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FACULTY OF AGRICULTURAL SCIENCES

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Research Project prior to obtaining the title of Agricultural Engineering.

Title:

Evaluation of the Crop Booster device in the cultivation of pepper (Capsicum annuum L). under micro-sprinkler irrigation conditions

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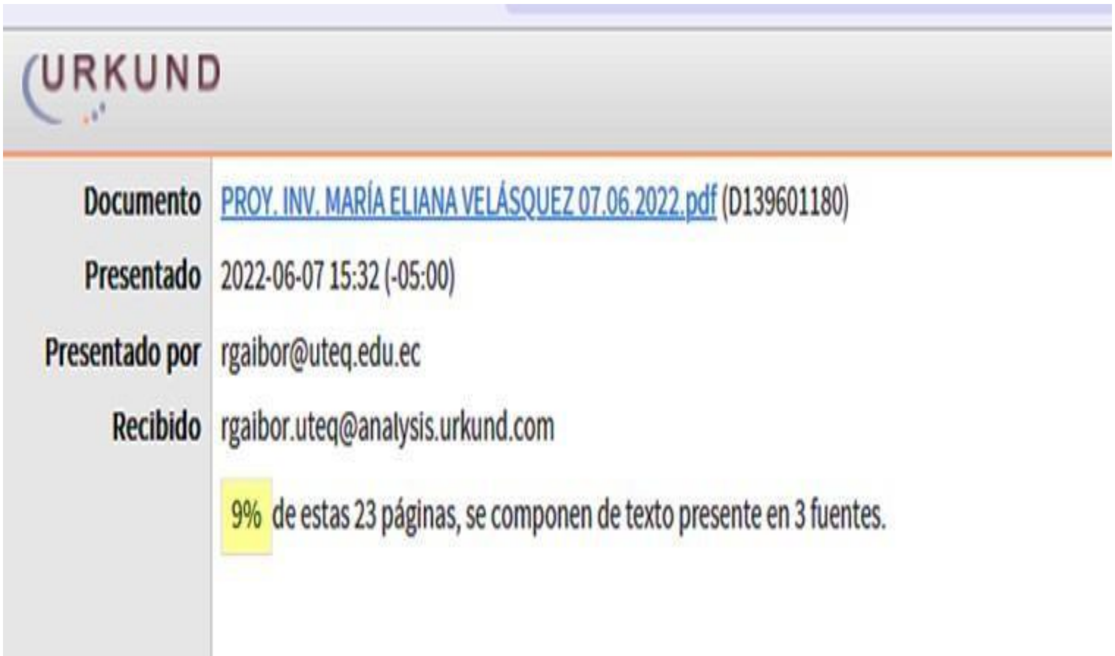

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DEDICATION

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Maria Eliana Velasquez Intriago

ABSTRACT

The Crop Booster technology implemented in the irrigation system optimizes both quantity and quality, helping plants grow stronger, healthier and with less use of fertilizers and pesticides. The general objective was to evaluate the effect of the Crop Booster microtransmitter in a microsprinkler irrigation system, implemented in the pepper crop. The research was carried out in the experimental Campus La María of the UTEQ. The Design of divided plots was used: the main plots, the irrigation system and the subplots, three varieties: Cubanelle, Marconi, California Wonder. The device was installed in one of the main pipes that leads to the sprinklers that irrigate the treatments with the system. The application of the irrigation system with the Crop Booster device had a greater effect on the number of fruits and length in the Cubanelle variety, while the Wonder variety exceeded the Marconi and Cubanelle varieties in weight. The cultivation variables without the application of the device reached a lower number of fruits, length and weight, as well as in the crop yield. The treatment with the device was superior in 8621.67 kg/ha; while in the varieties plus the Wonder device exceeded with averages between 7835.5 and 21837 kg, ratifying the effect of the device and the use of a variety with great yield potential with the use of the Crop Booster system plus the Wonder variety, which showed the highest profitability with 137.51%, followed by the Marconi variety without the device with 130.04%.

Keywords: biophysics, microtransmitter, quantum technology, radio waves, irrigation

TABLE OF CONTENTS

INDEX OF TABLES

INDEX OF FIGURES

INDEX OF ANNEXES

DUBLIN CORE METADATA

Title:	"Evaluation of the Crop Booster device in the cultivation of pepper (Capsicum annuum L.), under micro-sprinkler irrigation conditions"
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INTRODUCTION

The cultivation of pepper (Capsicum annum L.) in Ecuador has been favored because it has geographical, climatic and soil characteristics suitable for its development, as argued by the author Pinto (2013), being planted on the Coast and part of the Sierra, especially in the provinces of Guayas, Santa Elena, Manabí, El Oro, Imbabura, Chimborazo and Loja, where the climate, altitude and soil are favorable. In the country, it has a vegetative cycle, depending on the variety, between sowing and harvest, of 4 to 6 months.

The pepper is a vegetable whose consumption provides a series of benefits to human beings, especially with regard to nutrition and health. It can be consumed both raw, boiled or roasted, being very tasty and aromatic, and can accompany a variety of meats, cereals and vegetables. According to the author Pinto (2013), it is one of the foods richest in fiber.

Technology goes hand in hand with agriculture, since the farmer has always tried to facilitate the hard work that the field implies. The Crop Booster is a new technology that uses low frequency radio waves to improve plant metabolism, plant and soil health. It consists of more than 3,000 unique frequencies that are programmed into small alloy steel discs through special equipment, which are connected to the irrigation system and carry the signals through the water to the soil and plants. (Organiko Latam, 2019).

The results offered by this technology are: faster growth and increased plant yields, healthy and strong plants with more resistance to pests and diseases, and larger and more abundant fruits and vegetables. According to Agronoticias (2020), fresh production is kept better and longer; after harvest, it produces a better flavor and quality.

This research project deals with the implementation of the Crop Booster device in the sprinkler irrigation system in the cultivation of pepper (Capsicum annuum.). This vegetable is in great demand as it is part of the seasoning of the diet of many families and provides different nutritional values.

CHAPTER I
RESEARCH CONTEXT

1. Research Problem

1.1 Problem Statement

One of the problems that affects the crops is the inefficiency of the sprinkler irrigation systems, which can present difficulties, such as the obstruction of the sprinklers, making it difficult to irrigate the crops correctly. Another problem is the inadequate selection of the type of irrigation intended for the different types of crops; as well as the non-application of new technologies that provide better development in all stages of cultivation.

1.1.1 Problem formulation

How does the application of the Crop Booster device affect the development, growth and yield of the pepper crop with micro-sprinkler irrigation?

1.1.2 Systematization of the problem

Does the implementation of new technologies such as Crop Booster increase production in crops such as peppers?

Will the Crop Booster system provide faster growth and increased yields, strong and healthy plants?

Are there differences in the morphological characteristics of the pepper crop through the application of Crop Booster in the irrigation system?

1.2. Objectives

1.2.1. General objective

Evaluate the effect of the Crop Booster microtransmitter in a microsprinkler irrigation system implemented in the cultivation of pepper (Capsicum annuum).

1.2.2. Specific objectives

- To determine the effects of the Crop Booster technology on the agronomic characteristics of the pepper crop.
- Establish the percentage increase in the yield of pepper varieties in relation to the use of the Crop Booster device.
- Carry out the economic analysis of the yield of the pepper crop based on the treatments studied.

1.3. Justification

The Crop Booster technology advances through the irrigation system bringing acoustic frequencies to your crops, with a view to improving the plants and their own ability to increase the development, growth and yield of the crop.

The use of irrigation systems in crops consists of providing water to the soil to meet the water needs that were not covered by precipitation or to increase agricultural production by transforming rainfed agricultural areas into irrigated areas. This type of agriculture requires capital investment and water infrastructure: canals, aqueducts, sprinklers, ponds, etc., which in turn require advanced technical development.

Agricultural irrigation, due to its close relationship with the use, management and conservation of water, is one of the areas within agriculture that requires further studies, technological advances and application without affecting the environment, using techniques that they are getting better and better, they provide water savings, energy savings and, being extensive, reduce costs, with an increase in productivity.

Crop Booster is a new technology that uses low frequency radio waves to improve plant metabolism, plant and soil health. The benefits provided by this technology are low cost. Devices last 2 years from first use, easy to install and use, reduced production costs, faster growth, increased crop yields, improved taste and quality, water savings, less use of pesticides and fertilizers.

The research is aimed at benefiting small, medium and large farmers, as well as professionals and academics dedicated to agronomy. This will be a great contribution for future research on new technologies for use in irrigation systems, providing a precedent.

CHAPTER II
THEORETICAL FOUNDATION OF THE RESEARCH

2.1. Theoretical framework

2.1.1. taxonomic description

The taxonomic description of the pepper crop is as follows (2) :

- **Kingdom:** plant
- **Division:** Magnoliophyta
- **Class:** Magnoliopsida
- **Subclass**: Astiradae
- **Order:** Solanales
- **Family:** solanaceae
- **Subfamily:** Solanoideae
- **Tribe:** Capcisea
- **Gender:** *capsicum*
- **Species:** *Capsicum annuum*L.

2.1.2. Botanical description

The pepper is an annual type of Solanaceae, it is a bushy annual plant that grows by seed propagation in the Solanaceae family that varies in height from 75 cm to 1 m in height, which will depend on the variety used. It has an erect green body, which in turn is divided into two parts. The leaves are elongated, large, lance-shaped, dark green (3).

The pepper is an annual herbaceous plant, it has erect, herbaceous and branched stems of dark green coloration. Its root system is pivoting and reaches a depth of 0.7 to 1.2 meters and laterally it measures 1.2 meters, it is reinforced by adventitious roots. The average height of the plant is 60 cm, but it varies according to the type or species in question (3).

The leaves are flat, simple, hairless, entire, oval or lanceolate with a very pronounced apex (acuminate) and a long or inconspicuous petiole and elongated ovoid shape. In order for flowering to occur, in addition to suitable climatic conditions, a certain “maturity” of the plant is required, which in the species materializes with the minimum presence of 8 to 12 leaves (3).

The flowers appear solitary at each stem node. They are small and consist of a white corolla. The fruit is a hollow, semicartilaginous and depressed berry, of variable color (green, red, yellow, orange, violet or white); some varieties turn from green to orange and even red as they mature (4).

The size of the fruit can vary and can weigh from a few grams to more than 500 grams. The seeds are inserted into the conical placenta in a central arrangement. They are round, slightly kidney-shaped, pale yellow, and 3-5 mm long (4).

2.1.3. Plantation frame

The planting frame is adjusted to the size that will depend on the commercial variety that is grown. It is usually used in greenhouses with a distance of 1 m between rows and 0.5 m between plants, although in the case of medium-sized plants and depending on the type of pruning formation, it is possible to increase the planting density by 2.5-3 plants per square meter (5).

It is also common to have planting rows 0.80 m apart and to leave a corridor of
1.2 m between each double row to facilitate the performance of cultural tasks and avoid unwanted damage to the crop. For this reason, Infoagro (2020) states that, for greenhouse crops, the planting density is usually between 20,000 and 25,000 plants/ha. At the open field level, it generally reaches 60,000 plants/ha (5).

2.1.4. Types of pepper fruits

There are different types of peppers, among them the following stand out (6):

- **Cubanelle:**

It is in many ways similar to the popular sweet pepper. However, unlike its cousins, it has an elongated conical shape, often reaching 2-3 inches (13-18 cm) in length. Tending to twist and bend as it grows, giving it a unique rustic look, the peppers have a mild sweet flavor (7).

They start out in shades of bright yellow to green and mature to a striking red. They can be picked up and eaten when they are any color. The plants tend to reach a height of 24-30 cm (60-76 cm.). Ripe fruits are ready to start picking 70-80 days after planting (7).

- **Long pepper:** It is the most common. Examples are peppers from Reus and peppers from Lamuyo (6).
- **Marconi**

It is a variety with fleshy and large fruits, its sowing is done in seedbeds and at the time of transplanting they are placed at a distance of 40 to 50 cm between plants. It is used for grilling and stuffing. This cultivar produces peppers 15 to 20 cm in length. It is a cultivar resistant to tobacco and potato mosaic virus, which is reflected in its development and yield. This pepper can be harvested green approximately 72 days after transplanting (8).

- **Sweet peppers:** they are red, yellow or green, of different shapes and sizes. This group includes both the bell pepper and the Italian sweet (6).
- **California Wonder**

It is a variety of pepper with a semi-early cycle, the plant is very productive and of medium size. It produces large, square-shaped fruits, 11 cm long and 11 cm wide with 3-4 hulls, green to bright red when ripe at 75-85 days, thick, fleshy and sweet pulp (9).

This very productive variety, also suitable for protected crops. Transplant with 5 – 6 leaves and 15 cm high in fresh and soft soil at a planting density of 0.70 m between rows and 0.40 m between plants. They are the most demanding cultivars in terms of temperature, so planting is done early (from mid-May to early August, depending on the weather in the area), to lengthen the production cycle and avoid fruit set problems with the excessive drop in night temperatures (9).

- **Square pepper.** Appearance: It is a homogeneous pepper with thick flesh. Three types are included in this group: California Wonder pepper, sitaki pepper, and salsa pepper (6).

2.1.5. Crop requirements

The pepper is a crop that is very sensitive to low temperatures, which is why it prefers sub-warm and warm climates, although it adapts to temperate climates, with an optimum temperature between 22ºC and 25ºC for germination and vegetative development and between 26ºC and 28ºC for flowering and fruiting. Low temperatures result in the formation of deformed and smaller fruits (1).

2.1.6. cultural work

2.1.6.1. Soil preparation and planting

The basic preparation of the soil begins a couple of weeks before transplanting the pepper plants, before transplanting all crop debris, weeds, rocks and other unwanted materials found in the soil (10).

Most of the farmers integrate base fertilizer the same day, using tillage machinery. Some producers prefer to apply it only in planting rows, while others spread it throughout the field (10).

2.1.6.2. Fertilization

In the cultivation of pepper, the first month is a critical period, since it is when the plant is formed and the flowering develops, which will later translate into the harvest. A bottom fertilization is recommended in order to provide the bulk of fertilizer units at a lower cost (11).

The pepper is very demanding in terms of potassium and magnesium. Potassium and magnesium guarantee a good development even of the earliest peppers, improve firmness and improve the color of the fruit. Potassium must be provided with the development of the crop, increasing from flowering and then maintaining it at a constant level during the maturation period, likewise magnesium is also essential in this phase of maturation (11).

Special attention must be paid to fertilization because the plant has a root system that is very sensitive to excess salt, requires a lot of nitrogen, phosphorus and potassium, and also requires a constant high amount of nitrogen, it does not grow uniformly but slowly in the first stages, then quickly when the fruits begin to grow (12).

The inputs of organic matter or mineral fertilizers improve this condition, because they contain particles that feed the microbial communities that secrete the enzymes necessary to dissolve or mineralize minerals, but do not meet the needs of most crops (12).

2.1.6.3. Irrigation

The water requirements for the production of good peppers range between 600 and 1250 mm per year. The pepper is very sensitive to water stress, due to excess and lack of moisture. Irregular water supply can lead to flower and fruit drop and apical necrosis, so reduce water more frequently (12).

Most vegetables require uniform moisture throughout the cycle to obtain good yields and fruit quality. Therefore, for most vegetables it is important that water is available at all times. In addition, the availability of water must have a sufficient quantity of it, normally with distances between furrows of 1.6m using drip irrigation strip, which is the most common today with an expenditure of 360 to 450 LPH (liters per hour in 100 m) it is required from

0.8 to 1.2 LPS (liter per second) per hectare depending on temperature, crop, phenological stage and soil type (12).

2.1.7. irrigation methods

The irrigation methods can be considered as the application to the soil for the development of crops and these are: a) Surface or gravity irrigation: the water is distributed over the surface of the field by gravity, that is, through furrows, flood, boxes and terraces, among others; b) Sprinkler irrigation: the water is distributed in the form of artificial rain through special spray equipment; c) Drip irrigation: the water is supplied in the form of drops directly to the root zone of each plant (13).

Irrigation is the activity most used by man for the production of food. It is an activity as old as the creation of man, we find that the Bible speaks of it in the book of Genesis 2: 10 when it says “A river came out of Eden that watered the Garden, from there it divided, and four arms were formed. The knowledge that we have about irrigation in agriculture acquires vital importance and we have the obligation to know how to take advantage of the water with which we irrigate (13).

Sprinkler irrigation is a mechanized or pressurized irrigation method, since it requires mechanisms that generate pressure to move the water. With this irrigation method, it is not necessary to level the soil, and a newly planted paddock can be irrigated without causing erosion or seed run-off problems, if the appropriate sprinkler is used (14).

2.1.8. Micro-sprinkler irrigation

Micro-sprinkler irrigation was born as an adaptation of the sprinkler irrigation system, where the application of water to crops is an imitation of rain. Micro-sprinklers are responsible for converting the flow of water to small drops with a range of no more than 5 meters, making them ideal for greenhouse crops, mainly for leafy vegetables, irrigation in gardens or fruit crops (15).

It is considered one of the most versatile irrigation methods due to its easy adaptation to all types of terrain, regardless of whether they have large slopes and slopes, self-compensated micro-sprinklers achieve a fairly high percentage of irrigation uniformity compared to any type of conventional irrigation. Among other benefits are the following: greater savings and efficiency of water use compared to any other system, ability to create microclimates, visual control over the malfunction of any micro-sprinkler, adaptable to all stages of crop growth as required, greater control of weeds and foliar diseases (15).

The pepper crop is relatively very jealous of nutrition and water management; therefore, it is advisable to keep track of both factors. Any imbalance of the same will be quickly reflected in the yield or also in the presence of both radical and aerial fungal diseases (16).

Sprinkler irrigation systems can be a very efficient alternative to keep crops in good condition. The correct irrigation of the crops is absolutely essential to have a successful harvest; for this reason, it is necessary to find a system that fits your needs and the characteristics of your production (17).

2.1.9. Effect of irrigation on crop yield

Plants draw water from the soil and this need will be determined by a variety of factors such as ambient temperature, weather, light intensity, wind, atmospheric humidity, the amount of water that the plant uses to grow and the dissolution of minerals and organic inputs that it will retain in its structure, returning unusable water to the atmosphere through transpiration (12).

The irregular supply of water, due to excess or lack, can cause forced defoliation of flowers and fruits and the appearance of apical necrosis, rarely frequent irrigations. The greatest sensitivity to water stress occurs during the flowering and fruiting phases, where the vegetative growth phase is less sensitive to water scarcity. The lack of water causes a decrease in yield in quantity and quality by reducing the number of fruits and/or unit weight, by increasing the proportion of non-commercial and industrial fruits by lowering the pH and increasing the water content (12).

When the soil does not have a sufficient amount of water or its availability through rain or natural sources is not opportune, irrigation is necessary. Irrigation is the artificial supply of water to crops. The irrigation system depends on the type of soil, the crop, the amount of water needed, the available workforce and economic resources, since an irrigation system represents a considerable investment in the agricultural business. Irrigation not only implies the cost of its installation but also its maintenance (18).

Crops have critical moments for their water needs that, if not corrected, translate into losses in yield or lack of germination. In the current drought conditions in our country, the needs of irrigation districts in different areas are evident. There is gravity irrigation, which consists of the supply of water through continuous flow pipes or hoses, which supply water to the land either in the furrows or in the streets. Similar to this system is flood irrigation, which is used in crops such as rice (18).

Drip irrigation that can be on the surface or underground and consists of the distribution of water through hoses and drippers strategically located in the area of absorption by the plants. Also by sprinkling, which deals with the distribution of water through specific points through sprinklers that simulate the fall of rainwater (18).

2.1.10. Availability of water in the soil

Water is the main constituent of living beings, among which are plants, occupying between 75% and 90% of plant tissue, depending on the species. At the same time, it is essential to carry out vital processes such as photosynthesis, hydrolysis of substances, regulation of turgor, transport of nutrients and hormonal substances, regulation of temperature through perspiration, etc. The soil is the storage reservoir for water, air and nutrients from where plants extract them. The storage capacity and availability for plants depends on the existing quantities and the characteristics of each soil (19).

Therefore, it is necessary to know how the soils are constituted and the forces that act in the retention and movement of water. From the agricultural point of view, the soil is a complex, dynamic and living system, formed by a thin superficial layer, which is located on the lithosphere and on which the growth of plants and the production of food, fiber, fodder, wood, etc. depend. Soil properties can be maintained, worsened or improved based on various physical, chemical and biological processes (19).

2.1.11. Crop water needs

The need for irrigation water is the amount of water that must be supplied to a crop to ensure that it receives all of its water needs or a certain fraction of them. When irrigation is the only water supply available, the need for irrigation water will be at least equal to the water needs of the crop, being greater when there are losses (runoff, percolation, lack of uniformity in distribution, etc.), and lower when the plant can meet its water needs from other resources (rain, water reserves in the soil, etc.) (20).

Therefore, in order to plan irrigation, both in terms of frequency and dose, it is necessary to know the water needs of crops, that is, the amount of water they require for optimal development (20).

2.1.12. Irrigation requirement in pepper cultivation

The water requirements for a good production of the pepper crop are between 600 and 1250 mm per year, pepper is sensitive to water stress, both due to excess and deficit of moisture. An irregular supply of water can cause the fall 13 of flowers and fruits recently set and the appearance of apical necrosis, with little copious and frequent irrigation being advisable (12).

Useful water for plants represents the amount of water present between the difference between the field capacity point and the permanent wilting point. This volume of water contains water that is readily available to plants, that is, the volume of water that plants can absorb with low absorption (0.5-1 atm). Depending on the total amount of beneficial water and the plant, between 30 and 50% of the water is readily available to plants (12).

2.1.13. Humidity of ground

Soil moisture is a vitally important factor for proper plant development, which directly affects yield, since, without the necessary moisture to be used by plants, they do not grow properly. The soil's moisture retention capacity is used by plants and is called usable moisture, which varies according to the type of soil and the practices carried out in the production system (16).

Soil moisture content determines the amount of water present in the soil and moisture potential shows the degree to which water adheres to soil particles as they affect soil air content and salinity. The values of moisture content and potential are important to know in an agricultural system, thereby establishing the frequency of irrigation and the amount of water applied, for each plant species (16).

2.1.14. Optimum pH levels in the soil for pepper cultivation

Peppers do not have strict soil requirements. They grow well in a wide variety of soils. However, the plant thrives best in medium to sandy soils with adequate aeration and drainage. It is a plant sensitive to both drought and waterlogged soils. Optimal pH levels range from 6 to 7; however, we do have cases where plants can tolerate extreme pH levels close to 5.5 or 8 (10).

2.1.15. Saturation

In this case, all the porosity of the soil (macro, meso and micro pores) is occupied by water. At the field level, this condition resembles a wet or saturated soil, which does not allow mechanization. If this condition persists in the soil, the plants are affected in their development. After a heavy rain, most soils temporarily reach their saturation point (12).

2.1.1. Field Capacity (DC)

When this point is reached, the ground is said to be at Field Capacity (FC). Much of the water retained in FC can be used by plants; but, as the water decreases, a point is reached where the plant cannot absorb it. In this state, the soil is said to be at wilting point. The difference between the FC and the wilting point represents the fraction of useful (available) water for the crop (21).

FC and wilting point values can be expressed as percentages of dry soil weight. Thus, a field capacity of 27% means that 100 g of dry soil retains 27 g of water, and a wilting of 12% means that, when plant wilting is reached, the soil has 12 g of water per 100 g. of dry land. The useful (available) water for the plant would therefore be 15 g of water per 100 g of dry soil (21).

2.1.2. Permanent Wilting Point (PWP)

The permanent wilting point (PWP) is the negative potential for the available water in the soil since the leaves do not recover their green hue. In fact, the value of PMP depends on the climatic conditions of the soil and the hydraulic conductivity. If the soil does not receive a new supply of water, evaporation from the soil and extraction of roots cause the water supply to decrease to the point where the roots cannot absorb the water. The wilting point is not a fixed value for a particular type of soil but varies according to the type of crop. The finer the texture, the higher the soil-water ratio, both in field capacity and permanent wilting point. Good soil structure also increases beneficial water content (22).

2.1.3. Evaporation

Evaporation is the primary process by which water changes from a liquid to a gaseous state. Evaporation is the reason why liquid water from the oceans enters the atmosphere, in the form of vapor, returning to the water cycle. Several studies have shown that the oceans, seas, lakes and rivers provide about 90% of moisture to the atmosphere via evaporation; the remaining 10% comes from plant transpiration (23).

The heat (energy) is necessary for it to prevent evaporation. The energy is used to break the bonds that hold water molecules together, which is why water evaporates more easily at the boiling point (100ºC, 212ºF), but evaporates more slowly at the freezing point. When the relative humidity of the air is 100 percent, which is the saturation point, evaporation cannot continue to occur. The evaporation process takes heat from the environment, which is why the water that evaporates from the skin during perspiration cools you down (23).

2.1.4. Perspiration

Transpiration is a primary determinant of leaf energy balance and plant water status. This process includes the evaporation of water from the surface cells inside the intercellular spaces and its diffusion outside the plant tissue mainly through the stomata and to a lesser extent through the cuticle and lenticels. Together with the exchange of carbon dioxide (CO), it determines the water use efficiency of a plant. The leaves lose water through their stoma as a consequence of the photosynthetic activity of the mesophyll cells. Stomata exert the greatest short-term control over a plant's water relations because they control the outflow of water that occurs in response to a strong vapor pressure difference (VPD) gradient between the air and the leaf (24).

2.1.5. Evapotranspiration (ETc)

The term evapotranspiration encompasses the evaporation of water intercepted by vegetation, evaporation of water from the ground, and transpiration from vegetation. It is an important variable because it links the water cycle, the energy cycle and the carbon cycle. Being accurately quantified, it can contribute to better management of water resources and improve predictions and mitigation of climate change. The variables of greatest magnitude of the hydrological cycle are usually precipitation, flow and evapotranspiration. To quantify precipitation and flow, rain gauges and weirs, respectively, are commonly used (25).

The most used methods to measure evapotranspiration are “eddy-covariance” and lysimeters. The first measures with high resolution the amount of water vapor (evaporation) from turbulent winds; while the lysimeters are cylinders of undisturbed soil and vegetation sample in which, knowing the precipitation, a balance is made water, where evapotranspiration is equal to precipitation minus the amount of water that drained from the lysimeters and minus the difference in the water stored inside the lysimeters (in a given period of time) (25).

2.1.6. Harvest

The first fruits of the "Cubanelle" type pepper can be ready to harvest 60 to 70 days after transplanting, while in the "bell" type pepper it can take around 70 to 80 days. After a pepper flower opens and is pollinated, it will take 35 to 50 days for the fruit that develops from it to be ready to harvest. These periods of time depend on the variety that is planted (26).

Peppers are generally harvested when the fruits are fully developed in size, and physiologically set, but still green in color (green set). They should feel firm and crisp when slightly squeezed and their skin shiny. Some markets, particularly for the "bell" type pepper, prefer them when they are completely red when ripe (yellow, orange, purple or brown in some varieties) (26).

The efficiency of the operation depends on the use of an experienced or trained human team and the adoption of methods that satisfy the needs of the buyers. The general objective of the harvest is to obtain a fruit with excellent physical and chemical conditions for an increasingly demanding market. To achieve this objective, it is necessary to (12):

- Use proper tools.
- Select fruits according to the established maturity index.
- Harvest at the right time of day.
- Handle the fruits in an appropriate way, avoiding mechanical damage as much as possible

2.1.7. Performance

In the "Evaluation of the yield of the pepper crop (Capsicum annuum L.) under three levels of chemical fertilization and three planting distances", the treatment planting distance 0.45 x 0.80 m and high fertilization reached the highest average with 100 %, statistically similar to the remaining treatments, with the exception of the treatment planting spacing 0.15 x 0.80 m and medium fertilization, planting spacing 0.30 x 0.80 m and high fertilization and planting spacing 0.45 x 0.80 m without fertilizer, with the lowest average of 93.67 % (27).

In a study carried out, the yield and quality of 15 pepper genotypes grown under greenhouse conditions were evaluated. The data show a wide variability between the genotypes in terms of days at the beginning of the harvest (74 - 83 days after transplant), number of first quality fruits per plant (2.00 - 7.25), average weight of the fruit of first quality (171.15 – 243.45 g), and commercial yield (44.29 – 77.34 ton/ha) and total (55.13 – 90.45 ton/ha). The genotypes that presented a higher number of first quality fruits per plant were XC-425, MACR103-07 and Vikingo (7.25; 5.63; and 5.38, respectively). The genotypes that produced the highest commercial yield were XC-425 and Vikingo (77.34 and 75.37 ton/ha, respectively) (28).

2.1.8. Applied biophysics in agriculture

The Crop Booster device is a non-chemical catalyst that was born as a result of 30 years of research, improves the absorption of nutrients and the cellular metabolism of plants, using precise frequencies to tune the molecular vibrations inherent in plants for their optimal functioning (29).

The technology consists of more than 3,000 unique harmonic signals that are programmed into small alloy steel disks through special equipment, which are connected to the irrigation system and carry the signals through the water to the soil and plants. These signals help plants grow stronger, healthier, and faster, with less fertilizer and pesticides (29).

2.1.9. Benefits of the Crop Booster Micro Transmitter

The greatest benefit of this microtransmitter is in the soil, since it gives it greater oxygenation, allowing it to generate more roots and improve water infiltration, achieving significant savings. In addition to reducing pests and diseases, the device lowers electrical conductivity from 2.3 to 1.7 and sodium from 1.1 to 0.6, leaving the plant free of salts (29).

2.1.10. Operation of the Crop Booster device

The device works on different principles than an IR spectrometer, but it also measures frequencies that are emitted by vibrational bonds between atoms. It focuses on a delivery system for the frequency. Water, by its polar nature (a slight positive charge on one side and negative on the other), proves to be very effective; therefore, any moving charged object will create a magnetic field. When the microtransmitters are mounted on the metal pipe of an irrigation system, the small magnetic field created by the flowing water passively extracts the information stored in the microtransmitters and carries it to the plants (30).

Over 3,000 separate frequencies are programmed into the micro transmitters. The signals are emitted in pulses that act sequentially on the plants providing the desired "tuning" effect. In other words, certain frequencies produce a change in a plant that will allow it to absorb a different set of frequencies and so on until normal vibrational frequencies are reached. This interaction is simply defined as "a combination of frequencies that travel together in pulses that provide sequenced instructions for ideal plant function at the molecular level" (30).

2.1.11. Natural frequency waves

A vibrating object can have one or more natural frequencies. These can be used as simple harmonic oscillators to model the natural frequency of an object. In physics, frequency is a property of a wave, consisting of a series of peaks and troughs. The frequency of a wave refers to the number of times a point on a wave passes a fixed reference point per second (30).

2.1.12. Frequencies Transmitted by the micro transmitter

Plants emit electromagnetic fields of specific frequencies, which occur through an individual organism and maintains it in perfect balance, by regulating all its vital processes. The frequencies emitted by each organ produce a communication that ensures optimal survival for a particular organism (29).

2.1.13. Adaptation of the Crop Booster device in the irrigation system

This device can be adapted to any type of property without making general modifications, under the type of technified or furrow irrigation, it resists a flow rate of up to 2,600 gpm (173 lts/s), the length of the property and the flow rate is what is important to evaluate the amount of Crop Booster at the time of installation (29).

Agricultural irrigation, due to its relationship with the use, management and conservation of water, is one of these areas within agriculture that requires further studies, technological advances and their application without damaging the environment. Irrigation is considered as a science, in some countries irrigation was established as an activity of vital importance (14).

2.1.14. New technologies applied in agriculture

One of the most significant changes of the last decades is that technology has advanced exorbitantly, in all sectors and at many levels. This has improved people's quality of life and, in our sector, agriculture, crop yields. Every day new devices and systems are developed with the aim of facilitating the work of the farmer, since these can detect, in part, the needs of our crop (31).

Through the introduction of technologies applied to agriculture, production systems have evolved not only in the results of their crops, but even in the profitability of the business with greater efficiency. These technologies applied to agriculture, is also known by the term agrotechnology, and has had a great place in recent times due to the applications that have been developed to carry out agricultural practices (32).

CHAPTER III
RESEARCH METHODOLOGY

3.1. Location

The present research work was carried out during the dry season, at the “La María” Campus, premises of the State Technical University of Quevedo, located at kilometer 7½ of the Quevedo el Empalme road, Mocache canton, province of Los Ríos, located in the geographic coordinates 01°03'18" south latitude and 79°25'24" west longitude, at 75 meters above sea level.

Figure 1: Satellite photograph of the study area experimental farm La Maria of the UTEQ
Source: Google Earth

Table 1: Climatic characteristics of the study area.

Parameters	Characteristic
Average annual temperature	24.9° C
Average annual rainfall	2295.1 mm
Annual average heliophany	870.2 hours
RH annual average	84%
Soil type	Clay loam
Ecological zone	BH-T
Topography	flat

Source: Meteorological Station “Pichilingue” -INAMHI Multiannual Series, 1990- 2019

3.2. Kind of investigation

The research was experimental and comparative, contributing to the line of research and the use of new technologies applied in the agricultural area, where the effects of the Crop Booster device in the irrigation system were evaluated, which was established in the cultivation of pepper.

3.3. Research method

The deductive method was used to obtain general information on the use of Crop Booster technology in the micro-sprinkler irrigation system in pepper cultivation; In addition, the observation method was used to count the fruits per plant and the number of leaves with the technology and without the technology.

3.4. Source of information collection

For the present study, direct observation was used as the primary source, while the secondary sources were the following: books, scientific journals, theses, research bulletins, etc.

3.5. Research instruments

3.5.1. Factors under study

Two factors will be studied:

A-Factor (Implementation and non-implementation of the Crop Booster device)

B-Factor (pepper varieties): V1: California Wonder V2: Cubanelle V3: Marconi

3.5.2. Treatments under study

With the combination of the two factors, 6 treatments will be established, which are detailed below:

T1: (Variety Cubanelle + Crop Booster)

T2: (Marconi variety + Crop Booster)

T3: (California wonder variety + Crop Booster)

T4: (Cubanelle variety without Crop Booster)

T5: (Marconi variety without Crop Booster

T6: (California wonder variety without Crop Booster)

3.6. Experiment Design

The Divided Plots design was used, corresponding to the main plots the irrigation systems (with the Crop Booster device and without the device) and to the subplots the 3 varieties of pepper. The test was carried out with 4 repetitions, all the variables were subjected to the analysis of variance to determine the statistical significance and the Tukey test at 95% probability for the comparison of means of the factors and interaction.

3.7. Scheme of Analysis of Variance

Table 2 presents the variance analysis of the selected design.

Table 2: Analysis of variance scheme

Sources of Variation	Degree of Freedom
Repetitions	3
Crop Booster System (PG)	1
Error (a)	3
Main Parcels	7
Varieties (SP)	2
Interac (System x Variety)	2
Experimental error	12
Total	23

3.7.1. Experimental Design

The following table indicates the outline of the experimental plot with the most relevant values:

Table 3: Experiment outline

Characteristic	**Quantity**
Total area	385.2m2
Total usable area	86.4 m2
Useful area of the subplots	4.80m
Planting Distance	0.40m x 0.60m
Rows by subplots	4
Useful rows by subplots	2

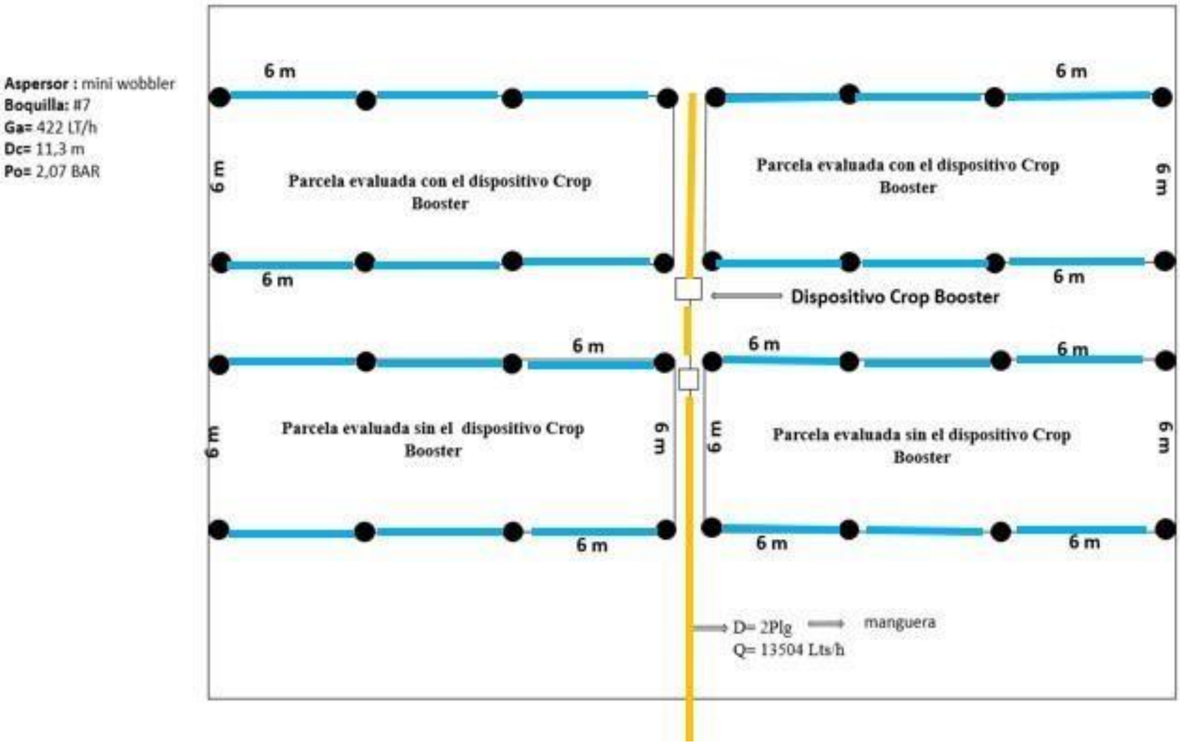


Figure 2: Hydraulic design of the irrigation system

3.8. Experiment Management

3.8.1. Hotbed

For the implementation of the seedbed, disposable cups with holes and seedbeds were used, the mixture of the sand and soil substrate appropriate for seedbeds was made. The nursery was provided with good shade and ventilation.

3.8.2. Transplant

The right time to transplant was when 5 to 6 true leaves appeared and were about 15cm tall. The seedlings were placed in rows approximately 0.40 m apart between plants and 0.60 m between rows.

3.8.3. Irrigation

The microsprinkler irrigation system was used, which was already installed in the experimental area. The irrigation frequency that was applied was passing 1 day, turning on the system for an hour and a half, supplying the water needs of the crop of 3.47 mm/day. This was calculated manually using the irrigation interval formula.

3.8.4. Fertilization

Evergreen systemic biostimulant was applied at the doses specified for the experiment, 15, 30 and 45 days after transplantation.

3.8.5. Weed control

Weed control or weeding was carried out every 15 days, removing them manually with the help of a hoe, machete and rake.

3.8.6. Insect and disease control

The control of insects according to the incidence was carried out with a chlorpyrifos insecticide at a dose of 750 cc/ha for the control of the cutworm and, according to the incidence of diseases, the control was carried out with systemic insecticides and fungicides.

3.8.7. Harvest

Two harvests were made when the crop reached its physiological maturity and the fruits were suitable for marketing.

3.9. Recording of data and forms of evaluation

3.9.1. Plant height

Five plants were taken at random in each useful plot, then measured from the soil level to the apex of the youngest leaf. This was done with the help of a measuring tape.

3.9.2. Number of days to flowering stage

The number of days elapsed was counted, from sowing in the nursery until the plants presented their first flowers within the useful area of each experimental plot, which appeared on day 65.

3.9.3. Number of days to fruiting stage

The counting of the number of days elapsed from sowing in the nursery until when the plants presented their first fruits within the useful area of each experimental plot, which occurred on day 80, was performed.

3.9.4. Fruit length (cm)

The length of 5 randomly chosen fruits within the useful area of each experimental plot was measured, from the neck of the fruit to its base and was taken in (cm).

3.9.5. Fruit weight (gr)

Five randomly chosen fruits were weighed within the useful area of each experimental plot in the first and second, averaging the means obtained and their weight was expressed in grams.

3.9.6. Number of fruits per plant

Five plants were randomly considered within the useful area of each experimental plot. The number of fruits of each plant in each of the 2 harvests was recorded and the total value was averaged.

3.9.7. Yield (kg/ha)

The yield was determined by the weight of the fruits that were obtained from the useful area of each experimental plot and were expressed in (kg/ha).

3.10. Human and material resources

3.10.1. Human Resources

- Director of the Research Project.
- Student responsible for the research project.
- Field workers.

3.10.2. Genetic material

- **California wonder**

Fruits with four hulls, thick, very fleshy, with an intense color. Red in color when ripe. Sweet and consistent meat. Annual herbaceous plant, although after pruning it can be grown as a biennial. Erect stem, determined growth, with a height that varies according to conditions and variety. It branches at each node and the older parts are slightly lignified.

- **Cubanelle**

Fruits of elongated and conical shape that usually reach 5 to 7 cm (13-18 cm) in length. It tends to twist and bend as it grows, giving it a unique, rustic appearance.

- **Marconi**

fruits are colored red, long with a mild flavor. If they are eaten green, they taste sweet, and red, an even sweeter taste. Occasionally the variety can also produce pungent fruit.

3.10.3. field material

Table 4: field materials

Materials	**Quantity**
Seeds	2
String rolls	3
Flexometer (flexible measuring tape)	1
Rake	1
Shovel	1
Pump	1
200-liter tank	1
Stopcocks	2
Seedbeds	8
Machete	2
Crop Booster device	1

CHAPTER IV
RESULTS AND DISCUSSION

4. Results

4.1.1. Plant height

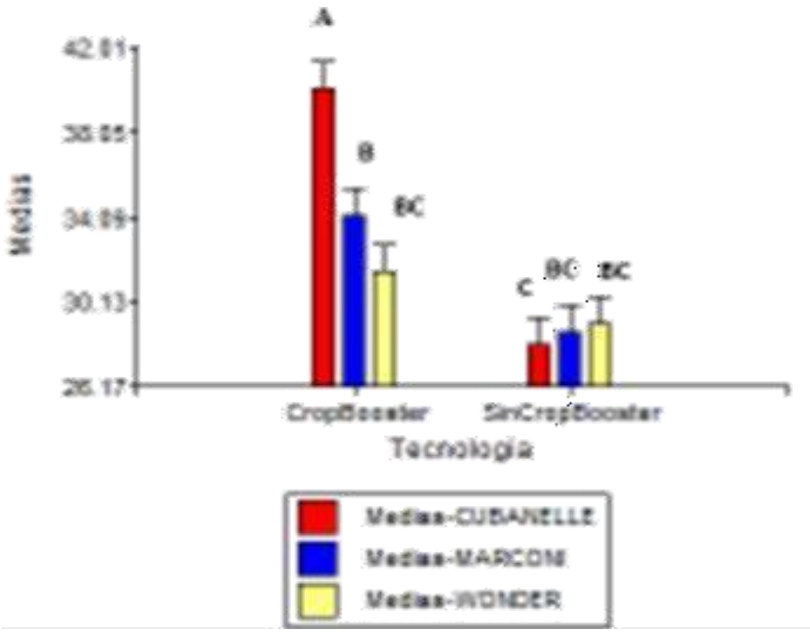
According to the analysis of variance, the Crop Booster and control irrigation systems without Crop Booster, varieties and interaction, showed statistical significance. Being the coefficient of variation 7.69%

With the irrigation system provided with the Crop Booster device, it reached taller plants with 40.7cm, statistically superior to the system without the device with plants of 29.10 cm.

The Cubanelle variety registered the tallest plants with 40.7cm in statistical equality of the other varieties that reached heights of 28.70 to 29.10 cm.

The interaction between the Cubanelle Marconi and Wonder varieties with the Crop Booster device presented the tallest plants with 40.7cm, 34.15cm and 31.55cm, statistically higher than the other treatments with plants between 29.10, 28.12cm and 28.70cm, which were control treatments without the device.

Figure 3: Plant height (cm) of three pepper varieties (Capsicum annuum L.) in response to the application of the Crop Booster device installed in the irrigation system.



Means with a letter in common are not significantly different at $p<0.05$ (Tukey's test)

4.1.2. Number of Days to Flowering Stage

In order to know the effect that occurred between the pepper varieties and the Crop Booster device, the time elapsed from the transplant date to the flowering days was taken into account, it was considered that the plants have a 50% presence of flowers for data collection of days elapsed.

According to Table 5, the Marconi and Wonder varieties with the Crop Booster device flowered 23 days after transplantation, while the Cubanelle variety flowered 27 days after transplantation. The control treatment took longer than the other varieties to reach 50% flowering. Among them, the one that took the longest time to reach its stage was the Cubanelle variety, since its flowers appeared 35 days after the transplant.

Table 5: Number of days to the flowering stage of three pepper varieties (Capsicum annuum L) in response to the application of the Crop Booster device installed in the irrigation system.

TREATMENTS	BLOOM	TRANSPLANT DAY	FLOWERING DATE	DAYS PASSED
VARIETY +DEVICE (CB)	**(%)**			
MARCONI	50	27-10-2021	19-11-2021	23
WONDER	50	27-10-2021	19-11-2021	23
CUBANELLE	50	27-10-2021	23-11-2021	27
VARIETY WITHOUT DEVICE (CB)				
MARCONI	50	27-10-2021	24-11-2021	29
WONDER	50	27-10-2021	24-11-2021	29
CUBANELLE	50	27-10-2021	30-11-2021	35

4.1.3. Number of Days to Fruiting Stage

Once the plant has entered the fruiting stage, the day of sowing was taken into account to the day of the fruiting stage. For this, it was considered that all plants have 50% presence of fruits for data collection.

Table 6 shows that the varieties with the device reached 50% of the stage, taking into account that the Cubanelle variety took 4 days longer than the Marconi and Wonder varieties, since these occurred on day 70 after planting, while the varieties without the device took 2 to 7 days apart to have 50% fruiting on the plants.

Table 6: Number of days to the fruiting stage of three pepper varieties (Capsicum annuum L.) in response to the application of the Crop Booster device installed in the irrigation system.

TREATMENTS	FRUITING	PLANTING DAY	DATE OF FRUITING STAGE	DAYS PASSED
VARIETY +DEVICE (CB)	**(%)**			
MARCONI	50	09-19-2021	29-11-2021	70
WONDER	50	09-19-2021	29-11-2021	70
CUBANELLE	50	09-19-2021	29-11-2021	70
VARIETY WITHOUT DEVICE (CB)				
MARCONI	50	09-19-2021	30-11-2021	71
WONDER	50	09-19-2021	01-12-2021	72
CUBANELLE	50	09-19-2021	05-12-2021	77

4.1.4. Number of Number of Leaves

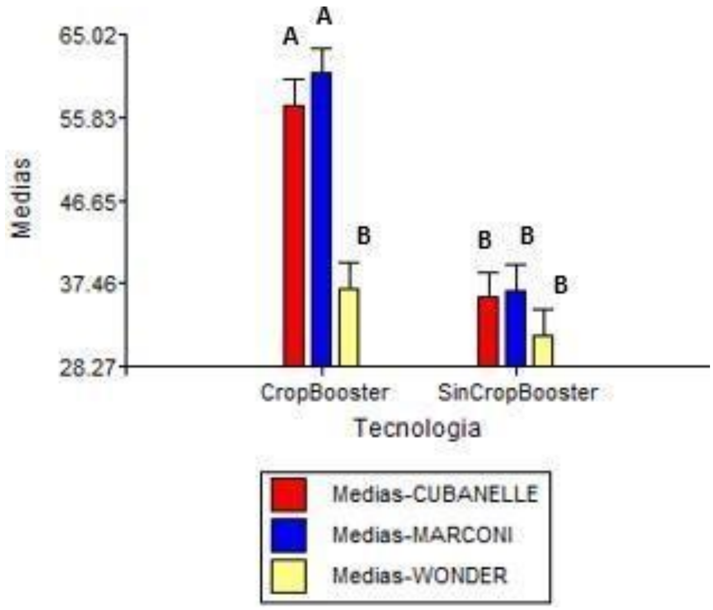
In figure 4, the averages of the use of the Crop Booster device and without the device in the aforementioned variable are shown, carrying out the variance analysis of the treatments that present statistical significance, with the variation coefficient being 13.15% at 100 days after the sowing.

With the irrigation system installed, the Crop Booster device reached plants with a greater number of leaves of 60.70 and 57.20, statistically superior to the system without the device with plants which only had 31.65 leaves.

The varieties that had the best performance was Marconi and Cubanelle, registering plants with the highest number of leaves with 60.70 and 57.20 in statistical equality with the other varieties that reached 36.65 to 31.65 leaves per plant.

The interaction between the Marconi and Cubanelle varieties plus the irrigation system with the Crop Booster device presented the plants with the highest number of leaves with 60.70, 57.20 and 36.85, statistically higher than the other treatments with plants between 36.65, 35.85 and 31.65 leaves, which were control treatments without the device.

Figure 4: Number of leaves of three varieties of pepper (Capsicum annuum L.) in response to the application of the Crop Booster device installed in the irrigation system.



Means with a letter in common are not significantly different at P<0.05 (Tukey's test).

4.1.5 Fruit Length

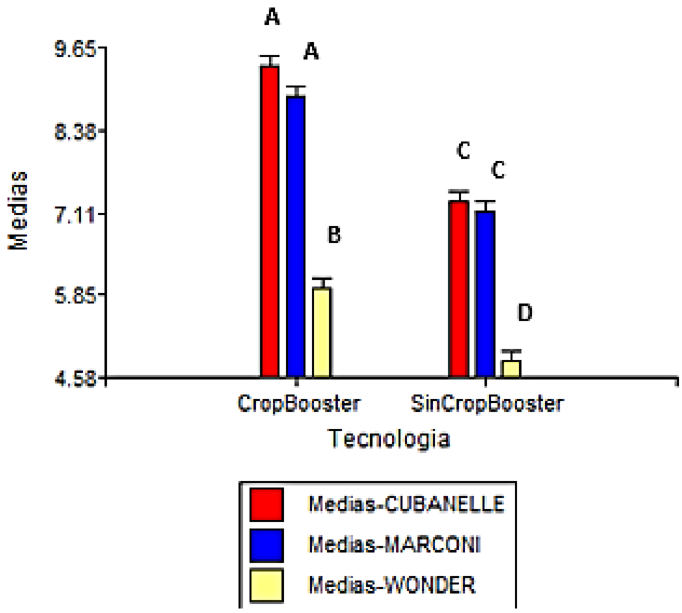
Figure 5 indicates the averages of the use of the Crop Booster device and without the device in the aforementioned variable, carrying out the variance analysis of the treatments that present statistical significance, the variation coefficient being 4.51%.

The Crop Booster device installed in the irrigation system reached fruits with a maximum length of 9.37 cm, statistically surpassing the system that did not have the device, which only reached 7.28 cm in length.

The variety that had the best performance was Marconi and Cubanelle, registering plants with greater length of fruits with 9.37cm and 8.82cm, in statistical equality of the other varieties that reached lengths of 4.28cm to 7.28cm.

The interaction in the Cubanelle and Marconi varieties with the Crop Booster device installed in the irrigation system presented longer fruits with an average of 9.37 cm and 8.89 cm and 5.95 cm, highlighting that it was the best treatment, statistically surpassing the other treatments with lengths between 7.28 cm, 7.13 cm and 4.82, which were control treatments without the use of the device.

Figure 5: Fruit length (cm) of three pepper varieties (Capsicum annuum L.) in response to the application of the Crop Booster device installed in the irrigation system.



Means with a letter in common are not significantly different at P<0.05 (Tukey's test)

4.1.6. Fruit Weight (gr)

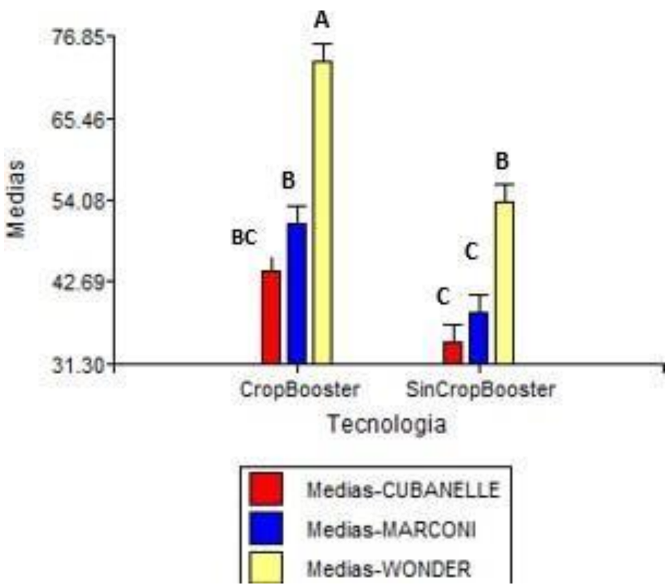
Figure 6 shows the weight of the fruit, the averages of the use of the device in the irrigation system and without the device in the evaluated variable, performing the analysis of variance of the treatments that presented statistical significance, with a coefficient of variation of 9.84%.

The Crop Booster device with the varieties reached fruits with a weight of 73.22 grams, statistically surpassing the system that did not have the device, which only weighed 34.46 grams per fruit.

The variety that performed best was Wonder, registering the highest weight of fruits with a maximum of 73.22 grams in statistical equality of the other varieties that reached lengths of 53.85 grams to 34.46 grams.

The interaction in the Wonder, Marconi and Cubanelle varieties with the Crop Booster device presented fruits of greater weight in grams, reaching an average of 73.22 gr, 50.90 and 44.32g, highlighting that it was the best treatment statistically with the use of the irrigation system more the device, surpassing the other treatments with weights between 34.46g and 38.45g, which were control treatments without the use of the device.

Figure 6: Fruit weight (gr) of three pepper varieties (Capsicum annuum L.) in response to the application of the Crop Booster device installed in the irrigation system.



Means with a letter in common are not significantly different at P<0.05 (Tukey's test)

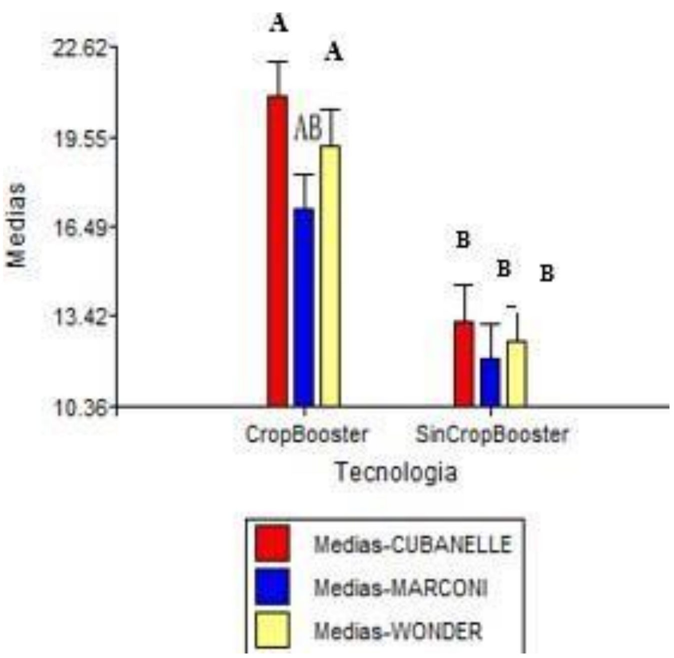
4.1.5. Number of Fruits per Plant

Figure 7 shows the number of fruits per plant of each variety with the Crop Booster device and without its use, performing the analysis of variance for the treatments that present statistical significance, with a coefficient of variation of 15.36%.

With the irrigation system installed the Crop Booster device, the number of fruits per plant with the highest average was 20 fruits, being one of the highest averages statistically, the system without application of the device presented plants that had 11 to 13 fruits.

The interaction in the Wonder, Cubanelle and Marconi varieties with the Crop Booster device presented a greater number of fruits per plant, reaching an average of 20, 19 and 17 fruits, highlighting that they were the best treatments statistically with the use of the irrigation system with the device surpassing the other treatments with 13, 12 and 11 fruits, which were control treatments without the use of the device.

Figure 7: Number of fruits per plant of three varieties of pepper (Capsicum annuum L.) in response to the application of the Crop Booster device installed in the irrigation system.

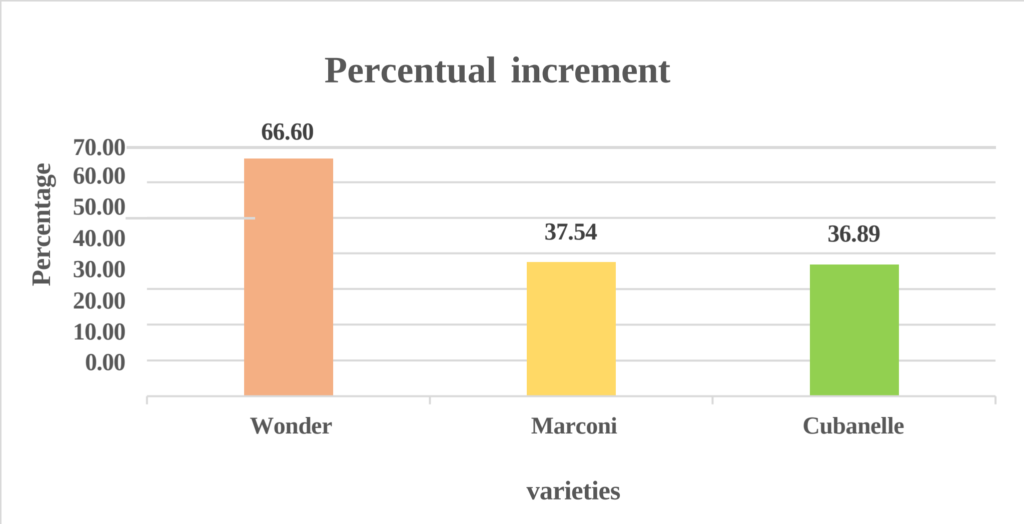


Means with a letter in common are not significantly different at P<0.05 (Tukey's test).

4.1.6. Percentage Increase in Yield of Pepper Varieties

Figure 8 represents the percentage increase obtained by the different varieties of pepper after the application of the Crop Booster technology. The variety that reached the highest increase was the Wonder variety, which obtained a difference of 74,767.76 kg/ha, which represents 66.60%; On the other hand, the Cubanelle variety achieved a difference of 29,517.24 kg/ha, representing 36.89% of the increase in yield, this being the lowest.

Figure 8: Percentage increase in the yield of the varieties in the cultivation of pepper (Capsicum annuum L.)



4.1.7. Yield (kg/ha)

Figure 11 shows the yield of the varieties with the use of the device in the irrigation system and without the device, performing the analysis of variance, the varieties and the interaction presented statistical significance at levels 0.01 and 0.05, but not the irrigation systems. The coefficient of variation was 20.26%

The varieties with the Crop Booster device registered a yield of 38,513.89 kg/ha, statistically surpassing the system that did not have the device with an average of 29,892.22 kg/ha.

The Wonder variety reached the highest yield with 35,554.5 kg/ha in statistical equality of the Marconi variety 32,877.0 and superior to Cubanelle, which registered the lowest yield with 23,915.70 kg/ha.

The interaction in Wonder variety and the Crop Booster device presented a greater response in yield per hectare, reaching an average of 42,154.5 kg/ha, statistically higher than the other interactions that registered averages between 20,317.5 for the Cubanelle variety without Crop Booster and 34,318.50 in the Marconi variety with Crop Booster.

Table 7: Yield kg/ha of three pepper varieties (Capsicum annuum L.) in response to the application of the Crop Booster device installed in the irrigation system

Treatments	**Yield kg/ha**
With Crop Booster	38513.89 a
Without Crop Booster	29892.22 b
VARIETIES	**kg/ha**
Wonder	35554.50 a
Marconi	32877.00 a
Cubanelle	23915.70 b
T1 (Crop Booster + Wonder)	42154.50 a
T2 (Crop Booster + Marconi)	34318.50 b
T3 (Crop Booster + Cubanelle)	27514.50 c
T4 (without Crop Booster + Wonder)	28954.50 c
T5 (without Crop Booster + Marconi)	31437.00 bc
T6 (without Crop Booster + Cubanelle)	20317.50 d

Means in each group with a letter in common do not differ at P<0.05 (Tukey test)

4.1.8. Economic analysis

Table 6 presents the economic analysis of the performance achieved by each treatment based on its costs. The Wonder variety with the Crop Booster device (T1) obtained the highest yield with 42154.50 kg/ha, which generated the highest gross income with $14754.50 at a total cost of $6212.99 and profitability of 137.51%. The Marconi variety registered 31437.0 kg/ha without the Crop Booster device, showing profitability 130.04% because the cost of treatments with the device increases by 33.33%. It should be noted that all treatments generated economic benefits and profitability greater than 99%.

Table 8: Economic analysis of the yield of the pepper crop (Capsicum annuum L.) with and without the Crop Booster Technology

Treatment	Yield, kg/ha	Yield, adjusted	Gross Income	Cost of treatment	Cost, variable	Cost, total	Benefit, Net	Benefit/ /Cost Ratio	Cost Effective- -ness (%)
T1 (Wonder +KPCB)	46838.33	42154.50	14754.07	375.00	5011.99	6211.99	8542.08	2.38	137.51%
T2 (Marconi +KPCB)	38131.67	34318.50	12011.48	375.00	4150.04	5350.04	6661.44	2.25	124.51%
T3 (Cubanelle +KPCB)	30571.67	27514.50	9630.08	375.00	3401.60	4601.60	5028.48	2.09	109.28%
T4 (Wonder, Control)	32171.67	28954.50	10134.08	125.00	3310.00	4510.00	5624.08	2.25	124.70%
T5 (Marconi, Control)	34930.00	31437.00	11002.95	125.00	3583.07	4783.07	6219.88	2.30	130.04%
T6 (Cubanelle, Control)	22575.00	20317.50	7111.13	125.00	2359.93	3559.93	3551.20	2.00	99.75%

System cost (useful life 2 years)	1000.00*	Resale price	0.35	/kg
Irrigation system installation	500.00	Harvest + trans	0.1	/kg
		Fixed cost	1200.00	/ha

4.2. Discussion

The optimal performance treatment demonstrated was the one that contained the implementation of the device in the irrigation system. The height of the pepper plants evaluated in the research showed significant differences. The Cubanelle variety within the technology was the one with the best performance with 40.7 cm, being one of the most robust varieties in terms of height. Unlike the other varieties Marconi and Wonder, these were not affected by technology, so their height did not change.

According to a study carried out by the author Vicente (2021), it shows that the study cultivars are statistically different in the variable height of the plant, the Padrón cultivar (44.8 cm) reached the highest value, followed by the Marconi (42.7 cm), Cubanelle (37.1 cm) and Yolo Wonder (32.1 cm) cultivars.

The number of fruits counted with the Crop Booster technology was the one that obtained the highest number of fruits per plant, having 17, 19 and 20 fruits per plant in each evaluated variety, while the treatment without the Crop Booster technology did not obtain a greater number of fruits by plants of the three varieties.

According to the study carried out by the author Vicente (2021), it shows that the Cubanelle (3 fruits) and Marconi (3 fruits) cultivars reached intermediate values of the number of fruits per plant in the first harvest, presenting equality between them, but statistically different with the other cultivars. cultivars Yolo Wonder (2 fruits) that presented the lowest value and Padrón (5) reaching the highest value, which can be attributed to the genetic characteristics of each cultivar.

In the weight of the fruit with the implementation of the Crop Booster technology, it gave greater weight in terms of the Wonder and Cubanelle variety with 73.22 grams, being the varieties that obtained the best performance, the information below demonstrates the similarity, considering the cultivars studied by the author Vicente (2021), Marconi (48.9 g) and Cubanelle (47.9 g) present intermediate values in fruit weight, presenting equality between them, but statistically different from the Padrón cultivars (22.6 g), being the one with the lowest value and Yolo Wonder (68.7 g), presenting the highest weight, which can be attributed to the genetic characteristics of each cultivar.

The yield obtained from each variety studied was with the purpose of knowing the production generated with the Crop Booster technology, denoting that with the application the yield increased 8621.67 kg/ha, on the application of the Crop Booster, agreeing with Vicente (2021), who maintains that the device enhances performance. The Wonder variety exceeded Marconi and Cubanelle by 8.14% and 48.66%, agreeing with Organiko Latam (2015), who stated that the peppers obtained an average of 25% larger than the control peppers, with 70% more yield in weight. The weight gain was due to thicker membranes, due to which the consumption time increased favorably from 10 to 15 days more than normal.

CHAPTER V CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

- With the application of the irrigation system with the Crop Booster device, the one that showed the greatest effect on the number of fruits was the Cubanelle variety with 20.9 units, with a fruit length of 9.37 cm, while the Wonder variety exceeded in weight to the Marconi and Cubanelle varieties. The variables of the crop without the application of the device reached a lower number of fruits, length and weight.

- In the yield of the pepper crop, the treatment that included the device was superior in 8621.67 kg/ha, while in the varieties with the device Wonder exceeded with averages between 7835.5 and 21837 kg, ratifying the effect of the device and the use of a variety with great yield potential.

- The system with the Crop Booster device with the Wonder variety obtained the highest profitability with 137.51%, followed by the Marconi variety without the device with 130.04%. All other treatments achieved returns higher than 99.75%

5.2. Recommendations

- Use the Crop Booster technology in the irrigation system due to the increase in yield and confirm its use in other crops of agricultural interest.

- Design a hydraulic design for the irrigation system so that the use of irrigation water is efficient in quantity and quality, including the Crop Booster system in comparison with Control treatments.

- Apply the use of new technologies in agriculture to improve the production of all types of crops, allowing experience in the application of irrigation and increasing profitability.

CHAPTER VI
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6.1 Bibliography

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CHAPTER VII
ANNEXES

7.1 Annexes

Annex 1. Land cleaning

Annex 2. Determination of Soil Field Capacity

Annex 3. Land preparation prior to planting

Annex 4. Flow measurement of the irrigation system

Annex 5. Crop Booster Device Installation

Annex 6. Mix of the substrate for seedbed

Annex 7. Sowing in seedbeds

Annex 8. Germinated plants in seedbeds

Annex 9. Appearance of the first 5 leaves

Annex 10. Soil preparation for transplanting

Annex 11. Seedlings suitable for transplanting

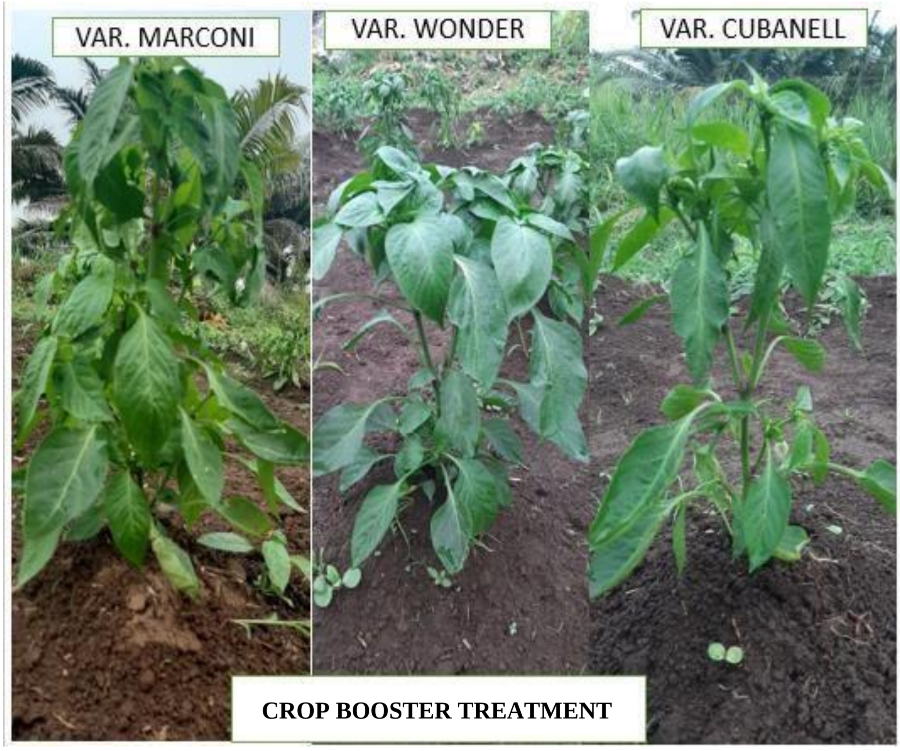
Annex 12. Plants in the open field

Annex 13. Cultural work hilling in the crop

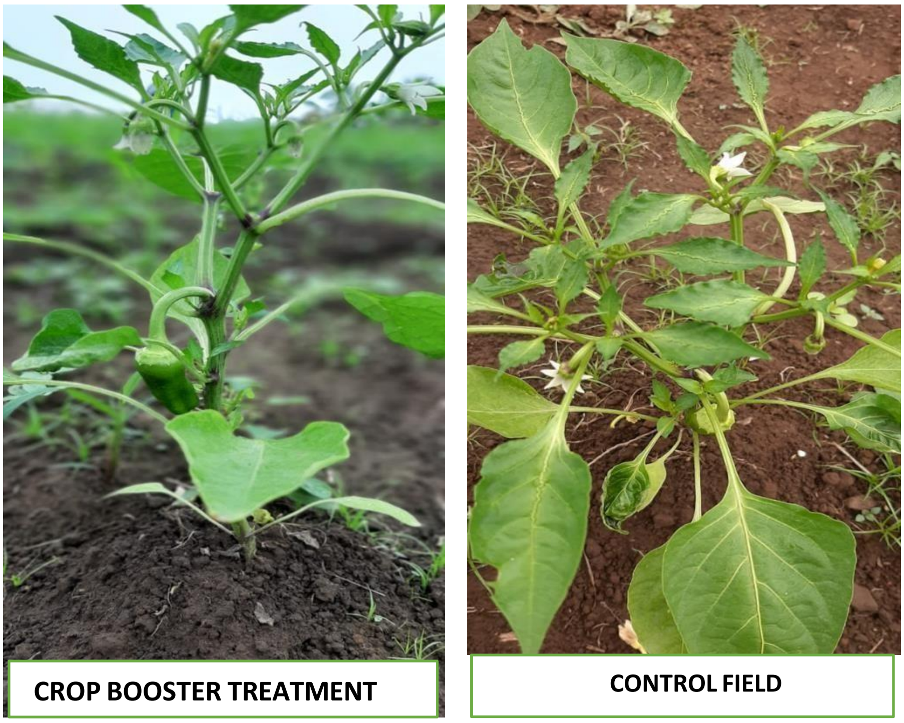
Annex 14. Treatment Comparison

Annex 15. Random plant data collection

Annex 16. Treatments with technology



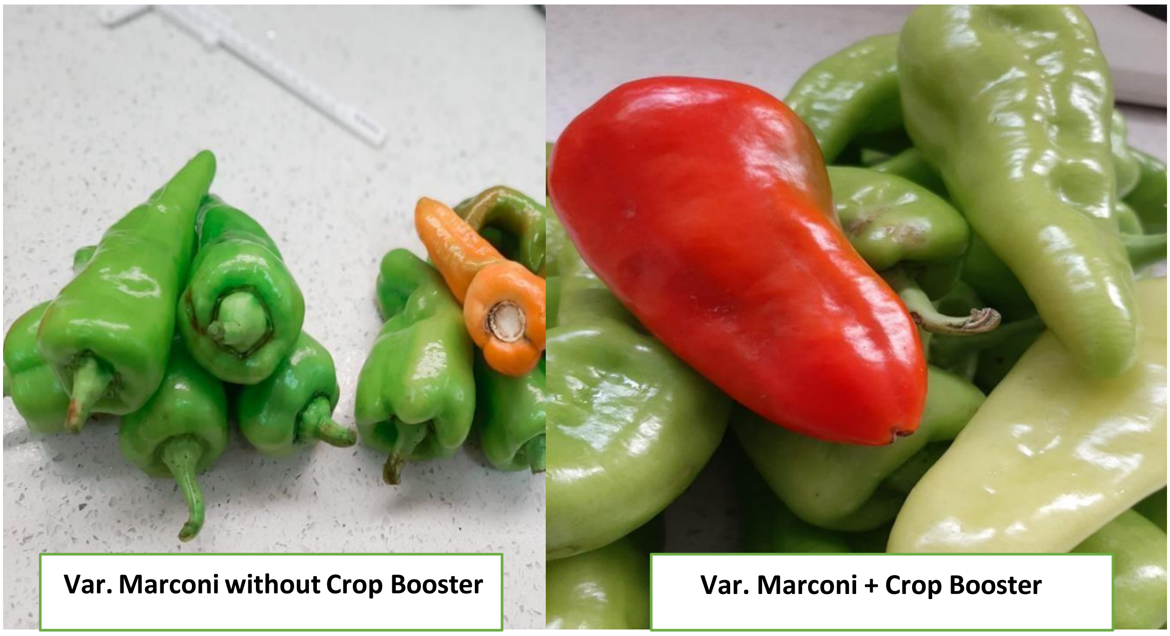
Annex 17. Appearance of the first fruits



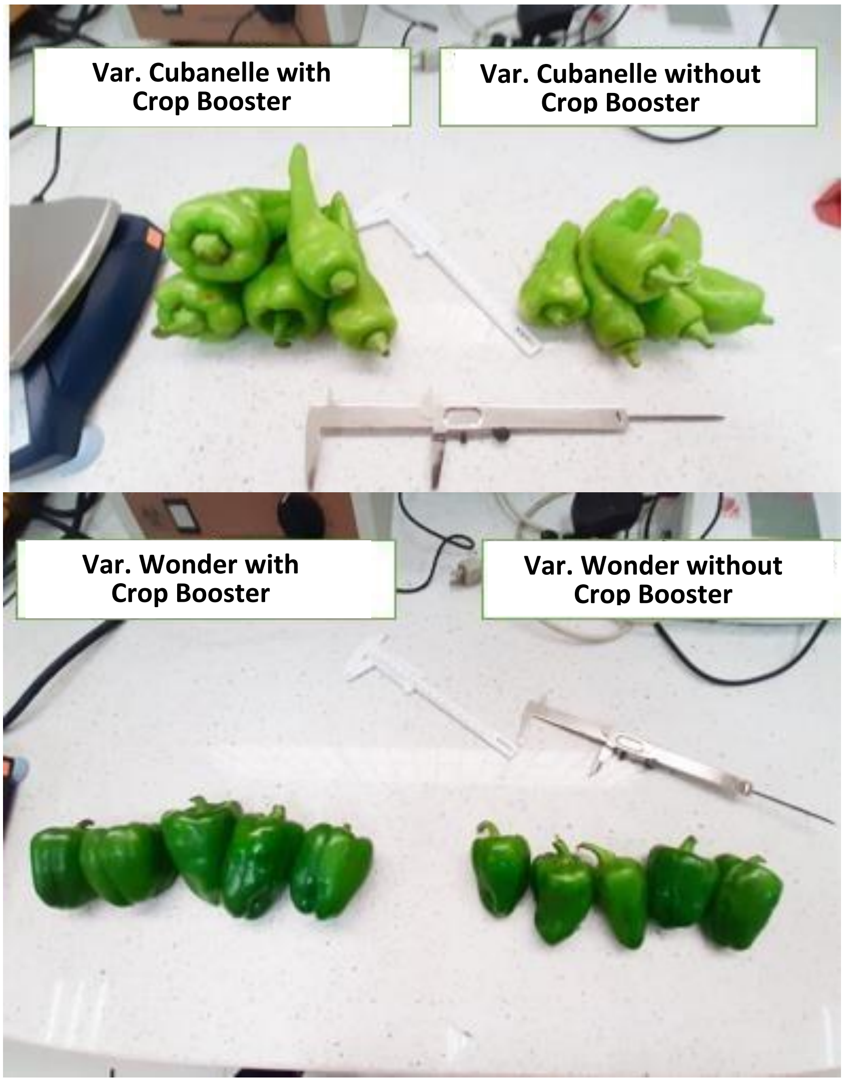
Annex 18. Fruit harvest

Annex 19. Selection of harvested fruits

Annex 20. Comparison of varieties with the technology and without the technology



Annex 21. Fruit measurement

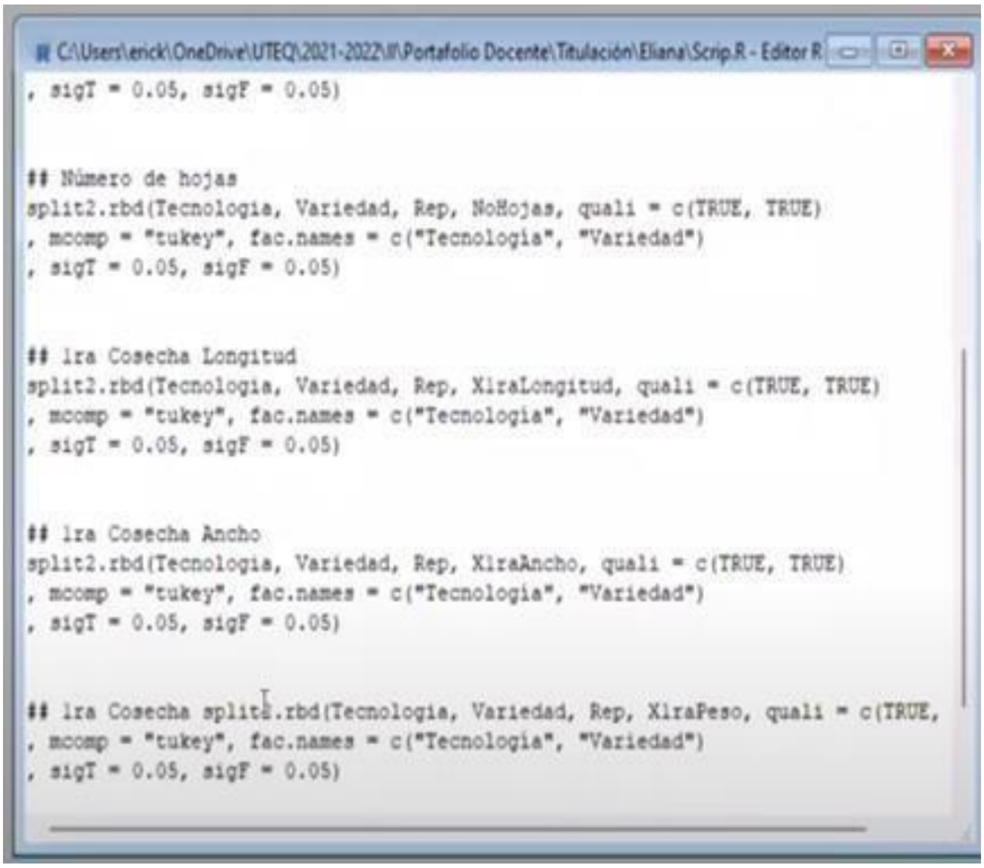


Annex 22. Measurement and weight of fruits

Annex 23. Fruit collection

.

Annex 24. Program where the data was entered




```
, sigT = 0.05, sigF = 0.05)


## Número de hojas
split2.rbd(Tecnologia, Variedad, Rep, NoHojas, quali = c(TRUE, TRUE)
, mcomp = "tukey", fac.names = c("Tecnologia", "Variedad")
, sigT = 0.05, sigF = 0.05)


## 1ra Cosecha Longitud
split2.rbd(Tecnologia, Variedad, Rep, X1raLongitud, quali = c(TRUE, TRUE)
, mcomp = "tukey", fac.names = c("Tecnologia", "Variedad")
, sigT = 0.05, sigF = 0.05)


## 1ra Cosecha Ancho
split2.rbd(Tecnologia, Variedad, Rep, X1raAncho, quali = c(TRUE, TRUE)
, mcomp = "tukey", fac.names = c("Tecnologia", "Variedad")
, sigT = 0.05, sigF = 0.05)


## 1ra Cosecha split2.rbd(Tecnologia, Variedad, Rep, X1raPeso, quali = c(TRUE,
, mcomp = "tukey", fac.names = c("Tecnologia", "Variedad")
, sigT = 0.05, sigF = 0.05)
```

```
> str(dados)
'data.frame':   24 obs. of  11 variables:
 $ Tecnologia   : chr  "CropBooster" "CropBooster" "CropBooster" "CropBooster" .$
 $ Variedad     : chr  "CUBANELLE" "CUBANELLE" "CUBANELLE" "CUBANELLE" ...
 $ Rep          : int  1 2 3 4 1 2 3 4 1 2 ...
 $ Altura       : num  39.5 38.7 38.6 43.4 29.6 ...
 $ NoHojas      : num  58.6 56.4 50 63.8 55.6 48.8 63.4 75 28.8 26.4 ...
 $ X1raLongitud: num  9.94 10.02 8.94 10.2 8.66 ...
 $ X1raAncho    : num  2.84 3.3 3.12 3.16 4.72 5.12 3.28 4.14 4.52 4.66 ...
 $ X1raPeso     : num  44.2 45.4 49.8 50.2 69.5 ...
 $ X2daLongitud: num  9.32 9.44 8.7 10 8.6 8.8 8.28 9.88 5.36 6.08 ...
 $ X2daAncho    : num  3.6 3.52 3.3 3.62 3.6 3.98 3.6 3.58 4.32 4.38 ...
 $ X2daPeso     : num  46.6 44.8 41 44.9 52.8 ...
>
```

Annex 25. ADEVA[1] total data.

```
> ## Altura de las plantas (cm)
> split2.rbd(Tecnologia, Variedad, Rep, Altura, quali = c(TRUE, TRUE)
+ , mcomp = "tukey", fac.names = c("Tecnología", "Variedad")
+ , sigT = 0.05, sigF = 0.05)
------------------------------------------------------------------------
Legend:
FACTOR 1 (plot):  Tecnología
FACTOR 2 (split-plot):  Variedad
------------------------------------------------------------------------

------------------------------------------------------------------------
$`Analysis of Variance Table`
                    DF     SS      MS      Fc  Pr(>Fc)
Tecnología           1 262.68 262.682 17.0040 0.025857 *
Block                3  46.36  15.452  1.0003 0.499915
Error a              3  46.34  15.448
Variedad             2  59.97  29.983  8.1338 0.005853 **
Tecnología*Variedad  2  94.33  47.167 12.7953 0.001058 **
Error b             12  44.24   3.686
Total               23 553.92
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

------------------------------------------------------------------------
CV 1 = 12.30307 %
CV 2 = 6.009899 %


Significant interaction: analyzing the interaction
------------------------------------------------------------------------

Analyzing  Tecnología  inside of each level of  Variedad
------------------------------------------------------------------------
                                       DF        SS         MS        Fc
Tecnología : Variedad CUBANELLE  1.000000 285.60500 285.605000 37.545498
Tecnología : Variedad MARCONI    1.000000  59.40500  59.405000  7.809353
Tecnología : Variedad WONDER     1.000000  12.00500  12.005000  1.578172
Pooled Error                     6.194035  47.11743   7.606904        NA
                                  p.value
Tecnología : Variedad CUBANELLE  0.000766
Tecnología : Variedad MARCONI    0.030350
Tecnología : Variedad WONDER     0.254327
```

[1] AVEDA: Automatic Visual Exploratory Data Analysis

```
ADEVA Total (2): Bloc de notas
Archivo   Edición   Formato   Ver   Ayuda
------------------------------------------------------------------------
                                        DF         SS         MS         Fc
Tecnología : Variedad CUBANELLE  1.000000 285.60500 285.605000 37.545498
Tecnología : Variedad MARCONI    1.000000  59.40500  59.405000  7.809353
Tecnología : Variedad WONDER     1.000000  12.00500  12.005000  1.578172
Pooled Error                     6.194035  47.11743   7.606904         NA
                                  p.value
Tecnología : Variedad CUBANELLE  0.000766
Tecnología : Variedad MARCONI    0.030350
Tecnología : Variedad WONDER     0.254327
Pooled Error                           NA
------------------------------------------------------------------------


 Tecnología inside of Variedad CUBANELLE
------------------------------------------------------------------------
Tukey's test
------------------------------------------------------------------------
Groups Treatments Means
a       CropBooster     40.065
 b      SinCropBooster          28.115
------------------------------------------------------------------------

 Tecnología inside of Variedad MARCONI
------------------------------------------------------------------------
Tukey's test
------------------------------------------------------------------------
Groups Treatments Means
a       CropBooster     34.15
 b      SinCropBooster          28.7
------------------------------------------------------------------------

 Tecnología inside of Variedad WONDER
------------------------------------------------------------------------
According to F test, the means of this factor are not different.
------------------------------------------------------------------------
          Levels Means
1    CropBooster 31.55
2 SinCropBooster 29.10
------------------------------------------------------------------------


Analyzing  Variedad  inside of each level of  Tecnología
```

Annex 26. Formula for calculating the watering interval.

Calculating the watering interval

- Ir = In / Etc
  - Ir = intervals of watering, in days
  - In = net leaf, in mm
  - Evaporation of the crop, in mm/day