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RESPONSE OF GROWTH PARAMETERS AND NUTRIENTS CONTENT OF CUCUMBER VARIETIES TO INOCULATION BY VA MYCORRHIZAE UNDER DIFFERENT ROCK PHOSPHATE DOSES

BY

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ABSTRACT

A pot experiment was carried out to study the effect of VA mycorrhizal inocula on growth parameters (leaf area, net assimilation rate (NAR), relative growth rate (RGR), leaf area ratio (LAR), specific leaf area (SLA), shoot/root ratio), nutrients uptake of shoot, nutrients content of fruit, total yield and VA mycorrhizal colonization of cucumber varieties under different rock phosphate doses (50, 100 and 200% recommended dose). Data showed that application of the VA mycorrhizal inocula was always superior to that of uninoculated treatments in the two tested varieties of cucumber. However, cucumber variety bitostar showed superior responses in all parameters tested than cucumber variety amasis.

Moreover, the application of 100% of recommended dose of rock phosphate in addition to VA mycorrhizal inocula gave more pronounced effect in all parameters evaluated as compared with the other treatments.

Key words: VA mycorrhizae, cucumber varieties, rock phosphate, growth parameters, minerals content.

INTRODUCTION

Vesicular-arbuscular mycorrhizae (VAM) are type of fungi that interact with numerous plant species and produce vesicles and arbuscules in root tissue along with extra-ordinary hyphae in the soil (Harley & Smith, 1983).These hyphae represent an extension for that improve the exploratory ability of the roots and increase the attainment of ions which are slow diffusing ions through the soil (Barea, 1991). VA mycorrhizal fungi are also capable of dissolving weakly soluble soil minerals by releasing acid (Leyval & Berthelin, 1989) or increasing CO_2 partial pressure (Knight *et al.*, 1989). Therefore, they have the ability to enhance host plant uptake of relatively immobile nutrients particularly P and Zn (Thomposon, 1987). In addition, mycorrhizal hyphae can provide access on insoluble nutrient sources through enzyme activity or some physical or chemical modification of the rhizosphere (Hetrick, 1989). Other studies also showed that VA mycorrhizal fungi could alleviate drought stress in their host plants via the direct uptake and transfer of water and nutrients through the fungal hyphae to the host plant (Harely & Smith, 1983).

The present work aimed to study the effect of VA mycorrhizal inoculation on both growth parameters and nutrient contents of cucumber varieties cultivated under different levels of rock phosphate.

MATERIALS AND METHODS

This study was conducted at Central Laboratory for Agriculture Climate (CLAC), Agriculture Research Center, Dokki, Giza governorate, Egypt, during the period from 2003 to 2004.

VAM inoculum:

Mixed inoculums consisted of 3 VA mycorrhizal fungi, i.e. *Glomus etunicatum, Glomus intraradices* and *Glomus monosporum* along with VAM infected maize root segments were used in this study. The inoculum was prepared through cooperative program between the Unit of Biofertilizers, Fac. Agric., Ain Shams University and the Central Laboratory for Agricultural Climate (CLAC).

Soil

Sandy soil was used in this study. The collected soil samples were mixed and then passed through a 2mm sieve in order to give a uniform growth medium. Soil characteristic was 94.5% sand, 3.5% clay, 2% silt, pH 7.4, EC 0.4 Mmohs/cm according to the method described by Piper (1950) and Jackson (1958).

Layout of experiment

Cucumber seeds *(Cucumis sativus* L. cv. Bitostar F1 hybrid and cv. Amasis F1 hybrid) were sown in nursery on 5 September 2003 and after 15 days the seedlings were transferred into plastic bags (30 cm in diameter) filled with 10 kg. Soil in bags was washed four times with tap water before planting. The experiment was carried out in one single type plastic houses (40 m long and 9m wide and 3m height, 200 micron polyethylene film).

Experimental treatments were performed summarized as follows:

1- Full recommended dose of NPK fertilizers (control plant).
2- 50% recommended dose of rock phosphate.
3- 50% recommended dose of rock phosphate +VAM.
4- 100% recommended dose of rock phosphate.
5- 100% recommended dose of rock phosphate +VAM.
6- 200% recommended dose of rock phosphate.
7- 200% recommended dose of rock phosphate + VAM.

Chemical fertilizers

Ammonium nitrate (33.3 % N), super phosphate (15.5% P_2O_5), rock phosphate (30% P_2O_5), potassium sulfate (50% K_2O) and magnesium sulfate (30.5% MgO) were used as nitrogen, phosphorus, potassium and magnesium fertilizers, respectively.

Parameters measured

VA mycorrhizal colonization:

The percentage of cucumber root colonization with VAM was estimated by the method described by Phillips & Hayman (1970).

Plant parameters:

Leaf area was recorded as cm^2 using a digital leaf area meter (L1-300 portable area meter produced by L1-COR, Lincoln, Nebraska, USA). Shoot/Root ratio and total yield were recoded. Net assimilation rate (NAR), relative growth rate (RGR), leaf area ratio (LAR) and specific leaf area (SLA) were calculated by using the following equations (Matsuura *et al.*, 2005):

$$NAR = \frac{(W_2 - W_1)(Log_e A_2 - Log_e A_1)}{(T_2 - T_1)(A_2 - A_1)} \text{ mg/cm}_2\text{/day}$$

$$RGR = \frac{Log_e W_2 - Log_e W_1}{T_2 - T_1} \text{ mg/day}$$

Where, W_1 and W_2 are dry weight of plant in the first (T_1) and second (T_2) time between taken samples. (A) is leaf area.

$$LAR = \frac{\text{Leaf area/plant (cm}_2\text{)}}{\text{Dry weight/plant (g)}} \text{ cm}_2\text{/day}$$

$$SLA = \frac{\text{Leaf area/plant (cm}_2\text{)}}{\text{Leaf dry weight/plant (g)}} \text{ cm}_2\text{/g}$$

Chemical analyses

Total nitrogen, phosphate and potassium contents of shoots and fruit of

cucumber plants were determined by the method described by Jackson (1958).

Statistical analyses:

A split plot design with three replicates was adopted. Two varieties of cucumber plant were arranged as a main plot, sevsn fertilization treatments were used as a sub-main plot. Each replicate consisted of 12 plants. Duncan method was used as a statistic analyses according to Snedecor & Cochran (1971).

RESULTS

VA mycorrhizal colonization

Percentages of VA mycorrhizal roots colonization of the two verities of cucumber grown under increased levels of RP were increased with time (Fig. 1). The highest records were obtained after 90 days from transplantation. No considerable differences were detected between Bitostar and Amasis varieties. The mycorrhizal colonization level was also reduced with increasing RP level. For example, Bitostar roots sampled after 90 days from transplantation showed 89.3, 86.3 and 76.0% with 50, 100 and 200 % RP level, respectively. The corresponding levels for Amasis variety were 88.3, 86.3 and 73.7% in the same above mentioned respective order.

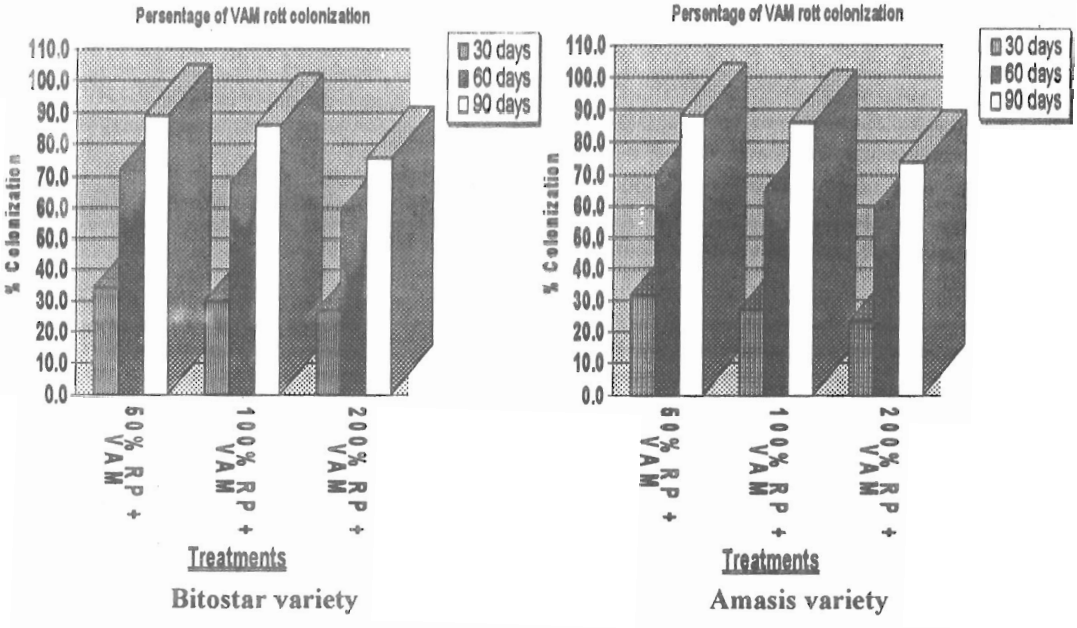

Figure (1): Percentage of VAM root colonization of two cucumber varieties as influenced by VA mycorrhizal inoculums under different RP levels.

Net assimilation and relative growth rates

Higher records of relative growth rates (RGR) and net assimilation rates (NAR) were generally observed in non mycorrhizal plants grown with 50 and 100 % RP. The reverse, however were true with the higher rates of RP (200%) (Figs. 2 & 3). Such response was obvious in the records monitored during the 30 to 60 and 60 to 90 for Bitostar variety and during the former period for Amasis variety. However, the mycorrhizal plants of Amasis variety evaluated during 60 to 90 days of growth showed consistent lower net assimilation and relative growth rates compared with non mycorrhizal ones with all the tested rates of RP amendments.

Leaf area related parameters

Data in Figures (4 and 5) and Table (1) illustrate the calculations of leaf area ratios (LAR) specific leaf area (SLA) and leaf area indexes (LAI) of cucumber varieties grown under different P and VA mycorrhizal treatments. Values of LARs and SLAs were

generally increased with sampling intervals. Bitostar variety was superior to Amiss variety in all records of LARs obtained after 60 days of planting. The reverse was true for SLAs obtained after 30 days of planting. However, the most pronounced differences between mycorrhizal an non mycorrhizal treatment were observed when the 2 above mentioned parameters were calculated after 90 days for plants grown with 100% RP, such difference was greater in Amasis compared to Bitostar variety being 122.8cm^2 / days and 436.9 cm^2 / g against 104.2 cm^2 / day and 432.9 cm^2 /g, respectively.

Records leaf areas indexes (LAIs) also showed gradual increase with time this finding was shown in mycorrhizal and non mycorrhizal plant grown under different RP levels while the highest LAI recorded after 30 days of planting was that of mycorrhizal Bitostar variety amended with 200% RP. The application of 100% was more effective at the 2 other intervals being 11.4 and 32.9, respectively.

Shoot / Root ratios

Mycorrhizal inoculation intended to decrease shoot / root ratio recorded for the two tested cucumber varieties grown under 3 RP levels and sampled at 3 intervals (Table 2). However, the differences between the shoot / root ratios of mycorrhizal and non mycorrhizal plants were smaller at the 1st and 3rd intervals (30and 90 days from planting). The varietal response to mycorrhizal inoculation as indicated by the shoot/ root ratios was more pronounced in amasis variety grown at 50or 100 % RP and sampled after 60 days from planting.

NPK uptake of shoots

Higher records of shoot NPK uptake were generally detected in mycorrhizal than non mycorrhizal varieties of cucumber (Tables 3, 4 and 5). In this respect Bitostar variety was superior to Amasis variety under all tested levels of RP and the three sampling intervals. However, the effects of mycorrhizal inoculation on NPK were more pronounced at 50 and 100% compared with 200% level. This finding was consistent with at the three intervals but more pronounced at the 3rd one.

For example mycorrhizal Bitostar plants absorbed 2.31, 0.424 and 1.86 mg NPK against 1.49, 0.296 and 1.26 mg for non mycorrhizal, ones, respectively; the corresponding figures for Amasis variety were 2.15, 0.406 and 1.68 against 1.08, 0.259 and 1.11 in the same respective order.

NPK contents of fruits

The effects of VA mycorrhizal inoculation on NPK content of harvested fruits of the two cucumber varieties are given in Table (6). Generally, the NPK contents of fruits on mycorrhizal plants were higher than those of non mycorrhizal ones. Little variations were observed in the contents of NPK between Bitostar and Amasis variety. The variation within each tested variety appeared to be influenced by RP applied level. The responsiveness of either of the two varieties was gradually diminished with the increased RP level.

Fruits of mycorrhizal Bitostar variety contained 3.5, 0.72 and 3.2 % NPK respectively the corresponding figures for non mycorrhizal plants were 1.9, 0.39 and 2.3% in the same above mentioned respective order. When the same variety was amended with 200% RP, the records of NPK contents of mycorrhizal fruits reached 2.4, 0.69, and 2.9 % against 2.2, 0.60 and 2.9 % for non mycorrhizal plants respectively .

Total yield

Data in Table (7) shows the total yield (Kg/plant) of two varieties of cucumber plant under different rates of rock phosphate and VA mycorrhizal inoculation at the end of experiment. Data indicated that mycorrhizal plant were higher than non mycorrhizal ones. Addition of 100% RP + VAM significantly increased the total yield and gave highest value. Meanwhile, the lowest total yield (Kg/plant) was obtained by the addition of 50% RP.

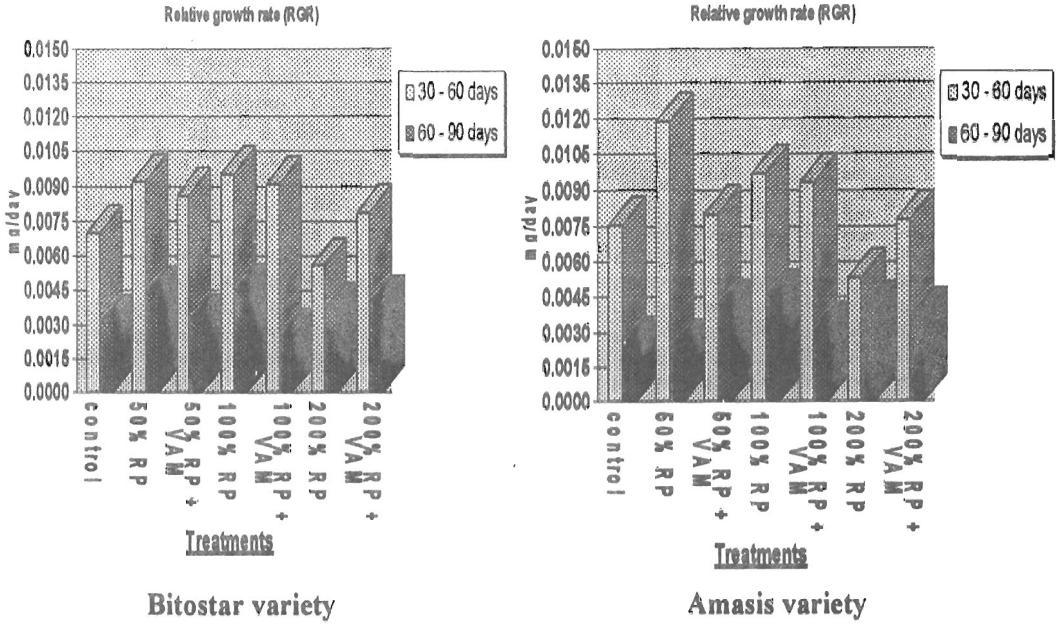

Figure (2): Relative growth rate (RGR) of two varieties of cucumber as influenced by VA mycorrhizal inoculums under different RP levels.

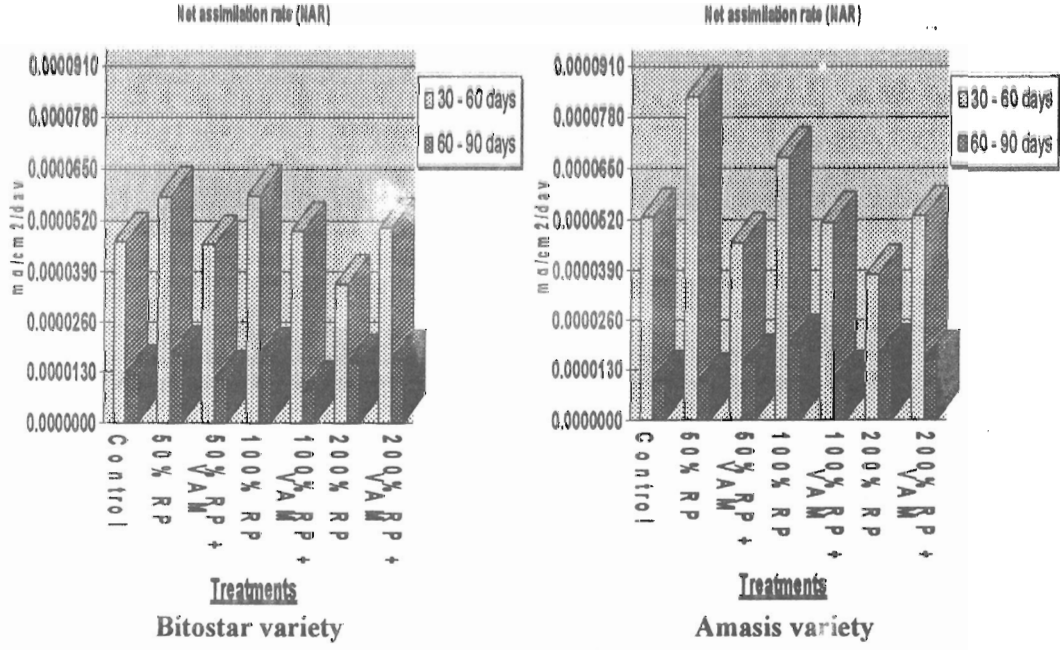

Figure (3): Net assimilation rate (NAR) of two cucumber varieties as influenced by VA mycorrhizal inoculums under different RP levels.

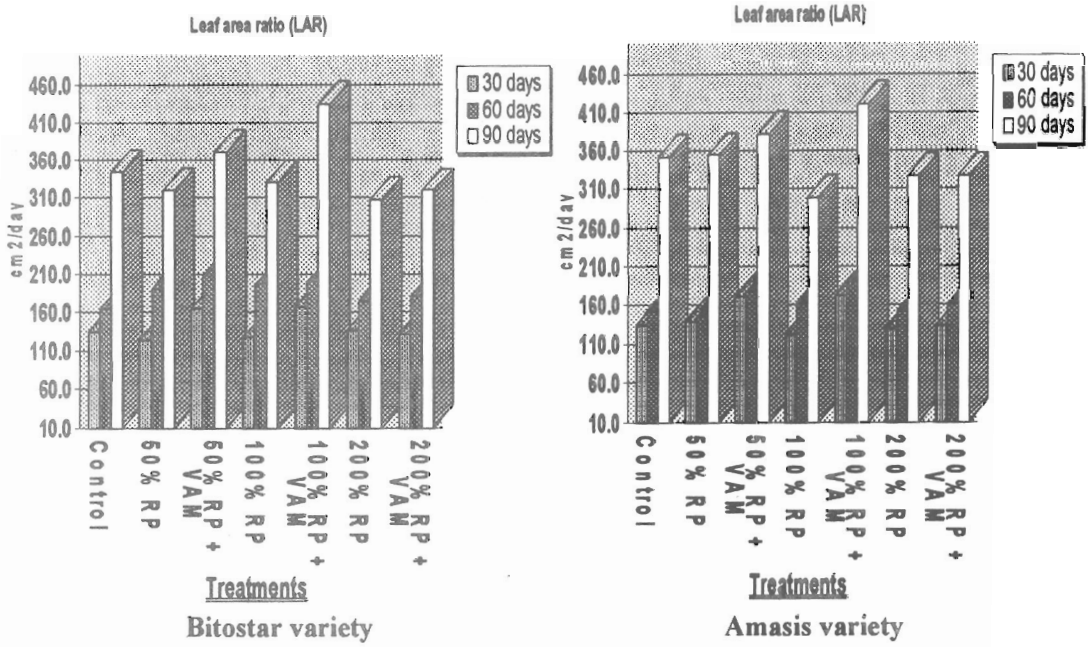

Figure (4): Leaf area ratio (LAR) of two cucumber varieties as influenced by VA mycorrhizal inoculums under different RP levels.

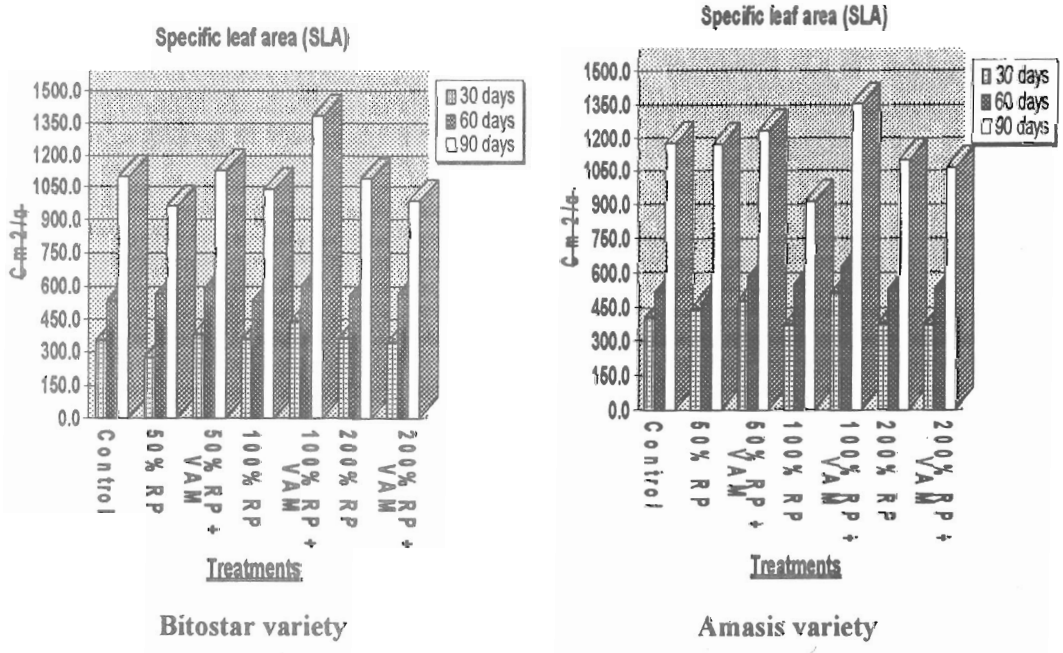

Figure (5): Specific leaf area (SLA) of two cucumber varieties as influenced by VA mycorrhizal inoculation under different RP levels.

Table (1): Leaf area index of two varieties of cucumber as influenced by VA mycorrhizal inoculation under different RP levels.

Cucumber variety	Super phosphate	50 % RP	50 % RP +VAM	100 % RP	100 % RP +VAM	200 % RP	200 % RP +VAM	Mean A
Days from transplantation								
After 30 days								
Bitostar	4.8 E	3.5 J	4.1 H	4.7 F	5.3 D	6.1 B	6.3 A	**4.9 A**
Amasis	4.5 G	2.9 K	3.8 I	4.5 G	5.2 D	5.7 C	6.1 B	**4.7 B**
Mean B	**4.7 D**	**3.2 G**	**3.9 F**	**4.6 E**	**5.2 C**	**5.9 B**	**6.2 A**	
After 60 days								
Bitostar	9.4 D	7.2 J	10.1 C	9.6 D	11.4 A	7.6 G	9.6 D	**9.3 A**
Amasis	7.3 F	5.4 K	9.1 F	7.4 H	11.3 B	7.3 J	9.1 F	**8.1 B**
Mean B	**8.4 C**	**6.3 G**	**9.6 B**	**8.5 D**	**11.3 A**	**7.4 F**	**9.4 E**	
After 90 days								
Bitostar	21.2 G	16.5 L	27.1 C	22.0 F	32.9 A	19.4 I	22.4 E	**23.1 A**
Amasis	20.4 H	15.4 M	26.1 D	18.6 J	31.1 B	17.9 K	21.1 G	**21.5 B**
Mean B	**20.8 D**	**15.9 G**	**26.6 B**	**20.3 E**	**32.0 A**	**18.6 F**	**21.7 C**	

Means data not followed by the same letters are significantly different according to Duncan's test, $P < 0.05$.
1. **RP:** Rock phosphate fertilizer. 2. **VAM:** Vesicular arbuscular mycorrhizae.

Table (2): Shoot/root ratio of two varieties of cucumber as influenced by VA mycorrhizal inoculation under different RP levels.

Cucumber variety	Super phosphate	50 % RP	50 % RP +VAM	100 % RP	100 % RP +VAM	200 % RP	200 % RP +VAM	Mean A
	Days from transplantation							
	After 30 days							
Bitostar	14.1 A	13.1 C	10.4 G	10.3 I	10.1 J	13.6 B	12.8 D	**12.1 A**
Amasis	11.9 E	10.4 G	9.4 K	10.5 H	10.0 J	13.1 C	11.4 F	**10.7 B**
Mean B	**13.0 B**	**11.8 D**	**9.9 G**	**10.4 E**	**10.1 F**	**13.4 A**	**12.1 C**	
	After 60 days							
Bitostar	7.4 J	10.0 C	8.6 G	7.6 I	5.7 K	9.8 D	8.0 H	**8.2 A**
Amasis	9.0 F	13.0 A	7.6 I	10.3 B	5.7 K	9.2 F	8.6 G	**9.0 B**
Mean B	**8.2 E**	**11.5 A**	**8.1 F**	**8.9 C**	**5.7 G**	**9.5 B**	**8.3 D**	
	After 90 days							
Bitostar	8.5 C	9.1 B	6.8 H	7.2 F	6.3 J	7.4 D	6.7 I	**7.4 A**
Amasis	6.9 G	10.9 A	6.3 J	7.3 E	6.1 K	7.2 F	6.7 I	**7.3 B**
Mean B	**7.7 B**	**10.0 A**	**6.5 A**	**7.2 C**	**6.2 F**	**7.3 C**	**6.7 D**	

Means data not followed by the same letters are significantly different according to Duncan's test, $P < 0.05$.
1. **RP:** Rock phosphate fertilizer. 2. **VAM:** Vesicular arbuscular mycorrhizae.

Table (3): Nitrogen uptake of shoot of two varieties of cucumber as influenced by VA mycorrhizal inoculation under different RP levels.

Days from transplantation								
After 30 days								
Cucumber variety	Super phosphate	50 % RP	50 % RP +VAM	100 % RP	100 % RP +VAM	200 % RP	200 % RP +VAM	Mean A
Bitostar	0.86 E	0.49 K	1.04 B	0.68 H	1.14 A	0.79 F	0.94 D	**0.85 A**
Amasis	0.7 G	0.31 J	0.85 E	0.63 I	1.02 C	0.65 I	0.81 E	**0.71 B**
Mean B	**0.78 D**	**0.40 G**	**0.95 B**	**0.65 F**	**1.08 A**	**0.72 G**	**0.88 C**	
After 60 days								
Bitostar	1.40 E	0.90 I	1.86 B	1.34 E	2.05 A	1.19 G	1.58 D	**1.47 A**
Amasis	1.35 EF	0.86 I	1.65 C	1.23 F	1.87 B	1.07 H	1.46 D	**1.36 B**
Mean B	**1.38 D**	**0.88 G**	**1.75 B**	**1.28 E**	**1.96 A**	**1.13 F**	**1.52 C**	
After 90 days								
Bitostar	1.58 F	0.98 G	2.09 B	1.49 D	2.31 A	1.22 F	1.77 C	**1.64 A**
Amasis	1.07 G	0.76 H	1.82 C	1.08 G	2.15 B	1.01 G	1.40 E	**1.33 B**
Mean B	**1.33 D**	**0.87 G**	**1.96 B**	**1.29 E**	**2.23 A**	**1.12 F**	**1.59 C**	

Means data not followed by the same letters are significantly different according to Duncan's test, $P < 0.05$.
1. **RP:** Rock phosphate fertilizer. 2. **VAM:** Vesicular arbuscular mycorrhizae.

Table (4): Phosphate uptake of shoot of two varieties of cucumber as influenced by VA mycorrhizal inoculation under different RP levels.

Days from transplantation								
After 30 days								
Cucumber variety	Super phosphate	50 % RP	50 % RP +VAM	100 % RP	100 % RP +VAM	200 % RP	200 % RP +VAM	Mean A
Bitostar	0.182 E	0.062 I	0.197 C	0.144 G	0.225 A	0.188 D	0.199 C	**0.171 A**
Amasis	0.155 F	0.046 J	0.158 F	0.122 H	0.202 B	0.157 F	0.156 F	**0.142 B**
Mean B	**0.168 E**	**0.054 G**	**0.178 B**	**0.133 F**	**0.213 A**	**0.172 D**	**0.178 C**	
After 60 days								
Bitostar	0.276 F	0.105 L	0.343 B	0.265 H	0.372 A	0.242 J	0.294 D	**0.271 A**
Amasis	0.267 G	0.101 M	0.293 E	0.244 I	0.341 C	.201 K	0.267 G	**0.245 B**
Mean B	**0.272 D**	**0.103 G**	**0.318 B**	**0.254 E**	**0.357 A**	**0.221 F**	**0.280 C**	
After 90 days								
Bitostar	0.306 F	0.135 L	0.371 C	0.296 G	0.424 A	0.244 J	0.312 E	**0.298 A**
Amasis	0.241 J	0.114 M	0.327 D	0.259 I	0.406 B	0.224 K	0.264 H	**0.262 B**
Mean B	**0.273 E**	**0.124 G**	**0.349 B**	**0.277 D**	**0.415 A**	**0.234 F**	**0.288 C**	

Means data not followed by the same letters are significantly different according to Duncan's test, $P < 0.05$.
1. **RP:** Rock phosphate fertilizer. 2. **VAM:** Vesicular arbuscular mycorrhizae.

Table (5): Potassium uptake of shoot of two varieties of cucumber influenced by VA mycorrhizal inoculation under different RP levels.

Days from transplantation								
After 30 days								
Cucumber variety	**Super phosphate**	**50 % RP**	**50 % RP +VAM**	**100 % RP**	**100 % RP +VAM**	**200 % RP**	**200 % RP +VAM**	**Mean A**
Bitostar	0.75 D	0.37 M	0.80 B	0.50 K	0.88 A	0.56 I	0.71 E	**0.65 A**
Amasis	0.68 F	0.27 N	0.67 G	0.44 L	0.78 C	0.52 J	0.59 H	**0.57 B**
Mean B	**0.71 C**	**0.32 G**	**0.74 B**	**0.47 F**	**0.83 A**	**0.54 E**	**0.65 D**	
After 60 days								
Bitostar	1.23 F	0.71 L	1.63 B	1.12 I	1.78 A	1.03 K	1.30 E	**1.26 A**
Amasis	1.16 H	0.66 M	1.33 D	1.07 J	1.49 C	0.49 N	1.16 H	**1.12 B**
Mean B	**1.20 G**	**0.69 G**	**1.48 C**	**1.09 E**	**1.64 B**	**0.99 F**	**1.23 C**	
After 90 days								
Bitostar	1.30 D	0.78 J	1.56 B	1.26 E	1.86 A	1.02 G	1.29 D	**1.31 A**
Amasis	0.99 H	0.63 K	1.42 C	1.11 F	1.68 B	0.87 I	1.07 F	**1.11 B**
Mean B	**1.15 D**	**.70 F**	**1.53 B**	**1.18 C**	**1.77 A**	**0.95 E**	**1.18 C**	

Means data not followed by the same letters are significantly different according to Duncan's test, $P < 0.05$.
1. **RP:** Rock phosphate fertilizer. 2. **VAM:** Vesicular arbuscular mycorrhizae.

Table (6): NPK contents (%) of two varieties of cucumber as influenced by VA mycorrhizal inoculation under different RP levels.

Nitrogen (%)								
Cucumber variety	**Super phosphate**	**50 % R. ph**	**50 % RP +VAM**	**100 % RP**	**100 % RP +VAM**	**200 % RP**	**200 % RP +VAM**	**Mean A**
Bitostar	2.8 D	1.9 GH	3.5 C	2.4 E	4.0 A	2.3 EF	2.4 E	**2.76 A**
Amasis	2.3 EF	1.8 H	3.4 C	2.2 F	3.8 B	2.0 G	2.2 F	**2.53 B**
Mean B	**2.6 C**	**1.9 F**	**3. 5 B**	**2.3 D**	**3.9 A**	**2.2 E**	**2.3 D**	
Phosphorus (%)								
Bitostar	0.70 C	0.39 J	0.72 B	0.64 D	0.77 A	0.59 H	0.64 D	**0.64 A**
Amasis	0.61 F	0.36 K	0.63 DE	0.60 G	0.72 B	0.57 I	0.60 G	**0.58 B**
Mean B	**0.66 C**	**0.38 F**	**0.68 B**	**0.62 D**	**0.75 A**	**0.58 E**	**0.62 D**	
Potassium (%)								
Bitostar	2.9 D	2.3 G	3.2 B	2.8 E	3.4 A	2.8 E	2.9 D	**2.90 A**
Amasis	2.8 E	2.1 H	3.0 C	2.8 E	3.2 B	2.7 F	2.9 D	**2.79 B**
Mean B	**2.85 D**	**2.20 G**	**3.10 B**	**2.80 E**	**3.30 A**	**2.75 F**	**2.90 C**	

Means data not followed by the same letters are significantly different according to Duncan's test, $P < 0.05$.
1. **RP:** Rock phosphate fertilizer. 2. **VAM:** Vesicular arbuscular mycorrhizae.

Table (7): Total yield of fruit (Kg/plant) of two varieties of cucumber as influenced by VA mycorrhizal inoculation under different RP levels.

Cucumber variety	Super phosphate	50 % RP	50 % RP +VAM	100 % RP	100 % RP +VAM	200 % RP	200 % RP +VAM	Mean A
Bitostar	3.1 E	1.7 I	3.8 C	3.0 EF	4.5 A	2.1 GH	2.2 G	2.91 A
Amasis	**2.9 F**	**1.6 I**	**3.6 D**	**3.0 EF**	**4.2 B**	**2.0 H**	**2.2 G**	**2.79 B**
Mean B	**3.0 C**	**1.7 F**	**3.7 B**	**3.0 C**	**4.4 A**	**2.1 E**	**2.2 D**	

Means data not followed by the same letters are significantly different according to Duncan's test, $P < 0.05$.
1. **RP:** Rock phosphate fertilizer. 2. **VAM:** Vesicular arbuscular mycorrhizae.

DISCUSSION

The results presented in this experiment show that the highest percentage of VA mycorrhiza colonization of the two varieties of cucumber plant was found at low RP (50%) and at high RP level (200%) there was a reduction in VA mycorrhiza colonization and infection. Heavy fertilization of P decreased mycorrhizal colonization, affecting VAM functioning on mineral nutrient. Similar results have also been reported by (Brundrett *et al.*, 1999; Azcón *et al.*, 2003 and Raiesi and Ghollarata 2006).

There was a correlation between relative growth rates (RGR) and Net assimilation rate (NAR) that mean if there was any changes in (RGR) might reflect on (NAR) (Ruotsalainen, 2003). Within this general correlation, in plants with similar RGR, NAR was reduced in mycorrhizal plants compared with non-mycorrhizal plants. As RGR is the product of NAR and the leaf area ratio (LAR), increases in RGR in mycorrhizal plants were the results of increased LAR. Thus, VA-mycorrhizas increased growth rates of cucumber plant by altering the morphology of the seedlings (Lovelock *et al.*, 1996). This result is inconformity with those of (Ruotsalainen, 2003 and Grimoldi, 2006).

The response of leaf area to phosphorus is an important factor determining the productivity of plants. Phosphorus deficiency in plants is generally associated with reducing photosynthetic capacity and leaf area expansion is known to be more sensitive to P-supply (Freeden *et al.*, 1989). It is known that both phosphorus addition and VAM could promote plant growth, dry matter of plant and leaf area per unit of plant biomass (Koide, 1998). The data showed that there was increased in leaf area ratios (LAR), specific leaf area (SLA) and leaf area indexes (LAI) in mycorrhizal plant compared with non mycorrhizal plants (Jacobsen, 1991; Ruotsalainen, 2003 and Grimoldi, 2006).

The shoot-root ratio decreased by added high P level compared with the full recommended dose or low P (Smith and Read, 1997 and Ruotsalainen, 2003). The higher shoot/root ratio in mycorrhizal plant could be due to the high colonization and presumably as result of production of large quantity of extraradical mycelium (Smith and Read, 1997). The increase in shoot root ratio improved plant nutrition uptake (Sharma *et al.*, 2002).

The same result was found in nutrient uptake (N, P, and K) which enhanced in addition of moderate and low P level + VAM and reduced at high P level, these results are consistent with the suggestion of (Liu *et al.*, 2002 and Azcón *et al.*, 2003). Liu *et al.*, (2002) explained that the uptake of nutrients by mycorrhiza occurs in two mechanisms. The first enhance uptake by enlarging the absorption area of root system with extraradical hyphae. The second mechanism is increased uptake of nutrient by increased of water uptake.

The total yield and NPK content (%) of fruit was increased in plants inoculated with VAM at full recommended dose of RP and low RP fertilizers compared with plant fertilized with high level of RP and control plants (Valentine *et al.*, 2001 and Al Karaki, 2002). This enhancement generally attributed to increased growth and higher uptake of P and other nutrients by mycorrhizal plant (Davies *et al.*, 2000).

Finally it might be concluded that inoculating cucumber plants with VAM fungi led to increased in plant growth and nutrients content compared with uninoculated plants.

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استجابة معاملات النمو ومحتوى العناصر لأصناف من نبات الخيار للتلقيح بفطريات الميكوريزا الداخلية تحت مستويات مختلفة من سماد الفوسفات الصخرى

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تم اجراء تجربة اصص لدراسة تاثير التلقيح بفطريات الميكوريزا على معاملات النمو (مساحة الورقة- معدل التمثيل- معدل نمو النبات- نسبة مساحة الاوراق- مساحة الاوراق المخصصة- نسبة المجموع الخضري للمجموع الجذرى)، محتوى المجموع الخضري والثمار من العناصر، كمية المحصول الكلى والنسبة المئوية لاصابة الجذوربفطريات الميكورهيزا لاصناف من نبات الخيار والمسمدة بتركيزات مختلفة من سماد الفوسفات الصخرى (٥٠ %، ١٠٠%، ٢٠٠%) من كمية التسميد الموصى بها.

وقد اوضحت النتائج تفوق النباتات الملقحة بفطريات الميكوريزا الداخلية بالمقارنة بالنباتات الغير ملقحة وذلك فى كلا من صنفين الخيارالمستخدمين، فى حين اظهر صنف بيتوستار نتائج اعلى من النتائج المتحصل عليها مع صنف اماسيس فى جميع المعاملات تحت الدراسة.

وكان استخدام تركيز ١٠٠ % من سماد الفوسفات الصخرى مع التلقيح بالميكوريزا افضل المعاملات والتى اعطت تاثيرا ملحوظا فى جميع التقديرات مقارنة بباقى المعاملات