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Design of a Clean Production Methodology for the Agronomic Management of the Cholupa Crop (Passiflora Maliformis L) in the Municipality of Rivera, Huila

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Abstract

This article shows the results obtained from the descriptive study of the critical variables that generate contamination in the crop of cholupa (*Passiflora maliformis L*) in the municipality of Rivera, the largest producer of the fruit. The research was developed within the framework of the systematic information collection process that allowed the identification of the stages of cholupa crop that incur environmentally contaminating practices. The analysis of the information resulted in the study allowed to make a proposal for the management of cholupa crop that adjusts to the theoretical constructs of clean agriculture, in which the quality of the fruit and the agronomy of the crop were estimated.

Keywords: Cholupa, clean production, integrated crop management

1. Introduction

The cholupa crop has been planted in the department of Huila for approximately 43 years, being a young crop. In 2007 the Superintendence of Industry and Commerce

granted the signature of "Denomination of Origin", which required innovation and development for its cultivation.
This passion fruit, classified as exotic and promising fruit, has a deterioration in the quality of its physical properties, situation that has prevented its positioning in the global market. This problem is caused mainly by bad agricultural practices, by the negative effects of climate change and by pests and diseases that require high use of agrochemicals.
It is estimated that, out of the pesticides used in agriculture, regardless of whether or not a particular pest is present, only 1% reaches the crops, the rest contaminates soil, air and, mainly, bodies of water [1].

Agriculture is, at the same time, cause and victim of pollution. It is caused by the discharge of sediments in surface and underground water, by the net loss of soil as a result of inadequate agricultural practices and by the salinization and denial of irrigation for the land. It is a victim due to the use of wastewater and contaminated surface and underground water, which pollute crops and transmit diseases to consumers and agricultural workers [2].
These problems are characterized in a decline in productive capacity, dependence, migration and food self-sufficiency. In addition, there is a growing demand for foodstuff with superior quality externally and internally [3]. One of the greatest concerns in the global market is that the products that people eat are healthy and innocuous enough [4]. Every day the demand for organic eco-label products that guarantee the quality of the fruit grows more.

Therefore, knowing and implementing clean agriculture takes a relevant role for the producers of cholupa. There are two ways to carry out clean agricultura: the first is Good Agricultural Practices (GAP) and the second is Organic Agriculture. These two forms of production share the paradigm of caring for the environment.
As a matter of fact, this need for a clean agronomic management for the cultivation of cholupa in the department of Huila was the starting point for the development of this research, which was carried out within the framework of Good Agricultural Practices for fruits and vegetables since there are no specialized studies of that type for the cholupa crop.

In Colombia there is a study called: Agronomic management of Gulupa (Passiflora edulis Sims) within the framework of Good Agricultural Practices (GAP); although the study was applied to a passiflora of the same family of cholupa, it is not valid for its crop.

This evidences the need to describe the critical variables that generate pollution in the culture of cholupa in the municipality of Rivera, Huila, so that the productive sector can identify those flaws that do not allow it to produce clean fruits meeting the requirements of safety of the national and international markets and, in this way, improve their well-being and that of their families.

2. Agricultural Context

Cholupa is a fruit that belongs to the family Passifloraceae, and its species is named by Carlos Linneo in his book Species Plantarum (1753) as: Passiflora maliformis L [5]. It is native from Ecuador, Colombia, Venezuela and the Antilles [6]. In the Department of Huila, the cholupa is cultivated especially in the northwest, at altitudes of 1,000 to 1,200 MASL [7].
The plant of the cholupa is a vine or shrub climber glabrous and fickle stem, branched when it gets older, clings by cauliflower tendrils, axillary, resulting from deeply modified leaves, therefore, depends on driving systems or tutored. The systems implemented in the cholupa crop are trellised and simple trellis type [7].
The methods of propagation are: seed (sexual), almacigo, vegetative (asexual), cuttings and in vitro propagation; the flower is hermaphroditic with the receptacle considerably developed [7]. The irrigation systems used in cholupa cultivation are gravity irrigation, drip irrigation and, to a lesser extent, micro-sprinkler irrigation.
The cultivation practices and cultural activities have been oriented towards Clean Production through associations and cooperatives of fruit producers; on August 5, 2013, the producers formed the Multi-active Cooperative "Cholupa del Huila" with 30 founders.

Due to the fact that the seeds are not certified by the Colombian Agricultural Institute (ICA), the production implemented by the Cooperative in the cultures of cholupa is based on obtaining a seed of high quality, selected from crops and elite plants. At present, the producers associated to the Cooperative are in the process of applying for the certification in Good Agricultural Practices of ICA.
Rivera is the largest producing municipality of the Department of Huila, the area sown with this fruit is 116ha and the production of the municipality is 810tons with a yield in 2016 of 7.50Tons/ha, that is, more than 50% of the Department's production.
The municipality has a variety of crops and, in regard to pasifloras, it produces five of the six species of this family, with a total harvested area of 285.1ha, and a total production of 2982.9Ton among passion fruit, cholupa, passion fruit, badea and gulupa.

3. Conceptual Framework

A. Clean Agriculture

Currently, the processes taking place in the field have different names, such as traditional agriculture, sustainable agriculture or clean agriculture. The denomination of clean agriculture is adopted in this article since in Colombia the Government bodies do, however there are few studies that adopt this same denomination.
The clean agriculture is a model of sustainability, as it is supported on two pillars: Good Agricultural Practices and organic agriculture.

Sustainable agriculture means growing food in an ecologically and ethically responsible manner by using practices that enhance environmental quality and natural resource base (e.g., land, soil and water) while maintaining the economic viability of farm operations [8].

B. Good Agricultural Practices (GAP)

Good Agricultural Practices (GAP) are regulated by the Colombian Agricultural Institute (ICA) through resolution No. 20009 of April 2016: "by means of which establish the requirements for certification in best practices Agricultural primary production of vegetables and other species for human consumption".

Therefore, refers to the GAP as it adopts the resolution: the BPA are activities aimed at the environmental, economic and social sustainability of agricultural production processes, which guarantee quality and food safety and the food products.

For this purpose, refers to the GAP consist of the set of rules and technical principles applied to Integrated Crop Management (ICM), the Integrated Pests Management (IPM), wellness and safety for consumers and workers, and traceability properly documented crop.

Within this context, the requirements of GAP are: planning of cultivation, facilities, equipment, utensils and tools, management of water, management of soils, material plant health, nutrition of plants, crop protection, harvest and handling pos-harvest, documentation, records and traceability, health, safety and welfare of the worker and environmental protection.

C. Integrated Crop Management (ICM)

Integrated Crop Management (ICM) is considered a strategy of agricultural production that integrates the GAP based production. Integrated Crop Management (ICM) is a pragmatic approach to crop production which focusing on crop protection and is based on understanding the intricate balance between the environment and agriculture and is a whole-farm approach in achieving a proper balance [9].

Integrated Crop Management (ICM) basic components are crop management, nutrient management, pest management, financial management and one of its main objectives is reduction of external farm inputs, such as inorganic fertilizers, pesticides and fuel by means of farm produced substitutes [9].

D. Innocuousness

The food safety is major global public health issues, and are particularly important in heavily populated countries [10]. Most food safety incidents are related to microorganisms, toxic plants and animals, chemical contamination, illegal food additives and contamination with environmental hazards [10].

The progress in terms in food safety over the last 20 years have had little impact, not because the strategies are ineffective, but because of other factors such as globalization, changes in eating habits and changes in farming practice increasing risk [11].

E. Agrochemicals

The agrochemicals are one of the invaluable inputs in sustaining the agricultural production as considerable food production is lost due to insect pests, plant pathogens, weeds etc. [12].

In most cases, agrochemical refers to the broad range of pesticide including insecticides, herbicides, and fungicides. It may also include synthetic fertilizers, hormones and other chemical growth agents and concentrated stores of raw animal manure [13]. The classification of agrochemicals is determined according to the plague that they control.

The presence of agrochemicals and other pollutants, even in minute concentrations, is an indication of probable ecological problems and a threat to human health [14].

F. Contaminated Food

In today's global marketplace, as foods are produced and distributed throughout the world, food quality and food safety have become increasing concerns for consumers, governments and producers [15]. Because of the increase in consumers' concerns about what is in their food and its relation with health, control over the safety and quality of food has become tighter, particularly in developed countries where food availability problems are much lower [16].

Chemical contaminants have been described as "any chemical not intentionally added to food but present from many potential sources" [15]. Chemical contaminants can be present in foods mainly as a result of the use of agrochemicals, such as residues of pesticides, contamination from environmental sources (water, air or soil pollution), cross contamination or formation during food processing, migration from food packaging materials, presence or contamination by natural toxins or use of unapproved food additives and adulterants [17].

G. Environmental Contamination

Agricultural production of food depends on several policy, economic and biophysical conditions [18]. The factors controlling contamination are the crop grown, the irrigation method used to apply the wastewater, and the management and harvesting practices used [19].

The need to detect contamination that cannot be perceived at first glance, is what has led to the institutions of the State to exercise control and monitoring on the activities developed by the agricultural, industrial, and commercial, livestock sector, mining etc., so This will ensure, the conservation of the natural resources of the country and the security of the national population.

4. Metodology And Instruments

The research was based on a quantitative approach because it required a systematic process of data collection that it will involve the definition of a number of factors that were empirically happening in reality and which established specifically for the cultivation of cholupa comply with the theoretical constructs of clean agriculture.

Quantitative research is applicable to phenomena that can be expressed in terms of quantity [20]. Therefore, the goal of the research was to establish measurable variables that would describe and explain the factors of contamination in the cultivation of cholupa.

The scope was defined as exploratory and descriptive; the study was exploratory because the prospect of research, which in this case is clean agriculture, is different from what they have been working for the academic and productive community with regard to the cultivation of cholupa.

One of the main functions of the descriptive research is the ability to describe systematically a situation, problem, phenomenon, service, programme, or describes attitudes towards an issue [21], in this sense the research carried out a process of characterization of four factors that influence the generation of pollution, called in the agronomical management of the cultivation of cholupa: use of water resources, soils, integrated crop management and management waste.

Non-experimental Design

The research design was established in accordance with the development of two stages: the first stage is the determination of factors and the second establishment of measurable variables. The first stage was based on the theoretical constructs of clean agriculture, which are governed by the Good Agricultural Practices (GAP) in Colombia, was accordingly conducted a review of the literature. Information from two types of sources: primary or direct sources and indirect or secondary sources.

The primary sources were the public and private sector entities: the municipality of Rivera, the Institute of hydrology, meteorology and environmental studies (IDEAM) and the Corporation Center of technological development of the passion flower of Colombia (CEPASS), where was the application of a series of documents containing specific data from: ecological conditions of Rivera, Rivera weather and ecological conditions of the crop. These collected data dealt with through the Excel tool to create a database.

Secondary sources were academic databases, where articles on clean agriculture were consulted and pollution on crops, for the extraction and gathering of information was a log of references.

Variables that allow you to measure the factors were established in the second stage of the process and determines how to evaluate each of the factors. To do so was made using two data collection techniques: systematic observation and survey.

For systematic observation was built an array in order to operationalize the four factors of study, limited the field of observation, established categories and selected the sample size (EQ. 1), finally, was structured a logistics Guide constituted by the process of observation, which was direct staff. It was determined that the survey out personal descriptive, we designed a questionnaire with open and closed questions, and selected the sample of the population (EQ. 1). The design of the questionnaire was carried out under the following items: accuracy and clarity of the questions, structuring of the questions according to the four factors, inclusion of the possible answers and questions filters. The questionnaire was validated by an expert in Agricultural Engineering.

The procedure for the selection of the representative sample was equally divided into two stages: the first, determination of the population and the second, the sample size calculation.

The chosen people were thirty producers associated with the cooperative Multiactive "CHOLUPA of the HUILA" that are in process of applying for certification in good agricultural practices, since they are the only ones that have applied to this process. Considering the finite universe, the formula applied was:

$$n = \frac{Z^2 \times P \times Q \times N}{E^2(N-1) + Z^2 \times P \times Q}$$

where,

n: estimating sample size (number of producers that need survey for the portion of crops with polluting sources).

Z: level of confidence or reliability margin (97, 50%, i.e. Z = 1.96).

P: proportion of the pilot sample producers who have crops with polluting sources.

Q = 1-P: proportion of the pilot sample producers who do not have crops with contamination sources.

N: the total number of producers who have crops with contamination sources.

E: maximum accepted error of estimation (E = 0.1 or 10%). Therefore,

$$n = \frac{1{,}96^2 \times 0{,}1 \times 0{,}9 \times 30}{0{,}1^2(30-1) + 1{,}96^2 \times 0{,}1 \times 0{,}9}$$

$$n = 17$$

Finally, for a finite population of 30 producers, with a 97, 50% confidence level and an error of estimate of 10%, it was necessary to visit and survey a total de 17 producers who are in the process of application for certification in best practices Agricultural, in order to know the proportion of pollution generators crops.

5. Results

The producers associated to the Cooperativa Multiactiva are people located mostly in an age range of forty (40) or more, which 50% do not overcome the level of primary education and have average availability of their own property, since the 60 % are tenants (Table 1).

Tabla I. Study Population

<table>
<tr><th colspan="9">Characterization of the population</th></tr>
<tr><td rowspan="5">Educa-tion</td><td>Primary</td><td>50%</td><td rowspan="3">Age</td><td>18-28</td><td>10%</td><td rowspan="5">Cultiva-tion experi-ence</td><td>6 Months</td><td>0</td></tr>
<tr><td>Secundary</td><td>10%</td><td>29-39</td><td>20%</td><td>1 year</td><td>0</td></tr>
<tr><td>Technical</td><td>10%</td><td>40 or more</td><td>70%</td><td>2 years</td><td>30%</td></tr>
<tr><td>Technologist</td><td>10%</td><td rowspan="2">Own. of the pro-perty</td><td>Leased</td><td>60%</td><td rowspan="2">5 years or more</td><td rowspan="2">70%</td></tr>
<tr><td>Professional</td><td>20%</td><td>Proper</td><td>40%</td></tr>
</table>

A. Use of water resources

At present, the producers look after and avoid the pollution of the water sources of their crops, because none of the producers throw organic matter into the water currents, and they also avoid contaminating the water sources with pesticides or detergents and spilling oils, fats and other petroleum products.

This awareness is due to the policies established by the Colombian Agricultural Institute (ICA), and since for a clean agriculture it is essential that water does not represent a source of possible contamination for the products and through its efficient uses it contributes to protect the environment.

It is identified that the variables that have a lower contribution to the efficient use of water are: prevention of contact of large animals with water and sediment trawling. 20% of the producers declared that they did not carry out this type of activity.

According to the measurement of the water flow for irrigation and the use of water resources strictly necessary for cultivation, 60% of the producers are not doing so, therefore, a source of contamination is detected.

Starting from the theoretical assumptions, to ensure the quality of water, it is necessary to know and measure the water resource required by the crop, since it allows to reduce the estimated consumption of water and the incidence of pests and diseases, because this incidence is directly related to the humidity of the crop, finally, improve the cost-benefit ratio of the crop, because there will be no puddles and / or growth of weeds.

B. Soils

The soil is what provides the life, nutrients and all the nutritional care that the plant needs. That is why it is so important to take care of the soil in a clean way. 80% of producers make applications (corrective and / or preventive) of organic matter to the soil and crop rotation. Then, in Fig. 1, you can see the products that grow cholupa producer’s stationary in the municipality of Rivera.

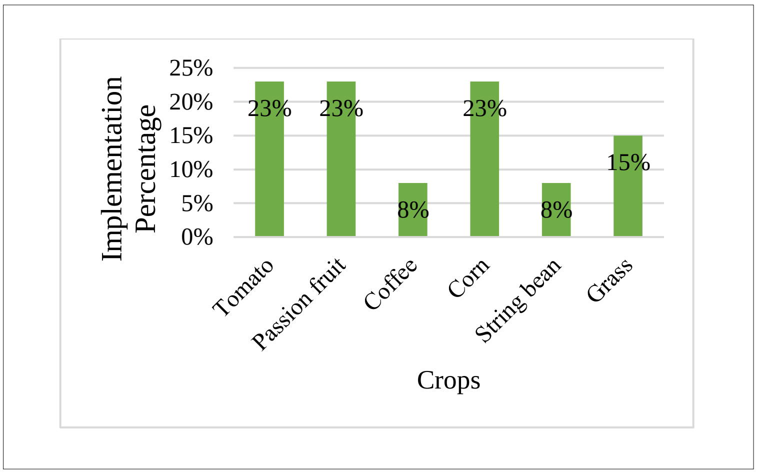

Fig. 1. Crop rotation.

On the other hand, fertilization based on the analysis of soil and the requirements of the plant and the construction of live barriers to prevent soil erosion, only 60% of producers do.
When comparing these evidences, it is determined that cholupa producers take actions to improve the carbon content in the soil and its structural stability and protect the soil satisfactorily from erosion by water and wind, thanks to crop rotation. However, fertilization must consider inherent technical aspects to conserve the soil and obtain a good harvest.

C. Integrated crop management

The seeds are perhaps the most controversial issue regarding the cultivation of cholupa since the producers do not have certified seeds facing the Colombian Agricultural Institute (ICA). Therefore, they can not comply with the section on Good Agricultural Practices demanded.

Currently, the importance of Cholupa producers acquiring certified seeds is being recognized, however, no significant progress has been made so far. As a result, healthy plant material is not guaranteed.

Pests are one of the problems that generate most expenses in the cultivation of cholupa. In Fig. 2, we can observe the pests and diseases that have an incidence in the cholupa culture.

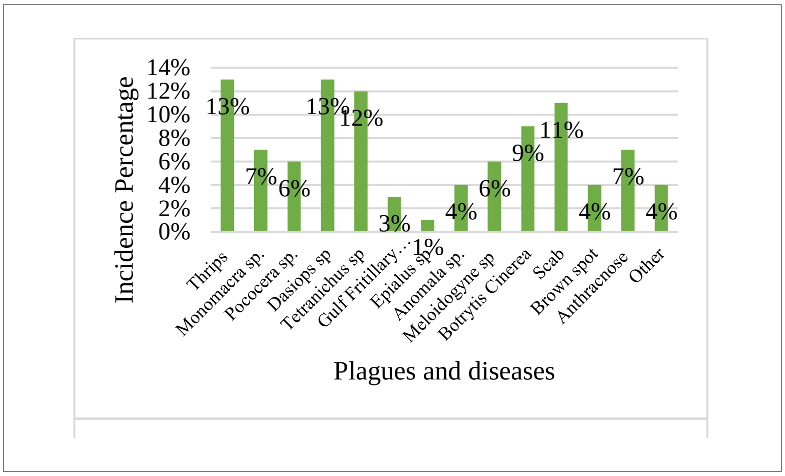

Fig. 2. Pests and diseases of cholupa culture.

The pests and diseases of greater incidence in the crop are the Trips, the fly of the floral button, the red spider and the scab, being the lower incidence the borer or weevil and the worm harvester. The category called 'other' refers to pests and migrant diseases from other passiflora crops such as Fusarium and Alternaria, which have producers concerned, although the cultivation of Cholupa is a species resistant to Fusarium.
On the other hand, 100% of the producers affirmed to carry out the monitoring and evaluation of pests and diseases, 50% verify it by furrows, 40% by plants and 10% by linear meter, the method is chosen in accordance with the established tutorate system. The systems of tutored employed are: the trellis system, which is applied by 20% of the producers and the simple trellis system (80%).
Plague control is done mostly once a week. The types of controls that are applied are presented below (Fig. 3), being the most welcome the physical and mechanical control and the ethological control.

The use of chemical control has an application in crops that is less than physical and mechanical and ethological control. It is determined that the indiscriminate use of agrochemicals becomes a source of contamination when producers are unaware of the other types of controls and their benefits and when the pests affect the culture of cholupa established controls are applied for other species. In relation to these implications, the integrated management of the crop can reduce costs, increase production and offer healthy products.

In fact, to demonstrate the production of a healthy product, the traces of the crop must be managed, this means keeping a meticulous record of all the inputs and practices that were used during the production of the fruit. This is a requirement that Cholupa producers must fulfill, since this requirement is required for certification in Good Agricultural Practices (GAP). In addition, keeping a track record generates trust between the producer and the customer.

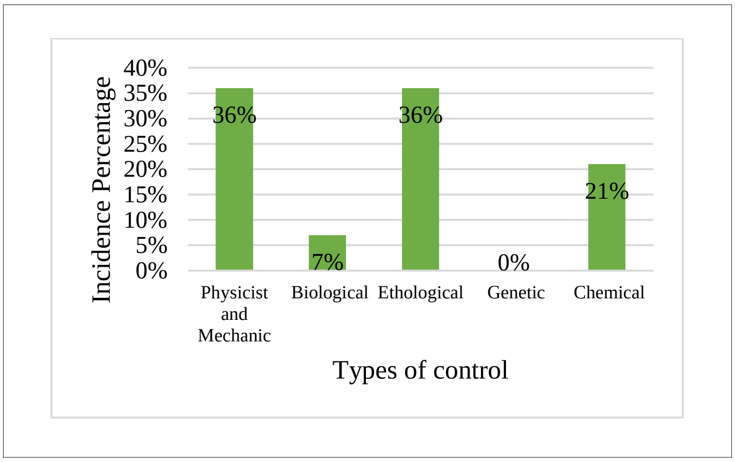

Fig. 3. Types of plague and disease controls.

D. Waste management

The indiscriminate use of pesticides, herbicides and insecticides and the treatment of waste in general have become a focus of environmental deterioration. Therefore, it is important to mitigate the effect of crop residues on the environment. In the case of this study, 60% of the producers carry out: collection of decomposing plant material and recycle the plant remains through incorporation and composting.

70% of the producers carry out activities to prevent cross-contamination in the crop: it deposits the plant remains that can not be recycled in plastic-capped containers and sends them to an authorized sanitary landfill, burying the resulting plant material of phytosanitary pruning in the lot, identifies and quantifies the waste products (such as paper, cardboard, crop stubble, oil, fuel, rock, wool, etc.) on its premises and has a septic tank technically built on its premises.

With this same purpose, an estimated 80% of the producers have a waste disposal area on their premises and remove the plants and organs affected by pests and diseases.

For this purpose, all the activities that will be carried out on the property must be planned to complete the storage, final disposal and recycling of the types of waste generated on the property, however, only half of cholupa producers have a recycling plan for waste products.

6. Conclusions

The reduction of the contamination of the fruits, due to the bad agricultural practices applied in the productive sector, the decrease of the environmental impact that causes the excessive use of agrochemicals in the cultivation over the environment and the increase of the quality of the fruit to comply with the demands of national and international markets, is possible through the implementation of the methodology called: Clean production for the agronomic management of cholupa cultivation, where the technical guide is established on how to manage the crop to produce clean fruits.

The measures proposed for the use of water resources revolve around the prevention of water pollution, that is, the planning and development of an action plan and monitoring.

The requirements for the action plan involve: determining the availability of water before making any decision or starting an activity, evaluating the quality of the water through physical, chemical and biological analysis of its sources, remembering the application every two years, comply with the regulations corresponding to the use of water in agriculture, establish goals and commitments to protect or improve the water quality of its water sources, document in writing the water quality management plan with the measures that will be implemented to ensure the proper development of their activities. In the meantime, for the monitoring, it is required not to neglect the measurements of the water resources and it is necessary to be constant to be evaluating the advance in the quality and the efficient use of the water.

Starting from the assumptions of the soil factor, different steps are structured that give the producer the guidance to avoid contamination and degradation of the soil, which for this purpose are: a) Prepare a diagram, map or document of the history of the land, which includes the crops planted in it and the crops surrounding it to know first hand the agrochemicals and pests that have been applied and affected these crops, the state of the land, the sources of available water and the physical, chemical and biological hazards to which it is exposed; b) Use the pits technique to study the soil profile and know its physical characteristics; c) Take the samples from the test pits to a certified laboratory to perform the respective analyzes and thus know the physicochemical characteristics of the land. With this, we avoid cost overruns in amendments; d) Apply amendments to the land such as pH stabilization, application of organic matter and addition of nutrients based on the results of soil analysis and the different types of identified hazards.

In relation to the implications of the integrated management of the crop, four fundamental axes are framed: seeds, pests and diseases, training and traces.

For the seeds, the traditional techniques used by the producers, as well as the recommendations of the agronomists and the specifications of the technical manual of the cholupa should be followed. Likewise, with pests and diseases, the efficiency of monitoring must prevail, which includes the following phases: prevention, monitoring and evaluation, and intervention.

The following indications must be considered for their control: perform manual control as a first step, that is, verify the plants and remove the insects that are affecting them, since some of them, such as the harvest worm, are quite large and visible, therefore can be removed; the second measure, based on principles of clean agriculture, are the biological controls. These are products of biological origin that are easily obtained in the market and are made from plant extracts with repellent function; as a third measure, the so-called ethological controls are also a way to combat pests. These controls can be carried out by releasing natural predators of some pests; As a last measure or emergency measure, the so-called shock control

must be carried out, which consists of applying third and fourth category chemical insecticides, which are the least toxic.
The optimum planting densities are 3.5m between plants and 3.5m between rows when it is the vine training system; when it is a one-tier espalier, planting densities of 3.5m between plants and 2m between rows are used. The one-tier training espalier system offers greater control of pests and diseases, because it allows more aeration, but plants are affected by the sun stroke, which burns the fruit, while the training espalier system facilitates the creation of a microclimate that increases the incidence of pests, in spite of the training system being the one which offers greater yield of the crop.

For its part, the indiscriminate use of agrochemicals has decreased the population of pollinators, which has forced producers to pollinate manually. This reason bases the importance of caring for and protecting the pollinating agents by implementing techniques for the agronomic management of the crop that do not harm or kill the pollinators.

In effect, the control of the traceability by the producers must be managed and promoted. In order to properly manage traceability, the records that must be kept are: the history of the land, documents on the planting material used, water and soil analysis carried out previously, record of maintenance and calibration of equipment and tools, registration of fertilizers applied, registration of organic fertilizers applied and prepared (if prepared on the farm), registration of the integrated pest plan that is being used and records of the training provided to the workers.

It is suggested that in the framework of solid waste management, planning, prevention and control measures be established to ensure the correct collection, storage, handling and disposal of waste. These measures are: a) Make a diagnosis or evaluation of all kinds of waste generated on the property; b) Plan all the activities that will be carried out on the property to carry out the storage, final disposal and recycling of the types of waste generated on the property; c) Comply with the technical requirements required by Colombian regulations for the design, construction and location of the sites where the waste generated on the property will be stored; d) Bring the different wastes that require special disposal to collection centers or authorized collection centers. If there is waste generation that does not require special disposal, this must be disposed in facilities that meet the requirements required by Colombian standards; e) Recycling and reusing without exception all waste products that has the recycling symbol on the container's label, in order to minimize waste disposal costs; f) Carry out an annual verification of compliance with recycling activities and strategies on the premises.

To close the discussion of the research, it is contemplated the attempt to implement the methodology of clean production for the agronomic management of cholupa crop in order to evaluate experimentally the effects that it has on the problem factors discussed here.

7. Declarations

Data Availability Statement
All the data type used to support the findings of this study are available from the corresponding author upon request.

Author contribution statement
Tatiana C. Puentes-Escobar and Jhoan S. Sánchez: Conceived and designed the analysis; Analyzed and interpreted the data.
Nasly A. Monedero Jaramillo: Conceived and designed the analysis; Analyzed and interpreted the data, wrote the paper.

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Interest statement
The authors declare the following conflict of interests: Nasly A. Monedero Jaramillo is professors of University Corporation of Huila - CORHUILA. The authors Tatiana C. Puentes-Escobar and Jhoan S. Sánchez are students of Industrial Engineering of the University Corporation of Huila – CORHUILA

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