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Research article

Control of root rot and wilt disease complex of some evergreen fruit transplants by using plant growth promoting rhizobacteria in the New Valley Governorate, Egypt

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Abstract

Root rot and wilt disease complex were detected in several guava, lemon and olive transplant nurseries and new orchards at El-Kharga, Baris, ballet, El-Dakhla and El-Farafrah districts, the New Valley Governorate, Egypt. The average percentage of root rot/wilt incidence and severity in surveying districts were 37.7, 26.5%in guava; 41.7, 34.0%;in lemon and 41.2, 29.5% in olive transplants, respectively. The most frequently isolated fungi from rotted roots of the guava, lemon and olive transplants were *Fusarium oxysporum*, *F. solani*, *Macrophomina phaseolina* and *Rhizoctonia solani*. In pathogenicity tests, all the tested fungi were pathogenic to guava, lemon and olive transplants. The effect of plant growth promoting rhizobacteria (PGPR) individually and/or mixed when used as a soil drench treatment were varied in reducing root rot/ wilt incidence and severity under greenhouse conditions compared with control. The mixed of PGPR gave the highest protection against root rot/wilt diseases compared with the use of PGPR individually. All treatments significantly increased plant height (cm), number of leaves transplanting^{-1}, leaf area (cm^2), fresh and dry weights transplanting^{-1} (gm) compared with control treatment.

Key words: Guava, Lemon, Olive transplants, *Fusarium oxysporum*, *Fusarium solani*, *Macrophomena phaseolina*, *Rhizoctonia solani*.

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Introduction

Guava (*Psidium guajava*), lemon (*Citrus lemon*) and olive (*Olea europaea*) are considered of the most important economic fruit crops in the world as well as in Egypt. Guava, lemon and olive transplants are subjected to attack by several soil-borne pathogens, causing severe deterioration in nurseries and new orchards. Root rot and wilt diseases of guava, lemon and olive transplants are primarily caused by several pathogens, *Fusarium oxysporum*, *F. solani*, *Macrophomina phaseolina* and *Rhizoctonia solani* and other fungi (Sergeeva, et al., 2005; Mousa, et al., 2006; El-Morsi et al., 2009; Almeida, et al., 2011; Yaseen; D'Onghia 2012; Asma, et al., 2013; Mishra, et al., 2013). These pathogens are capable of surviving in the soil in the absence of their host plants, and might become destructive under favorable conditions.

In Egypt, under the New Valley Governorate conditions of high temperature and low relative humidity, root rot and wilt diseases of transplants of young guava, lemon and olive trees has been observed in the early stages of plant development to nurseries or after being transplanted to new orchards (El-Morsi et al., 2009). Successful control of such disease has been obtained by using a wide array of fungicides, but the application of chemical fungicides is extensive, harmful to human, living organisms and the environment (Jarvis, 1988). A promising strategy for the replacement of chemical pesticides has been the implementation of biological control. In recent years, biological control has been suggested as a potentially attractive alternative disease management and disease reduction in many crops. The plant growth promoting rhizobacteria (PGPR) *viz*. *Azotobacter* sp., *Bacillus cereus*, *B. megaterium* and *B. subtilis* produce biologically active compounds (antibiotics and toxic substances) that have antifungal activity, besides bioactive compounds, including plant growth regulators (El-Mohamedy & Ahmad, 2009; Sharma et al., 2009; Baset, et al., 2010; Almeida, et al., 2011; Ismail, et al., 2011; Abdel-Monaim et al., 2012; Asma et al., 2013).

The present work was planned to assess root rot/wilt survey and to evaluate the effect of certain PGPR as a single treatment and/or in combination for controlling the disease as well as their effects on growth parameters of guava, lemon and olive transplants in the New Valley Governorate.

Materials and methods

Diseases survey: Survey of root rot and wilt diseases was carried out in nurseries and new orchards at El-Kharga, Baris, Balate, El-Dakhla and El-Farafrah Districts in New Valley Governorate, Egypt. Percentages of diseased guava, lemon and olive transplants, showing symptoms of root rot and/or wilt diseases were recorded. Disease severity was assessed on transplants exhibited symptoms typical of root rot and/or wilt diseases. Foliar symptoms, including dull, internally rolled or necrotic leaves, defoliated and death twigs, were evaluated on a scale of 0-4 based on the

percentage of the affected foliage, where 0= transplants healthy, 1= from 0 to 25% (milled symptoms), 2= from 26 to 50 % (intermediate symptoms), 3= from 51 to 75% (severe symptoms), 4= more than 76% diseased foliage (transplants nearly dead to dead).

Disease severity index (DSI) described by Liu et al., (1995) was adapted and calculated as follows: DSI= $\Sigma d/(d\ max \times n) \times 100$, Where: d is the disease rating of each transplant, d max the maximum disease rating and n is the total number of transplants/sample examined in each replicate.

Isolation and identification of the causal fungi: Diseased roots of guava, lemon and olive transplants showing yellowing or wilt symptoms were collected and taken for fungal isolation. The root samples were thoroughly washed under running tap water then cut into small pieces (1 cm), and surface sterilized with dipping in 0.1% mercuric chloride solution for 2 minutes, then washed with several times of sterile distilled water. The surface sterilized pieces were blotted dry on sterilized filter paper, and transferred individually to Petri dishes, each containing 20 ml potato dextrose agar (PDA) medium, then incubated at 25°C for 5-7 days and inspected for fungal growth. The developed fungal colonies were purified using hyphal tip or single spore techniques. The purified fungi were identified according to fungal morphological and microscopical characteristics as described by Barnett and Hunter (1986) and Sneh et al., (1991) and confirmed by Botany Department, Faculty of Science, Assiut University. The obtained cultures isolates were maintained on PDA slants and kept in refrigerator at 5°C for further study.

Pathogenicity tests: The pathogenic capability of the isolated fungi was carried out under greenhouse conditions in El-Kharga Agric. Res. Station. Plastic pots (30 cm in diam.) sterilized by dipping in 5% formalin solution for 15 min. Soil was also sterilized with formalin solution (5%), then covered with a polyethylene sheet for 7 days to retain the gas and left to dry for 2 weeks until all traces of formaldehyde disappeared. The sterilized pots were filled with sterilized soil (5 Kg/pot). The tested fungi were grown on autoclaved barley grain medium in 500 ml glasses. It was inoculated with discs (5 mm in diameter) taken from 7 day-old cultures of each tested fungal isolate, then incubated at 27 ±1 °C for 15 days. The sterilized soil was individually infested with the tested fungi at the rate of 5% of soil weight. The pots were irrigated regularly for three times a week before planting to ensure even distribution of the inoculated fungus in the soil. Four guava, lemon and olive transplants (ten-months old) were cultivated in each pot and six pots were used as replicates. Six pots contained uninfected soil was cultivated at the same rate of transplanting were used as control. Percentages of incidence and severity were recorded after three months from planting in pots. Re-isolation was carried out from infected transplants showing disease symptoms and the isolated fungus was compared with the original culture used.

Source of the PGPR and inoculum preparation: Four PGPR obtained from

Plant Pathol. Dep., New Valley Agric. Res. Station *viz*. *Azotobacter* sp. (isolate AZM1), *Bacillus cereus* (isolate BCM8), *B. megaterium* (isolate BMM5), *B. subtilis* (isolate BSM1), were used in this study. These bio-agents isolated by Dr. Montaser Fawzy Abdel-Monaim and were previously tested against several soil borne pathogens (Abdel-Monaim, 2010; Abdel-Monaim et al., 2012; Abdel-Monaim, 2013). Inoculum was produced as described by Landa et al., (2004). Bacterial concentration in suspension was adjusted to proximately 5 x 10^8 cells ml^{-1} by measuring absorbance at 600 nm in a spectrophotometer and using standard curves for each bacterial isolate.

Effect of PGPRon root rot and wilt diseases *in vivo*: The PGPR (*Azotobacter* sp., *Bacillus cereus*, *B. megaterium* and *B. subtilis*) mixed of them and one fungicide (Rizolex-T/ Tolclofosm methyl+ Thiram/50% WP/3gm/L) were evaluated to control root rot and wilt diseases on transplants of guava, lemon and olive transplants. This experiment was carried out on healthy look in guava (cv. Banaty), lemon (cv. Balady) and olive (cv. Toffahi) under pot experiments. Six pots of each treatment were used as replicates containing sterilized soil previously infested with inoculum of each fungus and drenched with each tested PGPR (250 ml per pot), 7 days later soil infestation. Four guava, lemon and olive transplants (ten-months old) were cultivated in each pot during 1st February, 2014. Six pots contained uninfested soil was cultivated at the same rate of transplanting and used as a control. After three months, disease severity index (DSI) and efficacy values were calculated according to the following formula:

$$DSI\% = \Sigma d/(d\ max \times n) \times 100$$

Where: d is the disease rating of each transplant, d max the maximum disease rating and n the total number of transplants/sample examined in each replicate. In the end of the experiment, vegetative growth parameters *i.e*. plant height (cm), number of leaf $plant^{-1}$, leaf area (cm^2) according to Ahmed and Morsy, (1999) as well as fresh and dry weights (gm $plant^{-1}$) were recorded.

Results

Survey of root rot and wilt diseases:

Typical symptoms of root rot and wilt disease on guava, lemon and olive transplants were observed in five examined districts in the New Valley Governorate. Data in Table (1) indicate that disease incidence and severity of root rot and wilt complex differed in the tested fruit crops in different inspected locations in the New Valley Governorate. Disease incidence and severity of guava transplants ranged from 30.2 to 43.2% and 18.3 to 33.7%, respectively, while, disease incidence and severity of lemon transplants ranged from 36.3 to 43.6% and 29.2 to 40.2%, respectively. Also, disease incidence and severity of olive transplants ranged from 35.3 to 46.3% and 21.6 to 37.1%, respectively. Generally, the disease incidence and severity differed at the five inspected locations, where the highest disease incidence and severity were recorded in El-Dakhla District and the lowest disease incidence and severity recorded in El-Farafrah District in the tested fruit crops. On the other hand,

disease incidence and severity was differed with different fruit crops. The highest means of disease incidence and severity were recorded for lemon transplants (41.7 and 34.0%, respectively) followed by olive transplants (41.2 and 29.5%), while, guava transplants revealed the lowest means (37.7 and 26.5%).

Table 1: Occurrence of root rot/wilt disease complex of guava, lemon and olive transplants in different nurseries and new orchards of the New Valley Governorate.

Locations	Guava		Lemon		Olive	
	DI[a]	DSI[b]	DI	DSI	DI	DSI
El-Kharga	38.6	26.8	41.4	33.6	43.7	29.3
Baris	37.0	24.3	37.2	30.1	35.4	26.0
Balat	39.8	29.6	43.6	37.0	45.6	33.3
El-Dakhla	43.2	33.7	50.2	40.2	46.3	37.1
El-Farafrah	30.2	18.3	36.3	29.2	35.3	21.6
Mean	37.7	26.5	41.7	34.0	41.2	29.5

[a]DI = Disease incidence , [b]DSI = Disease severity index

Table 2: Pathogenicity tests of fungi isolated from diseased samples collected from guava, lemon and olive transplants under greenhouse conditions.

Fungi	% Disease incidence	% Disease severity
Guava		
Fusarium oxysporum	100	100
F. solani	100	92.1
Macrophomina phaseolina	77.8	70.0
Mean	92.6	87.4
Lemon		
Fusarium oxysporum	100	86.5
F. solani	88.9	77.5
Macrophomina phaseolina	88.9	75.5
Mean	92.6	79.8
Olive		
Fusarium oxysporum	88.9	82.4
Fusarium solani	100	100
Rhizoctonia solani	77.8	72.5
Mean	88.9	84.9

Isolation, identification of pathogens and pathogenicity tests: The obtained results from isolation trials showed that *F. oxysporum*, *F. solani* and *M. phaseolina* where the main causal pathogens of guava and lemon transplants, while, *F. oxysporum*, *F. solani* and *R. solani* where the main causal pathogens of olive transplants under the New Valley Governorate conditions, which showed typical symptoms of root rot and wilt diseases. Data presented in Table (2) showed that all the tested fungi were pathogenic to guava, lemon and olive transplants. The pathogenic fungi isolates exhibited different degrees of pathogenic capabilities. However, the transplants inoculated with the tested fungi appeared

as crown and root rots characterized by light to dark color and foliar wilting symptoms. In case of guava transplants, *F. oxysporum* and *F. solani* caused the highest root rot/wilt incidence and severity, whereas they caused 100, 100% root rot/wilt incidence and 100, 92.1% root rot/wilt severity, respectively. While, in case of lemon, *F. oxysporium* caused 100% root rot/wilt incidence and caused 86.50% root rot/wilt severity. On the other hand, olive transplants affected with *F. solani* than *F. oxysporium* or *R. solani,* were recorded 100% root rot/wilt incidence and severity.

Table 3: Effect of tested PGPR strain sand Rizolex-T as soil drench on disease severity caused by pathogenic fungi as well as growth parameters on guava transplants.

Treatments	% Disease severity	% Protection	Plant height (cm)	Number of leaf Plant $^{-1}$	Leaf area (cm^2)	Fresh weight (gm $plant^{-1}$)	Dry weight (gm $plant^{-1}$)
				Fusarium oxysporum			
Azotobacter sp.(Az)	16.59	75.94	36.33	24.33	35.15	20.36	7.05
Bacillus cereus(Bc)	20.15	70.78	33.33	22	33.96	19.43	6.82
B. megaterium(Bm)	14.59	78.84	40	23.33	38.88	21.75	6.99
B. subtilis(Bs)	12.59	81.74	43.67	24.33	39.96	22.96	7.19
Az+Bc+Bm+Bs	6.59	90.44	52.67	30.67	43.37	32.96	10.28
Rhizolex-T	10.48	84.80	30.33	16.33	33.21	13.57	4.78
Control	68.96	-	20	9.67	30.83	6.6	2.26
				F. solani			
Azotobacter sp.(Az)	22.56	73.70	39.33	19.67	35.20	16.03	5.46
Bacillus cereus(Bc)	29.63	65.46	35.33	16	33.79	15.22	5.3
B. megaterium (Bm)	28.79	66.44	40	19.33	37.62	16.69	5.69
B. subtilis (Bs)	15.48	81.95	42.33	20.67	38.94	24.21	8.25
Az+Bc+Bm+Bs	10.89	87.31	47	25.33	40.37	28.69	9.79
Rhizolex-T	13.89	83.81	26.33	12	31.42	12.35	4.21
Control	85.79	-	9.67	7	30.26	3.96	1.28
				Macrophomina phaseolina			
Azotobacter sp.(Az)	30.59	69.41	34.67	22.67	32.78	19.59	6.69
Bacillus cereus(Bc)	25.47	74.53	35	23.00	32.99	20.66	6.76
B. megaterium (Bm)	22.47	77.53	38.33	24.67	36.25	23.19	7.67
B. subtilis (Bs)	18.96	81.04	39.67	25.33	37.05	26.43	8.69
Az+Bc+Bm+Bs	12.57	87.43	48.00	32.33	39.99	30.52	10.6
Rhizolex-T	18.79	81.21	26.00	14	32.00	14.26	4.79
Control	100	-	0.00	0.00	0.00	0.00	0.00
LSD at 0.05							
Treatments (A) =	1.19		1.48	1.52	1.96	1.25	0.56
Fungi (B) =	1.82		2.26	2.32	2.99	1.91	0.86
Interaction (AxB)=	3.16		3.91	4.03	5.18	3.31	ns

The efficacy of some PGPR and fungicide on root rot/ wilt severity and vegetative growth parameters *in vivo*

On root rot/wilt severity: Results in Tables (3 -5) showed that all tested PGPR strains and Rizolex-T (positive control) reduced severity of root rot/wilt diseases in guava, lemon and olive transplants which caused by *F. oxysporum*, *F. solani*, *M. phaseolina* and *R. solani* when applied individually or mixed as a soil drench in pots. The efficiency of the tested PGPR in controlling these diseases was varied. The mixed of PGPR recorded the highly significant reduction of root rot/wilt

disease severity than when used individually. Also, the mixed of PGPR were the best treatment compared with fungicide for controlling root rot/wilt diseases. On the other hand, the mixed of PGPR recorded the highest protection against infection with *F. oxysporum* followed by *F. solani*, *M. phaseolina* and *R. solani* in case of guava, lemon and olive transplants.

Vegetative growth parameters: Effects of PGPR strains individually and/or mixed together on some growth parameters of guava, lemon and olive transplants under artificial infections with *F. oxysporum*, *F. solani*, *M. phaseolina* and *R. solani* in pots conditions were studied. The obtained data in Tables 3 -5 revealed low values of growth parameters, plant height (cm), number of leaf plant $^{-1}$, leaf area (cm^2), fresh and dry weights (gm transplant^{-1}) in the control treatment compared with other treatments. All tested growth parameters of guava (Table 3), lemon (Table 4) and olive transplants (Table 5) were significantly increased with the mixed inoculation of PGPR strains compared with the individual one. Also, the mixed PGPR significantly increased growth parameters than the use of Rizolex-T (positive control) in all tested fruit crops.

Table 4: Effect of tested PGPR strains and Rizolex-T as soil drench on disease severity caused by pathogenic fungi as well as growth parameters on lemon transplants.

Treatments	% Disease severity	% Protection	Plant height (cm)	Number of leaf Plant $^{-1}$	Leaf area (cm^2)	Fresh weight (gm plant^{-1})	Dry weight (gm plant^{-1})
	Fusarium oxysporum						
Azotobacter sp.(Az)	25.69	63.24	17.00	19.67	14.13	5.73	2.19
Bacillus cereus(Bc)	32.48	53.53	15.67	18.67	13.18	5.30	2.00
B. megaterium (Bm)	30.47	56.40	16.00	15.33	15.18	4.27	1.72
B. subtilis (Bs)	15.47	77.86	21.00	22.33	16.74	6.43	2.41
Az+Bc+Bm+Bs	12.47	82.16	25.67	28.00	18.47	10.66	3.76
Rhizolex-T	16.59	76.26	13.67	12.00	14.25	3.70	1.23
Control	69.89	-	6.67	6.00	11.66	1.34	0.46
	Fusarium solani						
Azotobacter sp.(Az)	29.86	59.89	19.67	19.33	13.72	5.59	2.07
Bacillus cereus(Bc)	35.48	52.34	15.67	16.33	13.51	3.41	1.3
B. megaterium (Bm)	26.58	64.30	18.33	17.67	13.51	4.59	1.71
B. subtilis (Bs)	18.79	74.76	21.33	20.67	15.87	6.07	2.34
Az+Bc+Bm+Bs	8.48	88.61	25.67	27.33	17.67	8.98	3.03
Rhizolex-T	14.85	80.05	12.33	10.00	13.13	2.93	0.93
Control	74.45	-	5.33	5.67	10.58	1.27	0.47
	Macrophomina phaseolina						
Azotobacter sp.(Az)	22.56	73.60	17.67	15.67	12.84	4.44	1.57
Bacillus cereus(Bc)	29.45	65.54	14.67	12.33	12.52	3.83	1.30
B. megaterium (Bm)	22.56	73.60	18.00	16.67	13.49	5.09	1.79
B. subtilis (Bs)	15.85	81.45	19.67	18.67	15.21	5.86	2.13
Az+Bc+Bm+Bs	11.45	86.60	22.33	21.33	16.31	7.48	2.59
Rhizolex-T	19.56	77.11	10.33	10.00	12.8	2.47	0.82
Control	85.46	-	5.00	4.33	11.36	1.13	0.40
LSD at 0.05							
Treatments (A) =	1.88		1.10	1.77	ns	0.53	0.12
Fungi (B) =	2.87		1.68	2.7	1.70	0.81	0.19
Interaction (AxB)=	4.97		ns	4.68	2.94	ns	0.32

Table 5: Effect of tested PGPR strains and Rizolex-T as soil drench on disease severity caused with pathogenic fungi as well as growth parameters on olive transplants.

Treatments	% Disease severity	% Protection	Plant height (cm)	Number of leaf Plant $^{-1}$	Leaf area (cm^2)	Fresh weight (gm $plant^{-1}$)	Dry weight (gm $plant^{-1}$)
			Fusarium oxysporum				
Azotobacter sp.(Az)	20.67	74.35	27.33	31.33	3.78	23.85	11.26
Bacillus cereus(Bc)	16.55	79.46	30.33	38.00	4.10	29.02	14.47
B. megaterium (Bm)	28.59	64.52	21.00	24.67	4.09	21.16	10.87
B. subtilis (Bs)	10.46	87.02	28.67	34.00	4.15	28.78	14.49
Az+Bc+Bm+Bs	6.45	92.00	35.33	58.00	4.47	40.52	19.94
Rhizolex-T	19.25	76.11	15.67	18.67	3.54	14.23	7.51
Control	80.59	-	6.00	10.67	3.29	6.84	3.80
			F. solani				
Azotobacter sp.(Az)	25.69	63.43	27.33	40	3.57	28.7	14.59
Bacillus cereus(Bc)	19.45	72.31	27.67	35	3.93	29.87	14.83
B. megaterium (Bm)	18.15	74.16	32.33	42	4.12	31.88	15.85
B. subtilis (Bs)	14.56	79.27	31.67	42.67	4.03	27.25	13.8
Az+Bc+Bm+Bs	9.45	86.55	37.33	52.33	4.29	43.86	22.56
Rhizolex-T	16.56	76.43	22.67	30.33	3.54	21.79	10.97
Control	70.25	-	6.67	10.95	3.29	6.94	3.05
			Rhizoctonia solani				
Azotobacter sp.(Az)	30.25	69.75	24.33	32.00	3.28	20.05	10.00
Bacillus cereus(Bc)	25.46	74.54	19.33	29.33	3.58	18.45	9.90
B. megaterium (Bm)	15.46	84.54	30.00	39.00	3.98	28.31	14.07
B. subtilis (Bs)	17.45	82.55	27.33	37.00	3.97	25.25	13.59
Az+Bc+Bm+Bs	12.45	87.55	35.33	44.00	4.20	32.00	15.92
Rhizolex-T	22.56	77.44	18.67	26.33	3.32	13.40	6.91
Control	100	-	0.00	0.00	0.00	0.00	0.00
LSD at 0.05							
Treatments (A) =	1.64		ns	1.47	ns	0.42	1.32
Fungi (B) =	2.52		1.95	2.24	1.73	0.64	0.20
Interaction (AxB)=	4.36		3.38	ns	3.00	1.10	0.35

Discussion

Guava, lemon and olive transplants are subjected to attack by several soil-borne pathogens, causing severe losses and deterioration in nurseries and new orchards in the New Valley Governorate, Egypt. Survey of root rot and wilt disease complex in different locations of the New Valley Governorate indicated that root rot and wilt disease complex are the most important fungal diseases, since it cause a major problem on transplants and young trees. The disease incidence and severity differed at the five inspected locations. The highest values of disease occurrence and severity maybe attributed to warm and dry conditions in these Districts as well as long-term transplants cultivation in the same soils without using the correct and strict sanitation methods and preventive therapeutic control measures. The highest means of disease incidence and severity were recorded on lemon transplants followed by guava transplants, while, olive transplants revealed the lowest means. Such results are in agreement with those reported by Barrera et al., (2003); El-Morsi et al., (2009); Almeida et al., (2011); Yaseen, and D'Onghia, (2012) and Asma et al., (2013). The pathogenicity tests proved that all isolated fungi from rotted root and/or wilted samples of transplants and young trees were pathogenic to the guava, lemon and olive transplants, however *F. oxysporum*, *R. solani* and *M. phaseolina* were the most destructive pathogens.

Symptoms of root rot and wilt disease of guava, lemon and olive transplants as previously reported by Sergeeva et al., (2005); Mousa et al., (2006); El-Morsi et al., (2009); Yaseen and D'Onghia (2012) and Mishra et al. (2013). The efficiency of the tested PGPR strains for controlling root rot and wilt diseases and the improvement of vegetative growth parameters was varied. All the tested PGPR significantly reduced disease incidence and severity. In this respect, the mixture of *Azotobacter* sp., *B. cereus*, *B. megaterium* and *B. subtilis* were more effective than when they used as an individual. On the other hand, all treatments significantly increased plant height, number of leaf plant^{-1}, leaf area, fresh and dry weights when compared with control treatments. The testing PGPR have been applied successfully in many ways of plant production as a plant growth stimulant, soil conditioner. This positive action of tested PGPR can be a help in solubilization of mineral phosphates and other nutrients (Baset et al., 2010; Ismail et al., 2011), enhance resistance to stress (Almeida et al., 2011; Abdel-Monaim, 2013), stabilize soil aggregates and improve soil structure and organic matter content and retain more soil organic N and other nutrients in the plant soil system, thus reducing the need for fertilizer N and P enhancing release of the nutrients (Ismail et al., 2011). Plant growth promoting rhizobacteria has also been known to produce compounds which promote plant growth directly or indirectly, such as hydrogen cyanide, siderophores, indole acetic acid, solubilize phosphorus and antifungal activity and besides their role as enhanced natural resistance against plant diseases and pests (Sharma et al., 2009; El-Mohamedy & Ahmad, 2009; Abel-Monaim, 2013), stimulated plant growth and effective fertilizers through increased cell division, as well as optimized uptake of nutrients and water as well stimulating as soil microorganisms playing role in reducing root rot and wilt diseases (Vessey, 2003; Baset et al., 2010; Abel-Monaim et al., 2013). In conclusion, the results of the present study could suggest that soil drench with PGPR strains can be used as a safe control measure of the disease in guava, lemon and olive transplants and as a stimulant of vegetative growth parameters.

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