RESULTS AND DISCUSSION

4- RESULTS AND DISCUSSION

4.1. Annona Seedlings :

4.1.1. Vegetative growth:

Data reported in Table (1 & 2) and illustrated in Figs (1,2 and 3) show the effect of soil inoculation with mycorrhizae fungi i.e. *Glomus macrocarpum* and *Glomus australe* and soil fertilization with rock phosphate [$Ca_3(PO_4)_2$] at three levels (0.25, 0.50 or 1.00 g / pot) as well as their interaction on growth of annona seedlings cv - Cheriymoya during 1994 and 1995 seasons.

4.1.1.1. Stem length :

it is quite evident from Table (1) and Figs (1,2 and 3) that in both seasons, all tested treatments i.e. mycorrhizal inoculation or rock phosphate fertilizer treatments as well as their combination caused highly significant increase in shoot length as compared with the control. Generally, seedlings grown on sterilized soil, fertilized with the high level of rock phosphate (1.00 g/pot) and inoculated with *Glomus macrocarpum* produced comparatively the longest shoots. On the contrary, seedlings planted on unsterilized soil and received the low level of rock phosphate fertilizer gave shorter shoots as compared with all tested treatments. Besides, stimulating effect of rock phosphate increased as its level increased. Furthermore, soil inoculated with *Glomus macrocarpum* fungi exerted more enhancing effect than did *Glomus australe*, whether seedlings were grown on unsterilized soil or sterilized one and / or fertilized with the same level of rock phosphate. However, seedlings grown on sterilized soil, received the low and moderate levels of rock phosphate and inoculated with *Glomus macrocarpum* fungi gave more or less similar values from the statistical standpoint. Finally, seedlings grown on sterilized soil and fertilized with the three levels of rock phosphate and inoculated with *Glomus austrate* fungi induced statistically similar effect in this respect.

4.1.1.2. No. of lateral shoots / plant :

Table (1) shows that in 1994 and 1995 seasons, all tested treatments i.e. soil inoculation with mycorrhizae fungi and soil fertilization with rock phosphate treatments as well as their combinations succeeded in increasing number of lateral shoots per seedling as compared with the control. Generally, seedlings grown on sterilized soil, fertilized with 1.00 g rock phosphate and inoculated with *Glomus macrocarpum* fungi exerted the highest significant effect in this sphere. On the contrary, unsterilized soil + 0.25 g pot rock phosphate treatment proved to be the least effective treatment in this respect. Besides, inoculating the soil with both mycorrhizal species, whether the soil was sterilized or not increased number of produced lateral shoots per seedling as compared with those grown on unsterilized soil and fertilized with any level of rock phosphate. Finally, *Glomus macrocarpum* fungi were more effective in encouraging the opening of axillary buds as compared with *Glomus australe,* whether seedlings were grown on sterilized or unsterilized soil and / or the same level of rock phosphate was concerned. Anyhow, the differences between these combinations were statistically lacking.

4.1.1.3. Stem diameter :

In both seasons, rock phosphate fertilizer, mycorrhizae fungi and soil sterilization as well as their combinations significantly increased stem diameter as compared with the control (Table, 1). However, seedlings grown on sterilized or non sterilized soil and inoculated with *Glomus macrocarpum* or *Glomus australe* had thicker stems as compared with those grown on unsterilized soil and received any level of rock phosphate. Besides, seedlings grown on sterilized or unsterilized soil and inoculated with *Glomus macrocarpum* had thicker stems as compared with the analogous ones inoculated with *Glomus australe*. Anyhow, the differences were so small to reach the significant level. Moreover, seedlings grown on sterilized soil and inoculated with *Glomus macrocarpum* fungi gave thicker stems as compared with the analogous ones inoculated with *Glomus australe,* when the same level of rock phosphate was concerned. Generally, soil sterilization + high level of rock phosphate (1.00 g / pot) + soil inoculation with *Glomus macrocarpum* proved to be the superior treatment in this concern.

4.1.1.4. No of leaves / plant :

It is clear that in 1994 and 1995 seasons, all tested treatments succeeded in increasing number of leaves per plant as compared with the control (Table, 1) and Figs (1,2 and 3). Moreover, seedlings grown on unsterilized soil and fertilized with low or moderate level of rock phosphate fertilizer had the least number of leaves. Besides, seedlings grown on unsterilized or sterilized soil and inoculated with *Glomus macrocarpum* fungi produced higher number of leaves as compared with the analogous ones inoculated with *Glomus australe* fungi. Also, the two mycorrhizal species induced high stimulating effect when the soil was sterilized and surpassed the analogous (*Glomus australe*), under the same conditions of soil sterilization and rock phosphate level. Finally, seedlings grown on sterilized soil, fertilized with high level of rock phosphate and

Table (1): Effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on vegetative growth of annona seedlings (1994 & 1995 seasons).

Treatment			Shoot length (cm)		No. of lateral shoots / plant		Stem diameter (cm)		No. of leaves / plant	
S.S.*	+ $Ca_3(PO_4)_2$	+ VAM	1994	1995	1994	1995	1994	1995	1994	1995
--	Control	+ --	31.9	32.7	2.1	2.0	0.40	0.42	22.3	21.0
--	+ 0.25 g	+ --	39.7	40.5	2.5	2.4	0.50	0.52	32.9	32.7
--	+ 0.50 g	+ --	46.2	47.3	2.6	2.5	0.51	0.55	35.1	34.9
--	+ 1.00 g	+ --	50.9	49.8	2.6	2.6	0.52	0.53	37.5	37.0
--	+ --	+ G. m**	52.3	52.8	3.1	2.9	0.56	0.55	38.7	39.7
--	+ --	+ G.S.***	49.8	48.0	3.0	2.9	0.53	0.54	37.8	37.5
S.S	+ --	+ G.m	53.9	53.3	3.3	3.3	0.59	0.67	43.6	42.9
S.S	+ --	+ G.a	51.7	50.0	3.2	3.0	0.57	0.57	41.5	45.5
S.S	+ 0.259	+ G.m	61.1	62.3	3.6	3.5	0.62	0.63	45.8	42.3
S.S	+ 0.50 g	+ G.m	58.3	57.3	3.5	3.4	0.73	0.70	48.7	47.7
S.S.	+ 1.00 g	+ G.m	79.9	73.3	4.1	4.0	0.87	0.87	57.2	56.5
S.S.	+ 0.25 g	+ G.a	55.8	55.5	3.3	3.3	0.60	0.59	42.9	41.2
S.S.	+ 0.50 g	+ G.a	56.2	55.3	3.4	3.4	0.65	0.64	46.1	42.5
S.S.	+ 1.00 g	+ G.a	54.7	54.5	3.3	3.5	0.62	0.63	39.2	40.8
	L.S.D. at	5%	3.2	3.2	0.32	0.32	0.04	0.04	2.4	3.9
		1%	4.5	4.4	0.51	0.51	0.06	0.06	3.3	3.3

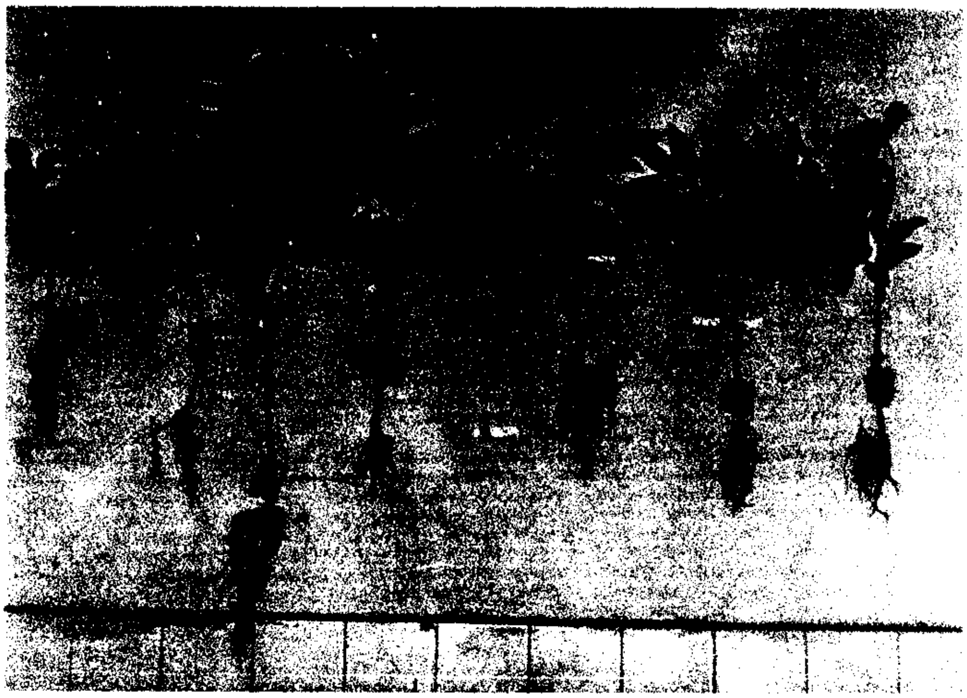
Where :
* S.S. = Soil sterilization.
** G.m = *Glomus macrocarpum.*
*** G.a. = *Glomus australe*.

(1) Control
(2) 0.25 g $Ca_3(PO_4)_2$ / pot
(3) 0.50 g $Ca_3(PO_4)_2$ / pot
(4) 1.00 g $Ca_3(PO_4)_2$ / pot

Fig.(1): Effect of rock phosphate fertilization one growth of annona seedlings.

(1) Control
(2) Unsterilized soil + G-m
(3) Unsterilized soil + G.a
(4) Sterilized soil + G.m.
(5) Sterilized soil + G.a.

Fig.(2): Effect of soil sterilization and soil inoculation with mycorrhizal fungi on growth of annona seedlings.



(1) Control
(2) S.S.+ 0.25 g $Ca_3(PO_4)_2$ + G.m
(3) S.S. + 0.50 g $Ca_3(PO_4)_2$ + G.m
(4) S.S. + 1.00 g $Ca_3(PO_4)_2$ + G.m
(5) S.S. + 0.25 g $Ca_3(PO_4)_2$ + G.a
(6) S.S. + 0.50 g $Ca_3(PO_4)_2$ + G.a
(7) S.S. + 1.00 g $Ca_3(PO_4)_2$ + G.a

Fig. (3): Effect of rock phosphate fertilization and soil inoculation with mycorrhizal fungi on growth of annona seedlings.

inoculated with *Glomus macrocarpum* produced the highest number of leaves.

4.1.1.5. Leaf content of chlorophyll a & b and carotene :

Data reported in Table (2) show the effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on leaf content of chlorophyll (a) & (b) and carotene of annona seedlings during 1994 and 1995 seasons.

It is obvious that in both seasons, all tested treatments succeeded in enriching leaf content of chlorophyll (a) & (b) and carotene as compared with the control, except for the three levels of rock phosphate which failed to affect leaf content of chlorophyll (a) from the statistical stand point. In addition, inoculating the sterilized soil with any of the two mycorrhizal species enhanced leaf content of chlorophyll (a) & (b) and carotene rather than when inoculation was done in unsterilized soil. Anyhow, the differences were insignificant. Generally, seedlings grown on sterilized soil, fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* had the richest leaves in their content of chlorophyll (a) & (b) and carotene. On the other hand, seedlings grown on sterilized soil, fertilized with different levels of rock phosphate gave statistically similar values of leaf content of chlorophyll (a) & (b) and carotene, whether the soil was inoculated with *Glomus macrocarpum* or *Glomus australe* fungi. Conclusively, all tested treatments succeeded in improving most of the studied vegetative growth parameters i.e. shoot length, number of lateral shoots per plant, stem diameter and number of leaves per plant as well as leaf content of chlorophyll a & b and carotene. Anyhow, the three levels of rock phosphate fertilization induced the least stimulating effect on shoot length, number of lateral shoots per plant and number of leaves per plant, but they failed to affect leaf content of chlorophyll a & b and carotene. Such results go in line with the findings of ***Davis and Menge (1980), Graham et al. (1987), Schebert et al. (1987), Gendiah et al. (1991-a), Guillem in et al. (1991), Saggin et al. (1992) and Siqueira et al. (1993).*** On the other hand, inoculating the soil with mycorrhizal fungi enhanced most of the studied vegetative growth parameters. However, soil sterilization increased the stimulating of mycorrhizal fungi, where as *Glomus macrocarpum* surpassed *Glomus australe* in enhancing the vegetative growth parameters. Furthermore, the addition of rock phosphate fertilization at the three levels to the sterilized and mycorrhizal inoculated soil induced high stimulating on all studied vegetative growth parameters. These results are in agreement with those mentioned by ***Menge et al. (1982), Graham and Fardelman (1987), Santoso (1989), Cuenca et al. (1990), Gendiah (1991), Helail (1993), Helail and El-Deeb (1993), Helail and Ikram (1993) and Helail and Awad (1993)*** who mentioned that inoculating different fruit plants (citrus and pecan seedlings) with mycorrhizal fungi improved most vegetative growth parameters i.e. shoot length, stem diameter, number of lateral shoots per plant, number of leaves per plant and leaf content of chlorophyll a & b and carotene. Briefly, annona seedlings grown in sterilized soil, received high rock phosphate level (1.00 g / pot) and inoculated with *Glomus macrocarpum* fungi showed the best growth parameters this result is conicided with those mentioned by ***Helail (1993), Helail and Awad (1993) and Helail et al. (1993)*** who mentioned that *Glomus macrocarpum* fungi surpassed *Glomus australe* in enhancing vegetative growth of avocado, citrus volkameriana and "Le Conte" pear plants. On the contrary, ***Gendiah (1991 - a)*** reported that *Glomus australe* induced more stimulating effect on growth of citrus rootstocks than did *Glomus macrocarpum* **fungi.**

4.1.2. Root growth and dry weight :

Table (3) shows the effect of rock phosphate and soil inoculation with *Glomus macrocarpum* or *Glomus australe* fungi as well as their combinations on root growth, dry weight and mycorrhizal dependency ratio of annona seedlings during 1994 and 1995 seasons.

4.1.2.1. Root length :

It is clear from Table (3) and Figs (1,2 and 3) that in both seasons, soil fertilization with rock phosphate and or soil sterilization and / or soil inoculation with mycorrhizal fungi enhanced the growth of annona roots as compared with the control. Anyhow, the three levels of rock phosphate particularly, the low level induced comparatively the lowest effect, in this concern. Besides, inoculating the sterilized or unsterilized soil with mycorrhizal fungi showed statistically similar values in this respect. Shortly, seedlings grown on sterilized soil, fertilized with 1.00 g rock phosphate / pot and inoculated with *Glomus macrocarpun* fungi gave the longest roots. Other combinations of mycorrhizal species and different levels of rock phosphate showed statistically similar effect.

4.1.2.2. No. of lateral roots / plant :

Table (3) and Figs. (1,2 and 3) reveal that in both seasons, all tested treatments except for low rock phosphate level (0.25 g / pot) significantly increased number of lateral roots per plant as compared with the control. Besides, moderate and high level of rock phosphate induced the lowest stimulating effect in comparison with other tested treatments.In additions,

Table (2) : Effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on leaf content of chlorophyll a & b and carotene of annona seedlings (1994 & 1995) seasons.

Treatment			Chlorophyll "A" (mg/100 g F.W.)		Chlorophyll "B" (mg / 100 g F.W.)		Carotene (mg / 100 g F.W.)	
S.S.*	+ $Ca_3(PO_4)_2$	+ VAM	1994	1995	1994	1995	1994	1995
--	Control	+ --	76.38	74.79	71.22	68.53	68.52	67.48
--	+ 0.25 g	+ --	78.88	79.53	80.37	82.54	75.63	73.40
--	+ 0.50 g	+ --	80.05	79.44	82.31	82.09	76.49	76.30
--	+ 1.00 g	+ --	79.81	77.47	80.27	82.14	79.19	77.10
--	+ --	+ G. m**	89.05	89.94	82.92	81.96	79.33	79.56
--	+ --	+ G.S.***	87.11	86.09	83.72	82.44	82.57	82.99
S.S	+ --	+ G.m	90.22	87.78	82.92	82.41	84.68	84.86
S.S	+ --	+ G.a	86.92	87.27	82.48	81.91	85.52	85.15
S.S	+ 0.259	+ G.m	87.66	91.59	83.77	84.09	86.67	86.37
S.S	+ 0.50 g	+ G.m	88.72	87.94	85.44	85.54	87.23	87.35
S.S.	+ 1.00 g	+ G.m	112.27	110.35	90.27	91.25	91.44	93.97
S.S.	+ 0.25 g	+ G.a	90.05	91.45	83.15	82.14	85.72	85.58
S.S.	+ 0.50 g	+ G.a	91.87	92.52	84.11	83.01	87.31	86.64
S.S.	+ 1.00 g	+ G.a	92.28	92.03	86.05	85.48	87.20	86.14
	L.S.D. at	5%	5.57	5.35	3.67	3.56	3.42	3.23
		1%	7.67	7.45	5.08	4.97	4.70	4.51

Where :

* S.S. = Soil sterilization.
** G.m = *Glomus macrocarpum.*
*** G.a. = *Glomus australe.*

Table (3): Effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on root growth, dry weight and mycorrhizal dependency ratio of annona seedlings (1994 & 1995 seasons).

Treatment			Root length (cm)		No. of lateral roots / plant		Shoot dry wt (g).		Root system dry wt (g)		Total dry wt (g)		Top : Root Ratio		Mycorrhizal dependency ratio (MDR)	
S.S.*	+ $Ca_3(PO_4)_2$	+ VAM	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995
--	Control +	--	17.2	17.0	28.1	26.0	2.4	2.5	2.0	2.1	4.1	4.2	1.20	1.19	--	--
--	+ 0.25 g +	--	27.3	27.3	31.5	31.3	3.9	3.8	3.0	3.2	6.9	7.0	1.21	1.18	--	--
--	+ 0.50 g +	--	32.7	32.5	42.0	41.0	4.1	4.0	3.5	3.5	7.6	7.5	1.17	1.14	--	--
--	+ 1.00 g +	--	33.0	32.9	43.7	43.5	4.4	4.3	4.0	3.9	8.4	8.3	1.10	1.10	--	--
--	+ --	+ G. m**	40.2	41.5	101.7	103.5	4.8	4.8	4.1	4.2	8.9	9.0	1.17	1.14	2.17	2.14
--	+ --	+ G.a***	38.2	39.0	75.8	78.3	4.9	4.8	4.0	4.1	8.9	9.1	1.22	1.17	2.17	2.16
S.S	+ --	+ G.m	42.0	43.1	105.7	108.2	4.7	4.8	4.5	4.5	9.2	9.3	1.14	1.06	2.24	2.21
S.S	+ --	+ G.a	37.9	37.2	87.1	85.9	5.2	4.8	4.3	4.2	9.0	9.0	1.20	1.14	2.19	2.14
S.S	+ 0.25 g	+ G.m	44.7	44.3	174.1	169.3	5.7	5.9	5.5	5.4	11.2	11.3	1.13	1.19	2.73	2.69
S.S	+ 0.50 g	+ G.m	46.5	46.3	195.7	196.2	6.0	5.9	5.6	5.7	11.6	11.2	1.17	1.13	2.82	2.67
S.S.	+ 1.00 g	+ G.m	57.7	57.5	237.9	241.2	6.5	6.3	6.0	6.1	12.5	12.4	1.18	1.03	3.04	2.95
S.S.	+ 0.25 g	+ G.a	41.5	41.9	137.0	133.9	5.1	5.0	4.7	4.8	9.8	9.8	1.18	1.14	2.39	2.33
S.S.	+ 0.50 g	+ G.a	43.7	43.9	146.2	149.3	5.5	5.3	4.8	4.8	10.3	10.1	1.14	1.10	2.51	2.40
S.S.	+ 1.00 g	+ G.a	45.2	44.2	157.0	160.2	5.6	5.7	4.7	4.9	10.6	10.2	1.20	1.61	2.58	2.42
	L.S.D. at	5%	4.29	4.26	6.31	6.34	0.73	0.72	0.73	0.70	1.03	1.12	N.S.	N.S.		
		1%	5.95	5.93	9.71	7.72	1.01	1.01	0.98	0.97	1.31	1.40	--	--		

Where :

* S.S. = Soil sterilization.

** G.m = *Glomus macrocarpum*.

*** G.a. = *Glomus australe*.

inoculating the soil with mycorrhizal fungi particularly *Glomus macrocarpum* encouraged the production of lateral roots. This was more obvious when mycorrhizal inoculation was conducted in sterilized soil. Moreover, seedlings grown on sterilized soil fertilized with different levels of rock phosphate and inoculated with mycorrhizal fungi produced statistically higher number of roots, particularly those fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* which produced the highest number of roots per seedling. Anyhow, seedlings grown in sterilized soil and fertilized with low and moderate levels of rock phosphate and inoculated with *Glomus macrocarpum* fungi had higher number of roots as compared with the analogous ones inoculated with *Glomus australe*, regardless of rock phosphate levels.

4.1.2.3. Shoot dry weight :

It is obvous from Table (3) that in both seasons, rock phosphate fertilization, soil sterilization and soil inoculation with mycorrhizal fungi as well as their combinations caused high significant increase in shoot dry weight as compared with the control. However, the different rock phosphate levels exerted not only the lowest, but also similar effect in this concern. Moreover, inoculating the soil with *Glomus macrocarpum* or *Glomus australe* induced statistically similar effect, whether inoculation was conducted in sterilized or unsterilized soil. Generally, seedlings grown on sterilized soil, fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* had the heaviest shoot dry weight. Furthermore, other combinations of rock phosphate levels and mycorrhizal fungi induced statistically similar effect in this sphere.

4.1.2.4. Root system dry weight :

Table (3) shows that in 1994 and 1995 seasons rock phosphate ferteilization, soil sterilization and mycorrhizal inoculation succeeded in increasing root system dry weight as compared with the control. Anyhow, the low level of rock phosphate fertilization showed the lowest stimulating effect in this concern. Moreover, mycorrhizal inoculation with *Glomus macrocarpum* or *Glomus australe* induced statitically similar effect whether the soil was sterilized or not. Furthermore, the addition of rock phosphate fertilization to the inoculated soil with mycorrhizal fungi increased the root system dry weight. This was more obvious when the soil was inoculated with *Glomus macrocarpum* fungi rather than *Glomus australe*. In other words, seedlings grown on sterilized soil, fertilized with the different levels of rock phosphate fertilization and inoculated with *Glomus macrocarpum* fungi had significantly heavier root system dry weight than the analogous ones inoculated with *Glomus australe* fungi, regardless of rock phosphate level. Briefly, seedlings grown on sterilized soil, fertilized with the high level of rock phosphate (1.00 g/pot) and inoculated with *Glomus macrocarpum* had statistically the highest root system dry weight.

4.1.2.5. Total dry weight :

It is clear from Table (3) that in 1994 and 1995 seasons, all tested treatments caused significant increases in total seedling dry weight as compared with the control. Anyhow, the low level of rock phosphate fertilization (0.25 g / pot) exerted the lowest stimulating effect on total seedling dry weight. Moreover, inoculating the soil whether sterilized or not with *Glomus macrocarpum* or *Glomus australe* not only enhanced total seedling dry weight but also induced statistically similar effect in this sphere. In other words, soil sterilization or not and / or soil inoculation with *Glomus macrocarpum* or *Glomus australe* showed similar results in this respect. Moreover, seedlings grown on sterilized soil, fertilized with different levels of rock phosphate and inoculated with *Glomus macrocarpum* fungi had statistically heavier dry weight as compared with the analogous ones inoculated with *Glomus australe* fungi, particularly when each rock phosphate level was compared. Generally, seedlings grown on sterilized soil, fertilized with higher rock phosphate (1.00 g / pot) proved to be the superior in their total dry weight.

4.1.2.6. Top : Root ratio :

In both seasons soil sterilization, rock phosphate fertilization (0.25, 0.50 or 1.00 / pot) and soil inoculation with mycorrhizal fungi (*Glomus macrocarpum* or *Glomus australe*) alone or in combination exerted statistically similar effect on top : root ratio as compared with the control.

Conclusively, the three levels of rock phosphate succeeded in improving root length, number of lateral roots per plant, shoot dry weight, root system dry weight, but failed to induce any significant effect on top : root ratio. The obtained results go in line with earlier reports of ***Davis and Menge (1980), Douds et al. (1988), Gendiah et al. (1991 - a) and Eissenstat et al. (1993)*** who stated that the effect of plant phosphorus status and the mycorrhizal fungus *Glomus* in traradices on the carbon economy of sour orange. Mycorrhizal colonization increased the root biomass fraction, root length leaf area ratio and the percentage of C^{14} recovered from below - ground components, although the effects were less pronounced thant those resulting from phosphorus nutrition. Furthermore, soil inoculation with *Glomus macrocarpum* fungi exerted more stimulative effect than did *Glomus australe*, particularly when inoculation was conducted on sterilized soil. Moreover, the application of rock phosphate fertilization at three levels to sterilized and mycorrhizal inoculated soil caused high remarkable increase in root length, number of lateral roots per plant, shoot dry weight, root system dry weight and total seedling dry weight. These results confirm those reported by ***Cabdoso et al. (1986), Branzanti and Inuacenti (1987), Lin and Chang (1987) and Santoso (1989),*** Recently, ***Helail and Ikram (1993), Helail et al. (1993), Helail and El-Deeb (1993), Helail and Awad (1993) and Helail (1993)*** who mentioned that inoculating pecan, "Le Conte" pear, citrus and avocado seedlings with *Glomus fasciculatus, Glomus calospora, Glomus macrocarpum or Glomus australe* enhanced all root growth parameters (root length, number of lateral roots per plant, shoot dry weight root dry weight and total seedling dry weight. Finally, seedlings grown on sterilized soil, fertrilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* had the highest values of root length, number of lateral roots per plant, shoot dry weight, root system dry weight and total seedling dry weight, Such result is in agreement with the findings of ***Helail and El-Deeb (1993), Helail et al. (1993), Helail and Awad (1993) and Helail (1993)*** who mentioned that *Glomus macrocarpum* surpassed *Glomus australe* fungi in improving root growth, parameters and dry weight of shoot and roots of "Le Conte", Rang pur lime, *Citrus volkameriana* and avocado plants. Also, ***Helail and Ikram (1993)*** mentioned that pecan seedlings produced longer roots and heavier dry weight when inoculated with *Glomus fasciculatus* than *Glomus calospora.*

The role of mycorrhizae fungi in enhancing seedling growth may be explained by the fact that (a) vesicular arbuscular mycorrhizae may improve the growth of host plant through increasing the uptake of P, Zn and other nutrients, reducing the incidence of soil born plant diseases and increasing tolerance to drought stress ***(Maronek et al., 1981 -b)***, mycorrhizae fungi may be capable of producing growth regulating substances like auxins, cytokinins, gibberellin or B vitamins which can be transfered to he host plant ***(MacDaugal and Dufernay 1944)*** and (C) mycorrhizae fungi may lead to marked increase in respiration which enhances the cation exchange and accumulation of the mineral elements ***(Blakeman et al., 1976)***.

4.1.3. Mycorrhizal dependency ratio (MDR):

Mycorrhizal dependency ratio is defined as the degree to which a plant is dependent on the mycorrhizal conditions to produce its maximum growth or yield at a given level of soil fertility ***(Gerdeman, 1975)***. Mycorrhizal dependency ratio can also be defined numerically by expressing the dry weight of mycorrhizal plant as a ratio of the dry weight of non - mycorrhizal plant. However, seedlings grown on sterilized or unsterilized soil and inoculated with *Glomus macrocarpum* or *Glomus australe* showed nearly similar values of mycorrhizal dependency ratio. However, the addition of rock phosphate fertilizar to the mycorrhizal-inoculated plants caused a remarkable increase in mycorrhizal dependency ratio. Moreover, seedlings grown on sterilized soil, fertilized with different levels of rock phosphate and inoculated with *Glomus macrocarpum* fungi gave higher mycorrhizal dependency ratio as compared with the analogous ones ionculated with *Glomus australe* fungi. In this concern, seedlings grown on sterilized soil, fertilized with low level of rock phosphate (0.25 g/ pot) and inoculated with *Glomus macrocarpum* fungi gave higher mycorrhizal dependency ratio (2.73 & 2.69) as compared with the analogous ones inoculated with *Glomus australe* (2.39 & 2.33) in 1994 and 1995 seasons, respectively. Besides, seedlings grown on sterilized soil fertilized with moderate level of rock phosphate (0.50 g / pot) and inoculated with *Glomus macrocarpum* fungi gave higher MDR (2.82 & 2.67) as compared with the analogous ones inoculated with *Glomus australe* fungi (2.51 x 2.40) in 1994 and 1995 seasons, respectively. Shortly, seedlings grown on sterilized soil, fertilized with high level of rock phosphate (1.00 g / pot) and inoculated with *Glomus macrocarpum* showed high mycorrhizal dependency ratio (3.04 & 2.95) in 1994 and 1995 seasons, respectively. In this respect, ***Helail et al. (1993)*** studied the mycorrhizal dependency ratio of "Le Conte" pear transplants grown on soil inoculated with two species of mycorrhizae fungi. They found that transplants grown on *Glomus macrocarpum* - inoculated soil showed (1.59 & 1.48) MDR, while those grown on *Glomus australe* - inoculated soil gave (1.44& 1.41) MDR. Also, ***Helail and El-Deeb (1993)*** mentioned that Rangpur lime seedlings grown on sterilized soil, inoculated with *Glomus macrocarpum* fungi showed (1.66 & 1.65). MDR in both seasons, respectively. In addition, ***Helail and Awad (1993)*** reported that, Citrus volkameriana seedlings grown on *Glomus macrocarpum* inoculated soil showed (1.34 & 1.37) MDR, while those grown on *Glomus australe*-inoculated soil gave (1.29 & 1.37) MDR in both seasons, respectively. Furthermore, ***Helail (1993)*** stated that mycorrhizal dependency ratio were (2.73 & 2.68) for *Glomus fasciculatus* and (2.51 & 2.61) for *Glomus calospora* fungi in avocado seedlings.

4.1.4. Leaf mineral content of annona seedlings :

The effect of soil sterilization, rock phosphate fertilization and soil inoculation with mycorrhizal fungi as well as their combinations on leaf mineral content of annona seedlings during 1994 and 1995 seasons is reported in Table (4).

4.1.4.1. Leaf nitrogen content :

It is obvious from Table (4) that in both seasons all tested treatments, except for the low rock phosphate level (0.25g $Ca_3(PO_4)_2$ / pot) succeeded in improving leaf nitrogen content as compared with the control. Besides, seedlings grown on non - sterilized soil and inoculated with *Glomus macrocarpum* or *Glomus australe* fungi had statistically similar leaf nitrogen content as compared with those received moderate or high levels of rock phosphate fertilizer. On the other hand, seedlings grown on sterilized soil and inoculated with *Glomus macrocarpum* or *Glomus australe* had not only similar values of leaf nitrogen content but also higher values as compared with the analogous ones grown on unsterilized soil. Furthermore, the combinaton of soil sterilization, soil inoculation with *Glomus macrocarpum* or *Glomus australe* fungi and rock phosphate fertilization (0.25, 0.50 or 1.00 g $Ca_3(PO_4)_2$ / pot) resulted in improving leaf nitrogen content. Anyhow, the differences between the different combinations were insignificant from the statistical standpoint.

4.1.4.2. Leaf phosphorus content:

In both seasons, all treated seedlings had higher leaf phosphorus content as compared with untreated ones control (Table, 4). Besides, rock

Table (4): Effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on leaf mineral content of annona seedlings (1994 & 1995 seasons).

Treatment			Elements concentration in dried leaves																	
S.S*	+ $Ca_3(PO_4)_2$	+VAM	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Calcium (%)		Magnesium (%)		Zinc (ppm)		Manganese (ppm)		Iron (ppm)		Copper (ppm)	
			1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995
--	Control	+ --	1.37	1.38	0.27	027	1.51	1.49	1.19	1.17	0.35	0.35	31	30	55	54	130	130	4	4
--	+0.25 g	+ --	1.48	1.46	0.33	0.33	1.52	1.52	1.19	1.19	0.37	0.36	32	31	60	60	131	131	4	4
--	+0.50 g	+ --	1.50	1.48	0.34	0.34	1.60	1.57	1.21	1.20	0.39	0.38	32	32	61	58	132	130	4	4
--	+1.00 g	+ --	1.52	1.49	0.33	0.34	1.60	1.58	1.21	1.19	0.38	0.39	33	32	60	60	130	132	4	4
--	+ --	+ G.m**	1.59	1.58	0.33	0.33	1.60	1.53	1.33	1.31	0.45	0.48	37	36	61	62	131	131	5	5
--	+ --	+ G.a***	1.57	1.56	0.33	0.33	1.61	1.59	1.27	1.14	0.45	0.44	37	38	63	63	140	141	5	5
S.S	+ --	+ G.m.	1.71	1.70	0.33	0.34	1.65	1.61	1.31	1.30	0.44	0.44	39	39	64	62	141	140	5	5
S.S	+ --	+ G.a	1.70	1.68	0.33	0.33	1.63	1.60	1.27	1.26	0.45	0.45	38	39	64	62	141	141	5	5
S.S	+0.25 g	+ G.m	1.76	1.74	0.36	0.35	1.67	1.68	1.33	1.32	0.50	0.49	48	43	69	68	142	140	5	5
S.S	+0.50 g	+ G.m	1.80	1.75	0.36	0.36	1.76	1.76	1.35	1.31	0.52	0.51	44	45	69	68	142	140	5	5
S.S	+1.00 g	+ G.m	1.86	1.83	0.37	0.37	1.75	1.76	1.35	1.33	0.53	0.52	46	47	70	68	141	141	6	6
S.S	+0.25 g	+ G.a	1.73	1.72	0.36	0.36	1.69	1.69	1.34	1.33	0.50	0.49	42	42	71	69	141	140	5	5
S.S	+0.50 g	+ G.a	1.81	1.78	0.36	0.36	1.64	1.65	1.35	1.32	0.49	0.48	43	42	68	65	141	140	5	5
S.S	+1.00 g	+ G.a	1.82	1.80	0.37	0.37	1.67	1.69	1.35	1.31	0.52	0.51	43	44	71	69	141	141	5	5
L.S.D. at		5%	0.11	0.10	0.03	0.03	0.15	0.14	0.05	0.06	0.04	0.04	3.2	3.2	6.5	6.6	4.1	4.2	0.35	0.37
		1%	0.15	0.14	0.05	0.05	0.21	0.21	0.07	0.08	0.05	0.05	4.6	4.5	9.2	9.2	5.7	5.8	0.52	0.51

Where :
* S.S. = Soil sterilization.
** G.m = *Glomus macrocarpum.*
*** G.a. = *Glomus australe.*

phosphate treatments and soil inoculation with *Glomus macrocarpum* or *Glomus australe* fungi whether mycorrhizal inoculation was conducted in sterilized or unsterilized soil exerted statistically similar effect in this respect. Furthermore, all combinations of soil sterilization, rock phosphate fertilization (0.25, 0.50 or 1.00 g $Ca_3(PO_4)_2$ /pot) and soil inoculation with mycorrhizal fungi (*Glomus macrocarpum* or *Glomus australe*) enhanced leaf phosphorus content and induced statistically similar results in this concern.

4.1.4.3. Leaf potassium content :

It is quite evident from Table (4) that in 1994 and 1995 seasons, soil fertilization with different levels of rock phosphate and soil inoculation with mycorrhizal fungi (*Glomus macrocarpum* or *Glomus australe*) whether inoculation was done in sterilized or unsterilized soil failed to induce any significant effect on leaf potassium content as compared with the control. On the other hand, the application of rock phosphate at any level to sterilized soil, inoculated with *Glomus macrocarpum* or *Glomus australe* significantly increased leaf potassium content as compared with the control. Generally, seedlings grown on sterilized soil, fertilized with moderate or high levels of rock phosphate and inoculated with *Glomus macrocarpum* fungi had the highest values of leaf phosphorus content. However, the differences were highly significant when compared with the control. Other combinations showed statistically similar values in this respect.

4.1.4.4. Leaf calcium content :

It is obvious from Table (4) that in 1994 and 1995 seasons, all tested treatments, except for rock phosphate treatments (0.25, 0.50 and

1.00 g $Ca_3(PO_4)_2$ per pot) enhanced leaf calcium content as compared with the control. Moreover, inoculating the soil with mycorrhizae fungi improved leaf calcium conent. This improvement of leaf calcium content was more obvious when the soil was sterilized and inoculated with *Glomus macrocarpum*. In addition, seedlings grown on sterilized soil, fertilized with different levels of rock phosphate and inoculated with *Glomus macrocarpum* or *Glomus australe* fungi had statistically similar and higher values of leaf calcium conent.

4.1.4.5. Leaf magnesium content :

In both seasons, rock phosphate treatments (0.25, 0.50 and 1.00 g $Ca_3(PO_4)_2$ /pot) failed to induce any significant effect on leaf magnesium content as compared with the control, (Table, 4). Moreover, inoculating unsterilized or sterilized soil with *Glomus macrocarpum* or *Glomus australe* fungi induced similar and high stimulating effect on leaf magnesium content. Furthermore, the addition of rock phosphate at different levels to sterilized and mycorrhizal inoculated soil caused high significant increase in leaf magnesium content. Besides, neither the rock phosphate level nor the mycorrhizal species induced a remarkable effect in this respect.

4.1.4.6. Leaf zinc content :

In both seasons, rock phosphate treatments (0.25, 0.50 and 1.00 g $Ca_3(PO_4)_2$ /pot) failed to affect leaf zinc content as compared with the control. Moreover, inoculating unsterilized or sterilized soil with *Glomus macrocarpum* or *Glomus australe* fungi induced statistically similar and higher leaf zinc content. Shortly, seedlings grown on sterilized soil, fertilized with high level of rock phosphate and inoculated with *Glomus* *macrocarpum* fungi had the highest leaf zinc content. Other combinations of rock phosphate levels and mycorrhizal species induced high and similar values of leaf zinc content.

4.1.4.7. Leaf manganese content :

Table (4) shows that in 1994 and 1995 seasons the three levels of rock phosphate (0.25, 0.50 and 1.00 g $Ca_3(PO_4)_2$/pot) failed to induce any significent effect on leaf manganese content of annona seedlings as compared with the control. On the other hand, inoculating unsterilized or sterilized soil with *Glomus macrocarpum* or *Glomus* australe significantly increased leaf manganese content. The stimulating effect was significant at 5% level, only. On the other side, planting annona seedlings in sterilized soil, fertilized with the different levels of rock phosphate and inoculated with *Glomus macrocarpum* or *Glomus australe* caused high significant increase in leaf manganese content. In other words, the enhancing effect of these combinations was significant at 1% level. Besides, the differences between the aforementioned combinations were so small to reach the significant level.

4.1.4.8. Leaf iron content :

It is quite clear from Table (4) that in both seasons, rock phosphate treatments exerted similar effect to that of the control from the statistical standpoint. In addition, inoculating unsterilized or sterilized soil with *Glomus macrocarpum* or *Glomus australe* without or with the addition of different rock phosphate levels caused not only similar but also higher increases in leaf iron content of annona seedlings.

4.1.4.9. Leaf copper content :

In both seasons, the three levels of rock phosphate had no significant effect on leaf copper content as compared with the control. Moreover, inoculating the unsterilized or sterilized soil with *Glomus macrocarpum* or *Glomus australe* in the absence or presence of different rock phosphate levels caused statistically similar and higher leaf copper content, except for seedlings grown on sterilized soil, fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* fungi which showed the highest values of leaf copper content.

Generally, rock phosphate fertilization improved leaf content of nitrogen, phosphorus and potassium of annona seedlings. Besides, mycorrhizal inoculation of sterilized soil caused more improvement in leaf mineral content as compared with unsterilized soil. This was more true when the soil was inoculated with *Glomus macrocarpum* fungi, rather than *Glomus australe*. Finally, seedlings grown on sterilized soil, fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* fungi had the highest values of leaf content of nitrogen, phosphorus, potassium, calcium, magnesium, zinc, manganese, iron and copper. Such results confirm the findings of ***Shen (1990), Treeby (1992), Helail and Ikram (1993), Helail and Awad (1993), Helail (1993) and Helail et al. (1993)*** who mentioned that soil inoculation with different mycorrhizal species improved most leaf mineral content of different fruit seedlings. However, two main mechanisms have been postulated to explain the way in which nutrients become more available to mycorrhizal than to non mycorrhizal plants. ***Burges (1936)*** put forward the view that the mycorrhizal fungi behaved in a way exactly analogos to other soil fungi, causing a breakdown of soil material and thus bringing nutrients into solution. In his view, these fungi are essentially parasitic and their morphological and histological effects on the host are irrelevant to thier stimulatory activity. This last arises from the local increase of soluble material near the root surface which might for offset any damage that their parasitic activity might cause. Although this view was really based only on surmise, it cannot be dismissed without detailed consideration, certain lines of evidence may be interpreted as arguing in its favour.

4.1.5. Mycorrhizal infection percent :

Table (5) shows the effect of endomycorrhizal fungi inoculation and phosphorus fertilization on infection percent of annona seedlings during (1994 & 1995 seasons).

It is interesting to notice that in both seasons vesicles formation (small spores) and arbuscules (big spores) increased with mycorrhizal inoculation.

Nevertheless, vesicles, arbuscules and mycelia on roots of control plants either fertilized or not were hill. On the other hand, vesicles formation on roots of *Glomus macrocarpum*-inoculated seedlings were higher as compared with the analogous ones inoculated with *Glomus australe* whether seedlings were grown on sterilized or unsterilized soil. Anyhow, the stimulating effect of mycorrhizal fungi on vesicles formation when the seedling were grown on sterilized soil. Furthermore, the addition of rock phosphate to the mycorrhizal inoculated seedlings, grown on sterilized soil caused high significant increase in vesicles and arbuscules formation. The differences between the different combinations were high

Table (5): Effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on infection percent of Annona roots (1994 & 1995 seasons).

Treatment			Infection percent					
			Vesicular		Arbuscular		Mycelia	
S.S.* +	$Ca_3[PO_4]_2$	+ VAM	1994	1995	1994	1995	1994	1995
--	Control	+ --	--	--	--	--	--	--
--	+ 0.25 g	+ --	--	--	--	--	--	--
--	+ 0.50 g	+ --	--	--	--	--	--	--
--	+ 1.00 g	+ --	--	--	--	--	--	--
--	+ --	+ G.m**	32.6	30.7	25.3	25.3	2.3	2.3
--	+ --	+ G.a***	27.3	26.3	24.1	24.1	2.3	2.3
S.S	+ --	+ G.m.	41.7	40.7	29.1	29.1	2.3	2.3
S.S	+ --	+ G.a	30.1	31.8	25.1	25.1	2.3	2.3
S.S	+ 0.25 g	+ G.m	48.5	49.3	35.9	36.3	2.3	2.3
S.S	+ 0.50 g	+ G.m	61.9	60.6	38.2	40.3	2.6	2.3
S.S	+ 1.00 g	+ G.m	70.5	72.3	41.8	41.5	3.3	3.3
S.S	+ 0.25 g	+ G.a	45.8	41.8	33.0	32.6	2.3	2.3
S.S	+ 0.50 g	+ G.a	53.5	52.3	34.2	31.3	2.6	2.6
S.S	+ 1.00 g	+ G.a	58.1	55.9	33.4	35.3	3.3	3.3
	L.S.D. at	5%	2.8	2.5	3.7	3.9	1.4	1.3
		1%	3.9	3.6	5.2	5.4	1.9	1.9

Where :
* S.S. = Soil sterilization.
** G.m = *Glomus macrocarpum.*
*** G.a. = *Glomus australe.*

when the each *mycorrhizal species* was compared with the another under the same rock phosphate level. Briefly, roots of seedlings grown on sterilized soil, fertilized with high rock phosphate level and inoculated with the high level of rock phosphate (1.00 g $Ca_3(PO_4)_2$ / pot) had the highest infection percent of vesicles and arbuscules spores.

Concerning, the effect of mycorrhizal inoculation and rock phosphate fertilization on mycelia percent, Table (5) reveals that inoculating the sterilized or unsterilized soil with *Glomus macrocarpum* or *Glomus australe* and received any level of rock phosphate greatly increased mycelia formation on roots of the treated seedlings. Although, seedlings grown in sterilized soil, inoculated with *Glomus macrocarpum* or *Glomus australe* and received the high rock phosphate level had high mycelia percent on their roots, but the differences were insignificant.

Conclusively, inoculating the sterilized soil with *Glomus macrocarpum* developed high percentages of vesicles, arbuscules and mycelia on the seedling roots than that of *Glomus australe*. This stimulating effect, parreled with rock phosphate level, particularly the high level.

Such results go in live with the findings of ***Menge et al. (1977)*** on citrus with *Glomus macrocarpum, Glomus microcarpum and Glomus monosporus* fungi. Besides, ***Gendiah (1987)*** mentioned that inoculating citrus rootstocks (sour orange and Cleopatra mandarin) with *Glomus macrocarpum* and *Glomus australe* with different levels of phosphorus fertilization increased the formation of vesicles, arbuscules and mycelia on roots of the treated - seedlings. *Glomus australe* surpassed *Glomus macrocarpum* in exerting the stimulating effect.

4.2. Gauva seedlings :

4.2.1. Vegetative growth :

Data reported in Tables (6 & 7) and Figs (4, 5 and 6) show the effect of soil inoculation with mycorrhizal fungi i.e. *Glomus macrocarpum* and *Glomus australe* and soil fertilization with rock phosphate at three levels (0.25, 0.50, 1.00 g/pot) as well as their interactions on growth of guava seedlings cv- El - Maamora during 1994 and 1995 seasons.

4.2.1.1. Stem length :

It is quite evident from Table (6) and Figs (4,5 &6) that in both seasons all tested treatments i.e. mycorrhizal inoculation or rock phosphate fertilizer treatments as well as their combinations caused highly significant increases in shoot length as compared with the control. Furthermore, soil inoculation with *Glomus macrocarpum* fungi exerted more stimulating effect than did *Glomus australe* fungi whether seedlings were grown on unsterilized or sterilized soil and / or fertilized with the same level of rock phosphate. However, seedlings grown on sterilized, soil received the low and moderate levels of rock phosphate and inoculated with *Glomus macrocarpum* or received the three levels of rock phosphate and inoculated with *Glomus australe* fungi gave more or less similar values from the statistical standpoint. Generally, seedlings grown on sterilized soil, fertilized with the high level of rock phosphate (1.00 g / pot) and inoculated with *Glomus macrocarpum* produced comparatively the longest shoots.

4.2.1.2. No. of lateral shoots / plant:

Table (6) shows that in 1994 and 1995 seasons, all tested treatments except for rock phosphate treatments succeeded in increasing number of lateral shoots per seedling as compared with the control. Generally, seedlings grown on sterilized soil, fertilized with high level of rock phosphate (1.00 g / pot) and inoculated with *Glomus macrocarpum* fungi produced the highest number of lateral shoots. On the contrary, rock phosphate treatments and inoculating unsterilized soil with *Glomus macrocarpum* or *Glomus australe* failed to effect the brust of axillary buds to produce lateral shoots. On the other hand, inoculating the sterilized soil with *Glomus macrocarpum* or *Glomus australe* and / or soil fertilization with low and moderate levels of rock phosphate for soil inoculation with *Glomus macrocarpum* or soil fertilization with any level of rock phosphate for soil inoculation with *Glomus australe* succeeded in increasing number of lateral shoots per seedling at 5% level, only. Anyhow, the differences between these combinations were statistically lacking.

4.2.1.3. Stem diameter :

In both seasons, rock phosphate fertilizer, mycorrhizae fungi and soil sterilization as well as their combination significantly increased stem diameter as compared with the control (Table, 6). However, seedlings grown on sterilized or non sterilized soil and inoculated with *Glomus macrocarpum* or *Glomus australe* had thicker stems as compared with those grown on unsterilized soil and received any level of rock phosphate. Besides, seedlings grown on sterilized or unsterilized soil and inoculated with *Glomus macrocarpum* had thicker stems as compared with the analogous ones inoculated with *Glomus australe.* Anyhow, the differences

Table (6): Effect os soil inoculation with mycorrhizal fungi and rock phosphate fertilization on vegetative growth of guava seedlings (1994 & 1995 seasons).

Treatment			Steem length (cm)		No. of lateral shoots / plant		Stem diameter (cm)		No. of leaves / plant	
S.S.*	+ $Ca_3(PO_4)_2$	+ VAM	1994	1995	1994	1995	1994	1995	1994	1995
--	Control	+ --	65.1	64.2	2.1	2.3	0.45	0.47	64.8	65.3
--	+ 0.25 g	+ --	114.2	112.5	2.2	2.3	0.52	0.51	79.9	80.6
--	+ 0.50 g	+ --	115.0	112.7	2.2	2.3	0.51	0.51	83.2	82.7
--	+ 1.00 g	+ --	113.7	113.8	2.2	2.3	0.52	0.53	83.5	84.0
--	+ --	+ G. m**	125.3	126.7	2.7	2.8	0.57	0.56	93.5	93.1
--	+ --	+ G.a.***	120.0	121.3	2.6	2.8	0.56	0.55	89.4	98.5
S.S	+ --	+ G.m	129.2	129.3	3.1	3.3	0.59	0.58	92.9	89.9
S.S	+ --	+ G.a	126.2	125.9	3.1	3.3	0.56	0.55	92.1	92.5
S.S	+ 0.25 g	+ G.m	132.7	130.2	3.2	3.3	0.64	0.64	98.3	98.8
S.S	+ 0.50 g	+ G.m	132.8	131.5	3.2	3.3	0.64	0.64	98.2	99.7
S.S.	+ 1.00 g	+ G.m	139.2	138.3	3.9	3.9	0.67	0.66	103.2	104.2
S.S.	+ 0.25 g	+ G.a	131.1	130.6	3.2	3.2	0.62	0.62	97.4	98.1
S.S.	+ 0.50 g	+ G.a	132.1	130.8	3.1	3.2	0.62	0.69	98.5	98.7
S.S.	+ 1.00 g	+ G.a	132.3	131.7	3.2	3.3	0.63	0.63	98.3	99.1
	L.S.D. at	5%	5.2	5.3	0.9	0.8	0.01	0.01	3.7	3.7
		1%	7.3	7.4	1.2	1.1	0.03	0.03	5.2	5.1

Where :

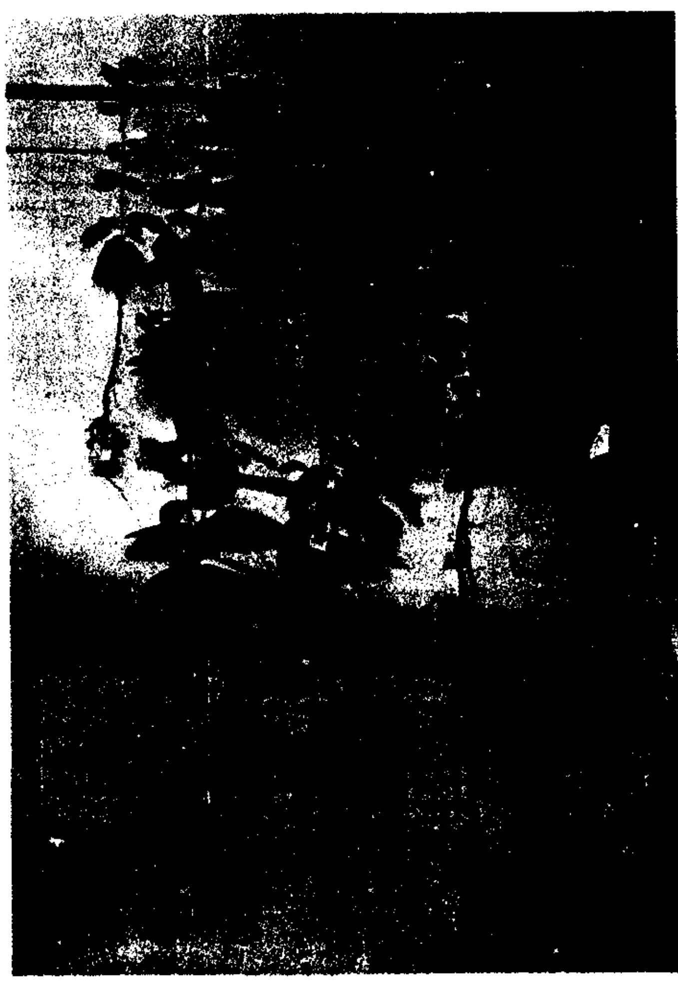
* S.S. = Soil sterilization.

** G.m = *Glomus macrocarpum.*

*** G.a. = *Glomus australe.*

(1) Control
(2) 0.25 g $Ca_3(PO_4)_2$ / pot
(3) 0.50 g $Ca_3(PO_4)_2$ / pot
(4) 1.00 g $Ca_3(PO_4)_2$ / pot

Fig. (4): Effect of rock phosphate fertilization on growth of guava seedlings



(1) Control
(2) Unsterilized soil + G.m
(3) Unsterilized soil + G.a
(4) Sterilized soil + G.m
(5) Sterilized soil + G.a

Fig. (5): Effect of soil sterilization and soil inoculation with mycorrhizal fungi on growth of guava seedlings

(1) Control
(2) S.S. + 0.25 $Ca_3(PO_4)_2$ + G.m
(3) S.S. + 0.50g $Ca_3(PO_4)_2$ + G.m
(4)S.S. + 1.00 g $Ca_3(PO_4)_2$ + G.m
(5) S.S. + 0.25 g $Ca_3(PO_4)_2$ + G.a
(6) S.S. + 0.50 g $Ca_3(PO_4)_2$ + G.a
(7) S.S. + 1.00 g $Ca_3(PO_4)_2$ + G.a

Fig. (6): Effect of rock phosphate fertilization and soil inoculation with mycorrhizal fungi on growth of guava seedlings.

were significant when the sterilized soil was concerned . Moreover, seedlings grown on sterilized soil and inoculated with *Glomus macrocarpum* fungi gave thicker stems as compared with the analogous ones inoculated with *Glomus australe,* under the same level of rock phosphate. Briefly, soil sterilization + high level of rock phosphate (1.00 g / pot) + soil inoculation with *Glomus macrocarpum* proved to be the superior treatment in increasing stem diameter.

4.2.1.4. No of leaves / plant :

It is clear that in 1994 and 1995 seasons, all tested treatments caused high significant increase in number of leaves perplant as compared with the control (Table 6) and Figs (4,5 and 6). Moreover, rock phosphate treatments, particularly, the low level which showed to be the least effective treatments in increasing number of leaves per seedling. Besides, seedlings grown on unsterilized or sterilized soil and inoculated with *Glomus macrocarpum* or *Glomus australe* fungi produced statistically similar and higher number of leaves as compared with rock phosphate treatments. Furthermore, seedlings grown on sterilized soil, received the low or moderate level of rock phosphate and inoculated with *Glomus macrocarpum* as well as those received any level of rock phosphate and inoculated with *Glomus australe* fungi produced statistically similar and higher number of leaves. Finally, seedlings grown on sterilized soil, fertilized with the high level of rock phosphate and inoculated with *Glomus macrocarpum* produced the highest number of leaves.

4.2.1.5. Leaf content of chlorophyll (a) & (b) and corotene:

Data reported in Table (7) show the effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on leaf content of chlorophyll (a) & (b) and carotene of gauva seedlings during 1994 and 1995 seasons.

It abovious that in both seasons, all tested treatment succeeded in enriching leaf content of chlorophyll (a) & (b) and carotene as compared with the control except for the three levels of rock phosphate which failed to induce any significant effect on leaf content of chlorophyll (a) & (b) and carotene. In addition, inoculating the sterilized soil with any of the two mycorrhizal species enhanced leaf content of chlorophyll (a) & (b) and carotene rather than when inoculation was conducted unusterilized soil. Anyhow, the differences were so small to be significant. Generally, seedlings grown on sterilized soil, fertilized with high level of rock phosphate (1.00 g / pot) and inoculated with *Glomus macrocarpum* fungi had the richest leaves in their content of chlorophyll (a) & (b) and carotene. On the other hand, seedlings grown on sterilized soil, fertilized with different levels of rock phosphate gave statistically similar values of leaf content of chlorophyll (a) & (b) and carotone, whether the soil was inoculated with *Glomus macrocarpum* or *Glomus australe* fungi.

Conclusively, the three levels of rock phosphate fertilization caused significant increase in shoot length stem diameter and number of leaves per plant, whereas number of lateral shoots per plant and leaf content of chlorophyll a & b and carotene did not show any significant response to rock phosphate fertilization. Moreover, soil sterilization did not show any additional effect on the previously mentioned vegetative growth. Furthermore, the addition of rock phosphate to inoculated soil with *Glomus macrocarpum* or *Glomus australe* fungi induced more enhancing effect on the studied vegetative growth parameters. Generally, all combinations of rock phosphate fertilization and soil inoculation with mycorrhizal fungi induced statistically similar effect, except for the high level of rock phosphate with *Glomus macrocarpum* fungi which proved to be the superior treatment in improving the vegetative growth of guava seedling.

Such results are in harmony with the findings of ***Palipane and Bandara (1985), Cabdoso et al. (1986), Michelini and Nemec (1988), Gendiah et al. (1991 -b), Nemec (1992), Helail (1993), Helail and Awad, (1993), Helail and El-Deeb (1993), Helail and Ikram (1993) and Taube - Baab and Baltruschat (1993)*** who mentioned that mycorrhizal inoculation enhanced vegetative growth i.e. shoot length, number of lateral shoots per plant, stem diameter, number of leaves per plant and leaf content of chlorophyll a & b and carotene.

4.2.2. Root growth and dry weight :

Effect of rock phosphate fertilization and soil inoculation with mycorrhizal fungi as well as their combinations on root growth and dry weight of guava seedlings reported in Table (8) and Figs. (4,5 and 6).

4.2.2.1. Root length :

Table (8) and Figs (4, 5 and 6) show that in both seasons rock phosphate treatments enhanced the growth of guava roots as compared with the control. Besides, inoculating the sterilized soil with mycorrhizal fungi showed statistically similar values as compared with the analogous ones inoculated with both mycorrhizal species and grown on unsterilized soil. On the other hand, seedlings grown on sterilized soil, fertilized with high level of rock phosphate (1.00 g $Ca_3(PO_4)_2$ / pot) and inoculated with

Table (7): Effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on leaf chlorophyll and carotene content of guava seedlings (1994 & 1995 seasons).

Treatment			Chlorophyll "A" mg / 100 g F.W.		Cholorophyll "B" mg / 100 g F.W.		Carotene	
S.S.*	+ $Ca_3[PO_4]_2$	+ VAM	1994	1995	1994	1995	1994	1995
--	Control		80.7	81.8	74.1	73.6	77.5	78.6
--	+ 0.25 g	+ --	80.5	81.4	74.9	75.3	82.3	82.7
--	+ 0.50 g	+ --	81.0	84.8	75.1	75.6	83.1	84.1
--	+ 1.00 g	+ --	81.2	83.0	75.2	75.5	83.2	84.9
--	+ --	+ G.m**	86.2	87.1	81.1	82.3	89.1	90.2
--	+ --	+ G.a***	86.9	87.1	80.7	83.5	89.2	89.5
S.S	+ --	+ G.m.	89.3	90.2	82.6	85.9	90.3	89.7
S.S	+ --	+ G.a	90.2	91.2	81.3	85.0	88.1	88.4
S.S	+ 0.25 g	+ G.m	100.2	101.4	92.0	94.1	98.2	97.5
S.S	+ 0.50 g	+ G.m	100.9	101.7	93.2	94.2	98.5	99.5
S.S	+ 1.00 g	+ G.m	107.7	109.1	105.7	108.3	109.3	111.3
S.S	+ 0.25 g	+ G.a	98.6	99.2	91.6	93.6	97.7	96.2
S.S	+ 0.50 g	+ G.a	99.8	101.1	92.2	94.5	98.2	97.5
S.S	+ 1.00 g	+ G.a	99.1	101.7	92.8	94.3	99.8	99.8
	L.S.D. at 5%		4.7	4.6	4.4	4.6	4.5	4.6
	1%		6.5	6.3	6.2	6.4	6.3	6.4

Where :
* S.S. = Soil sterilization.
** G.m = *Glomus macrocarpum.*
*** G.a. = *Glomus australe.*

Glomus macrocarpum fungi gave the longest roots. Other combinations of rock phosphate level and mycorrhizal species induced statistically similar results.

4.2.2.2. No. of lateral roots / plant :

Table (8) and Figs (4,5 and 6) reveal that in both seasons, all tested treatments except for three level of rock phosphate significantly increased number of lateral roots per plant as compared with the control. Moreover, the three levels of rock phosphate induced the lowest stimulating effect in comparison with other tested treatments. Besides, inoculating unsterilized or sterilized soil with mycorrhizal fungi particularly *Glomus macrocarpum* encouraged the production of lateral roots. This was more obvious when mycorrhizal inoculation was conducted on sterilized soil. However, the differences were lacking from the statistical standpoint. Moreover, seedlings grown on sterilized soil, fertilized with different levels of rock phosphate and inoculated with mycorrhizal fungi produced statistically higher number of roots, particularly those fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* which produced the highest number of roots per seedling. Morevoer, seedlings grown on sterilized soil and fertilized with low and moderate levels of rock phosphate and inoculated with *Glomus macrocarpum* fungi had statistically similar values as compared with the analogous ones, inoculated with *Glomus australe*, regardless of rock phosphate level.

4.2.2.3. Shoot dry weight :

It obvious from Table (8) that in both seasons, soil sterilization, rock phosphate and soil inoculation with mycorrhizal fungi and their combinations caused high significant increases in shoot dry weight as

Table (8): Effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on root growth, dry weight and mycorrhizal dependency ratio of guava seedlings (1994 & 1995 seasons).

Treatment			Root length (cm)		No. of lateral roots / plant		Shoot dry wt (g).		Root system dry wt (g)		Total dry wt (g)		Top : Root Ratio		Mycorrhizal dependency ratio (MDR)	
S.S.*	+ $Ca_3(PO_4)_2$	+ VAM	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995
--	Control	+ --	38.7	39.8	96.7	98.2	11.2	11.0	7.9	7.8	19.1	18.8	1.31	1.31	--	--
--	+ 0.25 g	+ --	50.2	49.2	110.2	107.1	12.4	12.5	9.5	9.3	21.9	21.8	1.30	1.34	--	--
--	+ 0.50 g	+ --	51.7	50.8	112.1	106.5	12.5	12.0	10.0	9.8	22.5	21.8	1.25	1.22	--	--
--	+ 1.00 g	+ --	50.9	51.0	107.4	105.8	12.8	12.6	9.9	9.9	22.7	22.5	1.29	1.37	--	--
--	+ --	+ G. m**	71.1	69.8	184.3	182.7	14.9	15.1	10.5	10.2	25.4	25.3	1.31	1.28	1.32	1.30
--	+ --	+ G.a.***	70.2	70.0	183.5	182.9	13.8	13.8	10.5	10.3	24.2	24.1	1.30	1.33	1.32	1.32
S.S	+ --	+ G.m	74.6	75.3	187.9	185.8	15.3	15.2	11.7	11.9	27.0	27.6	1.30	1.31	1.48	1.52
S.S	+ --	+ G.a	73.9	74.9	188.3	187.7	14.8	14.4	11.1	11.0	25.9	25.4	1.33	1.30	1.40	1.41
S.S	+ 0.25 g	+ G.m	90.5	91.3	195.7	193.5	18.2	18.0	15.7	15.3	33.9	33.3	1.15	1.17	1.98	1.96
S.S	+ 0.50 g	+ G.m	92.7	91.8	198.2	196.2	18.7	18.4	16.0	15.8	34.7	34.2	1.16	1.16	2.02	2.05
S.S.	+ 1.00 g	+ G.m	103.8	104.3	211.7	209.7	19.5	19.3	18.1	17.9	37.6	37.2	1.17	1.17	2.29	2.29
S.S.	+ 0.25 g	+ G.a	88.1	89.8	193.2	191.8	18.1	18.2	15.1	15.0	33.2	33.2	1.19	1.21	1.91	1.92
S.S.	+ 0.50 g	+ G.a	88.5	89.2	198.2	195.4	18.0	18.3	15.2	14.9	33.2	33.2	1.18	1.22	1.92	1.91
S.S.	+ 1.00 g	+ G.a	89.7	90.3	201.4	200.1	18.5	18.4	15.7	15.0	34.2	33.4	1.17	1.22	1.98	1.92
	L.S.D. at	5%	8.2	9.5	6.1	7.1	1.4	1.3	2.1	2.0	2.7	2.5	N.S	N.S.		
		1%	11.3	12.3	8.5	9.6	1.9	1.8	2.9	2.8	3.5	3.2	--	--		

Where :

* S.S. = Soil sterilization.

** G.m = *Glomus macrocarpum*.

*** G.a. = *Glomus australe*.

compared with the control. On the other hand, the different levels of rock phosphate failed to induce significant effect in this concern. Moreover, inoculating the soil with *Glomus macrocarpum* or *Glomus australe* induced statistically similar effect, whether inoculation was conducted on sterilized or unsterilized soil. Generally, seedlings grown in sterilized soil, fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* had higher shoot dry weight. Other combinations of rock phosphate levels and mycorrhizal fungi induced statistically similar effect in this sphere.

4.2.2.4. Root system dry weight :

Table (8) shows that in 1994 and 1995 seasons, all tested treatments except for rock phosphate treatments succeeded in increasing root system dry weight as compared with the control. Moreover, mycorrhizal inoculation with *Glomus macrocarpum* or *Glomus australe* induced statistically similar effect whether the seedlings were grown on unsterilized or sterilized soil. Furthermore, the addition of rock phosphate fertilization to the inoculated soil with mycorrhizal fungi, increased the root system dry weight. This was more obvious when the soil was inoculated with *Glomus macrocarpum* fungi rather than *Glomus australe*. In other words, seedlings grown on sterilized soil, fertilized with the high level of rock phosphate (1.00 g/ pot) and inoculated with *Glomus macrocarpum* had statistically the highest root system dry weight. Briefly, seedlings grown on sterilized soil, fertilized with different levels of rock phosphate fertilization and inoculated with *Glomus macrocarpum* fungi had statistically similar root system dry weight to that inoculated with *Glomus australe* fungi, regardless of rock phosphate level.

4.2.2.5. Total dry weight:

It is clear from Table (8) that in 1994 and 1996 seasons, all tested treatments caused significant increases in total seedling dry weight as compared with the control. Anyhow, the three levels of rock phosphate fertilization exerted the lowest stimulating effect on total seedling dry weight. Morever, inoculating the soil whether sterilized or not with *Glomus macrocarpum* or *Glomus australe* not only enhanced total seedling dry weight, but also induced statistically similar effect in this sphere. In other words, soil sterilization or not and / or soil inoculation with *Glomus macrocarpum* or *Glomus australe* showed similar results in this respect. Moreover, seedlings grown on sterilized soil, fertilized with different levels of rock phosphate and inoculated with *Glomus macrocarpum* fungi had statistically similar values of total dry weight as compared with the analogous ones inoculated with *Glomus australe* fungi, regardless of rock phosphate level. Generally, seedling grown on sterilized soil, fertilized with high level of rock phosphate (1.00 g / pot) proved to be the superior treatment in enhancing total seedling dry weight.

4.2.2.6. Top : Root ratio :

It is clear from Table (8) that in 1994 and 1995, rock phosphate fertilization (0.25, 0.50 or 1.00 g / pot) and soil inoculation with mycorrhizal fungi (*Glomus macrocarpum* or *Glomus australe*) as well as their combinations failed to affect top : root ratio of guava seedlings as compared with the control.

Briefly, rock phosphate treatments caused significant increase in root length and total seedling dry weight, but failed to affect number of lateral roots per plant, shoot dry weight and root system dry weight.

Furthermore, inoculating unsterilized soil or sterilized soil with *Glomus macrocarpum* or *Glomus* australe fungi enhanced the aforementioned parameters. Besides, the addition of rock phosphate fertilization to mycorrhizal inoculated soil induced more stimulating effect on root growth and dry weight. Both mycorrhizal species induced similar effect. Finally, seedlings grown on sterilized soil, fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* fungi showed the highest values of root growth and dry weight parameters.

Such results go in line with those reported earlier by ***Branzanti and Inuacenti (1987), Lopes et al. (1988), Cuenca et al. (1990), Gendiah (1991), Geudiah et al. (1991-b), Helail (1993), Geudiah et al. (1991 -b), Helail (1993), Helail and Awad (1993), Helail et al. (1993) and Helail and Ikram (1993).*** They mentioned that soil inoculation with different mycorrhizal species improved root growth and dry weight parameters of different fruit seedlings.

4.2.3. Mycorrhizal dependency ratio (MDR):

Seedlings grwon on unsterilized soil and inoculated with *Glomus macrocarpum* or *Glomus australe* fungi showed relatively lower values of mycorrhizal dependency ratio as compared with those grow on sterilized soil; inoculated with *Glomus macrocarpum* or *Glomus australe* (Table, 8). However, the addition of rock phosphate to the mycorrhizal inoculated plants caused a remarkable increase in mycorrhizal dependency ratio. On the other hand, seedlings grown on sterilized soil, fertilized with differentt levels of rock phosphate (particularly, the high and low levels) and inoculated with *Glomus macrocarpum* fungi gave higher mycorrhizal dependency ratio as compared with the analogous ones inoculated with

Glomus australe fungi. In this concern, seedlings grown on sterilized soil, fertilized with high level of rock phosphate (1.00 g / pot) and inoculated with *Glomus macrocarpum* fungi gave higher mycorrhizal dependency ratio (2.29 & 2.29) and (2.02 & 2.05) as compared with the analogous ones inoculated with *Glomus australe* (1.96 & 1.92) and (1.92 & 1.91). In 1994 & 1995 seasons, respectively.

Shortly, seedlings grown on sterilized soil fertilized with low level of rock phosphate (0.25 g / pot) and inoculated with *Glomus macrocarpum* showed relatively high mycorrhizal dependency ratio as compared with the analogous ones inoculated with *Glomus australe* fungi in 1994 & 1995 seasons. In this respect. ***Helail et al. (1993)*** studied the mycorrhizal dependency ratio of "Le Conte" pear transplants grown on soil inoculated with two species of mycorrhizae fungi. They found that transplants grown on *Glomus macrocarpum* - inoculated soil showed (1.59 & 1.48) MDR, while those grown on *Glomus australe* inoculated soil gave (1.44 & 1.41) MDR. Also, ***Helail and El-Deeb (1993)*** mentioned that Rangpur lime seedlings grown on sterilized soil, inoculated with *Glomus macrocarpum* fungi showed (1.66 & 1.65) MDR, while those grown on *Glomus australe* inoculated soil gave (1.29 & 1.37) MDR in both seasons, respectively. Furthermore, ***Helail (1993)*** stated that mycorrhizal dependency ratio for avocado seedlings were (2.73 & 2.68) for *Glomus fasciculatus* and (2.51 & 2.61) for *Glomus calospora* fungi.

4.2.4. Leaf mineral content :

The effect of rock phosphate fertilization and soil inoculation with mycorrhizae fungi as well their combinations on leaf mineral content of guava seedlings during 1994 and 1995 seasons is reported in Table (9).

4.2.4.1. Leaf nitrogen content :

It is obvious that in both seasons, all combinations of rock phosphate, soil sterilization and soil inoculation with mycorrhizal fungi except for (soil sterilization + high rock phosphate level + soil inoculation with *Glomus macrocarpum* fungi) failed to induce any significant effect on leaf nitrogen content as compared with the control. In other words, only seedlings grown on sterilized soil, fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* fungi had higher leaf nitrogen content as compared with the control. Anyhow, the differences were significant at 5% level only.

4.2.4.2. Leaf phosphorus content :

In both seasons, all treated seedlings had higher leaf phosphorus content as compared with untreated ones " control" (Table, 9). Besides, rock phosphate treatments and soil inoculation with *Glomus macrocarpum* or *Glomus australe* fungi whether inoculation was conducted on sterilized or unsterilized soil exerted statitically similar effect in this respect. Furthermore, all combinations of soil sterilization, rock phosphate fertilization (0.25, 0.50, 1.00 g $Ca_3(PO_4)_2$ / pot) and soil inoculation with mycorrhizal fungi (*Glomus macrocarpum* or *Glomus australe*) enhanced leaf phosphorus content and induced statistically similar results in this respect.

Table (9): Effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on leaf mineral content of guava seedlings (1994 & 1995 seasons).

Treatment			Elements concentration in dried leaves																	
S.S*	+ $Ca_3(PO_4)_2$	+VAM	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Calcium (%)		Magnesium (%)		Zinc (ppm)		Manganese (ppm)		Iron (ppm)		Copper (ppm)	
			1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995
--	Control		1.92	1.92	0.16	0.16	1.32	1.30	2.47	2.48	0.24	0.24	26	27	65	65	139	138	6	6
--	+ 0.25 g	+ --	1.93	1.90	0.19	0.18	1.35	1.32	2.45	2.49	0.24	0.24	28	28	67	65	141	142	6	6
--	+ 0.50 g	+ --	1.91	1.91	0.20	0.20	1.33	1.34	2.47	2.48	0.24	0.24	29	28	65	66	143	142	6	6
--	+ 1.00 g	+ --	1.90	1.93	0.20	0.29	1.34	1.35	2.47	2.49	0.24	0.24	27	28	67	65	140	142	6	6
--	+ --	+ G.m**	1.92	1.91	0.19	0.18	1.45	1.47	2.55	2.54	0.25	0.25	36	37	70	71	151	153	6	6
--	+ --	+ G.a***	1.93	1.92	0.19	0.19	1.46	1.47	2.53	2.53	0.25	0.25	35	35	70	71	151	152	6	6
S.S	+ --	+ G.m.	1.92	1.94	0.20	0.20	1.49	1.48	2.54	2.52	0.24	0.25	36	37	71	72	157	153	6	6
S.S	+ --	+ G.a	1.92	1.92	0.19	0.20	1.48	1.47	2.53	2.54	0.25	0.25	37	36	71	72	156	152	6	6
S.S	+ 0.25 g	+ G.m	1.93	1.93	0.21	0.20	1.74	1.73	2.52	2.53	0.24	0.24	42	42	73	74	170	172	6	6
S.S	+ 0.50 g	+ G.m	1.92	1.92	0.20	0.20	1.73	1.74	2.53	2.54	0.24	0.25	42	42	74	75	171	171	6	6
S.S	+ 1.00 g	+ G.m	2.01	2.05	0.21	0.21	1.82	1.83	2.55	2.54	0.25	0.25	46	45	82	85	174	172	6	6
S.S	+ 0.25 g	+ G.a	1.96	1.92	0.20	0.21	1.72	1.73	2.54	2.53	0.25	0.25	42	41	74	73	170	171	6	6
S.S	+ 0.50 g	+ G.a	1.98	1.90	0.21	0.21	1.70	1.71	2.51	2.52	0.25	0.24	41	42	74	76	172	171	6	6
S.S	+ 1.00 g	+ G.a	1.95	1.93	0.20	0.21	1.72	1.72	2.53	2.52	0.25	0.25	42	42	76	75	172	173	6	6
	L.S.D. at	5%	0.08	0.09	0.01	0.01	0.11	0.10	N.S	N.S.	N.S.	3.0	3.0	4.3	4.2	11.2	11.1	11.1	N.S	N.S
		1%	N.S.	N.S	0.02	0.02	0.17	0.15	--	--	--	4.2	4.1	6.1	6.0	15.6	15.6	11.5	--	--

Where :
* S.S. = Soil sterilization.
** G.m = *Glomus macrocarpum*.
*** G.a. = *Glomus australe*.

4.2.4.3. Leaf potassium content :

It is quite evident from Table (9) that in 1994 and 1995 seasons, soil fertilization with different levels of rock phosphate (0.25, 0.50, 1.00 g $Ca_3 (PO_4)_2$ / pot) and grown on unsterilized soil failed to induce any significant effect on leaf potassium content as compared with the conrol. On the other hand, the application of rock phosphate at any level to sterilized soil, inoculated with *Glomus macrocarpum* or *Glomus australe* fungi significantly increased leaf potassium content as compared with analogous ones received no rock phosphate fertilization. Generally, seedlings grown on sterilized soil, fertilized with high level of rock phosphate (1.00 g / pot) and incoulated with *Glomus macrocarpum* fungi had the highest values of leaf phosphorus content. Other combinations showed statistically similar values in this respect.

4.2.4.4. Leaf calcium content :

It is abvious from Table (9) in 1994 and 1995 seasons, rock phosphate fertilization, soil inoculation with mycorrhizal fungi (*Glomus macrocarpum* or *Glomus australe*) as well as their combinations failed to induce any significant effect on leaf calcium content of guava seedlings as compared with the control.

4.2.4.5. Leaf magnesium content :

Table (9) shows that in both seasons guava seedlings grown on fertilized soil with rock phosphate (0.25, 0.50 or 1.00 g/pot) and / or inoculated with mycorrhizal fungi *Glomus macrocarpum* or *Glomus australe*) whether the soil was sterilized or not had statistically similar values of leaf magnesium content as compared with the control.

4.2.4.6. Leaf zinc content :

In both seasons, rock phosphate treatments (0.25, 0.50, 1.00 g $Ca_3(PO_4)_2$/pot) failed to affect leaf zinc content as compared with the control. Moreover, soil inoculation with *Glomus macrocarpum* or *Glomus australe* combined with sterilized or unstarilized soil induced statistically similar and higher leaf zinc content as compared with the control. Besides, seedlings grown on sterilized soil, fertilized with high level of rock phosphate (1.00 g / pot) and inoculated with *Glomus macrocarpum* fungi had the highest leaf zinc content. Other combinations of rock phosphate levels and mycorrhizal species induced high and similar values of leaf zinc content.

4.2.4.7. Leaf managanese content :

Table (9) shows that in 1994 and 1995 seasons the three levels of rock phosphate (0.25, 0.50, 1.00 g $Ca_3(PO_4)_2$ / pot) failed to induce any significant effect on leaf manganese content of guava seedlings as compared with the control. On the other hand, inoculating unsterilized or sterilized soil with *Glomus macrocarpum* or *Glomus australe* significantly increased leaf manganese content. The stimulating effect was significant at 5% level only. On the other side, planting guava seedlings in sterilized soil, fertilized with the different levels of rock phosphate and inoculated with *Glomus macrocarpum* or *Glomus australe* fungi caused high significant increase in leaf manganese content particularly those received high rock phosphate level and inoculated with *Glomus macrocarpum* fungi which showed the highest values of leaf manganese content.

4.2.4.8. Leaf iron content :

Table (9) shows that in both seasons, rock phosphate treatments exerted similar effect to that of the control from the statistical stand point. In addition, inoculating unsterilized or sterilized soil with *Glomus macrocarpum* or *Glomus australe* fungi without or with the addition of different levels of rock phosphate induced not only similar, but also high values of leaf iron content of guava seedlings.

4.2.4.9. Leaf copper content:

It is obvious that in 1994 and 1995 seasons, seedlings grown on soil fertilized with different levels of rock phosphate and / or inoculated with mycorrhizal fungi (*Glomus macrocarpum* or *Glomus australe*) whether the soil was sterilized or not, had statistically similar values of leaf copper content as compared with the control.

Conclusively, the three levels of rock phosphate increased only leaf phosphorus content and failed to affect other studied leaf mineral content. Furthermore, inoculating unsterilized or sterilized soil with *Glomus macrocarpum* or *Glomus australe* fungi improved leaf content of phosphorus, potassium, zinc manganese and iron. The two mycorrhizal species induced similar effect in this respect. Anyhow, seedlings grown on sterilized soil, fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* produced leaves high in their content of nitrogen, phosphorus, potassium, manganese and iron.

These results are coincided with those reported earlier by ***Menge et al. (1980), Menge et al. (1982); Cuenca et al. (1990), Jaizme and Azcan (1991), Vidal et al. (1992) and Haugen and Smith (1993), Helail (1993),***

Helail and Awad (1993) and Helail et al. (1993), Furthermore, ***Helail and El-Deeb (1993)*** mentioned that leaf content of phosphorus iron and zinc of Rangpur lime were improved due to mycorrhizal inoculation. *Glomus macrocarpum* fungi exerted more stimulus effect than *Glomus australe* fungi

4.2.5. Mycorrhizal infection percent :

Table (10) shows the effect of endomycorrhizal fungi inoculation and phosphorus fertilization on infection percent of guava seedlings during 1994 and 1995 seasons.

Tabulated data reveal that in both seasons vesicles (small spores) and arbuscules (big spores) formation increased with mycorrhizal inoculation. However, vesicles, arbuscules and mycelia formation on roots of control plants, whether fertilized or not were nill. On the other hand, vesicles and arbuscules formation on roots of *Glomus macrocarpum* inoculated seedlings were higher as compared with the analogous ones inoculated with *Glomus australe*, whether seedlings were grown on sterilized or unsterilized soil. Moreover, the stimulating effect of mycorrhizae fungi on vesicles or arbuscules formation was increased when the mycorrhizal inoculated - seedlings were fertilized with rock phosphate. Briefly, *Glomus macrocarpum* inoculated seedlings, fertilized with different levels of rock phosphate had higher percent of vesicles and arbuscules on their roots than the analogous ones inoculated with *Glomus australe* fungi, regardless of rock phosphate level.

Concerning the effect of mycorrhizal inoculation and rock phosphate fertilization on mycelia, Table (10) reveals that soil inoculation

Table (10): Effect of soil inoculation with mycorrhizal fungi and phosphorus fertilization on infection percent of "guava" roots. (1994 & 1995 seasons).

Treatment			Infection percent					
			Vesicular		Arabuscular		Mycelia	
S.S.*	+ $Ca_3(PO_4)_2$	+ VAM	1994	1995	1994	1995	1994	1995
--	Control	+ --	-	-	-	--	--	--
--	+ 0.25 g	+ --	-	-	-	--	--	--
--	+ 0.50 g	+ --	-	-	-	--	--	--
--	+ 1.00 g	+ --	-	-	-	--	--	--
--	+ --	+ G. m**	37.2	35.3	35.7	31.6	2.6	2.5
--	+ --	+ G.a***	32.5	30.3	30.1	25.3	2.6	2.6
S.S	+ --	+ G.m	40.6	39.6	39.3	35.2	2.7	2.7
S.S	+ --	+ G.a	35.5	32.5	36.2	32.2	12.6	2.7
S.S	+ 0.25g	+ G.m	56.8	55.3	44.1	45.2	3.2	3.3
S.S	+ 0.50 g	+ G.m	53.7	52.3	48.0	49.3	3.3	3.4
S.S.	+ 1.00 g	+ G.m	63.7	60.6	57.9	58.3	3.5	3.6
S.S.	+ 0.25 g	+ G.a	44.1	42.3	42.7	41.3	3.0	3.1
S.S.	+ 0.50 g	+ G.a	46.8	45.1	39.3	39.6	3.0	3.1
S.S.	+ 1.00 g	+ G.a	52.9	50.6	38.2	39.3	3.2	3.3
	L.S.D. at	5%	7.1	7.2	5.1	5.0	N.S	N.S
		1%	9.8	9.9	7.2	7.0	--	--

Where :
* S.S. = Soil sterilization.
** G.m = *Glomus macrocarpum.*
*** G.a. = *Glomus australe.*

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with mycorrhizal fungi, whether the soil was sterilized or not, received any level of rock phosphate fertilization induced statistically similar effect in this respect.

Conclusively, inoculating the sterilized soil with *Glomus macrocarpum* induced high percentage of vesicles and arbuscules on roots of guava seedlings. Such results go in line with the findings of ***Menge et al. (1977)*** with *Glomus macrocarpum, Glomus microcarpum* and *Glomus monosporus* fungi. Besides, ***Gendiah (1987)*** mentioned that inoculating citrus rootstocks (sour organe and Cleopatra mandarin) with *Glomus macrocarpum and Glomus australe* with different levels of phosphorus fertilization increased the formation of vesicles and arbuscules on roots of the inoculated seedlings *Glomus australe* surpassed *Glomus macrocarpum* fungi in exerting the stimulating effect.

4.3. Mango seedlings :

4.3.1. Vegetative growth:

The effect of soil inoculation with mycorrhizal fungi (*Glomus macrocarpum* and *Glomus australe)* and rock phosphate fertilization (0.25, 0.50 and 1.00 g $Ca_3 (PO_4)_2$ / pot) as well as their combination on vegetative growth of mango seedlings during 1994 and 1995 seasons is illustrated in Tables (11 and 12) and Figs (7, 8 and 9).

4.3.1.1. Stem length :

It is clear that in both seasons, all tested treatments significantly increased shoot length as compared with the control (Table, 11) and Figs (7,8 and 9). Moreover, the three levels of rock phosphate induced

Table (11): Effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on vegetative growth of mango seedlings (1994 & 1995 seasons).

Treatment			Stem length (cm)		No. of lateral shoots / plant		Stem diameter (cm)		No. of leaves / plant	
S.S.*	+ $Ca_3(PO_4)_2$	+ VAM	1994	1995	1994	1995	1994	1995	1994	1995
--	Control	+ --	23.5	25.2	2.1	2.0	1.1	1.2	15.7	16.7
--	+ 0.25 g	+ --	35.1	39.3	2.6	2.6	1.3	1.3	22.7	22.9
--	+ 0.50 g	+ --	36.1	40.7	2.7	2.6	1.3	1.3	23.9	23.8
--	+ 1.00 g	+ --	35.5	41.4	2.6	2.5	1.3	1.3	24.2	24.0
--	+ --	+ G. m**	60.8	61.0	2.8	3.7	1.4	1.4	27.3	28.4
--	+ --	+ G.a.***	61.7	59.3	3.7	3.7	1.3	1.4	26.1	26.2
S.S	+ --	+ G.m	62.3	63.5	3.8	3.9	1.4	1.4	29.2	30.0
S.S	+ --	+ G.a	62.5	64.1	3.6	3.7	1.3	1.4	27.1	28.2
S.S	+ 0.25g	+ G.m	68.3	69.0	3.6	3.7	1.5	1.5	41.4	40.9
S.S	+ 0.50 g	+ G.m	68.3	69.2	3.7	3.7	1.5	1.5	42.3	43.4
S.S.	+ 1.00 g	+ G.m	71.2	71.0	3.8	3.8	1.6	1.6	45.6	44.3
S.S.	+ 0.25 g	+ G.a	62.7	63.9	3.8	3.7	1.5	1.5	36.6	37.1
S.S.	+ 0.50 g	+ G.a	62.7	63.8	3.7	3.8	1.5	1.5	36.3	37.7
S.S.	+ 1.00 g	+ G.a	63.8	64.1	3.6	3.7	1.6	1.5	38.2	39.0
	L.S.D. at	5%	3.87	3.99	0.64	0.67	0.15	0.14	4.0	3.8
		1%	5.69	5.56	0.90	0.64	0.21	0.19	5.5	5.7

Where :
* S.S. = Soil sterilization.
** G.m = *Glomus macrocarpum*.
*** G.a. = *Glomus australe*.

(1) Control
(2) 0.25g $Ca_3 (PO_4)_2$ / pot
(3) 0.50g $Ca_3 (PO_4)_2$ / pot
(4) 1.00g $Ca_3 (PO_4)_2$ / pot

Fig.(7): Effect of rock phosphate fertilization on growth of mango seedlings.

(1) Unsterilized soil + G.m.
(2) Unsterilized soil + G.a
(3) Sterilized soil + G.m.
(4) Sterilized soil + G.a

Fig.(8): Effect of soil sterilization and soil inoculation with mycorrhizae fungi on growth of mango seedlings.

(1) Control
(2) S.S. + 0.25 $Ca_3 (PO_4)_2$ + G.m
(3) S.S. + 0.50g $Ca_3 (PO_4)_2$ + G.m
(4)S.S. + 1.00 g $Ca_3 (PO_4)_2$ + G.m
(5) S.S. + 0.25 g $Ca_3 (PO_4)_2$ + G.a
(6) S.S. + 0.50 g $Ca_3 (PO_4)_2$ + G.a
(7) S.S. + 1.00 g $Ca_3 (PO_4)_2$ + G.a

Fig. (9): Effect of rock phosphate fertilization and soil inoculation with mycorrhizae fungi on growth of mango seedlinges

statistically similar and the least stimulating effect as compared with other tested treatments. On the other hand, inoculating unsterilized or sterilized soil with *Glomus macrocarpum* or *Glomus australe* greatly enhanced shoot growth. Anyhow, mycorrhizal species and soil sterilization did not induce a remarkable effect in this concern.

Furthermore, seedlings grown on sterilized soil, fertilized with any level of rock phosphate and inoculated with *Glomus macrocarpum* produced significantly longer shoots as compared with analogous ones received different levels of rock phosphate and inoculated with *Glomus australe* fungi.

4.3.1.2. No. of lateral shoots / plant :

Data in Table (11) reveal that in 1994 and 1995 seasons, all tested treatments, except for the three levels of rock phosphate succeeded in increasing number of lateral shoots / plant. Generally, inoculating the sterilized or unsterilized soil with *Glomus macrocarpum* or *Glomus australe* fungi significantly increased shoot length of mange seedlings. Anyhow, the combinations of soil sterilization and mycorrhizal species did not induce an additional remarkable effect, but exerted statistically similar effect in concern. Moreover, the addition of rock phasphate at different levels to the different combinations failed to increase the stimulating effect of mycorrhizal inoculation in this respect.

4.3.1.3. Stem diameter :

It is quite evident from Table (11) that in both seasons, all studied treatments caused significant increases in stem diameter of mango seedlings. Soil fertilization with the different levels of rock phosphate and soil inoculation with mycorrhizal fungi (*Glomus macrocarpum* or *Glomus australe*) whether the soil was sterilized or not exerted statistically similar stimulating effect in this respect. On the other hand, growing seedlings on sterilized soil, fertilized with different levels of rock phosphate and inoculating the soil with *Glomus macrocarpum* or *Glomus australe* caused high significant increases in stem diameter as compared with the control. However, the differences between the aforementioned combinations were lacking from the statistical standpoint.

4.3.1.4. No of leaves / plant :

Table (4) and Figs (7, 8 and 9) shows that in 1994 and 1995 seasons, rock phosphate fertilization, soil inoculation with mycorrhizal fungi as well as their combinations caused high significant increases in number of leaves per plant as compared with the control. Moreover, inoculating unsterilized or sterilized soil with *Glomus macrocarpum* or *Glomus australe* fungi surpassed rock phosphate treatment in inducing the enhancing leaves development.

Anyhow, the differences were so small to be significant, except for sterilized soil, inoculated with *Glomus macrocarpum* which exerted high significant effect in this respect when compared with low and moderate levels of rock phosphate. On the other hand, the addition of rock phosphate at three levels to inoculated soil with *Glomus macrocarpum* or *Glomus australe* caused high significant increase in number of developed leaves as compared with other tested treatments. Besides, Mycorrhizal inoculation with *Glomus macrocarpum* surpassed *Glomus australe* in enhancing the leaves development, regardless of rock phosphate level. Briefly, seedlings grown on sterilized soil, fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* fungi had the highest number of leaves.

4.3.1.5. Leaf chlorophyll and carotene content:

The effect of soil fertilization with rock phosphate and soil inoculation with mycorrhizal fungi as well as their combinations on leaf content of chlorophyll a & b and carotene of mango seedlings cv EL-Hindi during 1994 and 1995 seasons is reported in Table (12).

Data reported in Table (12) show that in both seasons, rock phosphate treatments failed to affect leaf content of chlorophyll a & b and carotene as compared with the control. On the other hand, inoculating unsterilized or sterilized soil with *Glomus macrocarpum or Glomus australe* fungi enhanced leaf content of chlorophyll a & b and carotene as compared with the control. Furthermore, mycorrhizae species induced statistically similar effect whether the soil was sterilized or not and / or received rock phosphate fertilizer or at any level of rock phosphate except for the seedlings grown on sterilized soil, received high level of rock phosphate and inoculated with *Glomus macrocarpum* fungi which showed the highest value of leaf chlorophyll a & b and carotene.

Briefly, rock phosphate fertilization increased shoot length, stem diameter and number of developed leaves per plant, whereas, number of lateral shoots per plant, and leaf content of chlorophyll a & b and carotene did not respond to rock phosphate fertilization. Moreover, soil sterilization had no additional effect on the studied vegetative growth parameters. Soil inoculation with *Glomus macrocarpum* or *Glomus australe* fungi enhanced the previously mentioned vegetative growth parameters.

Table (12): Effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on leaf content of chlorophyll and carotone of mango seedlings (1994 & 1995 seasons).

Treatment			Chlorophyll "A" mg / 100 g F.W.		Cholorophyll "B" mg / 100 g F.W.		Carotene	
S.S.*	+ $Ca_3[PO_4]_2$	+ VAM	1994	1995	1994	1995	1994	1995
--	Control	+ --	77.53	79.54	77.52	78.11	85.67	86.74
--	+ 0.25 g	+ --	80.42	81.11	80.11	81.05	88.33	88.82
--	+ 0.50 g	+ --	82.92	83.32	81.37	81.73	89.15	94.79
--	+ 1.00 g	+ --	83.39	84.52	80.05	81.73	89.05	90.25
--	+ --	+ G.m**	92.07	93.12	87.13	89.42	97.37	97.18
--	+ --	+ G.a***	90.52	91.62	85.20	87.31	97.25	98.02
S.S	+ --	+ G.m.	93.77	93.40	88.31	88.21	97.13	97.02
S.S	+ --	+ G.a	91.64	92.50	86.12	87.12	96.57	96.92
S.S	+ 0.25 g	+ G.m	105.22	104.98	94.05	90.03	98.91	97.19
S.S	+ 0.50 g	+ G.m	106.05	105.44	95.14	97.05	98.44	98.10
S.S	+ 1.00 g	+ G.m	118.33	116.19	99.74	102.22	110.01	108.24
S.S	+ 0.25 g	+ G.a	102.52	101.790	89.17	91.22	98.12	98.42
S.S	+ 0.50 g	+ G.a	102.67	102.13	90.55	92.19	97.92	98.51
S.S	+ 1.00 g	+ G.a	103.08	102.57	90.73	92.64	98.52	98.57
L.S.D. at 5%			11.36	12.21	5.93	5.82	4.83	4.92
1%			16.17	17.02	8.25	8.11	6.77	6.86

Where :
* S.S. = Soil sterilization.
** G.m = *Glomus macrocarpum.*
*** G.a. = *Glomus australe.*

Anyhow, the addition of rock phosphate fertilization to the inoculated soil increased the stimulating effect of mycorrhizal fungi on vegetative growth. Generally, seedlings grown in sterilized soil fertilized with different level of rock phosphate (particularly, the high level) and inoculatd with *Glomus macrocarpum* fungi were superior in their vegetative growth parameters as compared with the analogous ones inoculated with *Glomus australe.*

These results are in agreement with those mentioned by ***Menge et al. (1982), Graham and Fardelman (1987), Santoso (1989), Cuenca et al. (1990), Gendiah (1991), Helail (1993), Helail and El-Deeb (1993), Helail and Ikram (1993) and Helail and Awad (1993)*** who mentioned that inoculating different fruit plants (citrus and pecan seedlings with mycorrhizal fungi improved most vegetative growth parameters i.e. shoot length, stem diameter, number of lateral shoots per plant, number of leaves per plant and leaf content of chlorophyll a & b and carotene.

4.3.2. Root growth and dry weight :

Table (13) show and Figs (7,8 and 9) the effect of rock phosphate and soil inoculation with *Glomus macrocarpum* or *Glomus australe* fungi as well as their combinations on root growth, dry weight and mycorrhizal dependency ratio of mango seedlings during 1994 and 1995 seasons.

4.3.2.1. Root length :

It is quite clear from Table (13) and Figs (7,8 and 9) that in both seasons, all tested treatments caused high significant increase in root length as compared with the control. Moreover, the three levels of rock phosphate induced statistically similar and the least stimulative effect in this concern. In addition, inoculating unsterilized or sterilized soil with

Glomus macrocarpum or *Glomus australe* fungi greatly enhanced root growth. Both mycorrhizal species induced statistically similar effect. Furthermore, the addition of rock phosphate to the seedlings grown on sterilized soil and inoculated with *Glomus macrocarpum* or *Glomus australe* increased the stimulative effect of mycorrhizal inoculation. Anyhow, seedlings grown on sterilized soil, fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* fungi produced the longest roots. Other combinations induced more or less similar effect in this respect.

4.3.2.2. No of lateral roots / plant :

It is quite evident from Table (13) and Figs. (7, 8 and 9) that in 1994 and 1995 seasons rock phosphate fertilization failed to affect number of lateral roots per plant as compared with the control. Moreover, inoculating sterilized or unsterilized soil with mycorrhizal fungi caused high significant increase in number of lateral roots per plant. Anyhow, mycorrhizal inoculation in sterilized soil exerted more stimulating effect than unsterilized ones regardless of mycorrhizal species. Besides, *Glomus macrocarpum* fungi surpassed *Glomus australe* in enhancing the development of lateral roots. Furthermore, the addition of rock phosphate fertilization to sterilized and mycorrhizal inoculated soil caused high significant increase in number of lateral roots per plant. However, seedlings grown on sterilized soil, fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* fungi produced the highest number of roots. Other combinations of rock phosphate fertilization and mycorrhizal inoculation exerted more or less similar effect in this respect.

Table (13): Effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on root growth, dry weight and mycorrhizal dependency ratio of mango seedlings (1994 & 1995 seasons).

Treatment			Root length (cm)		No. of lateral roots / plant		Shoot dry wt (g).		Root system dry wt (g)		Total dry wt (g)		Top : Root Ratio		Mycorrhizal dependency ratio (MDR)	
S.S.*	+ $Ca_3(PO_4)_2$	+ VAM	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995
--	Control	+ --	50.2	52.7	131.7	133.9	9.8	10.0	10.2	10.0	20.0	20.2	1.05	1.07	--	--
--	+ 0.25 g	+ --	73.8	75.9	135.8	136.1	11.1	11.8	11.0	11.0	23.00	22.8	1.09	1.07	--	--
--	+ 0.50 g	+ --	74.1	73.2	136.0	136.9	12.7	12.5	11.5	11.3	24.2	23.8	1.10	1.10	--	--
--	+ 1.00 g	+ --	74.9	77.2	134.7	137.3	12.9	13.2	11.7	11.5	24.6	25.2	1.10	1.05	--	--
--	+ --	+ G. m**	83.7	85.2	179.9	180.2	15.3	15.0	17.5	17.8	32.8	32.8	1.09	1.06	1.71	1.78
--	+ --	+ G.a***	83.1	84.2	168.4	175.1	17.5	17.2	14.5	15.6	32.0	32.8	1.20	1.10	1.42	1.56
S.S	+ --	+ G.m	84.6	83.7	185.3	184.7	17.5	17.7	17.9	17.8	35.4	35.5	1.15	1.10	1.75	1.78
S.S	+ --	+ G.a	83.9	84.4	182.3	180.5	19.0	18.7	14.5	15.5	33.5	34.2	1.21	1.20	1.42	1.55
S.S	+ 0.25g	+ G.m	97.6	98.7	192.4	191.4	22.7	22.0	16.6	17.6	39.3	39.6	1.16	1.25	1.62	1.76
S.S	+ 0.50 g	+ G.m	99.0	99.3	193.5	193.6	22.4	22.2	16.4	17.4	38.8	39.6	1.26	1.27	1.60	1.74
S.S.	+ 1.00 g	+ G.m	101.2	101.8	201.4	199.7	24.8	24.7	18.4	19.0	43.2	43.7	1.24	1.23	1.80	1.90
S.S.	+ 0.25 g	+ G.a	96.7	96.8	189.9	189.7	22.0	22.2	14.9	15.3	36.9	37.5	1.27	1.25	1.46	1.53
S.S.	+ 0.50 g	+ G.a	98.3	97.7	189.2	190.3	22.5	22.9	15.2	16.2	37.7	39.1	1.28	1.21	1.49	1.62
S.S.	+ 1.00 g	+ G.a	99.8	98.2	191.6	192.7	22.6	22.8	15.7	16.3	38.3	39.1	1.23	1.29	1.53	1.63
	L.S.D. at	5%	6 .1	6.0	4.8	4.9	1.2	1.2	1.6	1.6	5.9	5.2	N.S	N.S		
		1%	8.4	8.4	6.7	6.8	1.7	1.7	2.3	2.3	7.8	7.1	--	--		

Where :
* S.S. = Soil sterilization.
** G.m = *Glomus macrocarpum.*
*** G.a. = *Glomus australe.*

4.3.2.3. Shoot dry weight :

Table (13) shows that in both seasons, rock phosphate fertilization, soil sterilization and soil inoculation with mycorrhizal fungi as well as their combinations caused highly significant increases in shoot dry weight as compared with the control. Besides, the three levels of rock phosphate exerted statistically not only the lowest, but also similar effect in this concern. However, inoculating sterilized soil with *Glomus macrocarpum* or *Glomus australe* induced high effect as compared with the analogous ones grown on unsterilized soil. Generally, seedlings grown in sterilized soil, fertilized with high level of rock phosphate and inoculated with *Glomus macrocarpum* had the heaviest shoot dry weight. Other combinations of rock phosphate and mycorrhizal fungi induced statistically similar effect in this sphere.

4.3.2.4. Root system dry weight :

It is abvious from Table (13) that in 1994 and 1995 seasons rock phosphate fertilization, soil sterilization and mycorrhizal inoculation succeeded in increasing root system dry weight as compared with the control. Anyhow, the three levels of rock phosphate fertilization showed statistically similar and insignificant effect in this concern. Furthermore, mycorrhizal inoculation with *Glomus macrocarpum* or *Glomus australe* induced statistically similar effect whether the soil was sterilized or not. Moreover, the addition of rock phosphate fertilization to the inoculated soil with mycorrhizae fungi increased the root system dry weight. This was more obvious when the soil was inoculated with *Glomus macrocarpum* fungi rather than *Glomus australe* fungi. In other words, seedlings grown on sterilized soil, fertilized with the different levels of rock phosphate fertilization and inoculated with *Glomus macrocarpum* fungi had significantly heavier root system dry weight than the analogous ones inoculated with *Glomus australe* fungi, under the same level of rock phosphate. Briefly, seedlings grown on sterilized soil, fertilized with the high level of rock phosphate (1.00 g / pot) and inoculated with *Glomus macrocarpum* had statistically the highest root system dry weight.

4.3.2.5. Total seedling dry weight :

Table (13) shows that in 1994 and 1995 seasons, all tested treatments except for rock phosphate treatments caused significant increases in total seedling dry weight as compared with the control. Inoculating the soil whether sterilized or not with *Glomus macrocarpum* or *Glomus australe* not only enhanced total seedling dry weight, but also induced statistically similar effect in this sphere. On the other hand, seedlings grown on sterilized soil, fertilized with different levels of rock phosphate and inoculated with *Glomus macrocarpum* or *Glomus australe* had heavier total seedling dry weight. Anyhow, the differences between the different combinations were lacking from the statistical standpoint.

4.3.2.6. Top root ratio :

In both seasons, soil sterilization, rock phosphate fertilization (0.25, 0.50, 1.00 g / pot) and soil inoculation with mycorrhizal fungi (*Glomus macrocarpum* or *Glomus australe* alone or in combination exerted statistically similar effect on top : root ratio as compared with the control.

Generalty, rock phosphate fertilization improved root length, and shoot dry weight, but failed to effect number of lateral roots per seedlings root. System dry weight and total seedling dry weight. Moreover, inoculating the soil with *Glomus macroscarpum* or *Glomus australe* fungi improved the previously mentioned parameters. Anyhow, *Glomus macrocarpum* surpassed *Glomus australe* in this respect. Furthermore, the addition of rock phosphate fertilization to mycorrhizal inoculated seedlings increased the stemulating effect of mycorrhizal fungi particularly the high level of rock phosphate with *Glomus macrocarpum* fungi.

These results confirm those resported by ***Cabodoso et al. (1986), Branzanti and Inuacenti (1987), Lin and Chang (1987) and Santoso (1989)*** Recently, ***Helail and Ikram (1993), Helial et al. (1993), Helail and El-Deeb (1993), Helail and Awad (1993) and Helail (1993)*** who mentioned that inoculating pecan "Le Conte", citrus and avocado seedlings with *Glomus fasciculatus, Glomus calospora Glomus macrocarpum* or *Glomus anstrale* enhanced all root growth and dry weight parameters (root length, number of lateral roots per plant, shoot dry weight root dry weight and total seedlings dry weight.

4.3.3. Mycorrhizal dependency ratio (MDR):

Table (13) shows that in both seasons, seedlings grown on sterilized or unsterilized soil and inoculated with *Glomus macrocarpum* fungi had higher values of mucorrhizal dependency ratio as compared with that of *Glomus australe* inoculated seedlings whether grown on sterilized or unsterilized soil. Moreover, the addition of rock phosphate fertilization to the mycorrhizal inoculated plants caused a remarkable increase in mycorrhizal dependency ratio. However, seedlings grown on sterilized soil, fertilized with different levels of rock phosphate and inoculated with *Glomus macrocarpum* fungi gave higher mycorrhizal dependency ratio as compared with the analogous ones inoculated with *Glomus australe* fungi. In this concern, seedlings grown on sterilized soil, fertilized with high level of rock phosphate (1.00 g / pot) and inoculated with *Glomus macrocarpum* fungi gave higher mycorrhizal dependency ratio 91.80 & 1.9) as compared with the anologous ones inoculated with *Glomus australe* (1.53 & 1.63) in 1994 and 1995 seasons, respectively. Besides, seedlings grown on sterilized soil, fertilized with moderate level of rock phosphate (0.50 g / pot) and inoculated with *Glomus macrocarpum* fungi gave a higher MDR (1.60 & 1.74) as compared with the analogous ones inoculated with *Glomus australe* fungi (1.49 & 1.62) in 1994 and 1995 seasons, respectively.

Furthermore, seedlings grown on sterilized soil, fertilized with low level of rock phosphate (0.25 g /pot) and inoculated with *Glomus macrocarpum* fungi showed low mycorrhizal dependency ratio (1.62 & 1.76) in 1994 and 1995 seasons, respectively. In this respect, ***Helail et al. (1993)*** studied the mycorrhizal dependency ratio of "Le Conte" pear transplants grown in soil inoculated with two species of mycorrhizal fungi. They found that transplants grown on *Glomus macrocarpum* inoculated soil showed (1.59 & 1.48) MDR, while those grown on *Glomus australe* inoculated soil gave (1.44 & 1.41) MDR. Also, ***Helail and El-Deeb (1993)*** mentioned that Rangpur lime seedlings grown in sterilized soil, inoculated with *Glomus macrocarpum* fungi showed (1.66 & 1.65) MDR, while those grown in *Glomus australe* inoculated soil gave (1.47 & 1.50) MDR in both seasons, respectively. In addition, ***Helail and Awad (1993)*** reported that, Citrus volkamerina seedlings grown on *Glomus macrocarpum* inoculated soil showed (1.34 & 1.37) MDR, while those grown on *Glomus australe* inoculated soil gave (1.29 & 1.37) MDR in both seasons, respectively. Furthermore, ***Helail (1993)*** stated that mycorrhizal dependency ratio for avocado seedlings were (2.37 & 2.68) for *Glomus fasciculatus* and (2.51 & 2.61) MDR for *Glomus calospora.*

4.3.4. Leaf mineral content :

The effect of rock phosphate fertilization, and soil inoculation with *Glomus macrocarpum* or *Glomus australe* fungi as well as their combinations on leaf mineral content of mango seedlings cv. El. Hindi during 1994 and 1995 seasons is illustrated in Table (14).

4.3.4.1. Leaf nitrogen content :

It is obvious that in both seasons, the rock phosphate fertilization (0.25, 0.50 and 1.00 g $Ca_3(PO_4)_2$ / pot) and soil inoculation with mycorrhizal fungi (*Glomus macrocarpum* or *Glomus australe*) as well thier combinations, whether the seedlings were grown on unsterilized or sterilized soil failed to affect leaf nitrogen content as compared with the control (Table, 14).

4.3.4.2. Leaf phosphorus content :

In both seasons, all tested treatments significantly increased leaf phosphorus content as compared with the control. Anyhow, the three levels of rock phosphate fertilization induced statistically similar stimulating effect, which was significant at 5% level, only. Moreover, inoculating unsterilized or sterilized soil with *Glomus macrocarpum* or *Glomus australe* exerted similar enhancing effect on leaf phosphorus content. The differences between these combinations were so small to be considered, but significant at 5% level as compared with the control. On the other hand, seedlings grown on sterilized soil, fertilized with different

Table (14): Effect of soil inoculation with mycorrhizal fungi and rock phosphate fertilization on leaf mineral content of mango seedlings (1994 & 1995 seasons).

Treatment S.S* + $Ca_3(PO_4)_2$ + VAM			Nitrogen (%)		Phosphorus (%)		Potassium (%)		Calcium (%)		Magnesium (%)		Zinc (ppm)		Manganese (ppm)		Iron (ppm)		Copper (ppm)	
			1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995
--	Control		1.63	1.65	0.12	0.12	1.09	1.10	3.35	3.36	0.23	0.21	35	36	33	35	71	73	5	5
--	+ 0.25 g	+ --	1.63	1.63	0.15	0.17	1.11	1.22	3.37	3.31	0.25	0.22	36	37	35	38	75	73	5	5
--	+ 0.50 g	+ --	1.65	1.65	0.16	0.17	1.12	1.11	3.30	3.30	0.26	0.25	37	39	34	37	75	74	5	5
--	+ 1.00 g	+ --	1.63	1.68	0.18	0.17	1.15	1.14	3.25	3.38	0.33	0.31	37	39	35	37	75	74	5	5
--	+ --	+ G.m**	1.70	1.72	0.16	0.17	1.34	1.34	3.33	3.39	0.33	0.31	45	44	48	47	87	85	6	6
--	+ --	+ G.a***	1.68	1.70	0.17	0.17	1.43	1.33	3.37	3.37	0.36	0.35	45	45	49	46	88	86	6	6
S.S	+ --	+ G.m.	1.70	1.72	0.17	0.17	1.41	1.41	3.41	3.39	0.36	0.35	48	49	49	47	89	86	6	6
S.S	+ --	+ G.a	1.72	1.75	0.17	0.17	1.42	1.40	3.36	3.39	0.41	0.40	48	50	49	47	88	87	6	6
S.S	+ 0.25 g	+ G.m	1.72	1.77	0.19	0.19	1.66	1.69	3.41	3.37	0.41	0.41	51	50	52	50	90	91	6	6
S.S	+ 0.50 g	+ G.m	1.92	1.93	0.19	0.19	1.70	1.72	3.35	3.41	0.43	0.42	53	52	53	52	99	100	6	6
S.S	+ 1.00 g	+ G.m	1.93	1.95	0.20	0.20	1.72	1.73	3.50	3.41	0.43	0.43	55	56	53	50	88	88	6	6
S.S	+ 0.25 g	+ G.a	1.88	1.90	0.19	0.19	1.66	1.58	3.35	3.44	0.42	0.42	50	51	53	50	89	85	6	6
S.S	+ 0.50 g	+ G.a	1.87	1.86	0.20	0.20	1.65	1.08	3.39	3.39	0.42	0.41	50	50	49	49	90	91	6	6
S.S	+ 1.00 g	+ G.a	1.85	1.87	0.19	0.19	1.66	1.68	3.35	3.38	0.42	0.41	51	51	50	50	89	90	6	6
	L.S.D. at	5%	N.S.	N.S	0.03	0.04	0.08	0.09	N.S	N.S	0.03	0.04	5.66	5.70	3.42	3.45	4.83	4.88	N.S	N.S
		1%	--	--	0.06	0.05	0.11	0.12	--	--	0.04	0.04	7.91	7.95	4.79	4.81	6.71	6.80	--	--

Elements concentration in dried leaves

Where :
* S.S. = Soil sterilization.
** G.m = *Glomus macrocarpum*.
*** G.a. = *Glomus australe*.

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levels of rock phosphate and inoculated with *Glomus macrocarpum* or *Glomus australe* fungi had statistically similar and significantly higher values of leaf phosphorus content.

4.3.4.3. Leaf potassium content :

Table (14) shows that in 1994 and 1995 seasons all tested treatments, except for rock phosphate treatments caused high significant increase in leaf potassium content as compared with the control. Moreover, soil sterilization had no significant effect on leaf potassium content, since seedlings grown on unsterilized or sterilized soil and inoculated with *Glomus macrocarpum* or *Glomus australe* fungi had statistically similar values of leaf potassium content. In addution, seedlings grown on sterilized soil, fertilized with any level of rock phosphate and inoculated with *Glomus macrocarpum* or *Glomus australe* produced leaves, similar and higher in their potassium content.

4.3.4.4. Leaf calcium content :

It is obvious from Table (14) that in both seasons, the three levels of rock phosphate fertilization (0.25, 0.50 and 1.00g $Ca_3(PO_4)_2$/pot) and soil inoculation with *Glomus macrocarpum* or *Glomus australe* fungi as well as their combinations failed to affect leaf calcium content as compared with the control.

4.3.4.5. Leaf magnesium content :

It is clear that in 1994 and 1995 seasons rock phosphate fertilization at the three levels i.e. 0.25, 0.50 or 1.00 $Ca_3(PO_4)_2$ / pot failed to affect leaf magnesium content as compared with the control. On the other hand, soil inoculation with *Glomus macrocarpum* or *Glomus australe* fungi caused high significant increase in leaf magnesium content, whether the inoculation was conducted on unsterilized or sterilized soil. The differences between the two mycorrhizal fungi were insignificant. Furthermore, the addition of rock phosphate to the seedlings grown on sterilized soil and inoculated with *Glomus macrocarpum* or *Glomus australe* fungi enriched leaf magnesium content. However, the differences between these combinations were so small to reach the significant level.

4.3.4.6. Leaf zinc content :

In both seasons, all tested treatments except for the different levels of rock phosphate succeeded in enriching leaf zinc content as compared with the control (Table, 14). Moreover, soil inoculation with *Glomus macrocarpum* or *Glomus australe* fungi caused high significant increase in leaf zinc content, regardless of soil sterilization. On the other hand, seedlings grown on sterilized soil, fertilized with different levels of rock phosphate and incoulated with *Glomus macrocarpum* or *Glomus australe* fungi had statistically similar and higher values of leaf zinc content.

4.3.4.7. Leaf manganese content:

Table (14) shows that in 1994 and 1995 seasons rock phosphate treatments failed to affect leaf manganese content as compared with the control. On the other hand, seedlings grown on unsterilized or sterilized soil and inoculated with *Glomus macrocarpum* or *Glomus australe* fungi had significantly higher leaf manganese content. Soil sterilization did not show an additional effect in this respect. Moreover, the addition of rock phosphate to the seedlings grown on sterilized soil, inoculated with *Glomus macrocarpum* or *Glomus australe* fungi caused high significant increases in leaf manganese content. Anyhow, the differences between these combinations were so small to reach the significant level.

4.3.4.8. Leaf iron content :

It is clear that in both seasons, all tested treatments, except for rock phosphate treatments succeeded in increasing leaf iron content as compared with the control (Table, 14). Moreover, inoculating unsterilized or sterilized soil with *Glomus macrocarpum* or *Glomus australe* fungi and / or the addition of rock phosphate at different levels caused high significant increase in leaf iron content. Anyhow, the differences between the different combinations were so small to be considered.

4.3.4.9. Leaf copper conent :

Table (14) reveals that in both seasons rock phosphate treatments failed to affect leaf copper content as compared with the control. On the other hand, soil inoculation with mycorrhizal fungi, supplemented or not with rock phosphate fertilization caused significant increase in leaf copper content at 5% level only. Anyhow, soil sterilization, mycorrhizal species and rock phosphate level did not show an additional effect in this respect.

Conclusively, rock phosphate fertilization improved only leaf phosphorus content and failed to effect leaf content of nitrogen, potassium, calsium, magnesium, Zinc, iron, manganese, and Copper. On the other hand, inoculating unsterilized soil with *Glomus macrocarpum* or *Glomus australe* fungi enhanced leaf content of the previously mentioned minerals except for nitrogen and calcium. Besides, Both mycorrhizal species induced similar effect in this respect. Furthermore, the addition of rock phosphate fertilization to mycorrhizal inoculated soil enhanced the stimulative effect of mycorrhizal species on leaf mineral content. These results are coincided with those reported earliar by ***Menge et al. (1980), Menge et al. (1982), Cuenca et al. (1990), Jaizme and Azcon (1991), Vidal et al. (1992) and Haugen and Smith (1993), Helail (1993), Helail and Awad (1993) and Helail et al. (1993).*** Furthermore ***Helail and El-Deeb (1993)*** mentioned that leaf content of phosphorus iron and zinc of Rangpur lime were improved due to mycorrhizal inoculation. *Glomus macrocarpum* fungi exerted more stimulus effect than Glomus australe fungi.

4.3.5. Mycorrhizal infection percent :

Table (15) shows the effect of endomycorrhizal fungi inoculation and phosphorus fertilization on infection percent of mango seedlings during (1994) and (1995) seasons.

Tabulated data show that in both seasons vesicles (small spores) and arbuscules (big spores) formation increased wtih mycorrhizal inoculation. Anyhow, vesicles, arbuscules and mycelia formation on roots of control plants, whether fertilized or not were nill. On the other hand, vesicles and arbuscules formation on roots of *Glomus macrocarpum* - inoculated seedlings were higher as compared with the analogous ones inoculated with *Glomus australe*, whether seedlings were grown on sterilized or unsterilized soil. Besides, the stimulating effect of mycorrhizae fungi on vesicles or arbuscules formation was increased when the mycorrhizal inoculated seedlings were fertilized with rock phosphate. Generally, *Glomus macrocarpum* inoculated seedlings, fertilized with different levels of rock phosphate had higher percent of vesicles and

Table (15): Effect of soil inoculation with mycorrhizal fungi and rock phosphorus fertilization on infection percent of "mango" roots (1994 & 1995 seasons).

Treatment			Infection percent					
			Vesicular		Arabuscular		Mycelia	
S.S.*	+ $Ca_3(PO_4)_2$	+ VAM	1994	1995	1994	1995	1994	1995
--	Control	+ --	--	--	--	--	--	--
--	+ 0.25 g	+ --	--	--	--	--	--	--
--	+ 0.50 g	+ --	--	--	--	--	--	--
--	+ 1.00 g	+ --	--	--	--	--	--	--
--	+ --	+ G. m**	35.2	33.0	30.9	35.3	2.4	2.5
--	+ --	+ G.a***	33.7	30.3	27.3	31.3	2.4	2.6
S.S	+ --	+ G.m	42.9	44.2	40.9	41.3	2.4	2.5
S.S	+ --	+ G.a	43.8	40.5	31.3	33.6	2.5	2.6
S.S	+ 0.25g	+ G.m	77.8	76.6	49.3	45.6	2.6	2.6
S.S	+ 0.50 g	+ G.m	81.6	80.6	60.6	49.3	2.5	2.5
S.S.	+ 1.00 g	+ G.m	89.0	87.6	72.5	61.6	3.4	3.5
S.S.	+ 0.25 g	+ G.a	73.3	73.6	42.1	43.33	2.3	2.4
S.S.	+ 0.50 g	+ G.a	72.3	71.3	52.3	50.3	2.6	2.6
S.S.	+ 1.00 g	+ G.a	77.8	74.6	55.8	59.3	3.4	3.5
	L.S.D. at	5%	3.1	2.9	3.8	5.0	N.S	N.S
		1%	4.2	4.0	5.4	7.0	--	--

Where :
* S.S. = Soil sterilization.
** G.m = *Glomus macrocarpum.*
*** G.a. = *Glomus australe.*

arbuscules on their roots than the nalogous ones inoculated with *Glomus australe* fungi, regardless of rock phosphate level.

As for the effect of mycorrhizal inoculation and rock phosphate fertilization on mycelia formation, Table (15) shows that inoculating unsterilized or sterilized soil whether fertilized with different levels of rock phosphate resulted in similar percent of mycelia infection mango on roots from the statistical standpoint.

Briefly, inoculating the sterilized soil with *Glomus macrocarpum* developed high percentages of vesicles and arbuscules on roots of mange seedlings. Similar results were reported earlier by ***Menge et al. (1977)*** with *Glomus macrocarpum* and *Glomus monosporus* fungi. Also, ***Gendiah (1987)*** mentioned that inoculating citrus rootstocks (sour orange and Cleopatra mandarin) with *Glomus macrocarpum* and *Glomus australe* with different levels of phosphorus fertilization increased the formation of vesicles and arbuscules on roots of the inoculated seedlings. *Glomus australe* surpassed *Glomus macrocarpum* fungi in exerting the stimulating effect.