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IMPACT OF PLANT GROWTH PROMOTING MICROORGANISMS AS A BIOFERTILIZER ON ENZYMES ACTIVITY AND VEGETATIVE CRITERIA OF TOMATO CROP

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ABSTRACT

Tomato plants were inoculated with microorganisms PGPM *Azotobacter* chroococcum (A.Z), Bacillus megaterium (B.M), Bacillus circulans (B.C) and *Trichoderma viride* (T.V) to study their effect on some enzymes activity and plant growth parameters under greenhouse conditions as compared with untreated sample. Antagonistic effects of the isolated microorganisms against *F. solani* and *R. solani* were also studied. The growth inhibition percent of *B. megaterium* is always higher than those reported for *B. circulans* and much higher than *A. chroococcum* and *B. megaterium* is more efficient than the other strains in *F. solani* inhibition process. Percentages of growth inhibition of *R. solani* by *B. circulans* after 5 and 7 days are higher than those reported for tested strains.

Significant increase were found in dehydrogenase (DHA), phosphatase (PA) and Nitrogenase (N_2-ase) activities in treatments that inoculated with plant growth promoting microorganisms (PGPM) strains under either infestation with *F. solani* or *R. solani* compared with non-infected one.

Plant height was differed significantly at 30, 60 and 90 days after planting (DAP). The plant height increased continuously from 30 DAP to 90 DAP in all the treatments of both with and without compost. Among the treatments with compost was found to be significantly superior over without compost treatments in respect of plant height at all stages.

The highest values of tomato fresh weight /plant were found in samples inoculated with (Mix) + compost (695.12) followed by Mix + without compost (639.33). The lowest values of fresh weight/plant g were recorded in control sample (381.67). The dry weights/plant (g) of tomato were found in sample inoculated Mix (136.14) followed by sample inoculated with *T. viride* + *A. chroococcum*.

Keywords:- Antagonistic effects, *Azotobacter chroococcum*, *Bacillus circulans*, *B. megaterium*, compost, Dehydrogenase, Nitrogenase, phosphatase, plant growth promoting microorganisms (PGPM) , *R. solani*, *Solanum lycopersicum*, Tomato, *Trichoderma viride*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the important vegetable crops grown throughout the world and ranks next to potato in terms of the area but ranks first as a processing crop. Application of organic fertilizers has been a noble and traditional practice of maintaining soil health and fertility. The use of this organic fertilizers resulting in higher growth, yield and quality of crops (**Sreenivasa *et al*, 2010**).

A unique group of microorganisms that confer a great benefit to plants and/or involved in mutualistic interactions in the near root are known as plant growth-promoting rhizobacteria (PGPR) (**Igiehon, *et al*., 2019)**.

Plant growth-promoting rhizobacteria promote (PGPR) the growth of plants by utilizing varied mechanisms and assuring the accessibility of essential macro and micro-nutrients to the plant without adverse environmental consequences. Many PGPR can withstand unfavorable ecological conditions such as lack of water, salt stress, weed infestation, lack of nutrients and heavy metal pollution. Plant growth-promoting rhizobacteria promote (PGPR) have not only gained much importance for their ability to stimulate key biological functions in the soil, as well as improved crop yields through the breakdown, and competition for required nutrients (**Kumari and Kumar 2018 and Kour *et al*., 2020).**

Plant growth-promoting rhizobacteria promote (PGPR) can produce direct or indirect effects on the host plants, indirect effects are these related to the production of metabolites such as antibiotics, siderophores or cyanogen which increase plant growth by reducing the activity of pathogens. Plant growth-promoting bacteria (PGPB) are a group of naturally occurring non-pathogenic microorganisms that can be isolated from soil and phyllosphere (**Płociniczak *et al*., 2019**).

Dehydrogenase activity (DHA) was linked to a measure of microbial activity overall and respiration rate. Phosphatase activity was found to have a significant role in the breakdown of organic phosphorus compounds. An indicator of diazotrophs' atmospheric nitrogen fixing was soil nitrogenase activity.

Fusarium wilt caused by *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.) W.C. Synder and H.N. Hans is the major limiting factor in the production of tomato. An effort was made to develop an eco-friendly approach to control *Fusarium* wilt in tomato using fluorescent *Pseudomonas*, *Trichoderma harzianum* and *Glomus intraradices,* an arbuscular mycorrhizal fungus (AMF). Besides direct interaction with plant pathogens, bioagents have been reported to induce systemic resistance in plants.

In comparison to uninoculated treatments, *fluorescent Pseudomonas*, *T. harzianum*, and AMF greatly reduced disease incidence and severity, by 74% and 67%, in pots and the field, respectively. The yield was also increased by 20% by the combo treatments. In all treatments, the addition of cow dung compost (CDC) further decreased disease and increased yield output. The combination of the three bioagents with CDC significantly decreased disease by 81 and 74% in pots and field, respectively, and increased yield by 33% when compared to control (**Srivastava *et al.,* 2010 and Kour *et al*., 2020**).

The **aim objectives of the present work were to study:** (a)-Antagonistic effect of PGPR strains against *F. solani*

and *R. solani* (b)-Effect of inoculation with PGPR as biofertilizer on some enzymes activity and certain plant growth parameters.

MATERIALS AND METHODS

1- The soil used:

The soil used in this study was collected from the top layer (25 cm depth) of the soil at the farm of Faculty of Agriculture, Minia University. The soil was dried and ground to pass through 2 mm sieve.

The physical and chemical properties of the used soil were determined in the service laboratory for soils, Fac. of Agric. Minia Univ. according to the method described by Jackson (1973) and presented in Table (a).

Seedlings:

Tomato transplants hybrid 086 that have been used in this study were obtained from Horticulture Department, Fac. of Agric. Minia Univ.

Microbial strains:

The biofertilizing-PGPR strains namely, *Azotobacter chroococcum*, CLOA A27 was used as nitrogen fixing bacteria for tomato inoculation. *Bacillus megaterium* CLOA Bm 3 was used as phosphate dissolving bacteria (PDB). *Bacillus circulans* CLOA Bc 42 was used as potassium solubilization bacteria (PSB) and *Trichoderma viride* CLOA Tri 24 was used as biocontrol agent. Bacterial and fungal isolates were kindly obtained from Central Lap of Organic Agriculture (CLOA), Agricultural Research Center (ARC), Giza, Egypt.

Determination of some enzymatic activities:-

Dehydrogenase activity (DHA) in soil was measured using **Glathe's and Thalmann's technique (1970).** Dehydrogenase (DHA) was estimated at 30, 45 and 60 days after cultivation. Phosphatase activity was estimated three times 30, 45 and 60 days after cultivation according to **Drobrikova (1961).** Assessment of nitrogenase activity (N_2-ase) was measured two times after 50 and 60 DAP by using the acetylene reduction technique given by **Diloworth (1970)**.

Antagonistic experiment:

1- In vitro:

a- Antagonistic effect of the isolated microorganisms against *F. solani* and *R. solani:*

Azotobacter chroococcum, *Bacillus megaterium*, *Bacillus circulans and Trichoderma viride* was used to study their effect **against** root rot diseases caused by *F. solani* and *R. solani*.

Azotobacter isolates were used to study their effect against the fungal growth of the tested fungi (**Abdel-Magid, 2016)**.

Plates were streaked with the bacterial growth of the tested microorganisms obtained from 2 days old culture at opposite sides to the periphery by using needle. At the same time, one disc of the pathogen was placed at the center of each plate. Inoculated plates were incubated at 28°C. Four replicates for each treatment were used. When growth of the pathogen covered the plate surfaces (9.0 cm in diameter) of control treatment, antagonistic or mycoparasitic effect was determined by measuring the free inhibition zone, then percentage of mycelial growth

inhibition was calculated according to the following equation:

Mycelial growth inhibition % = [A — B/A] x 100 Where:

A = Length of the control hyphal growth.

B = Length of the treated hyphal growth.

2 - Greenhouse experiment:

Application of the tested antagonistic agents for controlling the pathogenic fungi

This experiment was carried out under greenhouse conditions during 2020 and 2021 growing seasons in the farm of Fac. of Agric. Minia Univ.

The experiment was designed to study the effect of inoculation with PGPR on enzymes activity and growth parameters of tomato plants. Fungal inoculum was added to the soil at the rate of 0.5% (5 g/kg soil). The infested soil was watered and mixed thoroughly for two weeks before sowing to ensure growth and distribution of inoculated fungi *(F. solani* and *R. solani).*

Thirty days old tomato transplants were inoculated with *Azotobacter chroococcum, Bacillus megaterium, Bacillus circulans and Trichoderma viride* isolates.

a- Effect of certain biofertilizer on the growth parameters of tomato plants:

1) Control without inoculation
2) Inoculated by *Azotobacter chroococcum* with or without compost.
3) Inoculated by *Bacillus megaterium* with or without compost.
4) Inoculated by *Bacillus circulans* with or without compost.
5) Inoculated by *Trichoderma viride* with or without compost.
6) Inoculated by *T. viride + A. chroococcum* with or without compost
7) Inoculated by *T. viride + B. megaterium* with or without compost.
8) Inoculated by *T. viride + Bacillus circulans* with or without compost.
9) Inoculated by above mentioned strains with or without compost

Preparation of bacterial inoculum

Heavy cell suspension of the selected isolates of *Azotobacter chroococcum*, *Bacillus megaterium*, *Bacillus circulans* and *Trichoderma virid* were obtained by growing them separately on modified **Ashby's** medium for *Azotobacter*, **Bunt and Rovira** medium for *Bacillus megaterium* modified Alexandrov's medium **(Zahra, 1969**), for *Bacillus circulans*, and Gliotoxin fermentation medium **(Brian and Hemming, 1945)** for *Trichoderma viride*.

for Bacillus 7 days at 28 ± 2°C with mild shaking (200 rpm). Transplants were successively washed and then soaked with biofertilizer for 30 minutes

Preparing the pathogenic inocula:

Each fungus was grown separately in conical flasks (250 ml) containing sorghum medium according to **Abdel-Moneem (1996),** which contain 75 g sorghum grain, 25 g clean sand, 2 g sucrose and 200 ml water sterilized and inoculated with equal discs (0.5 cm) taken from 7 days old cultures of the tested fungal isolates grown on PDA medium at 27°C. The inoculated flasks were incubated at 27°C

for two weeks, then mixed with sterilized clay soil with formalin 5%. Sterilized pots (30 cm in diameter) were filled with infested clay soil 7 days before sowing. Uninfested soil was used as control.

The tomato plants were evaluated for their susceptibility to root rot diseases caused by *F. solani* and *R. solani.*

RESULTS AND DISCUSSION

(1)-Antagonistic effect of PGPR isolates against *F. solani*

The growth inhibition percent of *B. megaterium* are always higher, followed by *B. circulans* and *A. chroococcum* (Table 1). The growth inhibition percentages after three days are the lowest values. Data also showed that *B. megaterium* is more efficient than the other strains in *F. solani* inhibition process.

(2)-Antagonistic effect of PGPR isolates against *R. solani*

Percentages of growth inhibition of *R. solani* by *B. circulans* after 5 and 7 days were higher than those reported by tested strains (Table 2). The results given in Table 1 and 2 showed that *B. megaterium and B. circulans* could be serve as proficient biocontrol PGPR inoculants.

Field experiment (without infested) and green house under infested with either *F. solani* or *R. solani* were carried out to evaluate the effect of PGPR to study effect of inoculation with PGPR on plant growth of tomato some soil enzymes activity and controlling tomato rot root diseases under green-house conditions to study the effect of the PGPM strains as biocontrol for root diseases of tomato caused by pathogenic fungi (*F. solani* and *R. solani*) as well as their effect on tomato growth

(3)-Effect of inoculation with PGPR as biofertilizer on some enzymes activities.

3.1.Dehydrogenase activity (DHA) (µg TPF.g^{-1} dry soil. 24^{-1})

Tomato plants were inoculated with PGPR *A. chroococcum*, *B. megaterium*, *B. circulans* and *T. viride* to study their effect on plant growth parameters as well as some enzymes activity under greenhouse conditions as compared with control (Table 3).

Significant increases were found in dehydrogenase activity in treatments that inoculated with PGPR strains under either infestation with *F. solani* or *R. solani* compared with non-infected one.

The obtained results show that treatments were varied widely in their DHA values. Higher values of DHA were recorded in treatment inoculated with *B. circulans* under *F. solani* infestation on the other hand the highest values of DHA under *R. solani* infestation recorded with *T. viride*.

In treatments infected with *F. solani*, high DHA activities were observed in treatment inoculated with *B. circulans*. While in the soil infested with *R. solani* the highest DHA activities were recorded in treatment inoculated with *T. viride*, followed by *B. megaterium*, *A. chroococcum* then *B. circulans* respectively. This result was recorded in almost experimental period.

It is clear from the obtained results that soil infested with the pathogenic fungi gave higher values of DHA compared with non-infected one. DHA with increased gradually until 45 days and then decreased at 60 days after planting.

The lowest values of DHA of tomato rhizospher soil were found at the treatments treated with compost only. On the other hand, higher effects of compost

were observed in treatments infected *F. solani* compared to those infected with *R. solani*.

According **to Abou-Aly (2005)**, tomato plants were inoculated with *Azospirillum* and *Bacillus megaterium var. phosphaticum* in combination, which boosted DHA activity at all growth stages. The maximum DHA was produced in squash plants when mychorriza or *Bacillus megaterium var. phosphaticum* were combined with *Paenibacillus polymyxa*, either with or without a single application.

3.2. Phosphatase activity (µg ρNP g^{-1} h^{-1})

Results of phosphatase activities are given in Table (4). The highest value of phosphtase activity was recorded by *B. megaterium* inoculation. While, the lowest values for the soil phosphtase activities were found at the non-infected flowed with infected one (control).

Higher P-ase activities were recorded in soil infested with *F. solani* or *R. solani* than those non-infected samples (control). The samples composed from *F. solani* + *B. megaterium* and *R. solani* + *B. megaterium* revealed the highest values of phosphtase at 30 and 60 DAP

Treatments which inoculated with *B. megaterium*, *A. chroococcum* or *B. circulans* recorded higher values of soil phosphtase activities than other tested PGPM strains in the treatments without compost while, *B. megaterium*, *T. viride* or *A. chroococcum* recorded higher values of phosphtase in the treatments with compost under *F. solani* infestation. Also, the higher values of phosphtase activities were recorded under *R. solani* infestation with *B. megaterium*, *T. viride* or *B. circulans* in the treatments without compost and the same in treatments with compost.

According to **Ponmurgan and Gopi (2006)**, the groundnut rhizosphere-isolated phosphobacteria *Pseudomonas sp*. displayed greater phosphatase activity Additionally, there was an association between phosphate-solubilizing bacteria and phosphatase activity that was favorable**.**

3.3.Nitrogenase activity (µL C_2H_4.g^{-1} dry soil. h^{-1})

In treatments infected with *F. solani*, high N_2-ase activities were observed in treatment inoculated with *A. chroococcum* in both treatments with compost and without compost. While in the soil infested with *R. solani*, high (N_2-ase) activity was the same as well as *F. solani* in both treatments. It is clear from the obtained results that soil infested with the pathogenic fungi gave higher values of N_2-ase compared with non-infected one.N_2-ase increased gradually until 45 days and then decreased at 60 days after planting.

The highest values of N_2-ase activity were higher in soil infested with *R. solani* or *F. solani* compared with those non-infected (control) and in with compost compared without compost. With regard to effect of compost amendment highest values of dehydrogenase activity of control rhizospher soil with recorded with plants treated with compost and inoculated with (PGPR). However, the lowest values of N_2-ase of tomato rhizospher soil were found at the treatments treated with compost only. On the other hand higher effect of compost was observed in treatments infected *R. solani* compared to those infected with *F. solani*.

According to **Zaghloul et al. (2007),** tomato inoculated with *Azotobacter chroococcum* either alone or in combination with the biocontrol agents *Trichoderma harzianum* and *Bacillus subtilis* showed considerably higher nitrogenase activity (N_2-ase) activity than un-inoculated treatments. Similar to this, when tomato inoculation with *A. chroococcum* mixed with either *Streptomyces aureofaciens* or *Bacillus subtilis* was compared to individual inoculation by either of them, dehydrogenase activity exhibited greater values.

The soil around healthy and *Rhizoctonia solani* infected tomato plants that were grown in greenhouses in Chile's V Region was sampled for bacteria. *B. subtilis* (one isolate) and *B. lentimorbus* (two isolates) were found to be the best bacterial strains based on their capacity to inhibit the development of three *R. solani* isolates (designated as belonging to the anastomosis groups AG- 2-1, AG-4) (two different isolates). All bacterial isolates were successful in controlling the development of all *R. solani* isolates in vitro, and the control methods employed by the bacteria did not involve the production of enzymes that break down fungal cell walls. Compared to R. solani AG-4, *R. solani* AG-2-1 was more sensitive on the other hand, all bacteria had a good capacity for tomato root colonisation and thrived under settings that were comparable to those observed in the field (taking pH, salinity, Fe^{3+}, and temperature into account). These findings imply that the investigated isolates of *B. subtilis* and *B. lentimorbus* have a high potential for application as biocontrol agents of *R. solani* in tomato greenhouses at the field level **(Montealegre et al., 2003).**

4-Effect of inoculation with PGPR as biofertilizer on certain plant growth parameters

4.1. Plant height (cm)

Data pertaining to the plant height are presented in Table 6. The plant height was differed significantly at 30, 60 and 90 days after transplanting (DAP). The plant height increased continuously from 30 DAP to 90 DAP in all the treatments of both with and without compost. Among the treatments with compost was found to be significantly superior over without compost treatments in respect of plant height at all stages. At 30 DAP the plant height was significantly higher in compost 40.4 cm over without compost application 33.93 cm significantly higher plant height (55.27) cm was observed in ix over all other treatment.

The obtained results show that in treatments without compost the treatment with mix of bio agent increasing plant height (cm/ plant) followed by *T. viride + B. megaterium, T. viride + B. circulans whereas Inoculated with T. viride + B. megaterium* 48.25, 47.84 and 46.21 cm/ plant while Inoculated with A. *chroococcum,* gave the lowest height plant 28.13 cm/ plant after control.

Results also, show that in the treatments with compost the treatment with *T. viride + B. circulans* give the highest followed by Inoculated with mix of bio agent and *T. viride + B. megaterium* these treatments recorded 65.42, 63.35, and 61.23 cm/ plant. At 60 DAP the plant height was significantly higher in compost compared without compost application. Moreover, treatment inoculated with mix of bio agent gave higher values was recorded 71.18 followed by Inoculated with *T. viride + A. chroococcum* was recorded 70.42, then followed by inoculated with

Inoculated with T. viride + B. megaterium recorded 70.35 in the in treatments without compost

The highest values in the treatments with compost recorded by inoculated with mix of bio agent followed by Inoculated with *T. viride* and inoculated with *T. viride+ B. circulans* these treatments recorded 83.71, 82.57 and 82.46 cm/ plant.

4.2.-No. of branches/plant

The results generally showed that with the increase in the age of the plants, the number of branches increased, and the highest increase was in the age of 90 days. It was also found that treatments fertilized with compost are better than those not fertilized with compost (Table 6).

Results of inoculation by combination composing from three different bacterial strains and *T. viride* (Mix) led to the highest number of branches/plant (31.57) whereas the lowest value was reported in control (3.87) treatment without compost at the first month of tomato transplanting (Table 6). This result meaning that double treatment (inoculation + compost) after 90 DAP increased the branches number ten-folds. inoculation with *T. viride + B. megaterium* recorded close value (30.87) to mix treatment (31.57) at the same DAP.

4.3.-No. of leaves/plant

The results in Table (7) showed that the number of leaves/plant in sample inoculated with *B. circulans* only after 60 days recorded the highest number of leaves /plant (82.20) followed by Mix (80.57). The treatments containing compost were better than those treated with compost. All values recorded after 60 days from transplanting are higher than those recorded after 90 days and all treatments inoculated with compost are higher than those untreated with compost.

Fresh and dry weight/plant w/mg

Data presented in Table (9) showed that both fresh weight/plant g and dry weight/plant g of samples received compost were heavier than those don't receive. The highest values of tomato fresh weight /plant were found in samples treated with inoculation by combination composing from three different bacterial strains and *T. viride* (Mix) + compost (695.12) followed by Mix + without compost (639.33). The lowest values of fresh weight/plant g were recorded in control sample (381.67).

The dry weight/plant (g) of tomato were found in sample inoculated Mix (136.14) followed by sample inoculated with *T. viride + A. chroococcum*.

Abdel-Fattah *et al.,* (2011) showed that colonization of bean plants with AM fungi significantly increased growth parameters, yield parameters and mineral nutrient concentrations. The results obtained by **Khan *et al.,* (2019)** in field experiment showed that yield and quality parameters of tomato fruit were significantly affected by the combined use of compost and inorganic fertilizers. Maximum tomato fruit and dry matter yields, fruit density, number of fruit kg^{-1} , N, P and K uptake by tomato plant were obtained from treatment where full dose of N, P and K with10 tons of compost were applied. The results obtained by **Khan *et al.,* (2019)** in field experiment showed that yield and quality parameters of tomato fruit were significantly affected by the combined use of compost and inorganic fertilizers.

CONCLUSION:

In the present article we concluded that the inoculation by PGPR improve the rate of respiration and total microbial activities (DHA), increase the availability phosphorus (Phosphatase) and accelerate N_2 fixation (N_2-ase). These bacteria are capable of stimulating physical, chemical and biological changes in plants, resulting both directly and indirectly in induced biotic and abiotic stress tolerance through a wide range of mechanisms. The use of PGPR as a key element of the agricultural system is a technology that has come to stay and the use of these techniques are already being embraced in many developed countries. Conversely, in Egypt, there is still room for growth. In advanced countries, where the cost of artificial chemicals is relatively high, the utilization of PGPR holds a major role in the development of nonchemical agriculture systems.

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Table (a): Physical and chemical analysis of the experimental soil.

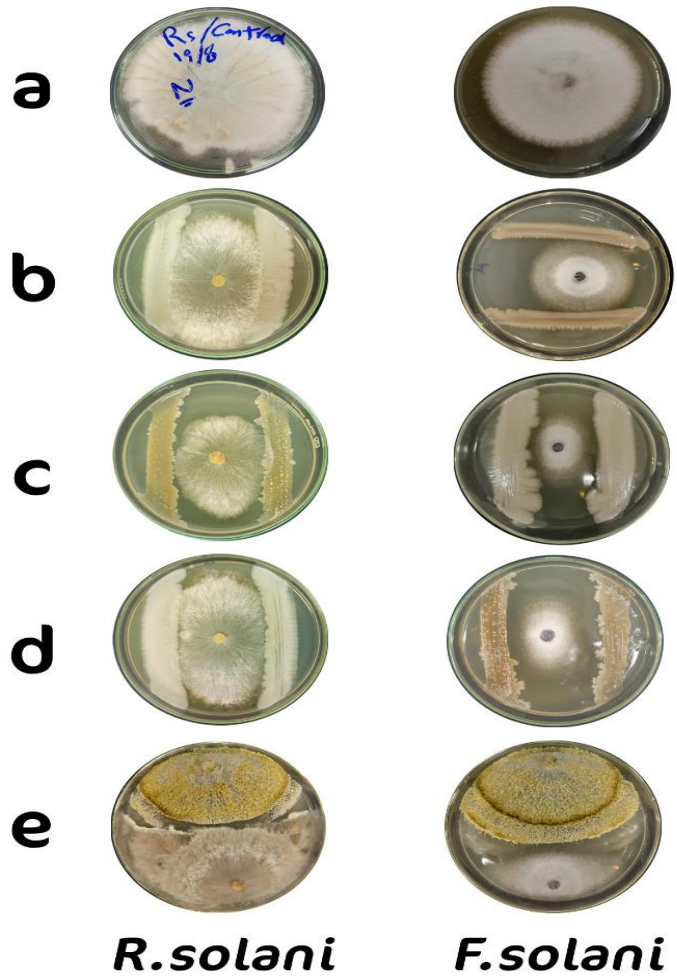
Coarse sand	Fine sand	Silt	Clay	Texture of soil	Organic matter	pH	Total N%	Available P ppm
5.1%	28.7%	32.6%	33.6%	Clay loam	0.82	7.82	0.18	12.27

Table (1): Antagonistic effect of PGPR isolates against *F. solani* (growth inhibition %)

	F. solani			
	A. chroococcum	***B. megaterium***	***B. circulans***	***T. viride***
3 days	19	34	33	13
5 days	20	62	54	21
7 days	25	64	61	31

Table (2): Antagonistic effect of PGPR isolates against *R. solani* (growth inhibition %)

	R. solani			
	A. chroococcum	***B. megaterium***	***B. circulans***	***T. viride***
3 days	5	51	26	3
5 days	6	58	61	8
7 days	3	61	64	37



a) control **b)** ***A. chroococcum*** **c)** ***B. megaterium*** **d)** ***B. circulans*** **e)** ***T.virid***

Figure (1): illustrate the antagonistic effect of bioagents on the mycelial growth of the tested pathogenic fungi *F. solani* and *R. solani* in vitro

Table (3). Effect of PGPR inoculation on dehydrogenase activity (µg TPF.g^{-1} dry soil. 24^{-1}) of tomato rhizosphere in soil infested with *F. solani* and *R. solani*.

Treatments	S1			S2		
	30 DAP	45 DAP	60 DAP	30 DAP	45 DAP	60 DAP
Non-infected soil with *F. solani*	9.90	12.40	11.30	7.62	14.50	12.70
Soil infected with *F. solani*	13.40	16.70	14.20	15.67	19.40	15.30
F. solani + *A. chroococcum*	10.08	27.25	20.18	20.28	30.17	28.46
F. solani + *B. megaterium*	11.35	26.14	19.98	22.14	33.45	36.44
F. solani + *B. circulans*	18.70	35.12	22.70	24.25	45.21	44.12
F. solani + *T. viride*	13.33	25.44	17.35	21.40	46.17	42.13
Non-infected soil with *R. solani*	10.02	15.30	13.25	16.12	17.42	15.72
Soil infected with *R. solani*	11.14	14.65	12.34	16.40	25.14	22.15
R. solani + *A. chroococcum*	15.47	15.36	21.12	15.72	35.40	36.70
R. solani + *B. megaterium*	19.45	39.81	32.17	16.40	33.65	30.40
R. solani + *B. circulans*	16.79	31.73	29.90	19.52	30.53	20.33
R. solani + *T. viride*	22.62	49.99	33.15	20.52	45.42	35.17

Table (4). Effect of PGPR inoculation on phosphatase activity (µg ρNP g^{-1} h^{-1}) of tomato rhizosphere in soil infested with *F. solani* and *R. solani*.

Treatments	S1			S2		
	30 DAP	45 DAP	60 DAP	30 DAP	45 DAP	60 DAP
Non-infected soil with *F. solani*	**6.90**	**11.89**	**10.42**	**9.44**	**11.15**	**11.21**
Soil infected with *F. solani*	7.30	12.70	11.30	9.02	13.15	13.99
F. solani + *A. chroococcum*	13.40	14.10	15.97	12.90	13.89	14.50
F. solani + *B. megaterium*	**14.20**	**17.30**	**17.90**	**18.99**	**25.40**	**20.23**
F. solani + *B. circulans*	11.81	13.90	14.43	10.30	13.22	14.40
F. solani + *T. viride*	11.38	9.22	11.99	14.30	15.23	20.10
Non-infected soil with *R. solani*	11.35	13.40	14.50	9.55	10.33	11.21
Soil infected with *R. solani*	11.20	11.99	12.90	10.71	10.11	12.02
R. solani + *A. chroococcum*	12.11	13.39	18.62	13.30	16.70	17.40
R. solani + *B. megaterium*	**30.51**	**29.90**	**27.80**	**20.32**	**29.40**	14.55
R. solani + *B. circulans*	12.42	15.36	15.89	13.20	12.50	17.36
R. solani + *T. viride*	13.82	15.92	23.64	16.70	15.30	18.29

Table (5). Effect of PGPR inoculation on Nitrogenase activity (µL $C_2H_4.g^{-1}$ dry soil. h^{-1}) of tomato rhizosphere in soil infested with *F. solani* and *R. solani*.

Treatments	S1			S2		
	30 DAP	50 DAP	60 DAP	30 DAP	50 DAP	60 DAP
Non-infected soil with *F. solani*	3.99	6.88	4.26	5.32	10.81	8.79
Soil infected with *F. solani*	4.90	9.23	6.21	7.34	13.52	9.97
F. solani + *A. chroococcum*	**21.40**	**41.30**	**30.90**	**26.87**	**55.30**	**20.46**
F. solani + *B. megaterium*	9.92	15.94	11.32	13.89	19.45	14.52
F. solani + *B. circulans*	7.90	14.30	10.62	11.97	17.80	15.77
F. solani + *T. viride*	7.50	15.92	9.32	14.40	16.92	13.50
Non-infected soil with *R. solani*	7.30	13.96	12.87	9.97	12.52	10.99
Soil infected with *R. solani*	8.90	17.82	14.92	12.98	12.96	15.73
R. solani + *A. chroococcum*	**29.56**	**40.21**	**30.15**	**30.25**	**44.30**	**30.94**
R. solani + *B. megaterium*	26.82	35.42	21.75	27.87	36.50	25.40
R. solani + *B. circulans*	16.40	20.50	17.49	20.37	33.20	20.50
R. solani + *T. viride*	16.67	23.70	18.43	20.87	36.62	23.17

Table (6): Impact of inoculation by four microbial strains, their combinations and compost treatments on plant height (cm) at different stages of tomato transplanting.

Treatments	After 30		After 60		After 90	
	Without compost	With compost	Without compost	With compost	Without compost	With compost
Control	22.57	23.50	35.43	40.36	51.33	60.12
Inoculated with *A. chroococcum*	28.13	29.35	36.27	58.73	58.12	68.37
Inoculated with *B. megaterium*	31.19	33.57	45.67	69.70	55.90	66.19
Inoculated with *B. circulans*	34.16	41.10	55.70	71.53	66.63	85.60
Inoculated with *T. viride*	42.77	60.57	67.13	82.57	76.37	95.38
Inoculated with *T. viride* + *A. chroococcum*	45.17	62.31	70.42	75.42	78.54	97.54
Inoculated with *T. viride* + *B. megaterium*	47.84	61.23	70.35	77.45	80.56	105.68
Inoculated with *T. viride* + *B. circulans*	46.21	65.42	68.32	82.46	83.74	107.48
Mix	48.25	68.35	71.18	83.71	84.62	111.38

Table (7) Impact of inoculation by different microbial strains, i their combinations and compost treatments on No. of branches/plant at different stages of tomato transplanting.

Treatments	After 30		After 60		After 90	
	Without compost	With compost	Without compost	With compost	Without compost	With compost
Control	3.87	5.60	7.73	11.70	11.87	13.40
Inoculated with *A. chroococcum*	7.28	7.32	10.57	13.00	17.62	23.77
Inoculated with *B. megaterium*	6.86	7.37	8.53	12.83	15.28	20.50
Inoculated with *B. circulans*	7.46	8.05	12.32	14.15	20.37	25.93
Inoculated with *T. viride*	8.38	9.70	16.32	17.53	27.17	29.53
Inoculated with *T. viride* + *A. chroococcum*	9.01	10.28	18.27	20.54	28.56	30.15
Inoculated with *T. viride* + *B. megaterium*	9.89	10.10	17.53	19.85	30.92	30.87
Inoculated with *T. viride* + *B. circulans*	9.24	12.45	16.49	21.67	29.51	31.12
Mix	10.45	12.85	20.57	22.51	30.63	31.57

Table (8) Impact of inoculation by different microbial strains, their combinations and compost treatments on No. of leaves plant at different stages of tomato transplanting.

Treatments	After 30		After 60		After 90	
	Without compost	With compost	Without compost	With compost	Without compost	With compost
Control	19.35	21.76	44.65	51.30	34.50	36.37
Inoculated with *A. chroococcum*	25.20	36.39	53.76	60.50	40.37	45.72
Inoculated with *B. megaterium*	31.08	44.35	57.75	75.13	45.02	56.76
Inoculated with *B. circulans*	36.90	48.78	64.70	**82.20**	50.37	62.14
Inoculated with *T. viride*	47.02	55.31	70.20	76.37	63.52	71.72
Inoculated with *T. viride* + *A. chroococcum*	48.54	56.34	71.34	77.34	63.94	72.34
Inoculated with *T. viride* + *B. megaterium*	49.53	58.46	72.02	78.24	64.53	73.05
Inoculated with *T. viride* + *B. circulans*	49.89	57.95	72.67	79.34	64.94	74.62
Mix	50.28	58.84	73.45	80.57	65.75	75.64

Table (9): Impact of inoculation by different microbial strains, their combinations and compost treatments on fresh weight/plant g and dry weight/plant g of tomato.

Treatments	Fresh weight/plant g		Dry weight/plant g	
	Without compost	**With compost**	**Without compost**	**With compost**
Control	381.67	399.20	84.33	88.89
Inoculated with *A. chroococcum*	495.33	520.12	96.67	101.36
Inoculated with *B. megaterium*	478.67	487.36	106.00	115.45
Inoculated with *B. circulans*	409.00	451.32	92.00	97.14
Inoculated with *T. viride*	442.00	497.30	86.33	91.36
Inoculated with *T. viride* + *A. chroococcum*	544.67	579.65	123.00	**133.22**
Inoculated with *T. viride* + *B. megaterium*	515.00	540.32	106.33	116.89
Inoculated with *T. viride* + *B. circulans*	505.00	531.06	117.33	122.12
Mix	**639.33**	**695.12**	129.00	**136.14**

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الملخص العربي

تأثير الكائنات الحية الدقيقة المشجعة لنمو النبات كسماد حيوي على نشاط الإنزيمات والصفات الخضرية لمحصول الطماطم

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تم تلقيح نباتات الطماطم بالكائنات الحية الدقيقة المشجعة لنمو النبات وهى (الازوتوباكتر والباسيلس ميجاتريم والباسيلس سيركولانس والتريكودريما فيردى) لدراسة تأثيرها على بعض أنشطة الإنزيمات ومعايير نمو النبات تحت ظروف الصوبة مقارنة بالعينة غير المعاملة. كما تمت دراسة التأثيرات المضادة للكائنات الدقيقة ضد فطرى الفيوزاريوم سولانى والريزوكتونيا سولانى

وكانت نسبة تثبيط نمو الباسيلس ميجاتريم أكثر كفاءة من السلالات الأخرى في عملية تثبيط الفيوزاريوم سولانى والريزوكتونيا سولانى والنسبة المئوية لتثبيط نمو الفيوزاريوم سولانى بواسطة والباسيلس سيركولانس بعد 5 و 7 أيام أعلى من تلك المذكورة في السلالات المختبرة.تم العثور على زيادة كبيرة فى نشاط انزيمات (الديهيدروجنيز والفوسفاتيز النيتروجنيز) فى المعاملات الملقحة بالبكتريا المشجعة للنمو تحت تأثير الاصابة بفطرى الفيوزاريوم سولانى والريزوكتونيا سولانى مقارنة بالمعاملات الغير ملقحة, كما اختلف ارتفاع النبات وعدد الاوراق والتفرعات بشكل كبير بعد 30 و 60 و 90 يومًا من الزراعة وايضا زاد ارتفاع النبات والصفات الاخرى بشكل مستمر من عمر30 يوم إلى 90 في جميع المعالجات سواء بإضافة الكمبوست او بدون اضافة وكانت المعاملات باستخدام الكومبوست أفضل بكثير من المعالمات بدون السماد فيما يتعلق بارتفاع النبات والصفات الخضرية الاخرى في جميع المراحل.وتم العثور على أعلى قيم لوزن نبات الطماطم الطازج / نبات (جم) في العينات الملقحة ب (الخليط) + كمبوست (695.12جم) تليها الخليط + بدون سماد (639.33). سجلت أقل قيم للوزن الرطب للجرام في عينة الكنترول (381.67جم).بينما كانت الأوزان الجافة للنبات / نبات (جم) من الطماطم اعلى في العينة الملقحة بالخليط (136.14جم) تليها العينة الملقحة بـ الازوتوباتاكتر +التريكودرما.