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# THE EFFECT OF IMPROVING THE CLIMATIC CONDITIONS IN THE GREENHOUSE ON THE CHERAMY TOMATO HYBRID GROWN IN GREENHOUSE CONDITIONS

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***Abstract***

*Climatic conditions are the most important for the development of tomato culture, namely temperature, humidity and the level of carbon dioxide concentration. The study was carried out in research greenhouses, which belongs to the UASVM in Bucharest on variety Cheramy F1. The environmental factors in the greenhouse, temperature, atmospheric humidity, $CO_2$ concentration inside the greenhouse. Also, the obtained productions were registered. In this paper we aimed to demonstrate the difference in production of tomatoes obtained in a culture compartment with normal air conditioning equipment and in a compartment in which the climatic conditions were improved by installing heat pump systems.*

***Key words****: soilless, tomatoes, cherries, Cheramy F1.*

## INTRODUCTION

Ground-water heat pumps (also known as geothermal heat pumps) use heat from the ground as a heating source. A technology encouraged and successfully adopted on a large scale in many countries (Sweden, Germany, Finland, France, Switzerland, Italy, etc.) is still in its pioneering phase here. However, more and more people are becoming aware of the real long-term advantages. Ground-water heat pumps have as their operating principle the transfer of heat from the ground to the greenhouse.

The ground water heat pumps help us to keep all climate factors constant throughout the year with a low energy cost and a higher productivity of the tomato culture.

Al Mamun Hossain et al. (2017) conducted studies on leaf area index evaluation using an AccuPAR-LP-80 ceptometer to find out the influence of water amount on tomato leaf size.

One of the major factors affecting the growth and productivity of tomatoes is the very high temperature in the growing space. In general, very high temperatures lead to some physiological disorders but also to a decrease in production.

Hurd and Graves (1984) mention that temperature variations have a negative effect on plant growth, and it has also been reported that it negatively affects nutrient absorption and tomato fruit maturity (Kawasaki et al., 2014; Koskitalo et al., 1972).

Legast et al. (2020) and Falah et al. (2021) in their studies mentioned that the gradual increase in temperature determines the optimization of the phenophase of growth and early development of tomato fruits.

Gruda and Tanny (2015) mentioned that in order to ensure optimal conditions for the best possible fruiting, it is necessary to ensure appropriate day and night temperatures, however, the energy consumption is significant and, therefore, it is necessary to adopt new control approaches of the climate to replace the use of conventional energy, with cogeneration or renewable energy sources, an aspect also emphasized by Li et al. (2015), Shamshiri et al. (2018), Sophoanrith et al. (2021) and Phunchok et al. (2021).

The integrated approach of all technological aspects leads to greater safety of the production obtained (Cañadas et al., 2017)

## MATERIALS AND METHODS

The present study was carried out by the Research Greenhouse and the Research Center for Studies of Food and Agricultural Products Quality within the University of Agronomic Sciences and Veterinary Medicine of Bucharest (USAMV). The biological material used was the Cheramy RZ F1 hybrid, which is a Dutch hybrid. The tomatoes seeds were procured from Rijk Zwaan with a seed quality certificate. The seedlings were produced in the greenhouse, they were 45 days old when planted. That was planted on 21. X. 2022, on the coconut mats, and 3 plants were planted on each mattress.

The culture was established in two different compartments denoted C12 (C1) and C13 (C2).

All environmental factors in the greenhouse were monitored using the greenhouse computer. According to the growth and development of the plants, determinations were made regarding the height of the plants, the number of leaves until the first inflorescence, the number of leaves between the inflorescences, the date of the appearance of the first flowers, the date of the appearance of the first set fruits, the date of the appearance of the first fruits at physiological maturity.

Fruit quality determinations were made, fruit mass was determined by weighing each fruit. The content in soluble dry matter was determined by the method of weighing and exposure to the temperature of 105°C for 24 hours, the results being expressed in percent fresh mass (FW). Determinations were made regarding the total production obtained up to the 8th inflorescence. Also, correlations were made regarding the analyzed parameters and vegetation factors, namely temperature, light, carbon dioxide content.

## RESULTS AND DISCUSSIONS

After planting the tomato seedlings in the greenhouse, in compartment 12 (C1) we found that average temperature values between 19.8°C and 33.23°C were recorded. Temperatures during the night did not vary much, they were between 15.23°C and 18.55°C. On average, the maximum and minimum temperature values ranged between 25.4°C and 18.72°C (Figure 1).

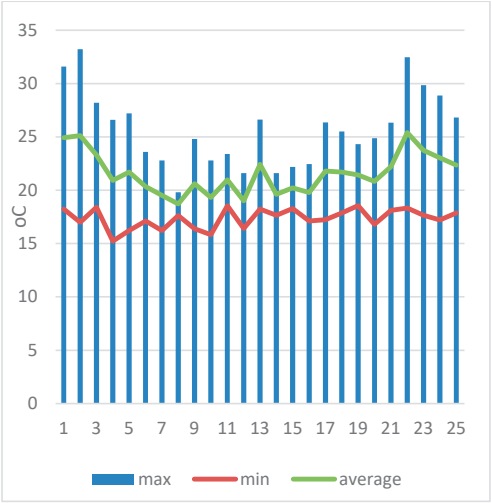



Figure 1. The temperature recorded in the greenhouse during the growth and fruiting period of tomatoes during 25 weeks in compartment 12 (C1)

Analyzing the temperatures outside the greenhouse, it was found that on average the values varied between 11°C and 34°C.

Inside the compartment, the temperature values were kept approximately constant, oscillating between 22.8°C and 24.8°C. The minimum temperatures recorded in this compartment were between 17.5°C and 19.32°C, temperatures corresponding to tomato plants for the night period. Average day-night temperatures between 20.3°C and 21.95 °C were recorded, considered optimal for tomato growth and development (Figure 2).

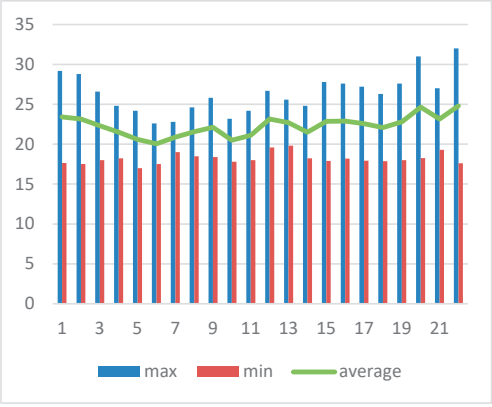



Figure 2. Average temperatures recorded in the greenhouse for 25 weeks after planting tomatoes in the greenhouse in compartment 13 (C2)

Analyzing the variation of the $CO_2$ content inside the culture space, compartment 12, it was found that the carbon dioxide values varied a lot during the vegetation period. The lowest average value recorded was 157.5 ppm. On average, a value of 252.92 ppm was recorded (Figure 3).

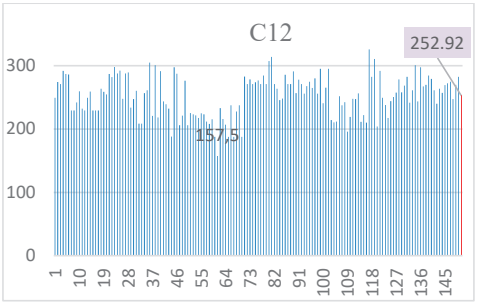



Figure 3. Variation of CO2 content in the greenhouse (C12)

In compartment 13 (C2), the $CO_2$ concentration remained approximately constant, with an average value of 275.67 ppm. We could appreciate that, since the temperature values remained almost at the programmed level, the ventilation system did not allow the windows to be opened for ventilation, thus, the CO2 content was higher in this compartment, with a beneficial effect on production (Figure 4).

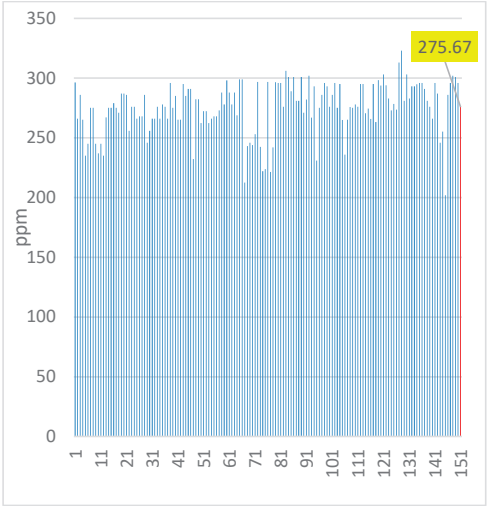



Figure 4. $CO_2$ content in compartment 13 (C2)

Following the determinations made in March, during the period when the insolation was very strong, weeks 22-23, it was found that in the culture spaces the temperatures varied depending on the position of the compartment. Thus, in C12, a compartment more exposed to solar radiation, the atmospheric temperature varied a lot, an aspect also observed in the culture substrate. Analyzing the temperature values recorded in this compartment, it was found that in the morning at 7:15 the average values were 18.1°C, but at 10:00 the temperature went up to 29.6°C, at 12:00 to 31.4°C, and at 2.30 p.m. at 33.2°C. The temperature recorded in the culture substrate before the application of fertigation, at 10:00 a.m. was 20.7°C, and after the application of fertilization the temperature increased to 21.4 °C in the situation where the temperature of the nutrient solution in the pool was at the value of 25.8°C. At 12:00 the temperature of the substrate was 26.4°C and after fertigation it remained almost constant even though the temperature of the nutrient solution was high, 29.8°C. The highest values were recorded at the substrate level of 30.8°C at 2:30 p.m. After fertigation, the temperature in the substrate recorded high values of 29.9°C, and in the pool the nutrient solution had a temperature of 30.1°C (Figure 5).

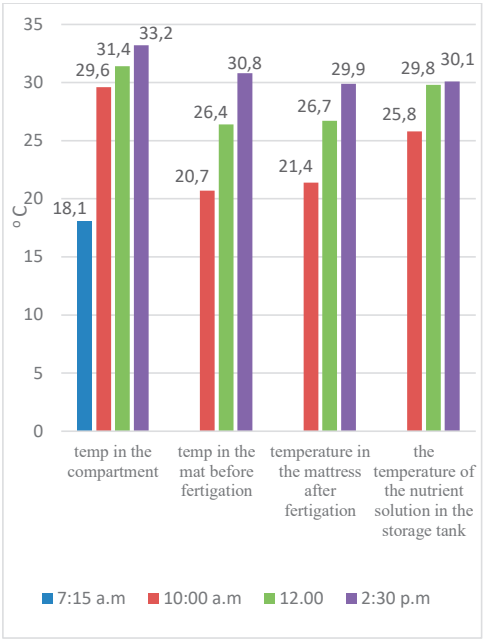



Figure 5. Temperatures recorded in the greenhouse, in the culture substrate before and after fertigation application in compartment C12 (C1)

In compartment 13 (C2) it was found that at 07:15 the average temperature recorded in was also 18.1°C, like that in C12, at 10:00 of 25.8°C, at 12: 00 of 26.3°C, and at 2.30 p.m. of 27.2°C. In this situation, it was found that the temperature values in the culture substrate before fertilizing the temperature remained around 22.7°C, and after fertigation the values remained almost constant at 22.4°C, a situation in which the value the temperature of the nutrient solution in the tank inside the compartment was kept at the approximate value of 22°C. Both at 12:00 and at 2:30 pm the temperatures remained almost constant in the culture substrate, being between 23.6 °C and 23.8°C, and after fertigation the temperatures dropped to 22.7°C and 22.9°C respectively. In the nutrient solution storage pool, the temperature remained almost constant at values between 22.1°C and 22.8°C (Figure 6).

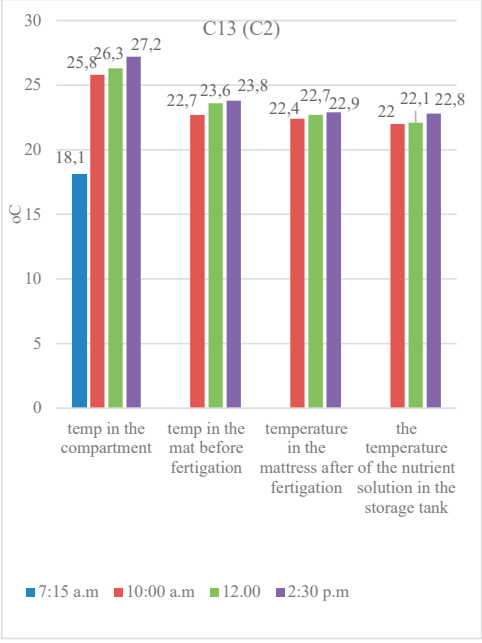



Figure 6. Temperatures recorded in the greenhouse, in the culture substrate before and after the application of fertigation in compartment 13 (C2)

Analyzing by comparison the data on the number of leaves formed until the first inflorescence, it was found that in compartments 12 and 13, the plants formed a number between 7.33 leaves, however, analyzing the average number of leaves between inflorescences, it was found that it was higher (3.66 leaves) in tomato plants grown in compartment 12 compared to compartment 13 where an average of 3.33 leaves were recorded between inflorescences. (Table 1).

Table 1. Number of leaves in tomato plants

| Compartment | Number of leaves to first inflorescence | The average number of leaves between the inflorescences |
|---|---|---|
| | No. | No. |
| C12 | 7.33 | 3.66 |
| C13 | 7.33 | 3.33 |

Analyzing by comparison the data obtained regarding the distance between the inflorescences, it was found that in the compartment where the temperature values were higher but also oscillating, the distance between the inflorescences was much greater compared to a variant grown in temperature conditions corresponding to the species. In compartment 12 the inflorescences the distance between the inflorescences was smaller, of 24.26 cm, respectively 28.1 cm and due to the fact that the temperatures increased being variable, the distance between the inflorescences was greater, of 34.89 cm, respectively 40.35 cm, values correlated with the very high level of temperature (Figure 7). In the conditions where the temperatures were kept constant and the distance between the inflorescences was almost constant, but much lower compared to that in the compartment where the temperature values varied a lot. Another aspect noted was that the number of fruits in the inflorescences as well as the length of the inflorescence was higher in the case of the compartment where the temperatures were variable.

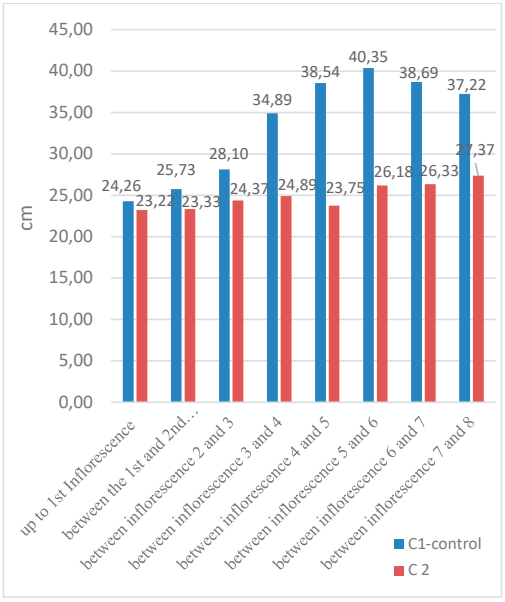



Figure 7. Distance between inflorescences recorded in Cheramy hybrid tomato plants in compartments 12 (C1) and 13 (C2)

Yu and Körner (2020) point out that there is a direct relationship between temperature, $CO_2$ content and the leaf surface of tomato leaves, an aspect also analyzed by Ouyang et al., (2021) and Quezada (2023) who show that the leaves have a different texture.

The leaf surface was greater by 30,365 cm2 in plants grown in C2 compared to C1, this being 928,5521 cm 2 and 898,1871 cm2 respectively (Figures 8 and 9).

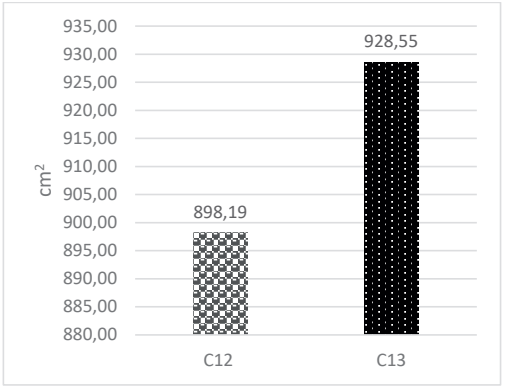



Figure 8. The foliar surface of tomato leaves

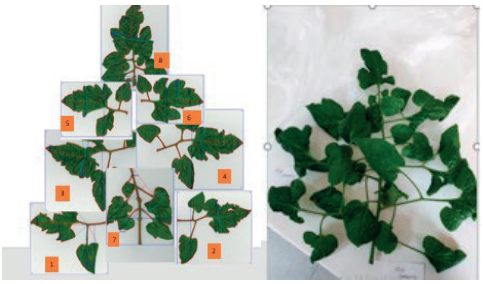


Figure 9. Appearance of leaves harvested from plants grown in C12 and C13 respectively

The dry matter content of tomato leaves was higher in the control variant (C1) of 9.1548% compared to the variant grown in C2 of 7.2864% showing a percentage of only 79.59% compared to the control (Table 2).

Table 2. Dry matter content of tomato leaves

| Compartment | Dry matter content % | Percentage of control |
|---|---|---|
| C12 control | 9.1548+0.537 | 100 |
| C13 | 7.2864+0.316 | 0.7847 |

It was noted that the chlorophyll content was different depending on the culture site. On average, following the determinations made at the base of the leaf, in the middle of the leaf and towards the tip of the leaves, the chlorophyll content was higher in compartment 12 (C1) compared to the mature leaves in compartment 13 (C2) being 25.01 CCM, respectively 20.39 CCM. The determinations made on the young leaves showed that, on average, the values were approximately equal to 43.79 and 43.32 CCM, respectively (Figure 10).

Analyzing by comparison the total weight of the fruits obtained per plant, it was found that the average weight of the fruits in the inflorescence was 182.1 g in compartment 12 (C1) and 191.4 g in compartment 13 (C2). From a statistical point of view, there were no significant differences between the 2 compartments regarding the average mass of fruits in the inflorescence.

There were significant differences between the 2 compartments regarding the number of fruits. In compartment 12 (C2) per plant being 17 fruits 1 and 15.4 in compartment 2.


| | mature leaf | mature leaf | the young leaf | the young leaf |
|---|---|---|---|---|
| | comp 1 | | comp 2 | |
| the base of the leaf | 20,74 | 16,80 | 45,30 | 42,37 |
| the middle of the leaf | 26,28 | 17,87 | 42,22 | 45,10 |
| top of the leaf | 28,00 | 26,50 | 43,83 | 42,50 |
| average | 25,01 | 20,39 | 43,79 | 43,32 |

Figure 10. Chlorophyll content of tomato fruits

Regarding the number of fruits formed in the inflorescence, on average, it was higher in plants grown in compartment 12 (C1) 17.0 fruits per inflorescence respectively 15.4 fruits per inflorescence in compartment 13 (C2). From a statistical point of view, distinctly very significant differences were found.

Analyzing the average mass of a fruit, it was found that in compartment 12 (C12) the fruits were of a smaller size of 10.8 g per fruit compared to those in compartment 13 (C2) where the fruits had an average mass of 12.6 g on the fruit. In this case, the differences from a statistical point of view were distinctly very significant both regarding the total number of fruits in inflorescences and the average weight of the fruits (Figure 11).

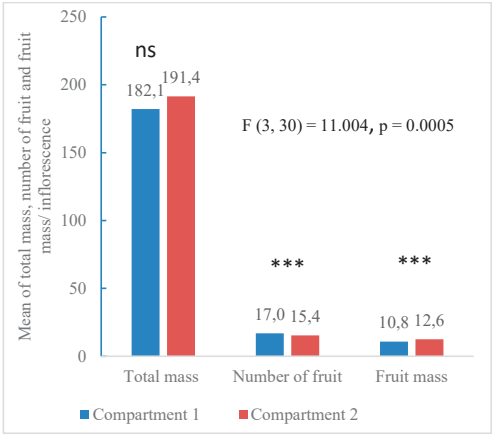
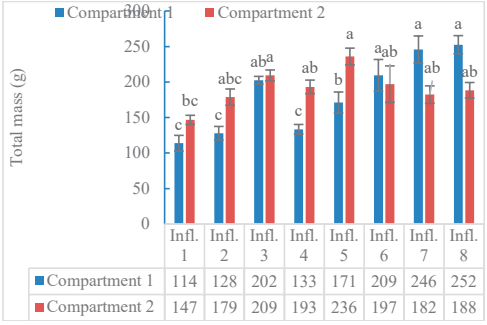



Figure 11. The average mass of fruits in the inflorescence, the number of fruits in the inflorescence and the average mass of a fruit

Analyzing by comparison the total mass of the fruits in the inflorescence, it was possible to find that there were differences between the inflorescences and also between the compartments. Thus, in compartment 12 (C1) at the first inflorescence an average mass of 114 g was determined and in compartment 13 (C2) of 147 g per inflorescence. Starting from inflorescence 6 to inflorescence 8, an increase in the average mass of fruits per total inflorescence was found, this being 209 g at inflorescence 6, 246 g at inflorescence 7 and 252 g at inflorescence 8, an aspect also correlated with the larger number of fruits formed in inflorescences. In compartment 13 (C2) the average mass of fruits per inflorescence did not vary much, being 147 g in the first inflorescence and 236 g in the 5th inflorescence (Figure 12).




| | Infl. 1 | Infl. 2 | Infl. 3 | Infl. 4 | Infl. 5 | Infl. 6 | Infl. 7 | Infl. 8 |
|---|---|---|---|---|---|---|---|---|
| Compartment 1 | 114 | 128 | 202 | 133 | 171 | 209 | 246 | 252 |
| Compartment 2 | 147 | 179 | 209 | 193 | 236 | 197 | 182 | 188 |

Figure 12. The average mass of fruits from inflorescences 1-8 determined in experimental compartments

The number of fruits in the inflorescence differed according to the position of the inflorescence. It was found that in the case of both cultivation variants in the first 2 inflorescences, the number of fruits was lower compared to the rest of the inflorescences, however, there were differences between the two compartments. In compartment 13 (C2) the number of fruits in the inflorescence was higher compared to those in compartment 12 (C1). In inflorescences 7 and 8, between 25 and 24 fruits were formed per inflorescence, but in compartment 13 (C2) the number of fruits remained almost constant (Figure 13).

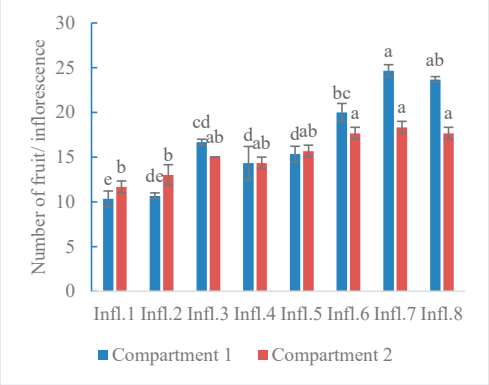



Figure 13. The number of fruits per inflorescence

Analyzing by comparison the average mass of the fruits formed per inflorescence, it was found that in the case of florescence 1 the fruits had an average mass of 11.01 g per fruit for those from compartment 12 (C1) and 12.6 g/fruit for those from compartment 13 (C2). In the case of the rest of the fruits from the inflorescences, it was found that in compartment 13 (C2) the weight of the fruits was higher compared to the weight of the fruits in compartment 12 (C1) (Figure 14).

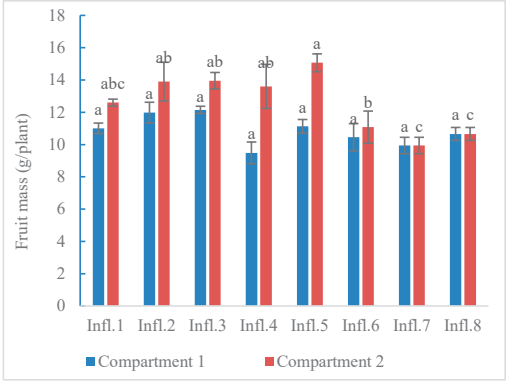



Figure 14. Average mass of a fruit per inflorescence per total plant

The cultural aspects are presented in Figure 15.


Figure 15. Appearance of inflorescences in C1 and C2

## CONCLUSIONS

The temperature in the culture space is also influenced by the surface exposed to solar radiation. The distance between the inflorescences was influenced by the temperatures in the culture space. This was higher in tomato plants grown in C12 where temperature values were higher and variable.

The dry matter content of tomato leaves in C1 was higher compared to C2.

On average, per plant, the mass of fruits per inflorescence was between 182.1 g in C1 and 191.4 in C2, the differences being statistically insignificant. But there were significant differences regarding the number of fruits in the inflorescence and the average weight of the fruits.

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