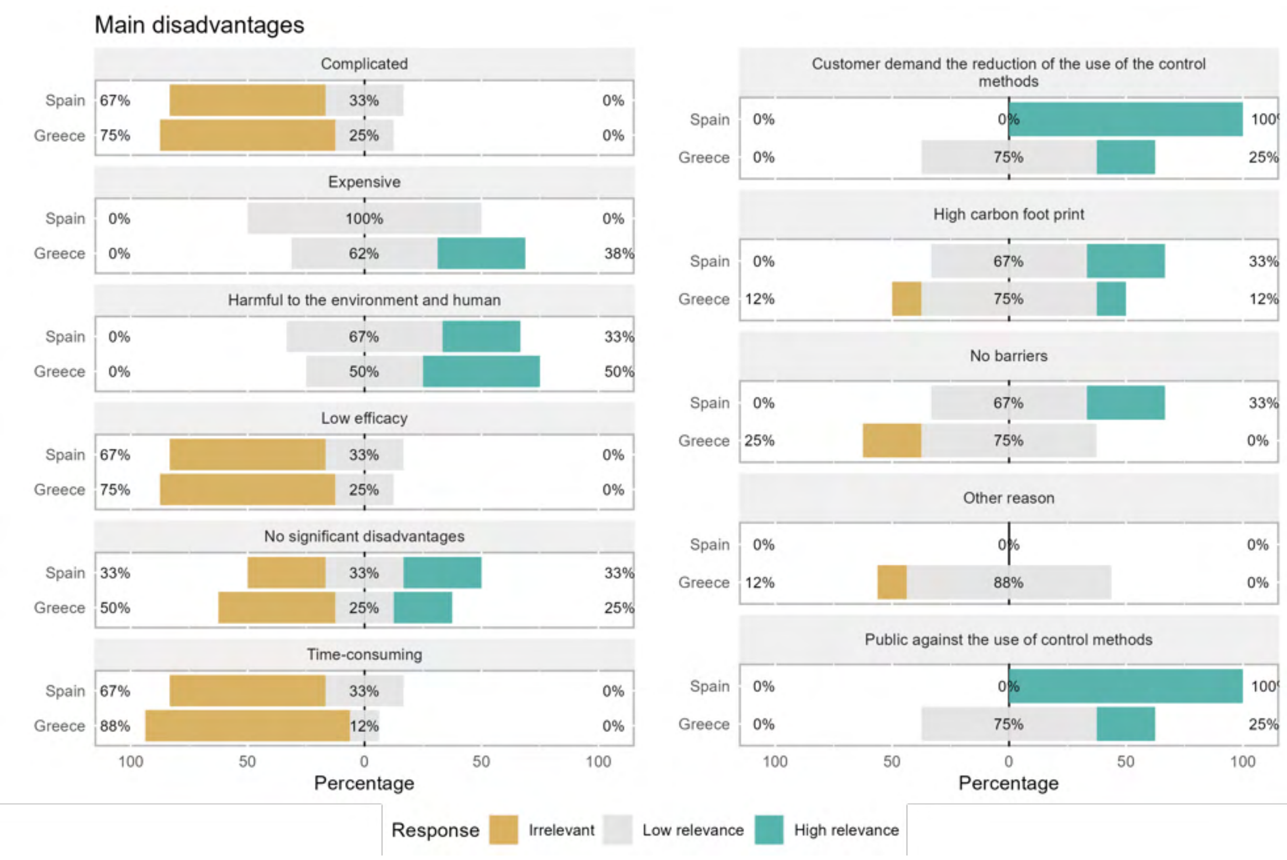


Figure 355. Main disadvantages for herbicides identified by advisors.

3.4.4.1.2.2 Consumers

Consumers across the studied regions shared a pessimistic view toward herbicides, collectively recognizing few opportunities while acknowledging important needs, barriers, and disadvantages. Consumers from Greece and Spain did not primarily regard any of the queried opportunities as highly relevant. Only 32% of the respondents considered increased business profitability, farmers' income, and crop yield stabilization as potential benefits derived from herbicide use.

Regarding primary needs, consumers collectively considered regulatory changes as the most important requirement, accounting for nearly three-quarters of the respondents. Moreover, over sixty percent of them cited practicing knowledge skills, training, maintenance and cost reduction, ecosystem services impact knowledge, and management expertise as relevant necessities.

A little over fifty percent of the surveyed consumers considered the lack of advisors as a relevant requirement. Environmental and human harm, along with regulatory challenges, were considered the most relevant barriers by over seventy percent of respondents. Additionally, 63% considered training, and 58% cited expense as relevant barriers. Environmental and human harm were also considered the most relevant disadvantages by nearly 80% of the respondents, followed by 68% citing expense. Over 50% of them shared concerns regarding public demands to either reduce or eliminate herbicide use altogether.

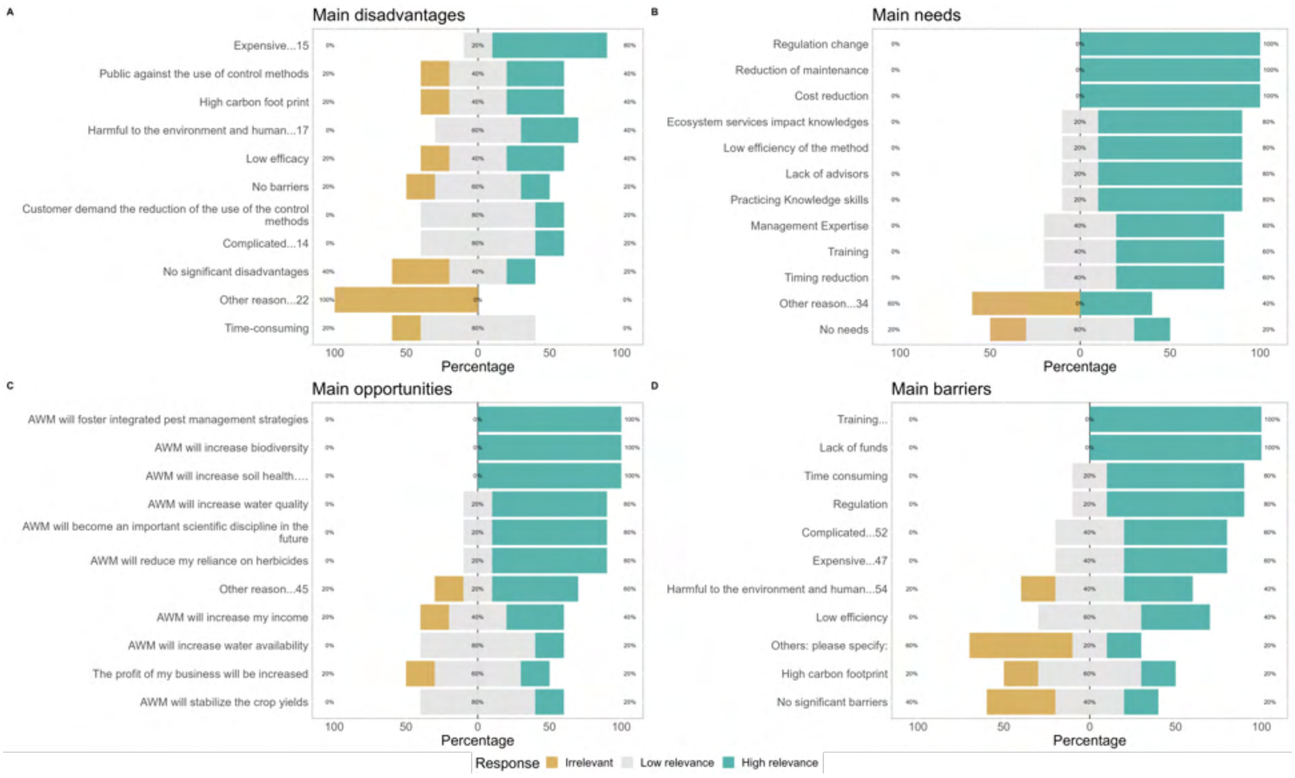


Figure 356. Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

3.4.4.1.2.2.1 By country

Aligned with the collective perspective, consumers from Greece and Spain did not perceive herbicide use as a practice with relevant opportunities, as none of the queried factors were considered significant by a significant proportion of respondents. Among Spanish consumers, forty percent viewed increased income and reduced herbicide reliance as the most relevant potential opportunities. In contrast, only one-third of Greek consumers regarded crop stabilization, increased business profitability, and increases in water availability and biodiversity as possible opportunities.

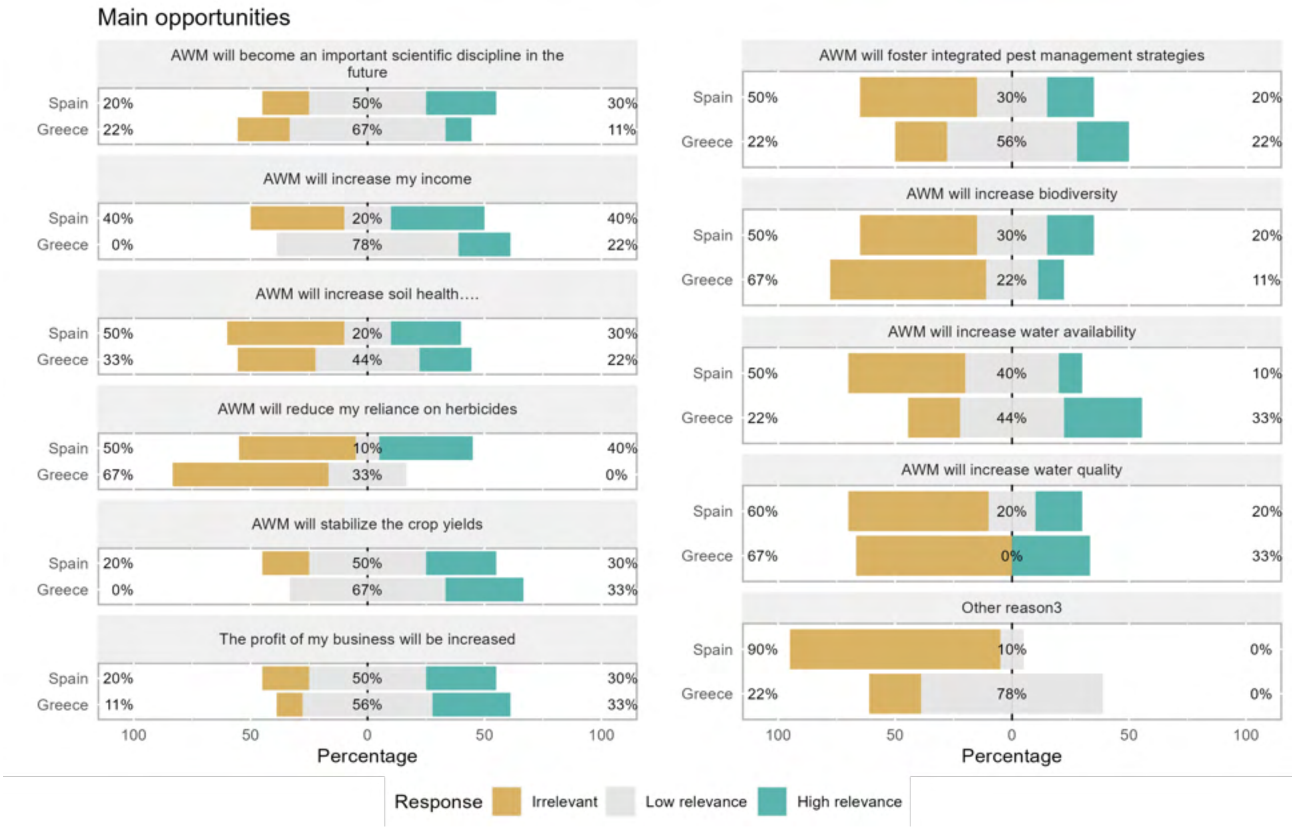


Figure 357. Main opportunities for herbicides identified by consumers.

Consumers collectively regarded herbicides as an AWM practice that entails relevant needs, yet the perception of the relative importance of appointed needs varies across the studied countries. Spanish consumers perceive herbicide as presenting more relevant needs compared to Greek consumers' perception. However, both groups emphasize regulatory changes as highly relevant needs, with 80% of Spanish respondents and 67% in Greece recognizing this aspect. Additionally, eighty percent of surveyed consumers in Spain and 56% of Greek respondents acknowledge practicing knowledge skills, reduction of maintenance, and training as important requirements for herbicide implementation. Moreover, both groups emphasize timing and cost reduction as relevant necessities.

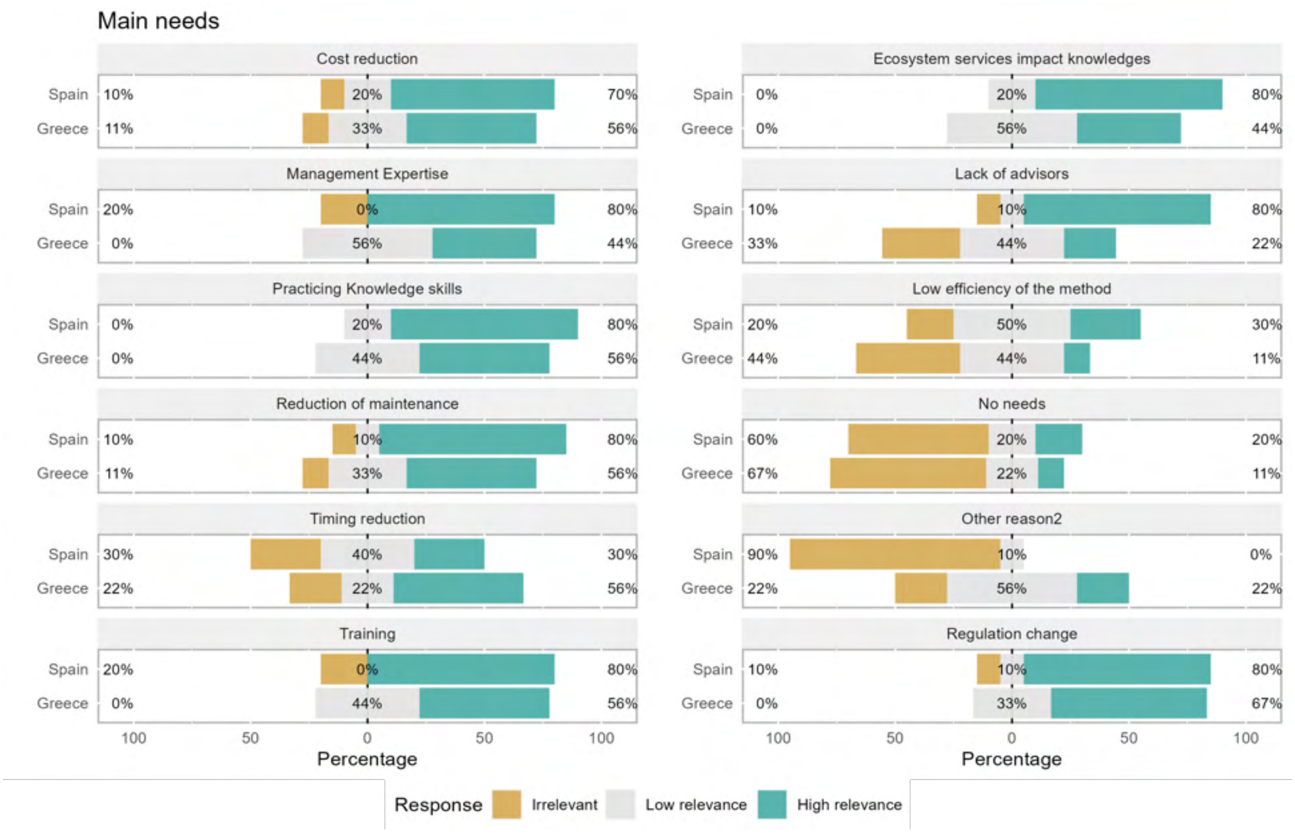


Figure 358. Main needs for herbicides identified by consumers.

Spanish and Greek consumers collectively recognize herbicides as a practice that faces relevant barriers, yet, as in the case of appointed needs, they differ in the relative importance of each factor, and Spaniards share higher rates of concern compared to their Greek counterparts. For instance, ninety percent of the Spanish respondents considered environmental and human harm as a relevant barrier, while the same category was considered relevant by 56% of the respondents from Greece. Eighty percent of the Spaniards and 67% of Greek consumers considered regulatory challenges and high carbon footprint as relevant impediments. Both groups recognized training, expense, and lack of funds as relevant barriers.

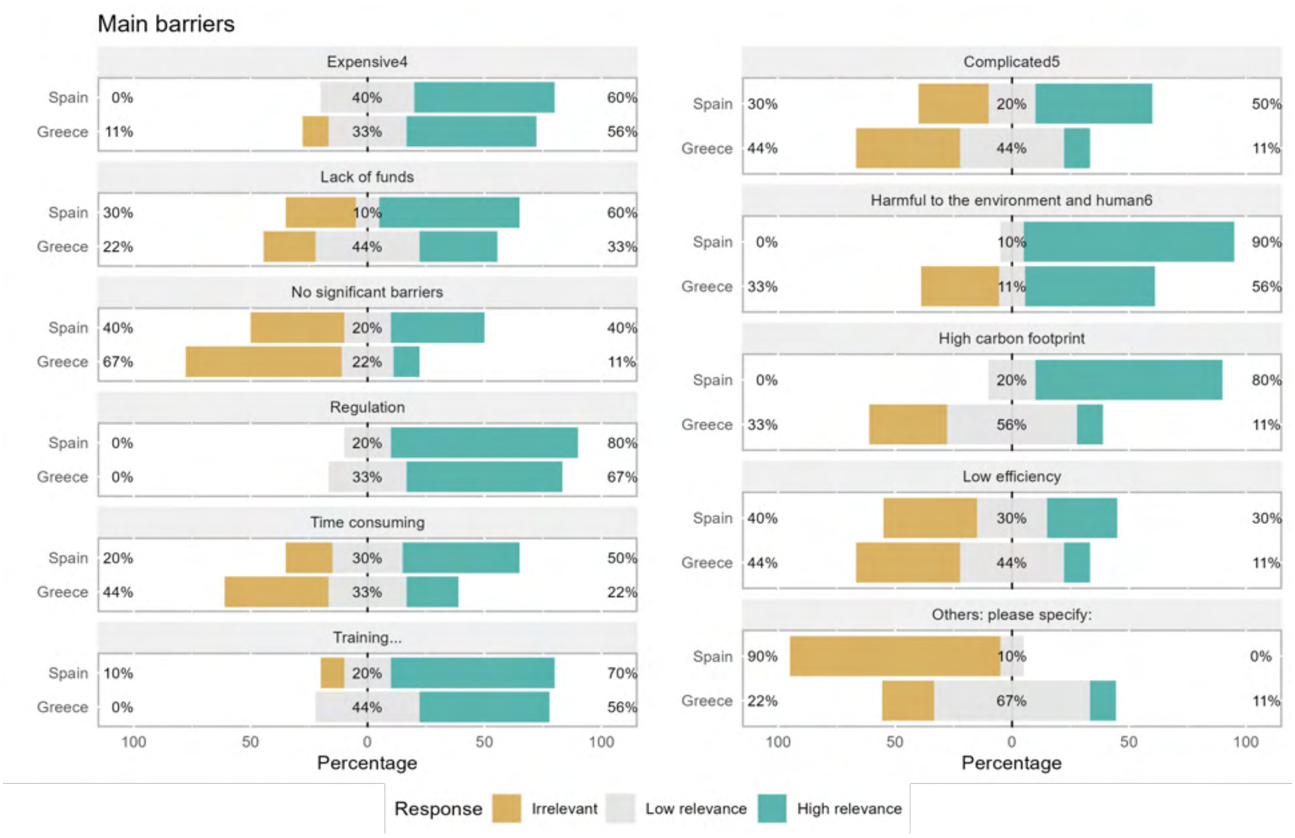


Figure 359. Main barriers for herbicides identified by consumers.

The collective perception of herbicide disadvantages by consumers was mostly influenced by the Spanish perspective, as they considered that this practice presents highly significant drawbacks compared to Greek respondents. While only 56% of Greek respondents considered expense and environmental and human harm as important concerns, these categories were deemed as highly relevant by 80% and 100% of Spanish respondents, respectively. Additionally, Spaniards highlighted customer demand to reduce or eliminate herbicide use (90%) and their high carbon footprint (70%) as important disadvantages.

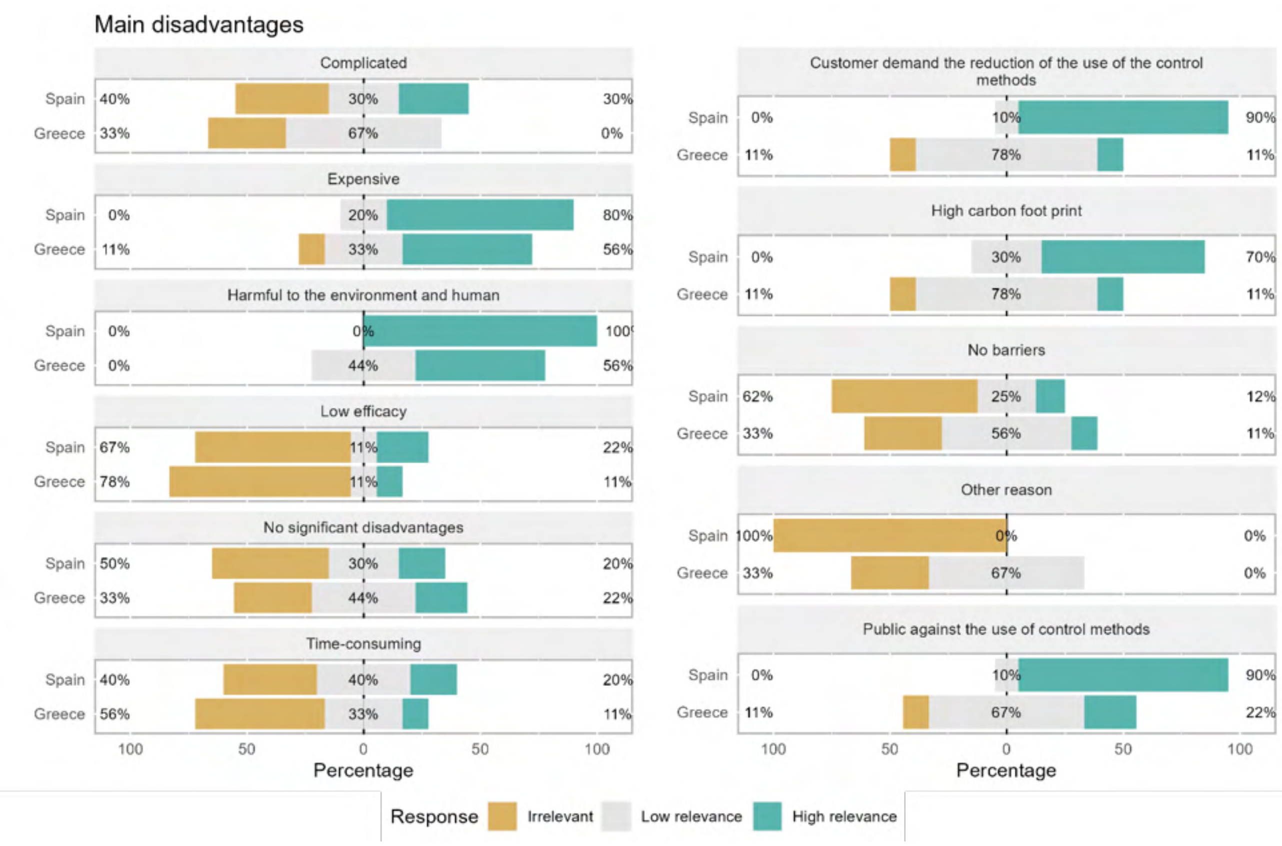


Figure 360. Main disadvantages for herbicides identified by consumers.

3.4.4.1.2.3 *Industry*

Industry representatives shared a conservative perspective on herbicides. They acknowledged that the practice presents important necessities and recognized some opportunities and disadvantages related to its use, while not considering any significant barriers. Half of the respondents considered increases in business profitability and crop yield stabilization as the most relevant opportunities. Additionally, one third of the respondents from both countries emphasized several factors, considering this practice as an IPM fosterer along with ecosystem services, among others. Nearly seventy percent of the surveyed industry representatives considered ecosystem services impact knowledge as the primary need for herbicides. Moreover, half of them emphasized regulatory concerns, practicing knowledge skills, training, cost, and timing reduction as relevant requirements. None of the queried barriers were regarded as relevant by more than half of the respondents. One third of them considered environmental and human harm, as well as complexity and training, among other factors, as relevant. As for the perceived disadvantages, half of the respondents considered environmental and human harm as relevant. Notably, the same proportion considered that this practice does not present any significant disadvantages.

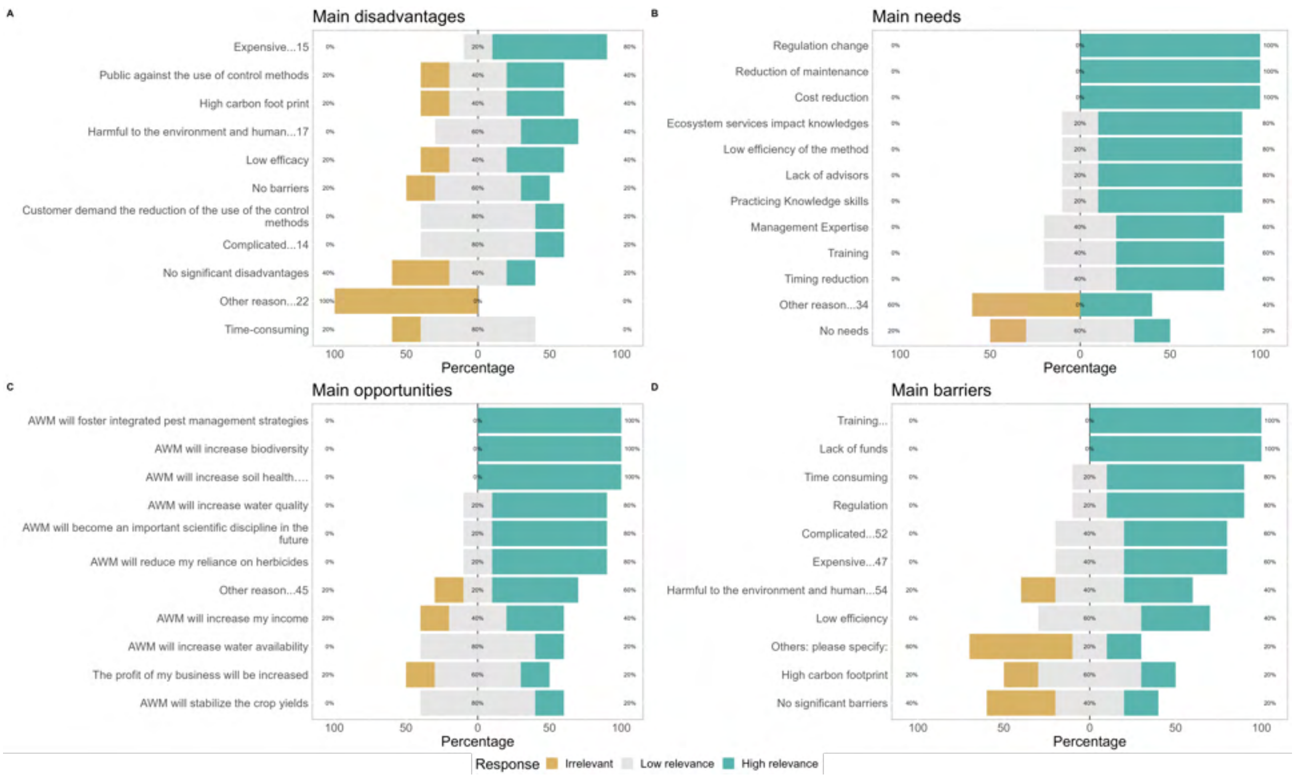


Figure 361. Main disadvantages, needs, barriers and opportunities for herbicides identified by industry.

3.4.4.1.2.3.1 By country

Spanish respondents considered that herbicides present more opportunities compared to their Greek peers. Two-thirds of the Spanish respondents regarded the practice as an IPM fosterer and recognized that it provides relevant ecosystem services, including increases in biodiversity, water quality and availability, as well as soil health improvements. Similarly, the same proportion of Greek industry representatives emphasized crop yield stabilization and increases in business profitability. These categories were regarded as relevant by one-third of the Spanish respondents, who also consider that its use will increase farmers' income and has the potential to evolve into an important scientific discipline.

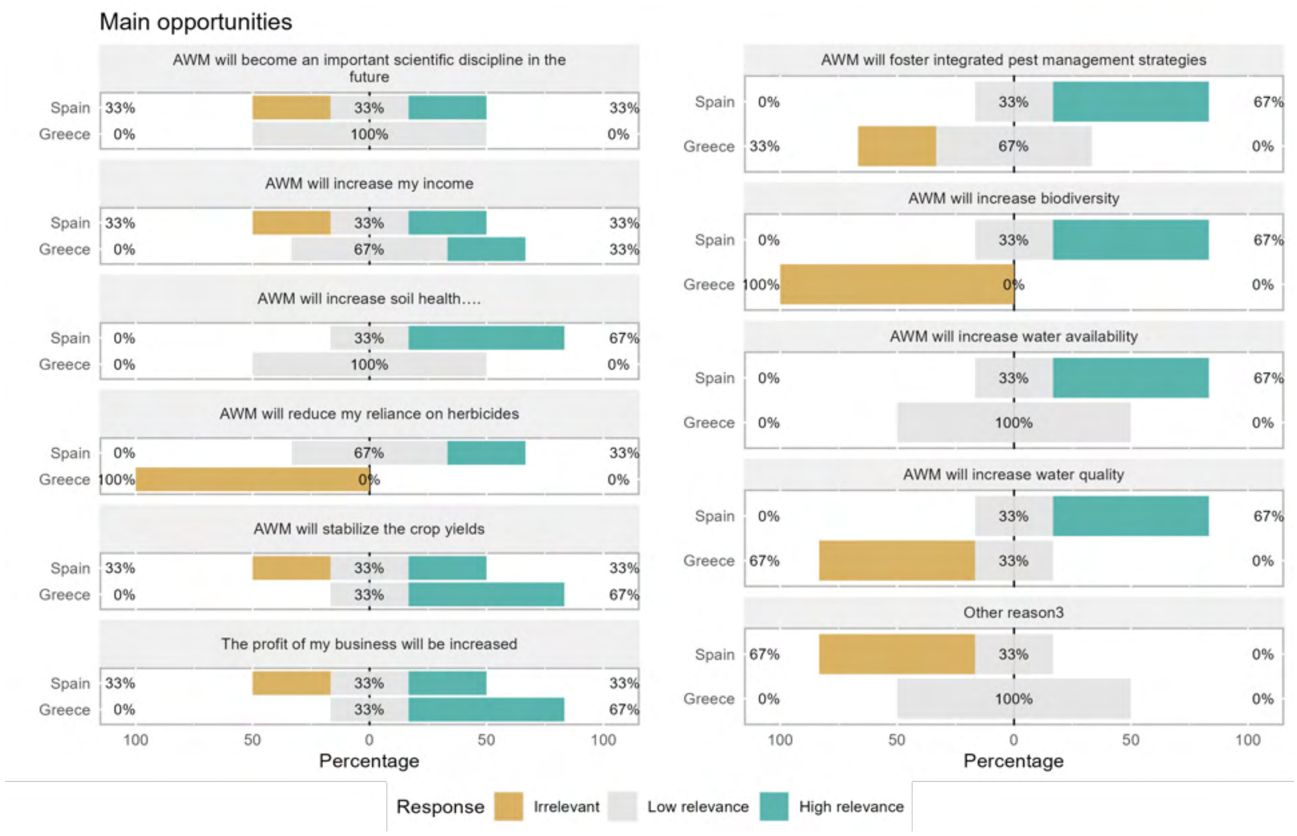


Figure 362. Main opportunities for herbicides identified by industry.

Industry representatives from Spain unanimously acknowledge ecosystem services impact knowledge, practicing knowledge skills, and training as primary needs. In contrast, the Greek respondents did not mainly consider any of the queried necessities as relevant for herbicides. Two-thirds of the respondents from Spain considered cost and timing reduction, management expertise, lack of advisors, and regulatory challenges as relevant requirements. One-third of the respondents from both countries consider reduction of maintenance as relevant. Additionally, Greek industry representatives emphasized ecosystem services impact knowledge, regulatory challenges, as well as reduction of timing and cost.

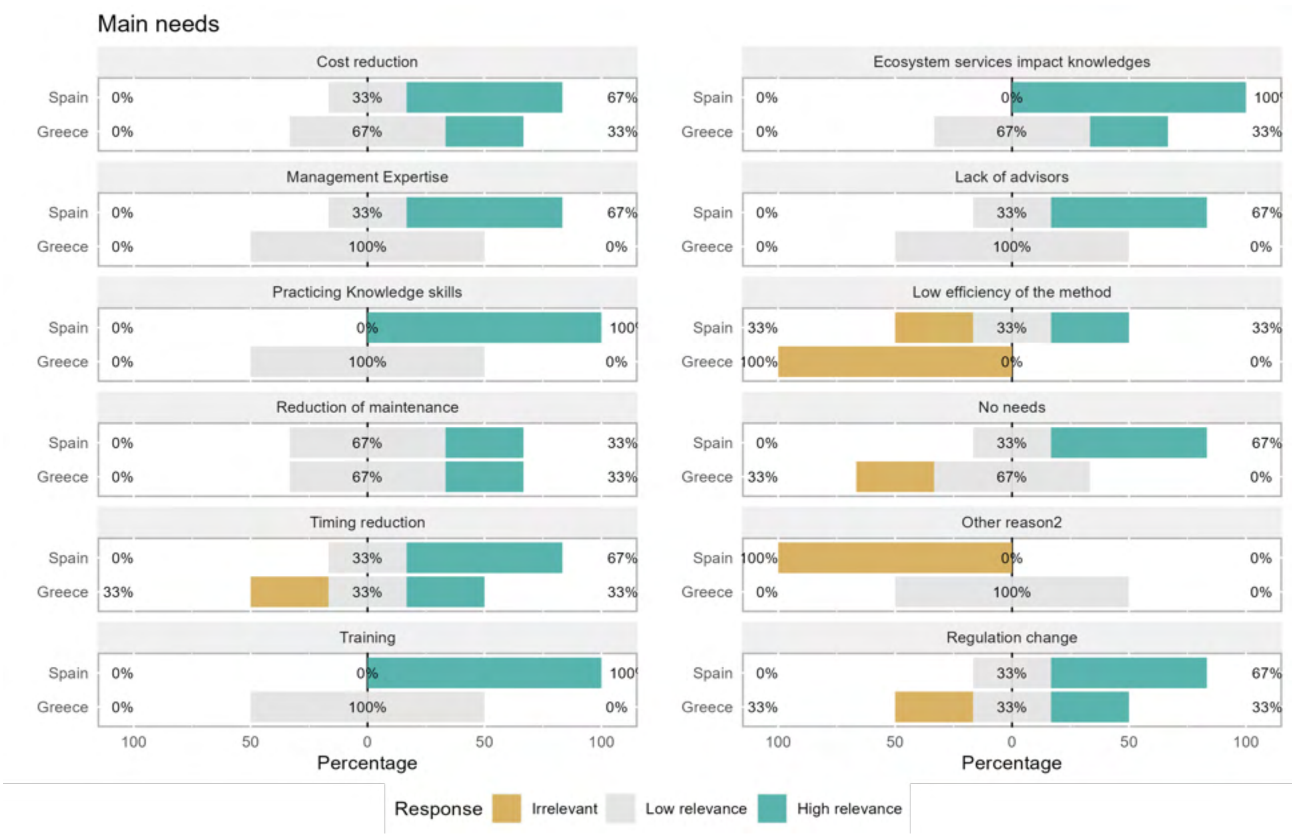


Figure 363. Main needs for herbicides identified by industry.

Greek respondents did not consider any of the queried barriers as relevant, while two thirds of Spaniards emphasized expense, lack of funds, regulatory challenges, time consumption, along with training, complexity as well as environmental and human harm as relevant barriers to herbicides. Besides, one third of the Spanish respondents considered low efficacy, high carbon footprint as relevant impediments. The same proportion of respondents considered that this practice does not present any significant barriers.

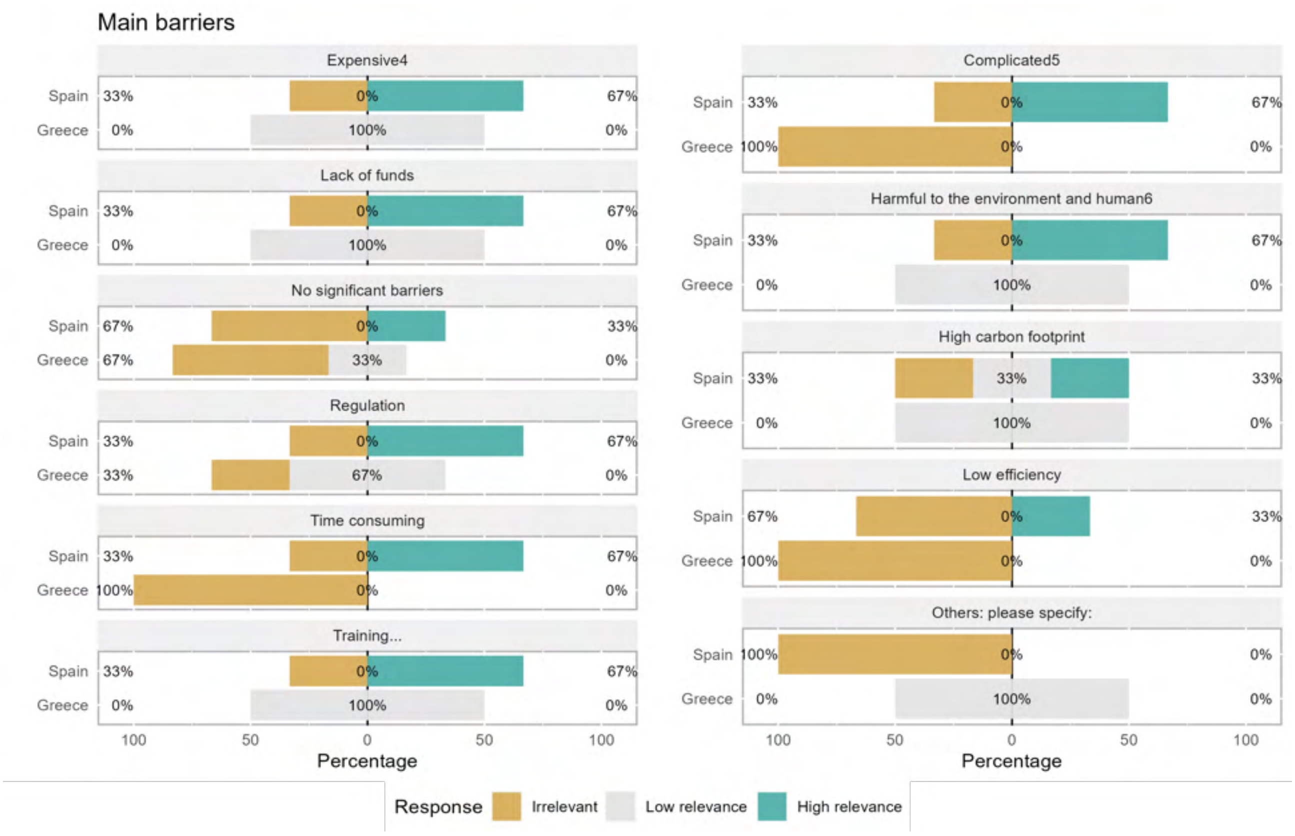


Figure 364. Main barriers for herbicides identified by industry.

Two-thirds of the Greek respondents considered that herbicides do not present any significant disadvantages. In contrast, Spanish industry representatives unanimously perceive the potential damage to environmental and human health as the most relevant disadvantage. Two-thirds of the Spaniards share concerns regarding public opposition to their implementation as important. Notably, half of them consider that herbicides do not present any significant barriers. One-third of the Spanish respondents considered method complexity, expense, along with other factors as highly relevant for herbicide use.

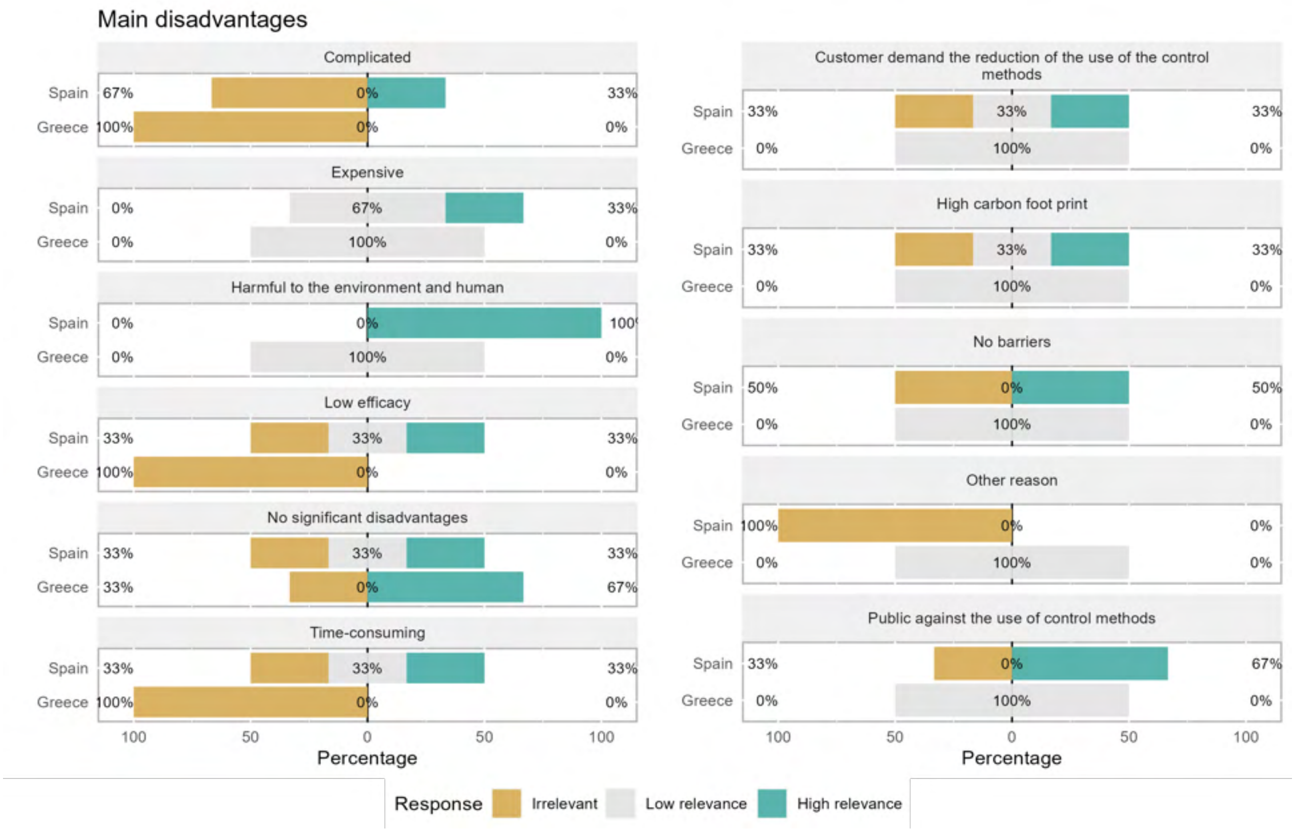


Figure 365. Main disadvantages for herbicides identified by industry.

3.4.4.1.2.4 Researchers

Collectively, researchers from Greece and Spain regarded herbicides as an AWM practice with relevant needs, some barriers, and disadvantages, presenting virtually no opportunities. Over 50% of the respondents considered its potential evolution into an important scientific discipline as a relevant opportunity, the sole factor deemed relevant by a majority of respondents. Additionally, 44% of them acknowledged that herbicides could improve soil health, increase business profitability, and reduce herbicide reliance; the rest of the queried opportunities were regarded as relevant by 33% of the respondents. Nearly seventy percent of surveyed researchers considered increasing ecosystem services impact knowledge, regulatory changes, and cost reduction as the primary needs for herbicides. Besides, over fifty percent of the respondents recognized management expertise, training, and reduction of maintenance as important necessities for herbicide implementation. Two-thirds of the surveyed researchers considered regulatory challenges as the primary barrier, followed by 56% of them citing environmental and human harm as relevant impediments, along with 44% who recognized training as an important hurdle. In line with expressed barriers, researchers considered environmental and human harm as the most relevant impediment. Additionally, two-thirds shared concerns regarding public demand to reduce or eliminate herbicide use.

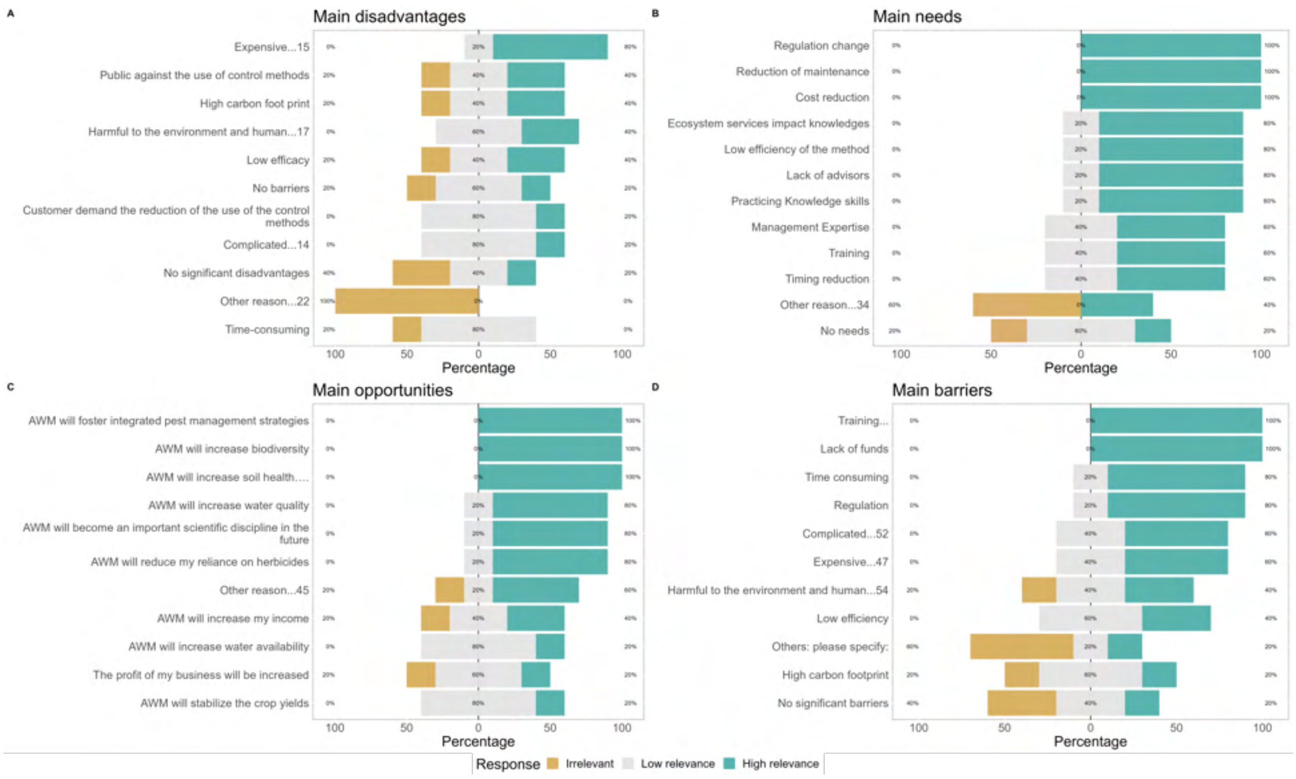


Figure 366. Main disadvantages, needs, barriers and opportunities for herbicides identified by researchers.

3.4.4.1.2.4.1 By country

Spanish researchers expressed a more optimistic view towards herbicides compared to their Greek colleagues. Three-quarters of the Spaniards believe that this AWM practice will enhance soil health, reduce herbicide reliance, and potentially evolve into an important scientific discipline in the future, while none of these factors were considered relevant by more than half of the Greek researchers. Half of the Spanish respondents anticipate that herbicide use will increase income and business profitability. They also believe that it will foster IPM strategies and provide ecosystem services, including increased biodiversity and improved water quality and availability. Forty percent of the Greek respondents acknowledge the potential of herbicides as a scientific discipline and believe that their use may stabilize crop yields, consequently increasing business profitability.

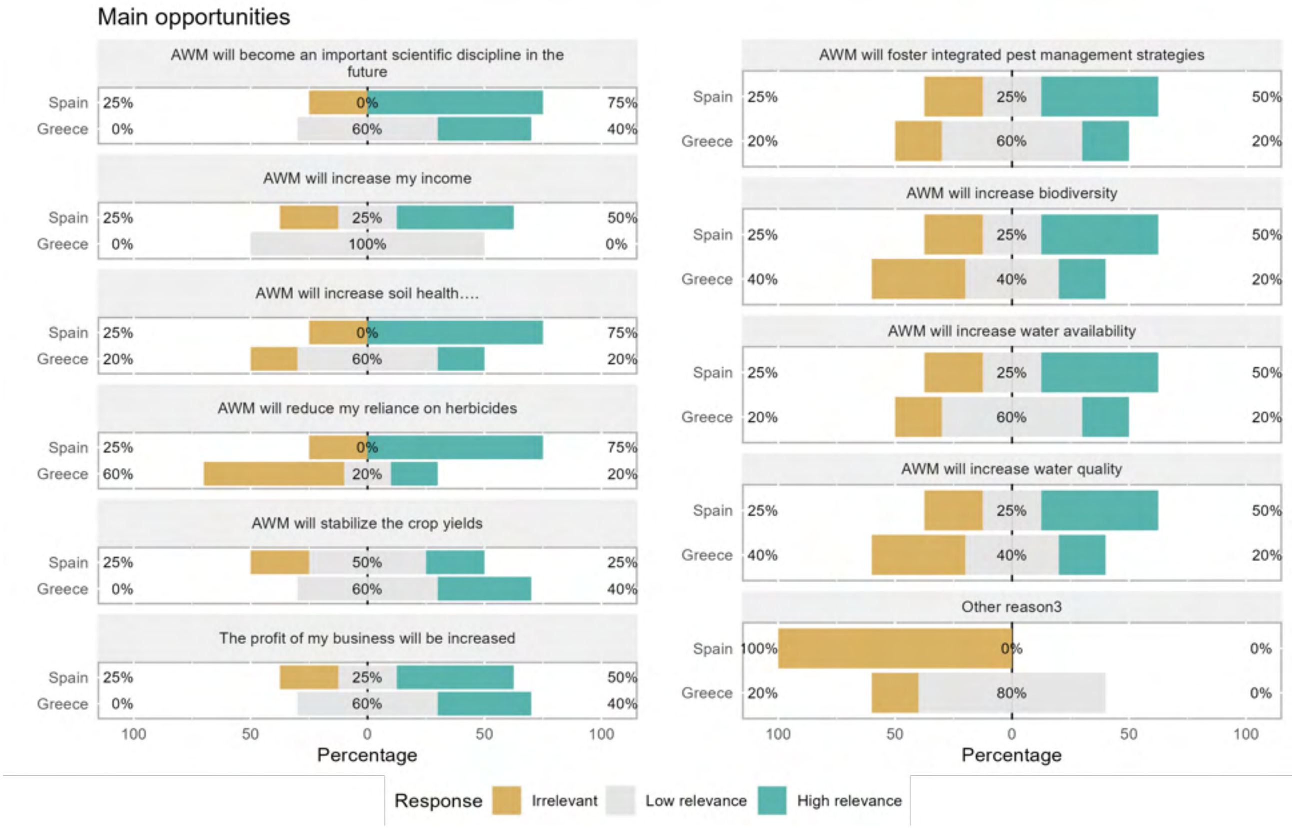


Figure 367. Main opportunities for herbicides identified by researchers.

Both groups recognize that herbicides present important needs, although they differ in the relative importance of the queried factors. Spaniards unanimously considered regulatory changes as the most relevant need for herbicides, while only 40% of the surveyed Greeks deemed this factor as highly relevant. Eighty percent of the Greek respondents considered cost reduction as the primary need, whereas this aspect was deemed relevant by only half of the Spaniards. Ecosystem services impact knowledge was seen as relatively important by 75% of Spanish researchers and 60% of their Greek peers. The same proportion of Spaniards considered training and management expertise as important, along with 40% of the Greeks. Reduction of maintenance was regarded as relevant by 60% of the Greek researchers, while this aspect was considered relevant by 50% of the Spaniards.

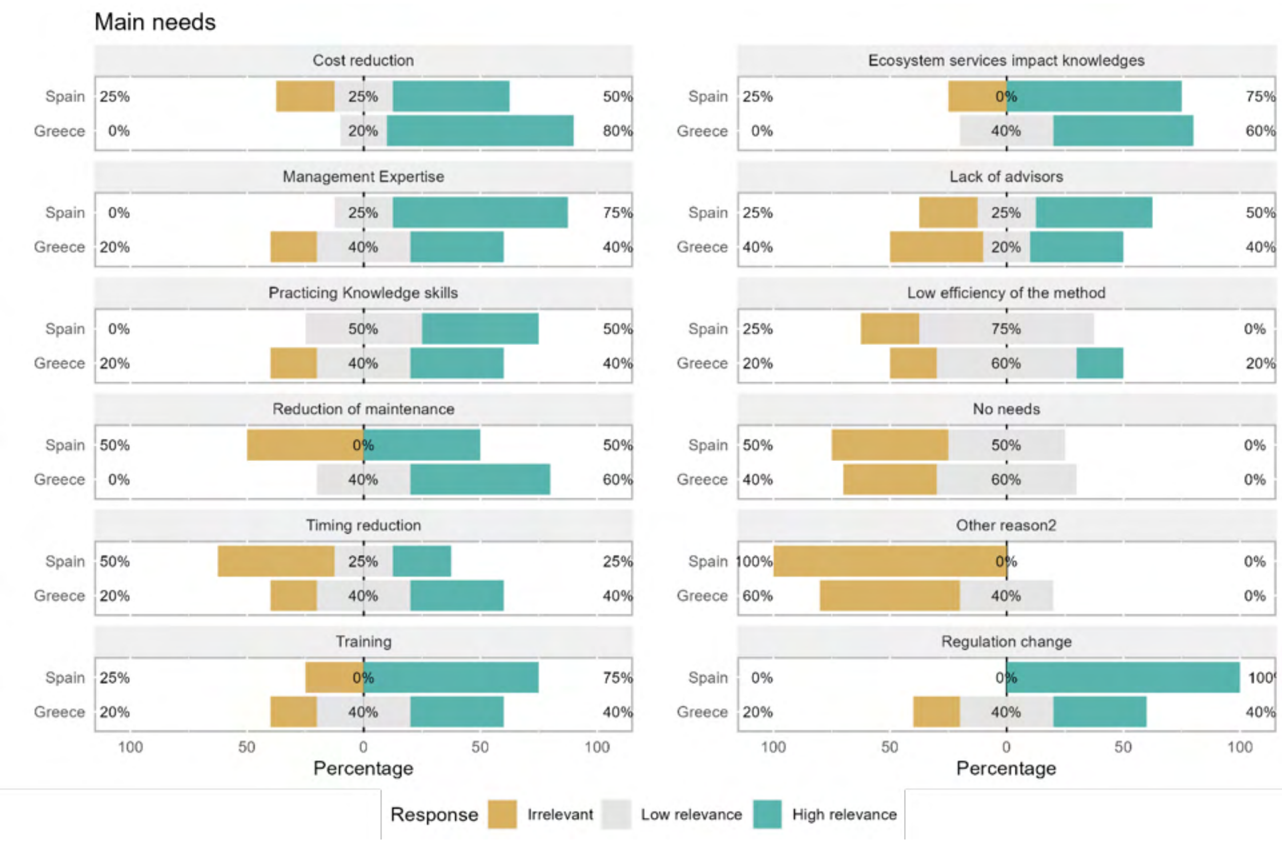


Figure 368. Main needs for herbicides identified by researchers.

Spanish researchers considered that herbicides face important barrier while their Greek colleagues did not mainly regard any of the queried impediments as relevant. Spaniards unanimously considered regulatory challenges as an important concern, while only 40% of the Greek researchers regarded this factor as of relevance. Besides, all Spaniards emphasize environmental and human harm as a relevant barrier for herbicide implementation, along with 75% which recognize method's high carbon footprint as well as half of the sample that acknowledge expense and training as important. Besides regulatory concerns, 40% of Greek respondents considered training and lack of funds as relevant hurdles.

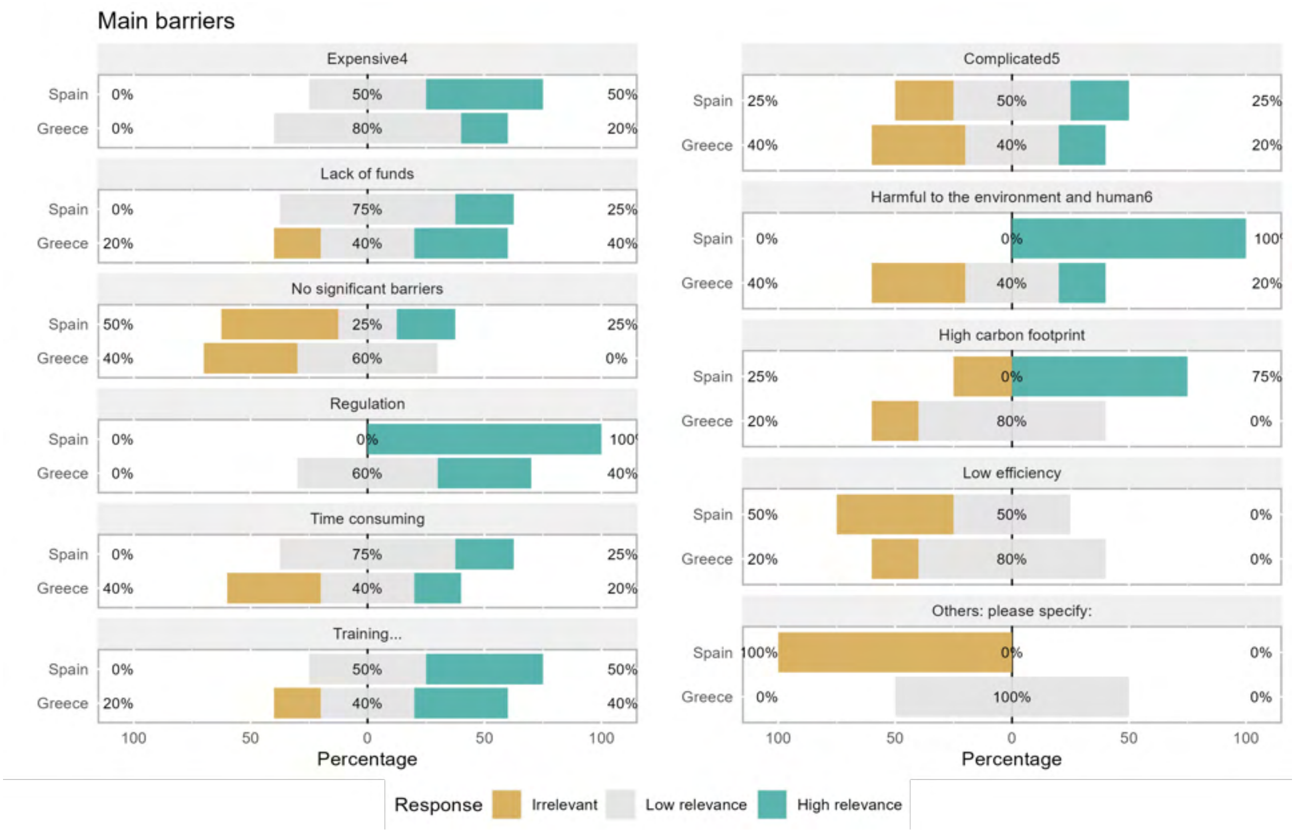


Figure 369. Main barriers for herbicides identified by researchers.

Researchers from both countries emphasize environmental and human harm, which was considered the most relevant disadvantage by all Spanish respondents and 60% of the Greeks. Moreover, public demand to eliminate or reduce herbicides were considered as relevant drawbacks by 100% of Spaniards, as well as by 40% of the Greek respondents. Besides these factors, Spanish respondents emphasized the high carbon footprint (75%) as well as expense (50%) as additional disadvantages.

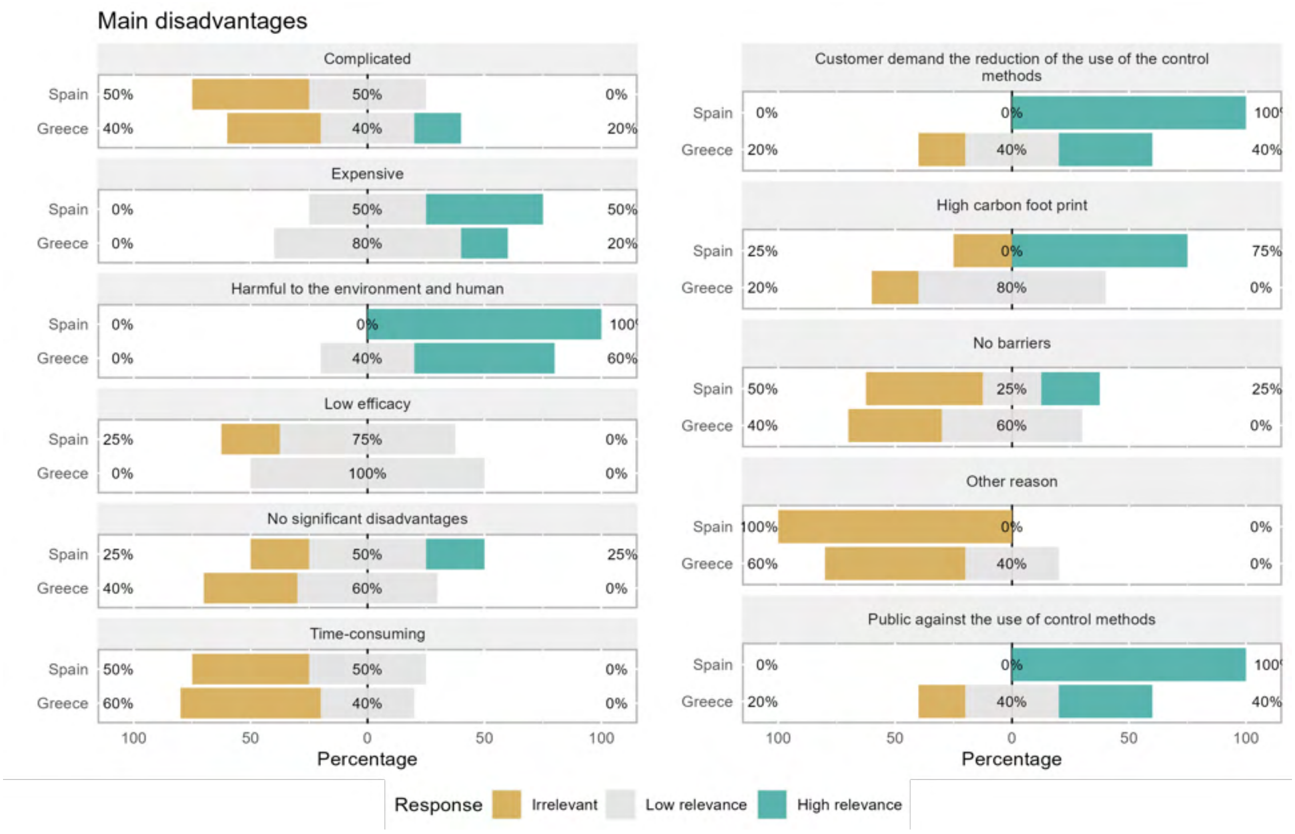


Figure 370. Main disadvantages identified by researchers.

3.4.4.1.2.5 Conclusion

Collectively, Spanish stakeholders and especially their Greek colleagues, shared a conservative perception toward herbicides, with the emphasized opportunities considered by approximately half of the respondents across the different participant groups. Over half of the surveyed advisors considered herbicides as fosterers of IPM strategies, with this factor being considered relevant by one-third of the Spanish advisors and by 62% of the Greek respondents individually. Consumers did not regard any of the queried opportunities as relevant, either as a whole or when analysing the responses by country. Half of the industry representatives acknowledged that herbicide use would increase business profitability and result in the stabilization of crop yields, with these factors being considered by two-thirds of the Greeks and one-third of the Spaniards. Additionally, nearly seventy percent of the Spanish respondents emphasized IPM fostering and considered herbicides as ecosystem services providers, including improvements in soil health as well as water quality and availability. Over half of the surveyed researchers considered that herbicides would evolve into an important scientific discipline, with this perspective being held by 75% of the Spanish respondents and 40% of the Greeks separately.

Stakeholders from both countries emphasized that herbicides face relevant necessities. Moreover, most of the considered needs were regarded as relevant across the different stakeholders as well as nationalities. Over ninety percent of the surveyed advisors considered reduction of maintenance as the most relevant need. Separately, Spaniards unanimously considered this factor as relevant, while 88% of the Greek respondents emphasized this aspect. Besides, 73% of the respondents considered regulatory changes, as well as cost reduction, along with 64% which considered ecosystem services impact knowledge as important needs. Regulatory challenges were also considered as a relevant need by 74% of the surveyed consumers, which was appointed as so by most Spanish and Greek respondents. Over sixty percent of the consumers recognized practicing knowledge skills, training, maintenance, and cost reduction, as well as ecosystem services impact knowledge, as important needs. Spaniards gave more relevance to these factors compared to their Greek peers. Industry representatives considered that herbicides present fewer needs compared to other stakeholders. Two thirds of them considered ecosystem services impact knowledge, and half of them recognized regulatory changes, as well as cost and timing reduction, among others, as important needs. Once again, Spanish respondents considered herbicides as having relevant needs; they unanimously regarded ecosystem services impact knowledge, practicing knowledge skills, and training as relevant, while Greek respondents did not regard any of the queried opportunities as relevant. In accordance with other stakeholders, two-thirds of the surveyed researchers considered ecosystem impact knowledge, regulatory changes, and cost reduction as primary needs. In this case, Spanish and Greek researchers considered that herbicides present important necessities. Spanish emphasized regulatory challenges, and Greeks considered cost reduction as paramount.

Greek and Spanish stakeholders considered herbicides to have few but significant barriers. Regulatory challenges and concerns about environmental and human harm were deemed the most relevant barriers across all interviewed stakeholders. Collectively, these concerns were considered the primary worry by over seventy percent of the surveyed advisors, with 100% of Spaniards and 62% of Greeks expressing this concern. Nearly seventy-five percent of consumers also emphasized these barriers as relevant, with 63% considering training and 58% recognizing expense as important barriers. A higher proportion of Spanish consumers considered these barriers relevant compared to Greeks. Industry representatives, collectively, did not mainly regard any of the queried opportunities as relevant. Similar to consumers, two-thirds of Spanish respondents considered expense and regulatory concerns, among others, as important barriers, while their Greek counterparts did not regard any of the queried impediments as relevant. Researchers, collectively, also considered regulatory challenges and environmental concerns as relevant barriers. Once again, Spanish researchers unanimously considered these factors paramount, while none of the queried barriers were considered relevant by Greek researchers.

Environmental and human harm, as well as public demand to reduce or eliminate herbicides, were considered disadvantages by stakeholders in different proportions. Most consumers and researchers recognize these factors as important disadvantages, while the majority of industry representatives and especially advisors did not consider these factors as relevant. Collectively, advisors did not regard any of the disadvantages as highly relevant. However, Spanish advisors unanimously consider public demand to reduce or eliminate herbicides as relevant, whereas half of their Greek peers consider environmental and human harm as relevant drawbacks. Similarly, the proportion of Spanish consumers and industry representatives who shared concerns regarding herbicide disadvantages was higher compared to respondents from Greece. Notably, Greek industry representatives mostly considered that herbicides present no significant disadvantages. Researchers maintain the trend observed between Greece and Spain in other stakeholders, as 60% of the Greeks acknowledge environmental and human harm as relevant, while this factor was unanimously considered relevant by Spanish respondents.

3.4.4.1.3 Mechanical weeding

3.4.4.1.3.1 Consumers

Consumers from Greece and Spain regard mechanical weeding as a significant AWM practice for grapes. Nearly eighty percent of the respondents believe that mechanical weeding reduces reliance on herbicides. However, the rest of the queried opportunities were not considered relevant by more than half of the respondents. Additionally, 44% of consumers view this practice as fostering IPM strategies, while one third acknowledge mechanical weeding as an ecosystem services provider, including benefits such as increased water quality and availability, biodiversity, and improved soil health. Lack of advisors was identified as the primary need by consumers in both Spain and Greece. Moreover, over forty percent of the respondents emphasize the importance of ecosystem services impact knowledge, practicing knowledge skills, management expertise, training, as well as cost and timing reduction for the effective implementation of mechanical weeding. Interestingly, none of the queried barriers or disadvantages were considered relevant by more than half of the consumers. However, 44% of them highlighted time consumption as the most significant barrier, while the same proportion identified the method's high carbon footprint as the most relevant disadvantage.

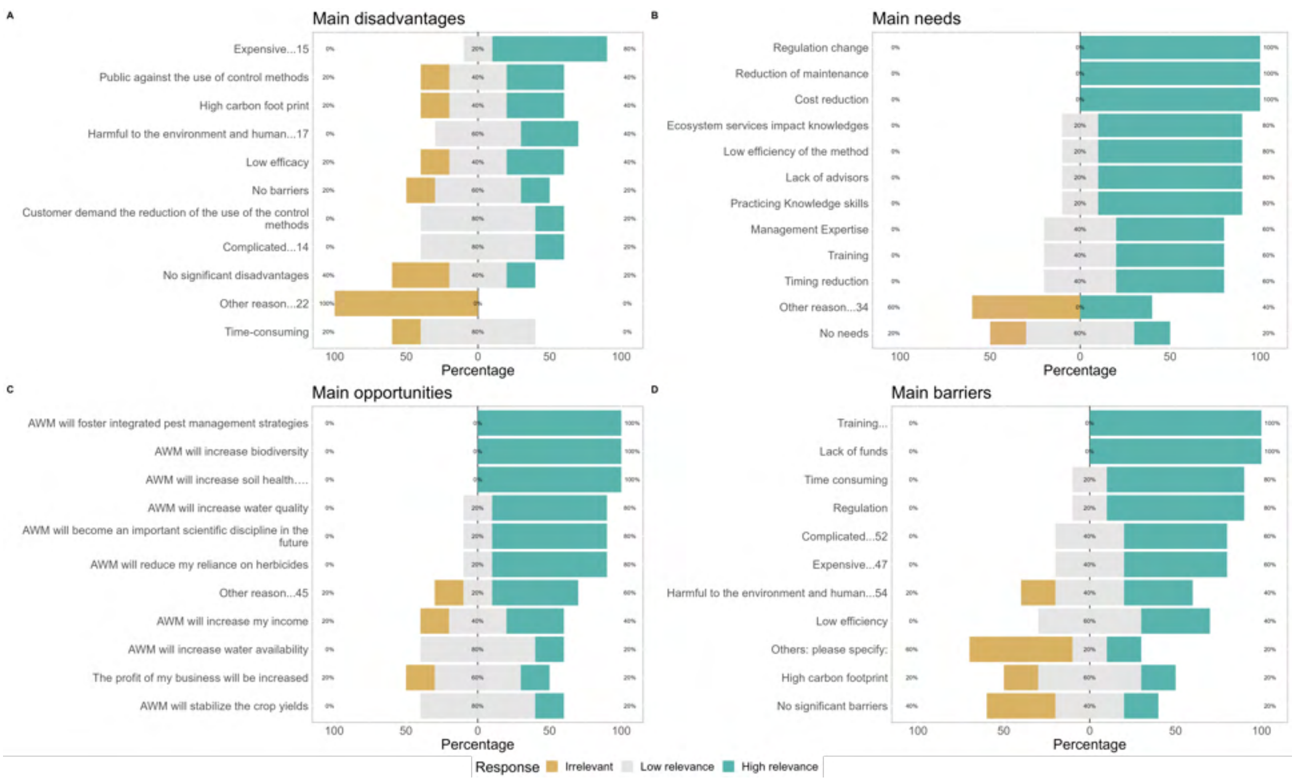


Figure 371. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by consumers.

3.4.4.1.3.1.1 By country

Consumers believe that the potential reduction of herbicide reliance is the most relevant opportunity presented by mechanical weeding, with Greek respondents unanimously agreeing and nearly seventy percent of their Spanish peers concurring. Additionally, two-thirds of the Greek consumers stated that mechanical weeding fosters the implementation of IPM strategies. Furthermore, one third of the respondents from both countries acknowledge mechanical weeding as an ecosystem services provider, citing benefits such as increases in biodiversity, soil health, and improvements in water quality and availability.

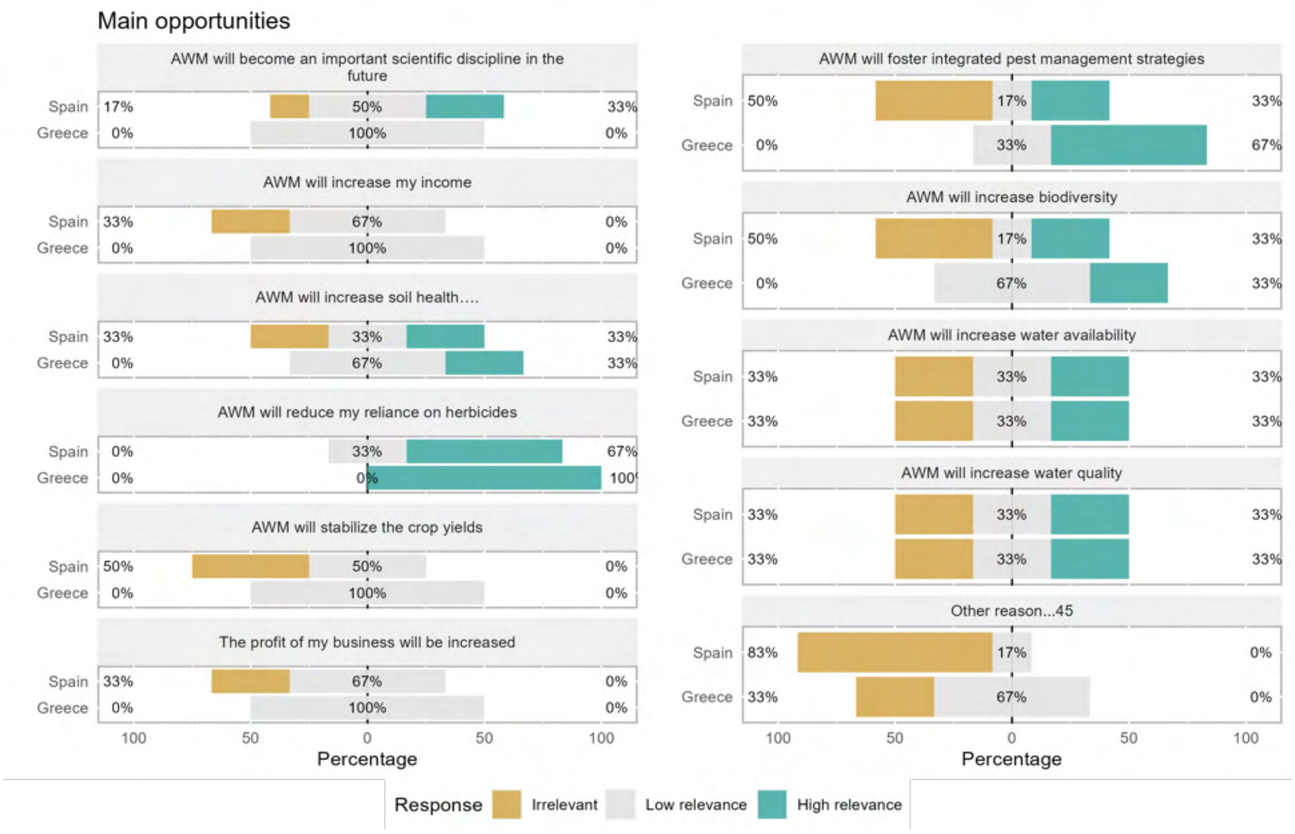


Figure 372. Main opportunities for mechanical weeding identified by consumers.

Spanish consumers considered lack of advisors as the primary need for mechanical weeding, while the Greek respondents emphasized timing reduction as relevant. Half of the Spaniards, along with one third of the Greek consumers, acknowledged cost reduction, management expertise, practicing knowledge skills, training, and ecosystem services impact knowledge as important necessities.

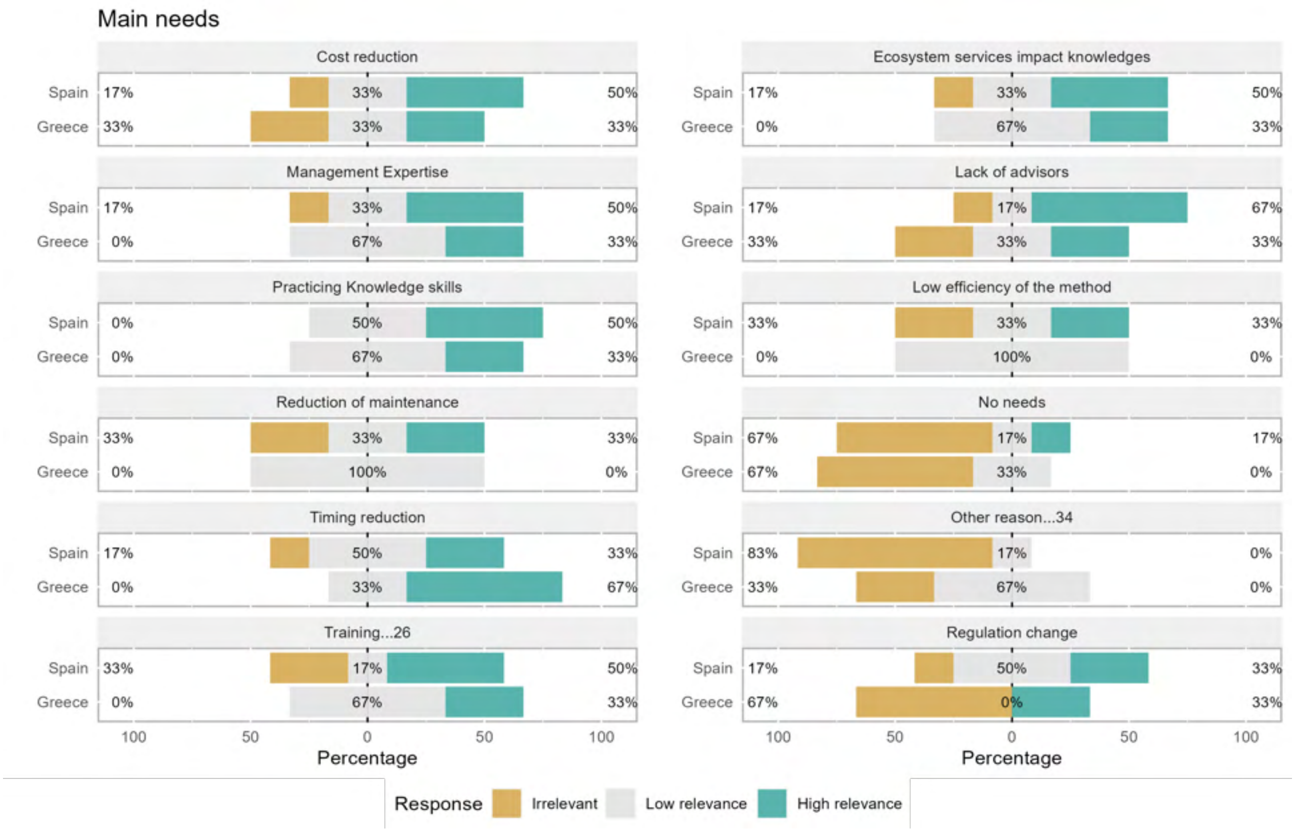


Figure 373. Main needs for mechanical weeding identified by consumers.

Nearly seventy percent of Greek respondents considered time consumption as the primary impediment, whereas only one third of Spanish respondents considered this factor as important. Half of the psanish respondents considered mechanical weeding high carbon footprint and its potential environmental and human harm as the most relevant barriers. One third of the respondents from each country considered training as a important hurdle to mechanical weeding use.

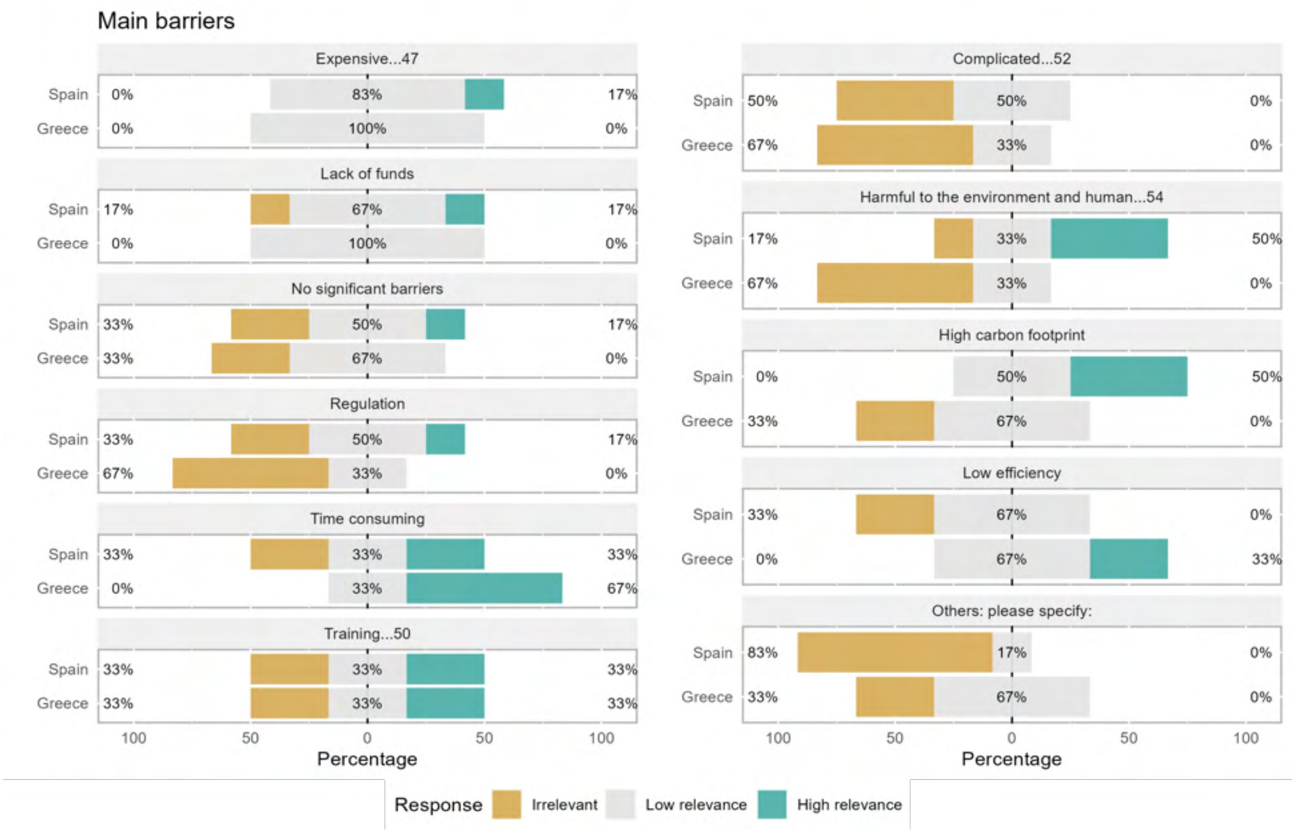


Figure 374. Main barriers for mechanical weeding identified by consumers.

None of the queried disadvantages was considered as relevant by more than half of the Greek respondents, while nearly 70% of the Spaniards emphasized high carbon footprint as the most relevant disadvantage related to mechanical weeding.

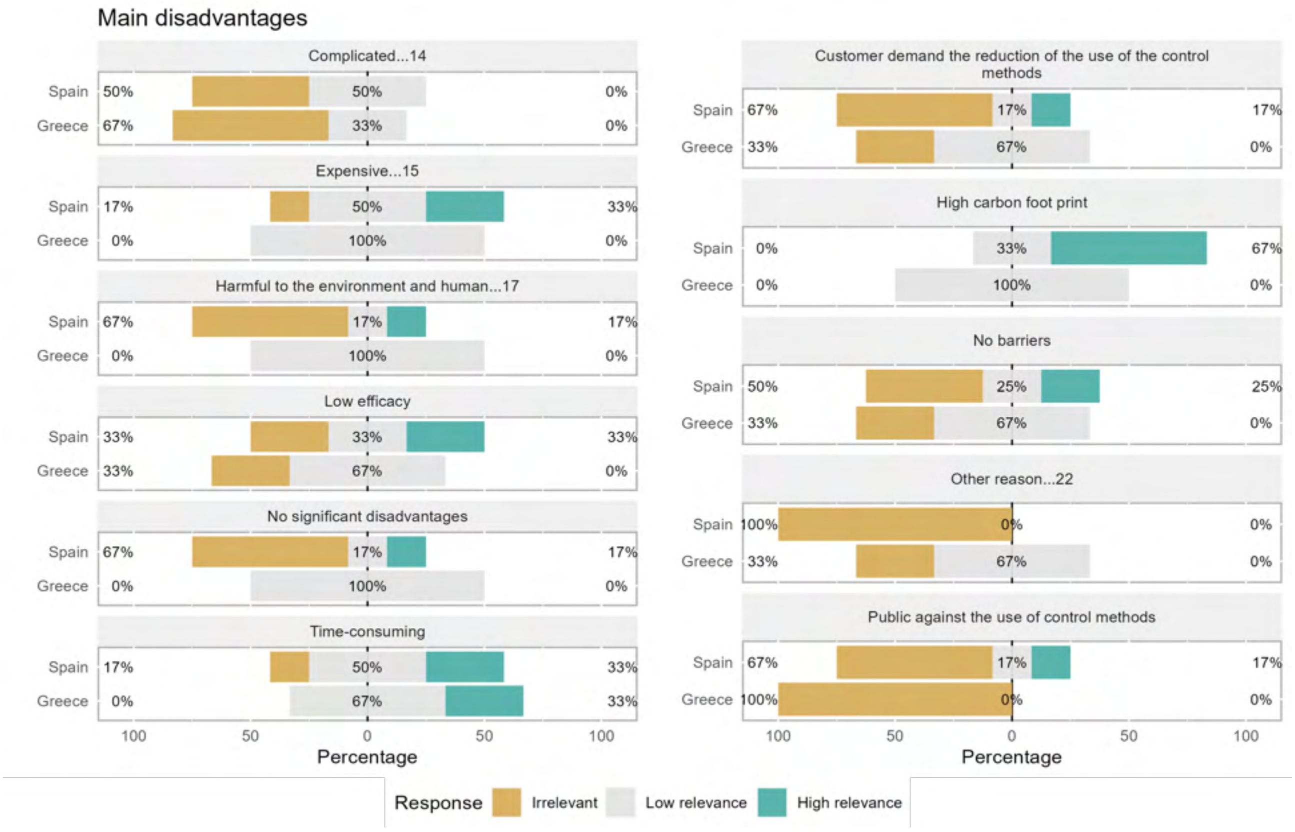


Figure 375. Main disadvantages for mechanical weeding identified by consumers.

3.4.4.1.3.2 Industry

Mechanical weeding was considered an important AWM practice for grapes by industry representatives in Spain, Italy, and Greece. They collectively regarded the reduction of herbicide reliance as the most relevant opportunity. Moreover, nearly seventy percent of the respondents viewed mechanical weeding as an ecosystem services provider. Around 70% of respondents emphasized increased biodiversity and improved soil health, along with 65% acknowledging an amelioration in water quality and 44% believing it increases water availability. Besides ecosystem services provision, over fifty percent of the surveyed industry representatives considered mechanical weeding as fostering IPM strategies, and one third believed it will evolve into an important scientific discipline. Cost reduction was deemed the primary need for mechanical weeding, with 56% of the surveyed industry representatives emphasizing it. The rest of the queried requirements were not considered relevant by more than half of our sample. However, one third of the respondents considered practicing knowledge skills, training, and reduction in maintenance as important necessities for mechanical weeding implementation. In line with expressed needs, 56% of the surveyed industry representatives considered expense a relevant barrier, along with time consumption. Additionally, 44% of them considered method’s high carbon footprint and lack of funds as important hurdles. Consistently, time consumption and expense were appointed as the practice's most relevant disadvantages by over 60% of the respondents, with complexity being an important concern for 40% of the surveyed industry representatives.

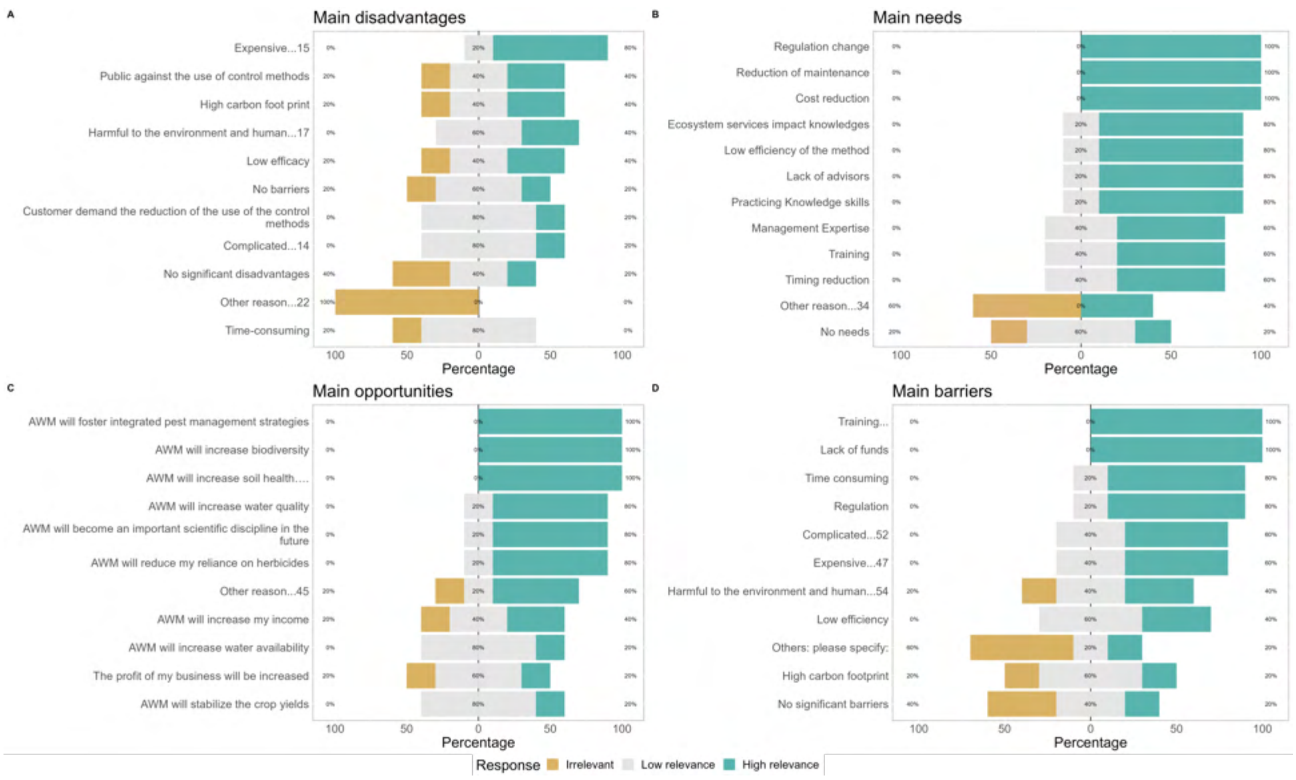


Figure 376. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by industry.

3.4.4.1.3.2.1 By country

Mechanical weeding was perceived differently across the studied regions. While Spanish and Italian respondents acknowledged numerous opportunities related to its use, Greek industry representatives did not primarily regard any of the queried opportunities as highly relevant. Spanish and Italian industry stakeholders unanimously considered the reduction in herbicide reliance as an important opportunity, while only 33% of Greek respondents considered this factor relevant. Besides, all surveyed Spaniards considered mechanical weeding as a provider of relevant ecosystem services, including improvement in soil health and biodiversity, along with 67% of the Italian respondents and just 33% of the Greeks. Spanish respondents unanimously regarded increases in water quality as important opportunities, as well as 33% of Italians and Greeks. Moreover, Italians unanimously considered mechanical weeding as a fosterer of IPM strategies, along with 67% of Spaniards.

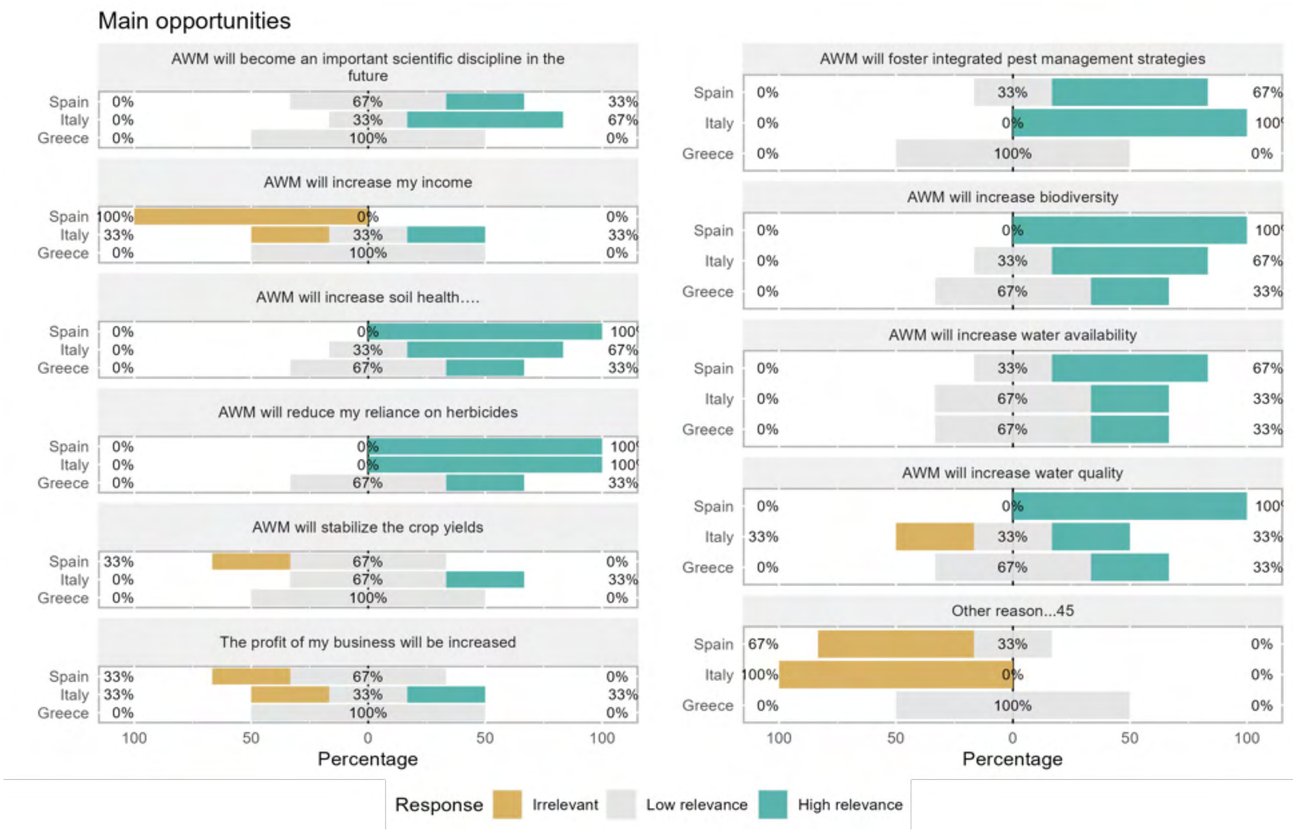


Figure 377. Main opportunities for mechanical weeding identified by industry.

As for the main needs associated with the practice, Spaniards did not primarily consider any of the queried factors as highly relevant, while their Greek and especially their Italian colleagues believed that mechanical weeding presents numerous needs. Cost reduction was unanimously considered the primary need by Italians, along with nearly seventy percent of the Greek respondents. Additionally, Italians unanimously acknowledged reduction of maintenance and training as primary needs for mechanical weeding. Moreover, nearly seventy percent of Italians emphasized management expertise and lack of advisors, as well as practicing knowledge skills, which was also considered relevant by one third of Spaniards.

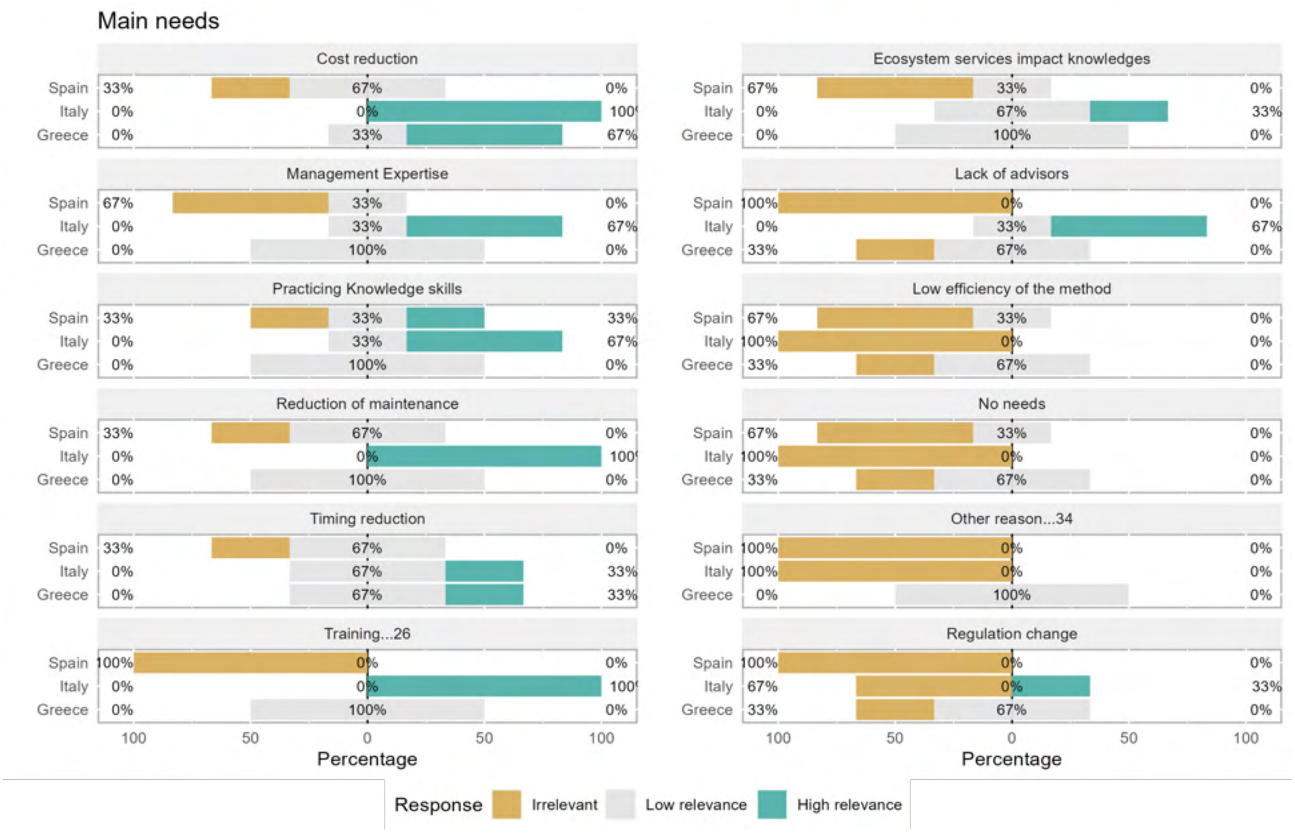


Figure 378. Main needs for mechanical weeding identified by industry.

Each region identified its own primary barriers regarding mechanical weeding. Spanish respondents regarded expense as the primary barrier, while two thirds of Italian respondents also considered this factor as relevant. Italians believed that training and lack of funds were the most relevant barriers faced by mechanical weeding; the latter factor was considered relevant by one third of the Spaniards. Additionally, time consumption was considered an important barrier by two thirds of Spanish and Italian respondents. Lastly, Greek industry stakeholders unanimously recognized high carbon footprint as the most relevant impediment for mechanical weeding.

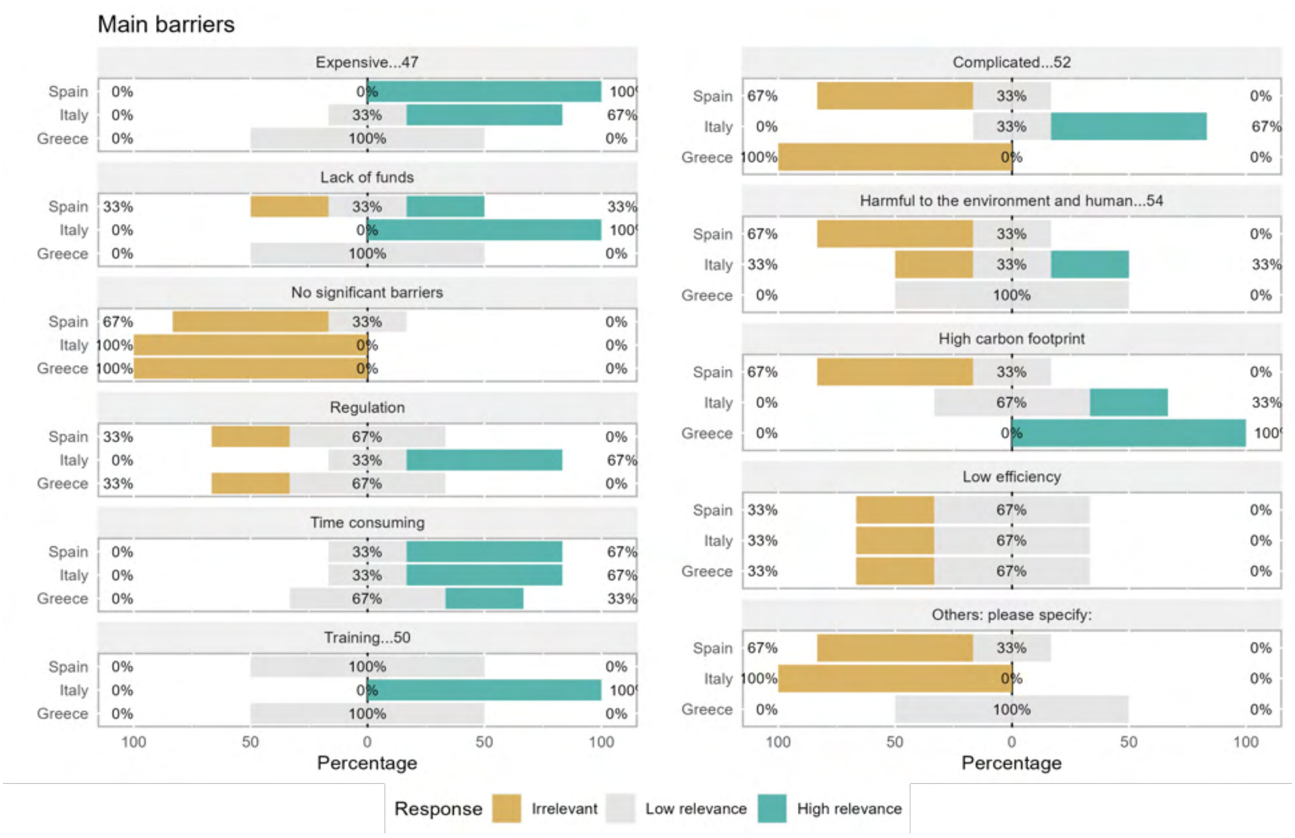


Figure 379. Main barriers for mechanical weeding identified by industry.

Spanish and Italians considered the same factors as relevant; both groups unanimously regarded expense as the most important disadvantage. Additionally, all Spaniards emphasized time consumption, along with nearly seventy percent of the Italian respondents, as a relevant drawback. Complexity was considered a principal factor by 50% of the Spanish respondents and 67% of the Italian respondents, respectively.

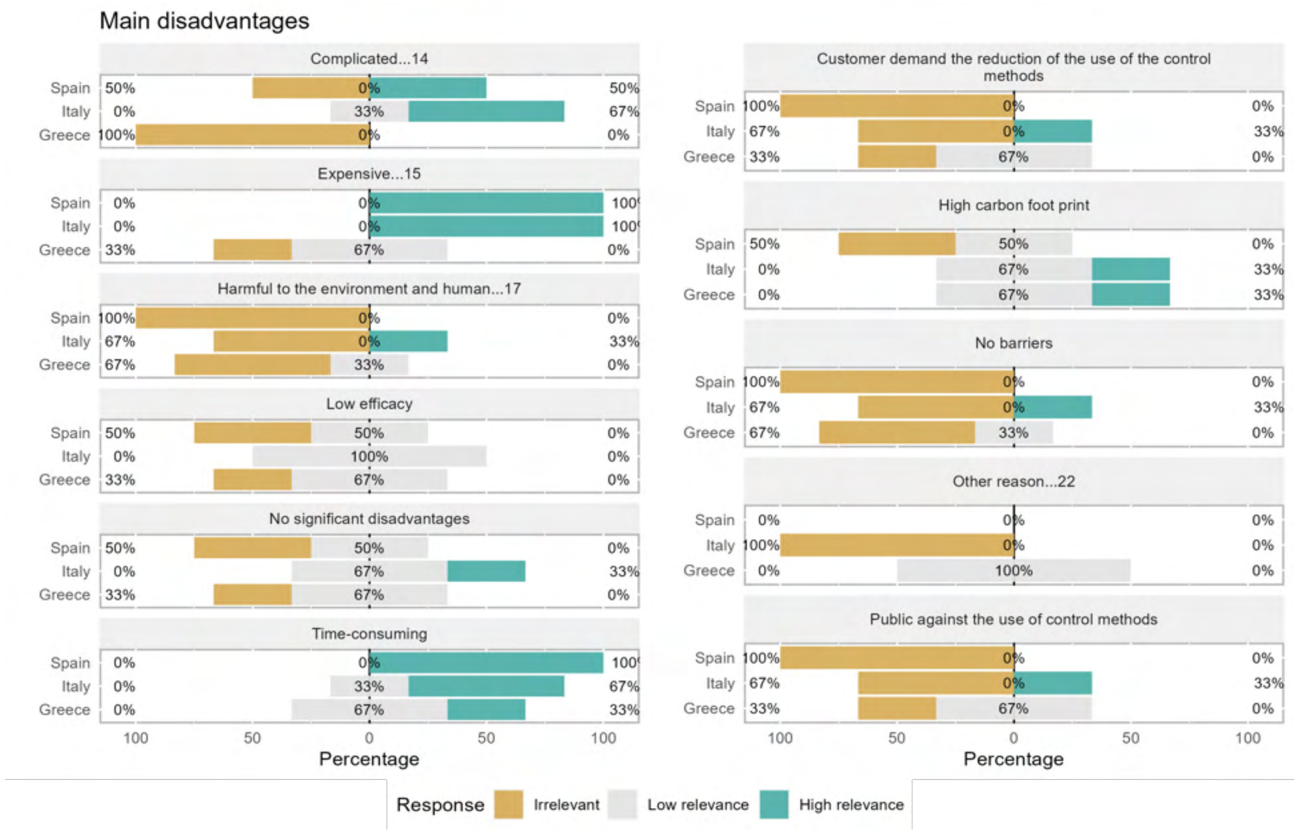


Figure 380. Main disadvantages for mechanical weeding identified by industry.

3.4.4.1.3.3 Conclusion

Consumers and industry stakeholders consider mechanical weeding a relevant practice in AWM for grape cultivation. Across the studied regions, both groups share a similar collective perspective regarding the practice's opportunities. Nearly eighty percent of them believe that mechanical weeding reduces reliance on herbicides. Industry representatives identify additional opportunities, recognizing the practice as an ecosystem services provider, promoting increased biodiversity, soil health, and water quality. They also view mechanical weeding as fostering IPM strategies. Spanish stakeholders are optimistic about the opportunities presented by the method, whereas Greek industry representatives do not see any opportunities as relevant. Conversely, Greek consumers are more optimistic. Over fifty percent of consumers and industry representatives agree that mechanical weeding does not present numerous opportunities. While consumers see lack of advisors as the primary need, industry representatives emphasize cost reduction as the most relevant need. Notably, Spanish industry representatives do not believe that mechanical weeding presents any significant needs. Nearly sixty percent of industry representatives see expense and time consumption as the most relevant impediments for mechanical weeding. Although none of the queried barriers are considered relevant by more than half of the consumers, 44% of them consider time consumption an important factor. Time and expense concerns are seen as relevant drawbacks by over 60% of industry representatives. Despite consumers not mainly considering any of the queried disadvantages as relevant, 44% of them express concerns about the high carbon footprint, and one third share time consumption concerns similar to those of industry representatives.

3.4.4.1.4 Mowing

3.4.4.1.4.1 Advisors

Collectively, advisors from Greece and Italy hold a positive view toward mowing as an AWM practice in grape cultivation. Over seventy percent of the respondents believe that mowing fosters IPM strategies and increases biodiversity. Additionally, nearly sixty percent of them see soil health as a relevant opportunity related to mowing implementation. Regarding the primary needs of the method, 71% of advisors in both studied regions identify timing reduction as the primary need, along with 57% of them considering reduction of cost and maintenance as important requirements for its implementation. Time consumption emerges as the most relevant impediment, as stated by 71% of respondents. None of the other queried barriers were deemed as relevant by more than half of the respondents. Consistently, advisors consider time consumption the sole disadvantage of relevance.

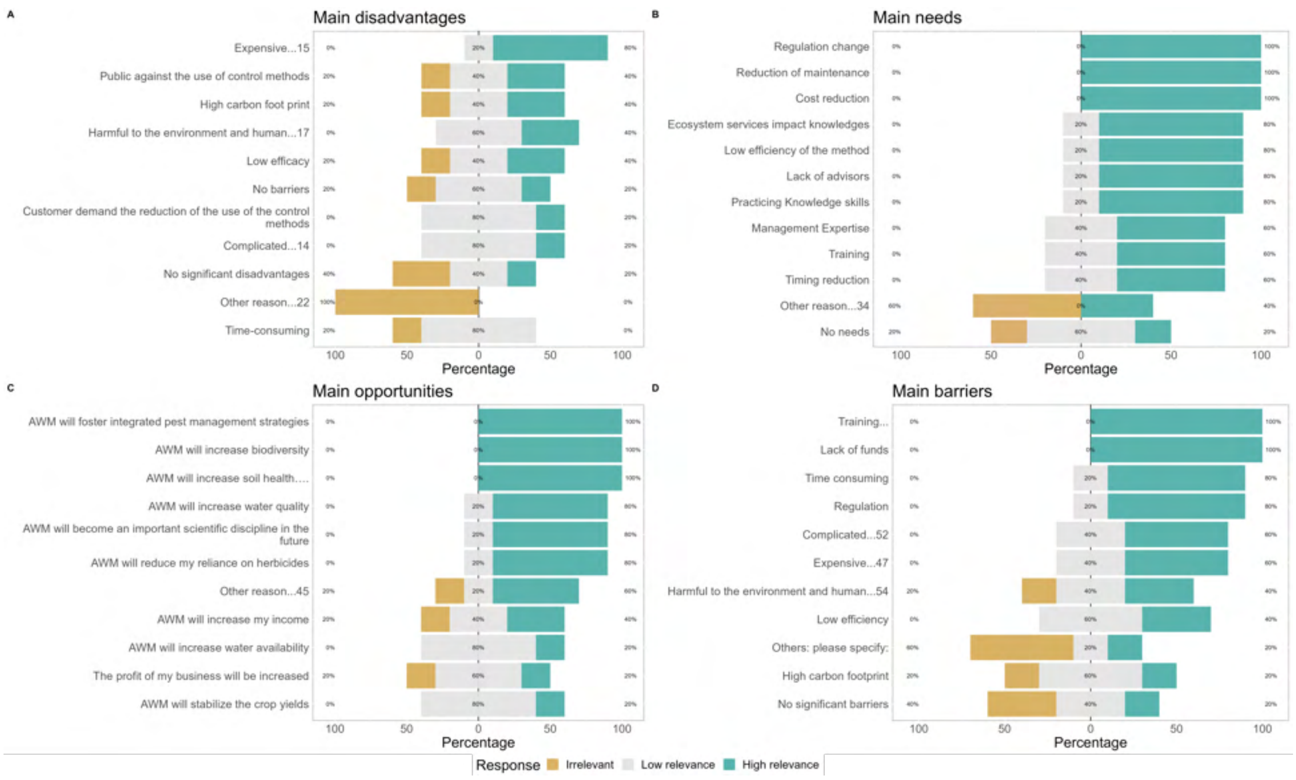


Figure 381. Main disadvantages, needs, barriers and opportunities for mowing identified by advisors.

3.4.4.1.4.1.1 By country

Advisors from Italy and Greece have identified significant opportunities associated with mowing. Italian respondents unanimously considered reduction of herbicide reliance and increases in biodiversity as relevant opportunities. Conversely, their Greek counterparts unanimously view mowing as a fosterer of IPM strategies, with 67% of Italians sharing this perspective. Advisors from both regions believe that this practice improves soil health and enhances water quality and availability.

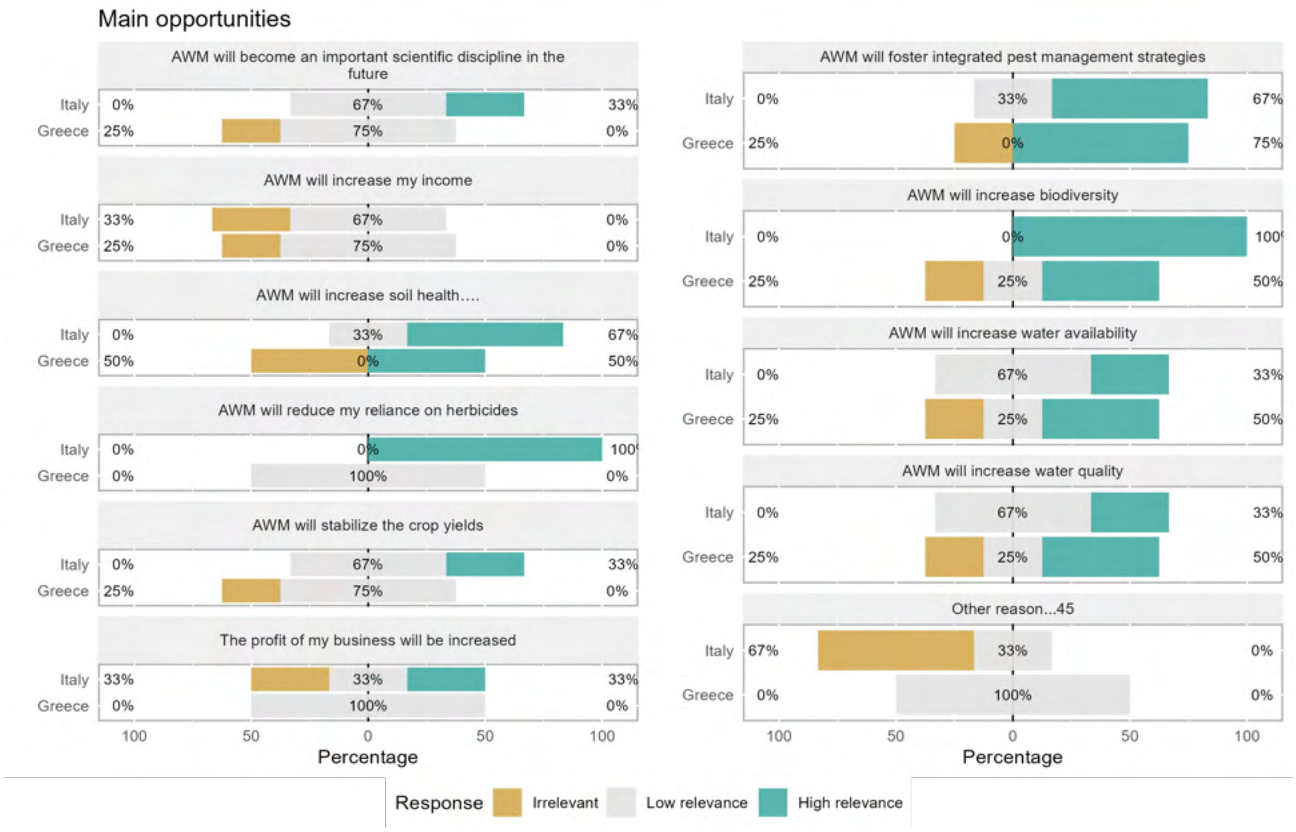


Figure 382. Main opportunities for mowing identified by advisors.

Advisors from Greece and Italy have differing perspectives on the primary need for mowing. Italians unanimously considered reduction of maintenance as the primary need, which was also acknowledged as relevant by 25% of Greek respondents. Conversely, advisors from Greece unanimously considered timing reduction as the primary need, which was considered relevant by 33% of Italians. Both regions agreed on the importance of cost reduction, with 50% of Greek stakeholders and 67% of Italian stakeholders stating its relevance.

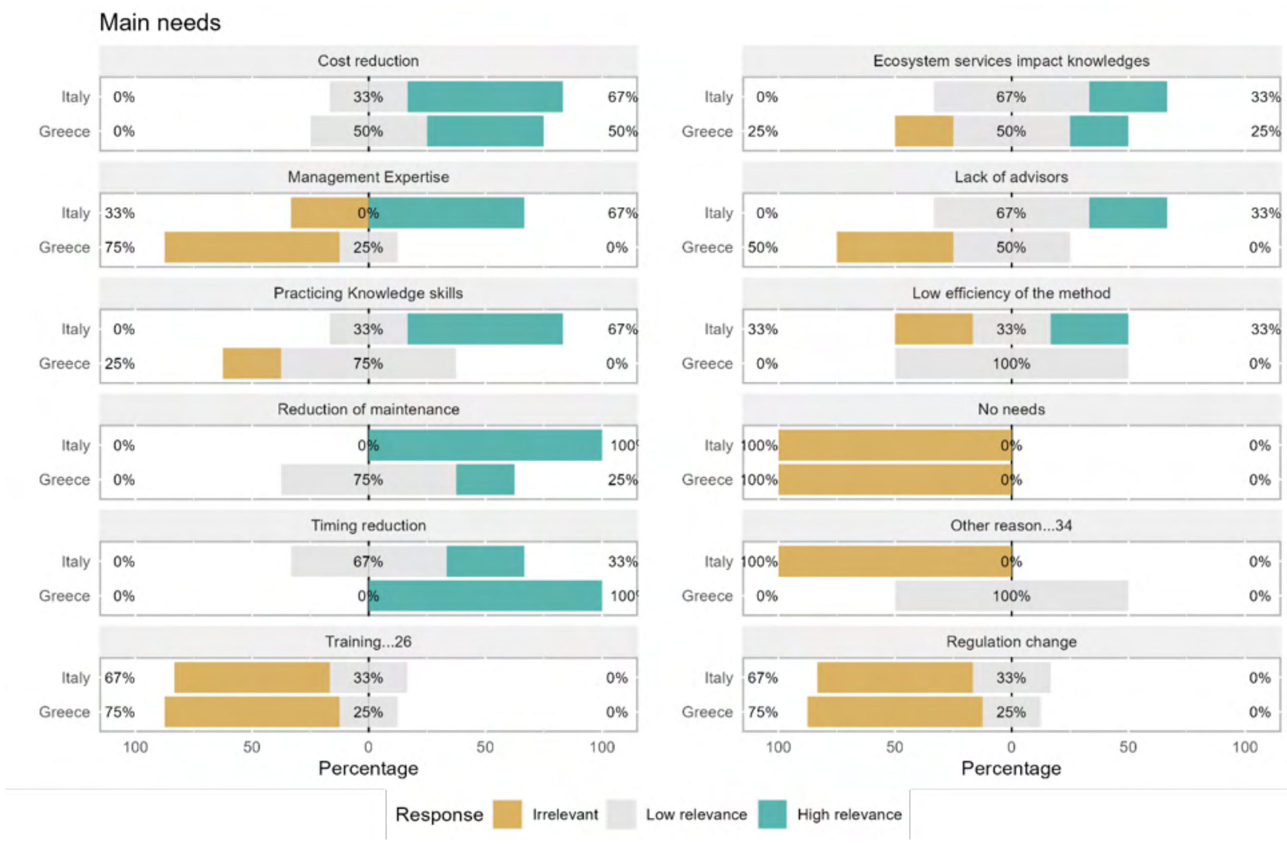


Figure 383. Main needs for mowing identified by advisors.

Italian advisors perceive mowing as facing more relevant barriers compared to their Greek counterparts. Unanimously, Italians consider time consumption as the most relevant impediment, shared by half of the Greek respondents. Additionally, two-thirds of the Italians emphasize expense, lack of funds, and training as relevant barriers. However, Greek respondents did not mainly consider any of the queried barriers as relevant impediments, besides time concerns.

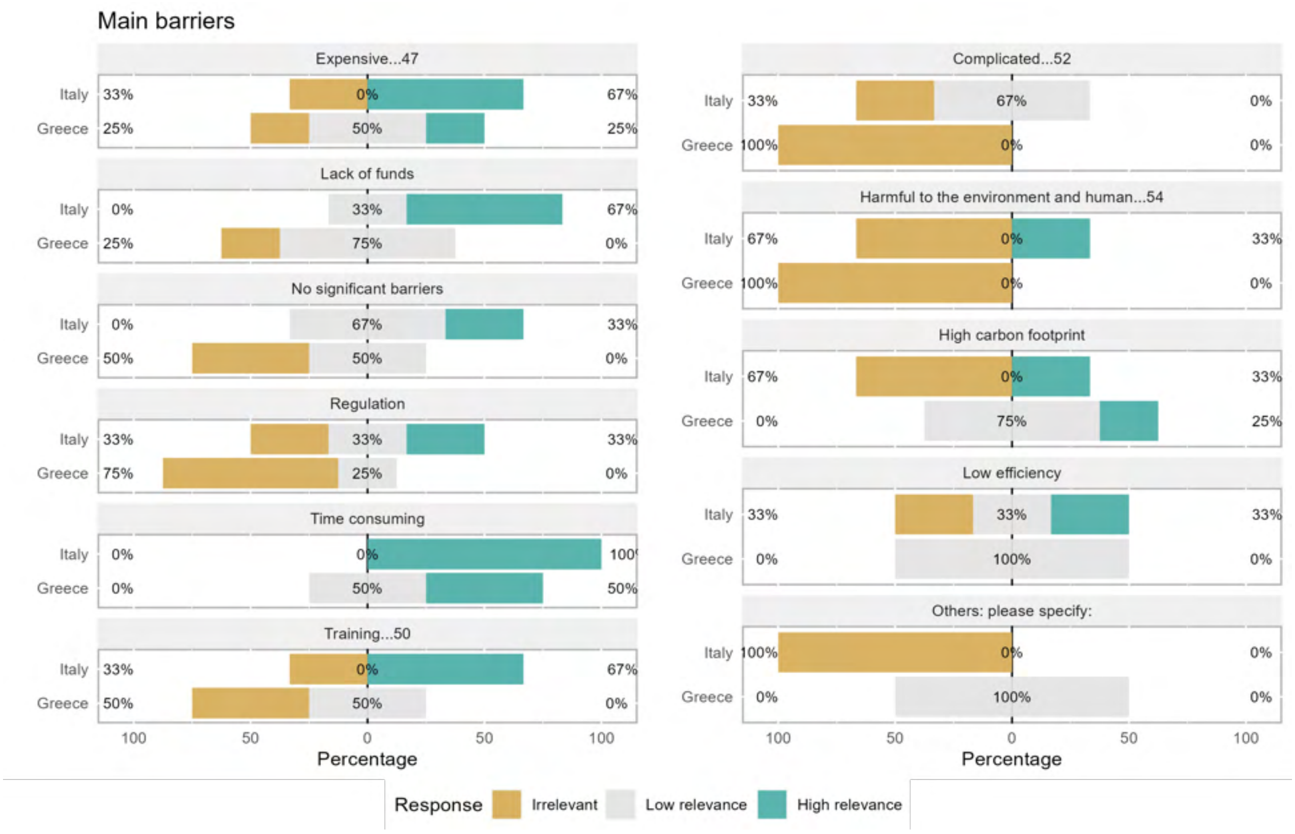


Figure 384. Main barriers for mowing identified by advisors.

Italian and Greek respondents consider that mowing presents few relevant disadvantages. Advisors from both regions unanimously consider time consumption as the most relevant disadvantage. The rest of the queried disadvantages were not regarded as relevant by more than half of the respondents.

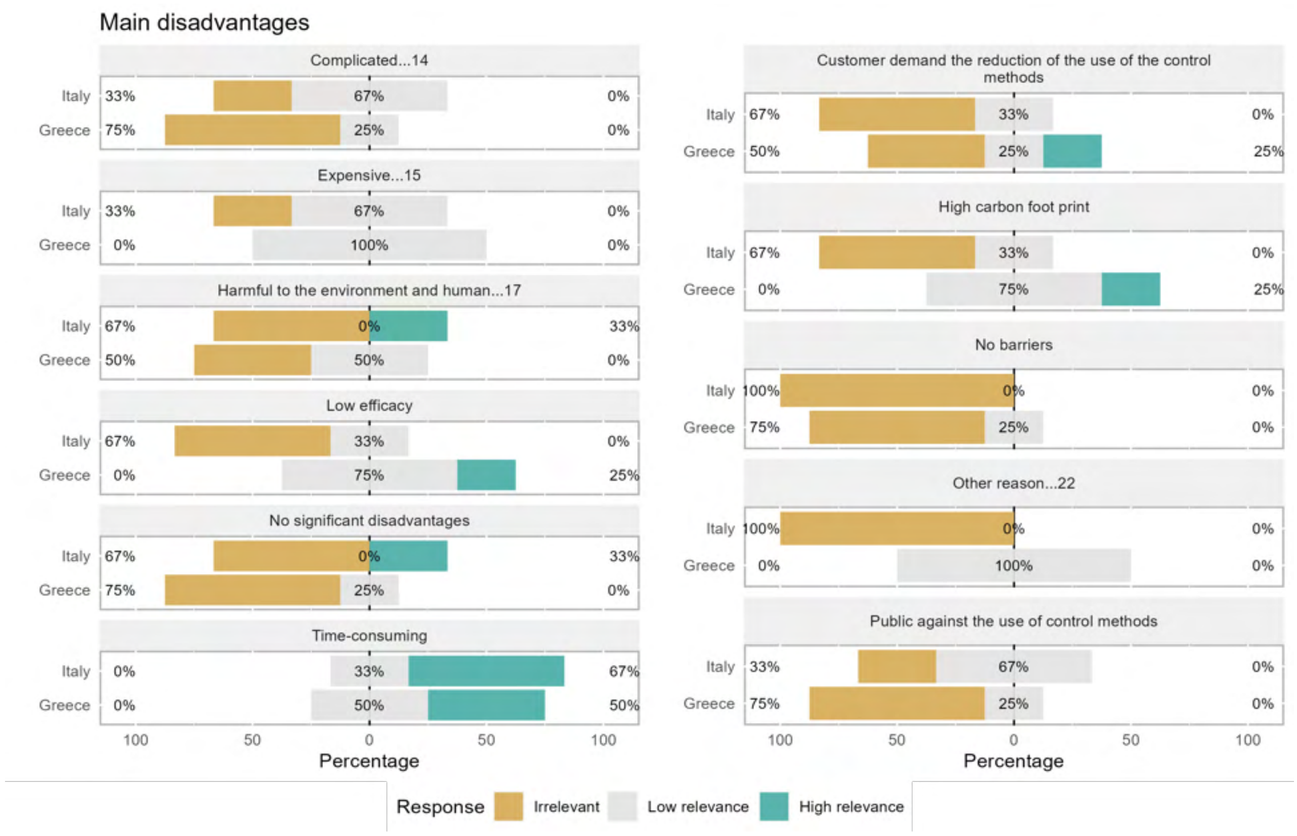


Figure 385. Main disadvantages for mowing identified by advisors.

3.4.4.1.4.2 Consumers

Mowing was viewed as a practice full of opportunities by consumers from Greece and Spain. Over eighty percent of them considered that mowing reduces herbicide reliance, along with nearly seventy percent perceiving improvements in soil health. Besides, half of the respondents view mowing as having the potential to evolve into an important scientific discipline in the future. Collectively, consumers from the studied regions perceived ecosystem services impact knowledge as the primary need related to mowing. Additionally, nearly 67% of the surveyed consumers consider practicing knowledge skills and management expertise as important requirements. Half of them shared concerns regarding regulatory changes and the reduction of maintenance as highly relevant needs for mowing. None of the queried barriers were identified as relevant by a majority of respondents. Half of the surveyed consumers cited training and regulation as important, stating that this practice does not present any significant barriers to its implementation. Similarly, none of the queried disadvantages was deemed of high relevance by most respondents; half of them stated method’s high carbon footprint, low efficacy, expense, as well as time consumption as important disadvantages.

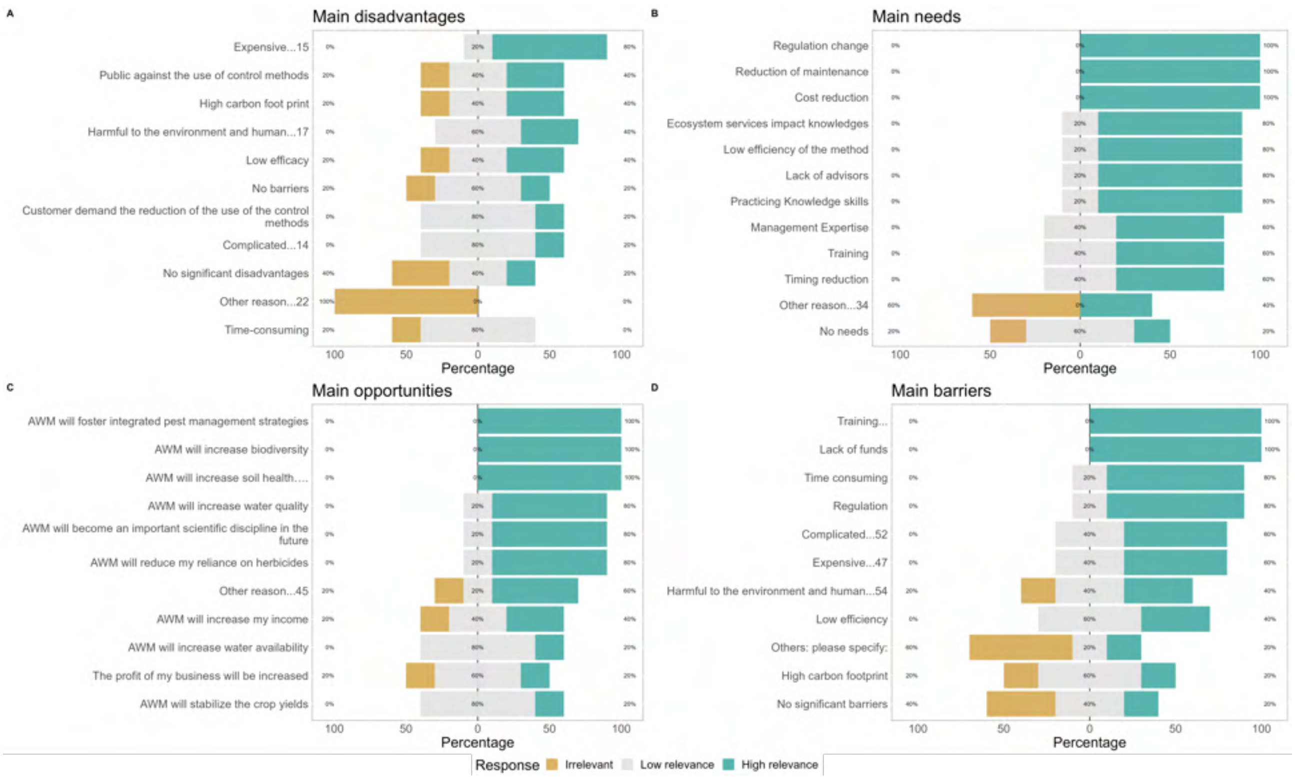


Figure 386. Main disadvantages, needs, barriers and opportunities for mowing identified by consumers.

3.4.4.1.4.2.1 By country

Consumers from both studied regions considered that mowing presents numerous opportunities, with Spaniards proportionally viewing mowing as having more opportunities compared to their Greek counterparts. Reduction in herbicide reliance was unanimously considered as a relevant opportunity by Spanish consumers, along with nearly seventy percent of Greek respondents. Two-thirds of the respondents from Greece and Spain considered that mowing increases soil health. Moreover, the same proportions of Spaniards emphasized increases in income, business profitability, as well as stabilization of crop yields, along with the recognition of other ecosystem services including increases in biodiversity as well as water quality and availability. Two-thirds of Spaniards consider that mowing will evolve into an important scientific discipline in the future, along with one third of their Greek counterparts. Lastly, one third of respondents from each region believe that mowing will foster IPM strategies.

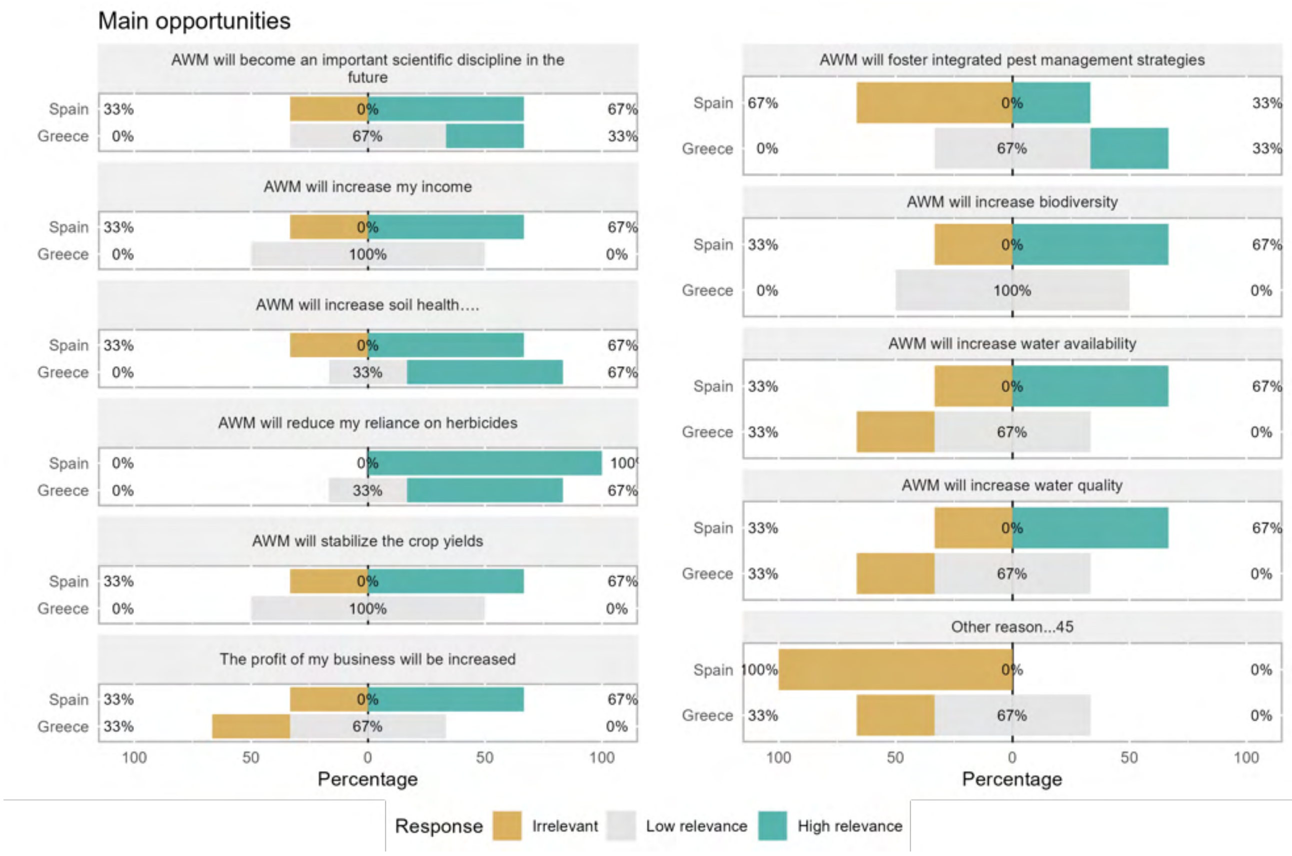


Figure 387. Main opportunities for mowing identified by consumers.

Spanish and Greek consumers believe that mowing presents several relevant needs. Spanish consumers unanimously consider ecosystem services impact knowledge as the primary need, while this factor was considered relevant by 67% of Greek respondents. Two-thirds of respondents from both regions view management expertise as well as practicing knowledge skills as highly relevant needs. Reduction of maintenance, training, and regulatory changes, among others, were also considered as highly relevant needs by different proportions of respondents.

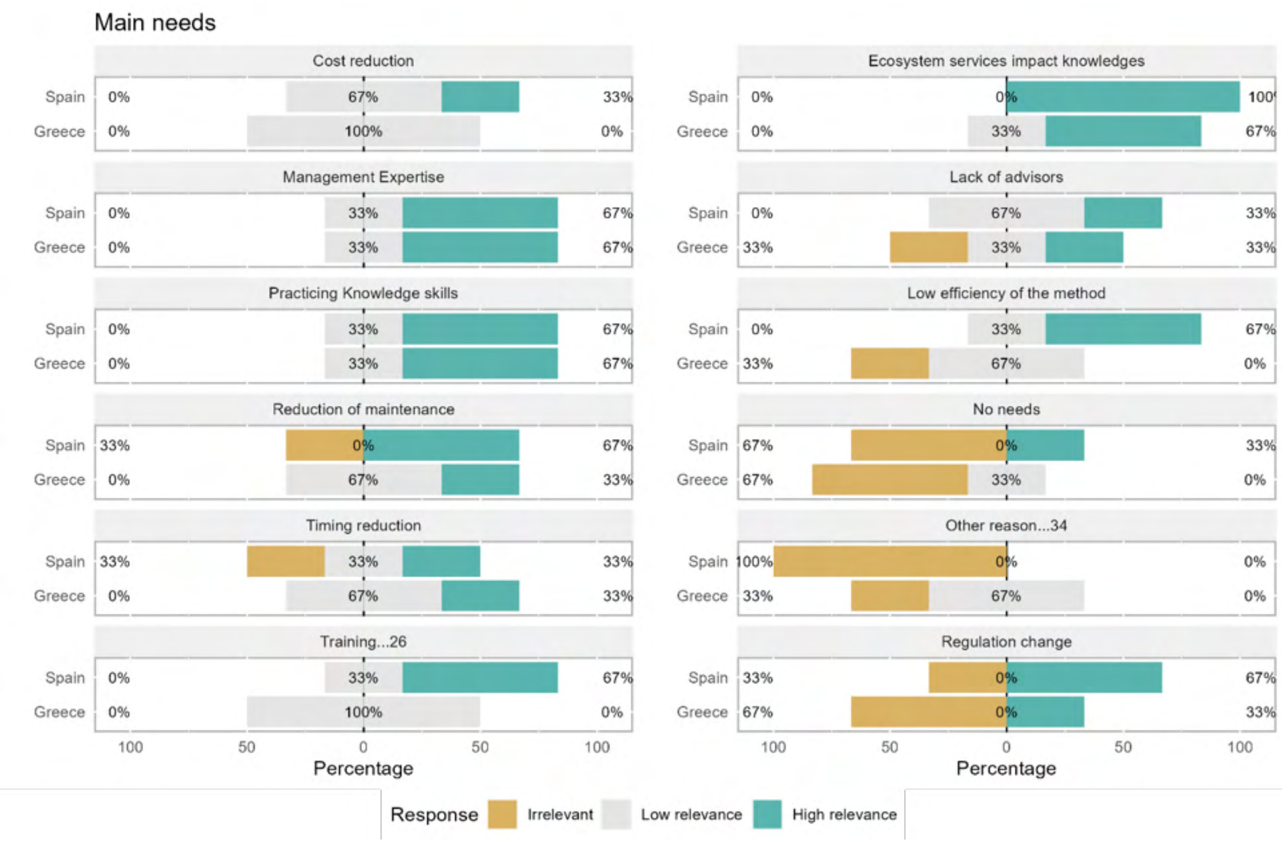


Figure 388. Main needs for mowing identified by consumers.

Greek consumers do not perceive that mowing presents any significant barriers, as they did not identify any of the queried factors as highly relevant. In contrast, nearly seventy percent of Spanish consumers considered expense, lack of funds, regulatory concerns, training, and complexity, among others, as highly relevant barriers.

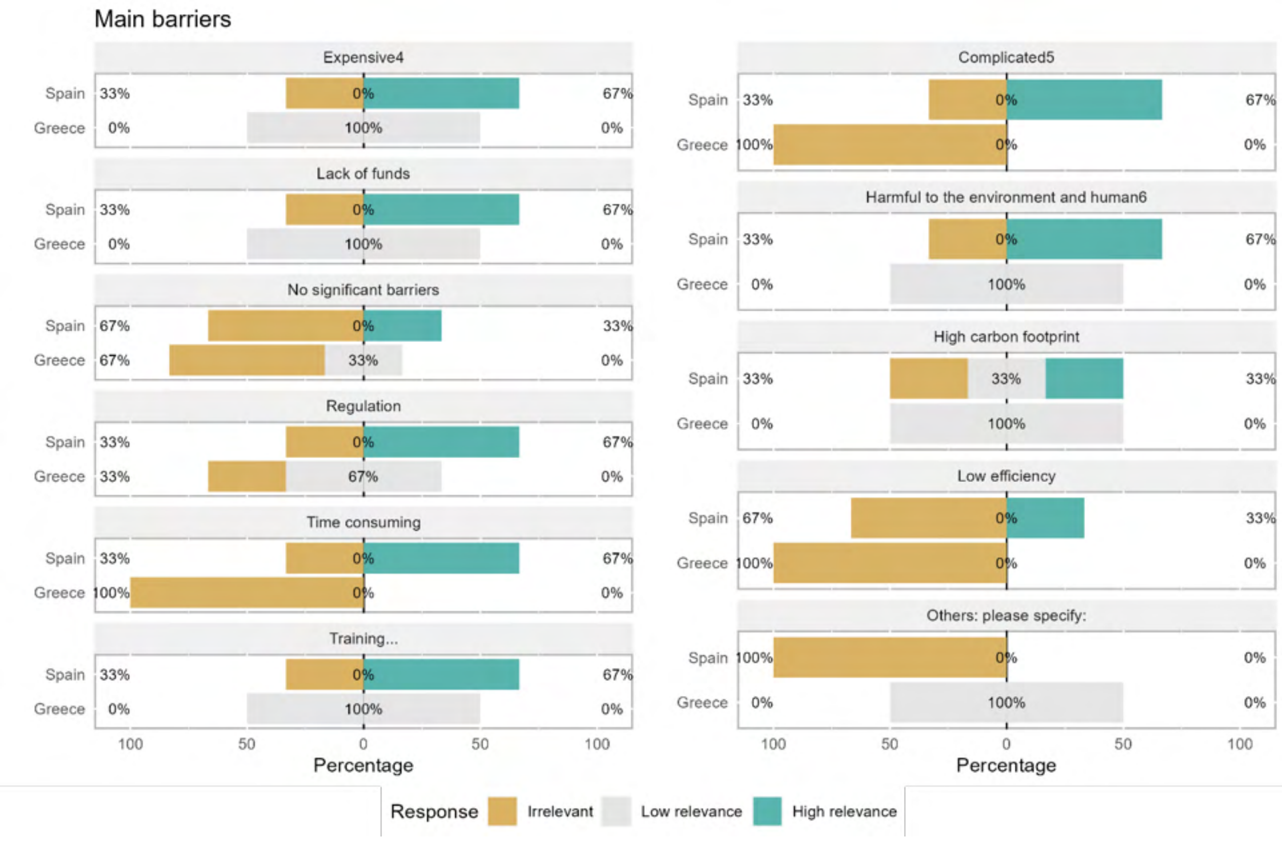


Figure 389. Main barriers for mowing identified by consumers.

Consumers from both countries believe that mowing presents some significant disadvantages. Spanish respondents unanimously considered the method's low efficacy as its most relevant drawback. Moreover, two thirds of them stated that expense and high carbon footprint, along with one third of their Greek counterparts, are important concerns. Nearly seventy percent of Greek respondents considered time-consuming as the principal disadvantage related to mowing.

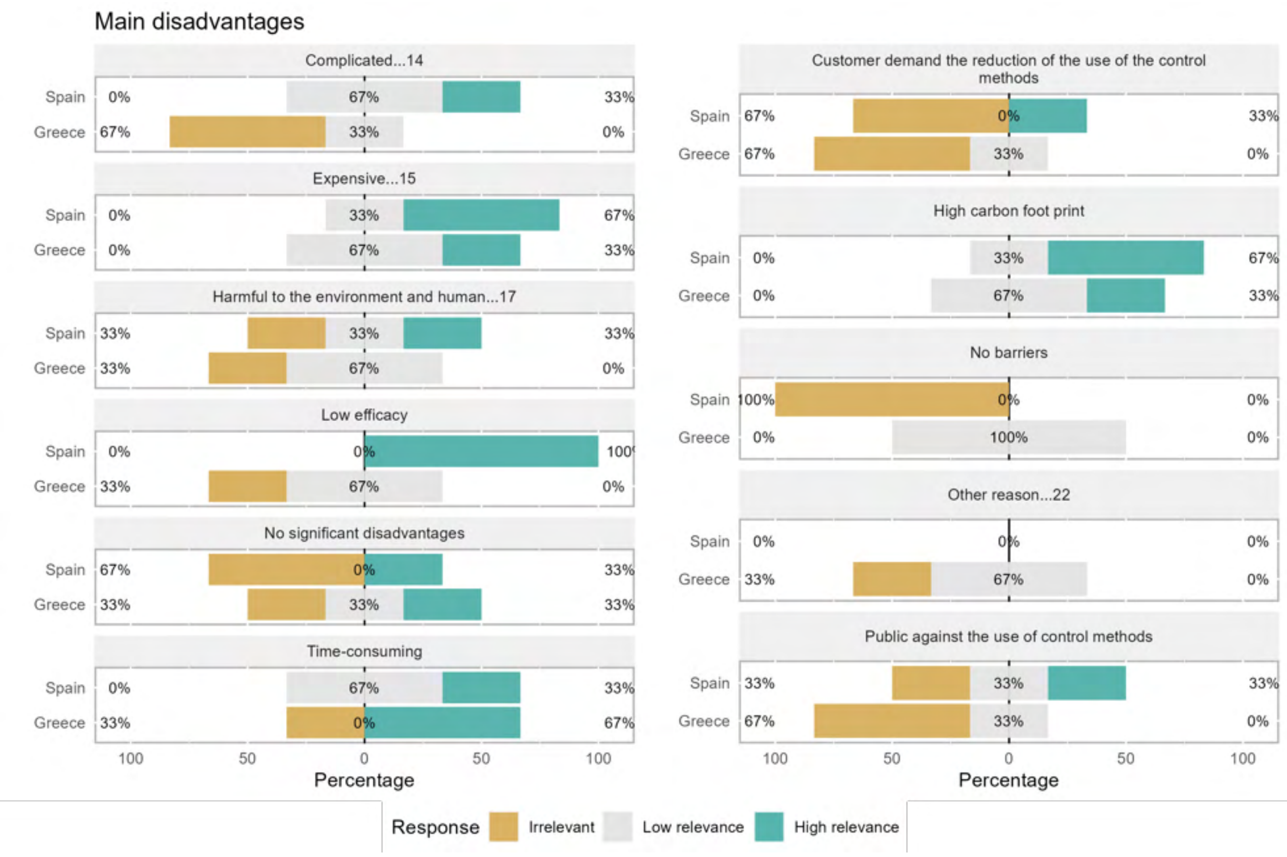


Figure 390. Main disadvantages for mowing identified by consumers.

3.4.4.1.4.3 Farmers

Farmers from Spain and Italy view mowing as a practice that entails numerous relevant opportunities, as well as few but significant barriers and disadvantages, with virtually no identified needs. Nearly ninety percent of the farmers considered that mowing reduces herbicide reliance. Additionally, over seventy percent of them acknowledge mowing as a fosterer of IPM strategies and believe that this practice is an ecosystem services provider, including increases in water availability, quality, and biodiversity, along with 57% of them who believe that its implementation improves soil health. None of the queried needs were identified as of high relevance by more than half of the respondents. Forty-three percent of the respondents cited ecosystem services impact knowledge, training, maintenance, cost, and timing reduction, among others, as important needs. Time consumption was considered a relevant barrier and disadvantage by nearly ninety percent of the surveyed farmers. Besides, nearly sixty percent of the respondents consider training, lack of funds, and expense as important impediments to mowing implementation. Expense was also regarded as an important disadvantage by 57% of farmers.

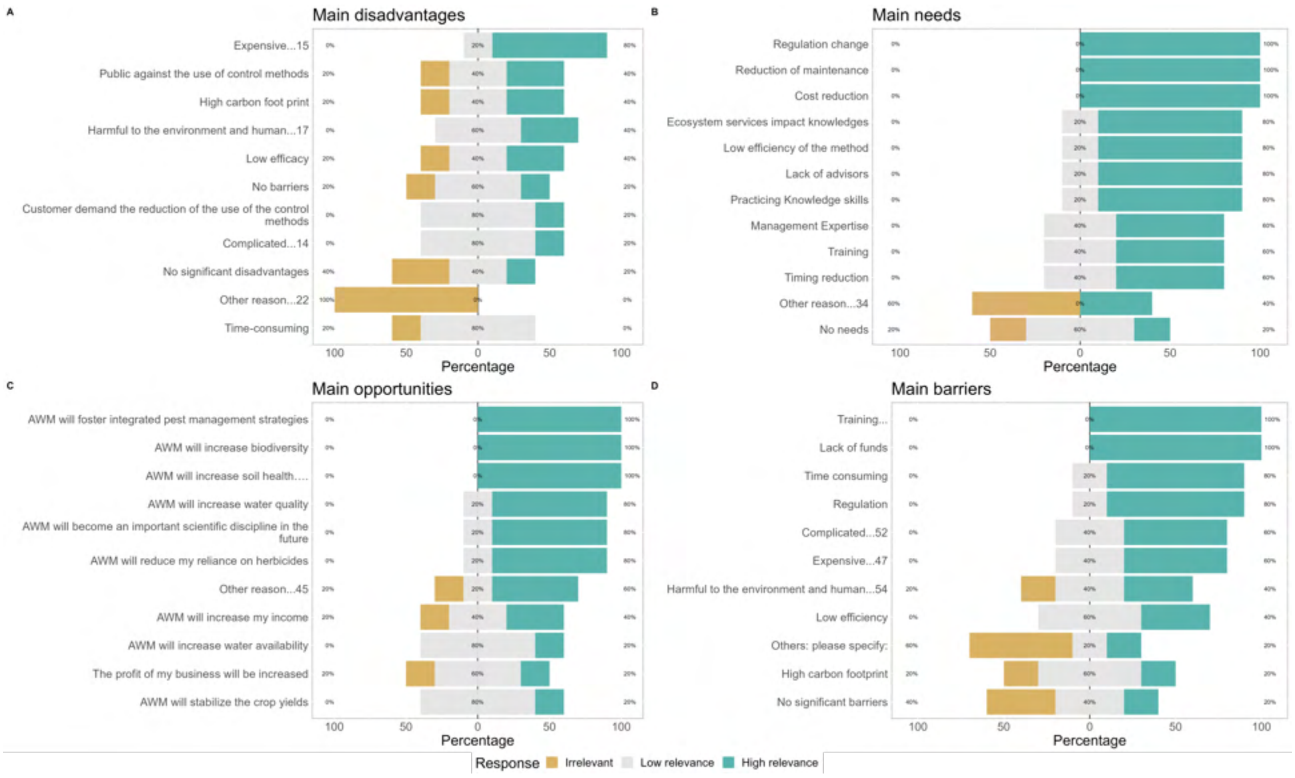


Figure 391. Main disadvantages, needs, barriers and opportunities for mowing identified by farmers.

3.4.4.1.4.3.1 By country

Spanish and Italian farmers considered that mowing presents relevant opportunities. Reduction of herbicide reliance was considered as highly relevant unanimously by Spaniards along with 67% of Italian respondents. All Spanish farmers consider that mowing increases water quality. Moreover, 75% of them consider the practice provides other relevant ecosystem services, including improvements in soil health, biodiversity, and water availability. Besides, they consider that this practice fosters IPM practices, which were mostly considered as relevant by 67% of Italians.

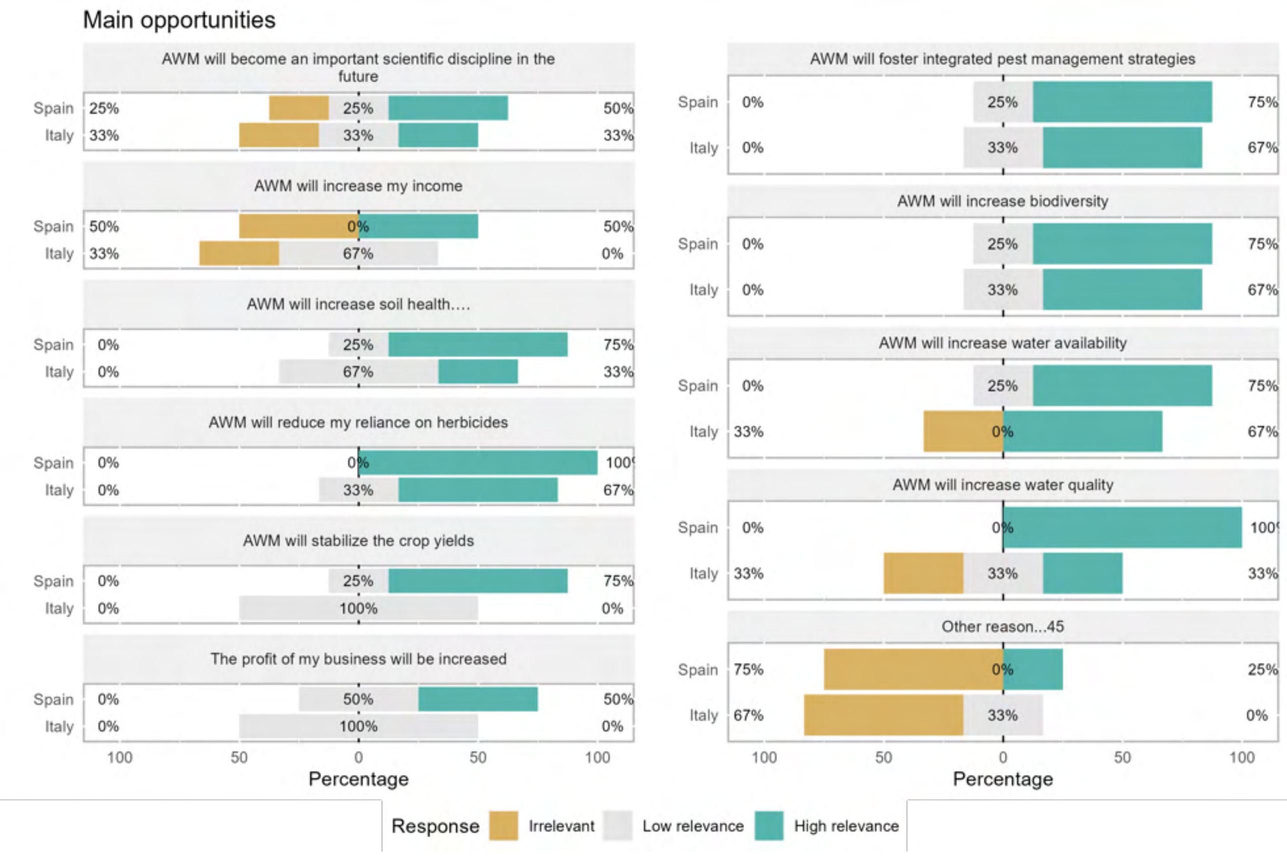


Figure 392. Main opportunities for mowing identified by farmers.

Spanish respondents did not mainly consider any of the queried needs as highly relevant, while two thirds of respondents from Italy acknowledged management expertise, practicing knowledge skills, as well as ecosystem services impact knowledge as primary needs. These were deemed as relevant by one quarter of Spanish farmers. Half of the surveyed Spaniards consider cost, maintenance, and timing reduction, as well as training, as important requirements, which were recognized as of relevance by one third of Italian farmers.

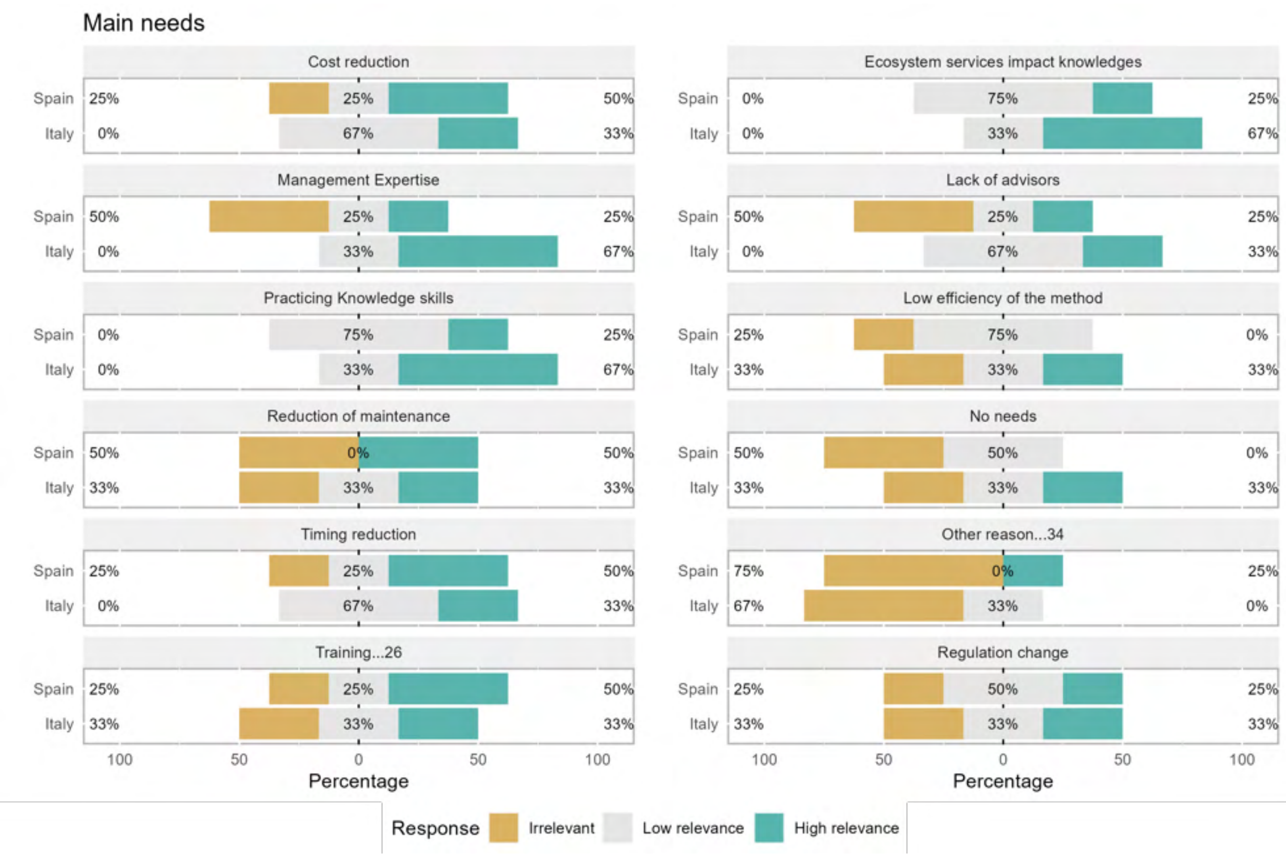


Figure 393. Main needs for mowing identified by farmers.

Farmers from both studied regions consider that mowing faces relevant barriers. Italian farmers unanimously perceive lack of funds, time consumption, and training as primary barriers, along with 67% of them emphasizing expense, complexity, and method's low efficiency as important barriers. Time consumption was also considered relevant by 75% of Spaniards, along with half of them deeming expense as important, as well as 25% of them recognizing lack of funds and training as important hurdles.

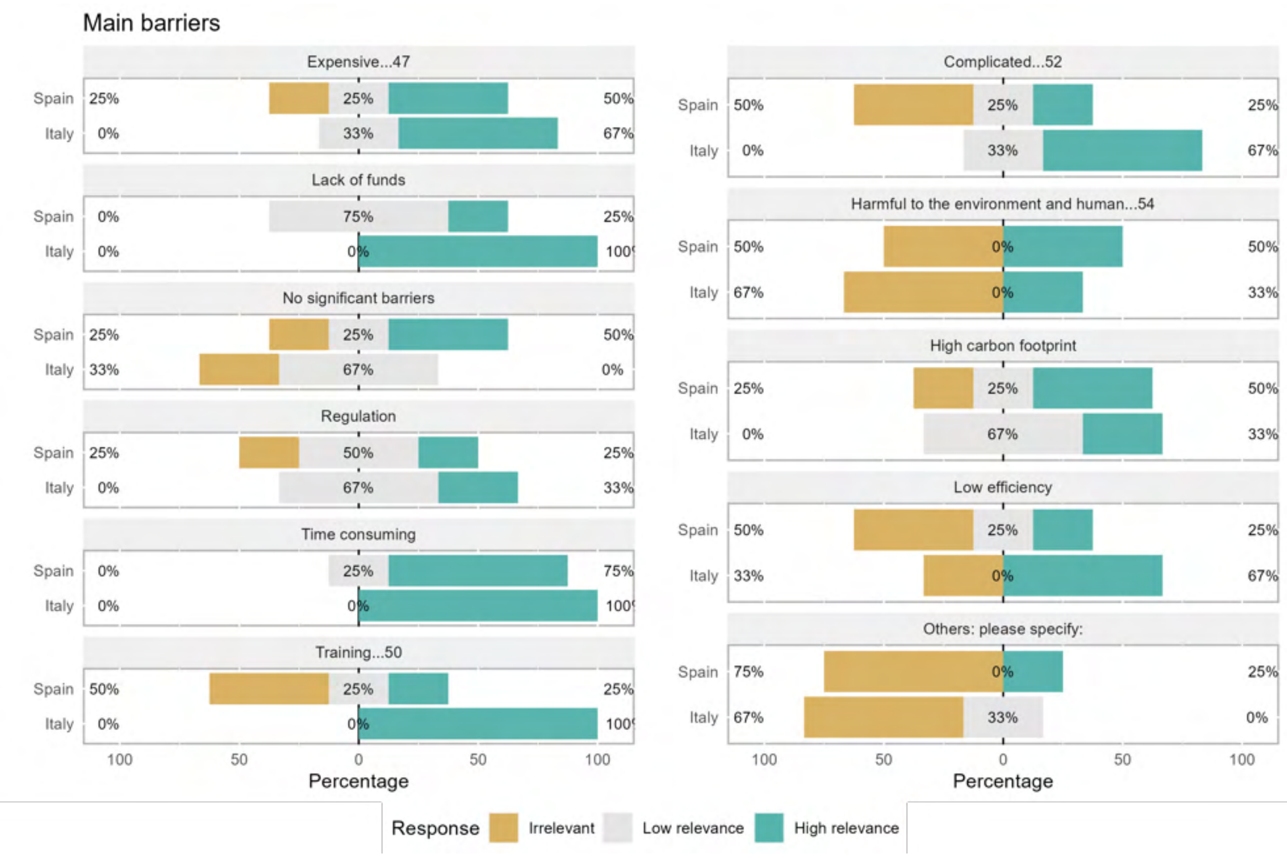


Figure 394. Main barriers for mowing identified by farmers.

In line with expressed barriers, farmers from the studied regions considered time consumption as the most relevant disadvantage, as stated by all respondents from Italy as well as 75% of the Spanish farmers. Besides, half of the Spaniards and nearly 70% of the Italians recognized expense as an important drawback for mowing.

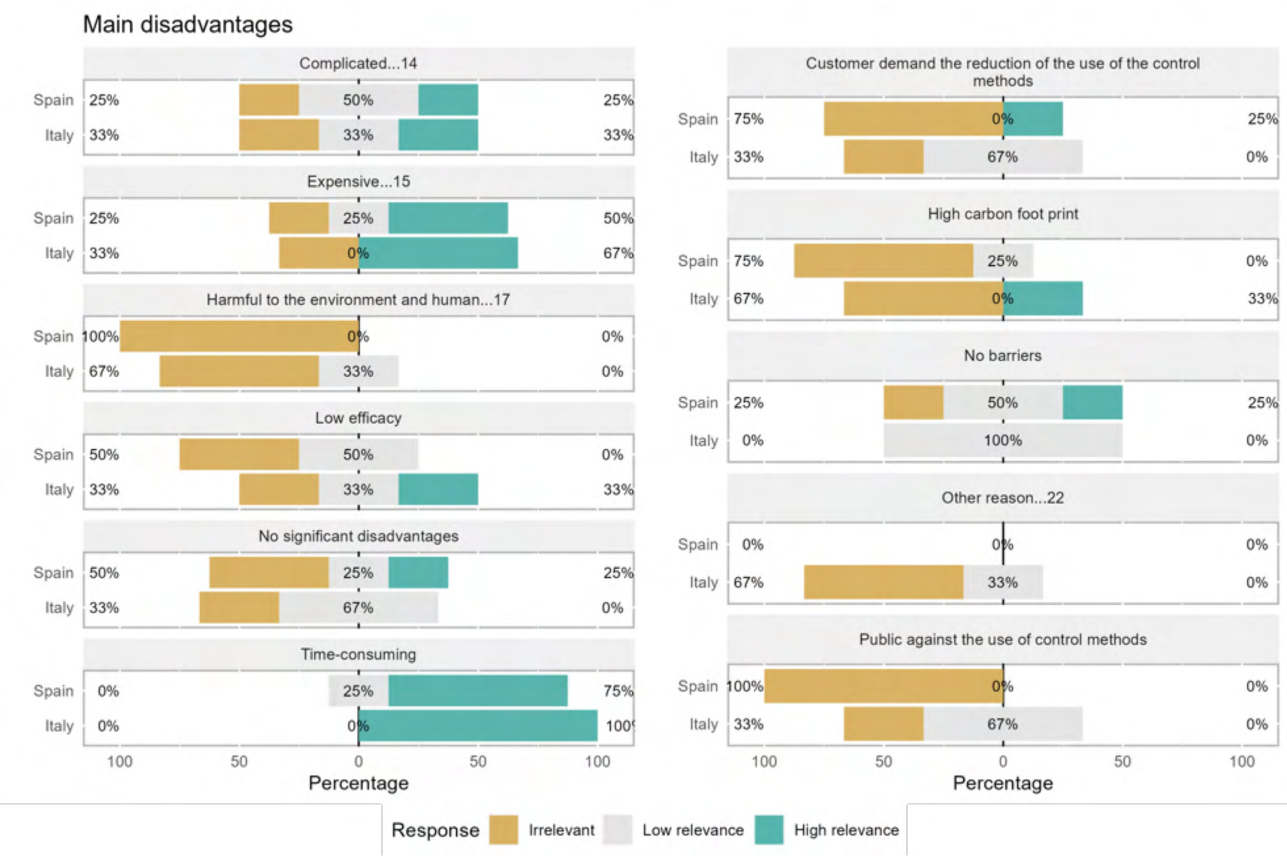


Figure 395. Main disadvantages for mowing identified by farmers.

3.4.4.1.4.4 Conclusion

Mowing was considered a relevant AWM practice for grape culture by stakeholders from different studied regions, including Italian and Greek advisors, Spanish and Greek consumers, as well as Spanish and Italian farmers. Advisors, consumers, and farmers recognized that mowing presents significant advantages. Consumers and farmers identified the reduction of herbicide reliance as the most relevant opportunity. In contrast, advisors and farmers deemed fostering IPM strategies and increases in biodiversity as highly relevant. All stakeholders agreed that mowing increases soil health. Regarding the main needs of the practice, advisors and consumers identified important requirements, while none of the queried factors were deemed highly relevant by more than half of the farmers. Advisors emphasized timing reduction as the primary need, along with cost and maintenance reduction, which were regarded as relevant needs. Consumers highlighted ecosystem services impact knowledge as the principal necessity, alongside practicing knowledge skills and management expertise.

Both advisors and farmers agreed that time consumption was the most significant barrier to mowing implementation. Additionally, half of the consumers, along with farmers, considered training and lack of funds as important impediments. Time consumption emerged as a relevant disadvantage across different stakeholders. Nearly half of the surveyed advisors and consumers perceived that mowing presents virtually no disadvantages. Apart from time consumption, nearly sixty percent of farmers and half of consumers identified expense as an important drawback.

3.4.4.1.5 Mulching

3.4.4.1.5.1 Consumers

Consumers from Italy and Spain view mulching as a relevant AWM practice, perceiving it as presenting important opportunities while entailing relevant needs, few barriers, and virtually no relevant disadvantages. Over seventy percent of the surveyed consumers consider mulching as an ecosystem services provider, increasing water quality and availability, and improving soil health, while also reducing herbicide reliance. Additionally, nearly sixty percent of the respondents believe that mulching fosters IPM strategies and increases biodiversity. Consumers from both studied countries view practicing knowledge skills as the primary need. Moreover, nearly ninety percent of the respondents consider lack of advisors and management expertise as important necessities, along with over seventy percent who view training as highly relevant. Furthermore, nearly sixty percent consider maintenance, cost, and timing reduction as important requirements. Over half of the respondents perceive low efficiency and complexity as highly relevant needs. Collectively, farmers from Spain and Italy believe that mulching does not present any significant disadvantages, as none of the queried factors were perceived as relevant by more than half of the respondents.

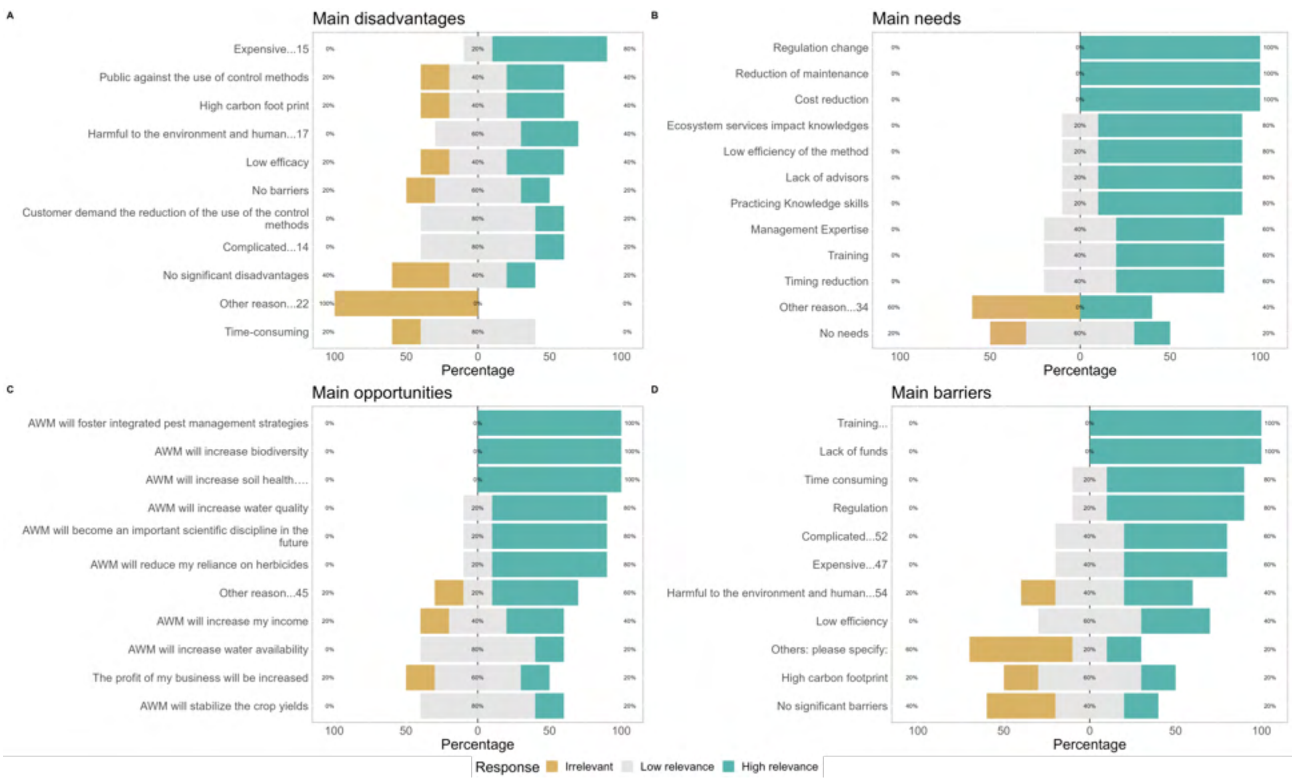


Figure 396. Main disadvantages, needs, barriers and opportunities for mulching identified by consumers.

3.4.4.1.5.1.1 By country

Consumers from both studied regions perceive mulching as a practice that presents relevant opportunities. Spanish respondents unanimously consider reduction of herbicide reliance as the most relevant opportunity. Italian consumers, on the other hand, emphasize ecosystem services provision as paramount, unanimously considering increases in water quality as the utmost relevant opportunity; this factor was also perceived as relevant by half of the Spanish respondents. Seventy-five percent of Spaniards also remark mulching as an ecosystem services provider, including improvements in soil health and water quality, along with 67% of Italian respondents, who recognize these as highly relevant. Nearly seventy percent of Italians consider economic advantages as important, including increases in income and business profitability as well as stabilization of crop yields. Besides, 67% of Italian and 50% of Spanish consumers perceive mulching as a fosterer of IPM strategies and consider its implementation as increasing biodiversity.

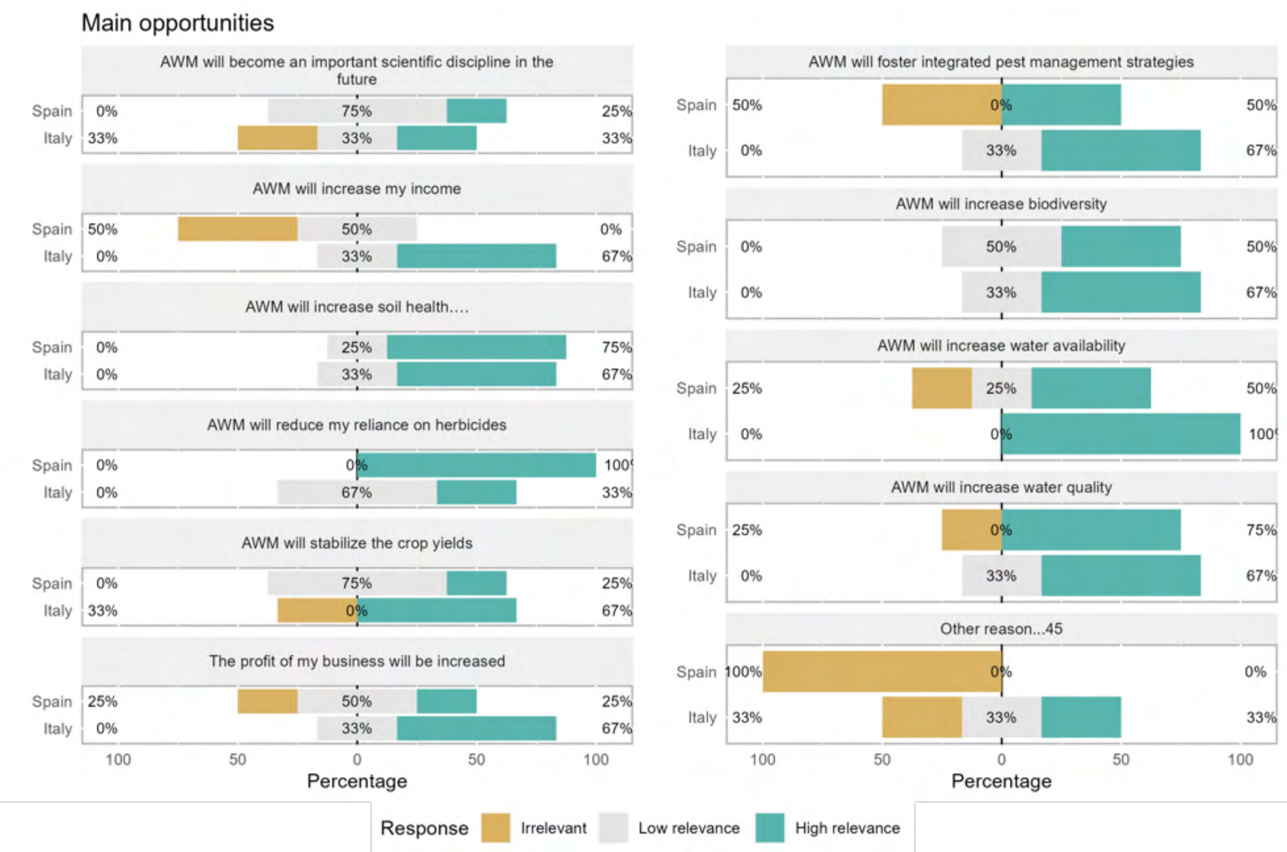


Figure 397. Main opportunities for mulching identified by consumers.

Spanish and Italian respondents recognize that mulching presents important necessities. Spanish consumers unanimously perceive management expertise, lack of advisors, and practicing knowledge skills as primary needs; all Italian respondents consider the last factor as highly relevant while 67% of them consider management concerns and lack of advisors as important. Seventy-five percent of the Spaniards and nearly seventy percent of the Italian respondents view training as an important concern. The same proportion of Italians and half of the Spanish respondents view reduction of cost, timing, and maintenance as important requirements for mulching.

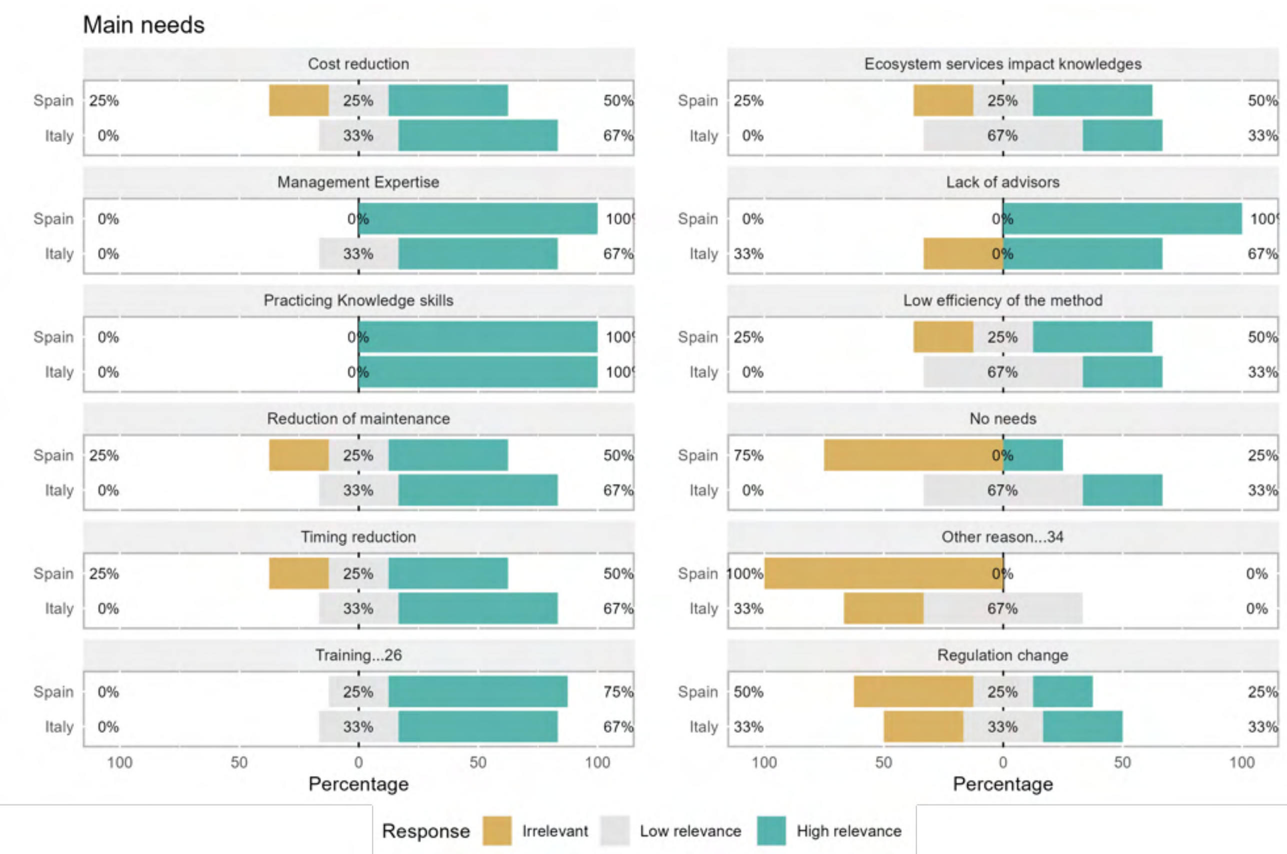


Figure 398. Main needs for mulching identified by consumers.

Regarding the most relevant barriers to the practice, the perspectives of the two studied regions diverge. Spanish respondents did not primarily identify any of the queried factors as significant, with only a quarter of them considering time consumption, training, complexity, and low efficacy of the method as relevant. In contrast, their Italian counterparts shared a different perspective. They unanimously regarded mulching as a complex practice with low efficacy. Additionally, nearly seventy percent of Italian consumers expressed concerns about expense, time consumption, training, environmental and human harm, as well as carbon footprint considering these factors as important barriers. Notably, the same proportion of Italian respondents stated that mulching presents no significant barriers.

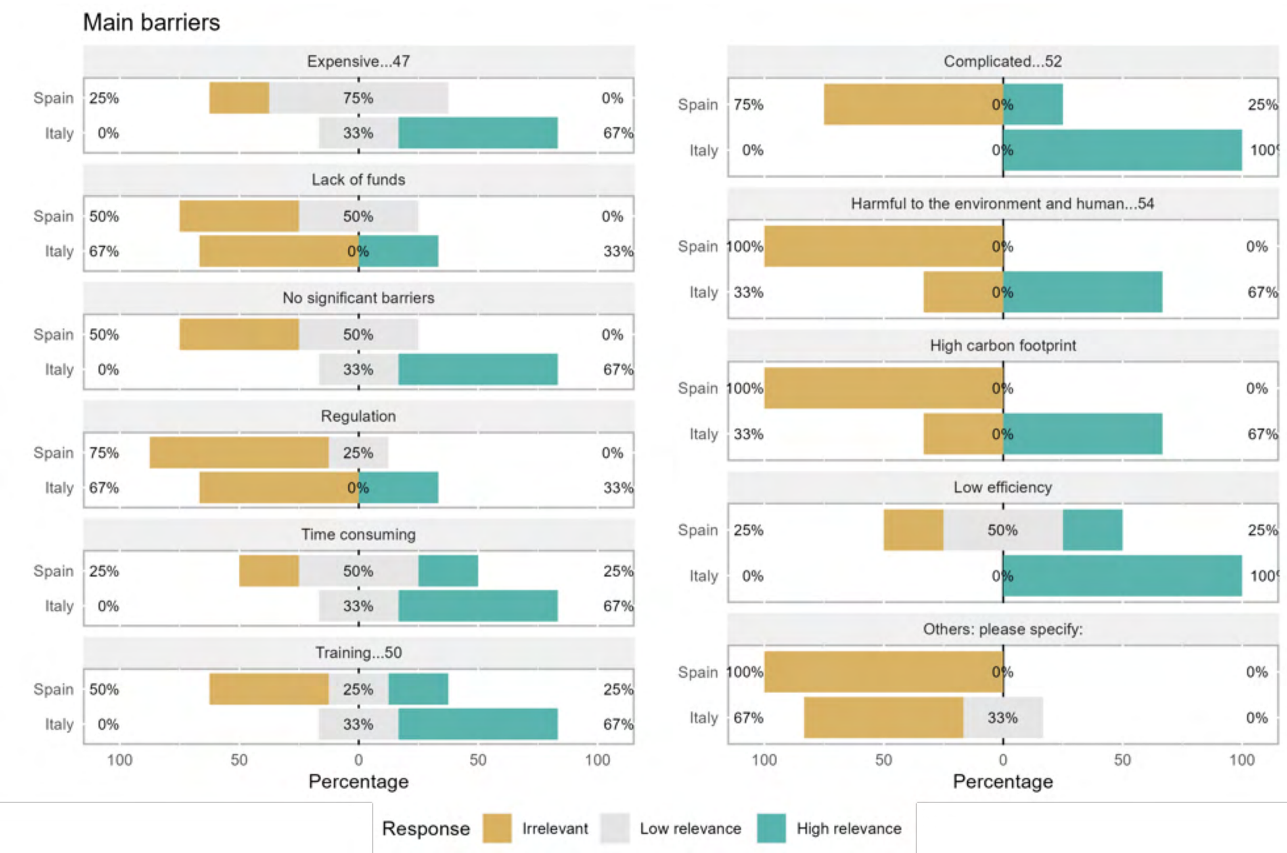


Figure 399. Main barriers for mulching identified by consumers.

The perception toward mulching disadvantages was similar to expressed barriers. No proportion of Spanish respondents consider any of the queried disadvantages as relevant, whereas two thirds of Italians perceive method's low efficiency as the most relevant disadvantage. Moreover, one third of them stated complexity, expense, and environmental and human harm, among others as relevant disadvantages.

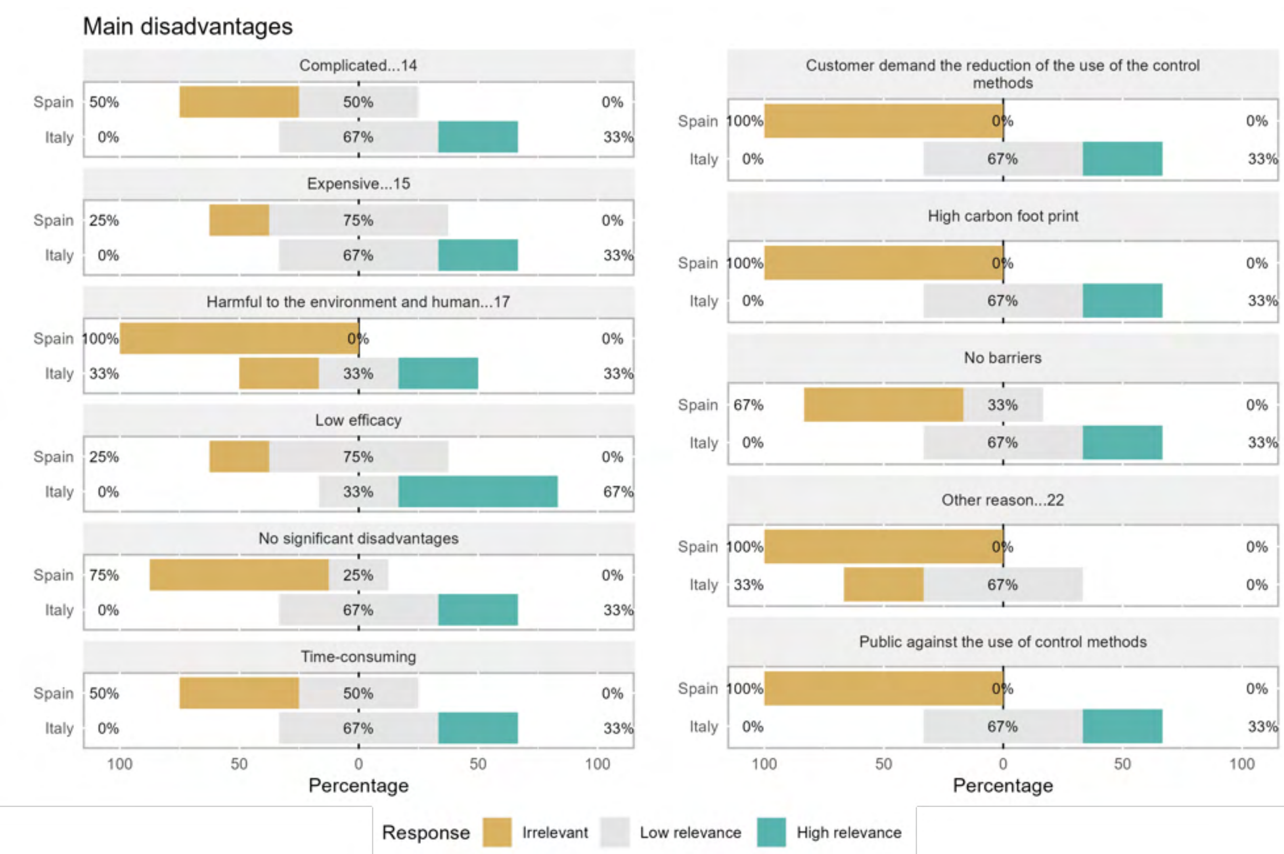


Figure 400. Main disadvantages for mulching identified by consumers.

3.4.4.1.5.2 Conclusion

In conclusion, consumers from Italy and Spain shared a positive perception of mulching as an essential practice in AWM. They perceive it as offering significant opportunities while having relevant needs and minimal barriers and disadvantages. Both Italian and Spanish consumers acknowledge mulching as a provider of ecosystem services, emphasizing improvements in water quality, soil health, and biodiversity, alongside the reduction of herbicide reliance. They also see mulching as fostering IPM strategies and providing economic benefits. The primary needs identified by consumers revolve around knowledge, sharing concerns such as practicing skills and training, as well as access to management expertise and advisors. However, they also recognize the importance of reducing costs and timing in mulching practices. While Spanish consumers did not identify significant barriers or disadvantages, Italian consumers expressed concerns about mulching's complexity and inefficiency. They also highlighted potential barriers related to expense, time consumption, and environmental impacts, although they also noted that mulching presents no significant barriers overall. This indicates a nuanced perception of mulching's challenges and benefits, reflecting the diverse contexts and priorities of stakeholders in Italy and Spain.

3.5 Citrus

3.5.1 Italy

3.5.1.1 Questionnaires

The citrus questionnaires yielded insights into five AWM practices, including biobased herbicides, herbicides, mechanical weeding, mowing, and site-specific spraying. However, none of these practices were deemed relevant for citrus culture across all stakeholders, as we did not gather enough responses from farmers and researchers. Table 39 presents the types of stakeholders who answered the questionnaires associated with different AWM practices and the number of respondents in each category.

Table 39. Number of responses for each AWM practice and stakeholder category in Citrus (Italy).

	Advisor	Consumer	Farmer	Industry	Policy maker	Researcher
Automated weed control		2		1	1	
Biobased herbicides	1	**3**		1	1	1
Cover crop inoculation to increase competitiveness						
Cover crops	1					1
False seedbed		2				
Grazing	2	2	1		1	1
Herbicides	1	**3**			2	1
Intercropping	2			1		1
Mechanical weeding	**4**	**5**	2	**3**	**3**	2
Mowing	**3**	2	2		2	2
Mulching	1	2		1	1	
Natural enemies				1	1	
Other						
Site-specific spraying		**3**			1	
Thermal weeding						
UAV						
n=28	4	11	3	4	4	2

3.5.1.1.1 Biobased herbicides

3.5.1.1.1.1 Consumers

Consumers unanimously consider biobased herbicides as providers of ecosystem services, including improvements in water quality and soil health, along with crop yield stabilization and the potential to evolve into an important scientific discipline. Additionally, nearly seventy percent of the respondents identify biobased herbicides as fosterers of IPM, contributing to increases in water availability, biodiversity, business profitability, income, and a reduction in herbicide reliance. Regarding the primary needs of the method, consumers unanimously consider ecosystem services impact knowledge, practicing knowledge skills, and management expertise as essential. Additionally, two thirds of them acknowledge regulatory changes, the method's low efficiency, lack of advisors, training, and reduction of maintenance as relevant necessities. All surveyed consumers recognize time consumption, training, lack of funds, and expense as the main barriers to biobased herbicides. Moreover, two thirds of them view the method's high carbon footprint, environmental and human harm, low efficiency, complexity, and regulatory challenges as relevant barriers. Notably, the same proportion of respondents stated that biobased herbicides face no significant barriers. Nearly seventy percent of respondents consider customer demand to reduce biobased herbicide use, expense, and time consumption as the method most relevant disadvantages.

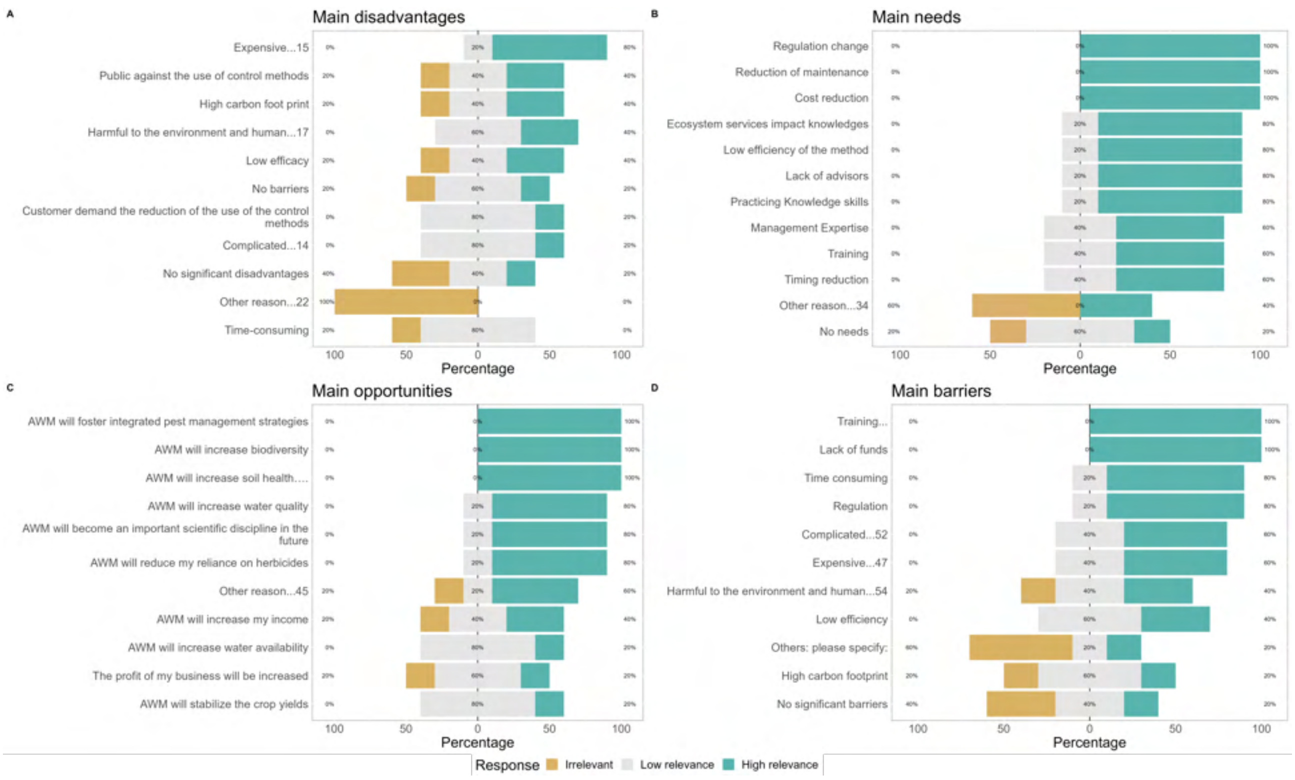


Figure 401. Main disadvantages, needs, barriers and opportunities for biobased herbicides identified by consumers.

3.5.1.1.1.2 Conclusion

Consumers exhibit optimism toward biobased herbicides, acknowledging their potential for ecosystem services and contributions to IPM strategies implementation. Despite unanimous recognition of needs like improved knowledge and management expertise, barriers such as time consumption and financial constraints pose significant challenges. Meeting customer demand for reduced usage and addressing expense and time concerns are paramount for overcoming disadvantages.

3.5.1.1.2 Herbicides

3.5.1.1.2.1 Consumers

Consumers unanimously consider that herbicides will increase biodiversity and stabilize crop yields. Moreover, two-thirds of the respondents recognize that it fosters IPM strategies and serves as a provider of ecosystem services, including increased water availability, quality, and improved soil health. Consumers believe that herbicides have the potential to evolve into an important scientific discipline and increase business profitability. Consumers consider several primary needs for herbicides. They unanimously identify ecosystem services impact knowledge, regulatory changes, lack of advisors, practicing knowledge skills, management expertise, and training. Additionally, nearly seventy percent of the surveyed consumers recognize that maintenance, cost, and timing reduction are relevant requirements. As main barriers, consumers consider high carbon footprint and lack of funds. Besides, two-thirds of the respondents cited environmental and human harm, complexity, time consumption, training, and expense as relevant impediments. Harm to the environment and humans was unanimously considered the most relevant disadvantages by consumers. Moreover, public opposition to herbicides, low efficacy, and expense were regarded as highly relevant drawbacks.

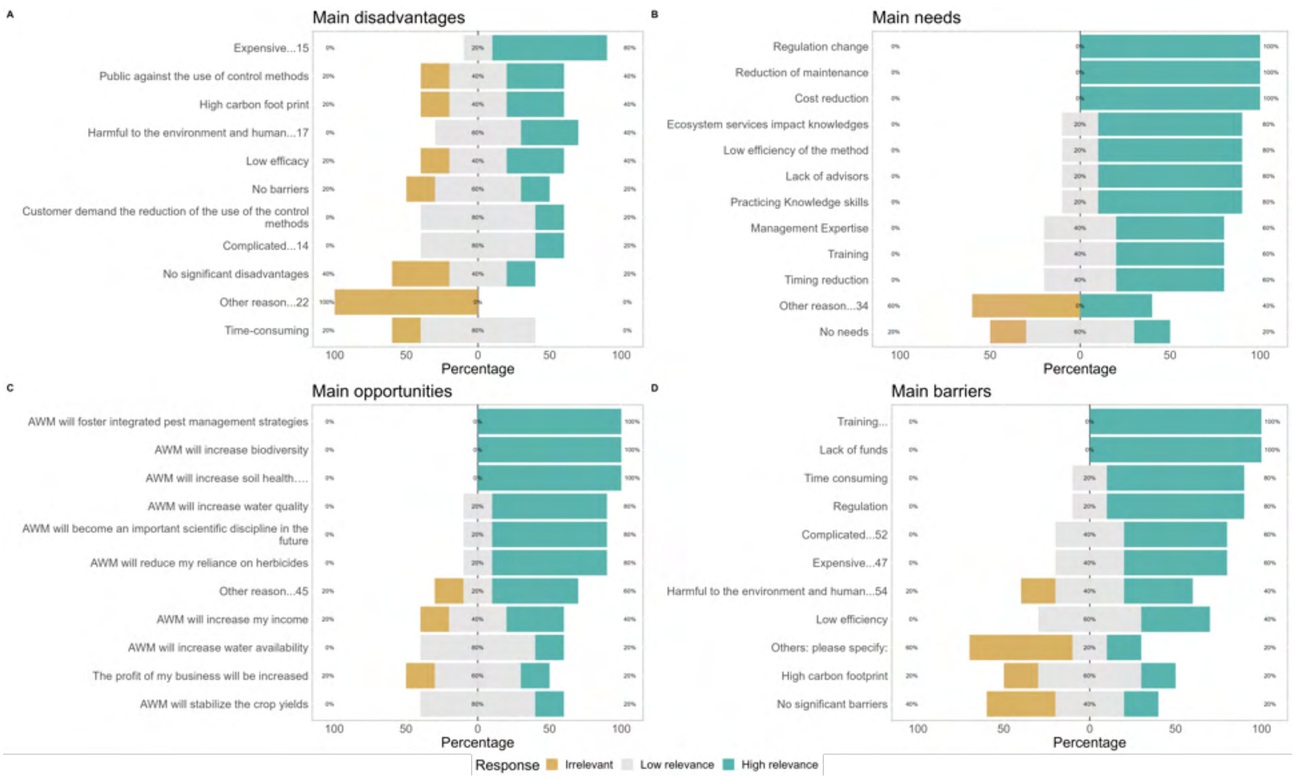


Figure 402. Main disadvantages, needs, barriers and opportunities for herbicides identified by consumers.

3.5.1.1.2.2 Conclusion

Consumers perceive herbicides as offering numerous opportunities, including biodiversity enhancement and crop yield stabilization, while acknowledging significant needs, barriers, and disadvantages. They emphasize the potential for herbicides to contribute to ecosystem services and business profitability, yet highlight the necessity for improved knowledge, regulatory changes, and management expertise. High costs and environmental concerns emerge as primary barriers. Environmental and human harm, public opposition, efficacy concerns, and expense are considered as notable disadvantages.

3.5.1.1.3 Mechanical weeding

3.5.1.1.3.1 Advisors

Advisors consider mechanical weeding to present relevant opportunities and needs, with virtually no barriers or disadvantages. Regarding opportunities, advisors unanimously regard that this practice may evolve into an important scientific discipline, and its use will result in a reduction in herbicide reliance. Additionally, two-thirds of the respondents acknowledge that mechanical weeding will increase water quality, biodiversity, and soil health. Advisors also believe that mechanical weeding will increase their income. As for the primary need of mechanical weeding, all respondents consider management expertise essential. Additionally, nearly seventy percent identify practicing knowledge skills and cost reduction as relevant necessities. Training was considered a relevant barrier by two-thirds of the respondents. However, none of the queried disadvantages were regarded as highly relevant by the majority of respondents.

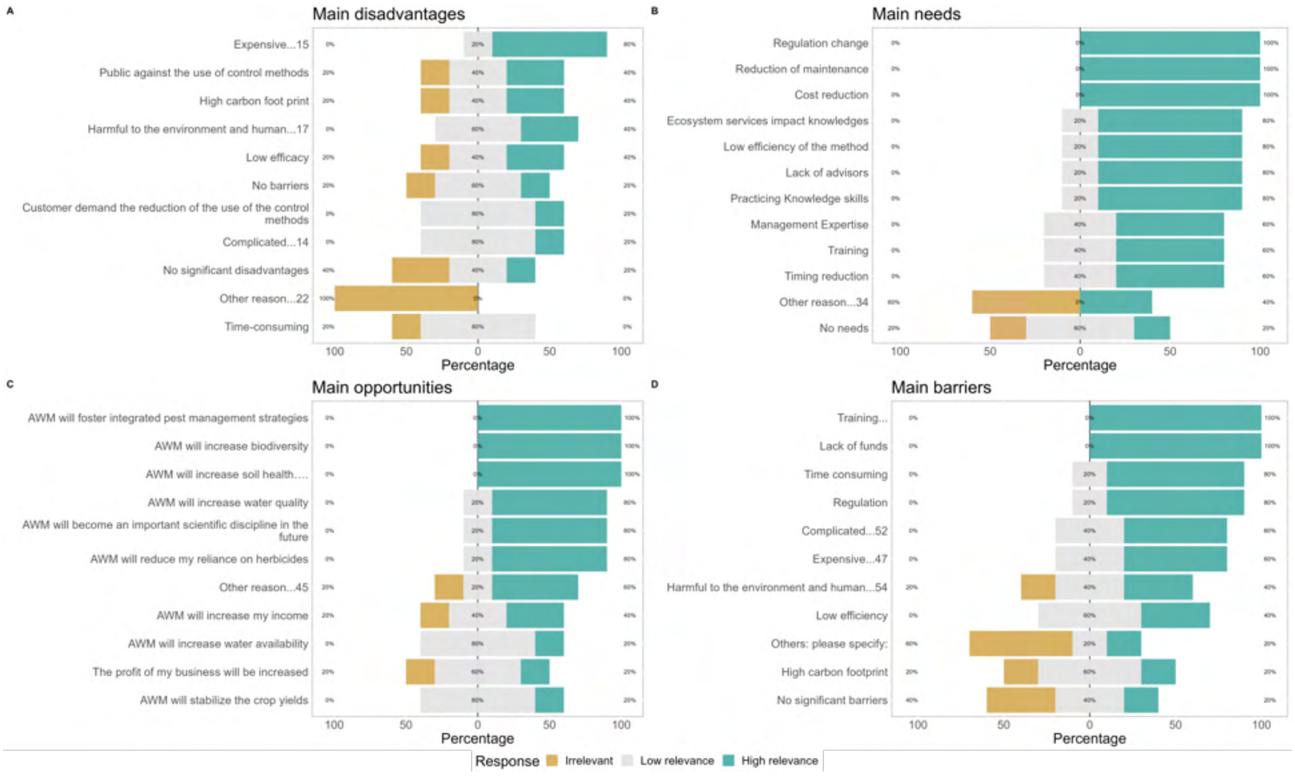


Figure 403. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by advisors.

3.5.1.1.3.2 Consumers

Sixty percent of the respondents believe that mechanical weeding results in increased biodiversity; besides, forty percent of them consider that it will foster IPM strategies and provide other ecosystem services, including increased water availability and quality, and soil health. They also believe that it will evolve into an important scientific discipline, stabilize crop yields, and reduce herbicide reliance. Consumers unanimously consider practicing knowledge skills as primary necessities; eighty percent of them consider management expertise, and sixty percent regarded ecosystem services impact knowledge and training as essential. Regarding the main barriers of the method, sixty percent of the surveyed consumers consider complexity, training, and expense. The rest of the queried factors were not considered by a majority of the respondents as relevant barriers. Similarly, none of the queried disadvantages were considered as relevant by most of the respondents, although forty percent of them highlighted, among other factors, customer demand to reduce or eliminate their use.

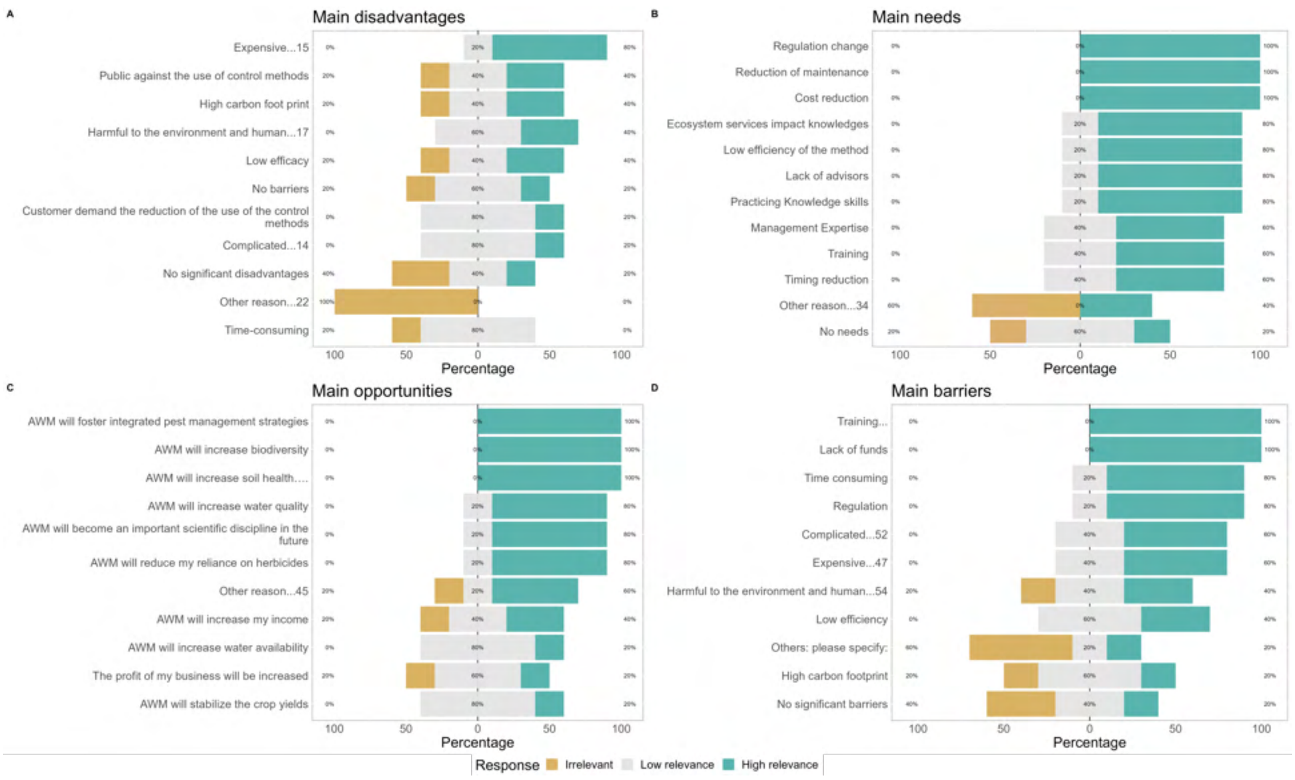


Figure 404. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by consumers.

3.5.1.1.3.3 Industry

As for the main opportunities, industry representatives unanimously consider that mechanical weeding results in increased soil health. Additionally, two-thirds consider that it will increase water availability. The rest of the queried opportunities were not regarded as relevant by a sufficient proportion. Regarding the primary needs, industry representatives unanimously consider practicing knowledge skills as well as reduction of maintenance, timing, and cost. Nearly seventy percent of the respondents consider environmental and human harm, time consumption, training, and lack of funds as relevant barriers. Lastly, expense was unanimously considered a relevant disadvantage. Moreover, nearly seventy percent of them regarded high carbon footprint and time consumption as other relevant disadvantages.

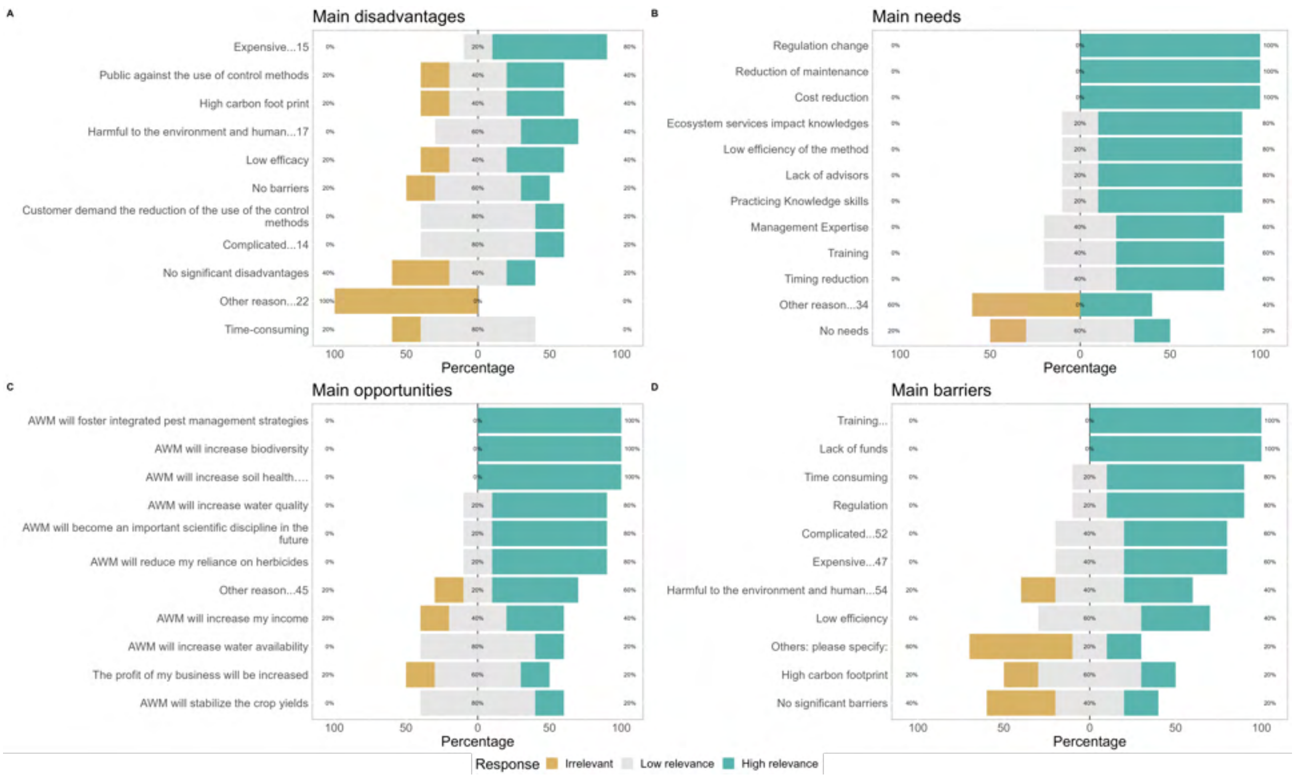


Figure 405. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by industry.

3.5.1.1.3.4 Policy makers

Policy makers unanimously consider mechanical weeding as an ecosystem services provider, as it increases water quality, biodiversity, and soil health. Additionally, they all recognize that mechanical weeding will evolve into an important scientific discipline and that its use will reduce herbicide reliance. Moreover, nearly seventy percent of the surveyed policy makers believe that mechanical weeding will foster IPM strategies, increase water availability, and result in an income increase. Policy makers unanimously consider reduction of maintenance and cost reduction as the primary needs. Two thirds of the respondents recognize training and timing reduction as relevant necessities. Time consumption was considered the most relevant barrier by seventy percent of the respondents. Expense was considered the most relevant disadvantage, and, in line with expressed barriers, seventy percent of respondents consider time consumption as significant.

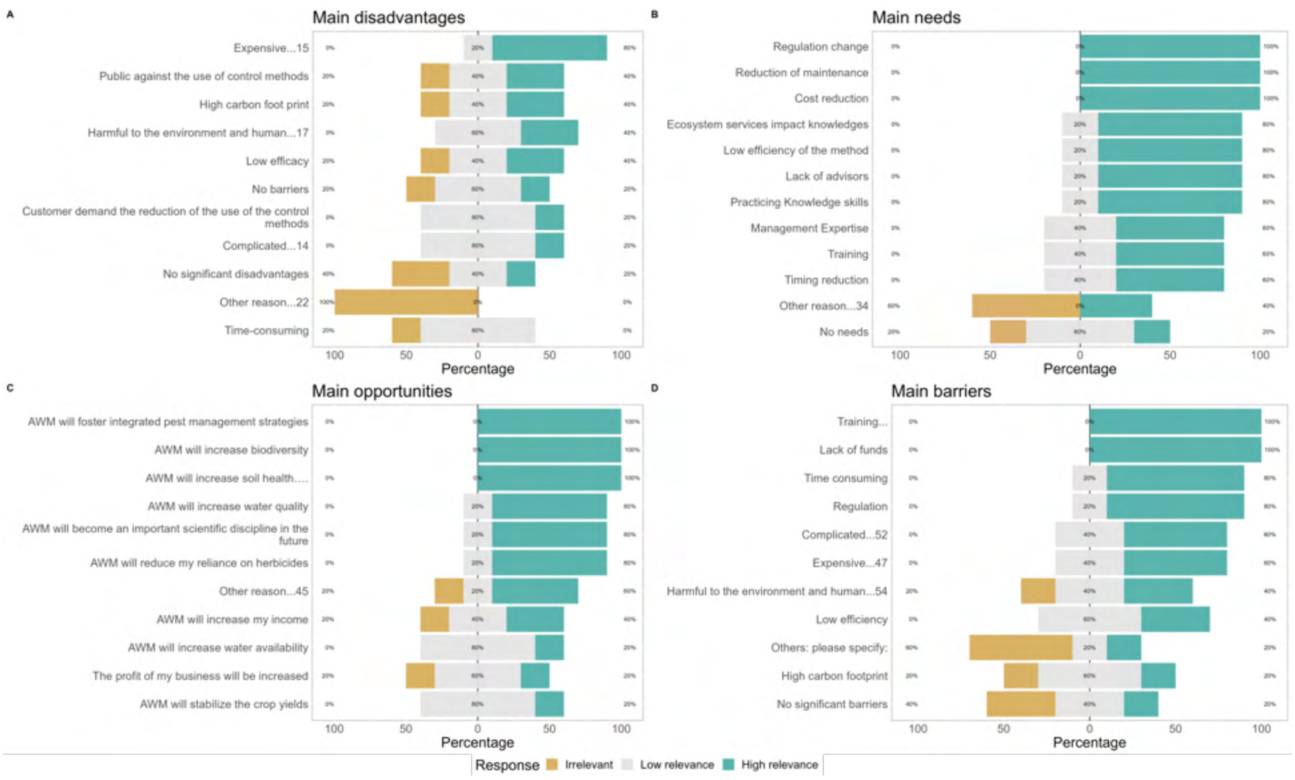


Figure 406. Main disadvantages, needs, barriers and opportunities for mechanical weeding identified by policy makers.

3.5.1.1.3.5 Conclusion

Mechanical weeding is considered a practice that presents relevant opportunities and important necessities, with virtually all stakeholders acknowledging numerous advantages, few barriers, and disadvantages. Regarding the most relevant opportunities, all stakeholders agree that mechanical weeding provides several ecosystem services. Additionally, advisors, consumers, and policymakers recognize that mechanical weeding results in a reduction in herbicide reliance among other benefits. As for primary needs, advisors emphasize management expertise, consumers emphasize practicing knowledge skills, while policymakers consider reduction of cost and maintenance crucial, a viewpoint shared by industry representatives. They also highlight practicing knowledge skills and timing reduction. Training was considered a relevant barrier across all stakeholder categories. Additionally, consumers, industry representatives, and researchers emphasize time consumption as relevant impediments. None of the queried disadvantages were considered highly relevant by advisors or consumers. However, industry representatives and policymakers regarded expense and time consumption as significant disadvantages.

3.5.1.1.4 Mowing

3.5.1.1.4.1 Advisors

Advisorsy perceive mowing as a fosterer of IPM strategies and an ecosystem services provider, including improvements in water quality, biodiversity, and soil health. Additionally, advisors believe that mowing will become an important scientific discipline. Moreover, two-thirds of the respondents consider that mowing reduces herbicide reliance and increases water availability. Regarding primary needs, two-thirds of the respondents identify lack of advisors, reduction of maintenance, and cost as crucial. Advisors unanimously consider lack of funds as the main barriers. Additionally, nearly seventy percent of the respondents emphasize complexity, time consumption, training, and expense as relevant impediments for mowing implementation. None of the queried disadvantages were considered as relevant by more than half of the respondents.

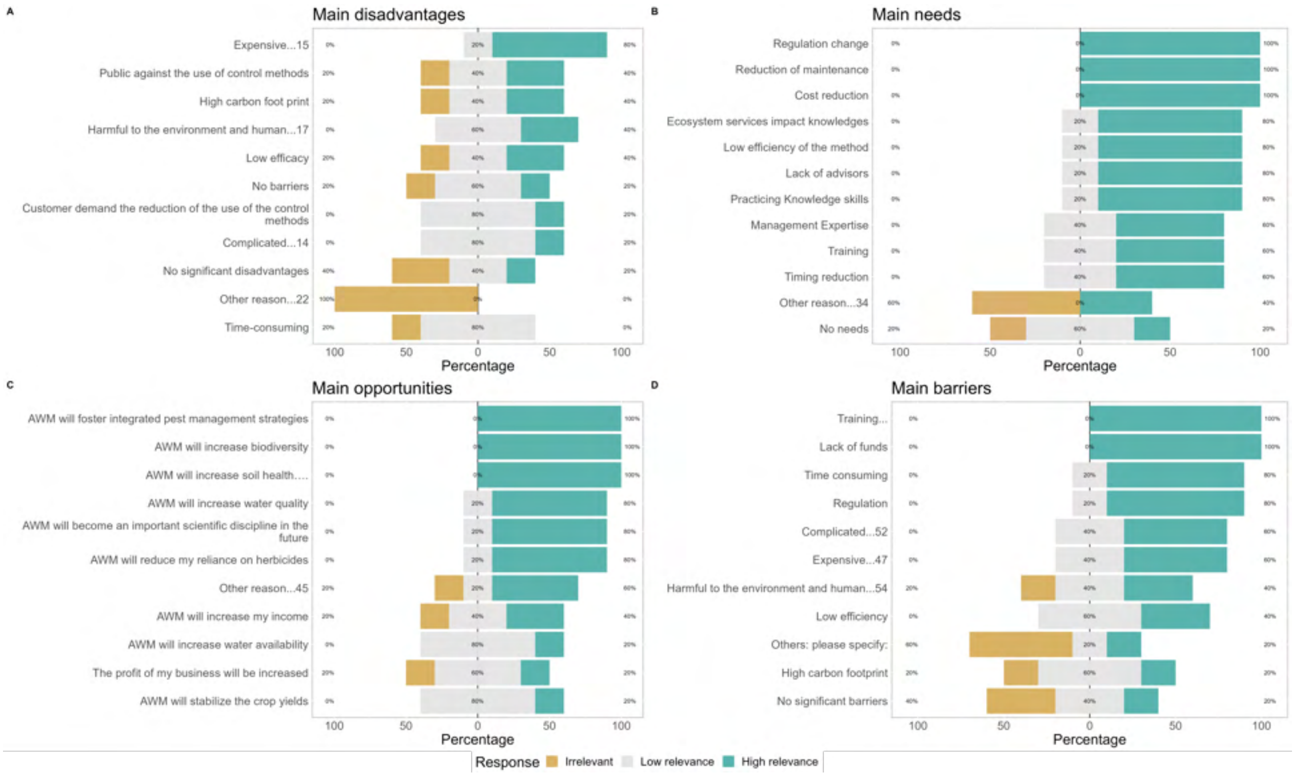


Figure 407. Main disadvantages, needs, barriers and opportunities for mowing identified by advisors.

3.5.1.1.4.2 Conclusion

Advisors recognize mowing as a technique offering ample opportunities, particularly in fostering IPM and enhancing ecosystem services such as water quality and biodiversity. They foresee its potential to evolve into an important scientific discipline while reducing herbicide reliance and increasing water availability. Primary needs identified by advisors include management expertise, reduced maintenance, and cost. Lack of funds emerges as the main barrier, alongside concerns about complexity, time consumption, and training. Notably, no single disadvantage was deemed significant by a majority of respondents, suggesting a balanced perspective on potential drawbacks.

3.5.1.1.5 Site-specific spraying

3.5.1.1.5.1 Consumers

Consumers primarily regard site-specific spraying as having the potential to evolve into an important scientific discipline and believe that its implementation will stabilize crop yields. Additionally, they consider this practice as an ecosystem services provider, recognizing that its use results in increased biodiversity. Virtually, the rest of the queried opportunities were considered highly relevant by one third of the surveyed consumers. Regarding site-specific spraying's primary needs, consumers unanimously consider ecosystem services impact knowledge, practicing knowledge skills, and management expertise as highly relevant. Moreover, nearly seventy percent of consumers consider lack of advisors, training, as well as maintenance, cost, and timing reduction as relevant necessities. Training was unanimously considered the most relevant barrier by surveyed consumers. Moreover, two-thirds of them emphasize complexity, time consumption, and lack of funds. Main disadvantages included expense, complexity, and time consumption as stated by all surveyed consumers. Additionally, 67% of them considered the practice's high carbon footprint, environmental and human harm, as well as low efficacy, as relevant drawbacks.

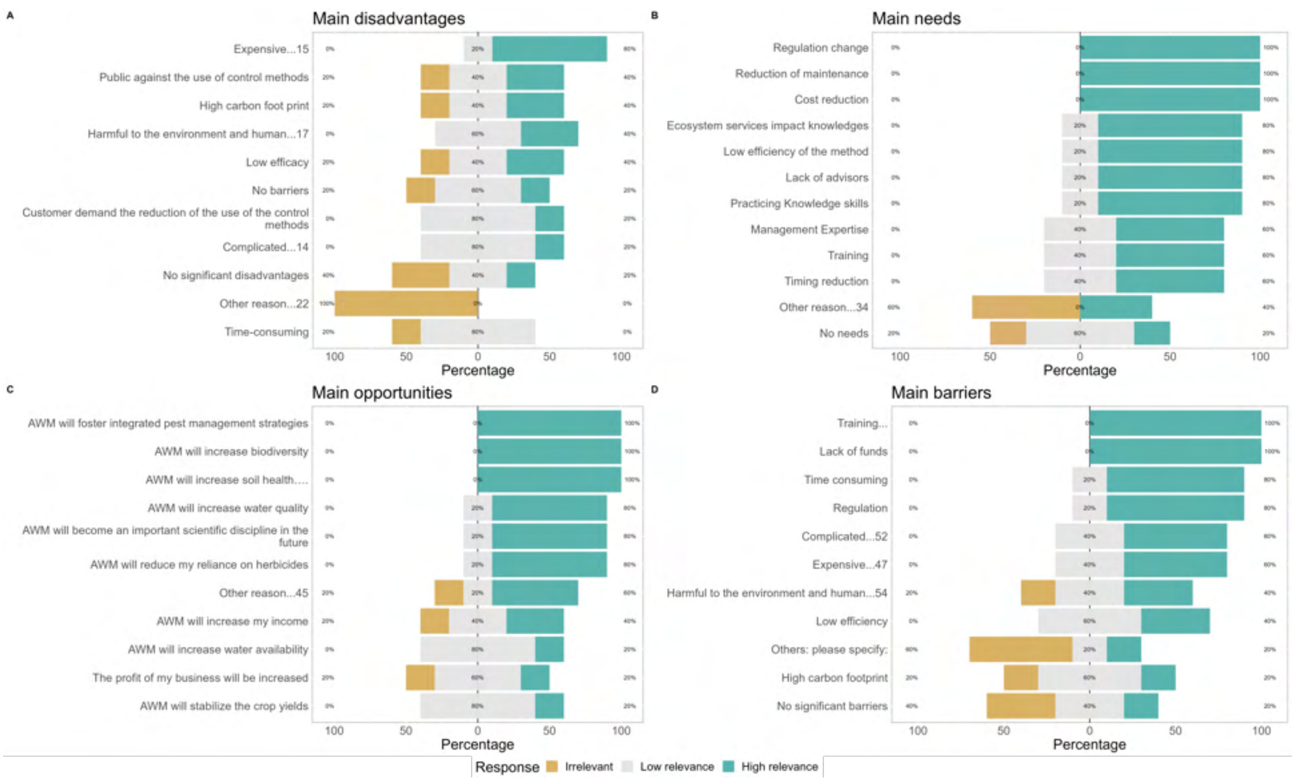


Figure 408. Main disadvantages, needs, barriers and opportunities for site-specific spraying identified by consumers.

3.5.1.1.5.2 Conclusion

Consumers perceive site-specific spraying as a promising technique with potential for becoming an important scientific discipline and crop yield stabilization, while also recognizing its role in enhancing ecosystem services and biodiversity. Primary needs identified include ecosystem services impact knowledge, practicing knowledge skills along with management expertise. Training emerges as the most significant barrier, accompanied by concerns about complexity and time consumption. Main disadvantages cited include expense, complexity, and time consumption.

3.5.1.2 Surveys

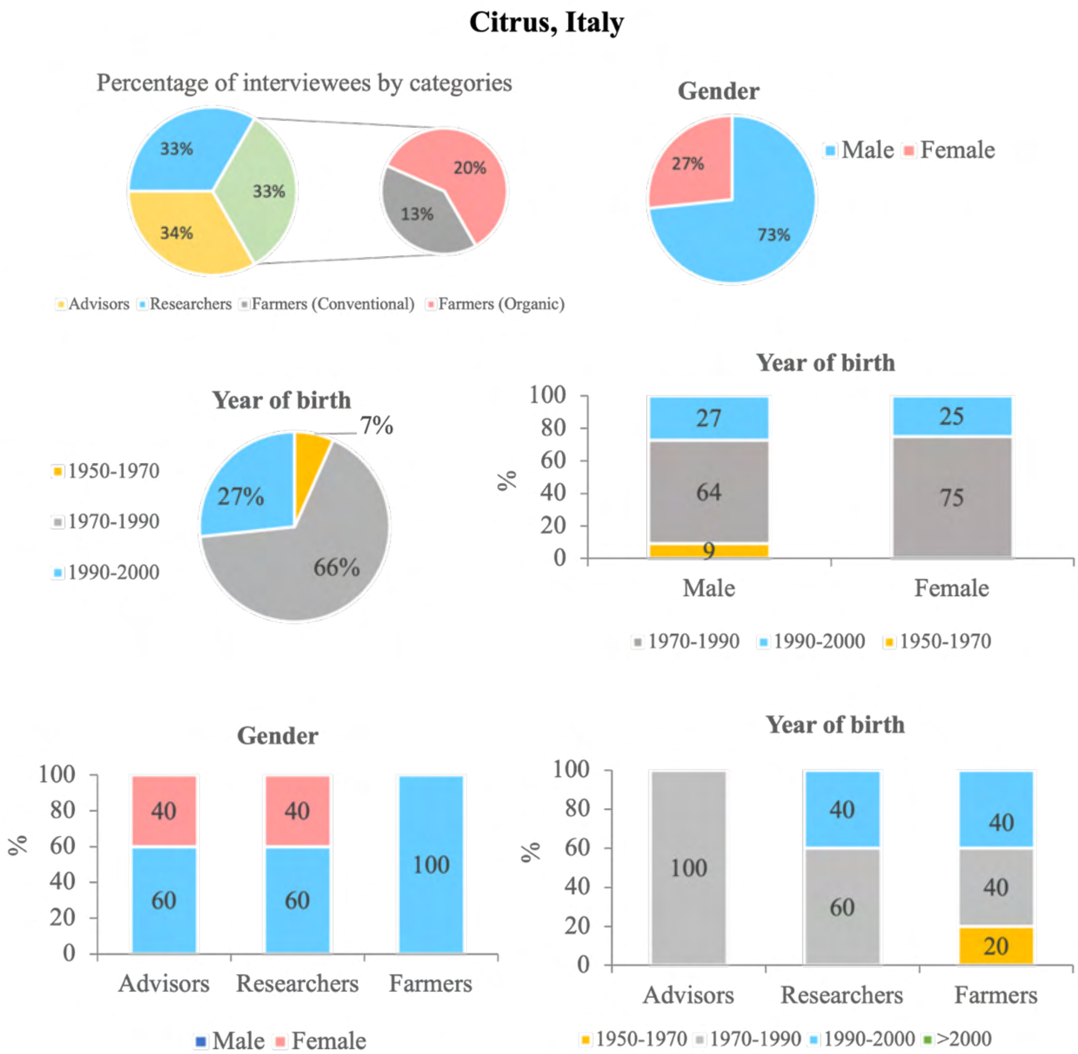


Figure 409. Interviewees description in the Citrus Living Lab (Italy)

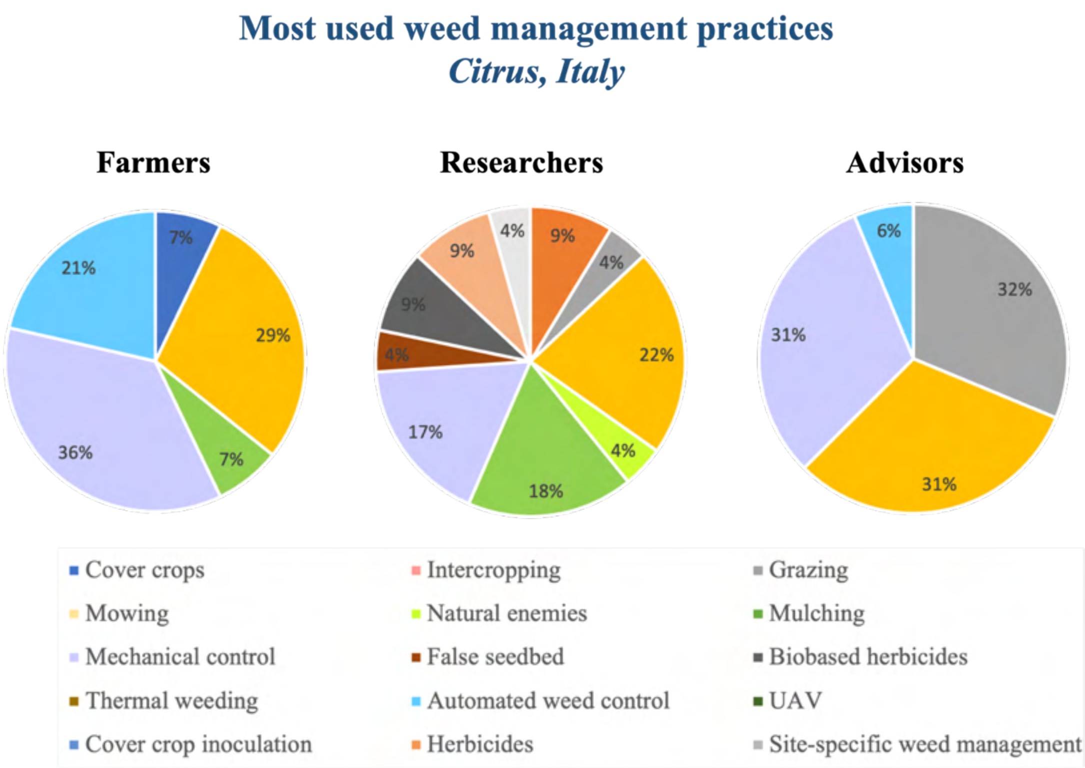


Figure 410. Most used weed management practices in the Citrus Living Lab (Italy)

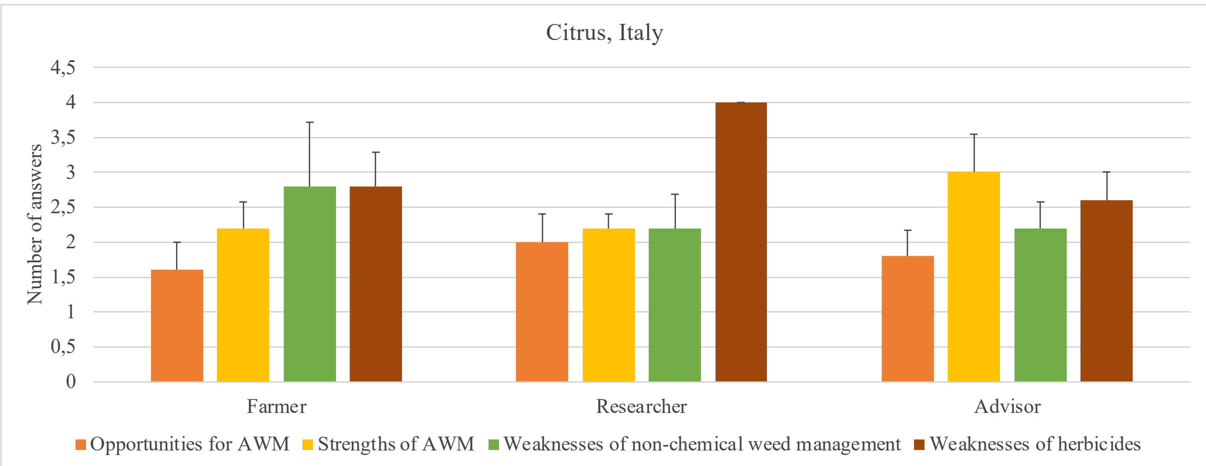


Figure 411. Mean number of answers (±se) per stakeholder group in the Citrus Living Lab (Italy)

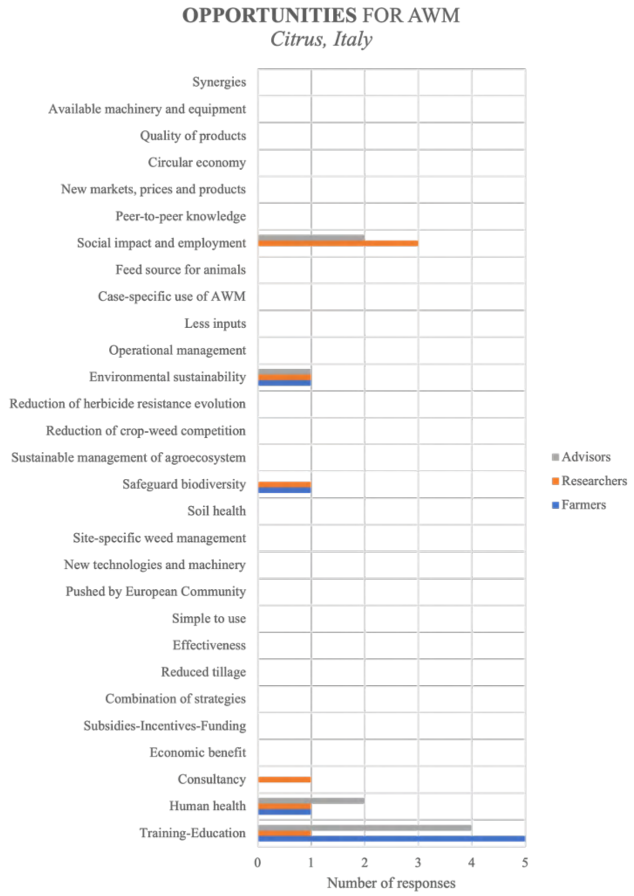
Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management

OPPORTUNITIES: Presented in the figure below.

STRENGTHS: Presented in the figure below.

THREATS: None.

WEAKNESSES: None.



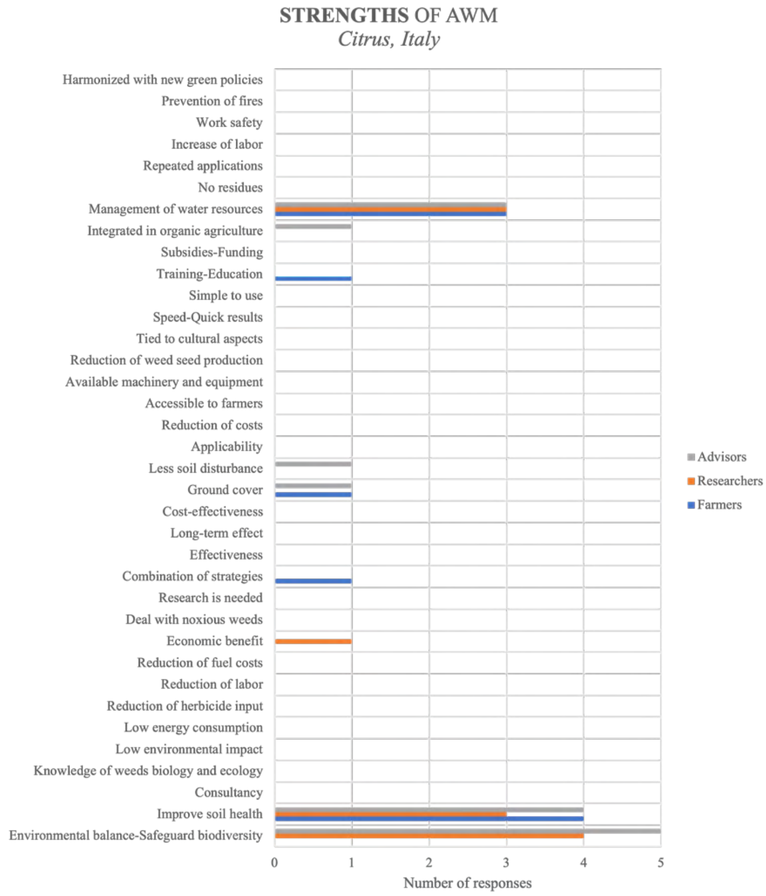


Figure 412. Opportunities and strengths of Agroecological Weed Management

Threats, and weaknesses for non-chemical weed management

THREATS: None.

WEAKNESSES: Presented in the figure below.

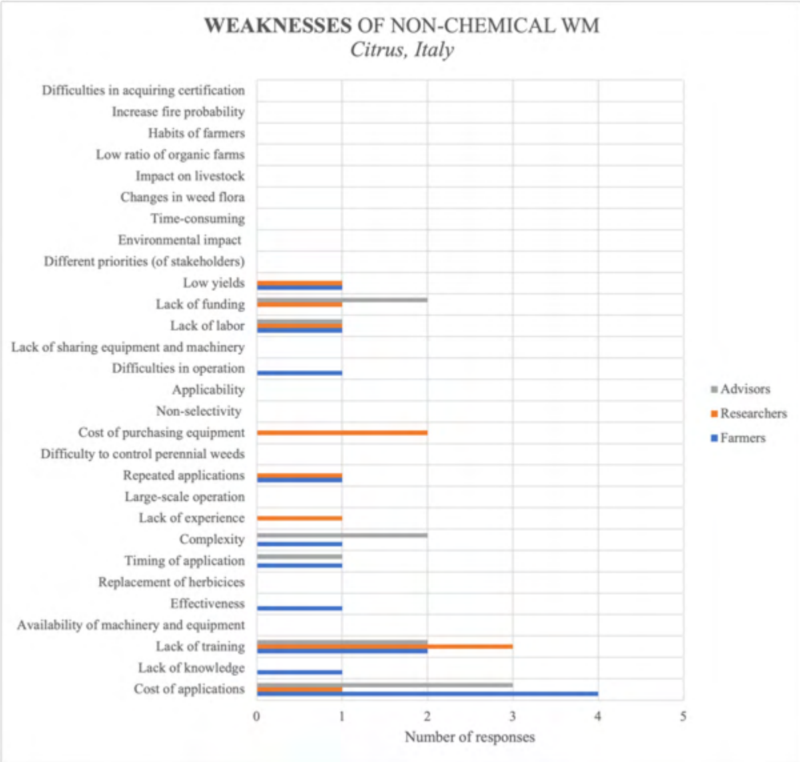


Figure 413. Weaknesses of non-chemical weed management

Opportunities, strengths, weaknesses, and threats for herbicides

OPPORTUNITIES: None.

STRENGTHS: None.

THREATS: None.

WEAKNESSES: Presented in the figure below.

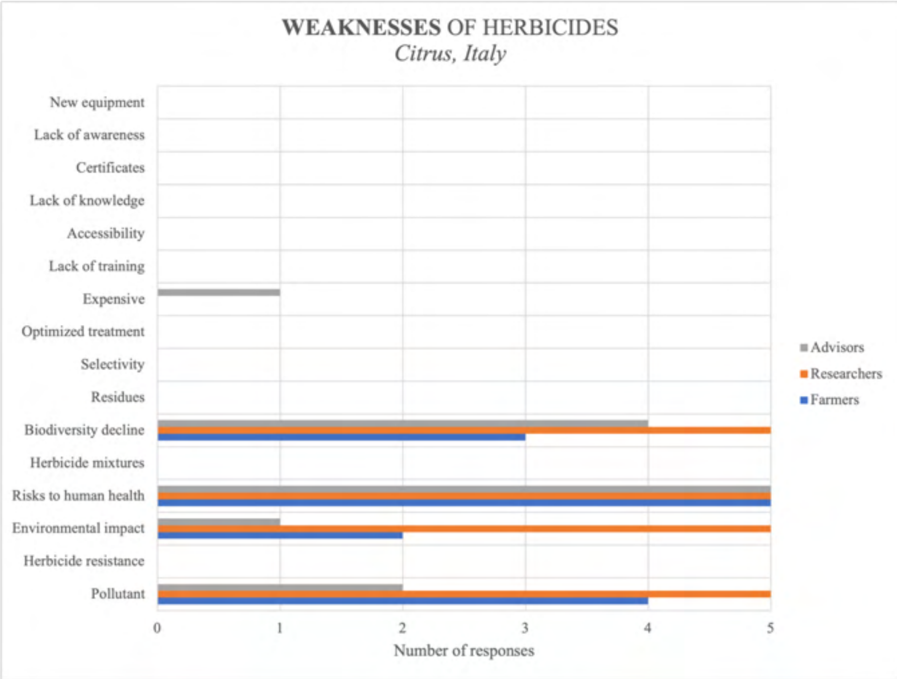


Figure 414. Weaknesses of herbicides

SUMMARY OF THE INTERVIEWS – CITRUS, ITALY
Most used weed management practices: Interviews with citrus farmers, researchers and advisors in Italy revealed that they are the most strongly opposed to chemical herbicides and they adopt many different practices for sustainable weed management. It is noteworthy that farmers mentioned the use of automated weed control, mechanical means and mowing as common practices for weed management in citrus. **Number of opportunities and strengths for Agroecological Weed Management, weaknesses of non-chemical weed management, and weaknesses of herbicides per stakeholder group**: The three different stakeholder groups provided almost the same number of responses for all categories. The number of identified weaknesses of herbicides was high in all stakeholder groups. **Opportunities, strengths, weaknesses, and threats for Agroecological Weed Management**: Training and education was the most important opportunity of agroecological weed management for farmers and advisors. Important was also the identified positive impact on social indicators and employment, and the positive impact on human health. AWM practices possess important strengths according to all stakeholder groups in the citrus Living

Lab in Italy and, specifically, improvement of soil health, management of water resources and protection of biodiversity.

Threats, and weaknesses for non-chemical weed management: Among a few identified weaknesses of non-chemical weed management, it is worth mentioning the lack of training and funding, which along with high cost of applications, are considered barriers to the adoption of chemical alternatives for weed management.

Opportunities, strengths, weaknesses, and threats for herbicides: All interviewees surprisingly agreed that herbicides pose risks to human health, while most of them identified them as pollutants and factors causing biodiversity decline with negative environmental impact.

3.5.1.3 Living lab board meeting

The committee meeting opens on 22nd November 2023 at 16:00 with the presentation of the participants. The 10 participants present were introduced, describing the motivation for which they were contacted to be part of the project committee. Joining the committee were (1GOOD Partner, 2 Farmers, 2 Consultants, 2 Researchers, 1 Consumer, 1 Public Administrator and 1 Supply Chain Entrepreneur). Once the presentations were over, the project activity with aims and objectives was presented. In introducing the GOOD project, a brief presentation of all the partners was done, describing the project strategies and specifying that the operational partners for the LL Citrus_23 activities are AIAB, UNICT and UNIPISA. The objective of the committee and why it is important to have a committee to monitor the project activities through an annual meeting and also to participate in the various project activities, especially those related to territorial information was indicated. The research activities activated in the LL were introduced by illustrating the objectives, and reminding the committee that the project activities have a duration of 48 months. The activities in the field were described, being in the first year the activities propaedeutic for the activities of other WPs coordinated and implemented by other partners, with particular regard to research on mycorrhizae application. The choices made for the realization of the experimental fields were described, introducing the agronomic aspects and motivating the choice of cover crop species selected. In introducing the 2 LL on Bergamot (one in an organic farm and one in a conventional farm) the agro-ecological strategies and the role that LL can play in the agro-ecological management of farms with the importance of reducing the use of synthetic chemical agents in line with the objectives of Green Deal were described. A presentation of the experimental fields and the farms involved was made, explaining why 15 experimental plots were made on the organically managed farm and 21 on the conventionally managed farm. Under organic farming 3 cover crop treatments (field bean, berseem clover and hairy vetch-oats mix) are compared with 1 untreated plot, left with spontaneous flora, and 1 plot managed with the usual tillage practices for the farm. Under the conventional farming system, the plots are joined by other two plots where herbicides will be used for monitoring purposes, with one plot sprayed at the label rate, and the other at half the rate. Each plot will be replicated three times on the same farm. On a representative and selected experimental area, fruits will be collected for monitoring yield responses to the proposed treatments and for lab qualitative analysis of the bergamot raw material, in order also to compare (if possible) the results with the incomes of other farm areas. The second part of the meeting was introduced, which involves all the committee participants, in order to collect useful information for the next project actions. This part of the meeting started with a general overview of bergamot cultivation, explaining why it is a typical cultivation of the lower Ionian region of Reggio Calabria, indicating how over the years the number of farmers has increased given the wide range of products derived from it in addition to the essential oil. In the last decade, its use in cosmetics, cooking and medicine has meant that bergamot has become better known, arousing greater interest in cultivating it, even though there are still not enough companies equipped for agronomic management and they must necessarily resort to work by third parties. However, on the whole, the bergamot chain is fairly well established and creates an important economy for the area. A farmer involved in the meeting, in view of his own experience, talks about the importance of technical means and the possibility of having a well-equipped fleet, especially when it comes to weed management, which very often involves actions that go beyond the company's timetable, although in his company there is no problem with weed management. He precises that when the problem arises, the practices used are chopping or using the harrow. He also specifies that in the cultivation area, adjacent to his organic farm, chemical weed control is not widely used. This farmer, as his farm is also organically managed, talks about alternatives to chemical weeding and how these practices are particularly proper in the management of citrus groves. Also important for his company is the use of manure as a replacement for technical means. Rotational pruning carried out on the farm with disinfestation of the tools used is also important for good management. In recent years he has also introduced beehives to the farm, pollinating insects such as bees, which are useful for pollination and biodiversity management, as well as making a sustainable economic profit on improved pollination and production. A consumer presented in the meeting, being an expert in the irrigation sector, raised the issue of how the shortage of water, in many of the bergamot-growing areas, can be an obstacle to successful agro-ecological practices, and how important it is for companies to organize themselves well on water management. The farmers involved in the meeting take the floor again, pointing out the need for the importance of promotion and information in the territories, and they recall how difficult it is, very often, to get farmers to change their minds, especially about agronomic management practices. As this is the first meeting, there are no further suggestions and new proposals to be undertaken for the LL, but all the guests approve of the project. In conclusion, the GOOD partner takes the floor on behalf of the AIAB partner, reminding how sensitive AIAB is to these issues and how it is involved in scientific research in several sectors. AIAB's project activities also foresee the realization of other actions in other WPs related to data dissemination, collection of interviews and questionnaires involving companies, consumers, industries, political representatives, technicians and researchers. The GOOD partner also explains that a copy of the signed documents, regarding the expression of consensus to be part of the committee board, will be kept for five years at AIAB head office. During the LL board meeting, this information was also collected:

What are the market characteristics of vine?	1. How many farmers cultivate vine in the region (approx.)?
	The bergamot production area extends over 100 km, from Villa San Giovanni to Monasterace, with the most cultivated area falling in the Grecanica area, the zone where the 2 companies involved in the LL are located. The number of primary agricultural operators is around 500 units for about 1,500 cultivated hectares.
	2. How many products are derived from the vine?
	The main product of bergamot is the essence, which is used by perfume industries all over the world. Over the last decade, bergamot has also been used in cooking (making entire menus and desserts). Juice has started to be marketed and, thanks to research, pharmaceutical products have been made, such as drugs against cholesterol, triglycerides and blood sugar.
	3. Do you think that agroecological products could be promoted in local markets?
	Cultivation of the bergamot on most farms is carried out with organic criteria, although not always officially certified. A better informed public could be beneficial for the local market of all crops.
	4. Do you believe that the region has a lack of technologies?
	In the region, not all farms are well structured to deploy up-to-date technologies. There is a shortage in terms of machinery and equipment and more than half of the farms in the sector rely to subcontractors for routine operations, while, very often, harvesting is carried out by family labor.

	5. Is the regional agri-food value chain sustainable?	There are different views on that, for the organic bergamot, yes, it is sustainable
What are the most common agricultural and weed management practices in vine?	1. What are the most common agronomic practices in vine?	Soil tillage with disks coulters or harrows, fertilization with both pelleted and foliar fertilizer, fertilization with manure. Pruning is carried out in bergamot in alternate years. Irrigation. Plant protection.
	2. What are the most common weed management practices in vine?	Flail or bar mowing, soil tillage
What is the herbicide use in vine?	1. How many active ingredients there are available? How many different mode of actions?	More than 10 ingredients are registered for the crop, from burn-down to pre and postemergence.
	2. How many times do you spray in-season?	Usually 1 time on the tree rows, more on edges to control bushes.
	3. Do you use pre-emergence, post-emergence or both herbicides?	No, usually burn down
	4. Are herbicides efficient?	It depends on many factors, usually they are not a definitive solution
	5. Do you think that alternatives to herbicides are equally efficient?	Mechanical weeding is very effective but time consuming and sometimes there is a feel of soil structure degradation
	6. What is your opinion about the impact of herbicides to environment (e.g., water, soil health, biodiversity)?	Herbicides have negative effects, but not so immediate, so the risk perception is sometimes “mitigate” among farmers and stakeholders, not so among consumers
	7. Do you believe that agriculture without herbicides is viable?	Yes, but more time consuming.
	1. What is needed to boost the uptake of agroecological practices?	

What are the needs and barriers to assist agroecological transitions & adopt agroecological weed management approaches?	More demo days on real farms
	2. What are the barriers towards agroecology implementation?
	Lack of knowledge about effective alternatives to herbicides
	3. Should policies need be redefined to allow agroecological transitions?
	Yes, the main perception is for a need of more financial sustain
	4. How confident you feel about the adoption of agroecological weed management practices?
	Not in the immediate for every farm
What are the main drivers of weed dispersion (e.g., mowing times, dispersion through manure, agricultural machinery), & the major weeds per cropping scenario?	**1. What are the main drivers of weed dispersal?**
	Mowing after seed dispersal, soil structure degradation
	2. Which are the major and most noxious weeds in your area?
	A major one is *Cynodon dactylon*, or similar species
	3. Are there any herbicide resistant weeds?
	There are no reports on that
	4. Do you know any invasive plants in your area?
	Datura stramonium. Sorghum halepense, Amarantus sp.
What do you think about the Living Lab?	**1. Which proposals do you have for a good performance of the LL?**
	Also practices that can be implemented in low tech farms
	2. Would you like it to remain over time?
	They are not sure yet, depends on results