Scientific Paper

Agro-productive characterization of farms in the Mayabeque province, Cuba

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Abstract

Objective: To characterize the agro-productive situation of farms in the Mayabeque province, Cuba.

Materials and Methods: The research was carried out in the Mayabeque province. It covered 57 farms in the San José de las Lajas, Güines, Nueva Paz, Madruga, Batabanó and Jaruco municipalities. The participatory action research methodology (PAR) was applied. Semi-structured interviews were used for data collection and analysis of relative frequency distribution for the studied variables was applied.

Results: Thirty-six cultivated agricultural species were identified. Of these, 27 are in high demand in markets or for animal feeding. With regards to training in the use of biofertilizers, 56 % of the farmers have participated in some type of training; while 47 % have not received training. There was a significant preference for the use of organic fertilizers (83,6 %) and mineral fertilizers (81,8 %). Most farmers (85 %) use irrigation systems compared with those practicing rainfed agriculture (15 %). The main identified challenges include pests and diseases, lack of herbicides, shortage of chemical fertilizers and organic fertilizers, soil fertility, labor, and lack of incentives for production and marketing.

Conclusions: The research highlights the need for innovation and training in sustainable agricultural practices, which was evidenced by the lack of knowledge in the use of green manures, organic fertilizers and biofertilizers. This finding shows the importance of strengthening education and adopting technologies that promote the efficient use of natural resources and environmental sustainability.

Keywords: organic fertilizers, alternative agriculture, training

Introduction

In recent years, the process of agricultural expansion has generated the need to create mechanisms to promote technological advances in the farming sector. Encouraging and supporting farmers means betting on sustainable development of the rural environment in its economic, social and environmental aspects. The environment for its promotion and development requires the common good, technology and user communities (Alfonso-Mesa and Socorro-Martínez, 2020).

For years, the Cuban agricultural sector has remained under the shadow of conventional production systems, simplified and dependent on external inputs. These systems are characterized by monoculture, soil degradation, loss of biodiversity and the appearance of massive pest outbreaks. Therefore, it is necessary to create productive systems that drive transformations, where correct decisions are made in production processes to provide answers to complex situations (Casimiro-Rodríguez and Casimiro-González, 2018).

Cuban agricultural production, today more than ever, needs to increase yields and raise the nutritional content of crops, mainly with domestic inputs, which contribute to the reduction of imported agrochemicals. Therefore, since the 1990s, intensive research has been conducted in the search for bioproducts from natural raw materials, which has led to the current existence of approximately 21 products classified as biofertilizers and biostimulants (Núñez-Vázquez *et al*., 2021; Yanes-Peón *et al*., 2022).

Several authors recognize the value of the use of bioproducts and the close relationship between the hard work of innovation through scientific and research knowledge and social development. Some experts promote the use of bioproducts to contribute to food and crop production in all seasons (Castro-Morales, 2021; González, 2022). It is known that the application of different bioproducts represents a vital element for the sustainability of agricultural systems and, in turn, is a means to reduce external inputs and increase the quality of productions (Bécquer-Granados *et al*., 2019).

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However, the lack of policies and distribution of bioproducts and programs for knowledge management, aimed at decision-makers and extensionists, has caused farmers and decision-makers to be discouraged from using these inputs, which are the result of the application of science and innovation in the Cuban countryside (Ortiz-Pérez *et al*., 2020).

There is a need to train farmers based on the results of scientific research, which represents an important resource, considering that agro-productive systems are exposed to changes in terms of their main productions (Tapia-Hermida *et al*., 2018).

Innovation is a factor of change in all sectors of the economy, society and daily life (Hernández-Hernández, 2019). It is currently recognized as a strategic priority of great importance to face the challenges of agriculture. It is considered necessary because of its contribution to lower costs, increased productivity, the possibility of substituting imports and raising export capacity.

For such reasons, these bioproducts have been combined and adopted as part of agricultural production technologies in peasant farms to increase yields of different crops. It is suggested that the generation and adoption of new technologies should be carried out in parallel with the farmer, taking into consideration his/her own idiosyncrasy, culture, interests and the agroecological and economic conditions under which he/she develops (Sánchez-Toledano *et al*., 2013).

Based on the above, at the international level, the characterization of farms and agricultural systems is used for the generation and adoption of technological alternatives and good sustainable and resilient agrifood practices. In this field, adequate knowledge of the circumstances of the rural producer is the basis of any research and transfer process, and the generated technology should be developed according to these circumstances, limitations and possibilities (García-Pinzón *et al*., 2021).

The objective of this research was to characterize the agro-productive situation of farms located in the Mayabeque province, Cuba.

Materials and Methods

Location. The research was carried out in the Mayabeque province. The selected 57 farms are located in the San José de las Lajas, Güines, Nueva Paz, Madruga, Batabanó and Jaruco municipalities.

Collection of information. The work methodology used was participatory action-research (PAR), developed by Sablón *et al*. (2011). For information gathering, semi-structured interviews were conducted with farmers (table 1) containing suggested variables (Marzin *et al*., 2014).

A general diagnosis of the farms was made based on the current situation, which included their general conditions, degree of knowledge and use of biofertilizers and other local sources of nutrients, among other aspects. It also included the criteria that farmers have on soil fertility management and the limiting factors that affect food production in the farms.

Based on the obtained information, the weaknesses, threats, strengths and opportunities shown by the farmers in the farms were established in order to carry out the proposed innovation studies. A SWOT matrix was used for this purpose.

Data analysis. The statistical method used to process the results was the relative frequency distribution analysis for each variable reported in the initial surveys. The information was analyzed with the STATGRAPHICS® Centurion XVI program.

Results and Discussion

Figure 1 represents the distribution of the farms under study according to their total area. It shows a significant diversity in the size of the farms. It is observed that 38,0 % of the farms are in the range of 0,01 to 9,5 ha, suggesting concentration of small plots. Of the farms, 29 % are located between 9,5 and 19,0 ha. Likewise, 16,0 % range from 19,0 to 28,5 ha. Finally, 13,0 % of the farms exceed 28,5 ha, indicating the existence of large farms. Of the interviewed farmers, 40 % did not provide information on the size of their farms.

This variability in farm size is mainly attributed to the limits established by the Cuban Ministry of Agriculture (MINAG) in Decree Laws 259 and 300, which regulate the granting of idle land in usufruct. These regulations have influenced the distribution of farms, which favors the existence of different sizes of properties in the Mayabeque province.

The linkage of farms to agricultural entities is shown in figure 2. All diagnosed farms belong to the non-state sector, where Credit and Service Cooperatives (CCS, for its initials in Spanish) occupy 93 %; while Agricultural Production Cooperatives (CPA, for its initials in Spanish) only occupy 4 %. The Basic Units of Cooperative Production (UBPC, for its initials in Spanish) represent the lowest percentage of linkage to the different forms of production, with 3 %.

Table 1. Suggested variables in the semi-structured interview with farmers in their farms.

Farm information	Established crops	Indicators for plant nutrition management	Limiting factors of production, according to farmer's criterion
Identification of the farm	Grains	Type, frequency and quantity of applied chemical fertilizers	Soil fertility, Soil type, stoniness, quality seeds Agricultural or draught machinery Irrigation Pests and diseases Weed infestation Shortage of herbicides and pesticides Shortage of fertilizers and manures Incentives for producing/ commercializing Utilized labor
Productive entity or dependency to which it belongs	Roots and tubers	Types, frequency and quantities of applied organic fertilizers Production of organic fertilizers	
Farm size	Vegetables	Types, frequency and quantities of biofertilizers and biostimulants used	
Soil type	Fruits	Types, frequency and quantities of green manures used Production of their seeds	
Irrigation type and energy source	Other crops	Use of analysis of soils and water for irrigation	

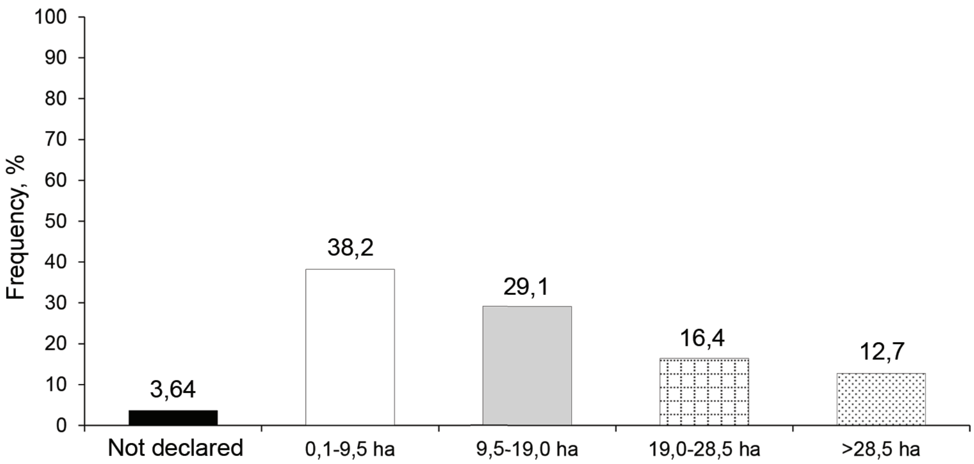


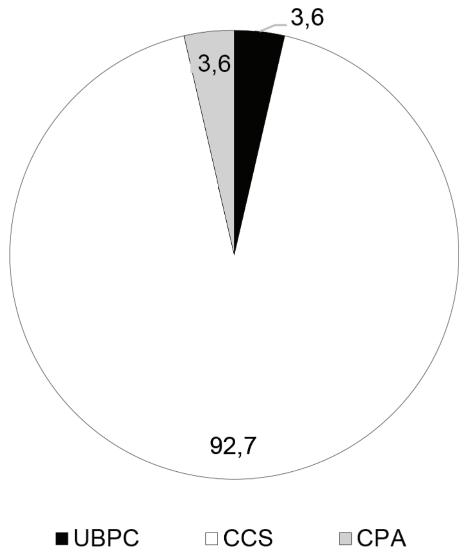
Figure 1. Distribution of the studied farms according to their total area.

According to data published by the National Office of Statistics and Information, land holders by legal entities in 2017 in Mayabeque province were broken down into 61 UBPCs, representing 31,9 % of the total number of legal entities in the non-state sector; 38,0 CPAs, representing 19,9 % and 92 CCSs constituting 48,2 % (ONEI, 2022).

Diversity of crop species cultivated in the farms. A total of 36 agricultural species were found to be managed by farmers in their farms (table 2). Of these, 27 represent crops of agricultural importance, with ample demand in the markets or for animal feeding.

Grains were the species most frequently managed by farmers, specifically *Phaseolus vulgaris* L., which occupies 87,5 % of the total, followed by *Zea mays* L. with 65,0 % of occurrence and *Manihot esculenta* Crantz with 57,5 %. *P. vulgaris* is closely linked to the diet of Cubans, together with *Oriza sativa* L. and roots and tubers in general. Many of the farms with *P. vulgaris* received the technological package assigned by the Ministry of Agriculture until 2019, as they were enhanced areas for the production of the crop (Rivera, 2018), so farmers had a little more inputs that, although insufficient, obtained high and constant yields.

Of all the farms, 57,5 % are dedicated to the cultivation of various types of roots and tubers, with *M. esculenta* being the most common, followed by *Musa* sp. and *Ipomoea batatas* (L.) Lam. As for vegetables, 42,5 % of the farms grow *Solanum lycopersicum* L. and 35,0 % *Allium sativum* L. A smaller percentage of farms are dedicated to other vegetables, which is mainly due to the attention



CCS: Credit and Service Cooperatives; CPA: Agricultural Production Cooperatives and UBPC: Basic Units of Cooperative Production.

Figure 2. Entities of the National Association of Small Farmers where farms are located.

Table 2. Percentage of the farms dedicated to the cultivation of different plant species.

Grains		Roots and tubers	
Name	%	Name	%
P. vulgaris	87,5	*M. esculenta*	57,5
Z. mayz	65,0	*Musa* sp.	40,0
O. sativa	12,5	*I. batatas*	35,0
Cicer arietimun L.	7,5	*Colocasia esculenta* (L.) Schott	17,5
Glicyne max (L.) Merr.	5,0	*Solanum tuberosum* L.	10,0
Sorghum bicolor (L.) Moench	2,5	*Dioscorea alata* L.	2,5
Vegetables		Fruits	
S. lycopersicum	42,5	*M. indica*	22,5
A. sativum	35,0	*Carica papaya* L.	15,0
Capsicum annuum L.	17,5	*Persea americana* Mill	12,5
Brassica oleracea L.	17,5	*Citrus* spp.	12,5
Allium cepa L.	17,5	*Psidium guajava* L.	12,5
Cucurbita moschata Duchesne	15,0	*Pouteria sapota* (Jacq.) H.E. Moore & Stearn	7,5
Cucumis sativus L.	7,5	*Coffea canephora* Pierre ex A. Froehner	2,5
Vigna unguiculata (L.)	7,5	*Chrysophyllum oliviforme* L.	2,5
Lactuca sativa L.	5,0	*Prunus avium* (L.) L.	2,5
Others			
Canavalia ensiformis (L.) DC.	17,5	*Sesamum indicum* L.	2,5
Arachis hypogaea L.	5,0	*Aloe vera* L.	2,5
Cajanus cajan (L.) Millsp.	2,5	Flowers (several species)	2,5

required by these crops, which are not supported by any government program, despite their high market price. Also, 22,0 % specializes in the cultivation of fruit trees, such as *Manguifera indica* L. (mango). They are mainly small farms with less extension, since it is practical for the farmers as a way of personal income and for commercialization.

Currently, the planting of green manures is promoted as an alternative to improve soil fertility, in addition to contributing to the supply and recycling of nutrients, maintaining soil moisture and controlling the appearance of weeds. This practice needs to be valued even more by farmers, since only 20,0 % of the farms implement it with *C. ensiformis* and *C. cajan*.

Other characteristics and agricultural practices in the farms

Soil chemical analysis. Soil analyses show the richness in nutrients that a soil can have for plants and allow, in turn, to make the required estimates to have a program of fertilization or organic fertilizer, depending on the needs of the crops. Their use is not very common among farmers in their farms.

The results of the survey (figure 3) indicated that only 19 % of farmers use it; while 81 % do not.

The farmers reported that the agricultural entities show marked insufficiency to offer this service, which constitutes a difficulty and, at the same time, a limitation to efficiently manage soil fertility in the farms. Cuban agriculture must necessarily increase the use of soil analysis in order to protect the most important resource that constitutes the basis for agricultural and forestry exploitation (Paíz-Gutiérrez, 2019).

Use of green manures. Green manures are an agronomic practice, which consists of incorporating a non-decomposed plant mass of plants cultivated in order to improve the nutrient availability and soil properties. Another advantage of green manures is that they promote soil biology, both natural and that of microorganism species, introduced through biofertilization (Videaux-Díaz *et al*., 2021).

The diagnosis (figure 3) revealed that this practice, in general, is very little used by farmers (77,0 %); while a minority applies it (23,0 %). In the interviews, the farmers said that the farms enhanced by MINAG with a technological package for planting beans, guarantee the necessary inputs for production and, therefore, do not raise awareness of the need to use this practice as a source of nutrient supply and recycling. Few farmers are engaged in the cultivation of green manure, mainly in seed production.

Most farmers perceive green manures as a practice that consumes resources, mainly fuel and labor, and are not able to value the economic and environmental benefits of this practice.

Use of organic fertilizers. The use of organic fertilizers in general, including worm humus, manure of various origins, compost and sugarcane filter cake, among others, represents a local source of nutrients in farms and, in turn, is an agricultural practice that helps improve soil fertility. According to survey results, this practice is applied by 83,0 % of farmers; while 16,0 % do not use it.

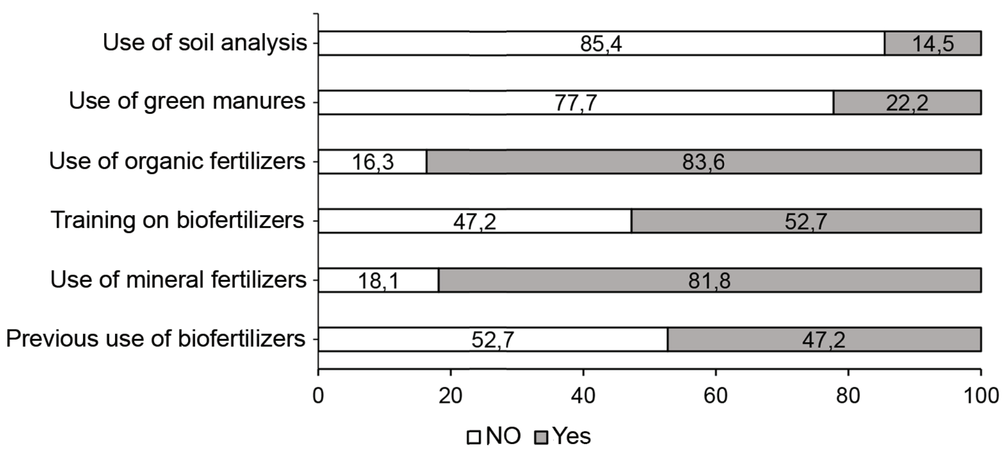


Figure 3. Proportion of farms using or not using various agricultural practices.

To achieve this purpose, in 2001 the emerging national program for organic fertilizers was created, through which actions have been carried out to achieve maximum popularization of the technology and its use in most crops. However, many farmers still do not use them, mainly because of difficulties in transporting manure and other residues to the farms and because producing them in their own farms takes time and material resources.

Training and use of biofertilizers and mineral fertilizers. Regarding the training of farmers on the use and management of biofertilizers, 56,0 % stated that they had received some type of training; while 47,0 % said they had not, and associated the term biofertilizer as a synonym for organic fertilizers, which shows little knowledge on the subject. Only one of the surveyed farmers reported applying *Rhizobium*, since he specializes in planting beans. Most of the farmers do not know how to combine the use of different bioproducts and biofertilizers efficiently and, in many cases, they do not differentiate the range of action and possibilities of each product.

Although the performance of this indicator shows that work has been done in this regard in Cuba, it is necessary to continue with activities related to this topic, due to the increase in the production capacity of this type of bioproducts, since the national biofertilizer program promoted by MINAG intends to generalize the use of different bioproducts of national origin throughout the country in different productive units (MINAGRI, 2020).

It is not just a matter of giving talks on the use of biofertilizers, bioproducts and the management of organic fertilizers in general. Training is a type of non-formal education outside of educational institutions, based on the participants' needs (Martínez-Gómez and Romo-Lozano, 2019). Therefore, when designing policies that encourage the adoption of environmentally friendly behaviors by farmers, psychological and behavioral factors coupled with others should be taken into account (Mishra *et al*., 2018). In addition, farmers who are aware of the consequences of biofertilizer use will be able to make appropriate decisions about their application (Varela-Candamio *et al*., 2018).

In accordance with the training on this subject, 52,7 % of the farms have not used this type of nutritional alternative; while 47,3 % have.

It is essential to accompany the training with the assembly of control fields, where the advantages of the use of biofertilizers and bioproducts compared with traditional production methods are demonstrated. The results regarding the significant effect of the farmers' intention to use biofertilizers show whether the application will be extended. In other words, a person who believes that the use of biofertilizers will have positive consequences will be more likely to use this technology (van den Broek *et al*., 2019 and Wang *et al*., 2020).

Regarding the use of mineral fertilizers, 81,8 % of respondents reported using them or having used them in their farms at some point before 2019. In this regard, as explained above, many farms received the technological package from MINAG for the cultivation of *P. vulgaris*, and that is why farmers were used to receiving various agricultural inputs, including chemical fertilizers, from their entities. This situation changed since 2019, when agrochemicals were no longer delivered to farmers. By July, 2023, only 1 % of the mineral fertilizers needed for agriculture had been delivered (Figueredo-Reinaldo *et al*., 2023), as the price of fertilizers has increased by 300 % on the world market (Alonso-Falcón *et al*., 2023), and the use of national resources or those produced in the farms has been encouraged.

Irrigation, types and source of energy. Another element evaluated in the characterization of the farms was the use of irrigation systems. The highest percentage of farmers (figure 4) have irrigation systems (85,0 %); while a small group uses rainfed agriculture (15,0 %). This indicator is related to the size of the farms and the productions to which they are dedicated.

The type and source of energy for irrigation are shown in figure 4. The highest percentage corresponds to sprinkler or gravity irrigation and electric energy source (27,0 % of each type) and 31,0 % of the farms use diesel as fuel. None of the farms use renewable energy sources for this activity.

Soil types. Figure 5 lists the soil types present in each of the farms, according to the latest version of the Cuban Soil Classification (Hernández-Jiménez *et al*., 2015) and its correspondence with the World Soil Reference Base (IUSS Working Group WRB, 2022). The predominant type is leached Ferralitic Red (eutric nitisols), followed by Brown Sialitic (feozem), Fersialitic (chromic cambisols), and only one of the farms shows Ferralic soil (nitisol). These results are in correspondence with the predominant soil types in the Mayabeque province (Hernández-Jiménez *et al*., 2014).

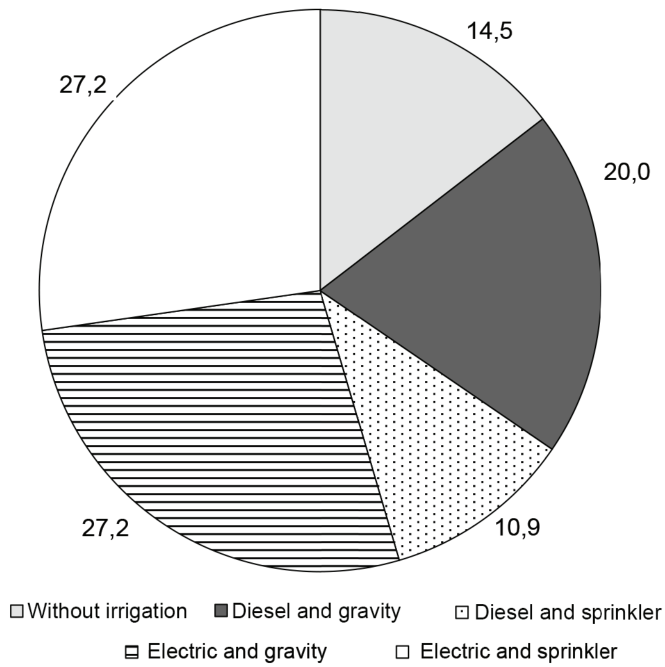


Figure 4. Main irrigation types and sources of energy found in the farms.

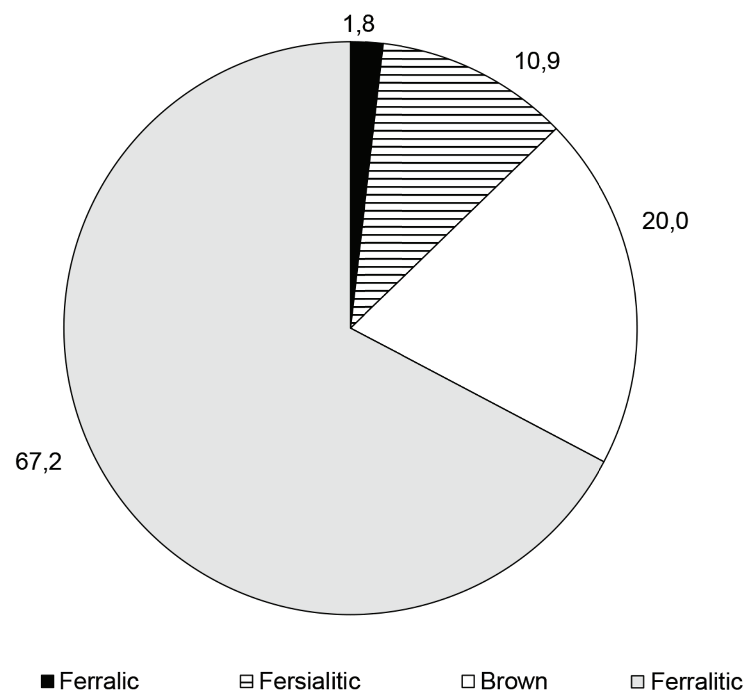


Figure 5. Soil types found on the farms.

It is important to know the type of soil in each farm, as this will determine the crops to be grown, the frequency of tillage to be carried out and the type of management to be implemented, depending on the type of clay and soil texture, among other properties.

Limiting factors. Figure 6 shows the performance of the limiting factors of the farms.

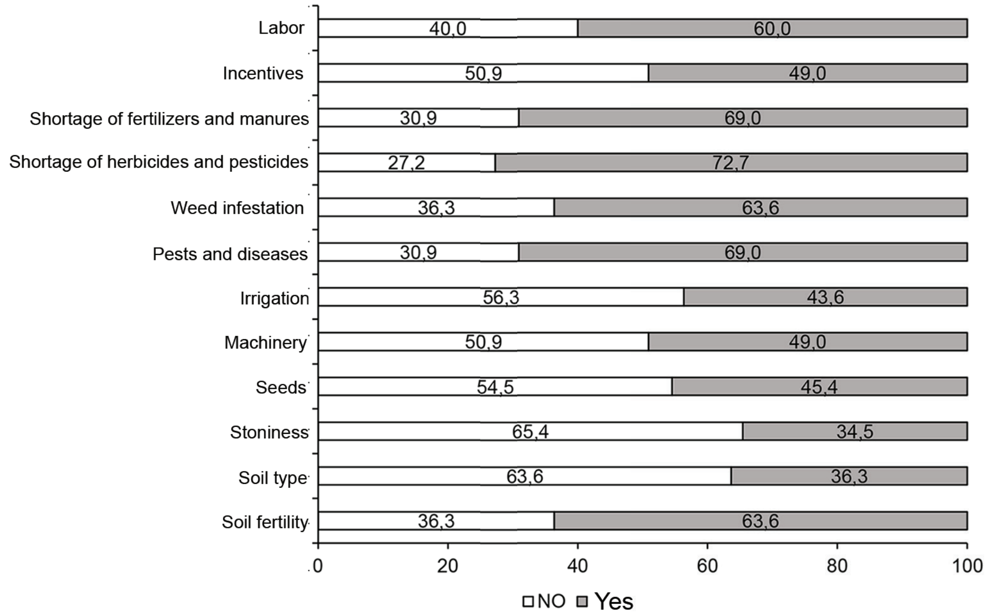


Figure 6. Main limiting factors identified by farmers in the farms.

The most important factors (in more than 50 % of the evaluated farms) were the occurrence of pests and diseases, the lack of herbicides, the scarcity of chemical fertilizers and organic fertilizers, soil fertility; labor, which is becoming scarcer and its price is increasing every day; the scarce incentives to produce and market, given the bureaucratic obstacles that still exist at the local level with respect to the marketing of products; irrigation, because although most farms have irrigation systems, the cost of energy sources (electric or diesel) is very high; the technical condition of agricultural machinery, which in most cases is very old, with high maintenance costs and great difficulty in purchasing spare parts. In addition to the above, there is the availability of quality seeds, since only half of the farmers have the conditions created for the production and conservation of their own seed.

All the evaluated aspects limit the production of most of the respondents. Very few farmers establish actions to mitigate or solve part of these limiting factors. In many cases, due to lack of knowledge of locally sourced products, which can replace high-priced commercial inputs (e.g., natural pesticides), they do not know how to implement the measures for the conservation, improvement and sustainable management of soils and the use of fertilizers, published in the Official Gazette of the Republic of Cuba (MINJUS, 2021). In other cases, there are factors beyond the farmers' control (labor costs, fair markets and prices according to production costs).

SWOT matrix analysis. After processing all the information obtained from the surveys and from the interviews with the farmers, the following weaknesses, threats, strengths and opportunities were identified (table 3).

A comprehensive assessment of the conducted research suggests the need to intensify training and other innovative actions with farmers, so as to promote the integrated use of bioproducts with local sources of nutrients, as well as seed production, the use of green manures, the production and use of organic fertilizers, the application of soil analysis and the maintenance of soil fertility. This will achieve higher efficiency, sustainable yields and economic impact, and will take advantage of the motivations of farmers in terms of acquiring new knowledge and exchanging experiences.

In countries such as Brazil, the need has been established for the creation of public policies that help in the generation of research and training of local leaders, as tools for the promotion and development of agriculture (Azevedo *et al*., 2021). The management of information networks is also handled to enhance the implementation of technologies, practices and knowledge (Ramírez-Gómez and Cuevas Reyes 2023).

Table 3. SWOT matrix of the farms under study.

Weaknesses	*Strengths*
• Soil fertility is worked according to the experience of the person involved in production and for many years there has been no chemical analysis of soil, irrigation water or agricultural production. • Many farmers prefer synthetic chemical products of external origin to producing their own organic and green fertilizers in their farms. For them, producing their own fertilizers is more expensive than buying chemical fertilizers. • Little use of green manures as an alternative for crop nutrition. • Little knowledge of the possibilities of co-management of biofertilizers with other bioproducts.	• Development of agricultural science, technology and innovation in specialized centers in the province. • Most of the farm soils are highly productive, with excellent physical properties. • Gradual increase in the growing need for the use of organic fertilizers. • The majority of farmers are grouped together in the CCS. • Most of the farmers have irrigation systems in their different modalities.
Threats	*Opportunities*
• Difficulties in the acquisition of inputs and bioproducts. • Labor instability. • Price fluctuations and high production costs. • Difficulties in marketing, low sale prices and delay in payments.	• Creation of the agricultural development bank. • Government directives and approval of laws that favor agricultural production with quality and safety. • Some farmers have been allocated inputs to guarantee the production of priority crops. • There are farmers linked to scientific centers and international projects. • There is a close relationship between researchers and specialists from different scientific institutions and farmers. • State indications to increase production capacity and availability of bioproducts.

In the Mayabeque province, several multi-management platforms have been developed, aimed at working with farmers in terms of local development (González-Espinosa *et al.*, 2021), which is necessary to be maintained and strengthened in order to achieve higher independence of farmers, and better and more successful application of agricultural innovation in the territories.

Conclusions

The research showed the need to adopt strategies that focus on agricultural innovation in farms, with emphasis on the alternatives that farmers apply for the integrated management of soil fertility. These strategies include the use of bioproducts of national origin and local sources of nutrients in farms, which contributes to the improvement of soil fertility and the promotion of sustainable agricultural practices.

Based on this diagnosis, training programs can be developed for farmers to facilitate the creation of permanent crop sequence areas and temporary control fields. These spaces will be crucial for the introduction and monitoring of various technologies, as well as for their subsequent evaluation. The implementation of these strategies will not only improve agricultural productivity, but will also contribute to soil conservation and the promotion of sustainable agricultural practices.

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Conflict of interests

The authors declare that they have no conflict of interests among them.

Authors' contributions

- Luis Roberto Fundora-Sánchez. Research design, data collection, processing and interpretation of results, and final writing of the paper.
- Gloria Marta Martín-Alonso. Research design, data collection, processing and interpretation of results, and final writing of the paper.
- Ilén Miranda-Mora. Interpretation of the results and final writing of the document.
- Ramón Antonio Rivera Espinosa. Research design and final writing of the document.
- Yusimy Reyes-Duque. Research design and final writing of the document.

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