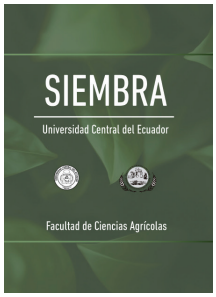
Characterization of Brassica oleraceae L var capitata production systems with emphasis on socioeconomic and phytosanitary aspects in four rural cooperatives in Jinotega, Nicaragua



Caracterización de sistemas productivos Brassica oleraceae L var capitata con énfasis en aspectos socioeconómicos y fitosanitarios en Jinotega, Nicaragua

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Abstract

The objective of this study was to characterize cabbage production systems in four rural cooperatives in Jinotega, with emphasis on socioeconomic, agronomic, and phytosanitary aspects. A prospective, cross-sectional, non-experimental study was carried out, 60 production systems were evaluated, the information obtained proceeding from primary sources (surveys and interviews), the variables were subjected to a descriptive analysis. The age of the producers was in the range of 20 to 80 years, their main economic activity is agriculture, with levels of initial literacy levels, housing conditions are in the range of fair to good, the cultivated area ranges between 0,34 to 5,0 hectares, they have training, the main crop management practices were: weed management, soil preparation, use of traps, monitoring of pests and diseases, use of certified seeds, use of resistant varieties, stubble management and irrigation. The main diseases are: *Rhizoctonia* spp *Xanthomonas* spp, *Alternaria* spp and *Mycosphaerella* spp and insect pests *Plutella xylostella* L, *Brevicoryne* spp and Mites. All controlled through synthetic chemical management.

Keywords: cooperatives, farmers, pests, *Brassica oleraceae L*, management

Resumen

El presente estudio tuvo como objetivo caracterizar sistemas productivos de repollo en cuatro cooperativas rurales en Jinotega, con **énfasis** en aspectos socioeconómicos, agronómicos y fitosanitarios. Se realizó un estudio prospectivo, transversal de tipo no experimental, se evaluaron 60 sistemas de producción, la información obtenida fue de fuentes primarias (encuestas y entrevistas), las variables fueron sometidas a un análisis descriptivo. La edad de los productores estuvo en un rango de 20 a 80 años, su principal actividad económica es la agricultura, con niveles de educación inicial, las condiciones de la vivienda están en el rango de regular a buena, el **área** cultivada oscila entre 0,34 a 5,0 ha, cuentan con capacitación, las principales prácticas de manejo del cultivo fueron: manejo de arvenses, preparación del suelo, uso de trampas, monitoreo de plagas y enfermedades, uso de semillas certificadas, variedades resistentes, manejo de rastrojo y riego. Las principales enfermedades son: *Rhizoctonia* spp,

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Xanthomonas spp, *Alternaria* spp *y Mycosphaerella* spp *y* plagas insectiles *Plutella xylostella L. Brevicoryne* spp y ácaros. Todas controladas mediante el manejo químico sintético.

Palabras clave: cooperativas, agricultores, plagas, *Brassica oleraceae L*, manejo

1. Introduction

Cabbage (*Brassica oleraceae L var capitata*) is a vegetable belonging to the cruciferous family and the Brassica genus, which is distributed throughout the world. In Nicaragua there are areas with climatic conditions suitable for its cultivation with temperatures ranging from 15-28 °C and altitudes of 600 to 1,500 m a.s.l. The main departments where it is grown are: Estelí, Jinotega, Matagalpa, Carazo and Masaya, with Matagalpa and Jinotega having the highest production (Díaz Blandón et al.,1999). The economic importance of the crop is due to its year-round demand, and the generation of employment. The crop is in the hands of small and medium producers with established areas of 0.34 to 3.49 ha under the monoculture or polyculture farming (Díaz Blandón et al.,1999).

This crop is affected by various pests and diseases that reduce yields (Culliney, 2014). These require agronomic and phytosanitary management to keep damage thresholds low and obtain adequate yields. Producers have both experience and knowledge in the agronomic management of the crop, as well as the adaptation of technologies needed to increase production. According to Monzon Ruiz (2016) this type of crop is mainly affected by *Plutella xylostella*, pest, and it is estimated that 20-38 % of production costs are used for pest control (Rao & Lal, 2004).

As per Cauas (2015), characterization is the analysis or description of the most relevant aspects of production systems, where the application of methodological instruments for data collection (survey) is of great importance to analyze variables independently, in order to describe specifically what the researcher wants (Morán Centeno & Jiménez-Martínez, 2023).

The agroindustrial model under the conventional productive approach, due to the serious consequences caused to the environment, has been the object of much criticism in recent years (Sarandón, 2002). This model has caused economic problems for farmers, an increase in the cost of production, as well as social problems such as displacement from rural to urban areas, and migration, among others. However, farmers are looking for productive alternatives to maintain their productive systems economically viable. The objective of this study is to characterize the cabbage production systems in four rural cooperatives in the municipality of Jinotega, with an emphasis on socioeconomic and phytosanitary aspects. It is hoped that this study will serve as a basis for future research topics in the horticultural sector of Nicaragua.

2. Materials and Methods

2.1. Location of the study area and climatic conditions

The department of Jinotega is located in northern Nicaragua (latitude: 85°46'05'', longitude: 13°80'24'') 142 km from the capital Managua, at an altitude of 1,004 m a.s.l.; its surface area is 880.3 km (Nicaraguan Institute of Statistics and Census [INIDE], 2012). The cooperatives under study are located near Lake Apanas, which belongs to the municipality of Jinotega. The department of Jinotega has three well-defined climatic zones. A dry climate zone: characterized by temperatures in the range of 22 to 27 °C, precipitation between 600 and 1,000 mm per year, and average elevations of 630 m a.s.l. An intermediate climate zone: precipitation between 800 and 1,200 mm per year, with temperatures in the range of 21 to 24 °C, and elevations in the order of 900 to 1,600 m a.s.l.. A Humid climate zone: where precipitation is higher than in the intermediate zone, ranging from 800 to 2,000 mm per year; and temperature varies from 19 to 22 °C, with elevations ranging from 900 to 1,600 m a.s.l. (Table 1).

2.2. Methodological design

In the department of Jinotega, approximately 446 vegetable producers are reported (INIDE, 2012). Of this universe, 120 producers are located in the municipality of Jinotega. A sample of 60 cabbage producers was selected, using as fundamental criteria their availability to participate in the study, and that they cultivated cabbage in their production areas. The present study was non-experimental, quantitative, and descriptive, with emphasis on socioeconomic and phytosanitary aspects.

Table 1. Geographical distribution of four rural cabbage-producing cooperatives in the municipality of Jinotega.

Cooperative	Members	Latitude	Longitude	Name	Area (ha)
Tomatoya	30	13°09'08''	86°03'39''	Cooperativa de servicios múltiples Tomatoya/Chagüite Grande	23
Coosprojin	25	13°24'18''	86°02'99''	Cooperativa de productores y servicios múltiples de Jinotega	34
Cosempode	40	13°22'16''	86°04'08''	Cooperativa de servicios múltiples padre Odorico de Andrea	24
Coosan	25	13°11'45''	86°00'42''	Cooperativa San Antonio	27
Total	120				108

The methodology applied was a model for participatory development. The study was divided into four stages, which are described below:

- **First stage**: the selected sample consisted of 60 production systems. Visits were made to the following state institutions: Institute for Agricultural Protection and Health (IPSA), IPSA Jinotega Departmental Delegation, Nicaraguan Institute of Agricultural Technology (INTA), Ministry of Agriculture (MAG), Jinotega City Hall, and the managers of the four rural cabbage producing cooperatives, in order to gather information on the number of producers associated with each cooperative. As well as information on official websites was collected.
- **Second stage**: identification of leading producers of each cooperative to coordinate field visits. The information was collected through the application of surveys in the February to March 2023 period /though the use of multiple methodological tools (surveys, interviews and global positioning device).
- **Third stage**: the purpose of the third stage was to organize the information collected in databases and processed in Microsoft Excel.
- **Fourth stage**: the fourth stage consisted in the socialization of results.

2.3. Methodology of data collection

Cabbage production systems were analyzed considering social, economic, productive and phytosanitary aspects that producers carry out. For this, a survey with semi-structured and open-ended questions was implemented, which allowed the empowerment of the reality of the field (Querol Lipcovich et al., 2014). To estimate the sample size, probability sampling was applied by using the formula (equation [1]) for finite populations (Aguilar-Barojas, 2005), with a confidence level of 95%.

$$n = \frac{N * Z^2 * p * q}{e^2 * (N-1) + Z^2 * p * q} = \frac{120 * 1.96^2 * 0.5 * 0.5}{0.09.^2 * (120-1) + 1.96^2 * 0.5 * 0.5} = 60 \quad [1]$$

Where:

- *n: Sample size*
- *N: Population size*
- *e: Error level*
- *Z: Confidence level*
- *p and q: Probability*

Information of interest was collected and analyzed to relate socioeconomic aspects of the rural cooperatives and the cabbage production system.

2.4. Variables evaluated

The survey was divided into two groups: a) socioeconomic and productive variables: age, sex, occupation, schooling, training, soil preparation, area (ha), housing characteristics b) agronomic and phytosanitary management, type of fertilization, main pests and diseases affected, etc.

2.5. Data analysis

The information generated by the survey was processed with Microsoft Excel using descriptive analysis (frequencies and percentages).

3. Results and Discussion

3.1. Socioeconomic variables

The age range is a very distinctive characteristic of Nicaragua's productive sectors, since it is found within the economically active population (EAP), and being an important resource within the productive processes. This is consistent with Andersen (2007), who reports that Nicaragua is a country that finds itself in an intermediate stage of the demographic transition. Figure 1 shows the age range of cabbage producers, with the largest number between 30 and 60 years of age, and with agriculture being their main economic activity (Figure 2). The educational level is low, with only 58% having completed initial education (primary), 17% having reached secondary education (intermediate), and 20% having completed higher education (university). Technical professional training is low (Figure 3). Studies by Morán Centeno and Jiménez-Martínez (2023) and Gasperín-García et al. (2023) mention that schooling in the rural sector is low, with agriculture being the main economic activity; they also report that the population is older. Other authors, such as Mejía-Valva et al. (2021), add that the populations dedicated to agricultural activities are older than 20 years of age, but younger than 80, also highlighting that this productive activity is in the hands of men.

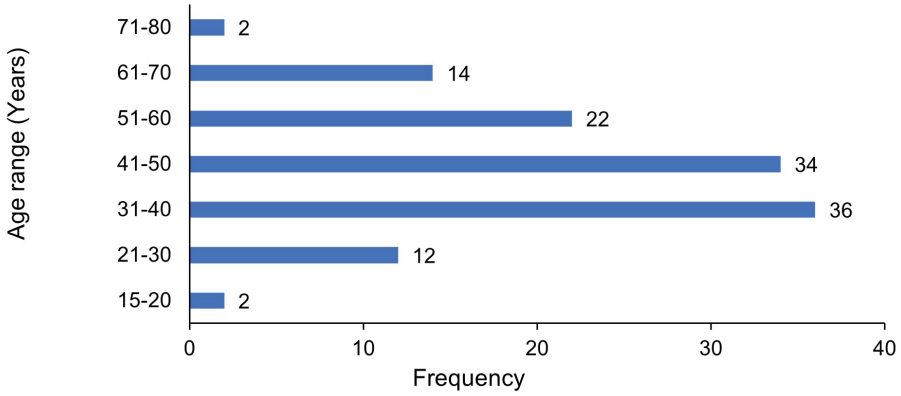

Figure 1. *Age range of cabbage producers, in four rural cooperatives in Jinotega, Nicaragua.*

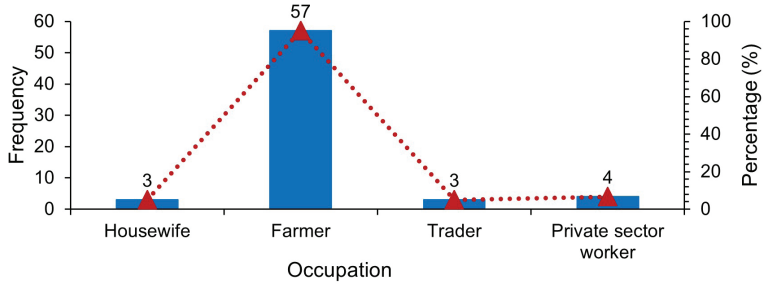

Figure 2. Occupation of cabbage producers in four rural cooperatives in Jinotega, Nicaragua.

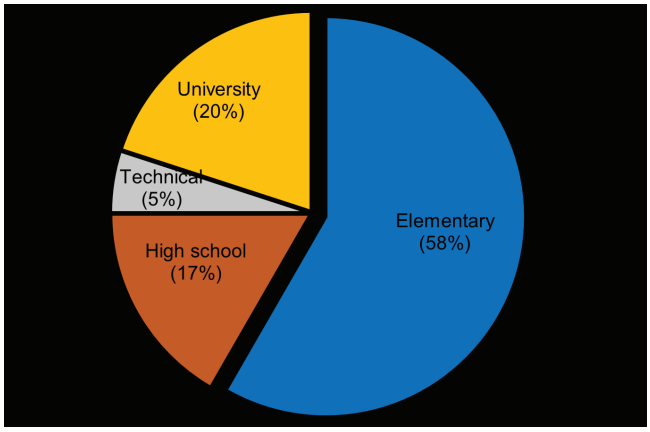

Figure 3. Literacy level of cabbage producers in four rural cooperatives in Jinotega, Nicaragua.

It is estimated that in Nicaragua 45% of houses do not provide the minimum conditions of habitability, as they do not provide a comfortable environment for people. Benavides-González and Morán Centeno (2014) found that in rural Nicaragua the construction materials used are those that can be easily purchased within the community or municipality, the main material used being zinc roofing due to its low cost and easy handling. Castillo-Martínez et al. (2019) report that, in the production units in the municipality of Tisma, department of Masaya, 56% of the house are classified as good to very good, 84% have zinc roofs and 16% tile roofs. These results are consistent with those found in the present study, where zinc roofs, concrete walls and floors predominate, and the houses were rated as regular (Table 2). The satisfaction of basic housing needs in rural communities, and its effect on improving living conditions represent a key factor in encouraging the permanence of producers in rural settings, thus ensuring the continuity of production (Mejía-Valva et al., 2021).

Table 2. Characteristics of houses in cabbage production systems in four rural cooperatives in Jinotega, Nicaragua.

Characteristics of housing											
Roof			Walls			Floor			Housing condition		
Material	**Freq**	**%**	**Material**	**Freq**	**%**	**Material**	**Freq**	**%**	**Material**	**Freq**	**%**
Zinc	57	95,00	Block	36	60,00	Dirth	19	31,67	Regular	31	51,67
Tile	3	5,00	Wood	17	28,33	Brick	4	6,67	Good	27	45,00
			Brick	7	11,67	Concrete	37	61,67	Very good	2	3,33
Total	60	100		60	100		60	100		60	100

3.2. Production variables

Eighty-two percent of the cabbage cultivated area in the four rural cooperatives in Jinotega ranges between 0.34 and 5 ha (Figure 4). Land preparation prior to planting is one of the agricultural practices that requires the most attention and care on the part of the farmer. Proper soil preparation will promote optimal growth and development of the plant's root system, will eliminate existing plant residues, will improve soil aeration, will facilitate the decomposition of organic matter, and favor the management of soil pests and diseases. Taking into consideration the high costs of fuel, machinery and tillage equipment (Martínez Garrastazú, 2016), 67% of the producers prepare the land prior to planting using oxen plows (animal traction), due to the topography of the productive areas, most of which consists of slopes greater than 15%, which makes it difficult to use agricultural machinery (tractor).

Producers were trained on topics such as crop management, fertilization and dosage (Figure 5). Training as a systematic process is based on the current and perspective needs of any entity, group, or individual oriented towards a change in the trainees' knowledge, skills and attitudes, which enabling their integral development. Opening new horizons allows to feel prepared for change, and raises the contribution of their effort within the organizations (Arévalo et al., 2018).

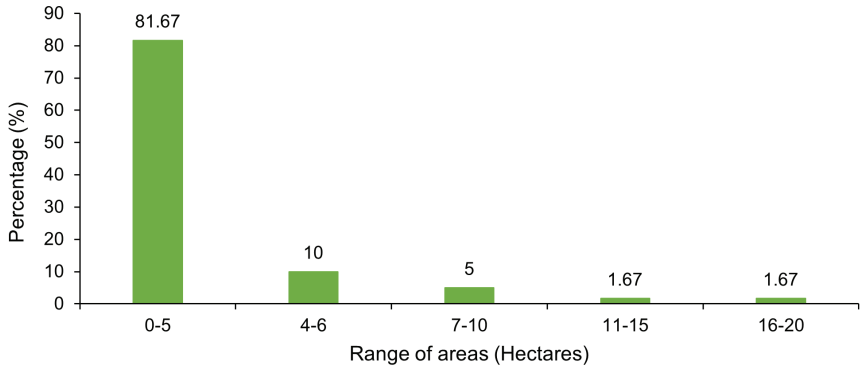

Figure 4. Range of areas established in cabbage cultivation in four rural cooperatives in Jinotega, Nicaragua.

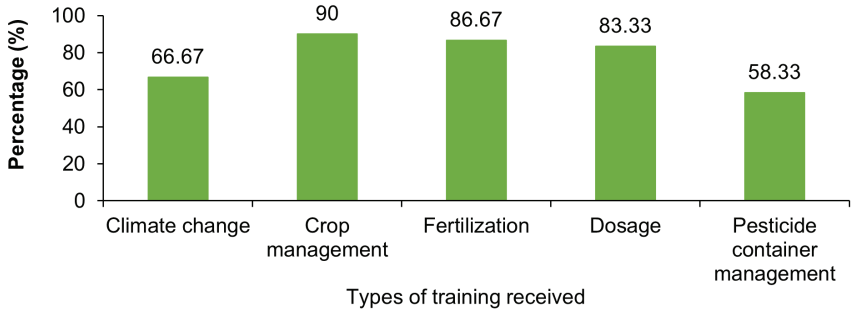

Figure 5. Types of training received by cabbage producers in four rural cooperatives in Jinotega, Nicaragua.

3.3. Agronomic and phytosanitary management in the cabbage crop

3.3.1. Type of fertilization

Any fertilization program should be based on the results of soil analysis and knowledge of the nutritional demand for each phenological stage. Since nitrogen is found in insufficient concentrations in most soils, its application is necessary (Guambo López, 2010). The cabbage crop is mostly fertilized with chemical molecules, as 96.67% of the producers choose to use chemical fertilization, while the use of organic products is present in 3.33% (Figure 6).

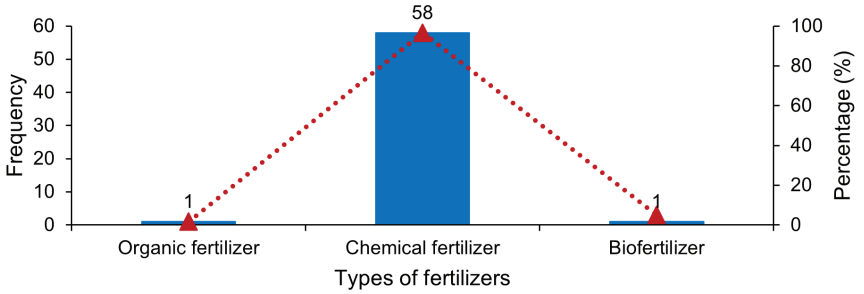

Figure 6. Types of fertilizers used by cabbage growers in four rural cooperatives in Jinotega, Nicaragua.

3.3.2. Main pest damage

The pest which mostly affected the crop was *Plutella xylostella*, in 100 % (n = 60), of the productive systems, followed by *Agriotis* spp with 98.33 % (n = 59) and, with lower frequency, *Brevicoryne* sp and *Acaros* sp (86.67

%), respectively. According to Mena Guerrero and Hernández Fernández (2017), this insect has developed resistance to pesticides, causing economic losses and high costs in management. According to Jiménez Martínez (2009), the application of chemicals is common in vegetable production; the presence and fluctuations of pests lead producers to increase the amount of agrochemicals per production cycle (Figure 7).

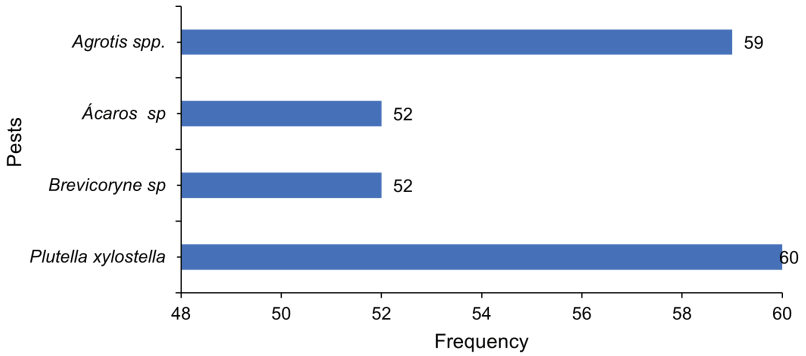

Figure 7. Main pests affecting cabbage cultivation in four rural cooperatives in Jinotega, Nicaragua.

3.3.3. Main disease conditions

Climate conditions, together with the presence of pathogens, cause diseases to affect the crop; many of these diseases attack the plants, reducing yields (Díaz Blandón et al., 1999). These affectations occur both in the head formation and filling stages. The diseases that producers reported in 95 % (n = 57) were stem rot (*Rhizoctonia* spp), Chamusco or yellow burn (*Xanthomonas* spp), in 83.33 %, *Alternaria* spp (88.33 %) and *Mycosphaerella* spp, directly or indirectly affecting crop yield (Figure 8).

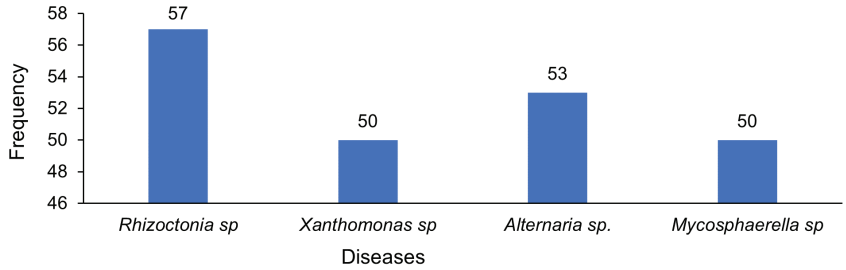

Figure 8. Main diseases affecting cabbage cultivation in four rural cooperatives in Jinotega, Nicaragua.

There are many techniques for pest control. In the cabbage crop, applications with chemical, biological and botanical products are recommended under a scheduled application program, in order to minimizing damage to the environment and the saturation of chemical molecules in the final product. Figure 9 shows that chemical applications are predominant for the pest control of soil (96.67%), foliage (75%) and fruit (78.33%); while the application of biological products is present only on a smaller scale.

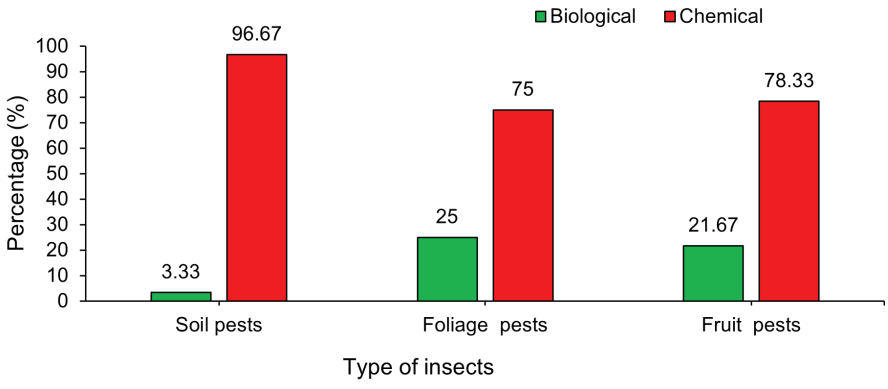

Figure 9. Types of treatments used to manage insect pests in cabbage crops in four rural cooperatives in Jinotega, Nicaragua.

In tropical countries, the application of synthetic insecticides is more frequent, with up to two applications of broad-spectrum insecticides per week (Furlong et al., 2013). Producers argue that if they do not apply insecticides the entire production may lose its commercial value (Cortez-Mondaca & Macias-Cervantes, 2007). Figure 10 shows that chemical applications are predominant for the control of soil, foliage and fruit diseases, however some inclination towards the use of biological products is also visible, but on a smaller scale.

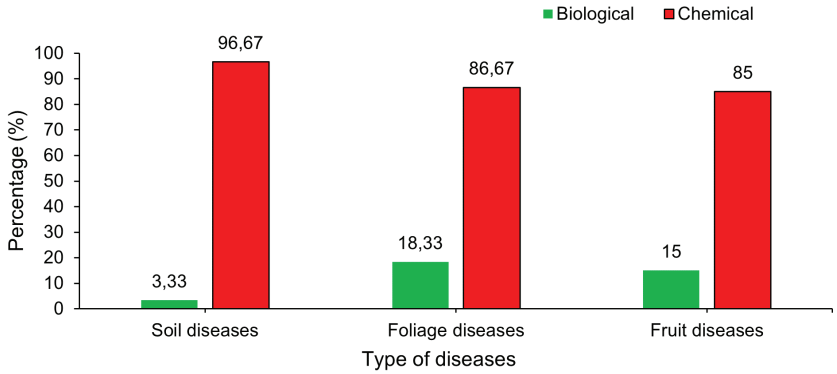

Figure 10. Types of treatments used to manage cabbage diseases in four rural cooperatives in Jinotega, Nicaragua.

It is important to take into mind some control measures in cabbage crop in order to improve yields at harvest, such as the use of varieties tolerant to pests and diseases, the use of seed banks with high genetic value, as well as to ensure good soil drainage, eliminate the remains of the harvest, carry out a good crop rotation with basic grains to break the cycle of diseases, and to use drip irrigation to prevent the spread of pests (Jaramillo & Diaz, 2005).

Among the agronomic and phytosanitary crop management strategies, producers expressed that they control the way the soil is prepared, the use of traps, permanent monitoring to identify the most frequent pests and diseases in the crop, the use of certified seeds, stubble management to reduce pest habitat, and irrigation, as these are key to the development of healthy and safe plants (Table 3).

Table 3. Agronomic and phytosanitary management practices used in cabbage production systems in four rural cooperatives in Jinotega, Nicaragua.

Practices	Frequency	Percentage
Weed management	60	100,00
Soil preparation	59	98,33
Use of traps	28	46,67
Pest and disease monitoring	59	98,33
Use of certified seed	60	100,00
Use of resistant varieties	59	98,33
Use of irrigation	56	93,33
Stubble management	52	86,67

The results obtained from the characterization of cabbage production systems could be incorporated as a reference for future studies of production systems in other rural areas of the department of Jinotega. It is necessary to deepen this type of research to strengthen the socioeconomic and phytosanitary management that farmers carry out in rural cooperatives and producers' associations at both the local and national levels (Morán Centeno & Jiménez-Martínez, 2023).

4. Conclusions

The analysis carried out identified that the farmers part of this study were between 20 and 80 years old, that their main economic activity was agriculture, that the predominant literacy level was basic education, they have

received training in various topics such as climate change, crop management, fertilization, dosage, among others, the cultivated areas range between 0.34 and 5 ha, so they are considered small productive areas.

The main pests reported by farmers were: *Plutella xylostella* causing crop losses, *Rhizoctonia* spp, *Xanthomonas* sp, *Alternaria* spp and *Mycosphaerella* spp, all of which were controlled by synthetic chemical management.

The main agronomic management practices implemented were: vine management, soil preparation, use of traps, pest and disease monitoring, use of certified seeds, use of resistant varieties, stubble management, irrigation and chemical fertilization. Many of these practices were adopted to counteract the effects of climate change to improve production and, therefore, the socioeconomic situation of producers and families.

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Contributor Roles

- Freddy Rivera Umanzor: conceptualization, investigation, methodology, resources, data curation, formal analysis, writing – original draft.
- Edgardo Jiménez-Martínez: supervision, writing – review & editing.
- Juan Carlos Morán Centeno: data curation, formal analysis, writing – review & editing.

Ethical Issues

The authors declare that, according to Nicaraguan legislation, the approval of an Ethics Committee on Human Beings or similar is not required for conducting research through surveys, and that the information collected was provided by the producers voluntarily, being informed about the use given to the results generated.

Conflict of interest

The authors declare that they have no affiliation with any organization with a direct or indirect financial interest that could have appeared to influence the work reported.

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