Article

Sustainability and environmental performance of protected agriculture: the case of Zacatecas

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Abstract

The design of a public program that involves agro-environmental measures requires knowledge of producer opinions and applied production practices. In this work the opinions on sustainability in the production units (UPs) under protected agriculture in the state of Zacatecas are classified, their environmental practices are determined, as well as drivers and barriers for the adoption of the agro-environmental program. It is intended to support strategies for the design of public policies that contribute to the sustainability of the agricultural sector in Mexico. The information was obtained; through a questionnaire applied to owners or technicians of the UPs during the months of May to December 2016. The information was processed; through, analysis of main components and cluster analysis. The environmental performance index (IDA) was also obtained. The opinions on sustainability in the UPs show two great visions: one that is based on considering internal aspects of the organization and access to markets and the other that has a relaxed view on the care of the environment, considering for these purposes less relevance to the aspects of market, organizational and social. The IDA showed that in the UPs there is still a long way to go to achieve sustainable production systems. For the design and implementation of an agro-environmental program, it is suggested to condition direct support to producers to the establishment of sustainable agricultural practices or the acquisition of environmentally friendly infrastructure.

Keywords: environmental management, greenhouses, sustainable agricultural practices.

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Introduction

According to FAO (2014a), sustainability in agriculture is much more than ensuring the protection of the natural resource base in the production of goods and services. To be sustainable, agriculture must meet the needs of the present and future generations, while ensuring profitability, environmental health and social and economic equity. In this way, sustainable agriculture must conserve land, water, genetic resources of animals and plants, not degrade the environment and be technically appropriate, economically viable and socially acceptable. Sustainability is an increasingly relevant topic for the agricultural sector due to its high environmental and social impacts.

Agricultural areas, grasslands and forests occupy about 60% of the land area. The agricultural sector depends on natural resources for its production processes and can cause both damage and generate environmental benefits. On the one hand, unsustainable agricultural practices and change in land use are the most important causes of land degradation, resulting in loss of ecosystem services, declining yields and abandonment of agricultural land (FAO, 2012). Agriculture uses 70% of fresh water. Inefficient water use has diminished the capacity of aquifers, reduced wildlife and caused salinization in the agricultural irrigation area (FAO, 2014a). Current agricultural practices contribute 10 to 12% of total anthropogenic greenhouse gas emissions (IPPC, 2014).

On the other hand, good practices neutralize carbon, generate environmental services and renewable energy, while contributing to food security (FAO, 2012). In Mexico, 77% of the water is for agricultural use, with inefficient application being reported in large part of the irrigation area and negative impacts on the quality of the environment due to agricultural practices (Pérez Espejo *et al*., 2012).

In arid and semi-arid regions, these environmental problems occur more severely, as is the case in the state of Zacatecas, where 87.7% of the agricultural area is temporary and 13.3% is irrigated (SIAP-SAGARPA, 2017). The water used for irrigation of the latter area is obtained from 34 aquifers of which 41% are overexploited (CNA, 2015). In the state of Zacatecas, protected agriculture has presented high growth rates. During the period 2003 to 2010, it reported an average annual growth rate (TCMA) of 25%, registering a total of 277 ha in 2010 (Padilla-Bernal *et al*., 2012). However, this rate has decreased in recent years due in large part to the change in government support policies (Padilla-Bernal *et al*., 2018), with an area of 475 hectares being reported for 2017 (SIAP-SAGARPA, 2017).

The concept of protected agriculture applies to the production systems that carry out their activities under a cover in order to protect the crop from environmental conditions (Garcia *et al*., 2011) and the incidence of other living organisms. The rapid growth of production systems with protected agriculture is attributed to both technical production factors and social factors (Padilla-Bernal *et al*., 2015).

In the state of Zacatecas, all production systems under protected agriculture to irrigate their crops use groundwater. However, inefficient use of irrigation water, exaggerated and inappropriate application of chemical synthesis products and poor soil management is reported (Lara-Herrera *et al*., 2016). These excesses have presented environmental, economic and productivity consequences on crops in a protected environment (Padilla-Bernal *et al*., 2012).

Additionally, in protected agriculture there are other problems that can impact the environment and public health. This refers to the large amounts of solid and green waste, such as plastics discarded when renovating roofs and irrigation pipes, as well as plant residues that can carry pathogenic and phytopathogenic microorganisms and substrates; in addition to the large amounts of irrigation water applied to crops (Padilla-Bernal *et al*., 2015). Sustainability has become a great challenge for production units (UPs) under protected agriculture.

Agricultural producers in Mexico report a shortage of information on environmental aspects and their management, as well as established agro-environmental policies (FAO, 2014c). Padilla Bernal *et al*. (2018) indicate that there are few studies that show opinions of agricultural producers on sustainability and the environmental performance of the UPs, as well as the drivers and barriers for the adoption of agro-environmental programs, particularly in the case of protected agriculture.

Pérez-Espejo *et al*. (2011) indicate that before and after establishing a public program that involves agro-environmental measures, it is necessary to know the opinions and attitudes of the producers. Having clarity about the motivations of producers to participate in an agro-environmental program, beyond financial compensation, is crucial for those who design public policies. The objective of this work is to classify the opinions on sustainability in the UPs under protected agriculture in the state of Zacatecas, determine the applied environmental practices, as well as the drivers and barriers for the adoption of an agro-environmental program. The study intends to support strategies for the design of public policies that contribute to the sustainability of the agricultural sector in Mexico.

It should be noted that there are currently a large number of tools, measures and standards that address the different dimensions of sustainability in agricultural UPs and the value chain (FAO, 2014a). However, the workplaces greater emphasis on environmental sustainability and its management. The research questions are the following: what is the opinion on the sustainability of decision makers in the UPs under protected agriculture?, what kind of agricultural practices are being applied in these UPs?, what are the care strategies and environmental protection followed in the UPs under protected agriculture?

Materials and methods

Questionnaire design and data collection

The required information was obtained through a questionnaire applied to technicians or owners of UPs under protected agriculture in the state of Zacatecas. For the design of the questionnaire, the one applied in 2015 by Padilla-Bernal *et al*. (2018). The questionnaire was applied during the months of May to December 2016 at meetings of the Cluster of Protected Agriculture AC and visits to the UPs.

86 questionnaires were applied, only 81 were completely answered and not duplicated, proving useful for the study. The selection criteria of the units of analysis to be surveyed were an area under protected agriculture ≥1 ha, having reported activity in the 2015 agricultural year and the availability of the technician or owner to answer the questions. The number of UPs and their location was obtained from the registers of producers registered in the Cluster of Protected Agriculture, AC, the Tomato Product System and some others identified, through the Chile Product System or in producer meetings.

The UPs surveyed cover an area of 472.6 ha under protected agriculture and 2 665 ha in the open field (most UPs with protected agriculture also grow products in the open field), distributed in 19 municipalities of the state (Calera, Cañitas de Felipe Pescador, Fresnillo, General Enrique Estrada, Gral. Panfilo Natera, Guadalupe, Jeréz, Loreto, Morelos, Ojocaliente, Panuco, Pinos, Tepetongo, Trancoso, Vetagrande, Villa de Cos, Villa Hidalgo, Villanueva and Zacatecas).

The area with production systems under protected agriculture where the studied UPs are located represents 99.5% of the state area cultivated under this modality (SIAP-SAGARPA, 2017). The structure of most of the UPs is scrape and kneed, has passive climate control and cultivated in soil. Only 34 have any certification, of which 15 export their products (Table 1). The maximum degree of studies of 65% of respondents is undergraduate or postgraduate and 47% are older than 50 years.

Table 1. Characteristics of the production units.

Characteristics	Description		(%)
Type of agriculture (area cultivated in ha)	Protected agriculture (ha)	472.6	15.1
	Open field (ha)	2 665	84.8
	Total (ha)	3 137.6	100
Type of structure in protected agriculture (area cultivated in ha)	Shadow mesh	170.2	36
	Scrape and kneed	217.9	46.1
	Multi-tunnel	84.5	17.9
	Total area (ha)	472.6	100
Climate control (UPs)	Active	5	6.2
	Passive	76	93.8
Form of cultivation (UPs)	Soil	76	93.8
	Hydroponics	5	6.2
Type of market where they sell their products	Local	15	18.5
	National	34	42
	Local and national	17	21
	National and international	15	18.5
Certifications of the production unit	Have some certification	34	42
	It does not have certifications	35	43.2
	In certification process	12	14.8

Elaboration based on fieldwork.

Data processing

The determination of opinions on sustainability was made through 12 questions, adapting what was proposed by Rankin *et al*. (2011); Hauschildt and Schulze-Ehlersb (2014) and what is used by Padilla-Bernal *et al*. (2018). The questions were presented on a scale from 1 to 5 where 1= disagree and 5= totally agree. To reduce opinions on sustainability, to have greater clarity in data management, the information was subjected to a principal component analysis (ACP) with Varimax rotation.

Data was processed using SPSS v23. To include an indicator in a factor, a factor loads greater than or equal to 0.5 was considered and to determine the internal consistency and reliability of the factors, an Alpha Cronbach coefficient greater than or equal to 0.70 was considered. This coefficient can take values from 0 to 1, Tavakol and Dennick (2011) state that a value greater than 0.7 is considered acceptable. In order to group the respondents based on their opinions on sustainability, a hierarchical cluster analysis (ACJ) was made, applying the Ward method and using the agglomeration table and the dendrogram (Czillingová *et al*., 2012). The profile of the groups was determined using analysis of variance (Anova).

The environmental performance of the UP was obtained taking as a reference what was proposed by Carruthers (2005). Unlike Padilla-Bernal *et al*. (2018) where questions were asked about the perception of the actions carried out, the questions were asked taking into account agri-environmental practices, as well as the existing infrastructure in the UP. The variables evaluated were water, soil, biodiversity, agrochemicals, pollution, waste management and environmental management of the business.

Each variable had four questions (indicators), with answer options from 1 to 5, where 1 was non-application of agricultural practice or application in a more rudimentary or less environmentally friendly way or where appropriate the non-availability of infrastructure and 5 application of best agricultural practices in a sustainable way or availability of infrastructure aimed at caring for and protecting the environment. The index per variable represents the relationship between the score of the studied variable with respect to the maximum possible. To make all the scores comparable, the maximum score was considered as ten. The environmental performance index (IDA) was obtained as an average of the variables considered.

For the determination of the motivators and barriers for the adoption of an agri-environmental program, the proposal by Padilla-Bernal *et al*. (2018), seven questions were asked in each case, with options from 1 to 5 where 1= not important and 5= totally important. The value of the motivators and barriers were determined as an average per group of indicators.

Results and discussion

Opinion on sustainability and its management

The opinions on sustainability, the mean, standard deviation and the factor loads of the ACP are presented in Table 2. Three factors were obtained with eigenvalues greater than the unit that explain 65.52% of the total variance. These were called ‘environmental and regulatory’, ‘organization-oriented and market' and 'driven by profitability'. Unlike that obtained by Hauschildt and Schulze-Ehlersb (2014); Padilla-Bernal *et al*. (2018), only two factors were statistically significant. The third factor 'driven by profitability' was excluded in subsequent analyzes when a strategy to save costs was explained by the indicator alone. The indicator an opportunity to improve the income of the UP by obtaining a factor load greater than 0.5 in two factors is not considered within the third factor.

Table 2. Mean, standard deviation and ACP factor loads of sustainability opinions.

Opinions on sustainability	Mean†	Standard deviation	Environmentalist and normative	Organization and market oriented	Boosted by profitability
A belief that leads to care and protect the environment	4.38	0.845	0.849	0.078	0.201
Reduce the impact on the environment for its preservation in the future	4.38	0.86	0.821	0.238	0.138
A way to reduce risk in the UP	4.4	0.832	0.711	0.447	-0.192
Comply with environmental protection laws and standards	4.11	0.962	0.698	0.136	0.259
A strategy to improve the position of the UP in the long term	4.2	0.813	0.618	0.385	-0.117
Produce safe, safe products for consumers	4.46	0.759	0.504	0.428	0.181
A way to improve the work environment	4	0.88	0.137	0.793	0.191
Set of values on which the UP works	3.63	0.98	0.284	0.746	-0.102
A way to strengthen the image of the UP	4.22	0.806	0.191	0.689	-0.122
An opportunity to improve the income of the UP	3.91	1.002	0.214	0.647	0.574
A strategy to improve market position	4.25	0.929	0.381	0.573	0.392
A strategy to save costs	3.31	1.114	0.105	-0.062	0.85
Eigenvalue			5.335	1.309	1.219
Cronbach's Alpha			0.857	0.816	

†= totals observations= 81. Kaiser-Mayer-Olkin (KMO)= 0.849. Measurement scale: 1= does not apply or not according to 5= totally agree.

The opinion on sustainable agriculture is one of the most important factors that contribute to its adoption (SAI Platform, 2015). Pérez-Espejo *et al*. (2011) point out that the perception of sustainability and the potential implementation of agri-food policies, such as voluntary programs, is essential for the management of environmental problems in developing countries.

Agricultural practices oriented to the care of natural resources and environmental management

Regarding the agricultural practices oriented to the care and protection of the environment, the IDA was calculated by type of market where the UPs market their products. Based on the single-factor Anova, it was found that the UPs that sell their products in national and international markets report higher average IDAs than those in the local, national and local and national markets (Table 3), reporting statistically significant differences between these three groups and the first.

Table 3. Environmental performance index of protected agriculture UPs by market type.

Environments	Local		National		Local and national		National and international		Total	
	Media	DE	Media	DE	Media	DE	Media	DE	Media	DE
Water	5.6	1.26	6.06	1.43	5.74	1.49	7.03	1.08	6.09	1.42
Soil	5.83	1.89	6.56	1.69	6.21	2.46	7.5	1.46	6.52	1.92
Biodiversity	6.83	1.73	6.81	1.35	6.82	1.14	7.7	1.4	6.98	1.41
Agrochemical	7.73	2.51	8.46	1.73	8.82	1.41	9.8	0.41	8.65	1.79
Pollution	6.4	2.25	7.26	2.27	6.76	2.34	9.6	0.69	7.43	2.32
Waste management	3.23	1.79	4.21	2.16	4.47	2.12	6.73	1.94	4.55	2.31
Environmental management of the business	2.93	1.28	3.57	1.87	3.76	1.86	5.63	1.71	3.88	1.93
IDA	5.51	1.21	6.13	1.33	6.08	1.45	7.71	0.82	6.3	1.43

DE = standard deviation; ‡IDA= environmental performance index.

Having found homogeneity of variances (p-value= 0.197) the Tukey procedure was applied (p-value < 0.001). The results suggest that marketing the product in the international market makes a difference in the agricultural practices of environmental care applied in the UPs. However, it should be noted that the average IDA of the UPs studied is 6.3, a value 37.0% lower than the reference index (IDA= 10). The results show that there is still worked to be done to achieve more sustainable UPs.

The highest IDAs per variable were obtained in agrochemicals (8.65) and pollution (7.43). In the agrochemical variable the indicators were considered: storage of agrochemicals in an adequate place; use of doses and proper application of agrochemicals to crops; pest monitoring to decide the application of agrochemicals and use only of agrochemicals authorized by regulatory bodies. In the case of the pollution variable, the indicators were: avoid burning straw and stubble, as well as other materials; use of drinking water for hygiene of equipment and workers, use of iron for preparing solutions for mixing agrochemicals and use of a special area for storage of clothing and protective equipment different from the pesticide store.

The values obtained in the agrochemical and pollution variables are attributed to the wide dissemination of government programs that promote certification in the good use and management of agrochemicals (BUMA) and the reduction of pollution in their application -risk reduction system Primary Vegetable Production Pollution (SRR)- (SENASICA, 2016).

The variables that recorded the lowest values in the IDA were those involving activities with environmental management of the business (3.88) and waste management (4.55). The indicators considered in the business management variable are: application of a training program in environmental aspects for workers, preparation of environmental contingency plans, design of a program to reduce solid and green waste and use of alternative energy for agricultural production or in postharvest management.

The aspects evaluated in the variable waste management were: triple washing and perforation of empty pesticide containers; it send empty agrochemical containers to a confinement center, send plastic waste, pipes, belt to a collection center for recycling, plant waste deposit in a special area for fertilizer production. The values obtained in these variables denote a 50% lower performance than the maximum value of the IDA, suggesting the need for more information and training in the UPs on the mentioned aspects. Most respondents replied that they do not carry out the activity related to the indicator or do not have the spaces required for the development of the activity.

Strategies oriented to the adoption of a comprehensive program of care and protection of the environment (PICPA): motivators and barriers

The most important motivations for the adoption of a PICPA were: to facilitate access to national and international markets (4.5) and avoid damage to workers (4.5) (Table 4) responses similar to those found by Padilla-Bernal *et al*. (2018) and consistent with what was stated by Carruthers and Vanclay (2012) and SAI Platform (2015), who consider the market as one of the main factors for the adoption of good agricultural practices and innovation.

Table 4. Motivators by type of market for the adoption of an agro-environmental program.

Motivators	Local		National		Local and national		National and international		Total	
	Mean	DE	Mean	DE	Mean	DE	Mean	DE	Mean	DE
Facilitate access to national and international markets	4.8	0.6	4.4	0.7	4.2	1.1	4.8	0.6	4.5	0.8
Improve the image of the production unit	4.6	0.5	4.2	0.7	3.9	1	4.9	0.4	4.3	0.7
Compliance with regulations for environmental protection	4.1	0.8	3.8	1.2	3.9	1	4.7	0.6	4	1.1
Reduction of production costs	4.4	1.1	4.2	1	4.6	0.7	3.9	1.5	4.3	1.1
Improve the sustainability of the production unit	4.7	0.5	4.1	1.1	4.1	0.8	4.5	0.8	4.3	0.9
Consistency with personal principles	3.9	0.8	3.7	1.1	3.8	1.1	4.2	1	3.9	1
Avoid damage to workers	4.4	0.7	4.4	0.9	4.7	0.6	4.5	0.9	4.5	0.8
Index: motivators	4.4	0.4	4.1	0.6	4.2	0.5	4.5	0.5	4.3	0.6

† DE= standard deviation. Measurement scale: de 1= not important to 5= totally important.

The barriers to the adoption of a PICPA, these were determined according to what was proposed by Carruthers (2005); Carruthers and Vanclay (2012); Merli *et al*. (2016). Respondents on average indicated that one of the most important barriers is not having government support (4.2), followed by additional expenses in monitoring, training and investment in infrastructure and equipment (4) (Table 5). Result similar to that reported by Padilla-Bernal *et al*. (2018), who point out that the acceptance of an agri-environmental program increases as the costs and technical efforts decrease and the benefits are clearly perceived.

Table 5. Barriers by type of market for the adoption of an agro-environmental program.

Barriers	Local		National		Local and national		National and international		Total	
	Mean	DE	Mean	DE	Mean	DE	Mean	DE	Mean	DE
Additional expenses in monitoring, training, infrastructure and equipment	4.3	1.2	4	1.1	4.1	1	3.5	1.2	4	1.1
Not having trained personnel in the UP on actions that help protect the environment	4.2	0.9	3.8	1.3	3.8	0.9	3.9	1.3	3.9	1.1
Ignorance about environmental aspects and their management	4	1.2	3.6	1.2	3.9	0.9	4	1	3.8	1.1
Not knowing how to quantify environmental damage	3.9	1.3	3.8	1.3	4	1.1	4.1	1.1	3.9	1.2
Lack of time to plan and implement environmental actions	3.7	1.3	3.4	1	3.4	1.1	3.7	1	3.5	1.1
Too much paperwork and documented requirements	3.9	1.4	3.8	1	3.6	1.4	3.8	0.9	3.8	1.1
Not having government support	4.1	1.2	4.4	0.8	4.5	0.6	3.5	1.4	4.2	1
Index: barriers	4	0.8	3.8	0.7	3.9	0.5	3.8	0.7	3.9	0.7

DE= standard deviation. Measurement scale: de 1= not important to 5= totally important.

Cluster analysis n sustainability opinions

Cluster analysis was performed based on the two statistically significant components obtained from the ACP applied to sustainability opinions. Three groups consisting of 44 (54.3%), 21 (25.9%) and 16 (19.8%) UPs respectively were obtained. The groups are described based on the one-way ANOVA (Table 6). Applying the Levene test, variance homogeneity was found for most of the variables. In these cases, the Tukey procedure was used to identify significant differences between the groups, and in the rest of the cases the Games-Howell was applied (Morgan *et al*., 2011).

The three groups presented statistically significant differences in the 'environmentalist and normative' opinions of sustainability, showing higher average values in group 1 (4.66), followed by group 3 (4.43) and then group 2 (3.53). However, in the opinions on sustainability 'oriented to the organization and market', groups 2 and 3 do not show statistically significant differences. On the other hand, the average value of group 1 (4.49) was statistically different from groups 2 and 3. These results suggest the denomination of the three groups as follows: group 1 'rational environmentalist', group 2 'environmentalist by rule' and group 3 'potential environmentalist'.

Table 6. Analysis of conglomerates and Anova for opinions on sustainability and environmental management indicators in the UPs.

Factor/concept (mean/desv. est.)	A	B	C	F-Value
	Rational environmentalist (N= 44)	Environmentalist by standard (N= 21)	Potential environmentalist (N= 16)	
Environmentalist and normative[GH]	4.66	3.53	4.43	47.28***
	0.24***(B)*(C)	0.71***(A, C)	0.39*(A)***(B)	
Organization and market-oriented [GH]	4.49	3.52	3.29	58.15***
	0.33***(B, C)	0.61***(A)	0.5***(A)	
Environmental performance				
Environmental performance index (IDA)	6.68	5.71	6.04	3.89**
	1.37**(B)	1.28**(A)	1.52	
Motivators and barriers to adoption of a PICPA				
Motivational index	4.39	3.95	4.28	4.75**
	0.49***(B)	0.61***(A)	0.54	
Barriers index	3.86	3.84	3.92	0.061
	0.72	0.63	0.6	

Mean= arithmetic mean; des. est.= standard deviation. Capital letters in brackets indicate significant differences between individual groups. Index of the components: simple average of the responses in each indicator included in the factor GH, the Levene test statistic indicated that the variances are not homogeneous at least at 10% significance. Therefore, the Posthoc test was based on Games-Howell.

Regarding the IDA, the results of the cluster analysis show statistically significant differences between the agricultural practices applied in groups 1 and 2, while the average value of the IDA of group 3 (6.04) does not show differences with the average values of the groups. 1 and 2 (6.68 and 5.71 respectively). As regards the motivators and barriers to the adoption of a PICPA, the average barrier indices shown in the three groups do not show statistically significant differences. On the other hand, the average index of motivators has statistically significant differences between groups 1 and 2, the opposite being the case between groups 2 and 3. The results of the cluster analysis show that the 'rational environmentalist' group presents average values higher than the other two groups in the indexes analyzed, except for the case of the barriers index that was not statistically significant.

Regarding the willingness to adopt a PICPA in the UPs, it was found that 85.2% of the respondents (69 UPs) expressed their acceptance of the adoption of the program, 12.3% said they did not accept (10 UPs), while 2.5% do not know (2 UPs). These values showed statistically significant differences (χ^2 test). The reasons that the respondents argued for the acceptance of the program are improve the sustainability of the UP, avoid damage to the environment and have better access to national and international markets. Those who do not accept it or doubt its acceptance, the reasons they presented were mainly: negligence of the owner, lack of resources for activities that help take care of the environment, distrust of government programs and lack of information on the subject.

Unlike the groups 'environmentalist by standard' and 'potential environmentalist', the group 'rational environmentalist' presents indicators that show better environmental performance and characteristics that guide the UPs towards the adoption of a PICPA (Table 7). 50% of the group 'rational environmentalist' has scratch-protected and protected environment structures, in this group there are 3 (60%) of the 5 UPs analyzed with active climate and 80% of those that grow in hydroponics. 65.9% of this group has some certification or is in the process of obtaining it. Most of the UPs export their products and 61.4% of respondents have higher education.

Table 7. Comparison of the profile of the groups.

Characteristics		A	B	C
		Rational environmentalist (N= 44)	Environmentalist by standard (N= 21)	Potential environmentalist (N= 16)
Willingness to adopt a PICPA †	Yes	42	14	13
	Not	1	7	2
	I dont know	1		1
Structure ‡	Shadow mesh	6	8	3
	Scrape and kneed	22	8	11
	Multi-tunnel	7	1	2
	Shadow mesh and scrape and kneed	3	3	
	Scrape and kneed and multi-tunnel	3		
	Shadow mesh and multitunnel	2		
	Shadow mesh, scrape and multitunnel	1	1	
Climate control	Active	3	1	1
	Passive	41	20	15
Form of cultivation	Soil	40	21	15
	Hydroponics	4		1
Certifications	Yes	21	7	6
	Not	15	13	7
	In process	8	1	3
Market	Local	10	4	1
	National	15	12	7
	Local and national	9	4	4
	National and international	10	1	4
Schooling of the respondent	Primary	3	1	1
	Secondary	7	6	1
	High school	7	0	2
	Bachelor's degree	23	13	8
	Postgraduate	4	1	4

†= χ^2-value= 13.98 < 0.05; ‡= in the same UP there may be ships built with different types of structures.

Conclusions

The opinion of the respondents on sustainability was summarized in two factors, suggesting that it is determined by two main axes: caring for and protecting the environment based on compliance with the rules and internal aspects of the UP and market, a situation that allows us to appreciate that the social aspect is not a central part in the perception of sustainability of the UPs. The IDA showed that in the UPs under protected agriculture there is still much to change to achieve sustainable production systems, that is, the adoption of production practices that support the conservation of natural resources. Aspect that becomes more visible in activities related to waste management and the establishment of formal environmental protection strategies.

However, the UPs that market their products in national and international markets presented higher IDAs than those only in the local or national market, suggesting that the market is a determining factor in the adoption of more sustainable production practices, condition it helps them to be economically viable.

The three groups obtained based on sustainability opinions fundamentally show two great views on the topic. A first group that bases its vision from caring for and protecting the environment considering internal aspects of the organization and access to markets and the other group that has a relaxed view on caring for the environment, considering for these purposes less relevance to market and organizational aspects, as well as social aspects. The first group is characterized by having a high proportion of UPs willing to accept the adoption of a PICPA (95.4%), more than 50% of the UPs have some certification or are in the process of obtaining it and have the highest number of UPs which markets its product in the international market.

For the design and implementation of a PICPA in the agricultural sector, the following is suggested: a) condition direct support to producers to the establishment of sustainable agricultural practices or the acquisition of environmentally friendly infrastructure, integrating food safety standards, biodiversity and environmental management. This should be accompanied by an extension service that provides effective technical assistance; and b) start the promotion of the program with a pilot group composed of the UPs that are part of the ‘rational environmentalist’ group, together with an information campaign on the implications of good agricultural practices in the sustainability of the UPs.

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