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THE INFLUENCE OF THE CLIMATIC CONDITIONS IN THE GREENHOUSE AND OF THE CULTURE SUBSTRATE ON SOME PARAMETERS OF TOMATO GROWTH

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Abstract

The study was carried out in the greenhouses of the Research Center for the Study of the Quality of Horticultural Products, within the USAMV of Bucharest, Romania, on a tomato crop, the cultivar Cheramy F1, carried out in an unconventional system on a coconut substrate. The effect of temperature variation on the growth, development and yield of the tomato crop (Lycopersicon esculentum Mill.) was studied. The observations made on tomato plants led to the conclusion that temperatures above the optimal parameters, especially in the period from May to July, determined the formation of leaves with a smaller leaf surface but also a decrease in fruiting, therefore lower production which led when clearing the crop because it was ineffective. The aim of the study was to identify the effect of temperature variations on the vegetative mass formed and tomato production.

***Key words**: greenhouse, temperature, tomatoes, soilless, production.*

INTRODUCTION

In the context of climate change, crops in protected areas are expanding more and more because a favorable microclimate can be ensured for the production of a wide variety of vegetables. Tomato crops can be grown throughout the year, both in the winter months and in the summer. If in the cold periods the temperature in the greenhouse can be controlled much more easily, in the summer, when the light radiation is very strong, inside the greenhouse they can reach values around 64ºC, an aspect also mentioned by Angmo et al. (2019) in very hot climates, however, overheating is a very serious problem in these greenhouses during the summer months, as the use of such greenhouses is limited only to crops in cycle II, from August-December or January-June.

For tomato cultivation in the greenhouse, maintaining an optimal average daily air temperature especially, during the flowering and fruiting period is particularly important for pollen development.

Numerous researchers have mentioned different values of temperature and relative air humidity for each specific growth stage Thus, Sato et al. (2001) and Sato et al. (2006) recommended for the vegetative growth period of tomatoes, an optimal air temperature of 22°C for and 22-25°C for fruit formation, and Drăghici et al. (2021), Jerca (2021) mention temperatures of 20-22°C vegetative growth during the day and 18-19°C during the night and 20-27°C for the period of fruit setting during the day and 17-18°C during the night.

Various authors (Kittas et al., 2011; Cherie, 2010; Hochmuth and Hochmuth, 2012; Altes-Buch et al., 2019) mention for tomatoes grown in the greenhouse at optimal air temperatures between 17-27°C, even up to 35°C because some varieties are adapted to high temperature values, with day/night amplitudes between 5-7ºC but also to radiation of 2.34 $kWh/m^2/day$).

Wei (2018) mentions that if the day/night temperature difference is less than or equal to 2°C and 5°C, the total number of inflorescences increases and that the lower temperature has a great effect on the production of tomato and Hernández (2015).

The experiments performed by Firon et al. (2006) under controlled conditions to see their effect on pollen viability and the influence on

the number of seeds in the fruit, on several tomato cultivars, showed that day/night temperatures of 32/26°C) as well as day/night temperatures of 28/22°C led to thermal stress, pollen viability being affected. A similar aspect was also reported by Huang et al., (2011). Hernández (2015) who showed that 24°C to 32°C during the flowering period of tomatoes causes flower abortion and a significant decrease in both production and fruit quality.
Kittas et al. (2011), appreciated that providing shading in the greenhouse reduced solar radiation, temperature and humidity in the greenhouse with an effect of increasing the leaf surface index, the number of flowers and fruits per plant, but also the total production.
Leaves showed the highest biomass accumulation, followed by stems, petioles, roots and flowers, (Mejía de Tafur, 2009; Li et al., 2014).

MATERIALS AND METHODS

The present study was carried out at the research greenhouse, from UASMV Bucharest, Faculty of Horticulture, it belongs to the Research Center for the Study of the Quality of Horticultural Products. The biological material used in the study was represented by the Cheramy F1 variety. The seedling was produced in the greenhouse, between September 15 and October 29, 2021. Planting was carried out on October 30, 2021, in the greenhouse, under controlled conditions. At planting, the seedling was 40 days old, and the first inflorescence was formed.
The culture space was properly prepared in compliance with phytosanitary hygiene conditions.
After the preparation of the greenhouse, the coconut villages were distributed and placed on the culture troughs. After placing them, the substrate was moistened with a nutrient solution that had a pH of 5.5 and an EC of 3 mSiemens. 3 plants were planted on a mat 1 m long, at a distance of 30 cm between the plants. The distance between the rows was 1.5 m. The values of temperature in the greenhouse, atmospheric humidity, light and CO_2 content were recorded during the entire observation period, from the planting of the seedling in October to the final harvest in July.

All the plant care work was carried out, this consisted of staking the stems, pruning, removing the leaves, as the plant grew, lowering the plants. The vegetative mass of the leaves resulting from the gradual removal as the plants grew, the height of the plants, the mass of the fruits as they reached physiological maturity, their quality was determined. All inflorescences on the plant were recorded. At the same time, the temperature values in the culture substrate were monitored in relation to the values in the culture space.

RESULTS AND DISCUSSIONS

Temperatures were retrieved from the computer database, recorded by the temperature sensor in the culture compartment, throughout the culture period, for 24 hours, day and night.
Atmospheric humidity in the tomato culture compartment recorded appropriate values for the growth and fruiting period. The data recorded between October 2021 and April 2022 showed that the atmospheric humidity values were between 50% and 62.09%, with very few exceptions, when the atmospheric humidity dropped to 41.85% (Figure 1).

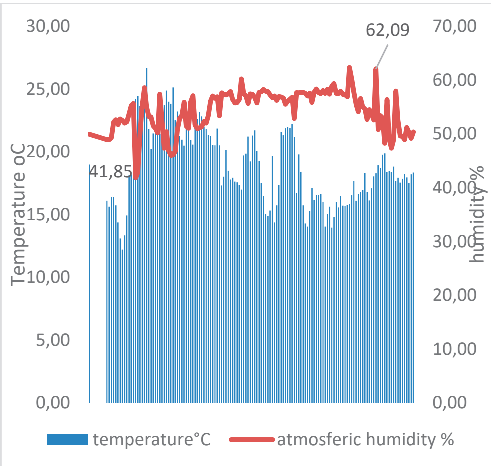

Figure 1. Temperature and atmospheric humidity values recorded in the greenhouse during October 2021-April-2022

In May, the lowest values of 22°C were recorded on May 11, and in most days the temperatures exceeded 25°C, reaching values of 38°C towards the end of the month. During the night the temperatures were between 15°C and 21°C (Figure 2).

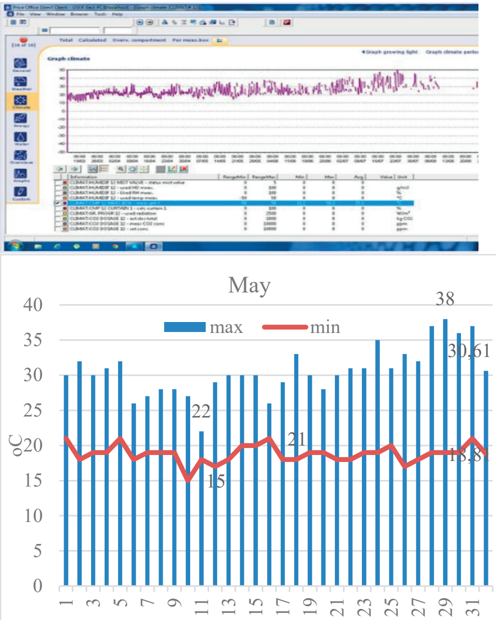

Figure 2. Minimum nighttime and maximum daytime temperature recorded in May 2022

In the month of June 2022, temperatures in the greenhouse recorded values above 26°C with the vast majority reaching values above 35° to 47°C. Temperature values during the night averaged 20°C (Figure 3).

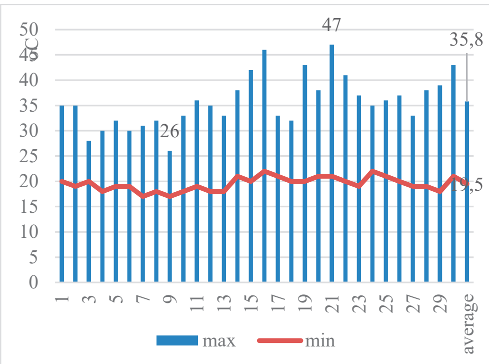

Figure 3. Minimum nighttime and maximum daytime temperature recorded in June 2022

In July 2022, temperatures in the greenhouse recorded values of over 35°C reaching values of 45 °C. Nighttime lows ranged from 17°C to 22°C (Figure 4).

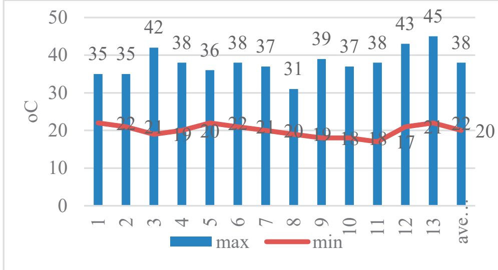

Figure 4. Minimum nighttime and maximum daytime temperature recorded in July 2022

In May the average maximum temperature was 30.61°C and in June 35.8°C with maximum values of 38 °C in July. During the night, the average temperatures were 18.81°C in May, 19.5°C in June and 20°C in July (Figure 5).

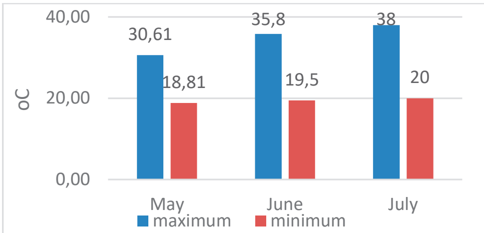

Figure 5. Average maximum and minimum temperatures recorded in May, June and July

It was noted that the temperature in the greenhouse correlated with the intensity of the light radiation also influenced the temperature increase in the culture substrate at the level of the plant's roots. The relationship between the temperature in the greenhouse, temperatures in the culture substrate, starting from the first watering, at 8 am, during the day at 10 am, at 12 pm and 3 pm, was analyzed. Temperatures were measured before the application of fertigation, after each fertigation accordingly analysis periods.

Shishido and Kumakura (1994) but also Kawasaki et al. (2013), Kawasaki et al. (2014), Kawasaki and Yon (2019) mention that an optimal temperature of 24.6°C at the root level favors nutrient assimilation by the roots.

It was found that in July, at 3 p.m., the temperature recorded in the culture space reached 46°C, the temperature of the nutrient solution when fed from the pool was 29.2°C and in the culture substrate before fertigation it was 35.5°C and after 10 minutes after watering it dropped to 35.1ºC. The lowest values were recorded in the morning, at the first watering. This aspect is important because it was found that very high values of the substrate temperature led to a difficulty in its absorption by the plants (Table 1).

Table 1. Determinations of temperatures recorded in the greenhouse and in the culture medium before and after fertigation

Temperatures	UM	Temperature values at:			
		8 am o'clock	10 am o'clock	12 pm o'clock	3 pm o'clock
In the greenhouse	ºC	24	28	36	46
the nutrient solution in the basin	ºC	25.7	26.4	27.0	29.2
In the substrate before watering	ºC	23.1	25	28.4	35.5
In the substrate after watering	ºC	23	25	28.7	35.1

Aspects of the culture compartment during the vegetative growth period are presented in Figure 6, also some aspects of the tomato culture during the fruiting period are presented in Figure 7.

Figure 6. Aspects of tomato culture

Figure 7. Aspects of tomato culture

In the greenhouse, CO2 values of over 200 ppm were maintained and throughout the culture period, they did not exceed the value of 370 ppm (Figure 8).

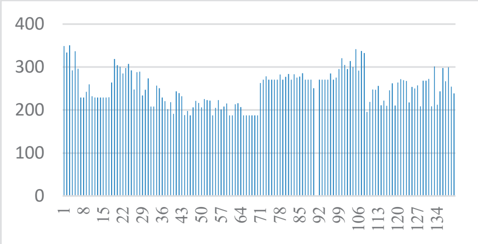

Figure 8. CO_2 content in the culture compartment during the vegetative growth and fruiting period of the plants

In October, the external light radiation showed values between 100 W/m^2 and a maximum of 300 W/m^2. In November, the values remained relatively low, reaching only on certain days the value of 250 W/m^2. In December, higher values were recorded compared to previous months, reaching for short periods maximum values of 447.85 W/m^2, an aspect observed until the end of December. At the beginning of January 2022, the light intensity was low in the first weeks of the month and towards the end of the month the values reached 211.27 W/m^2 (Figure 9 a and b).

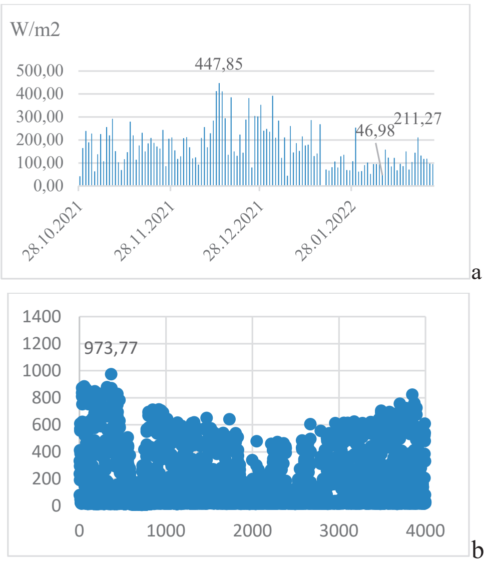

Figure 9. Light radiation outside the greenhouse: a - during October 2021-March 2022; b - April-July 2022

At the end of the crop, in July, the total number of leaves formed per plant was 76 leaves, and the total number of inflorescences per plant was 23. The number of leaves until the first inflorescence was on average 8, and between inflorescences 1 and 2 to 4 leaves. Between inflorescence 2 and 3, an average of 4 leaves were formed, and after inflorescence 3 to inflorescence 23, an average of 3 leaves were formed (Figure 10).

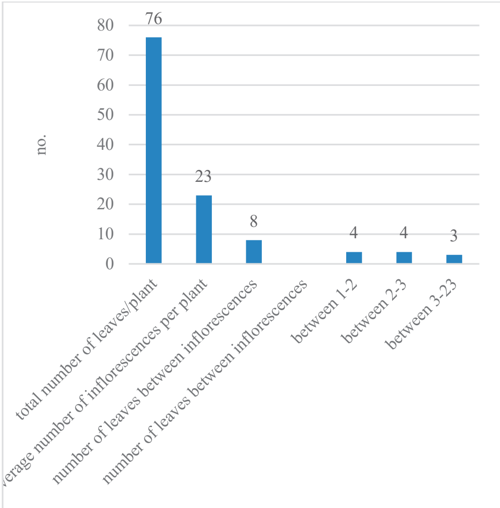

Figure 10. Total number of leaves on plant and between leaves

The Figure 11 shows in detail the harvests carried out, by stages.

At the first defoliation carried out, after 34 days from planting, carried out on 11.11.2021, a quantity of only 0.122 kg of leaves was harvested. In November 2021, the total mass of leaves harvested from the 288 plants was 13.97 kg. In December 2021, a quantity of 84.6 kg of leaves was harvested, a quantity almost similar to that of March 2022, which was 85.40 kg. In January, February and May 2022, the largest quantities of leaves were harvested, 136.4 kg in January 2022, 135.5 kg in February and 132.8 kg in May 2022. In April, an amount of only 25.27 kg of leaves. In June, no defoliation was carried out, but in July, following defoliation, a total mass of only 2.81 kg of leaves was obtained. The total mass of harvested leaves was 606.8 kg at an average number of 285.42 plants in the culture under study (Figures 11 and 12).

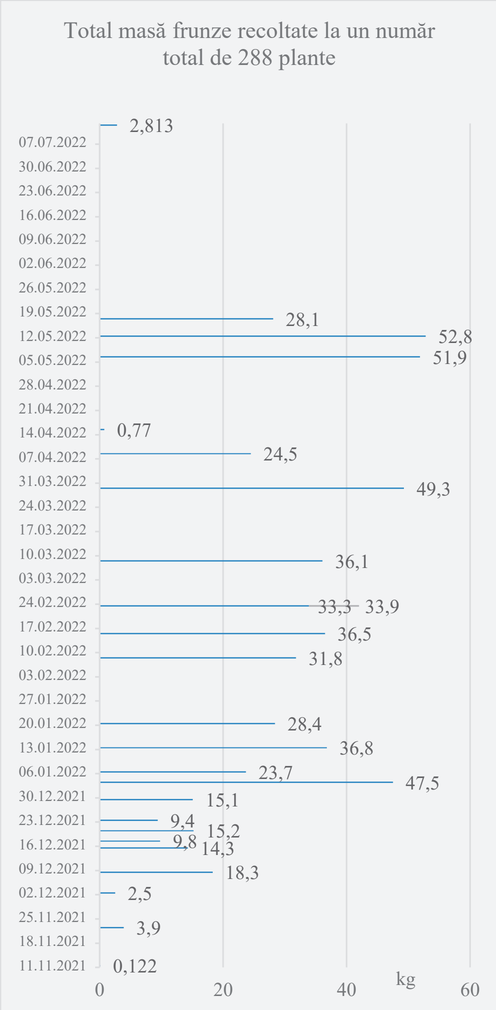

Figure 11 Total mass of harvested leaves for a total number of 288 plants per harvesting stage

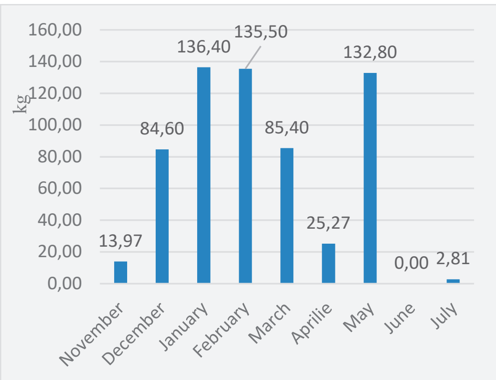

Figure 12. Total mass of leaves harvested during November-July

It was noted that at the first harvests the average mass of a leaf was lower, 48.49 g, an aspect noticed also in the leaves harvested towards the end of the crop where only 10.19 g/leaf were recorded. In the months of January, February and May, leaves were harvested that reached 473.61 g in January, 472.13 g in February and 479.42 g in May. In March, 301.23 g of leaves were harvested, and in December, 293.75 g (Figure 13).

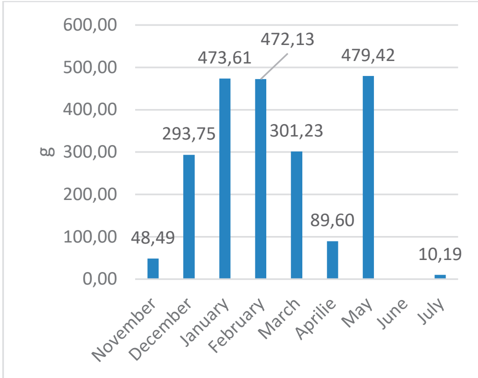

Figure 13. Mass of leaves harvested from the tomato crop - Cheramy F1

The surface of the tomato leaves varied between 240.08 cm^2 and 248.79 cm^2 for the basal and upper leaves and between 371.05 cm^2 and 393.35 cm^2 for the middle leaves.

Figure 14. Leaf surface of tomato leaves

It was noted that by the end of the crop, a total amount of vegetative mass (leaves and stems) of 926.96 kg was harvested from the tomato crop, cultivar Cheramy F1, of which 320.16 kg represented the mass of tomato plant stems and 606.8 kg total mass of leaves obtained from the 288 plants (Figure 15).

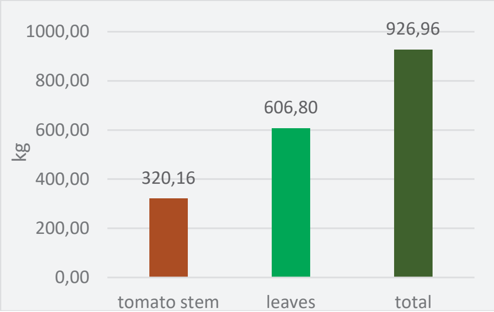

Figure 15. Vegetative mass, stems and leaves harvested from the tomato cultivar Cheramy

It was found that of the total vegetative mass, 65.46% was represented by the mass of the leaves and only 34.54% by the mass of the tomato stem (Figure 16).

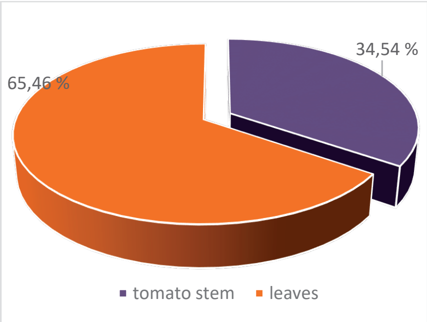

Figure 16. The percentage of the mass of leaves and the mass of tomato stems from the total vegetative mass of tomatoes - Cheramy cultivar

The first harvests were carried out in January and were 177.6 kg. In April and May, 514 kg and 397.3 kg respectively were harvested in May (Figure 17).

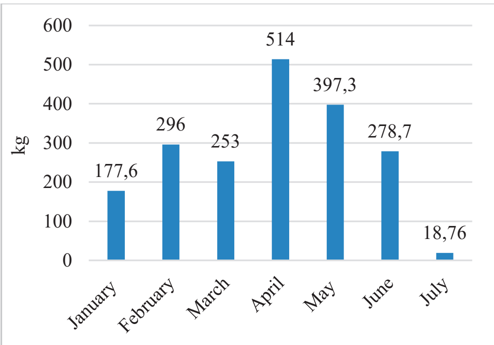

Figure 17. The harvests carried out between January and July 2022

The total vegetative mass of the plants obtained at an average number of 285.42 plants (288 plants at the beginning of the crop respectively 276 plants at the end of the crop) was 2862.32 kg, this being represented by the stem, leaves and fruits. Of this amount, 1935.36 kg were tomato fruits, 926.96 kg were leaves (320.16 kg) and stems (606.80 kg) (Figure 18).

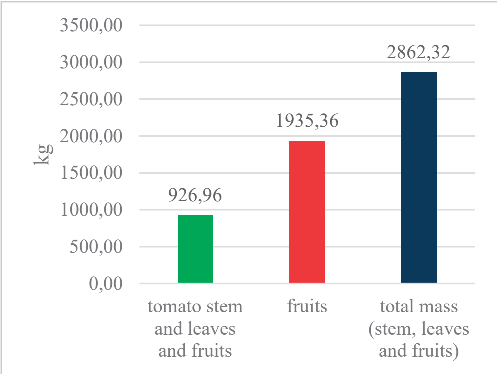

Figure 18. Total plant mass obtained on total plants in the crop, of which the total mass of fruits, leaves, and stems

It was found that, of the total vegetative mass of the plants, the leaf mass represented the largest part, 67.62%, followed by the leaf mass of 21.20% and the stem mass of 11.19% (Figure 19).

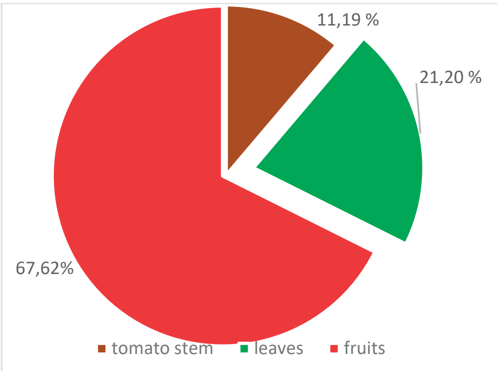

Figure 19. Percentage of fruit, leaf and stem mass in tomato plants at Cheramy F1 cultivar

CONCLUSIONS

Analyzing the data obtained in the tomato crop, Cheramy F1 cultivar, we found that in the first period of vegetative growth and fruiting, the temperature values in the greenhouse were within the normal parameters recommended by the technology. The temperature in the greenhouse did not exceed the value of 25ºC during the day and was not lower than 18ºC during the night, which led to a very good growth and development of the seedlings. Starting from May, we noticed that, during the day, the temperature values recorded values of up to 38ºC, which contributed to a decrease in production, vegetative growth, and fruiting. This aspect was accentuated in June and July when the temperature values in the greenhouse were as high as 47ºC, in July the daytime values did not drop below 35ºC.

Another aspect noted was the influence of very high temperatures on the root system.

The productions obtained were 1935.36 kg for the 288 plants taken into analysis. Total vegetative mass stems 320.16 kg and leaves 606.8 kg. It should be emphasized that the fruit production obtained represented 67.62% of the total vegetative mass, the leaves 21.20% and the stems 11.19%.

Based on these results, we can conclude that maintaining appropriate climatic conditions in the culture space ensures constancy and high production.

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