EFFECTS OF PGPR ON GROWTH AND NUTRIENTS UPTAKE OF TOMATO

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ABSTRACT

Tomato is one of the most popular garden vegetable in the world. Tomatoes have high values in Vitamin A and C and are naturally low in calories. Inoculation with plant-growth promoting rhizobacteria (PGPR) has been attributed to the production of plant growth regulators at the root interface, which stimulate root development and result in better absorption of water and nutrients from the soil. A greenhouse experiment was conducted to evaluate the effects of some PGPR on growth and nutrients uptake of tomato (Lycopersicon esculentum Red Cherry*) plants. Seven treatments were used for bacteria (Pseudomonas, Azotobacter, Azosprillum, Pseudomonas + Azotobacter, Pseudomonas + Azosprillum, Azotobacter + Azosprillum and Pseudomonas + Azotobacter + Azosprillum) which were compared to control. Plants were cut at prebloom stage. Maximum level of shoot fresh weight was shown on Azotobacter + Azosprillum, Pseudomonas + Azotobacter + Azosprillum and Azosprillum treatments which significantly differed from other treatments. Maximum level of root fresh weight was achived in Azotobacter + Azosprillum, Pseudomonas + Azotobacter + Azosprillum and Azotobacter treatments which significantly differed from other treatments. Maximum level of shoot and root dry weights were achieved on Azotobacter + Azosprillum and Pseudomonas + Azotobacter + Azosprillum treatments. Minimum level of shoot and root dry weights were obtained in Pseudomonas + Azosprillum. Maximum root length was shown on Azotobacter + Azosprillum which significantly differed from other treatments. The highest amount of N, P and K were achieved on Pseudomonas + Azotobacter + Azosprillum treatment and the lowest amount was shown on Pseudomonas + Azotobacter treatment. Maximum level of Ca and Mg were obtained on Pseudomonas + Azotobacter and Pseudomonas + Azosprillum treatments which significantly differ from other treatments.*

KEYWORDS: *Pseudomonas, Azotobacter, Azosprillum, Lycopersicum esculentum*

I. INTRODUCTION

Plant growth-promoting rhizobacteria (PGPR) help plants through different mechanisms, for example (i) the production of secondary metabolites such as antibiotics, cyanide, and hormonelike substances; (ii) the production of siderophores; (iii) antagonism to soilborne root pathogens; and (iv) phosphate solubilization [1,2,3,4,5,6,7]. These organisms possessing one or more of these characteristics are interesting since it may influence plant growth. Improvement of phosphorus (P) nutrition is one of the factors involved in plant growth promotion by PGPR. These bacteria may improve plant P acquisition by solubilizing organic and inorganic phosphate sources through phosphatase synthesis or by lowering the pH of the soil [8]. The objective of this study was to compare the effects of the PGPR at several treatments (alone and mixed) on growth and nutrients uptake of tomato plants.

II. MATERIALS AND METHODS

2.1. Plant Materials and Experimental Conditions

A greenhouse experiment was conducted to evaluate the effects of 7 treatments of bacteria (Pseudomonas, Azotobacter, Azosprillum, Pseudomonas + Azotobacter, Pseudomonas + Azosprillum, Azotobacter + Azosprillum and Pseudomonas + Azotobacter + Azosprillum) on tomato (Lycopersicon esculentum Red Cherry) growth and nutrients uptake. The plants were grown from seeds after inoculated with bacteria in pots containing 7 kg of field soil, sand and peat (1/3 ,v/v each of them). Experiment was set in a complete randomized design with four replicates. At prebloom stage, the shoots were cut at the soil surface level. The roots were separated from the soil. Shoot and root fresh weights and root length were measured, then dry weights of shoots and roots were determined after drying at 75°C.

2.2. Nutrient Determination

N, P and K were determined by kjeldahl, Olsen and flame photometery methods, respectively. Ca and Mg were determined by calciometery.

2.3. Statistical Analysis

Statistical analyses were done using SAS software. SAS (Statistical Analysis System) is an integrated system of software products provided by SAS Institute Inc. that enables programmers to perform statistical analysis. SAS is driven by SAS programs, which define a sequence of operations to be performed on data stored as tables. Means were compared by Duncan's multiple range test at $P < 0.05$ (5% level of probability).

III. Results

The highest shoot fresh weight was observed in *Azotobacter* + *Azosprillum* (53.77 g/plant), *Pseudomonas* + *Azotobacter* + *Azosprillum* (53.29 g/plant) and *Azosprillum* (51.87 g/plant) treatments which significantly differed from other treatments. The lowest shoot fresh weight (42 g/plant) was obtained in *Pseudomonas* + *Azosprillum*. The maximum level of root fresh weight was achieved in *Azotobacter* + *Azosprillum* (10.81 g/plant), *Pseudomonas* + *Azotobacter* + *Azosprillum* (10.49 g/plant) and *Azotobacter* (10.30 g/plant) treatments which significantly differed from other treatments. Maximum level of shoot dry weight was shown on *Azotobacter* + *Azosprillum* (6.84 g/plant) and *Pseudomonas* + *Azotobacter* + *Azosprillum* (7.05 g/plant) treatments which significantly differed from others. The highest root dry weight was achieved on *Azotobacter* + *Azosprillum* (0.92 g/plant) and *Pseudomonas* + *Azotobacter* + *Azosprillum* (0.94 g/plant) treatments. Minimum level of shoot and root dry weights were achieved in *Pseudomonas* + *Azosprillum*. The maximum root length was shown on *Azotobacter* + *Azosprillum* (40.33 cm) which significantly differed from other treatments (Table 1).

Table 1. Effect of bacterial treatments on shoot and root fresh weights, shoot and root dry weights and root length.

Treatments	Shoot fw (g/plant)	Shoot dw (g/plant)	Root fw (g/plant)	Root dw (g/plant)	Root length (cm)
Pseud.	43.29b†	5.38cd	8.29c	0.63cd	34.18b
Azoto.	44.06b	5.46bcd	10.30a	0.79b	27.23c
Azosp.	51.87a	5.15d	8.59bc	0.58d	32.85b
Pseud. + *Azoto.*	43.75b	5.68bc	9.03b	0.60cd	32.13bc
Pseud. + *Azosp.*	42.00b	4.13e	7.59d	0.43e	31.40bc
Azoto. + *Azosp.*	53.77a	6.84a	10.81a	0.92a	40.33a
Pseud. + *Azoto.* + *Azosp.*	53.29a	7.05a	10.49a	0.94a	33.45b
Control	42.41b	5.93b	8.03cd	0.66c	34.00b

† In each column, means with the same letters are not significantly different at 5% level of Duncan's multiple range test.

The highest amount of N (32.65 mg/g dry matter), P (3.40 mg/g dry matter) and K (35.10 mg/g dry matter) were shown on *Pseudomonas* + *Azotobacter* + *Azosprillum* treatment which significantly differed from other treatments and the lowest amount was shown on *Pseudomonas* + *Azotobacter* treatment. The maximum level of Ca was achieved on *Pseudomonas* + *Azotobacter* (30.38 mg/g dry matter) and *Pseudomonas* + *Azosprillum* (30.30 mg/g dry matter) treatments which significantly differed from other treatments. The maximum level of Mg was observed on *Pseudomonas* + *Azotobacter* (6.18 mg/g dry matter) and *Pseudomonas* + *Azosprillum* (6.27 mg/g dry matter) treatments (Table 2).

Table 2. Effect of bacterial treatments on nutrients uptake in tomato.

Treatments	N (mg/g dry matter)	P (mg/g dry matter)	K (mg/g dry matter)	Ca (mg/g dry matter)	Mg (mg/g dry matter)
Pseud.	15.15cd†	2.28bc	24.60bcd	20.05c	4.30c
Azoto.	16.70d	2.23bc	26.6bc	24.93b	5.15b
Azosp.	24.45b	2.55b	28.70b	22.05bc	5.18b
Pseud.+ Azoto.	10.93e	1.93c	21.23d	30.38a	6.18a
Pseud.+ Azosp.	18.53cd	2.08bc	20.73d	30.30a	6.27a
Azoto.+ Azosp.	24.25b	2.30bc	24.10bcd	21.90bc	5.45b
Pseud.+ Azoto.+ Azosp.	32.65a	3.40a	35.10a	21.40bc	4.05c
Control	22.15bc	2.35bc	22.60cd	22.20bc	4.43c

† In each column, means with the same letters are not significantly different at 5% level of Duncan's multiple range test.

IV. DISCUSSION

The results indicated that PGPR affect the growth and nutrients uptake. In the impact of root inoculation with beneficial rhizosphere microorganisms on some quality parameters is being explored [9,10,11].

Facilitating plant nutrition could be the mechanism by which PGPR enhance crop yield, since the nutritional plants status is enhanced by increasing the availability of nutrients in the rhizosphere [12,13].

Phytohormones produced by PGPR, are believed to be changing assimilate partitioning patterns in plants altering growth in roots, the fructification process and development of the fruit under production conditions [14].

This work supports that tomato root inoculation with PGPR enhances growth under greenhouse conditions. However, field experiments should be carried out to ensure that positive effects are maintained under conventional production systems.

A series of other factors (ability to grow on root exudates, to synthesize amino acids and vitamins) defined as "rhizospheric competence" is involved in the establishment of effective and enduring root colonization by an introduced bacterium [15].

Pseudomonas fluorescens 92rk, alone or co-inoculated with P190r, increased mycorrhizal colonization of tomato roots by *G. mosseae* BEG12. This result suggests that strain 92rk behaves as a mycorrhiza helper bacterium (MHB) in *L. esculentum*. MHB have been described for ectomycorrhizal symbiosis [16] and only a few examples of MHB have been reported for AM symbiosis [17,18]. *P. fluorescens* 92rk increased total root length, surface area and volume. This is in agreement with the effects of *P. fluorescens* A6RI [19] and 92r [20] on the development of tomato and cucumber root, respectively. Longer root systems are more adapted to soil exploration and exploitation [21].The

modification of root architecture parameters induced by the bacterial strains could be related to increased P acquisition: root systems with higher root surface area and volume are indeed characterized by a higher absorptive surface.
An investigation showed the effects of inoculating of two Bred cultivars of tomato (F1 Hybrid, Delba and F1 Hybrid, Tivi) roots with plant growth-promoting rhizobacteria (PGPR). *Azotobacter* was more effective than *Pseudomonas* to increase all traits' value except for shoot dry weight and K Content [22]. Differences between genotypes can explain differences between results.
An investigation showed that PGPR and AMF (fungus) can increase tomato fruit quality. It may be related to increasing of minerals by inoculated plants [23].
Increased nutrient uptake by plants inoculated with plant growth promoting bacterium has been attributed to the production of plant growth regulators at the root interface, which stimulated root development and resulted in better absorption of water and nutrients from the soil [24,25,26].

V. CONCLUSION

In conclusion, *Azotobacter* + *Azosprillum* and *Pseudomonas* + *Azotobacter* + *Azosprillum* resulted in the highest values of shoot fresh and dry weights and root fresh and dry weights at prebloom stage. *Pseudomonas* + *Azotobacter* + *Azosprillum* treatment was the best for N, P and K uptake in tomato shoots.

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