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Adoption and difusion of agroecological practices in the horticulture in Catalonia

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Citation: Polonio Punzano, A.; Rahmani, D.; Cabello Delgado, M.M. Adoption and difusion of agroecological practices in the horticulture in Catalonia. *Sustainability* **2021**, *13*, x. https://doi.org/10.3390/xxxxx

Academic Editor: Firstname Lastname

Received: date
Accepted: date
Published: date

Abstract: The environmental impact of conventional food production systems imposes a rapid transition towards sustainable production systems through the adoption of agroecological practices. The barriers and accelerators of the adoption of agroecological practices were identified for horticultural crops in Catalonia. 8 interviews and 30 surveys were conducted with local producers. Results show that the loss of producer income and the lack of social awareness regarding organic products are some important barriers to the adoption of agroecological practices, while informing about experience of other farmers is considered as a motivator factor. Finally, the study concludes that the adoption of agroecological practices has an economic, political, social, academic and agronomic component.

Keywords: Agroecological practices, barriers, accelerators, Farmers' adoption.

1. Introduction

Agroecology is a type of agriculture which appeared at the end of the last century with the objective of providing an alternative to conventional agriculture (agriculture which favors destruction of the circular economy and the loss of biodiversity [1]). Organic farming uses biological control to treat pests and diseases; organic amendments, livestock and / or plant remains to fertilize the fields; direct seeding or minimum tillage to reduce the loss of soil through erosion, increases biodiversity and soil fertility (increasing the content of organic matter in the soil); crop application of coverage; use of useful microorganisms to help the plant absorb with greater ease of macro and micronutrients in the soil in order to strengthen the plant to be more resistant to pests and diseases and thus increase yield; application of genetics to extract cultivable species more resistant to change climatic conditions (droughts, saline soils, pests and diseases) and with high yields. In addition, the application of genetics allows diversification and crop rotation, which are the two fundamental pillars of agroecology.

According to Róger [2], agroecology is a scientific discipline which gathers, synthesizes and applies knowledge from agronomy, ecology, sociology, ethnobotany and, with a holistic, systemic and ethics; therefore, it is an agricultural system which provides a rational ecological base for the management of the agroecosystem through innovative production technologies, stable and highly adaptable to the environment and society. Wezel et al. [3] classified agroecological practices according to the level of integration that the crops have and depending on the degree of implementation they have. According to them, the integration of organic fertilization, cover crops, irrigation by drip, biological pest control, among others, have already reached an average level of integration into the current agriculture and have a high potential for a wider application in the next decade already benefiting from a good scientific knowledge; however, the integration of allelopathic plants, biofertilizers, agroforestry systems and the management of landscape elements at scale have a low level of integration, and will not be easily implemented in the field in the near future since it relies on a larger scale of management and largely on the regional and national general conditions which are subject to the project framework and territorial development planning.

This article shows how agroecology affects the social, economic, environmental, political, ethical and cultural aspects. At the social level, agroecology aims to configure a system which values food sovereignty of producers, reinforces health and well-being of present and future generations of farmers, and their independence and autonomy in their development, participation and decision-making. In the field of economics, agroecology assumes that the benefit makes it possible to cover the needs of the producer and reduces the risks associated with dependence on markets, inputs or the low product diversification; makes efficient use of goods, services (production) and equitable distribution, without damaging the renewal, reproduction and distribution of the agroecosystem. In the same way, politics analyze and act on social conditions, networks and conflicts resulting from the support for sociocultural agroecological change, with a view to achieve a sustainable social or socio-vital metabolism, which affects the construction of styles food (patterns and networks of production, distribution and consumption) equitable and sustainable (democratization food). Finally, agroecology understands that at an ethical and cultural level, humans should reduce the excessive food consumption and environmental degradation; incorporate ancestral and character values and knowledge avant-garde in order to eliminate hunger, poverty and negative consequences for the environment, and that farmers should decide to modify natural ecosystems to transform them into agroecosystems through the choice and distribution of spontaneous crops, animals and plants considering values, beliefs and objectives.

Over the last few years and coinciding with what Gil et al. [4] reported, consumers, companies and administrations have been becoming aware of issues related to food safety and environmental problems. Consumers' concern for food safety has increased its sensitivity to environmental degradation. That is why their conscience and behaviors (which are closely related to ecology) have been taking a center stage in such a manner that they try to make their actions less damaging to the environment. The tendency to purchase of organic products is influenced by demographic, socioeconomic, psychographic and behavioral variables. All of them explain in different studies why consumers, companies and institutions are committed to buy and sell organic products [5], [6]. Díaz et al. [7] found that consumer lack of

information and knowledge as well as high prices are the most relevant barrier to the consumption of organic food. Grymshi et al. [8] analyzed consumer' purchasing behavior towards ecolabeled food products and based on the degree of familiarity and consumption patterns, they identified three typologies of consumers including indifferent, committed, and skeptical. At the European level, age is a very important factor when buying organic products; The people who are more interested in purchasing organic products are aged between 15-55 years [9]. In particular, 26% of this segment are people under 35 years, while 76% are above 35 years [10].

Agriculture in general is undergoing a change at a social, economic, political and environmental level which requires farmers and ranchers to adopt more sustainable agricultural practices and methods. This will force the transition from a polluting conventional agriculture characterized by excessive use of chemical inputs (fertilizers, pesticides, etc.) to a green agriculture, efficient, profitable and socially, economically and environmentally sustainable. This reality is reflected in the great interest shown by the scientific community (Brzozowski and Mazourek, 2018; Keulmans, 2019; Clark and Tilman, 2017) in assessing the economic, social and environmental conditions of agriculture in recent years. However, despite social pressure (environmental awareness), warnings from national and international environmental organizations and the public support with favorable policies and programs, the rate of adoption of agroecological practices among farmers and ranchers continues to be very low, as reflected by the low presence of organic products in the market. The objectives of the present work are: i) to make a diagnosis on the diffusion of agroecological practices in the horticulture in Catalonia; ii) to assess farmer' intention to adopt agroecological practices; iii) to describe the profile of the potential adopters of agroecological practices; and iv) to understand the most relevant barriers and drivers. To reach these objectives, interviews and surveys were conducted among a group of farmers in Catalonia.

Literature showed that the adoption of agroecological practices is determined by a series of barriers and motivations [11]. Horrillo et al. [12] showed how organic farms are no economically profitable for farmers. Horrillo et al. [13] reported that organic livestock farms could be economically remunerated for the ecosystem services they provide to society, especially when their net CO2 balance is negative. Dessart et al. [14] classified the behavioral factors that affect the decision to adopt or not agroecological practices in dispositional (personality, motivations, values, beliefs, preferences, goals), social (interactions, social norms, signaling motives) and cognitive (learning, reasoning, perceptions of benefits, costs and risks). Pearce et al. [15] and Damalas et al. [11] indicated that the variation in pesticide use among farmers is associated with a set of factors including low level of internal inputs, market demand, the presence of pests and diseases, the need to produce food in abundance, the pursuit of the greatest financial benefit, the adoption of methods of organic farming, the efficacy of pesticides, concerns about pesticide exposure and environmental pollution. Horrillo et al. [16] identified the stagnation of sales, the lack of self-sufficiency in organic feed and the difficulty of access to organic certified slaughterhouses are relevant barriers to the transition from a conventional farm to an organic system.

Runhaar et al. [17] identified age, sex, social and educational level, knowledge and experience of the farmer, as well as the size of the farm as variables which affect the willingness of farmers to adopt innovative practices. Hashemi and Damalas [18] highlighted the importance of factors such as the perception of pesticide safety and knowledgeable

experience of pest integration methods in the decision of farmers to adopt or not practices alternatives to conventional agriculture.

Other authors [17] highlighted the role of factors such as motivations, information, social context, government agreements, demand, particular skills / abilities of implementation, legitimization, the holistic framework which integrates personal and contextual factors and the multidisciplinary framework (nature conservation and factors that stimulate behavior change) in the decision to adopt sustainable alternatives by farmers. For example, some authors [19, 20] investigated farmers' intention to adopt new soil conservation practices focusing on variables such as biophysical, economic, social, regulatory and institutional conditions (Table 1).

To adopt a new practice, a farmer should be sure of the steps he or she is going to take, so he or she should know if he or she can receive financial aid, if the crop is going to be profitable [21] and should also know the new practices and products. He or she also needs to have knowledge, awareness, attitude and perception of the risks associated with these practices [22]. Another very important factor is the prior adoption of ecological practices by other farmers who can positively influence those who have not yet taken the decision to switch to agroecological practices.

Table 1. Barriers and Solutions

Authors	Subject	Barriers	Solutions
Valerio et al. (2016)	**Conservation agriculture (Mexico)**	Business orientation; The short term expected objectives; The economic limitations.	
Brzozowski and Mazourek (2018)	**Organic plague management**	Biological complexity due to having difficulty in accessibility to data and concepts.	**Invest in:** cultivar development adapted to the environment and/or that are resistant to pests and diseases; plant breeding; and, understanding and promotion of plant-relations rhizosphere.
Schoonhoven and Runhaar (2018)	**Adoption of agroecological practices: holistic frame**	Absence of commercial models; Structural difficulty/barrier → difficulties to find funds.	
Hashemi and Damalas (2011)	**Farmer perceptions towards the plaguicide efficiency**	Beliefs, perceptions and preferences; Scarce of technical and advisory support.	
Bijttebier et al. (2014)	**Adoption of conservation practicesmin Europe**	Changes in economic conditions after adoption; Lack of adequate machinery; Presence of the plow; Soil texture (compaction); Slope; legislation; nature of crops; Yields(decrease); Lack of stimulation.	Understand the differences between countries when adopting practices for soil conservation.; Inform the person or institution.
Pearce et al. (2019)	**Promotion of alternatives to plaguicides**	Lack of training (and knowledge); Difficulties to access the network.	Alternatives to the use of pesticides: Train the farmers; Educate the young students through practical classes with the help of technology.

Malina et al. (2019)	**Disposition and perception to pay for bio-plaguicides**	Literature shortage; The perceived risk;the price of the biopesticide; High perception of pesticide efficacy.	Introduce definitions of pesticides and biopesticides in the interviews; Perform communication efforts (campaigns of information and education). For sustainable agriculture: Development of techniques to reduce negative impact of chemical inputs; Implementation of a legal framework; The contribution of consumer; More research to understand needs, motivations o factors that hinder the consumption of sustainable products; Conduct studies taking into account the intensity of the willingness to pay.
Dessart et al. (2019)	**Factors affecting the adoption of agrological sustainable: politics.**	Group behavior; Resistance to change; Difficulty in policy agricultural segmentation; Treat all farmers the same; and, Lack of knowledge of sustainable agriculture practices by the citizen; Lack of Knowledge → Lack of participation; Greater fluctuation in demand and the offer of organic production; Prohibition from the use of chemical fertilizers or synthetic pesticides → increases the risk of failure of crops; The variability of the soil reaction to sustainable practices and uncertain efficacy of sustainable practices; Uncertainty; and, financial risks.	Segment farmers indirectly according to: age, sex and country or region; Design a combination of policies based on voluntary adoption and mandatory of sustainable practices; and, designs subsidized environmental schemes. Policy tools to decrease Perceived risks: Insurance offering; Promotion of mutual funds; Promotion free practice sustainable tests.
Keulemans (2019)	**Can we grow up without the use of herbicides, fungicides and insecticides?**	For increased performance: acidification; The loss of biodiversity; Soil erosion; and the eutrophication of superficial water. Reduction of active substances → higher resistances → decrease in the effectiveness of the products → higher losses. Longer time required to get a new product; Sub-optimal factors: fertilizers, adapted varieties, irrigation, other techniques of crops; Difficulty relating the use of phytosanitary products with performance through experimental and quantitative data; Unclear and precise media communication; Lack of knowledge of diseases or pests and of the impact of these by agronomists, advisers or farmers; The MIP incorporates a wide range of practices, but does not establish explicitly	To bridge the gap: Promote sustainable intensification of agriculture; reduce losses and food waste; Change diet; Prohibit crop production for bioenergy; and, Give an optimized use of phytosanitary products.

		the degree of reduction of APP to farm level; and, Little / Low accuracy on whether the greater biodiversity in organic agriculture is due to the management of biopesticides or the low performance.	
Damalas and Koutroubas (2017)	**The training of the use of pesticides associated to a safety behavior**	Low acceptance of training on pesticides and job aging; Limited studies on the relevance and effectiveness of the training; Lack of educational guides for treat the destruction of beneficial insects; Problems: Spray more often and at a higher dose; Factors (1 and 2) to evaluate the training by any means available: The decision making (1) and To design most effective training components (2).	To bridge the gap: Promote sustainable intensification of agriculture; reduce losses and food waste; Change diet; Prohibit crop production for bioenergy; and, Give an o timized use of phytosanitary products.
Clark and Tilman (2017)	**Comparative Analysis of environmental impacts of the system of agricultural production, efficiency of the agricultural inputs and choice of food.**	The limitation focused on food of animal origin or a single environmental indicator; and the comparative environmental impacts control practices with a lower use of pesticides.	Apply management technologies and techniques to increase the efficiency of agricultural inputs through: agriculture of precision, conservation tillage and cover crop, feed intake in livestock systems: use of agricultural waste and by-products; Interventions to reduce future environmental impact aspects of agriculture: adoption of low-meat diets in countries with an excessive meat consumption , increase sustainable yields of crops and reduce waste of food; and,Implementation of initiatives of policies and education designed to increase the adoption of low-fat foods impact, of less impact production systems and systems with high efficiency of agricultural inputs.
Damalas et al. (2018)	**Criteria for the selection and use of pesticides**	Little evidence on use of pesticides patterns; Limited information; Techniques limitations; Little research on nature of farmers' criteria for select and use pesticides; Reduction of subsidies; Limited knowledge of allowed amounts of pesticides; Low levels of education and training in management of pesticides; and, Ineffectiveness of training training courses.	
Kragt et al., 2017	**Motivations and barriers so that large**	For participation: The complexity of the scheme (amount of paperwork involved for become a registered provider); the strict program rules	

extension land Occidential Australian agricultures adopt carbon agriculture	(requirements for permanence); and, Information limitations.

2. Materials and Methods

In this work, two research techniques were combined including a qualitative method (interviews) and a quantitative technique(questionnaire). The purpose of the interviews with the farmers was to extract ideas which would feed the preparation of the questionnaire. In total, 8 farmers were interviewed in the province of Barcelona. The farmers interviewed mostly practiced traditional horticulture. 3 of the eight farmers were engaged in fruit growing (two were from conventional agriculture and one from ecological agriculture). The interviews were planned to be conducted physically in the field, however, we were forced to carry out these interviews via telephone due to the restrictions imposed by the authorities to reduce the propagation of COVID-19.

Based on the interviews and the literature review, a first survey was carried out (A pilot test). A pilot test was carried out with ten farmers from different sectors in order to correct errors, refine the questions, identify important aspects not included to take them into consideration, as well as to estimate the average time required to complete the survey. Subsequently, we proceeded to the realization and shipment (via email) of the final survey. For data collection, we proceeded to contact farmers, companies and public and private institutions of the agri-food sector such as cooperatives, ADV's (Groups of Plant Defense of Catalonia), associations and universities. It took two months to collect the 30 surveys. This delay was due to the fact that the months of collecting data coincided with the full harvest period.

The interview script consisted in open or semi-open questions. For example, the first question consisted in finding out the characteristics of the farm and the farmer (cultivable hectares, farmer's age, number of family members who are engaged in agricultural exploitation, number of workers, etc.) and what type of agriculture they practice and the type of crops they cultivate. The following questions were dedicated to extract information about whether they adopted (or not) agroecological practices and why. To do this, they were asked directly if they had ever adopted any agroecological practice and what type, and if they had done it with or without aid, what type of barriers and / or motivations to adopt these practices, if they plan to adopt (or not) agroecological practices in the future and why. Finally, we asked them whether they will continue using the same production system after the COVID-19 crisis or they plan to switch to agroecological or more sustainable practices and why.

The survey was designed focusing on aspects related to the adoption (or not) of agroecological practices by farmers (conventional and / or organic) and what factors affect this adoption. The survey was divided into 11 sections: 1) Characteristics of the farm; 2) Agroecological practices adopted until now; 3) Barriers of agroecological practices; 4)

Accelerators of the adoption of agroecological practices; 5) Perception of the benefits of agroecological practices; 6) Intention to adopt agroecological practices in the future; 7) Trust in the different sources of information on agroecological practices .; 8) Attitudes (preferences) to risk; 9) Attitudes towards the environment; 10) Perception of exposure and risk to chemicals; and, 11) Sociodemographic characteristics.

To measure the Attitudes towards the environment, we used the new reduced version of the Ecological Paradigm scale (NEP-R). Farmers were required to indicate their level of agreement with the statements in a 5-point scale (from 1 'Strongly disagree' to 5 'Strongly agree'. This scale allows us to segment farmers into ecocentric and / or anthropocentric persons.

Data analysis was performed with the SPSS statistical program. We started with some descriptive analyzes which we represented in figures and tables. A factor analysis was carried out with the objective of reducing the elements of the environmental attitudes scale (NEP-R). Finally, bivariate analyzes were carried out to describe the relationship between the variable "intention to adopt agroecological practices in the future" with various characteristics of the farmers and their farms in order to identify the profile of potential adopters of agroecological practices in the future. The relationships between the variables are represented in figures. These analyzes are performed using statistical tests (analysis of variance and Tukey) to detect which groups of farmers were more susceptible to adopt agroecological practices. It was not possible to conduct some multivariate analysis due to small size of the sample we used.

3. Results

The results are presented in the following way: first we described the results from the interviews, then we reported the results from the surveys. Those from the surveys were divided into the following sections: 1) Characteristics of farmers and their farms; 2) Level of knowledge, perceptions and farmers' attitudes towards pesticides and agroecological practices; 3) Main barriers, accelerators and perceptions of the adoption of agroecological practices; and, 4) Results related to the adoption of agroecological practices (profile of farmers who are potential adopters of agroecological practices in the future).

The results related to the interview are divided into: agroecological practices already adopted, barriers for the adoption of agroecological practices and accelerators of the adoption of these practices. Regarding the already adopted agroecological practices, the most indicated practices are: Do not abuse the land; Try to maintain high soil conservation in terms of low tillage and promote biodiversity by leaving vegetation cover; Do not pretend to substitute ones' inputs by others but decrease any of them; Seeks the balance between plant-soil-adventitious herbs; Change of agricultural practices to improve the health of cultivated plant species. The most cited barriers to the adoption of agroecological practices are: the lack of advice and technical support for the conversion to agroecology; the lack of agroecological training for farmers; the lack of knowledge on the application of biopesticides; the lack of research on new phytosanitary products; the lack of citizen awareness; Difficulty in the control of MH without herbicides, among others. Regarding the accelerators, the most cited are: possibility of introducing technological innovation in organic production methods;

Payment of the product at a fair price; Farmers ecological grouping to support each other and facilitate the transfer of knowledge of agroecological practices; Maintain or increase the viability of crops; Obtain support and social recognition of the farmer's ecological work; Offer quality; Experimentation in the own farm of effective and more respectful methods with the environment; Gratification of success, etc. The results related to the survey are subdivided into:

3.1. Characteristics of farmers and their farms

In Figure 1 it can be seen that 30% and 27% of respondents belong to the horticultural sector and extensive crops (cereal, hops, ...), respectively. 27% of the farmers have exploitations of 3 to 5ha, while 20% cultivate exploitations of 6 to 10ha. 43% of farmers cultivate family exploitation, while 28% rent their exploitations. The surveyed farmers aged between 41 to 60 years.

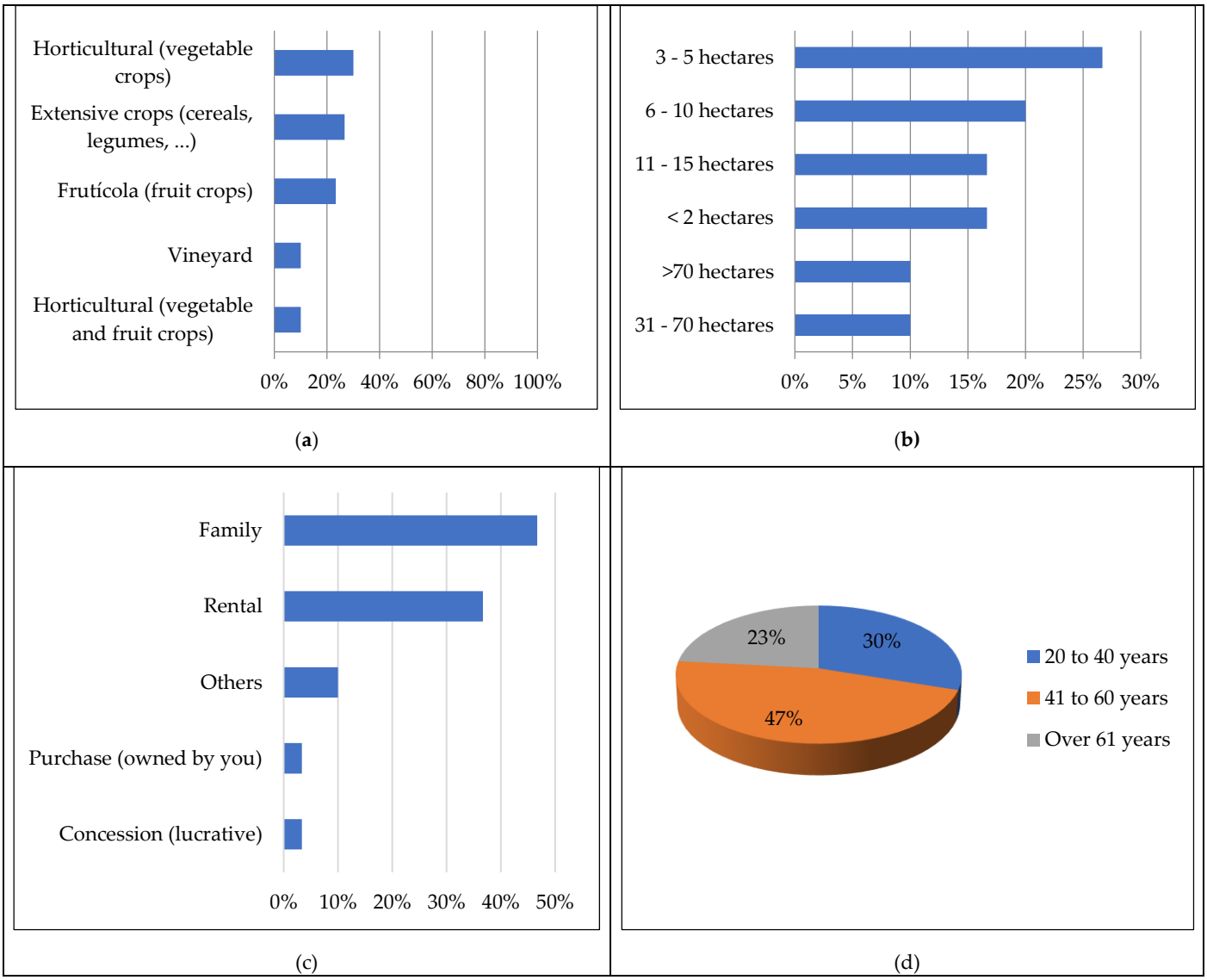


Figure 1. (a) Agricultural sector (% surveyed); (b) Number of hectares (% surveyed); (c) Type of exploitation (% surveyed); and, (d) Percentage of farmers according to age.

3.2. Level of knowledge, perceptions and attitudes of farmers towards pesticides and agroecological practices

Farmers understand by agroecological practices those agricultural practices which are ecologic and meet the daily demand of the exploitation enhancing the natural processes of crops' defense. They are practices environmentally friendly which maximize ecosystem services. It is also a symbiosis between profitability and sustainability. Agroecological practices are those that allow food to be produced without using pesticides from chemical synthesis neither herbicides nor transgenic maintaining the regenerative capacity of the soil (its fertility) and the ecosystem biodiversity. Producing agroecologically is producing with care and respect, living together in harmony with the environment and its natural surroundings. On the other hand, the farmers most reluctant to change practices comment that using agroecological practices is simply going from having a conventional farm to an ecological, and doing agricultural practices following the regulations of the CCPAE or that it is even a scam since producing this way would require more time and inputs to have a plant pathogen-free. Also to those who do ornamental it is very difficult for them to carry out agroecological practices.

The level of knowledge that the farmers have about the aspects of agroecological practices and that shown in Figure 2, were valued using a scale that goes from 1 (not informed) to 7 (very informed). The results show that farmers have a good level of knowledge about all aspects of agroecological practices. The aspects best known by farmers are the "cost of adopting agroecological practices", the "Crop rotation", "crop diversification" and the general concept of "agroecological practices". The aspect that has received the lowest valuation is "the production of agro-ecological products". Therefore, farmers need more information about the agroecological production system.

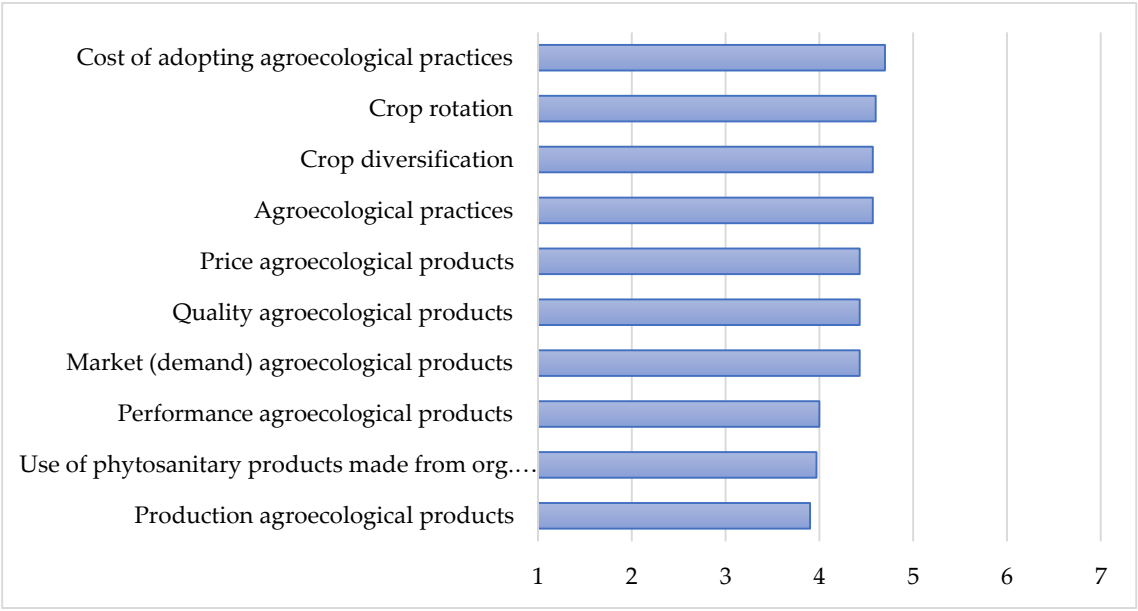


Figure 2. Scaled average according to the degree of knowledge about different aspects of agroecology.

53% of farmers have very little information on agrochemicals, 57% of farmers has very little information on the negative health effects of agrochemicals and, as Figure 3 shows, and 83% of farmers affirm that agrochemicals are a health risk.

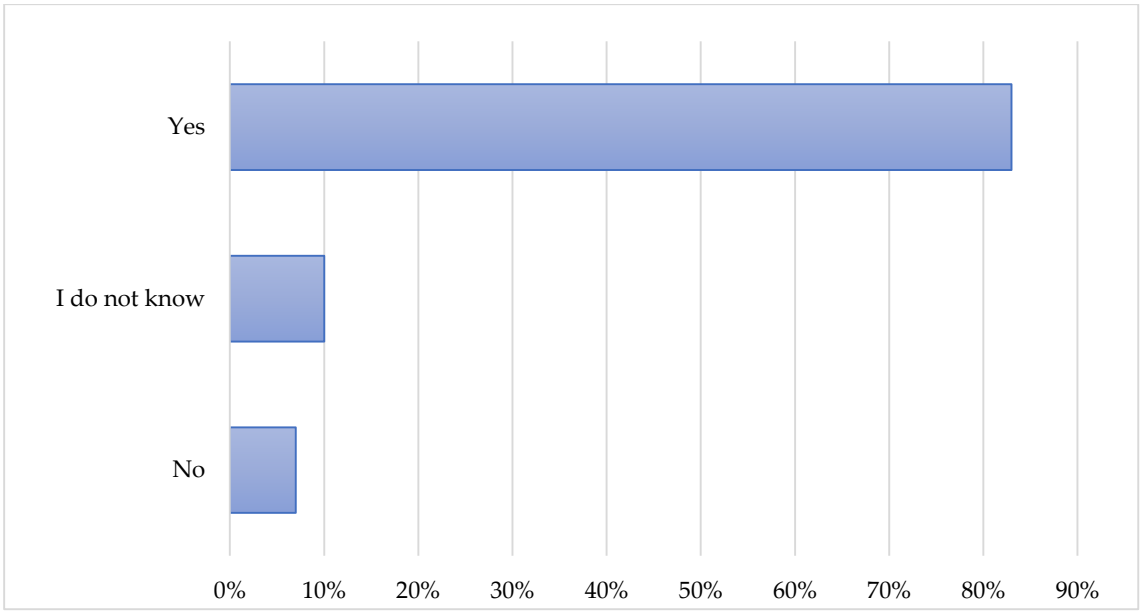


Figure 3. Percentage of farmers who affirm or deny that agrochemicals are a health risk.

In figure 4 we can see how the media that offers them more information about the agrochemicals and their possible negative consequences on health are: 'agrochemical labels' with 28% of the respondents, 'Internet' with 25% and participate in 'Courses' with 17%.

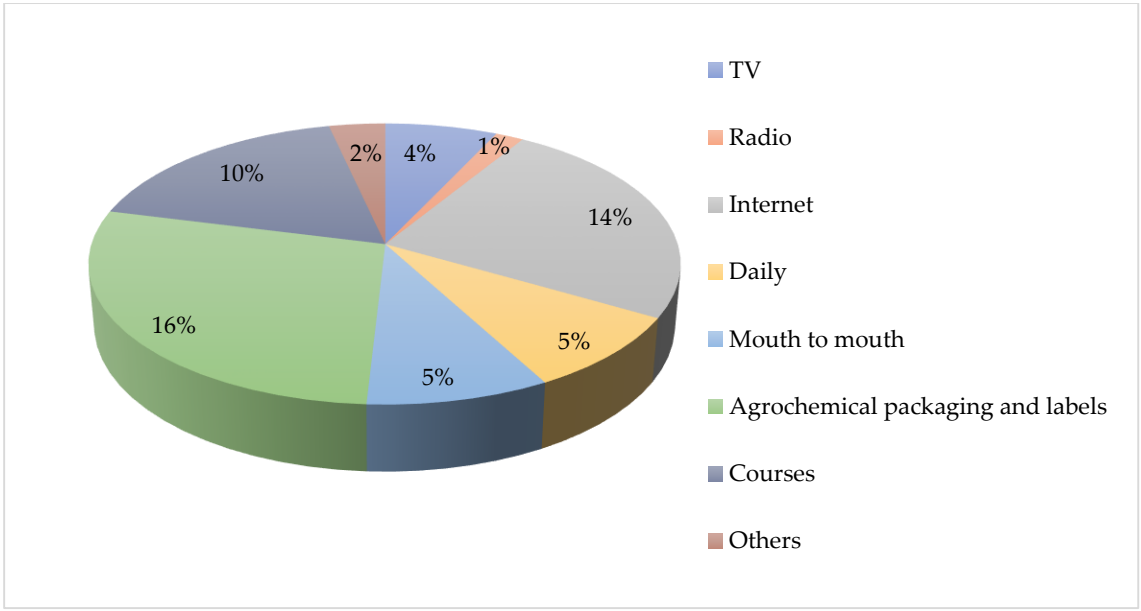


Figure 4. Percentage of farmers according to the communication medium observed.

3.3. Main brakes, accelerators and perceptions of the adoption of agroecological practices

In figure 5 it can be seen that the most important brakes / barriers for farmers when it comes to adopting agroecological practices are: "Loss of producer income", "Lack of social awareness regarding the production of ecological products", "Low prices at origin and / or market", the "lack of agroecological training, technical and research advice". On the other hand, we have the less important barriers such as "low diversity organic products", "the economic situation does not allow to put agroecology into practice", and the "type of soil and relief of the farm". Thus, farmers tend

to give more importance to those barriers that are more focused on the economic field (related to aid and payment of the product), social (that the ecological product or the production of organic products is not fully assimilated by the consumer), academic (lack of knowledge in the norms and use of ecological pesticides and advice by technicians) than those of an agronomic type (typology and soil relief, new varieties adapted to the conditions of the area, yields, ...).

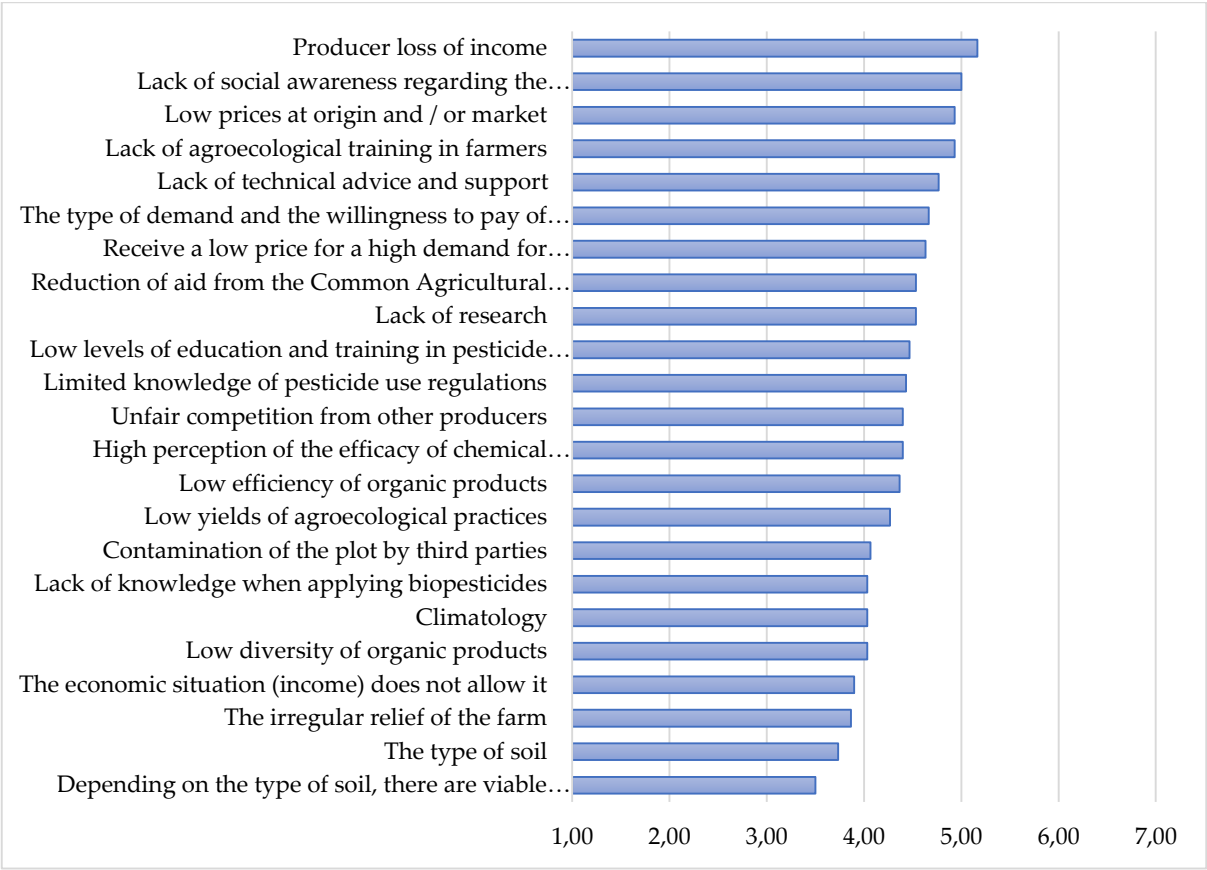


Figure 5. Average according to the different barriers when adopting (or not) agroecological practices.

In reference to accelerators when adopting agroecological practices the most notable for the farmers are: the "Know experiences of other farmers", the "Rigor of legislation and product ecological standards "and the" favorable cultural environment to motivate the adoption of agroecological practices ". The appearance you have received the lowest rating is “Government Support (Grants)”. Therefore, farmers demand more rigorous exteriors and interiors policies in which the adoption of agroecological practices is favored. In addition, knowing the experiences of other farmers who practice organic farming is of vital importance since that amongst them they understand each other much better than, for example, with the administrations. Thus, exchanging experiences between groups of farmers in a specific area would facilitate the transfer of knowledge in agroecological matters, thus facilitating the adoption of these practices (Figure 6).

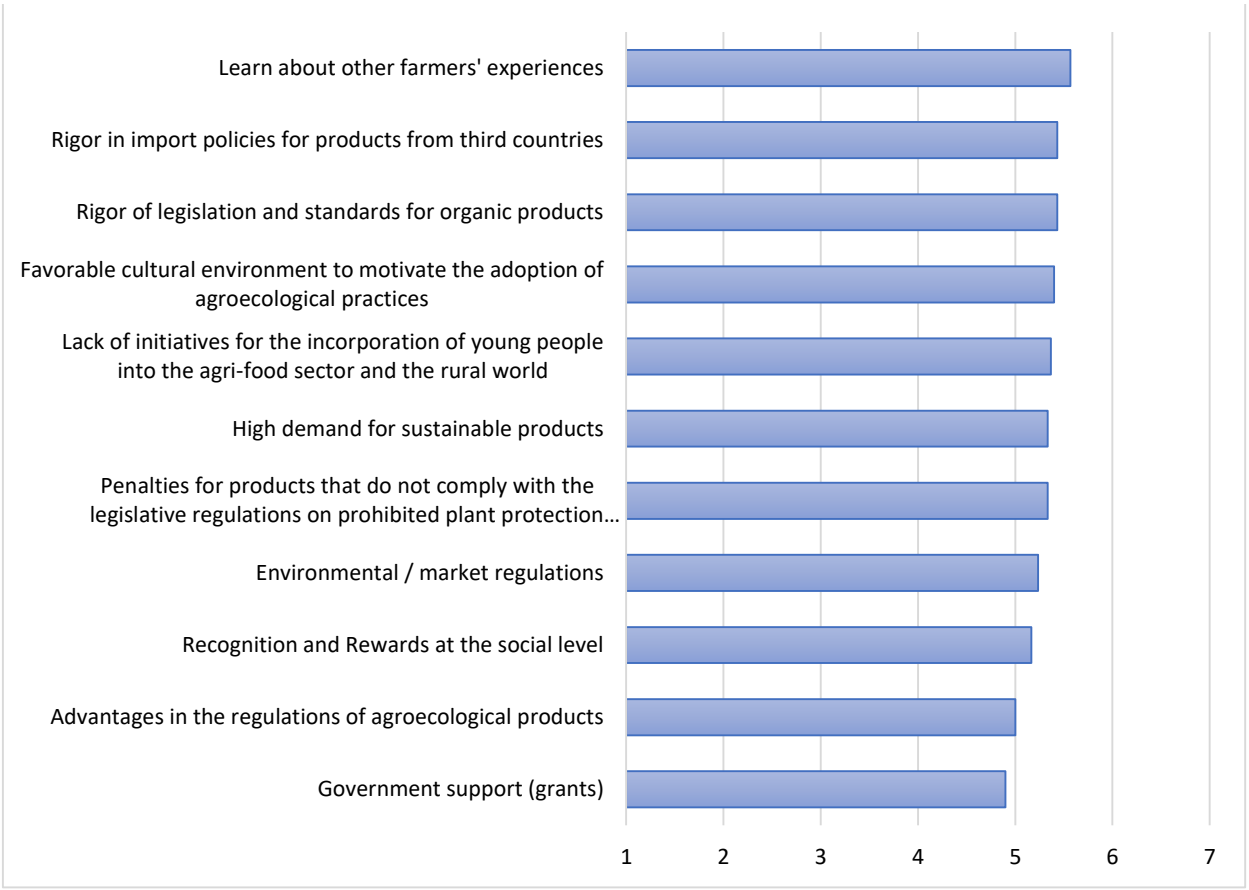


Figure 6. Scalar average according to the degree of importance of a series of factors to adopt agroecological practices.

The benefits most perceived by farmers are "Agroecology reinforces the health and well-being of the soil, environment, producer and consumer", "Agroecology allows to protect and / or conserve ecosystems"," Agroecology reduces environmental deterioration "and" Agroecology incorporates ancestral values and knowledge and of avant-garde character". The aspects that have received the lowest valuation are "Agroecology increases sovereignty of the farmer", "Agroecology allows the generation of medium-high benefits", "Agroecology eliminates hunger, poverty and negative consequences for the environment "," Government support "and" Agroecology empowers the farmer set the final price of the product". Therefore, farmers are clear that agroecology is not only based on the production of food without the use of synthetic chemical pesticides, but rather puts in value the ecosystem of the farm, that of its surroundings and that of the planet, thus contributing to the reduction of pollution and environmental deterioration. Besides, the agroecology can be one of the agricultures of the future with great weight in the development and research of new phytosanitary products of animal or natural origin for the control of pests and diseases. On the other hand, they do not see clearly that agroecology will allow them to have sovereignty over their products and the ways of doing agriculture, or that it will be a practice that contributes to eradicating hunger in the world (Figure 7).

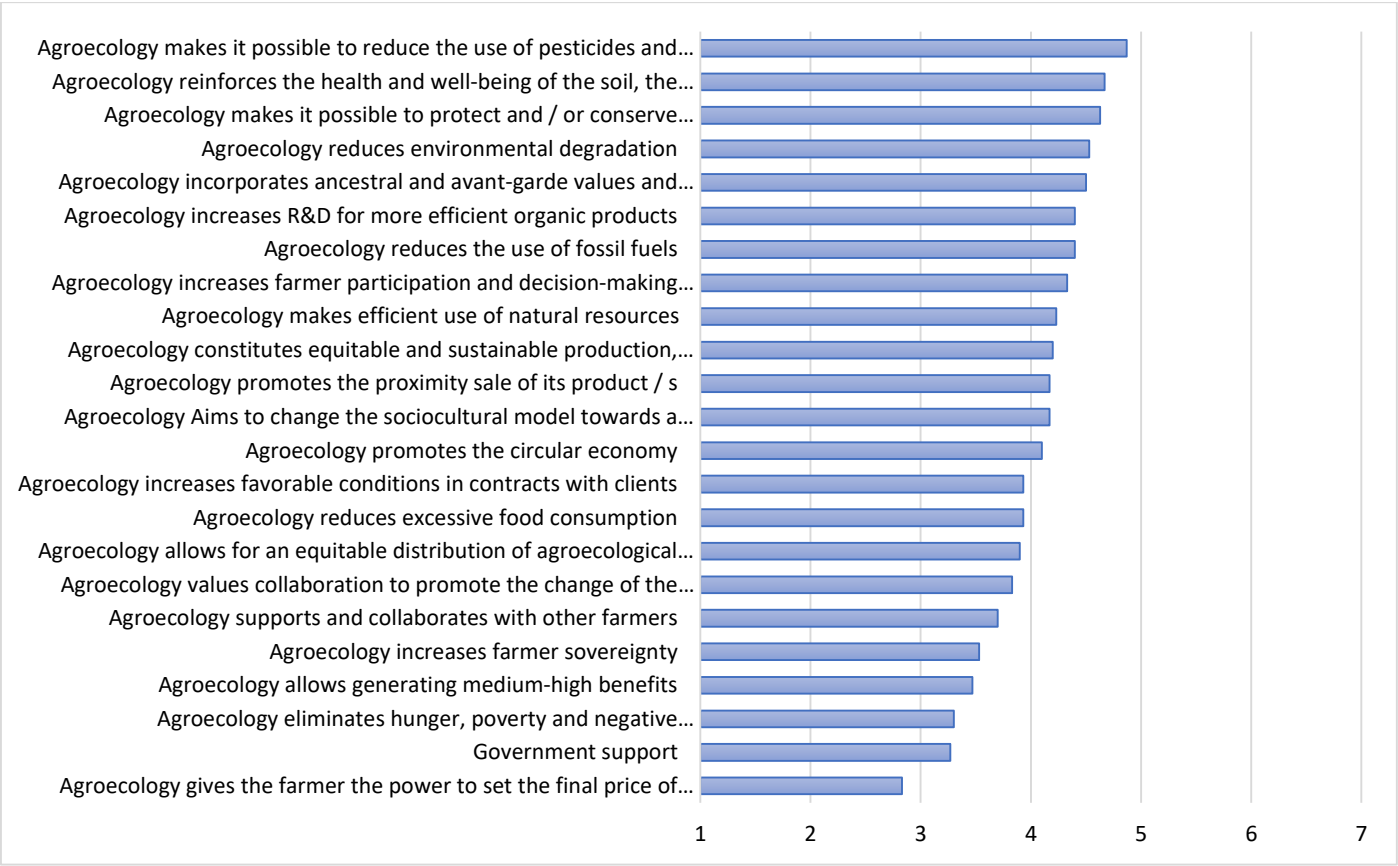


Figure 7. Scalar average according to the assessment of some statements related to agroecological practices.

3.4. Results related to the adoption of agroecological practices

The agroecological practices most adopted by farmers so far are "Organic fertilization", the "Reduction of the use of inputs harmful to the environment", "Conservation agriculture", "Biological control of pests", "Drip irrigation", "Split fertilization" and "Choice of crops and rotations". This is shown in Table 2.

Tabla 2. Number of farmers who have chosen each practice and number of practices who have chosen each of the farmers.

Practices	Number of practices
Organic fertilization	**19**
Reduction in the use of inputs that are harmful to the environment	**19**
Conservation agriculture (soil protection through soil cover with plant remains from a previous crop, planting of plant covers, ...)	**18**
Biological pest control	**18**
Drip Irrigation of Crops	**17**
Split fertilization	**16**
Choice of crops and rotations	**14**
Biofertilizer	**13**
Use of the soil's own organisms (to promote the activity biological soil to increase crop yields and promote soil health)	**13**
Create plant barriers around your crops, plots or the same farm	**11**
Polyculture. Diversification of cultivable species on the same farm	**11**
Production of organic fertilizers	**12**
Elimination of synthetic chemical pesticides	**11**
Choice of cultivars	**10**

The intention to adopt agroecological practices in the future. With an average adoption of 5.07, 40% show a high probability of adoption. In the short term, the most adopted practices will be: “Reduction of the use of inputs harmful to the environment”, “Drip irrigation of crops”, “Effective management of nutrients and biomass”, and "Conservation Agriculture". In the medium term they will be: the "Elimination of synthetic chemical pesticides", the "Choice of crops and rotations ", the" Reduction of the use of inputs harmful to the environment "and" Tillage 0 ", in the long term: the “Use of the soil's own organisms”, the “Use of crops resistant to any stress”, the “Use clean and efficient technologies ", among others and will never be:" Agroforestry "," Tillage 0 "," Divided fertilization ", ...

3.5. Profile of potential farmers adopting agroecological practices in the future

At this point, the variable "Intention to adopt agroecological practices in the future" measured in a scale from 1 to 7, with the characteristics of the farmers and their farms. The graphs are shown below where the variable "intention to adopt " is statistically higher. Therefore, those farmers who have a higher intention to adopt agroecological practices in the future are those who engage in other types of sectors, that is, fruit and vegetable crops, extensive crops and vineyards compared to horticultural and fruit crops (Figure 8), those who practice conventional and integrated agriculture compared to organic (Figure 9), those with a cultivable area of 11ha compared to those who have less of these ha (Figure 10), those who have more experience in the adoption of agroecological practices compared to those who have the least (Figure 11), those who have a lot of confidence in the different sources of information exposed in the questionnaire (Government; Producers; Associations or cooperatives of producers; Universities; Media (Newspapers, TV, radio); Neighboring producers or friends; Family,friends, colleagues; Social networks (Twitter, Facebook, etc.); and, EU) (Figure 12), those who have a lot of information with regard to agrochemicals compared to those who have little (Figure 13) and those who have a high concern for health effects of agrochemicals (Figure 14).

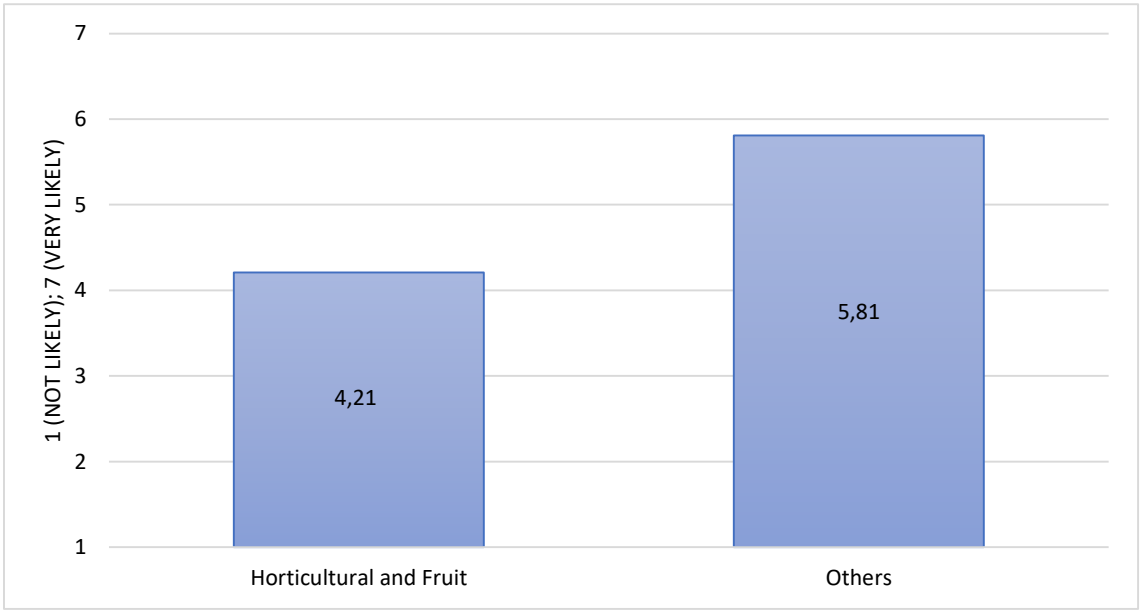


Figure 8. Probability of adopting agroecological practices depending on the sector that the farmers belong to.

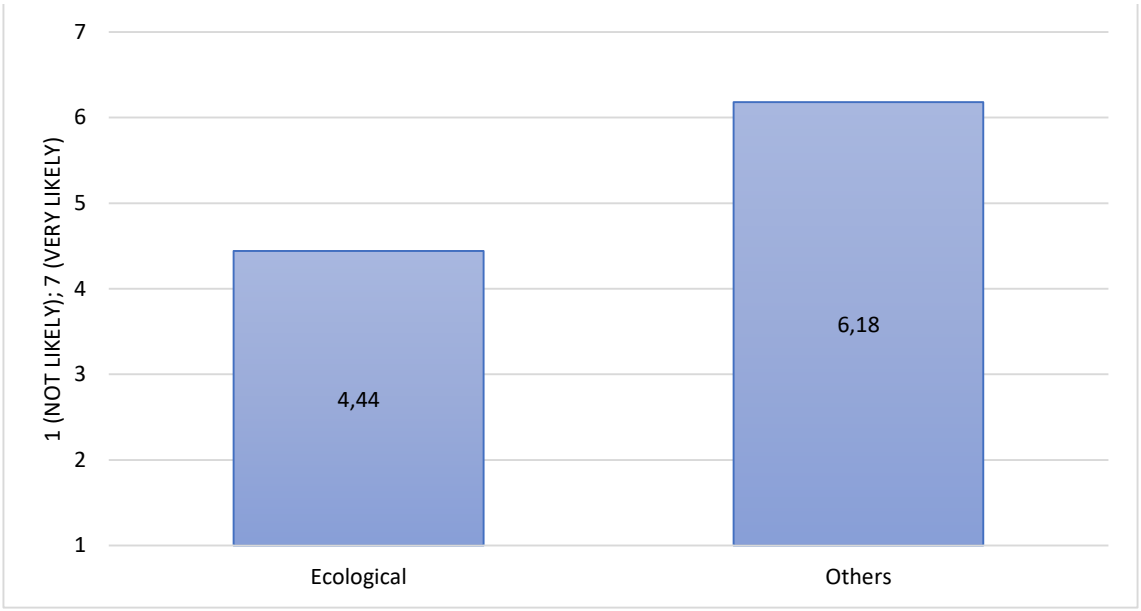


Figure 9. Probability of adopting agroecological practices in the future depending on the type of agriculture practiced by the Farmers.

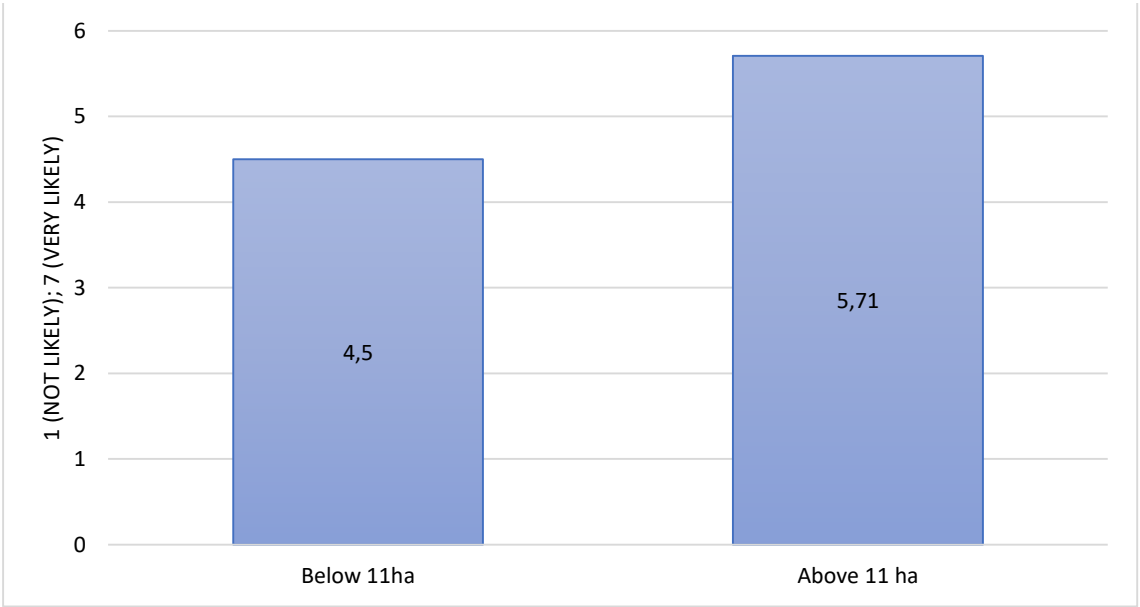
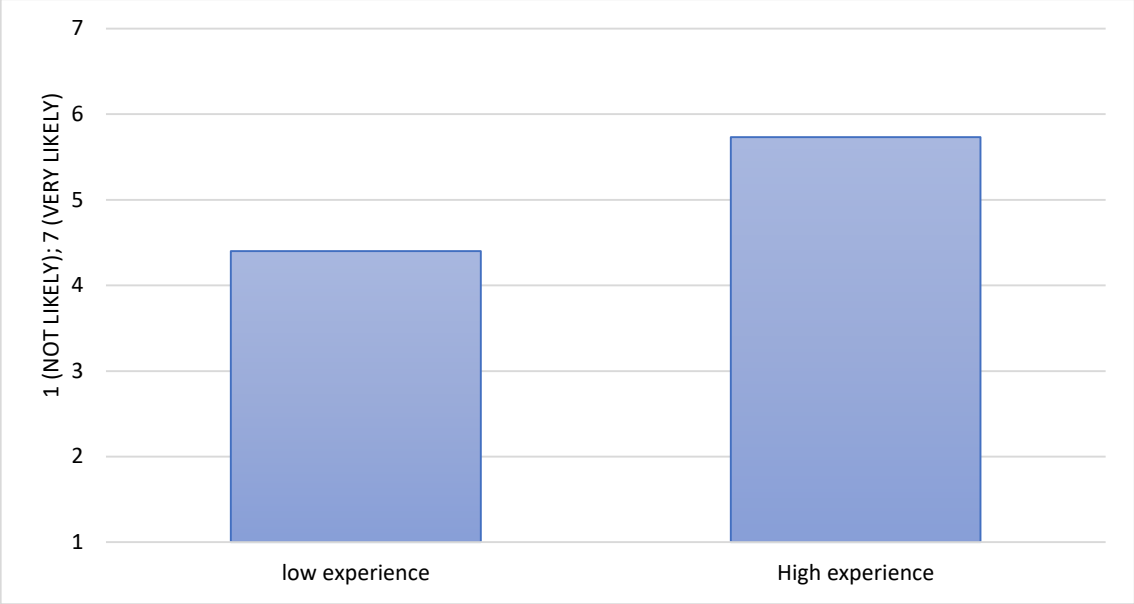
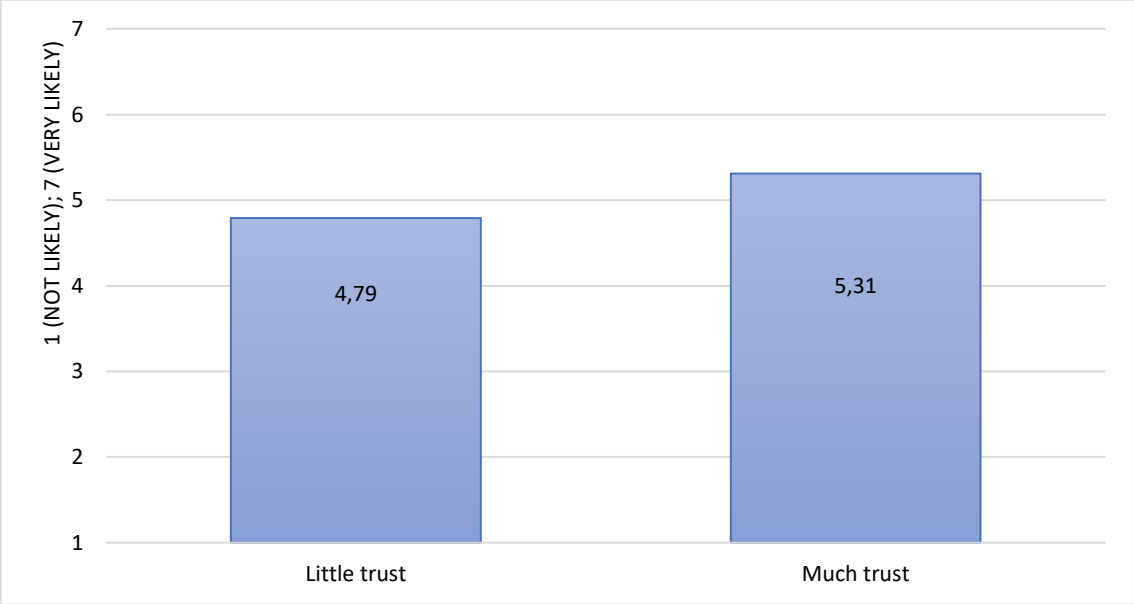


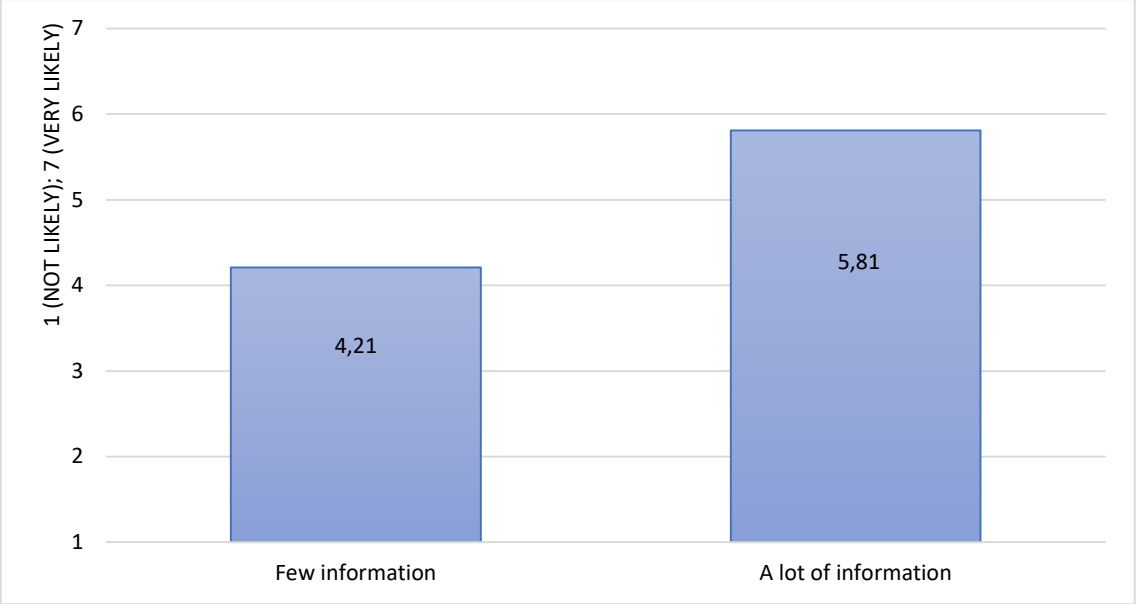
Figure 10. Probability of adopting agroecological practices in the future depending on the size of the farm



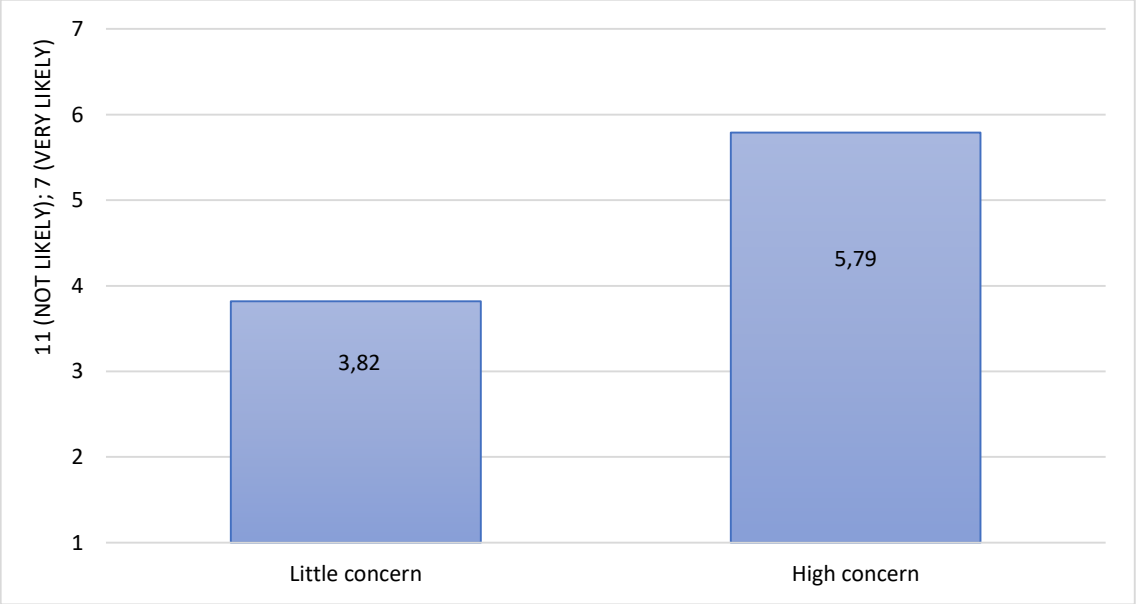
311
312 **Figure 11.** Probability of adopting agroecological practices in the future based on their experience with
313 agroecological practices
314



315
316 **Figure 12.** Probability of adopting agroecological practices in the future based on trust in information sources
317 related to the adoption of agroecological practices



318
319 **Figure 13.** Probability of adopting agroecological practices in the future depending on the degree of
320 information regarding the agrochemicals.
321



322
323 **Figure 14.** Probability of adopting agroecological practices in the future depending on the degree of
324 concern for the effects of agrochemicals.
325

326 **4. Discussion**

327 The results show that the main obstacles to the adoption of agroecological practices are focused on the economic
328 sphere (related to subsidies and the low price they receive for the product at origin) coinciding with the results of other
329 studies [11, 14, 19], social (the organic product is not fully assimilated by the consumer), political (the lack of attention
330 on the part of the institutions) as it was verified [20], academic (lack of knowledge in the norms and the use of ecological
331 pesticides and advice by technicians that are essential to avoid problems at the time of the adoption) [11, 15, 23] and
332 agronomic (typology and soil relief, new varieties not adapted to the conditions of the area, low yields of organic farm-
333 ing,… all of them coincide with the results of other studies [14, 20, 24]. On the other hand, farmers do not see clear that

agroecology can allow them to have sovereignty over their products and the ways of doing agriculture or that its contribution is key in the eradication of hunger in the world. Horrillo et al. [12] showed that the production cost of ecological farms is high and highlight the need for ecological farms to be compensated with subsidies for their contribution to the territory and biodiversity conservation and the provision of ecosystem services. Horrillo et al. [13] reported that ecological livestock production is a sustainable model which benefits society by providing several ecosystem services, including carbon sequestration. They suggested that the imposition of a tax on CO2 emissions will benefits ecological farms improving their incomes.

Potential accelerators of the adoption of agroecological practices identified by farmers include the demand of more rigorous foreign and domestic policies in which they favor the adoption of such practices in which a good planning and policy management [14] and, have the opportunity to learn about the experiences of other farmers who practice organic farming in specialized centers for the transfer of knowledge in agroecological matters. This, compared to the transfer of knowledge through public and / or private institutions, would guarantee a greater successful adoption of agroecological practices due to the simple fact that there is greater trust among farmers. The lack knowledge transfer is linked to the lack of stimulation to learn new agricultural practices [11, 15, 20].

The most adopted agroecological practices by farmers are: organic fertilization, reducing the use of inputs harmful to the environment, conservation agriculture, biological pest control, drip irrigation, divided fertilization (fertilization according to the demand of the crop and the growing period) and the choice of crops resistant to biotic and abiotic actions of the environment and crop rotations. Other techniques adopted are: cultivating according to the calendar and cycle moles, practice solarization (Physical strategy to control soil pathogens), use of plastics to avoid water losses and reduce the use of herbicides, use of long-life boxes in the handling and sale of products and the use of farm birds to combat pathogenic insects.

On a scale from 1 (Not at all likely) to 7 (Very likely), the intention to adopt agroecological practices in a future stands at the average of 5.07 points. Regarding the above, 60% of the farmers indicated an intention to adoption below the average, which indicates that more than half are not considering adopting. However, the intentionality of adoption deepened in the choice of agroecological practices in the short, medium and long term. Therefore, the practices agroecological measures most adopted in the short term have been the reduction of the use of inputs that are harmful to the environment, drip irrigation of crops, effective nutrient and biomass management, and conservation agriculture; to medium term, the elimination of synthetic chemical pesticides, the choice of resistant crops and rotations of crops, reducing the use of inputs harmful to the environment and tillage 0; and, in the long term, the taking advantage of the soil's own organisms, the use of crops resistant to any stress, the use of clean and efficient technologies, not depending 100% on external inputs from the farm.

Farmers, in general, have little confidence in the main sources of information on practices agroecological. The most prominent sources on the part of the farmers are the "Family, friends, colleagues", the other "producers" and the University".

368 The surveyed farmers who are dedicated to extensive crops, fruit and vegetables and integrated production have
369 an intention to adopt agroecological practices in a future greater than those dedicated to horticulture and fruit culture.
370 The same happens with conventional farmers and integrated production compared to production ecological; those with
371 more than 11 arable hectares of land compared to those with less than 11 hectares; those who have already adopted
372 more agroecological practices in front of the least adopters; those who most trust the different sources of information
373 on agroecological practices in front of those who least trust these sources of information; farmers who feel highly in-
374 formed about agrochemicals are more likely to adopt agroecological practices in the future (the opposite of what gives
375 away [9]; as well as very concerned farmers about the negative effects of agrochemicals on the health versus less con-
376 cerned farmers.

377 The potential farmer adopting agroecological practices in the future can be described as: farmer who dedicates
378 to the cultivation of cereals, fruits and vegetables and a practitioner of integrated production, from conventional and
379 integrated agriculture, who has more than 11 cultivable hectares, relies on different sources of information that provide
380 information related to agroecology, with high experience with agroecological practices, feels very informed about ag-
381 rochemicals and very concerned about the negative effects they may have on both the health of the population and the
382 environment. Parra López and Calatrava Requena [25] reported that compared to conventional growers, organic grow-
383 ers are younger, with a part-time dedication to agriculture, with less productive orchards, more involved in manage-
384 ment and administration of the holding and more informed and formed on organic agriculture. Läpple and Van Rens-
385 burg [26] showed that early adopters were the youngest to adopt organic farming. Djokoto et al. [27] found that being
386 male from smaller households with access to credit have a tendency of adopting organic cocoa production. According
387 to Ashari et al. [28], information and knowledge, economic and financial resources, technical and management skills,
388 social aspects, environmental concern, institutional environment, and socio-economic and demographic characteristics
389 of farmers are the key factors of organic farming adoption. Lohr and Salomonson [29] and Pietola and Lansink [30]
390 demonstrated the role of subsidy in encouraging farmers for organic conversion.

391

392 **5. Conclusions**

393 In general, farmers need to be provided with more information about the agroecological production system
394 through means closer to them such as friends, other producers in the same sector, university trials in experimental fields
395 and that these belong to an organic producer because this way it will serve as an example to gain a certain positive
396 perspective for adopting agroecological practices.

397 On the other hand, there is no significant difference in the intention to adopt agroecological practices in the future
398 among the farmers who have been working in the agricultural sector for more than 20 years and those who have been
399 working in the agricultural sector for less than 20 years, among the farmers who have family or rental farms and those
400 who have concession and / or purchase farms, among those who have indicated a greater number of barriers to the
401 adoption of agroecological practices and those that have indicated a lower number of barriers, among farmers who

perceive many benefits of adopting agroecological practices in the future and those who do not perceive or perceive few benefits, among risk-disliking farmers and risk-takers, among highly productive farmers environment and those who are not so protective of the environment, among farmers whose age is higher than the average age of the sample (48 years) and farmers whose age is lower than the mean age of the sample, and there is no difference in the intention to adopt agroecological practices in the future among men and women; nor among those who say that agriculture is or is not the only source of income their household receives. There is also no significant difference in the intention to adopt agroecological practices among those with university and secondary education and those with primary or simple studies.

With all the data collection, the profile of the potential farmer adopting agroecological practices in the future can be described as: farmer who dedicates to the cultivation of cereals, fruits and vegetables and a practitioner of integrated production, from conventional and integrated agriculture, who has more than 11 cultivable hectares, relies on different sources of information that provide information related to agroecology, with high experience with agroecological practices, feels very informed about agrochemicals and very concerned about the negative effects they may have on both the health of the population and the environment.

Producing in an ecological way implies higher production cost which forces farmers to sell the resulting product at higher prices than conventional ones. Consumers interest in organic products in increasing, however, the prices are a barrier. So, policymakers should support economically farmers paying them for the ecosystem services they provide to society.

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