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REVIEW ON IMPROVING TOMATO CULTURE TECHNOLOGY IN PROTECTED SYSTEM FOR ENVIRONMENTAL PROTECTION AND INCREASING PRODUCTIVITY USING PGPR

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Abstract

Tomato (Solanum lycopersicum L.)is one of the world's most prolific vegetables . Researchers are still looking for solutions to improve crop technology using plant protection and stimulation products that are neither harmful to the environment or the plants they treat. Many technologies for cultivating and treating plants with Bacillus spp. have been developed. For this reason, we analyzed the influence of PGPR on two tomato hybrids Cocete F1 and Nissos F1 in the greenhouse. The results showed that there weren't considerable differences in the quantitative characteristics of plant studied. Regarding stem thickness, the variants had values between 0.5 cm and 0.7 cm. The number of leaves was 16.8 = F1 Cocete 15.9 = F1 Cocete+PGPR, 16.6 = Nissos F1, 16.5 = Nissos F1 + PGPR). The plants height for Cocete F1 was 193.1 cm and 188.1 cm for Cocete F1 + PGPR, while for Nissos F1, the plants had 218.9 cm and 211.3 for Nissos F1 + PGPR. In terms of inflorescences number, Cocete F1 recorded 6.4 and 5.7 for Cocete F1 + PGPR whereas Nissos F1 had 5.1 and Nissos F1 + PGPR 4.9. Referring to the flowers number, the hybrid Cocete F1 in both variants registered similar values (30 flowers/plant) but Nissos F1, Nissos F1 + PGPR had 24.8 and 26.7, respectively. The number of fruits per plant was 14.8 for Cocete F1 while other variants produced 16 fruits/plant.

***Key words**: biologic, tomatoes , bacteria, PGPR.*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most productive vegetables in the world. It is consumed in a wide variety and has a beneficial impact on human health mainly due to the high content of lycopene, folic acid, ascorbic acid, flavonoids, α-tocopherol, potassium and phenolic compounds (Daniela Erba et al., 2013).

In 2019, world production of tomatoes was 180 million tons, and China was the main producing country with 62 million tons, contributing 35% of total world production (FAO, 2019, http://www.fao.org).

Tomatoes have been grown in our country for about two centuries, they have a special economic and food importance, being consumed in all seasons.

For the purpose to achieve higher quality production, researchers have sought and are looking for solutions to improve crop technology using various plant protection and stimulation products. A first step in this area was the use of products that do not affect the environment and thus the treated plants. Over the years, various technologies for cultivating and treating plants with Bacillus spp. have been developed in order to increase plant productivity but also to reduce plant residues, thus helping to protect the consumer.

Bacillus spp. is a bacterium that has been shown to be beneficial in various fields. Studies are still being conducted today to determine its usefulness.

Regarding the studied field, *Bacillus* spp. Was distinguished both by positive effects on the microorganisms existing in the soil but also by a better assimilation of nutrients, which led to increased productivity. It is also used to control certain diseases specific to both tomato cultivation and fruit growing. The rhizosphere provides essential habitat for microbial communities and facilitates a variety of plant-microorganism interactions. Members of the genus *Bacillus* are an important group of rhizobacteria that promote plant growth (PGPR), which improve crop growth and yield. PGPR improves plant growth and yield by facilitating the absorption of mineral nutrients

(Sadaf et al., 2020). *Bacillus* spp. also enhances the main transport functions of nutrients from soil to plant by solubilizing insoluble zinc compounds and increasing the bioavailability of zinc in soil (Muhammad et al., 2017).

Another important factor in maintaining the optimal balance in the soil of microorganisms is the way of irrigation. Drip irrigation has a significant role in the distribution of soil moisture, pH, porosity and growth of tomato roots, as well as their degree of branching.

Underground drip irrigation showed the highest values of the root index, the most intense positive root-soil-microorganism interactions and the highest fruit yield. The effects of surface drip irrigation on the development of tomato roots and soil microbial communities were lower, and the resulting fruit yield was also lower (Jingwei Wang et al., 2022).

In greenhouse plants, an obvious stimulant effect was observed on the quantity and quality of fruit when *Bacillus* spp. Was applied on the substrate in high concentration. The results showed the potential of *Bacillus* spp. to stimulate tomato production in the expected range for greenhouse cultivation. Due to the yields and the quality of the obtained fruits, it was estimated that the profitability of the treatment was 2.5 times higher than the control (Karina A et al., 2021). Bacillus spp. is also used in the biological control of various diseases that can occur in tomato cultivation. Bacillus spp. has a strong antibacterial activity in vitro against various pathogenic plant bacteria, being extremely effective in reducing the development of symptoms of three bacterial plant diseases, namely, bacterial wilt of tomatoes, bacterial staining of peach leaves and bacterial staining of red pepper leaves in pot experiments. The application of the bacterium Bacillus, effectively suppressed the development of bacterial wilting of tomatoes in the greenhouse experiment, with an effectiveness in controlling the disease, being comparable to that of dazomet, a commercial pesticide (Seong Mi Im et al., 2020).

From this research it is admitted that the use of Bacillus spp. Can have as effective results as chemicals, but without toxic residues for both the environment and the consumer.

Inoculation of *Bacillus* spp. improved the ability of tomatoes to defend against the yellow leaf curl virus, TYLCV by activating gene expression and enzymatic activity related to systemic resistance in tomatoes. Specifically, the rate of infection and the symptoms, disease level and symptoms present on the leaves decreased in tomato plants treated with Bacillus spp. Meanwhile, treatment with Bacillus spp. positively influenced the development of roots, green color of leaves and growth of tomato shoots. Secondly, culture-dependent microbiological analysis showed that *Bacillus* spp. increased the bacterial-fungal ratio and the number of beneficial microorganisms, while decreasing the number of pathogenic fungi in the rhizosphere (Qiao Guo et al., 2019).

In order to maintain plant health, research has evolved to the application of carbon-based nanomaterials that have significantly reduced the incidence and severity of *F. oxysporum* in inoculated tomato plants. Also, all carbon-based nanomaterials (CNM) treatments increased the yield of tomato fruit when the plants were inoculated with *F. oxysporum*. However, the application of carbon nanotubes (CNTs) has shown the best results. The application of CNMs can be a tool to increase the content of biocomposites and increase the nutritional quality of tomato fruits, because the production of this type of compound is stimulated. The decrease in the incidence and severity of *F. oxysporum* observed in this study is not fully explained by the modification of the antioxidant defense system of tomato, because the plants that received treatment with CNMs behaved similarly to the positive controls inoculated with the pathogen. However, NMCs may be a product that can be applied in the field as an alternative to traditional pesticides. Therefore, several studies are needed to consider biochemical, micromorphological, genetic or other relevant physiological processes of plants in order to properly understand how CNMs induce tolerance or resistance to pathogens. At present, this technology is not yet available for agricultural production, however, with the increase in research on this topic, it is possible that commercial products based on nanomaterials will be available in the near future (Yolanda González-García et al., 2022).

The application of treatments with *Bacillus* spp. proved to be useful during the storage period after harvest. In cherry tomatoes, they have been shown to play an important role in controlling foodborne pathogens in postharvest fruit. The treatments produced 2 complementary effects. On the one hand, at high concentrations, it showed strong antibacterial activity against *B. subtilis* by inhibiting cell division and oxidative phosphorylation, in addition, it reduced the motility of biofilm formation in *B. subtilis*. On the other hand, at low concentrations they increased the antioxidant capacity of cherry tomatoes and induced an ethylene-based defense response. It has been found that the application of treatments with *Bacillus* spp. Delays senescence in cherry tomatoes (Gui-Yang Zhu et al., 2021).

MATERIALS AND METHODS

The experiment took place in didactic greenhouses of the Agricultural University of Athens from September 2021 to February 2022. The main purpose of the experiment was to observe and monitor the main quantitative and qualitative characteristics of planted hybrids in the presence and/or absence of PGPR (Plant Growth-Promoting Rhizobacteria).
In order to perform the experiment, two hybrids Cocete F1 and Nissos F1 were used.
During the growing season, the crop was cared for according to known technology, using both chemical and biological products to control diseases and pests.
The fertilization recipe was calculated using the NUTRISENSE program (software for the nutrition and fertilization of hydroponic cultivated crops).
The quantitative observations that were made during the vegetation period were: the thickness of the package, the number of leaves, the number of inflorescences, the number of flowers and fruits and the total height of the plants.
The determinations were performed at 5 repetitions with 6 plants/repetition at an interval of 10 days. In order to establish the differences between the variants, the analysis of the variant, Test F and Test T was used.

RESULTS AND DISCUSSIONS

After 45 days from planting, the Cocete F1 hybrid did not register any significant difference between the plants treated with PGPR and the plants without treatment (P <0.76) with values of 0.7 cm for both variants studied (Figure 1).

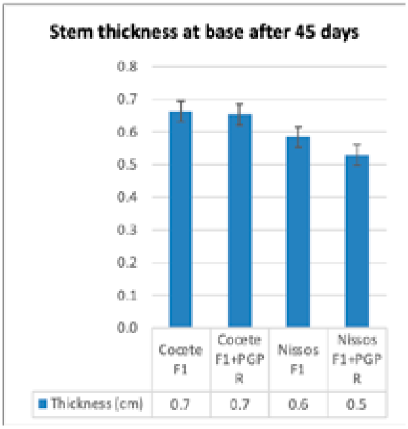

Figure 1. Stem thickness at base after 45 days

Regarding the hybrid Nissos F1 and Nisssos F1 + PGPR there was a significant difference (P <0.01) so that Nissos F1 recorded the value of 0.6 cm and Nisssos F1 + PGPR 0.5 cm.

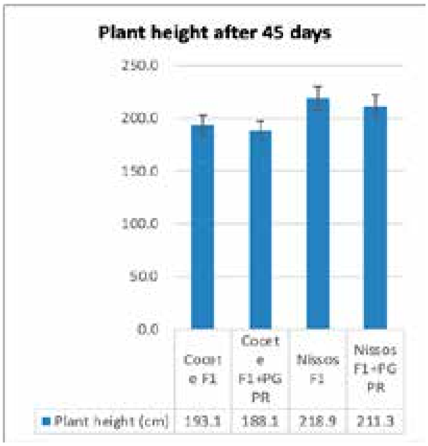

Figure 2. Plant height after 45 days

The height of the plant was determined after the removal of the main shoot. The results confirmed that there is a significant difference between PGPR-treated and untreated plants (P <0.03) for the Nissos F1 hybrid, respectively Nissos F1 recorded a plant height of 218.9 cm and Nisssos F1 + PGPR 211, 3 cm (Figure 2).
There was no significant difference for the Cocete F1 hybrid (P <0.15), with only 5 cm of

difference between the control plants and those treated with PGPR.

Regarding the number of leaves, the results confirmed that there is a significant difference between the plants treated with PGPR and the plants without treatment (P <0.0008) for the hybrid Cocete F1. However, for the Nissos hybrid, there was no significant difference (P <0.76) (Figure 3).

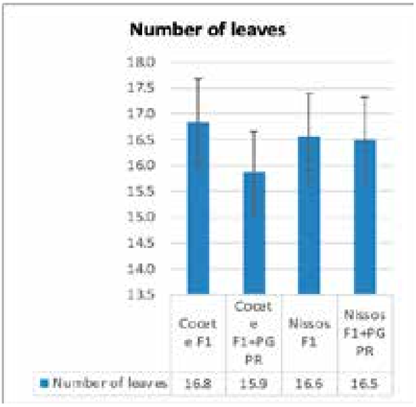

Figure 3. Number of leaves

Given the number of inflorescences (Figure 4). the analysis showed a significant difference between the plants treated with PGPR and the plants without treatment (P <0.0004) for the hybrid Cocete F1, so that the variant without PGPR had an average of 6.4 inflorescences/plant and the variant with PGPR recorded 5.7 inflorescence/plant.

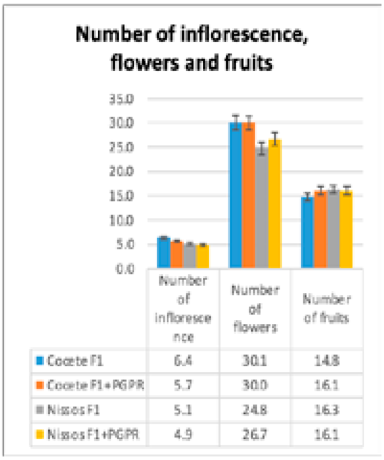

Figure 4. Number of inflorescence, flowers and fruits

There were no significant differences for the Nissos F1 hybrid (P <0.17), both variants having values close to 5.

Regarding the number of flowers, the analysis did not show a significant difference between the plants treated with PGPR and the plants without treatment for both hybrids (P <0.11 Nissos F1, P <0.96 Cocete)F1).

The values for Cocete F1 were similar of 30 flowers/plant, and for Nissos F1 it registered a number of 25 flowers/plant.

For the number of fruits, the results did not show a significant difference between the plants treated with PGPR and the plants without treatment for both hybrids (P <0.82 Nissos, P <0.19 Cocete).

The values for Cocete F1 were around 15 fruits/plant, and for Nissos F1 it was 16 fruits/plant.

The distance between the inflorescences for the hybrid Cocete F1 and Cocete F1 + PGPR did not register significant values from the point of view of the statistical analysis (P <0.83), the two variants having similar and close values (Figure 5).

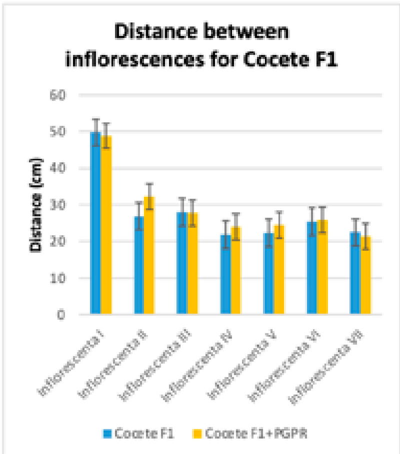

Figure 5. Distance between inflorescences for Cocete F1

In the case of the Nissos F1 hybrid, there were no significant differences in the presence/absence of PGPR (P <0.83), as the varieties studied had similar values (Figure 6).

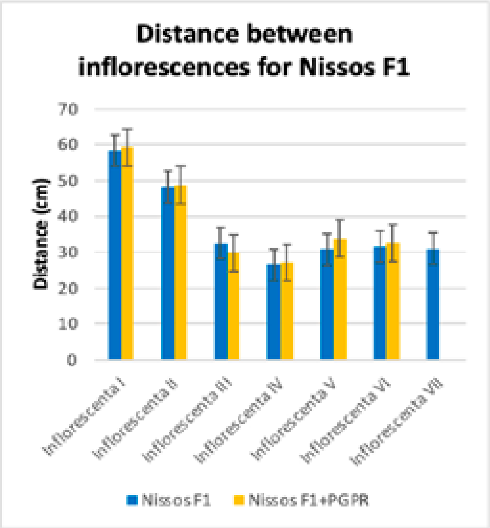

Figure 6. Distance between inflorescences for Nissos F1

CONCLUSIONS

The following results were obtained from this study:

In terms of stem thickness and plant height after removal of the main shoot, a significant difference was obtained between plants treated with PGPR and plants without treatment for the Nissos hybrid. No differences were observed for the Cocete hybrid.

For the number of flowers and fruits, there was no significant difference between PGPR-treated plants and untreated plants on both hybrids.

The number of leaves and the number of inflorescences were different, the difference being significant between the plants treated with PGPR and the plants without treatment for the hybrid Cocete. No difference was observed for Nissos.

The distance between the inflorescences for both studied variants was not influenced by the presence / absence of PGPR.

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