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Socioeconomic determinants that influence the agricultural practices of small farm families in northern Colombia

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ABSTRACT

Access to agricultural services promotes agricultural production and livelihoods of smallholders in most developing countries. The purpose of this study was to analyze the socioeconomic determinants that influence the application of agricultural practices in peasant families in northern Colombia. Categorical and numerical variables of demographic information were evaluated at 200 Agricultural Production Units (APU) in the five prioritized municipalities. With the data obtained, multiple correspondence analysis (MCA) and principal component analysis (PCA) were performed. The results indicated heterogeneity in terms of farmer cooperative, socioeconomic factors and agricultural practices. The study found that education level, income from agriculture, farmer cooperative and credit were determinant factors for most of the agricultural practices that were considered. The results also indicate that non-agricultural income did not influence household well-being. It was found that extension services in the area of the study are insufficient and that farmers face difficulties in having access to credit and loans. Understanding of these factors is essential for the formulation and implementation of intervention strategies aimed at improving the quality of life of these communities, and to preserve and manage human, social, agricultural and financial capital.

1. Introduction

Small family farms are the drivers of the expansion of agriculture both in developed and developing countries, and they display particular socioeconomic, environmental and technological dynamics (Bonfiglio et al., 2017). They have developed life strategies to face various ways of applying a set of practices and functions that contribute to the improvement of agricultural systems, not only at the local level but in urban environments (Santacoloma-Varón, 2015, Quimbayo Ruiz et al., 2020). Farmers have experienced continuous transition processes that in many cases have favored the development of agriculture, strengthening productive agricultural employment and increasing the total income of the sector, globally, regionally and nationally (van der Ploeg et al., 2019, Laurett et al., 2021). Peasants are a clear example of applying agricultural management practices to improve crop productivity and subsequently implement various ways to alleviate poverty, especially among small farmers (Teklewold et al., 2013, Abera et al., 2020). Some of these practices include mixed cropping techniques, crop rotation, integrated pest and disease management, application of animal manure, planting of cover crops, and no-tillage (Nkomoki et al., 2018, Darkwah et al., 2019, Abera et al., 2020, Oyetunde-Usman et al., 2021).

According to Foguesatto et al. (2020), the adoption of various agricultural practices can be an alternative that generates changes not only at the local level but also at the regional level. They improve soil fertility, water retention capacity, reduce the level

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of residues to the product and increase carbon sequestration; thus maintaining agroecosystemic resilience (Jara-Rojas et al., 2012, Ehiakpor et al., 2021, Mogaka et al., 2021). The decision to apply agricultural practices by small peasant farmers is strongly influenced by the socio-economic level of the farmer (Mazvimavi and Twomlow, 2009, Mogaka et al., 2021), cultural practices (Zugravu-Soilita et al., 2021) and in many cases the availability of natural resources (Asfaw & Neka, 2017, Handavu et al., 2019, Benitez-Altuna et al., 2021, Ehiakpor et al., 2021).

A broad set of empirical studies has focused on solving agricultural problems by analyzing the components that affect or influence the adoption of multiple agricultural practices at the farm level (Foguesatto et al., 2020). For example, Pham et al. (2021), identified four factors that influence specific decisions to apply sustainable agricultural practices; 1) socioeconomic factors of the household, 2) characteristics of the plot, 3) resource limitations, and 4) social capital. These elements have been suggested as reasons for the low application of agricultural practices by households. Without taking these aspects into account, it is unlikely to understand the intentions and behavior of farmers to incorporate agricultural practices that generate benefit to the small farmer (Zeweld et al., 2017).

Gutiérrez García et al. (2020) evaluated the knowledge level of Cacao producers, analyzed how knowledge is affected by socioeconomic, productive, organizational variables and determined the importance of training producers regarding the application of multiple practices that include; soil fertility, pruning, good agricultural practices, crop management, transformation and marketing. Circumscribing the institutional factors of the farmer. The authors warned that the level of local knowledge is generally affected by different sociocultural factors such as the level of education, the level of association and the areas where the planting is carried out.

Kassie et al., (2013) identified that demographic variables have heterogeneous impacts on the application of various agricultural practices. They also underline the importance of controlling pests and diseases; take into account the level of farmer associativity in rural institutions, land tenure and the cost of incorporating labor into household decisions by applying a series of practices that improve the income of the small farmer. Similarly, various studies have documented the importance of analyzing the institutional factors of the farmer (Mazvimavi and Twomlow, 2009, Anang and Asante, 2020;); promoting support for innovation, commercial partnerships between public and private actors, marketing channels, state interdependence to encourage policies that benefit small farmers through subsidized inputs and technical assistance (Mazhar et al., 2021). The objective of the institutions is to promote and encourage small farmers towards the different services to intensify agricultural production and improve the quality of life of peasant families (Anang and Asante, 2020).

Institutional factors contribute to solving the concerns of farmers in developing countries and help to encourage the improvement of agricultural practices through crop diversification (Nyantakyi-Frimpong et al., 2017), productive improvement (Benitez-Altuna et al., 2021), subsidy in the purchase of inputs, technical assistance (Anang and Asante, 2020), minimization of production costs, increased agricultural income and agricultural insurance (Sihem, 2019). Despite the critical role of access to services in agricultural production and productivity, many small peasant farmers have limitations. On the one hand, they live in remote communities where access to most agricultural services is difficult. On the other hand, the low participation in social organizations (producers association) makes it difficult to participate in programs and projects promoted by the state (Anang and Asante, 2020).

In developing countries, there are few studies that highlight the importance of the role of institutions in the application of different agricultural practices among small farmers. Less emphasis is made on how the combination of socioeconomic and institutional factors affect or favor in many cases the application of various practices at the farm level. This is particularly deficient in Latin America where there are numerous limitations to the application of various agricultural practices by peasant families. Consequently, the contribution of both socioeconomic factors must be understood in the local context. Given that most of the studies in the literature evaluate the components separately; for example, education, income, labor, access to credit, extension service, etc. Our study seeks to explore the existing associations between the factors and how they influence the application of agricultural practices in peasant families in northern Colombia. This article aims to analyze the socioeconomic determinants that influence the application of agricultural practices in peasant families in northern Colombia. This study is the first in the region (northern Colombia), therefore, it provides a valuable input for decision-making by governmental and professional entities, on the design of initiatives based on strategies that readjust the current agricultural development model.

2. Material and method

2.1. Area of the study

This study was carried out in the department of Sucre in Northern Colombia which is located between 08° 16′ 28″ and 10° 09′ 34″ of latitude north, and 74° 32′ 05″ and 75° 42′ 55″ of longitude east (Fig. 1). It covers an area of 10,917 Km^2, which accounts for 1.0% of the area of the country and 8.5% of the Caribbean region (Gobernación de Sucre, 2020b). Its population is 949252, of whom 38% are small farm (campesino) families (DANE, 2016, Gobernación de Sucre 2020a). It is comprised by 26 municipalities, of which 37% (392651 ha) are suitable for agriculture, 15% (163165 ha) for agroforestry, and 5% (49851 ha) for livestock (UPRA, 2019). Annual temperatures in the department range between 27 °C and 30 °C, and relative humidity is approximately 85% (IDEAM, 2020). The precipitation regime is bimodal, with low levels of rainfall in the first half of the year, a brief dry period in July and August, and higher rainfall in in the second half of the year, reaching values above 2800 mm (Aguilera, 2005, Gobernación de Sucre, 2020b).

The department is divided into five physiographic subregions. In order to cover the five subregions, five municipalities were prioritized, one for each subregion of the Department of Sucre: San Marcos (San Jorge subregion), Majagual (Mojana subregion), Morroa (Montes de María subregion), Corozal (Sabana subregion), and San Onofre (Golfo de Morrosquillo subregion) (Table 1). Most of the territories are in dry tropical forest areas (bs-T), according to Holdridge (1978), except the Mojana subregion, which due to the effects of climate variability is classified as tropical rainforest (bh-T). Large sections of the region are covered by wetlands with ecosystem complexes composed by swamps and streams that merge into the Cauca, Magdalena and San Jorge rivers (Aguilera, 2005).

The livelihoods of the small farm families consist primarily of diversified agricultural systems. They tend to be more at the subsistence than the commercial farming level (Abera et al., 2020, Phondani et al., 2020). The prevailing crops are mechanized and manual rice (*Oryza sativa*), mechanized and traditional maize (*Zea mays*), Ñame (*Dioscórea villosa*), sweet and industrial yucca (*Manihot esculenta*), plantain (*Mussa* Sp.), watermelon (*Citrullus lanatus*), and others (Gobernación de Sucre, 2020b). Other

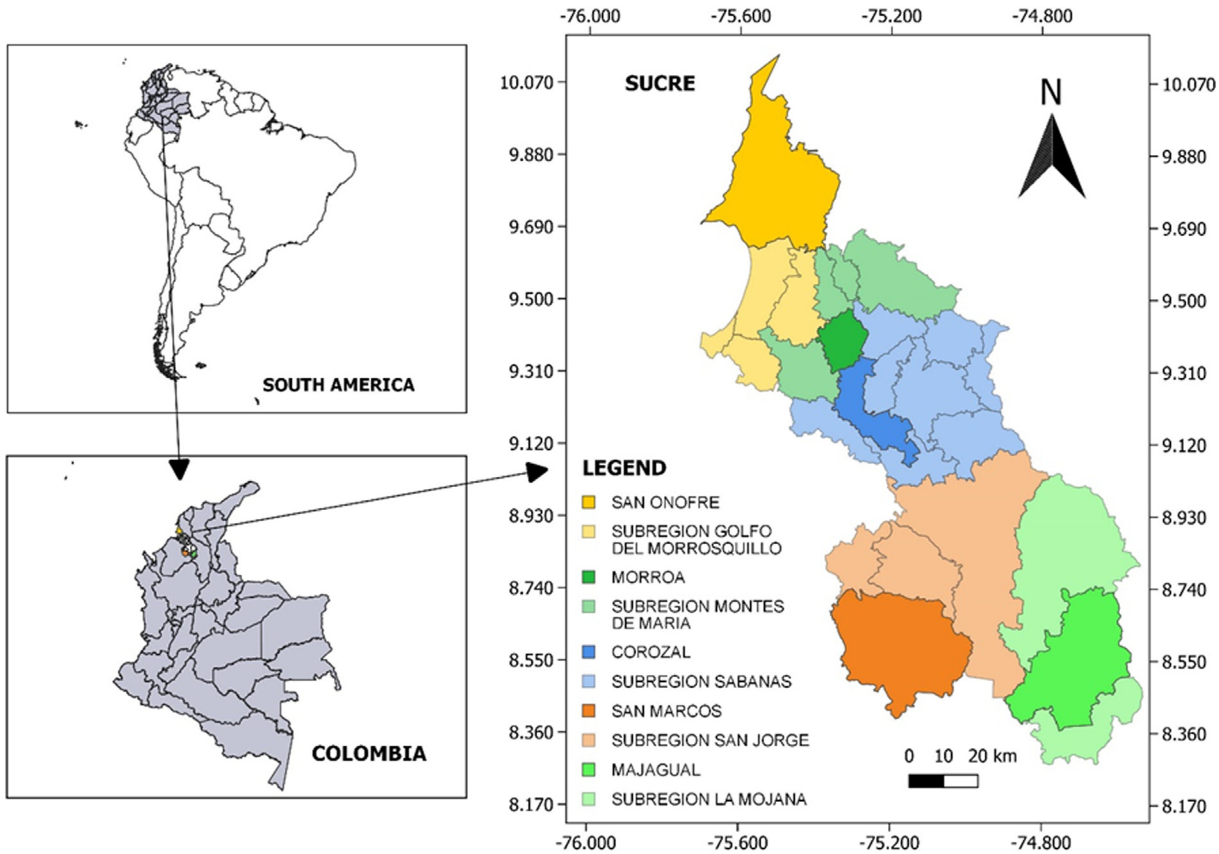

Fig. 1. Area of influence of the study, Department of Sucre in Northern Colombia.

Table 1
Characteristics of the subregions of the department of Sucre.

Subregion	Area (Km^2)	Percent of total (%)	Municipality	Range of elevation (m)	Annual Precipitation (mm)	Average Temperature (°C)
Montes de María	6400	60	Morroa	1–1000	1000–1200	27
Golfo de Morrosquillo	1886	18	San Onofre	0–30	900–1200	27.5
San Jorge	2934	28	San Marcos	20–65	1300 – 2300	28
La Mojana	2337	22	Majagual	16–36	2800	28
Sabana	2101	21	Corozal	70–185	990–1275	27

subsistence livelihoods include fishing (artisan fishing), bee farming and hunting.

2.2. Information gathering techniques

This study was carried out by means of a participative characterization survey, with the aim of assessing the practices of small farmers in the department of Sucre. Descriptive statistics were developed from the obtained values after the information gathering process, they were analyzed using two multivariate techniques: multiple correspondence analysis (MCA) and principal component analysis (PCA). These techniques are used to interpret the data based on the multidimensional associations observed between the variables that characterize the practices of the producers and the socioeconomic factors, which allow identifying similarities and differences between them. Therefore, Biplot representations were obtained to show the existing relationships.

These analysis techniques were used, since they are considered exploratory and their application does not require having any kind of pre-existing assumption regarding the interdependence between variables. Additionally, in this study a response variable was not defined with the intention of making inference regarding the way in which the other factors condition it; rather, technically it seeks to describe the patterns observed between the multiple fields of interest. Additionally, a Biplot technique was used to obtain a multidimensional representation of the agricultural practices and their relationships with different services, in order to describe the associations that are perceived between them.

The surveys were taken at 200 Agricultural Production Units (APU) in the five selected municipalities, distributed into 40 for each municipality. The APUs were chosen randomly and are part of the project "Application of engineering techniques that increase the resilience of agroecosystems to climate variability in the Department of Sucre". The survey was carried out in the months of July and August of 2020. The survey consisted of 139 questions with detailed information on the socioeconomic drivers of the agricultural practices, including characteristics of the households, demographic factors, and access to institutional support in the different agricultural production units, etc. The survey included open-ended questions on the adoption of agricultural practices and on institutional services. The families included in the sample are from diverse social groups whose main vocation is agriculture. They participate in different programs developed by the state and their agricultural practices differ in certain aspects (Viteri and Toledo, 2020, Oyetunde-Usman et al., 2021).

2.3. Data analysis

Once the socioeconomic characterization stage was completed, codes were assigned by category and the data was input to a database. The key variables were extracted (32 variables) that describe socio-demographic data (family members, education level, labor, community organization), financial data (access to credit, agricultural insurance, perception of income per harvest), agricultural diversity of the APU (property ownership, number of productive hectares, type of system implemented), and crop management practices in the area of the study (perceived soil quality conditions, irrigation system, water saving practices, fertilization, pest and disease control, weed control, property management). MCA was run to explore the associations between the categories of qualitative variables, and PCA was run to identify quantitative associations.

MCA is a technique that studies relationships between categories of qualitative variables based on a sample of individuals. This technique offers a graphic representation of the categories in rows and columns and enables comparing their "correspondence" (association) at the category level. It is also useful for efficiently gathering large data sets, which provides considerable information in population studies (Costa et al., 2013). On the other hand, PCA is a dimensionality reduction technique that seeks to summarize in a multidimensional way the interdependencies between different quantitative variables, which are associated with the aspects that make it possible to establish links between the application of different agricultural practices and the different socioeconomic aspects. A relevant feature of multivariate analysis is the graphical display of row and column points in Biplots, which can help detect structural relationships between categories of variables, offering a visual map that allows data interpretation (Costa et al., 2013). In the context of agriculture, this type of technique has been used in research such as those of Robert et al. (2017), Humbert et al. (2019), Gutiérrez García et al. (2020), Mucherumuna et al. (2021). In this study, the FactoMineR package of the software R (version 3.0.1) was used to obtain the results (R Development Core Team, 2013).

3. Results and discussion

3.1. Descriptive statistics

The demographic information enables us to assess the influence of the population in terms of social and economic aspects, its size, the way in which resources are distributed and their various uses. It also enables identifying limitations and relevant characteristics. The description of the variables used in this study is presented in Table 2. Description of the results of the 200 surveys indicate that 72% (n = 144) of the households are headed by men. Even though this reflects greater participation, and indicates a smaller contribution of the role of women in the agricultural population, it does not mean that the female population does not influence the decisions on the adoption of agricultural practices, given that, on the contrary, they represent 28% (n = 54) of the surveyed households. This suggests that even though there is a strong male tradition in agricultural activities, women are increasingly engaged in this economic activity. This undoubtedly implies that additional efforts must be made so that these activities are carried out under conditions of equality (Baylina and Rodó 2020, Gobernación de Sucre, 2020b). According to Tanumihardjo et al., (2020), education and the reduction of discrimination are key factors for supporting gender equality. Notwithstanding the participation of women in agricultural research projects, participative experiments and field trips, they are limited by other responsibilities, primarily related to the home (Pattnaik and Lahiri-Dutt, 2020), which implies that they are often considered passive actors in rural dynamics (Baylina and Rodó-Zárate, 2020; Tanumihardjo et al., 2020). Agricultural work is widely considered a male activity, whereas household chores are the responsibility of women (García-Reyes and Wiig, 2020). However, this study displays a positive influence in terms of the participation of women in decision-making processes, contribution and social empowerment.

On the other hand, the household statistics indicate that slightly less than half (40.5%) of the surveyed households have less than 6 years of formal education, which suggests that many of the heads of household have low educational levels, and it could consequently be assumed that they have limited knowledge of agricultural practices. These results are consistent with those of the national agricultural survey results (DANE, 2016), which states that 44.5% of small farmers in the department of Sucre do not have more than basic primary education. This explains the low level of education in the explored areas. A low level of education is normally associated with risk factors, as farmers fear knowing new work alternatives due to their limited capacity (Handavu et al., 2019). Different studies indicate that the level of knowledge is a key aspect for the adoption of practices that involve a high level of innovation for the implementation of sustainable practices (Kassie et al., 2013, Handavu et al., 2019;). In this regard, Gutiérrez et al. (2020) point out that deficient knowledge is an aspect that limits crop capacity and is therefore a factor that affects soil degradation.

According to the descriptive analysis, most survey participants agree that family labor is the most important factor (Table 2). Santacoloma (2015) says that a determining factor for the prosperity and permanence of production systems over time is the permanent availability of labor, especially family labor. For Jara-Rojas et al. (2012) a high number of family members represents a larger workforce, therefore, the probability of applying a set of practices at the farm level is increased. In this regard Berry (2018), holds that small-scale family agriculture uses more labor and has greater capacity to create jobs than other sources of work. In general, the number of family members is found to vary between 1 and 8. It is believed that the size of the family in many cases is considered a burden when it comes to fundamental needs (Handavu et al., 2019).

Regarding the property ownership regime reported by the small farmers, 35.5% of the properties were acquired through purchase. This form of acquisition is related to better economic income (Table 2). It is believed that farmers with better economic conditions are more likely to apply new agricultural practices on their farms (Foguesatto et al., 2020). Therefore, having your own home could be a determining factor that indicates greater freedom to carry out new forms of work on the property. On the other hand, 12% of survey participants indicated that they had obtained the property by means of a land restitution process. Esta condición se relaciona con bajos niveles de ingresos y escasa participación en farmer cooperative (Table 2). According to Guarín and Amaya (2018), the rural areas of these municipalities were strongly affected by violence and displacement of the inhabitants. When the small farmers are forcibly displaced, they face the challenge of planting in small plots or in lands of low productivity (Vallejo Cabrera et al., 2020)

3.2. Multivariate analysis results

The multiple correspondence analysis was run using only qualitative aspects. The first two factors of the MCA explain as a whole less than 30% of total variability, and do not display a significant

Table 2
Description of categorical variables and numerical.

Variable	Codification	Description	Category	Corozal	Majagual	Morroa	San Marcos	San Onofre
Gender (%)	G_1	Gender of household head	Male	72	62	75	70	80
	G_2		Female	28	38	25	30	20
Educational level (%)	EL_1	Farmers education level	Grade school	13	43	48	40	50
	EL_2		High school	30	40	13	30	18
	EL_3		University	30	10	18	20	5
	EL_4		None	28	18	23	10	28
Marital status (%)	MS_1	Marital status of household head	Single	13	23	13	18	20
	MS_2		Living together	45	55	50	60	45
	MS_3		Married	43	23	38	23	35
Family members	FM	Number of members in the household	Average	2.7	2.82	2.62	3.1	3.27
			St. Dev.	1.81	1.50	1.56	1.89	1.76
Days of work on property	DWP	Days of work on property of household head	Average	6.12	6.5	6.22	5.87	5.97
			St. Dev.	1.34	1.06	1.38	2.06	0.86
Days of work off property	DWOP	Days of work off property of household head	Average	1.9	0.5	0.575	1.1	1.025
			St. Dev.	2.41	1.06	1.41	2.07	0.86
Family labor (%)	FL	Labor availability familiar	availability	60	70	82	60	85
			Otherwise	40	30	12	40	15
Paid day work (%)	PW	Availability to pay for the work on the land	availability	45	7	10	43	15
			Otherwise	55	94	90	57	85
Combined labor (%)	CL	Availability to combine labor on the land	availability	0	0	2	2	0
			Otherwise	100	100	98	98	100
Minga (%)	M	Availability to work in community	availability	2	0	2	0	0
			Otherwise	98	100	98	100	100
Community organization (%)	CO_1	The head of the household belongs to a community organization	Member	10	18	12	3	3
	CO_2		Otherwise	90	82	88	98	98
Farmer cooperative (%)	FC_1	The head of the household belongs to a Farmer cooperative	Member	7	5	25	0	18
	FC_2		Otherwise	93	95	75	100	82
Property ownership (%)	PO_1	Type of Land ownership	Inherited	38	45	8	45	15
	PO_2		Acquired	60	35	23	55	5
	PO_3		Restitution	0	0	58	0	3
	PO_4		Subsidy	3	20	13	0	78
Total hectares	TH	Total size of land's of household head	Average	15.55	8.5	14.37	10.3	7.85
			St. Dev.	20.75	7.75	8.42	8.70	8.69
Productive hectares	PH	Total productive hectares in the farm	Average	9.75	8.6	7.875	9.625	2.4
			St. Dev.	17.21	7.45	4.58	8.39	1.17
System implemented (%)	SI_1	type of system implemented on the land	Agroforestry with native species	3	95	3	0	18
	SI_2		Agroforestry	48	0	13	0	40
	SI_3		Single crop	28	3	28	90	18
	SI_4		Agro-ecological	23	3	58	10	25
Perceived soil quality (%)	PSQ_1	Farmers perception of soil quality status	Color	45	43	28	28	10
	PSQ_2		Texture	28	20	45	55	30
	PSQ_3		Moisture	10	28	20	8	25
	PSQ_4		Structure	18	10	8	10	35
Pruning (%)	P_1	Farmers prune crops	Performs	80	90	73	73	65
	P_2		Otherwise	20	10	28	27	35
Plant health control (%)	PHC_1	Farmers carry out sanitary control on crops	Performs	60	100	65	55	90
	PHC_2		Otherwise	40	0	35	45	10
	WS_1	Farmers save water in the farm	Performs	37	63	90	0	85
Water saving (%)	WS_2		Otherwise	63	37	10	100	15
Water for irrigation (%)	WI_1	Availability of irrigation system on the farm	availability	50	100	50	36	90
	WI_2		Otherwise	50	0	50	64	10
Fertilization (%)	F_1	Farmers carry out fertilization work	Performs	60	100	65	90	32
	F_2		otherwise	40	0	35	10	68
Fertilizations per year (% year)	FPY	Number of fertilizations per year on the farm	Average	0.55	1.12	0.9	1.62	1.85
			St. Dev.	0.84	0.99	0.87	0.66	0.53
Type of fertilizer (%)	TF_1	Fertilization type used by the head of the household	Organic	35	84	35	38	23
	TF_2		Chemical	23	16	30	55	8
	TF_3		Does not apply	42	0	35	8	69
Weed control (%)	WC_1	Form of weed control in crops	Manual	57	15	28	33	40
	WC_2		Chemical	38	65	64	57	32
	WC_3		Mechanical	5	20	8	10	28
Pest and disease control (%)	PDC_1	Form of pest and disease control	Chemical	87	97	70	87	75
	PDC_2		Biological	13	3	30	13	25
Extension service (%)	ES_1	Access to Technical Assistance Service	In contact	5	0	20	0	37
	ES_2		Otherwise	94	100	80	100	63
Monthly income ($ COP)	MI	Monthly household income	Average	1,106,923	621,250	619,750	1,180,000	499,125
			St. Dev.	1,145,506	561,692	369,646	505,457	452,924
Income per harvest ($ COP)	IH	Availability of income per harvest	Average	614,075	254,700	380,000	660,025	769,500
			St. Dev.	1,576,786	192,100	434,062	1,229,581	170,353
Monthly expenses ($ COP)	ME	Monthly household expenditure	Average	732,500	553,125	526,125	937,500	383,500
			St. Dev.	635,544	350,133	275,649	392,681	348,326

Table 2 (*continued*)

Variable	Codification	Description	Category	Corozal	Majagual	Morroa	San Marcos	San Onofre
Agricultural credit (%)	AC_1	The head of the household	Beneficiary	30	37	30	35	32
	AC_2	received agricultural credit	Otherwise	70	63	70	65	68
Perception of harvest income. (%)	PHI_1	Farmers perception over the	Average	10	40	17	40	5
	PHI_2	harvest income	Good	55	35	68	32	90
	PHI_3		Poor	35	25	15	28	5

COP: Colombian Peso $.

fraction of the explanation due to low variability, that is, the first factors is not enough to explain everything that could be say from the data. For this reason, the results of the study are complemented with what is observed through the PCA technique, with the multidimensional analysis of the quantitative variables analyzed.

Despite the above, the MCA technique enables focusing on the relationships between variables, because there are no prior conditions in place such as normality or linearity (Costa et al., 2013), but contributes, compared to other methods, statistical results that can be visually assessed, indicating patterns that are worth mentioning. The MCA shows that the application of agricultural practices by the small farmer households generally depends on different socioeconomic factors. The interrelationship between these qualitative variables is represented by means of groups of factors. If two or more elements are close, it means there is equivalent associativity. The projection of the MCA chart by municipality (Fig. 2) clearly indicates the presence of five well differentiated groups. As displayed in the chart, the first group (A) primarily consists of households who work outside the farm (Table 2). They are economically diverse households, and most of them depend on external income. this is evident in Shayaa Al-Shayaa et al. (2021) because most farmers base their economy on off-farm jobs, probably due to changes in their lifestyles. Their sources of income are greater than those of the other groups. However, 55% earn deficient income from agricultural activities (PHI_3). This is the reason why these households tend to carry out activities off the premises. This is consistent with Jara-Rojas et al. (2012) in the argument that farmers with lower incomes tend to diversify their economy in search of additional resources. The survey participants attribute the decrease in income to the high cost of agricultural supplies. The use of chemical inputs in these households to control weeds (WC_2), pests and diseases (PDC_1), could be causing a reduction in income from harvests, causing many of the families a situation of scarcity. Added to this is the unavailability of extension services (ES_2), little promotion of agricultural credit (AC_2) and low participation in local organizations (CO_2).

A second group (B) is made up of households that perceive average income from harvests (PHI_2). Income from agriculture represents the main source of family income from the sale of the crops (Mutyasira et al., 2018). A characteristic of these households is that they apply innovative systems (SI_1). They stand out for their great affinity for forest services. Handavu et al. (2019) indicates that these resources are fundamental for these communities, since they respond to an alternative that generates additional income. The use of organic compost becomes evident (TF_1). The application of organic fertilizer by these households reduced the probability of using external supplies (mainly herbicides, pesticides, fertilizer). This finding is consistent with the findings of Oyetunde-Usman et al. (2021), who consider that this practice is due to the low cost of adoption and the reduction in use of chemical fertilizers. It was also found that education level was a determining factor in the application of organic fertilizer (Fig. 2). Households with better education often apply better agricultural practices and are more knowledgeable about the benefits of adopting new ways of working the land. Therefore, having basic knowledge is essential for safeguarding the agricultural potential and driving growth in the countryside (Gutiérrez García et al., 2020). This finding is contrary to the findings of Zugravu-Soilita et al. (2021), whose study indicated that a greater education level did not necessarily have an incidence in agricultural production processes.

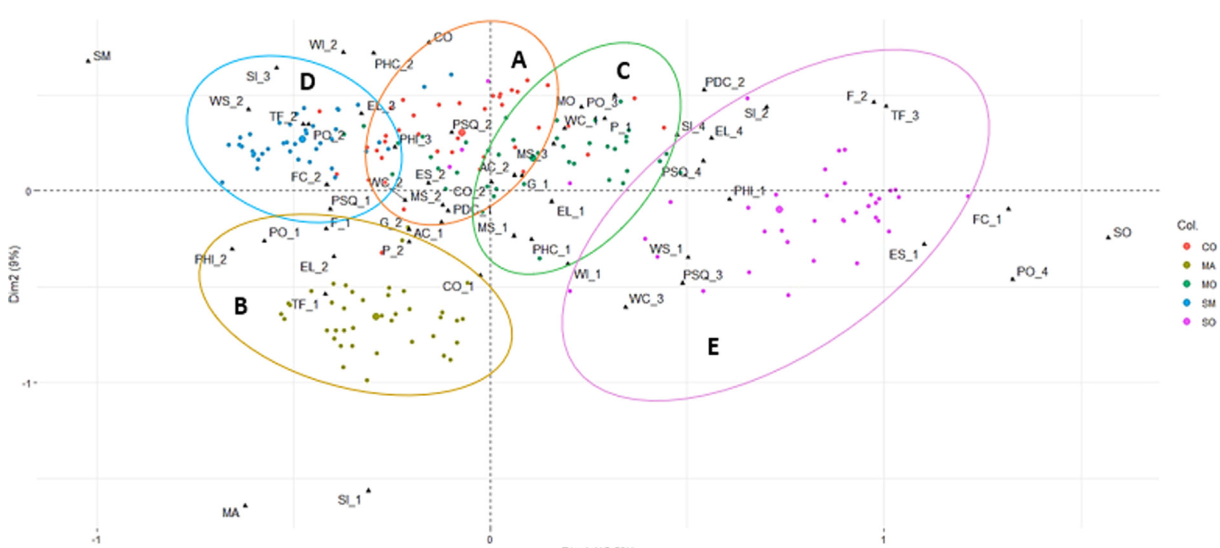

Fig. 2. Interpretation of the conglomerates in the MCA graph by each prioritized municipality: A) Corozal (CO); B) Majagual (MA); C) Morroa (MO); D) San Marcos (SM); E) San Onofre (SO). The conglomerates were defined based on the associations observed between categories.

In the third group (C), associations were found between: pruning (P_1) and weed control (WC_1); pest management (PDC_1) and plant health control (PHC_1). It is highlighted that pruning and weed control are decisive in the cultural approach and pest management and sanitary control, resulting in the reduction of problems in forest plantations and high levels of plant growth (Daniel et al., 2011, Handavu et al., 2019). The small farmers reported that frequent contact with other groups of farmers increases the probability of adopting these practices, probably because there is a wide variety of self-help groups that motivate and train them in the different services. These groups act as intermediaries between low-income farmers and the extension workers. Even though most of these households have less than six years of formal education, they displayed adequate knowledge on the application of several agricultural practices (P_1-WC_1, PDC_1-PHC_1). This was also found by Oyetunde-Usman et al. (2021) in the adoption of sustainable agricultural practices in Kenya.

The fourth group (D) displayed association between education level (EL_3), the type of system implemented (SI_3) and the type of fertilizer (TF_2) (Fig. 2). According to Mucheru-muna et al. (2021) education is positively correlated with chemical fertilization, as are systems composed of a single crop. A higher level of education indicates greater knowledge about certain practices, in this case, single-use crop management. Although this implies higher income from the harvests, it implies a high cost for the purchase of inputs (TF_2). It was evidenced that a higher education level implies performing work off the property (Tabla 2). Even though this implies higher income, it was found that the participation of some members in non-agricultural activities outside the property involves a risk factor, for example, abandoning the Agricultural Production Unit or implemented other types of practices that could lead to a reduction in crop yields.

A last group (E) represents the households with low education levels. These households apply practices that are not costly to implement. Even though such practices involve having simple knowledge on the application of diverse practices, surprisingly, the results indicate that a high percentage of these households do engage in innovative practices, such as combining agroforestry systems with agroecological systems. These households adopt sustainable management practices such as saving water as an important option for crop irrigation; they normally do not use chemical fertilizers and perform mechanical weed control (Fig. 2). These practices are strongly related to contact with extension workers and joint work with community organizations (farmer organizations) (Fig. 2). This suggests that the farmers understand the importance of incorporating innovative practices and of sharing experiences with extension workers and other farmers (Abera et al., 2020).

3.2.1. Social organization and agricultural technical assistance

The MCA by level of cooperative membership (Fig. 3) suggests that the households that apply the best agricultural practices and those who have access to other services are also influenced by other factors including belonging to farmer groups (FC_1) and contact with extension workers (ES_1). It is evident that access to the extension services determines a substantial improvement in the ongoing implementation of several practices at the farm level (Oyetunde-Usman et al., 2021). In this study, 32.8 % of the agricultural households had access to this service. It should be noted that in these households access to extension services is not fully guaranteed, which represents a threat for the adoption of good agricultural practices and the adequate use of new technologies. As reported by Anang and Asante, (2020), the use of these services is determined by a set of interrelated elements. Our study does not indicate such relationships with the various aspects included, such as perception of income, the adoption of sustainable agricultural practices, agricultural credit and the use of equipment for agricultural chores (Fig. 3). However, the latter aspect is not strongly related to agricultural credit (Fig. 4). This aspect is considered a key determining factor for mechanization at the farm level, because many farmers need to have enough income to contract machinery to prepare the soil for planting (Anang and Asante, 2020).

3.2.2. Agricultural credit

Access to credit in these households is mainly influenced by socioeconomic factors related to the farmer's acquisition of agricultural supplies, agricultural improvements, livestock and

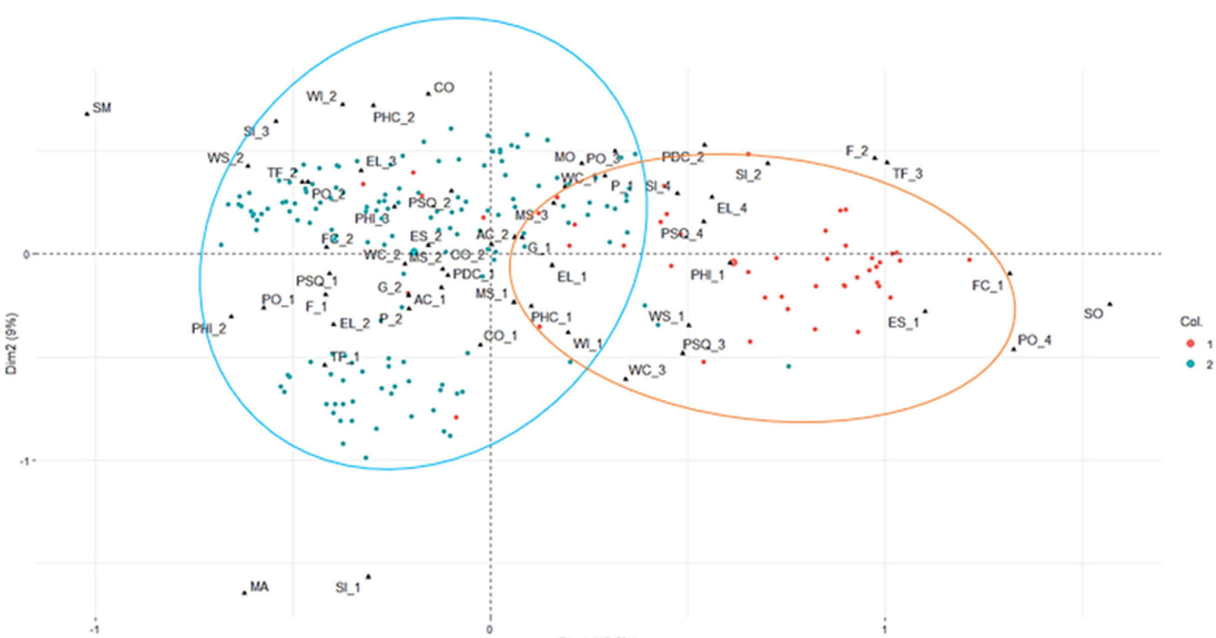

Fig. 3. Multiple correspondence analysis (MCA) graph of the distribution of plain 1–2 for cooperative membership (OPC): Member (1) or otherwise (2). The conglomerates were defined based on graphic visualization and the degree of association found.

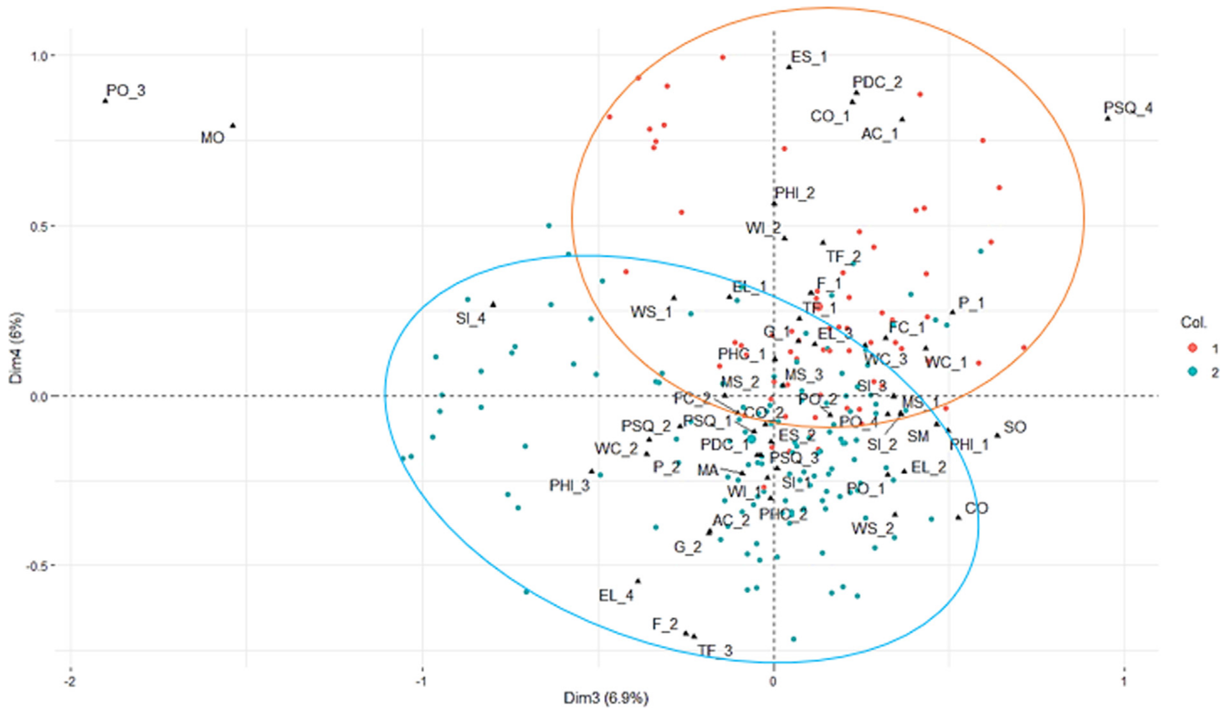

Fig. 4. MCA Plain 3–4 for agricultural credit (GAC): Beneficiary (1) or otherwise (2). The conglomerates were defined based on graphic visualization and the degree of association found.

machinery purchases. The financial institutions rarely grant credit to small farmers in these areas, partly because of their low credit capacity and the risk posed by the unpredictable weather. These situations limit the possibility of increasing their income by forcing them to plant small areas, and in the worst case scenario to abandon or sell their property, thereby increasing their risk and vulnerability (Anang and Asante, 2020). Due to the risks involved in agriculture at present, during the interviews the farmers indicated that they were reluctant to take on formal loans because they fear they might not be able to repay them and default. Others say they have not applied for credit because they do not know how to fill out the documentation, because they have received no offers or because they do not have a credit record.

3.2.3. Fertilization

Application of fertilizer by the small farmers was determined by their income level and access to agricultural credit. Overall, 69.5% of survey participants say they apply fertilizer at their properties. Most acknowledge that this practice is necessary because it increases the capacity of the soil and provides a stable supply of nutrients. The survey participants say they assign greater priority to organic fertilization. The farmers agree that organic fertilizer (manure) considerably improves the physical characteristics of the soil (PSQ). The results displayed in Fig. 5 indicate a close relationship between the use of organic fertilizer (TF_1), income level (MI) and agricultural credit (AC_1). That is, those households that earn higher income generally apply this practice, which is strongly related to the use of green fertilizers and the application of innovative systems (SI_1). The farmers displayed good affinity with this type of system for regulating soil erosion, controlling the loss of biodiversity, increasing productivity, greater diversity and more balanced crop cycles. The results of Fig. 5 also display a connection between the use of chemical fertilizers (TF_2) and education level (E). Paradoxically, the households with higher education use chemical fertilizers more frequently, perhaps encouraged to use modern supplies to increase productivity, an aspect that is consistent with the findings of Mucheru-muna et al. (2021) in the county of Embu, Kenya, which found that a large percentage of small farmers, especially those with high levels of knowledge, used inorganic fertilizers more intensely and adequately. According to Abera et al. (2020), farmers with a higher education level tend to select inorganic fertilizers rather than other methods in order to increase the crop's success. This practice requires having an adequate understanding of how to use and apply the inorganic fertilizers in order to avoid negative consequences if the established pattern is not adequately followed (Oyetunde-Usman et al., 2021). The results also indicate that the use of chemical fertilizers was motivated by the practice of single crops (Fig. 6), because when only one or two types of plant are planted, they require ever greater amounts of chemical fertilizers.

3.2.4. Agricultural systems

The agricultural practices are directly associated with the type of system implemented. The MCA displays a close relationship between agroforestry systems with native species (SI_1), pruning (P_1) and pest and disease management practices (PDC_2) (Fig. 6). The farmers say that pruning helps ensure that pests associated with the crop do not spread to other areas. According to Gutiérrez et al. (2020) pruning in this type of system improves air circulation and prevents the entry of new pathogens. A relationship is also found between single crop planting (SI_3) and chemical fertilizers (TF_2), mainly because it demands high use of chemical fertilizers and pesticides to maintain high crop yields. This aspect coincides with that reported by Jagoret et al. (2018) who indicates in their study that the sowing of a single crop with important genetic modifications requires greater amounts of chemical fertilizers to increase productivity. Association is also displayed between agroecological systems (SI_4) and organic fertilization (TF_1) (Fig. 6). The farmers indicated that these systems require

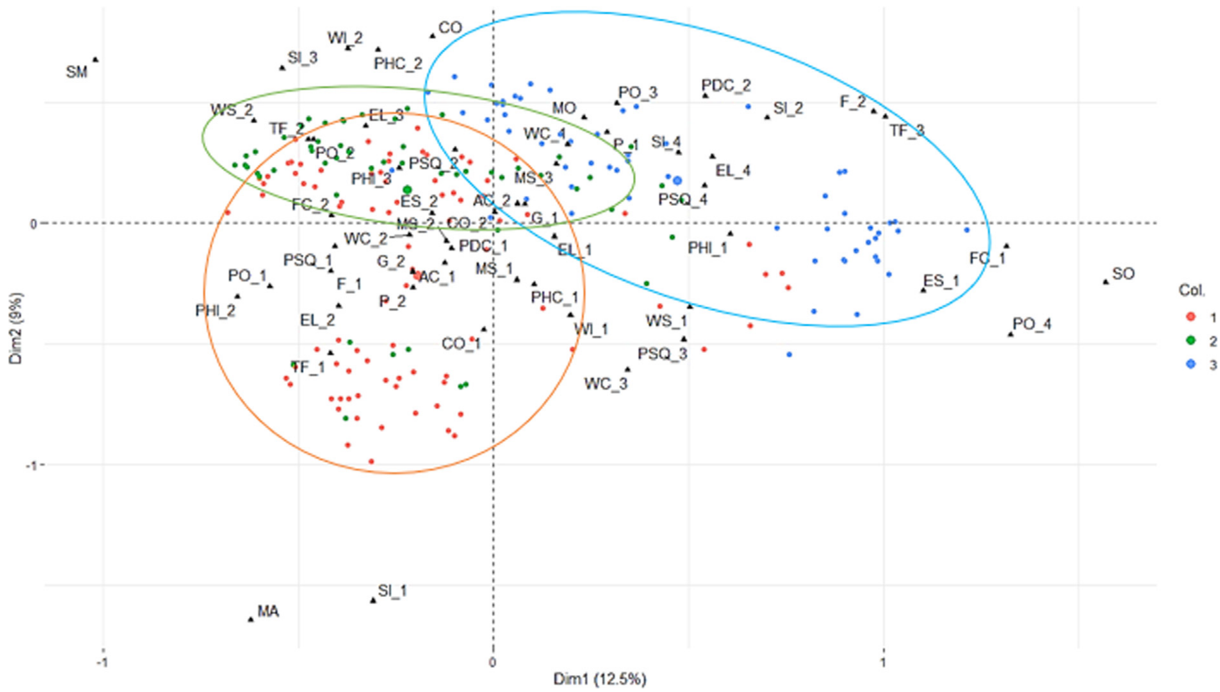

Fig. 5. Multiple correspondence analysis (MCA) graph of the distribution of plain 1–2 by type of fertilizer: organic (TF_1); chemical (TF_2) does not apply (TF_3). The three conglomerates indicate relationships of equivalent association between TP and the farmer's socioeconomic determinants.

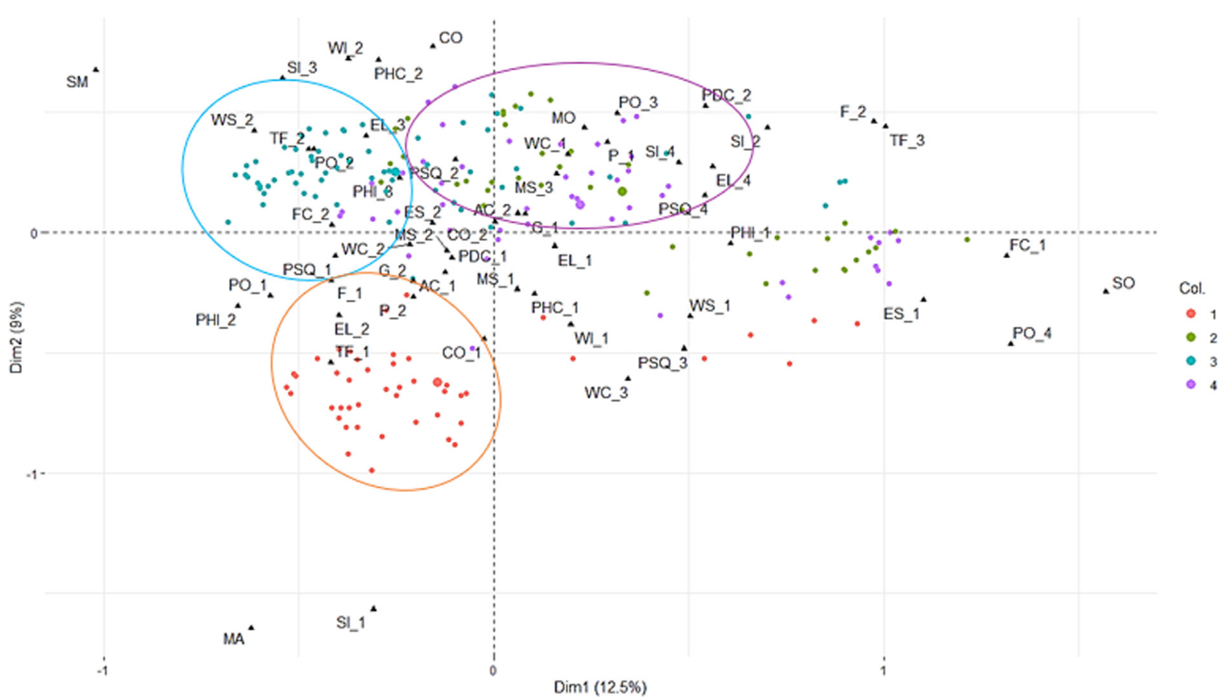

Fig. 6. Interpretation of the conglomerates in the MCA graph by type of system implemented and the different associations: agroforestry with native species (SI_1); agroforestry (SI_2); single crop (SI_3); agroecological (SI_4). The conglomerates were defined based on graphic visualization.

low levels of fertilizers, and most do not use fertilizers because they feel that the system itself is capable of generating it.

3.3. Principal components

Principal component analysis is useful for providing a summary view of a sample (Louati et al., 2019). In order to assess the interdependency between the variables, the relationships between the averages and values of the different quantitative parameters were studied, considering as supplementary variables the qualitative parameters measured. The first 4 axes of the plain indicate 53.26% of total variability. The first 2 axes of the PCA were selected for representation. The first axis accounted for 17.62% of total variability. High dispersion was found between the components days of work off property (DWOP), monthly income (MI) and paid day work (PW). The supplementary categories were analyzed to see

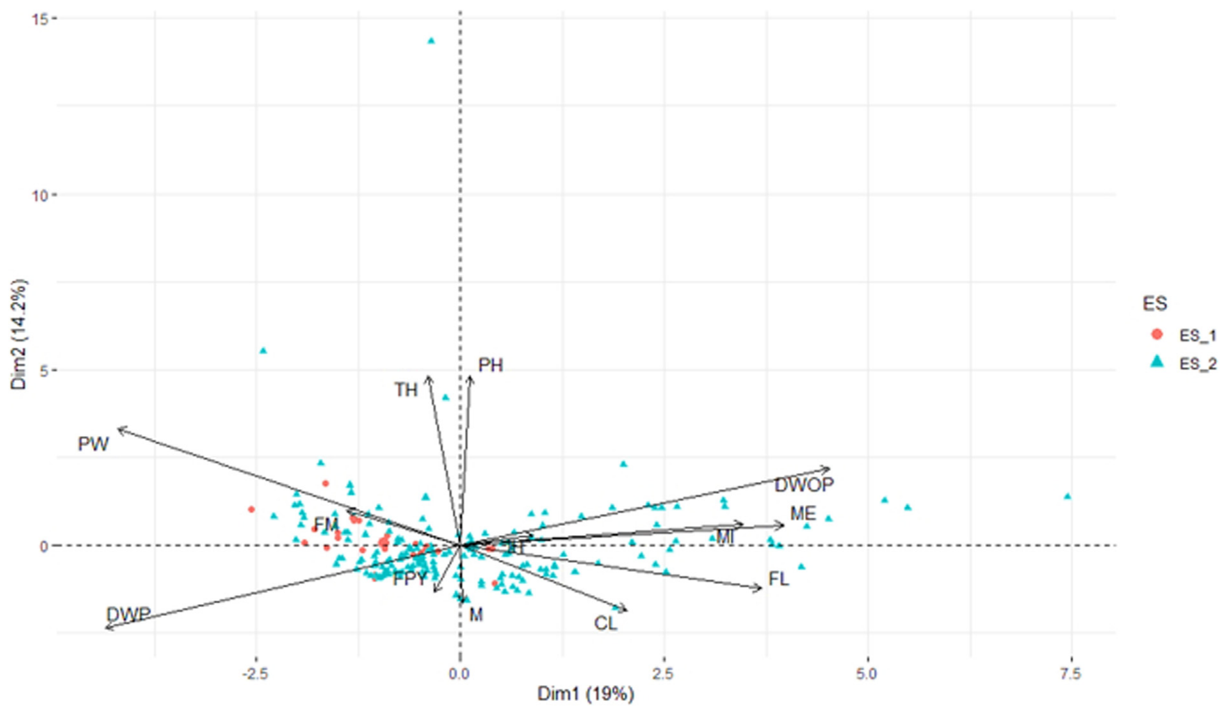

Fig. 7. PCA projection chart of factors 1–2 to assess the components of the different links of agricultural practices and extension service. Days of work on property (DWP); days work off property (DWOP); family labor (FL), paid day work (PW), income per harvest (IH), total hectares (TH); productive hectares (PH).

the relationship with the categorical variables (qualitative) agricultural credit and technical assistance. These variables displayed association with the measured variables in each socioeconomic link. The Biplot in Fig. 3 shows two clearly-defined groups: households in contact with extension workers (22.5%) and those who have not received agricultural technical assistance (87.5%) at their properties. In the opposite direction of the vectors a group is observed that is characterized mainly for performing agricultural and non-agricultural activities outside the property, which include working at neighboring farms (Fig. 7). They earn regular income, although the sources of income are varied. They tend to engage in non-agricultural activities due to seasonality, shifting agricultural labor (Fig. 7), and taking on economic risks associated with higher indebtedness. The second axis absorbs 14.44% of total variability. It seems to be related to the components number of productive hectares and days of work on the property (Fig. 7).

The livelihoods of these households largely depend on agricultural activities, which account for up to 62% of total family income (Tabla 2). Small producers in the department of Sucre depend mainly on a combined alternative of self-consumption and sales in market places 22.5% and 52.5% respectively (Gobernación de Sucre, 2020). Other destinations in smaller percentages are collection centers, transformation, intermediaries, sales to stores, stores and sales to neighbors. Due to their management capabilities, these households mainly have small agricultural areas for annual and short-cycle crops. They acknowledge the importance of incorporating innovative agricultural techniques on the property, along with high-value agricultural practices.

4. Conclusion

The principal socioeconomic factors, education level, income from agriculture, access to credit and level of cooperative membership play a determinant role in the adoption of sustainable practices, the acquisition of machinery and supplies for agricultural work. Extension services were also determining factors for the use of fertilizers in improving processes at the farm level. The findings demonstrate the need to critically identify the socioeconomic factors of the small farmer households, their relationships, challenges and dilemmas. The information obtained from the small farmer households indicates that it is relevant to incorporate processes that enable assessing simultaneously a variety of indicators in order to identify the best agricultural practices in the different production systems. The decision-making process can vary significantly, and the results may be specific for determined groups of people, places and situations.

The associations found in the demographic variables studied are important for science because in the literature information is fragmented, studies are scarce and they focus on qualitative descriptions; Therefore, it is recommended to carry out more studies using quantitative models to analyze the socioeconomic determinants that influence the application of agricultural practices. Understanding the variables studied is essential for the formulation and implementation of intervention strategies aimed at improving the quality of life of these communities, as well as preserving and managing human, social, agricultural and financial capital.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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