RESULTS AND DISCUSSION

Table (3-a): Effect of endomycorrhizal fungi inoculation and phosphorus fertilization on infection percent of citrus roots.

Treatments			Infection percent																											
			May									July									September								
			Mycelia			Vesicles			Arbuscules			Mycelia			Vesicles			Arbuscules			Mycelia			Vesicles			Arbuscules		
Rootstock	Mycorrhizae	Phosphorus	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
Cleopatra mandarin	Control	No P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Control	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	G.m.	No P	0.0	10	5	100	100	100	0.0	20	10	10	50	30	100	100	100	40	63.3	51.65	100	100	100	100	100	100	100	100	100
	G.m.	P	16.7	20	18.35	100	100	100	10	10	10	36.7	40	38.35	100	100	100	40	40	40	90	100	100	100	100	100	100	100	100
	G.a.	No P	20	20	20	100	100	100	70	70	70	70	80	75	100	100	100	80	80	80	100	100	100	100	100	100	100	100	100
	G.a.	P	0.0	20	10	100	100	100	30	40	35	20	30	25	100	100	100	50	60	55	100	100	100	100	100	100	100	100	100
Sour orange	Control	No P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Control	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	G.m.	No P	20	20	20	100	100	100	33.3	40	36.65	70	90	80	100	100	100	93.3	90	91.65	100	100	100	100	100	100	100	100	100
	G.m.	P	16.7	20	18.35	100	100	100	29.3	40	34.65	60	60	60	100	100	100	70	70	70	100	100	100	100	100	100	100	100	100
	G.a.	No P	30	20	25	100	100	100	43.3	40	41.65	30	70	50	100	100	100	60	70	65	100	100	100	100	100	100	100	100	100
	G.a.	P	0.0	10	5	100	100	100	40	50	45	66.7	70	68.35	100	100	100	86.7	90	88.35	100	100	100	100	100	100	100	100	100

Control = No inoculation with mycorrhizae.
G.m. = Glomus macrocarpus.
G.a. = Glomus australe.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.

on wheat plants with Endogone mycorrhizae and phosphorus and nitrogen fertilization, and Gerdemann (1974) on Eriacese endonycorrhizal fungi.

Furthermore, data of all sampling dates disclosed that plants inoculated with Glomus australe developed higher percentages of mycelia than that of Glomus macrocarpus. This result agrees with that reported by Menge et al., (1981) on citrus with Glomus macrocarpus, Glomus microcarpus and Glomus monosporus fungi.

Concerning vesicles formation (small spores) data tabulated in Table (3-a) indicated that in both rootstocks and seasons, vesicle percentages were the highest (100%) in all treatments of all sampling dates. In addition, control plants did not produce any vesicles on their roots. Since these plants were void from mycorrhizae.

Referring to arbuscules formation (big spores), it is found that in both rootstocks and seasons arbuscules were initiated with low percentages in May and increased in July to reach the maximum (100%) in September. This was true in all treatments used in this study. This is in conjunction with findings of Burgeff (1961) who found that the infection of mycorrhizae was increased during the growing season.

Considering the effect of mycorrhizae, data clearly showed that in May, for both rootstocks and seasons, inoculated and unfertilized plants were generally higher in percentages of arbuscules as compared to inoculated and fertilized ones. In July, the same trend of May was observed. However, sour orange seedlings inoculated with *Glomus australe* and either fertilized or unfertilized took the other way around. Beside, control plants of both rootstocks did not produce any arbuscules on their roots since these plants were free from mycorrhizae.

Moreover, data of sampling dates indicated that *Glomus australe* fungi were generally more promising in its increment of arbuscules percentages than *Glomus macrocarpus* mycorrhizae fungi. Similar results were found by Menge *et al.*, (1981) on citrus with *Glomus macrocarpus*, *Glomus microcarpus*, and *Glomus monosporus* fungi.

4.1.b. **Intensity :**

Table (3-b) shows the intensity of infection of citrus roots as affected by endomycorrhizal fungi inoculation and phosphorus fertilization. It is quite evident that intensity expressed as number of mycelia , vesicles, and arbuscules were initiated with lower number on roots in May followed by an increase in July and with a sudden increase in September. This was true in all treatments of both rootstocks used. Meanwhile, in May and July, number of mycelium on roots of inoculated and unfertilized plants were generally higher in respect of inoculated and fertilized ones of both rootstocks. Nevertheless, in September values of different treatments were more or less similar. On the other hand, control plants did not develop any number of mycelia on their roots in all sampling dates. Similar results were observed by Burgeff (1961) who found that the intensity of mycorrhizae/was increased during the growing season. Moreover, Hayman (1970) reached the same findings on wheat plants with Endegone mycorrhizae and fertilized with nitrogen and phosphorus.

Referring to number of vesicles and arbuscules on roots of both rootstocks of citrus in all sampling dates, it is obvious that inoculated and unfertilized

Table (3-b): The intensity of infection of citrus roots as affected by endomycorrhizal fungi inoculation and phosphorus fertilization.

Treatments			Intensity *																										
			May									July									September								
			Mycelia			Vesicles			Arbuscules			Mycelia			Vesicles			Arbuscules			Mycelia			Vesicles			Arbuscules		
Rootstock	Mycorrhizae	Phosphorus	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
Cleopatra mandarin	Control	No P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Control	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	010	0.0	0.0	0.0	010	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	G.m.	No P	0.0	0.1	0.05	6.3	7.2	6.75	0.0	0.2	0.1	0.1	0.5	0.3	7.2	9.0	8.1	0.8	1.4	1.1	1.0	1.0	1.0	13.5	16.0	14.75	5.7	5.3	5.5
	G.m.	P	0.1	0.2	0.15	4.7	5.4	5.05	0.1	0.1	0.1	0.4	0.4	0.4	5.9	7.5	6.7	0.6	0.9	0.75	0.9	1.0	0.95	7.8	11.8	9.8	6.1	7.4	6.75
	G.a.	No P	0.2	0.2	0.2	6.9	6.9	6.9	1.3	1.3	1.3	0.7	0.8	0.75	16.1	14.8	15.45	3.7	3.0	3.35	1.0	1.0	1.0	14.4	15.2	14.8	6.1	7.4	6.75
	G.a.	P	0.0	0.2	0.1	3.1	8.4	5.75	0.7	1.4	1.05	0.2	0.3	0.25	9.2	9.1	9.15	1.2	1.3	1.25	1.0	1.0	1.0	15.5	16.5	16.0	6.7	7.0	6.85
Sour orange	Control	No P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Control	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	G.m.	No P	0.2	0.2	0.2	8.4	8.5	8.45	0.8	0.8	0.8	0.7	0.9	0.8	15.5	18.1	16.8	3.5	3.2	3.35	1.0	1.0	1.0	29.8	28.7	29.25	13.4	12.4	12.9
	G.m.	P	0.2	0.2	0.2	6.7	7.5	7.1	0.6	0.6	0.6	0.6	0.6	0.6	11.4	11.6	11.5	1.7	1.7	1.7	1.0	1.0	1.0	21.7	22.0	21.85	9.8	9.6	9.7
	G.a.	No P	0.3	0.2	0.25	7.1	7.0	7.05	1.0	0.9	0.95	0.3	0.7	0.5	6.7	10.4	8.55	1.3	1.6	1.45	1.0	1.0	1.0	28.4	27.9	28.15	12.9	13.1	13.0
	G.a.	P	0.0	0.1	0.05	5.1	5.3	5.2	0.9	0.9	0.9	0.7	0.7	0.7	12.4	12.7	12.55	2.9	2.7	2.8	1.0	1.0	1.0	23.2	23.4	23.3	11.5	12.0	11.75

* Number of mycelium or spores inside 1cm. root.

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization
P = Phosphorus applied as superphosphate.

plants generally surpassed in their values the corresponding ones of inoculated and fertilized ones. This was true in both rootstocks. Such results are in close confirmity with those obtained by Hayman (1970) on wheat plants with *Endogone* mycorrhizae, Balyis (1971) on Leptospermum plants with *Endogone* mycorrhizae, Tucker and Anderson (1972) on citrus seedlings with mycorrhizae, and Daft and Nicolson (1972) on maize plants with *Endogone* mycorrhizae.

Concerning mycorrhizae species used in this study, it is found that in Cleopatra mandarin, number of mycelia on roots of inoculated plants with *Glomus australe* sampled in May and July was higher as compared with the analogous ones inoculated with *Glomus macrocarpus*. The picture was changed to the reverse when sour orange seedlings were put in consideration.

Concerning number of vesicles, it is well noticed that citrus seedlings inoculated with mycorrhizae and unfertilized were higher in their values than the corresponding ones of inoculated and fertilized plants in all sampling dates. Moreover, mycorrhizae species varied in their effect on number of vesicles according to citrus rootstock. In this concern, in all sampling dates, Cleopatra mandarin seedlings inoculated with Glomus australe were superior in their values as compared to the corresponding ones of those treated with Glomus macrocarpus fungi. The reverse was true when sour orange seedlings were concerned. Such results are in agreement with these of Hayman (1970) on wheat plants with Endogone mycorrhizae, Balyis (1971) on Leptospermum with Endogone mycorrhizae, Tucker and Anderson (1972) on citrus seedlings with mycorrhizae, and Menge et al., (1981) on citrus with Glomus macrocarpus, Glomus microcarpus, and Glomus monosporus fungi.

As for number of arbuscules on roots of citrus seedlings, it is worthy to notice that in both rootstocks used in this study, seedlings inoculated with mycorrhizae and unfertilized had generally higher number of arbuscules on their roots than the analogous plants inoculated and fertilized. Such result was clearly noticed in all sampling dates. Similar results were previously found by Balyis (1971), Tucker and Anderson (1972), and Menge et al., (1981).

Concerning mycorrhizae species effects on number of arbuscules on roots, data obviously showed that in all sampling dates citrus seedlings treated with *Glomus australe* fungi were mostly superior in their values than those of *Glomus macrocarpus* mycorrhizae.

4.2. Mycorrhizal dependency ratio (MDR):

Mycorrhizal dependency ratio of two citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization is presented in Table (4-a). It is clear that in both rootstocks used in this study, plants inoculated with the two species of mycorrhizae and unfertilized with phosphorus had higher values of MDR than the corresponding ones of inoculated seedlings and fertilized with phosphorus. The difference, however, was highly significant. This tendency is in close agreement with the findings of Schenck and Tucker (1974) on sour orange, Cleopatra mandarin, Alemow and rough lemon seedling rootstocks with endomycorrhizae, and Mehraveran (1977) on the mycorrhizal dependency of Keen and Brazilian sour orange, rough lemon and Alemow, and Carrizo citrange seedlings with different P levels and mycorrhizae. Also, Menge *et al.*, (1977)

Table(4): a. Mycorrhizal dependency ratio (MDR) of twocitrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization.
b. Specific effect of rootstock, mycorrhizal fungi, and phosphorus level on mycorrhizal dependency ratio(MDR).
c. The interaction between rootstock, mycorrhizal fungi, and phosphorus level on mycorrhizal dependency ratio (MDR).

(a)

Rootstock	Mycorrhizae	Phosphorus	MDR 85	MDR 86	MDR Mean
Cleopatra mandarin.	Control	No P	0.0f	0.0g	0.0e
	Control	P	0.0f	0.0g	0.0e
	G.m.	No P	4.63a	4.01b	4.32a
	G.m.	P	2.01e	2.79c	2.40d
	G.a.	No P	3.36c	2.31e	3.34b
	G.a.	P	2.21e	2.59d	2.41d
Sour orange	Control	No P	0.0f	0.0g	0.0e
	Control	P	0.0f	0.0g	0.0e
	G.m.	No P	4.18b	4.66a	4.42a
	G.m.	P	2.12e	2.53d	2.33d
	G.a.	No P	3.46c	2.68cd	3.07c
	G.a.	P	2.91d	1.74f	2.32d

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

(b)

Treatments	MDR 85	MDR 86	MDR Mean
1. Rootstock			
C.m.	2.11 a	2.12 a	2.08 a
S.o.	2.11 a	1.94 b	2.03 a
2. Mycorrhizae			
Control	0.0 c	0.0 c	0.0 c
G.m.	3.24 a	3.50 a	3.37 a
G.a.	2.99 b	2.58 b	2.79 b
3. Phosphorus			
No P	2.61 a	2.45 a	2.53 a
P	1.54 b	1.61 b	1.58 b

C.m. = Cleopatra mandarin.
S.o. = Sour orange.

(c)

Treatments	85		86		Mean	
1. Rootstock x Mycorrhizae						
Rootstock / Mycorrhizae	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.
Control	0.0c	0.0c	0.0d	0.0d	0.0e	0.0e
G.m.	3.32a	3.15a	3.04b	3.60a	3.18b	3.38a
G.a.	2.79b	3.19a	2.95b	2.21c	2.67c	2.70d
2. Rootstock x phosphorus						
Rootstock / Phosphorus	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.
No P	2.66a	2.55a	2.44a	2.45a	2.55a	2.50a
P	1.41c	1.68b	1.79b	1.42a	1.60b	1.55b
3. Mycorrhizae x phosphorus						
Phosphorus / Mycorrhizae	No P	P	No P	P	No P	P
Control	0.0e	0.0e	0.0e	0.0e	0.0d	0.0d
G.m.	4.41a	2.06d	4.34a	2.66c	4.38a	2.36c
G.a.	3.41b	2.51c	3.00b	2.17d	3.21b	2.34c

No P = No phosphorus fertilization.
P = phosphorus applied as superphosphate.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

found similar results on Brazilian sour orange, rough lemon, Alemow, Trifoliate orange, Bassie sweet orange, and Troyer citrange with mycorrhizae and phosphorus fertilization.

Generally, Cleopatra mandarin rootstock depends on mycorrhizae more than sour orange, hence the values of MDR of Cleopatra mandarin were higher than sour orange. As expected, control plants (non inoculated with mycorrhizae) showed no MDR. Such findings go in line with those obtained by Kleinschmidt and Gerdemann (1972) on rough lemon, Cleopatra mandarin, Troyer citrange, and keen sour orange with vesicular arbuscular mycorrhizae, Tucker and Anderson (1972) on Cleopatra mandarin, sour orange, Carrizo citrange, and rough lemon with vesicular arbuscular mycorrhizae, and Mosse (1973) on flowering plants with endomycorrhizae. Beside, the same trends were reported by Schenck and Tucker (1974) on rough lemon, sour orange, and Cleopatra mandarin rootstocks with endomycorrhizae, and Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin with *Glomus fasciculatus* fungi.

Specific effect :

Concerning the specific effect of citrus species, it is quite evident from Table (4-b) that altough Cleopatra mandarin seedlings gave slightly higher values of MDR than sour orange, differences, however, were generally insignificant.

As mycorrhizae effect was concerned, it is well noticed that in both seasons Glomus macrocarpus was more promising in increasing MDR than Glomus australe. The difference was so high to reach the significant level. Similar results were found by Nemec (1978) on sour orange, Cleopatra mandarin, sweet orange, rough lemon, Rangpur lime, andCarrizo citrange seedling rootstocks with Glomus etunicates, Glomus mosseae, and Glomus fasciculatus fungi.

Considering phosphorus level, it is worthy to notice that in both seasons applying phosphorus to seedlings caused a significant decrease in MDR as compared to unfertilized ones.

The interaction :

As regard to the interaction between rootstocks and mycorrhizae, it is clear from Table (4-c) that Glomus macrocarpus fungi with Cleopatra mandarin and sour orange seedlings had higher values of MDR than the analogous ones of Glomus australe mycorrhizae.

Concerning the interaction between rootstock and phosphorus level, it is quite evident that in both seasons and rootstocks, the fertilized plants had a lower MDR as compared with unfertilized plants.

Moreover, the interaction between mycorrhizae and phosphorus as indicated in Table (4-c) shows that phosphorus fertilization to seedlings inoculated with any one of the two mycorrhizal fungi caused a significant decrease in MDR as compared to unfertilized plants. Similar results were reported by Menge et al., (1977) on Brazilian sour orange, rough lemon, Alemow, Trifoliate orange, Bassie sweet orange and Troyer citrange with endomycorrhizae.

4.3. Dry weight :

Dry weight of different parts of both sour orange and Cleopatra mandarin seedlings and top/root ratio before transplanting are shown in Table (5-a). It is obvious that in both seasons dry weights of whole seedling, leaves, stem, and roots of sour orange were higher than those of Cleopatra mandarin. The opposite was true for top/root ratio hence Cleopatra mandarin had higher values in this respect than sour orange.

As regard to dry weight of different parts of the two citrus seedling rootstocks as well as top/

Table (5-a) : Dry weight of different parts of citrus seedlings and top/root ratio before transplanting.

Rootstock	Whole seedling		Leaves		Stem		Roots		Top/Root ratio	
	85	86	85	86	85	86	85	86	85	86
Cleopatra mandarin	1.83	1.80	0.63	0.65	0.57	0.54	0.63	0.61	1.90	1.95
Sour orange	3.82	3.72	1.38	1.33	0.73	0.70	1.71	1.69	1.23	1.20

Table (5-b): Dry weight of different parts of two citrus seedling rootstocks as well as top/root ratio as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization.

Treatments			Dry matter (g.) per plant														
			Whole seedling			Leaves			Stem			Roots			Top/Root ratio		
Rootstock	Mycorrhizae	Phosphorus	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
Cleopatra mandarin	Control	No P	4.65k	3.25h	3.95h	2.10g	1.76h	1.93g	0.94g	0.65g	0.80g	1.61f	0.85f	1.23f	1.90c	2.62de	2.27f
	Control	P	7.42h	4.05gh	5.74h	3.42fg	2.06h	2.74fg	1.61f	1.02fg	1.31f	2.40e	0.98f	1.69f	2.11c	2.69de	2.41ef
	G.m.	No P	19.63c	13.19cde	16.41c	9.94d	5.79ef	7.87c	3.74c	3.47c	3.61cd	5.95a	3.92b	4.94b	2.26c	2.37ef	2.32f
	G.m.	P	15.43d	12.29de	13.87d	7.69e	6.43ef	7.06cd	3.07d	2.30e	2.69e	4.68c	3.56cd	4.12c	2.33c	2.85d	2.59def
	G.a.	No P	12.74ef	11.30e	12.02e	7.78e	6.94de	7.22cd	2.41e	2.34e	2.38e	2.85de	2.01e	2.43e	5.59b	4.31b	3.96b
	G.a.	P	14.18de	12.17e	13.18de	7.30e	5.43ef	6.37de	3.31cd	3.07cd	3.20d	3.56d	3.67bc	3.62d	3.30b	2.87d	3.09cde
Sour orange	Control	No P	9.09gh	6.38fg	7.74g	4.32f	3.37g	3.85f	1.77f	1.03fg	1.40f	3.00de	1.98e	2.49e	2.04c	2.20f	2.12f
	Control	P	10.46fg	8.8f	9.63f	5.26f	5.09fg	5.18e	1.91ef	1.37f	1.64f	3.29d	2.33d	2.82e	2.17c	2.82d	2.50ef
	G.m.	No P	33.26a	32.59a	32.93a	21.03a	22.26a	21.65a	6.55a	6.38a	6.47a	5.68a	3.94b	4.81b	4.79a	7.04a	5.92a
	G.m.	P	20.78c	22.54b	21.66b	11.96c	12.20b	12.08b	3.17d	4.60b	3.89c	5.65ab	5.74a	5.70a	3.20b	3.65c	3.43bc
	G.a.	No P	26.69b	15.07c	20.88b	15.87b	8.83c	12.35b	5.86b	2.74de	4.31b	4.96bc	3.50cd	4.23c	4.62a	3.41 c	4.02b
	G.a.	P	27.56b	14.63cd	21.10b	15.51b	8.06cd	11.79b	5.78b	2.85d	4.31b	6.28a	3.72bc	5.00b	3.53b	2.94d	3.24cd

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

root ratio as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization, it is clear from Table (5-b) and Figs.(1, 2 and 3) that in both rootstocks, fertilized plants with phosphorus had higher dry weight values of whole seedling, leaves, stem, roots, and top/root ratio than those of unfertilized seedlings (control). Moreover, mycorrhizal plants of both rootstocks had higher values of dry weights of whole plant, leaves, stem, and roots and top/root ratio than those of non-inoculated plants. However, sour orange plants were the highest in this respect. These results coincided with the findings of Peuss(1958) on Tobacco plants with vesicular arbuscular mycorrhizae, Maronek *et al*., (1981) on horticultural plants with vesicular arbuscular mycorrhizae, and Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin seedlings with *Glomus fasciculatus* fungi.

Meanwhile, both rootstock seedlings inoculated with *Glomus macrocarpus* fungi developed higher amounts of dry weight of whole seedling, leaves, stem, and roots than the analogous ones of *Glomus australe*. Similar results were revealed by Menge and Zentmyer (1977) on avocado seedlings with *Glomus*

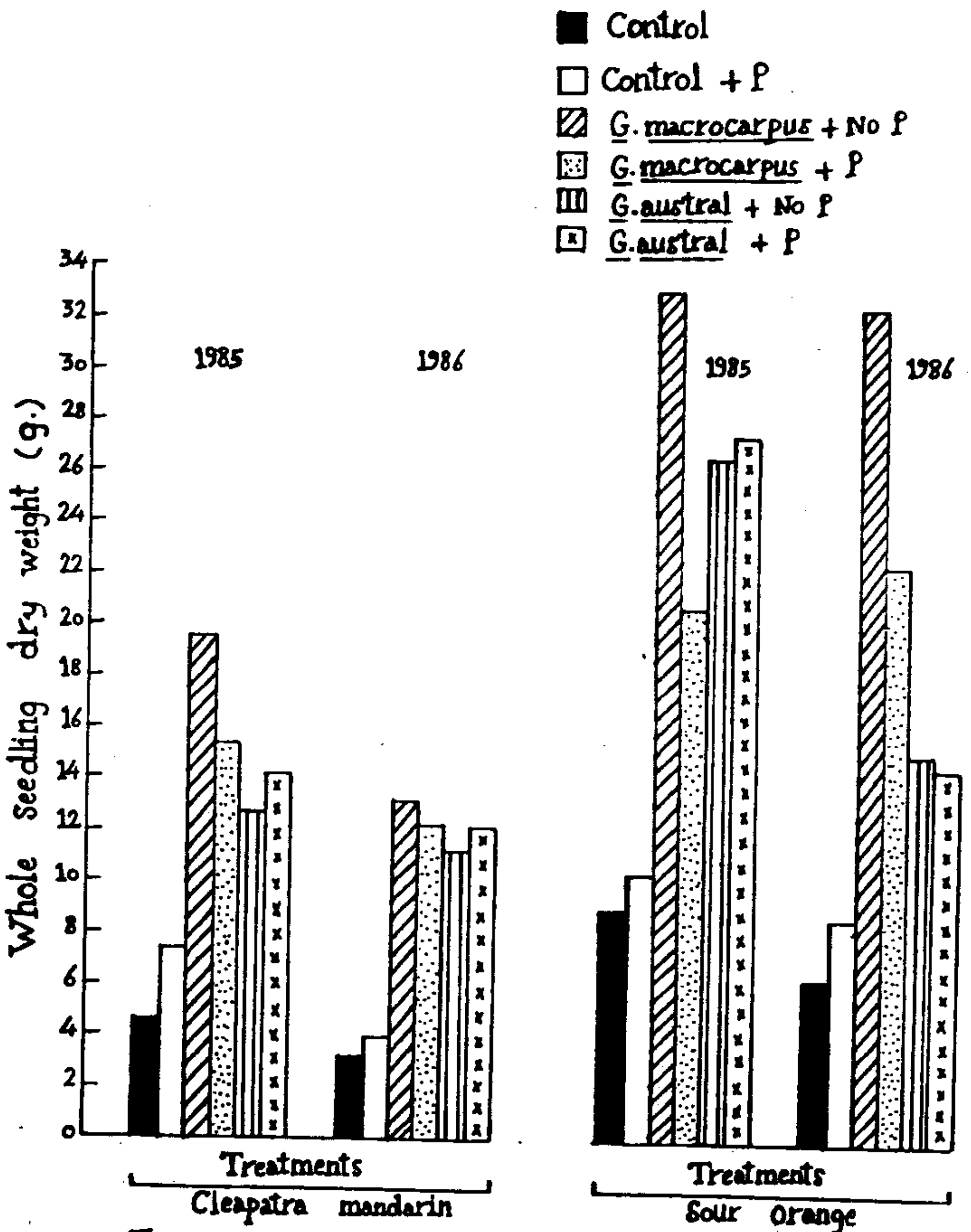


Fig (1) Effect of rootstock, mycorrhizal fungi and phosphorus level on citrus seedlings dry weight.

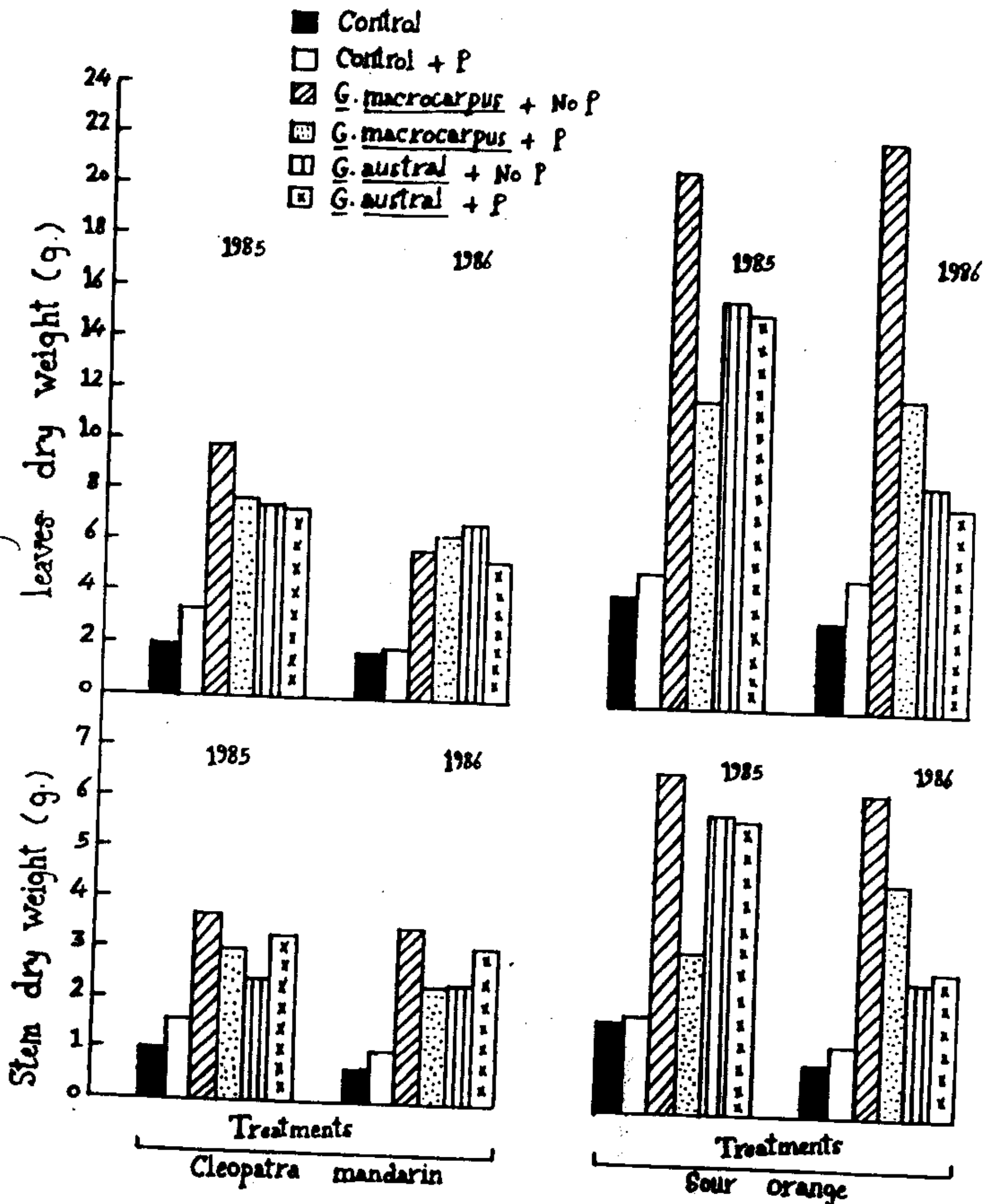


Fig (2) Effect of rootstock, mycorrhizal fungi and phosphorus level on leaves and stem dry weights of citrus seedlings.

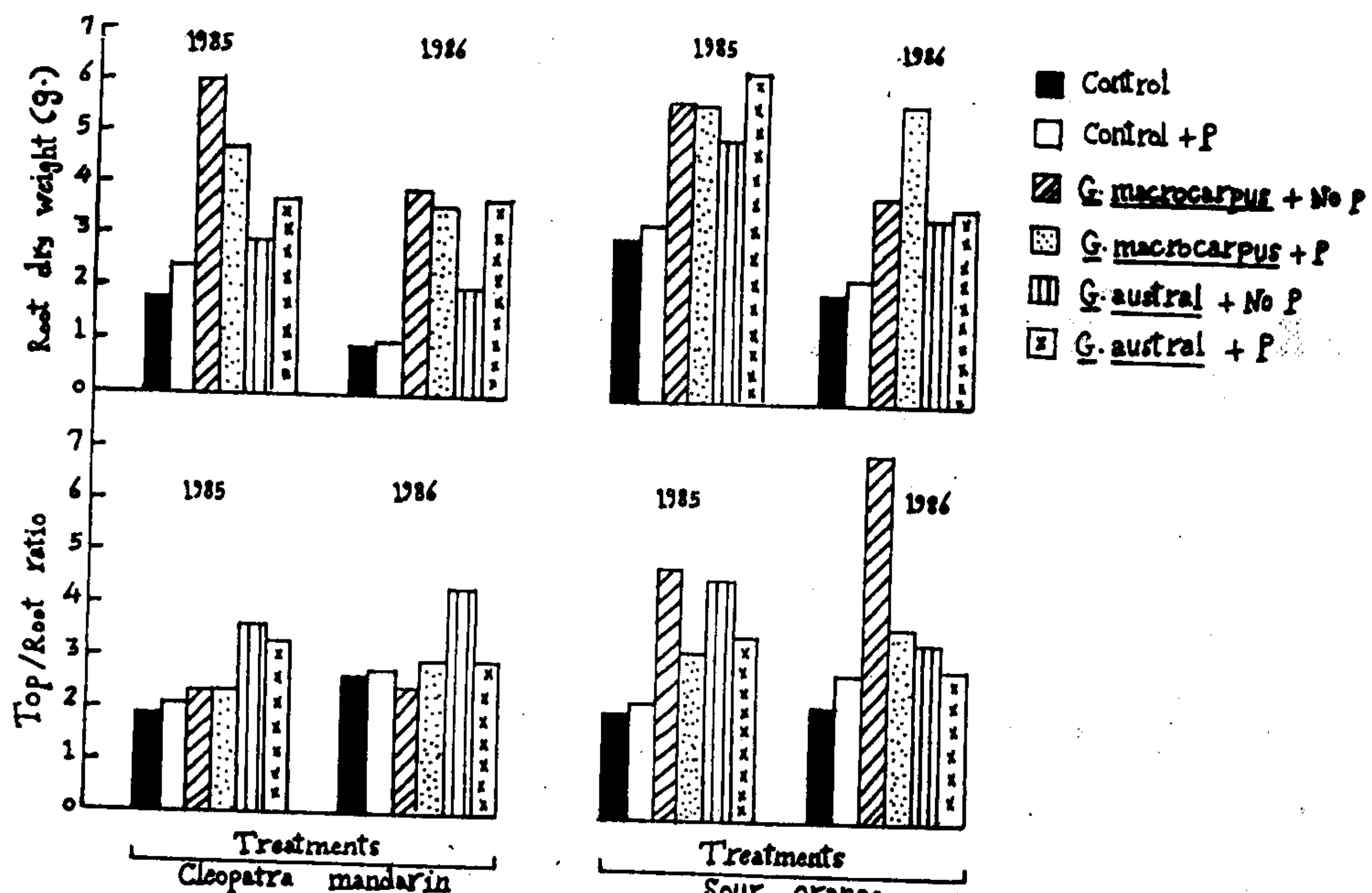


Fig (3) Effect of rootstock, mycorrhizal fungi and phosphorus level on root dry weight and top/root ratio of Citrus seedlings.

fasciculatus and *Glomus calospora* fungi, and Edrees (1982) on Cleopatra mandarin seedlings with *Glomus fasciculatus*, *Glomus mosseae*, and *Glomus macrocarpus* fungi.

Comparing inoculated seedlings with the two mycorrhizae fungi and unfertilized with those of unfertilized ones (control), it is quite evident that mycorrhizae fungi increased profoundly dry weights of whole plant, leaves, stem and roots than the corresponding ones of non-inoculated plants. The same effect was noticed when plants were fertilized and inoculated with either *Glomus macrocarpus* or *Glomus australe* fungi in respect of fertilized plants. Such results are in agreement with these of Hattingh and Gerdemann (1975) on citrus seedlings with *Endogone* mycorrhizae, Menge *et al*., (1978) on sour orange and Troyer citrange with *Glomus fasciculatus* fungi and phosphorus applied as superphosphate, Nemec (1978) on sour orange, Cleopatra mandarin, sweet orange, rough lemon, Rangpur lime, and Carrizo citrange with *Glomus etunicatus*, *Glomus mosseae*, and *Glomus fasciculatus* fungi and phosphorus fertilization. Also, Krikun and Levy (1980) on citrus trees with *Glomus mosseae* fungi, Menge *et al*., (1980) on avocado seedlings with *Glomus fasciculatus* fungi.

Considering top/root ratio, it is clear from Table (5-b) that adding phosphorus for Cleopatra mandarin seedlings increased generally top/root ratio than that of the unfertilized ones. The picture was changed to the reverse when sour orange seedlings were concerned. In both rootstocks, inoculated seedlings with mycorrhizal fungi were higher in their values of top/root ratio than that of non inoculated plants. These findings confirm those reported by Nemec (1978) on sour orange, Cleopatra mandarin, sweet orange, rough lemon, Rangpur lime, and Carrizo citrange with *Glomus etunicatus*, *Glomus mosseae*, and *Glomus fasciculatus* fungi and phosphorus fertilization.

Specific effect :

Referring to specific effect , Table (5-C) clearly shows that sour orange seedlings had the highest values of dry weight of whole seedling, leaves, stem, and roots as well as top/root ratio as compared to that of Cleopatra mandarin. These results are in agreement with those reported by Krikun and Levy (1980) on rough lemon and sour

Table (5-c): Specific effect of rootstock, mycorrhizal fungi, and phosphorus level on dry weight of different parts of citrus seedlings as well as top/root ratio.

Treatments	Dry matter (g.) per plant												Top/Root ratio		
	Whole seedling			Leaves			Stem			Roots					
	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
1. Rootstock															
C.m.	12.34b	9.37b	10.86b	6.32b	4.73b	5.53b	2.51b	2.14b	2.33b	3.51a	2.50b	3.01b	2.58b	2.96b	2.77b
S.o.	21.31a	16.67a	18.99a	12.33a	9.97a	11.15a	4.17a	3.25a	3.71a	4.41a	3.53a	3.97a	3.39a	3.68a	3.54a
2. Mycorrhizae															
Control	7.90c	5.62c	6.76c	3.77c	3.07c	3.42c	1.56b	1.02c	1.29c	2.57c	1.53c	2.05c	2.05c	2.59c	2.32b
G.m.	22.27a	20.15a	21.21a	12.66a	11.67a	12.17a	4.13a	4.20a	4.17a	5.49a	4.29a	4.89a	3.14b	3.98a	3.56a
G.a.	20.29b	13.29b	16.79b	11.54b	7.32b	9.43b	4.34a	2.75b	3.55b	4.41b	3.23b	3.82b	3.76a	3.38b	3.57a
3. Phosphorus															
No P	17.68a	13.63a	15.66a	10.12a	8.16a	9.14a	3.55a	2.77a	3.16a	4.01b	2.70b	3.36b	3.20a	3.66a	3.43a
P	15.97b	12.41a	14.19b	8.52b	6.54b	7.53b	3.14b	2.54b	2.84b	4.31a	3.33a	3.82a	2.77b	2.97b	2.87b

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.
S.o. = Sour orange.
C.m. = Cleopatra mandarin.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

orange with Glomus mosseae fungi, and Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin seedlings with Glomus fasciculatus fungi.

Moreover, data of mycorrhizae specific effect indicate that mycorrhizae fungi increased significantly dry weights of whole seedling, leaves, stem, and roots beside top/root ratio than that of the untreated seedlings. Similar results were obtained by Klinschmidt and Gerdemann (1972) on citrus with Glomus mosseae fungi, and Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin with Glomus fasciculatus. Furthermore, Glomus macrocarpus fungi gave the highest effect in this respect than Glomus australe. Similar results were obtained by Menge and Zentmyer (1977) on avocado seedlings with Glomus fasciculatus and Glomus calospora fungi.

Concerning specific effect of phosphorus, it is clear that unfertilized seedlings had higher dry weight values of whole seedling, leaves, stem, and top/root ratio and lower values of root dry weight, simultaneously than that of fertilized plants. The difference, however was highly significant.

The interaction :

As regard to the interaction (average of two seasons) between rootstock and mycorrhizae, it is clear from Table (5-d) that Glomus macrocarpus fungi with Cleopatra mandarin and sour orange seedlings had higher values in dry weights of whole seedling, leaves, stem, and roots as well as top/root ratio as compared to the analogous ones of Glomus australe fungi.

Concerning the interaction between rootstock and phosphorus, it is quite evident that applying phosphorus to sour orange seedlings caused a decrease in dry weights of whole seedling, leaves and stem as well as top/root ratio and the reverse in dry roots. Moreover, there is no significant differences between fertilized and unfertilized plants of Cleopatra mandarin dry weights for whole seedling, leaves, and stem and top/root ratio and noticed that fertilized plants had higher values of dry roots than the analogous ones of unfertilized plants.

Regarding the interaction between mycorrhizae and phosphorus, it is clear from Table (5-d) that Glomus macrocarpus fungi with P unfertilized plants

Table (5-d): The interaction between rootstock, mycorrhizal fungi, and phosphorus level on dry weight of different parts and top/root ratio of citrus seedling rootstocks (Average of two seasons).

Treatments	Dry matter (g.) per plant								Top/Root ratio	
	Whole seedling		Leaves		Stem		Roots			
1. Rootstock x mycorrhizae										
Rootstock / Mycorrhizae	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.
Control	4.85f	8.69e	2.34e	4.51d	1.06f	1.52e	1.46e	2.66d	2.34c	2.31c
G.m.	15.14c	27.29a	7.47c	16.87a	3.15c	5.18a	4.53b	5.25a	2.46c	4.67a
G.a.	12.60d	21.00b	6.79c	12.07b	2.79d	4.31b	3.03c	4.62b	3.52b	3.63b
2. Rootstock x phosphorus										
Rootstock / Phosphorus	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.
No P	10.79c	20.52a	5.67c	12.62a	2.26c	4.06a	2.87d	3.85b	2.85b	4.02a
P	10.93c	17.46b	5.39c	9.68b	2.40c	3.28b	3.15c	4.50a	2.70b	3.05b
3. Mycorrhizae x phosphorus										
Phosphorus / Mycorrhizae	No P	P	No P	P	No P	P	No P	P	No P	P
Control	5.85e	7.69d	2.89d	3.96c	1.10e	1.48d	1.86e	2.25d	2.17c	2.45c
G.m.	24.67a	17.76b	14.76a	9.57b	5.04a	3.29c	4.87a	4.91a	4.12a	3.01b
G.a.	16.46c	17.15bc	9.79b	9.08b	3.34c	3.76b	3.33c	4.31b	3.99a	3.16b

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*
G.a. = *Glomus australe*.
C.m. = Cleopatra mandarin.

No P = No Phosphorus fertilization.
P = Phosphorus applied as superphosphate.
S.o. = Sour orange.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

induced higher values of dry weights for whole seedling, leaves, stem, roots, and top/root ratio than the analogous ones of fertilized plants with the same fungi. Meanwhile, data clearly show that, Glomus australe fungi with no phosphorus fertilization had higher dry weight values of whole seedling, leaves, and top/root ratio than the fertilized plants. But the picture was changed when stem and roots were concerned in this respect. These results agree with that reported by Menge et al., (1978) on sour orange and Troyer Citrange with Glomus fasciculatus fungi and phosphorus fertilization as superphosphate.

4.4 Root growth of citrus seedling rootstocks as influenced by mycorrhizal fungi inoculation and phosphorus fertilization :

Root growth of citrus rootstocks expressed as root coefficient is shown in Table (6-a). It is clear in Fig. (4) that in both seasons, Cleopatra mandarin seedlings (control) fertilized with phosphorus had higher values of root coefficient for first, second, third, and fourth branches as compared to those of unfertilized control seedlings. The differences were so high to reach the significant level. Anyhow, neigher fertilized nor unfertilized control seedlings developed the fifth branching on their roots.

Table (6-a): Root growth of two citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization.

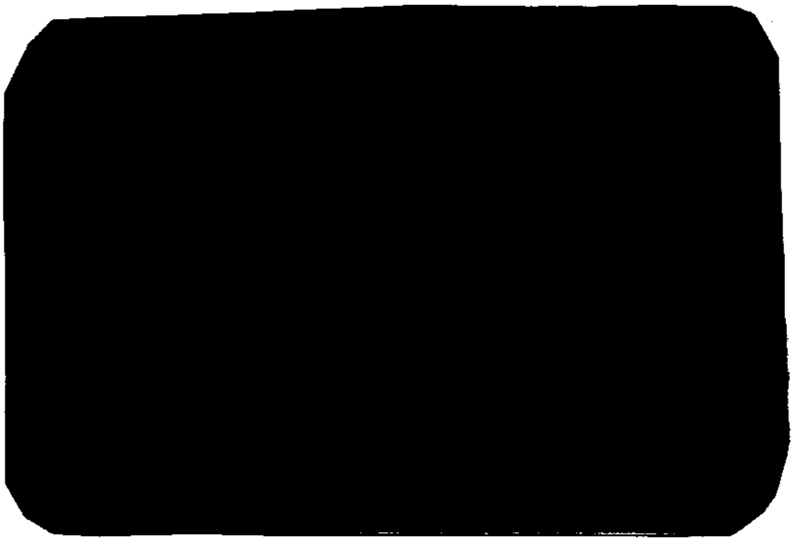
Treatments			Root growth "root coefficient" *														
			First branch			Second branch			Third branch			Fourth branch			Fifth branch		
Rootstock	Mycorrhizae	Phosphorus	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
Cleopatra mandarin	Control	No P	0.36e	0.41h	0.39i	1.28g	1.28h	1.28gh	2.63g	2.05g	235h	4.07j	3.49i	5.68i	0.0f	0.0h	0.0h
	Control	P	1.00c	0.88f	0.95g	2.59f	2.15f	2.37f	4.39e	4.25e	4.32g	6.61h	6.43g	6.53h	0.0f	0.0h	0.0h
	G.m.	No P	1.18bc	2.34ab	1.77d	4.51b	6.01b	5.26b	7.66b	9.6b	8.64b	15.87b	15.42b	15.65b	18.70a	17.4d	18.06b
	G.m.	P	0.55de	1.84d	1.20f	2.59f	3.75e	3.18e	4.26ef	6.48d	5.37f	11.30e	8.45f	9.88f	13.59e	11.57g	12.59g
	G.a.	No P	1.45b	1.99c	1.73d	2.53f	5.93bc	4.24d	5.44d	9.00c	7.32d	13.29c	14.42c	13.86c	15.63c	16.59e	16.12d
	G.a.	P	0.97c	1.86d	1.42e	3.56c	7.01a	5.29b	5.83c	9.47b	7.66c	12.78d	13.66d	13.23d	14.57d	16.37e	15.47e
Sour orange	Control	No P	0.90cd	1.00e	0.96g	1.13g	1.26h	1.20h	2.22h	2.17fg	2.20h	3.34k	3.42i	3.38l	0.0f	0.0h	0.0h
	Control	P	0.64cde	0.69g	0.67h	1.24g	1.66g	1.46g	2.27gh	2.45f	2.36h	5.31i	4.70h	5.01k	0.0f	0.0h	0.0h
	G.m.	No P	2.24a	2.38a	2.31a	4.83a	6.95a	5.90a	8.31a	10.43a	9.37a	16.45a	16.51a	16.48a	17.69b	20.51a	19.1a
	G.m.	P	1.56b	2.27b	1.92c	2.93e	3.74e	3.34e	3.89f	6.34d	5.12f	8.81g	9.73e	9.28g	23.61e	13.99f	13.81f
	G.a.	No P	1.04c	1.79d	1.42e	2.52f	5.62d	4.07d	4.42e	9.48b	6.96e	11.46e	14.45c	12.96d	13.57e	18.74c	16.16d
	G.a.	P	1.56b	2.44a	2.01b	3.27d	5.77cd	4.52c	6.15c	9.69b	7.87c	10.67f	13.76d	12.22e	14.28de	19.25b	16.77c

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.

* Root coefficient = $\frac{\text{White root length}}{\text{Brown root length}} \times 100$

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.



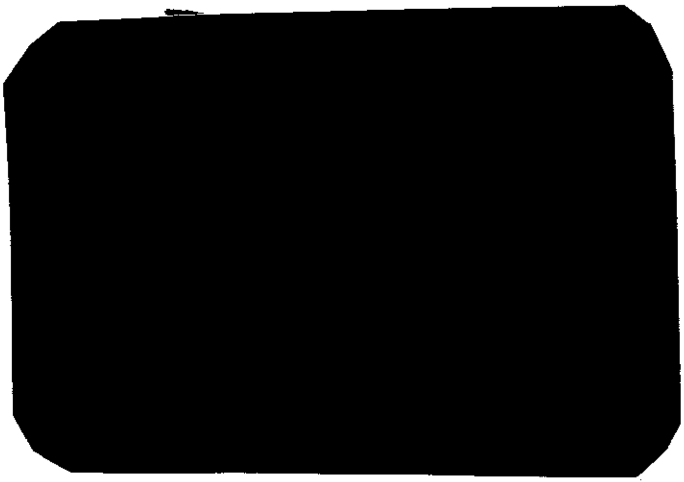
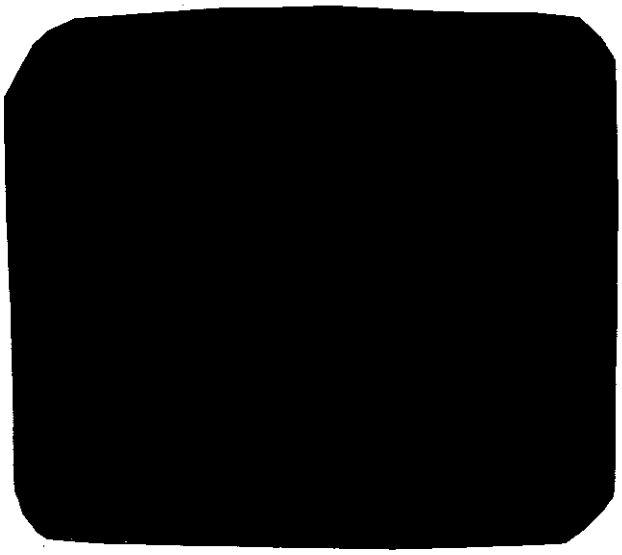


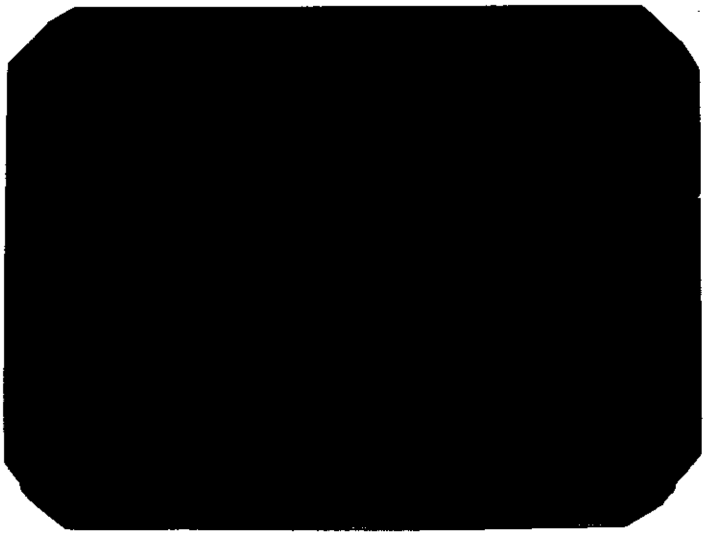
Fig (4): Root system of Cleopatra mandarin seedlings in response to phosphorus fertilization.

- Square areas in Fig. = 5X5 cm^2.

Referring to sour orange seedlings, it is obvious in Fig. (5) that P fertilized control plants had roots with less values of root coefficient for first branch than those of unfertilized ones. The picture was changed to the reverse as second, third, and fourth branches were concerned. However, significant differences were mostly observed. In addition, fifth branch were not develop on roots of either fertilized or unfertilized control plants.

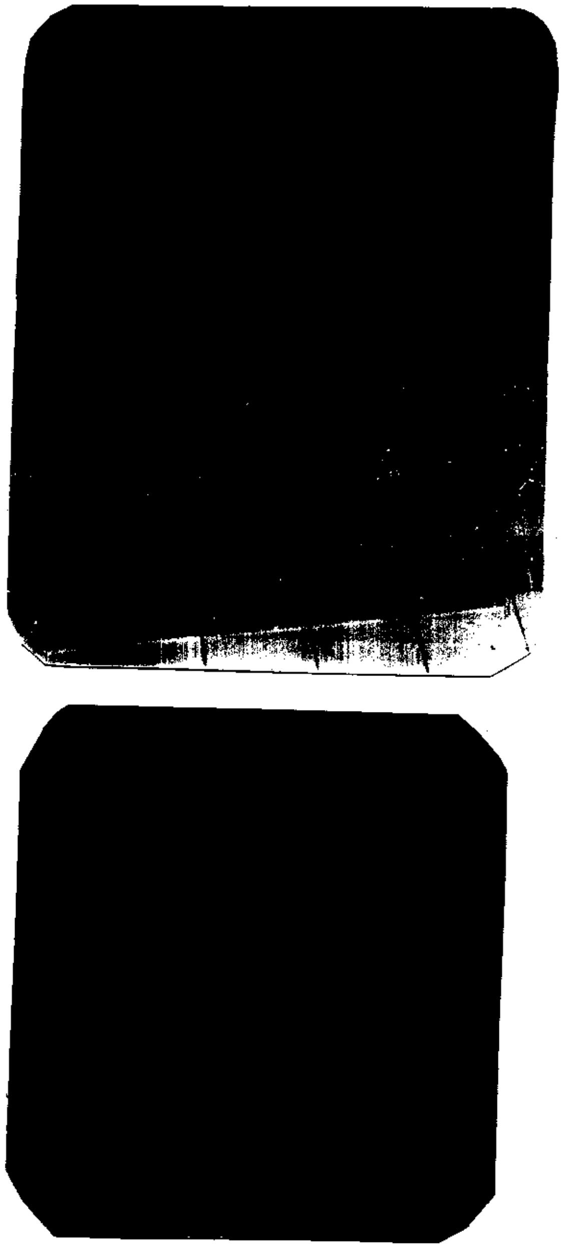
Concerning mycorrhizal fungi treatments, it is quite evident from Figs.(6, 7, 8, and 9) that in both rootstocks and seasons unfertilized and inoculated seedlings with either Glomus macrocarpus or Glomus australe fungi gave higher values of root coefficient for first, second, third, and fourth branches as compared to the corresponding ones of unfertilized and non inoculated control plants. Such effect was more remarkable in both third and fourth branches since the effect was twice or more. Furthermore, mycorrhizal fungi treatments stimulated profoundly the formation of the fifth branch on roots of both rootstocks whereas non mycorrhizal fungi treatment failed in this respect. These findings confirm those reported by schenck and Tucker (1974) on citrus seedlings with Glomus calospora and Endogone macrocarpa





Fig(5): Root system of sour orange seedlings in response to phosphorus fertilization.

- Square areas in Fig. = 5X5 cm^2.



Fig(6): Root system of Cleopatra mandarin seedlings inoculated with *Glomus macrocarpus* fungi as influenced by phosphorus fertilization .

– Square areas in Fig. = 5X5 cm^2 .

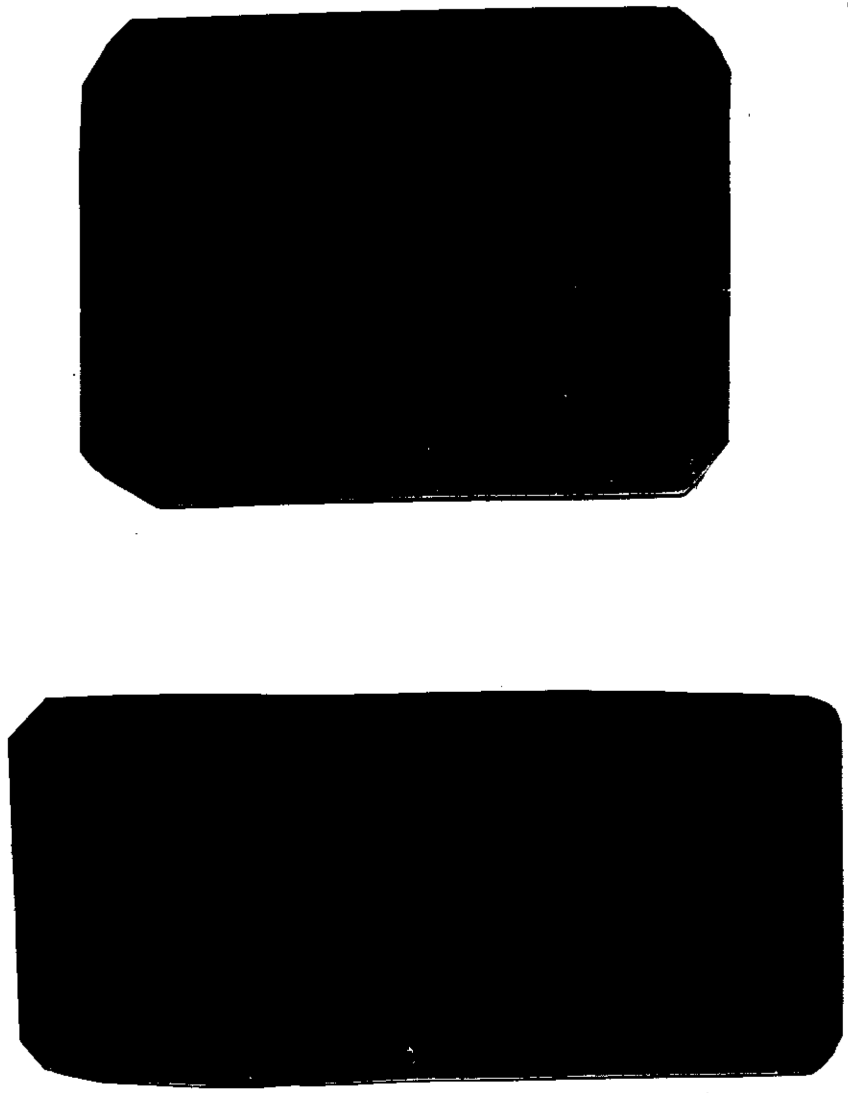
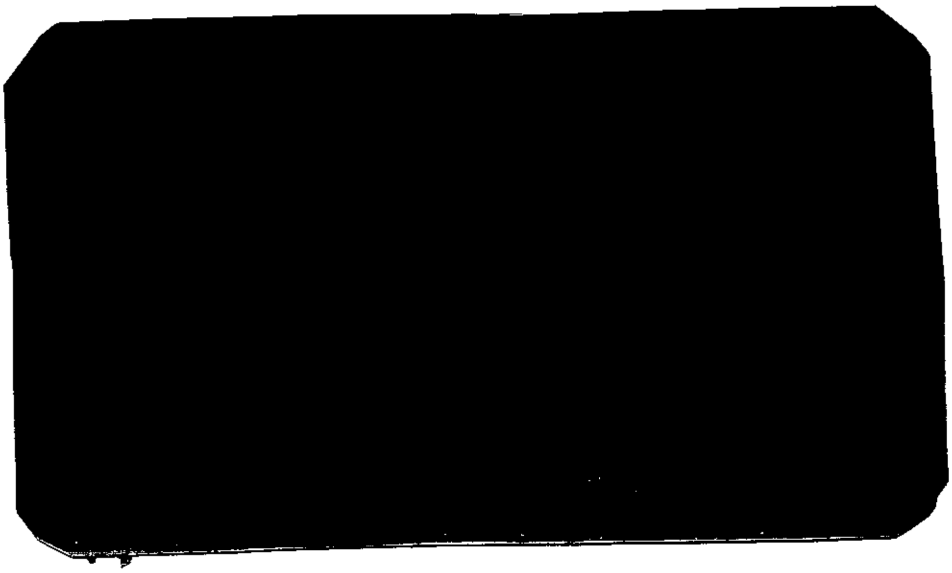


Fig (7): Root system of Cleopatra mandarin seedlings inoculated with *Glomus australe* fungi as influenced by phosphorus fertilization.

- Square areas in Fig. = 5X5 cm^2.
- Honey colour = *Glomus australe*.



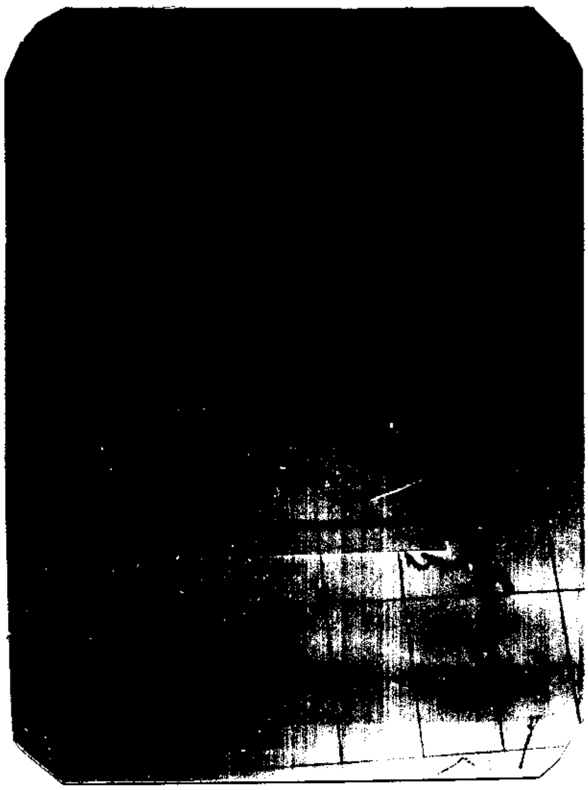
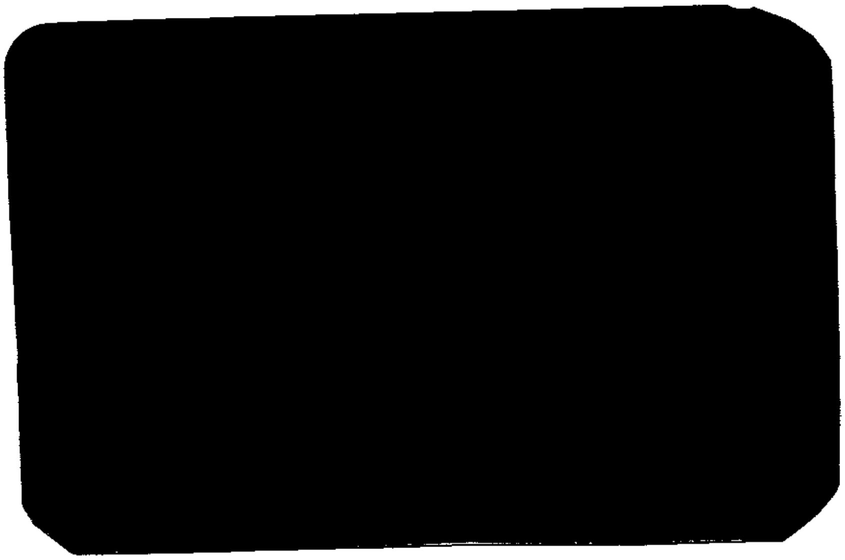
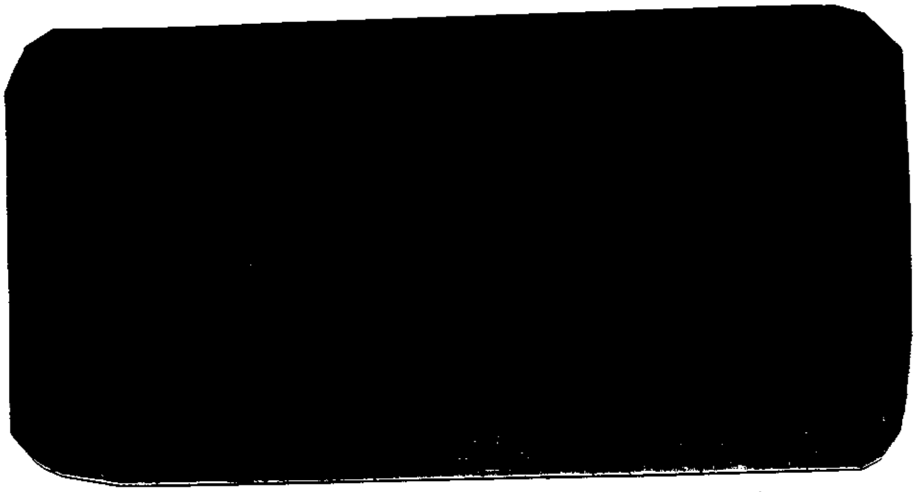


Fig (8): Root system of sour orange seedlings inoculated with <u>Glomus macrocarpus</u> fungi as influenced by phosphorus fertilization.

- Square areas in Fig. = 5X5 cm^2.





Fig(9):Root system of sour orange seedlings inoculated with *Glomus australe* fungi as influenced by phosphorus fertilization.

- Square areas in Fig. = 5 X 5 cm^2.
- Honey colour = *Glomus australe*.

fungi, Menge *et al.*, (1981) report on citrus with many *Glomus* species. Beside, Edrees (1982) found similar results on rough lemon, sour orange, and Cleopatra mandarin with *Glomus fasciculatus* fungi.

Meanwhile, the present study shows that *Glomus macrocarpus* fungi caused a higher effect on root growth than the *Glomus australe* in this concern. Such results are in agreement with those of Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin with *Glomus fasciculatus* fungi.

Moreover, it is found from Table (6-a) and Figs. (6, 7, 8, and 9) that seedlings inoculated with mycorrhizal fungi and fertilized with phosphorus plants surpassed in their root growth values those non inoculated with mycorrhizae and fertilized with phosphorus. Similar results were found by Boyer *et al.*, (1982) on blueberry with *Ericoid* endomycorrhizae. Moreover, plants treated with *Glomus australe* fungi and received phosphorus were superior in their values of root coefficient of different studied branches on roots than the analogous ones of plants treated with *Glomus macrocarpus* and fertilized with phosphorus in both used rootstocks.

Specific effect :

Data of specific effect of rootstock, mycorrhizal fungi, and phosphorus level on root growth of citrus seedlings are presented in Table (6-b).

Concerning rootstock it is worthy to notice that roots of sour orange seedlings had lower values of root coefficient for second, third, and fourth branches than the analogous ones of Cleopatra mandarin seedlings. The picture was changed to the reverse when first and fifth branches were concerned.

Regarding mycorrhizae effect it is found that treated seedlings gave higher values of root coefficient than those of non inoculated ones (control). The obtained results agree with the findings of Menge et al., (1981) on citrus with 7 Glomus species. In addition, control plants failed entirely to produce the fifth branch on their roots. On the other side, regdardless of first branch values, Glomus australe fungi surpassed in their values of root coefficient of studied root branches the analogous ones of plants inoculated with Glomus macrocarpus fungi. This result agrees with that reported by Edrees (1982) on Cleopatra mandarin seedlings inoculated with Glomus fasciculatus, Glomus macrocarpus, and Glomus mosseae fungi.

Table (6-b): Specific effect of citrus species, mycorrhizal fungi, and phosphorus level on seedlings root growth.

Treatments	Root growth " Root coefficient" *														
	First branch			Second branch			Third branch			Fourth branch			Fifth branch		
	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
1. Rootstock															
C.m.	0.92b	1.56b	1.24b	2.85a	4.36a	3.61a	5.04a	6.81a	5.93a	10.66a	10.31a	10.49a	10.42a	10.33b	10.38b
S.o.	1.33a	1.77a	1.55a	2.66b	4.17b	3.42b	4.54b	6.76a	5.65b	9.34b	10.43a	9.89b	9.86b	12.08a	10.97a
2. Mycorrhizae															
Control	0.73b	0.75c	0.74c	1.56c	1.59c	1.58c	2.88c	2.73c	2.81c	4.84c	4.51c	4.68c	0.0c	0.0c	0.0c
G.m.	1.38a	2.21a	1.80a	3.72a	5.11b	4.42b	6.03a	8.21b	7.12b	13.11a	12.53b	12.82b	15.90a	15.87b	15.89b
G.a.	1.26a	2.02b	1.64b	2.97b	6.08a	4.53a	5.46b	9.41a	7.44a	12.06b	14.08a	13.07a	14.52b	17.74a	16.13a
3. Phosphorus															
No P	1.98a	1.66a	1.82a	2.80a	4.51a	3.66a	5.12a	7.12a	6.12a	10.75a	11.29a	11.02a	10.93a	12.21a	11.57a
P	1.05b	1.67a	1.36b	2.70b	4.02b	3.36b	4.47b	6.45b	5.46b	9.25b	9.46b	9.36b	9.34b	10.20b	9.77b

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.
S.o. = Sour orange.
C.m. = Cleopatra mandarin.

* Root coefficient = $\frac{\text{white root length}}{\text{Brown root length}} \times 100$

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

As for phosphorus level was concerned, it is well noticed that unfertilized plants had higher values of root coefficient as compared to the corresponding ones of fertilized plants with phosphorus.

The interactions :

As regard to the interactions (average of two seasons) between rootstocks and mycorrhizae fungi, it is clear from Table (6-c) that Cleopatra mandarin seedlings with Glomus australe fungi had higher values of root coefficient for first, second, third, fourth, and fifth branches than the analogous ones of Glomus macrocarpus with the same rootstock. The picture was changed when sour orange seedlings were concerned.

Concerning the interaction between rootstock and phosphorus level, it is well noticed from Table (6-c) that phosphorus application to Cleopatra mandarin and sour orange seedlings caused a significant decrease in roots coefficient for first, second, third, fourth, and fifth branches as compared to unfertilized ones.

Table (6-c): The interaction between citrus species, mycorrhizal fungi, and phosphorus level on seedlings root growth (Average of two seasons).

Treatments	Root growth "root coefficient" *									
	First branch		Second branch		Third branch		Fourth branch		Fifth branch	
1. Rootstock x Mycorrhizae										
Rootstock / Mycorrhizae	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.
Control	0.67f	0.82e	1.83d	1.33e	3.34c	2.28d	5.16d	4.20e	0.0d	0.0d
G.m.	1.49d	2.12a	4.22c	4.62b	7.01b	7.25a	12.77b	12.88b	15.32c	16.46a
G.a.	1.57c	1.72b	4.76a	4.30c	7.44a	7.44a	13.54a	12.59c	15.80b	16.47a
2. Rootstock x phosphorus										
Rootstock / Phosphorus	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.
No P	1.29b	1.57a	3.60b	3.72a	6.07a	6.17a	11.10a	10.94b	11.39b	11.76a
P	1.19c	1.53a	3.62ab	3.10c	5.78b	4.63b	9.88c	8.84d	9.36d	10.19c
3. Mycorrhizae x phosphorus										
Phosphorus / Mycorrhizae	No P	P	No P	P	No P	P	No P	P	No P	P
Control	0.68e	0.81d	1.24f	1.92e	2.27f	3.34e	3.59f	5.77e	0.0d	0.0d
G.m.	2.04a	1.56c	5.58a	3.26d	9.01a	5.25d	15.87a	9.58d	18.58a	13.20c
G.a.	1.57c	1.71b	4.16c	4.91b	7.09c	7.79b	13.41b	12.72c	16.14b	16.12b

* Root coefficient = $\frac{\text{White root length}}{\text{Brown root length}} \times 100$

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.
C.m. = Cleopatra mandarin.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.
S.o. = Sour orange.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

Referring to the interaction between mycorrhizae and phosphorus level, it is quite evident that the inoculation with Glomus macrocarpus fungi and no phosphorus fertilization of citrus seedlings had higher values of root coefficient for first, second, third, fourth, and fifth branches than the analogous ones of fertilized plants. However, the picture was changed when Glomus australe fungi and phosphorus level were concerned as it appears in the root coefficient for first, second, and third branches, but not in the fourth and fifth branches. Similar results were found by Boyer et al., (1982) on blueberry plants with Ericoid endomycorrhizae.

4.5 Root distribution of citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization :

Root distribution expressed as number of roots for plant is shown in Table (7-a) and graphically illustrated in Figs. (10, 11, and 12). It is clear that for both rootstocks and seasons, seedlings fertilized with phosphorus gave higher number of roots of various diameters as compared to the unfertilized ones. The same result was obtained for total number of roots. However, the difference was more obvious

Table (7-a): Root distribution of citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization.

Treatments			Number of roots of different diameters											
			3-5 m.m.*			2-3 m.m.*			1-2 m.m.*			Total		
Rootstock	Mycorrhizae	Phosphorus	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
Cleopatra mandarin	Control	No P	8.6fg	6.0g	7.7d	107.3ef	79.3g	93.7g	129.0de	145.3h	137.7h	245.0f	230.6g	238.0i
	Control	P	12.3cd	8.0fg	10.3c	113.3ef	111.0f	112.3f	143.6d	185.3g	164.7g	269.3ef	404.3e	287.0g
	G.m.	No P	12.6c	23.6a	18.0a	188.3b	210.6bc	200bc	213.6b	380.0b	297.3c	414.3cd	614.0b	514.3c
	G.m.	P	12.6c	20.0bc	16.7a	142.0d	179.0d	160.7d	119.6e	284.6e	202.3f	274.3ef	417.0e	346.0f
	G.a.	No P	14.3b	22.0ab	18.3a	209.6a	258.3a	234.3a	277.3b	277.6e	277.7d	501.2a	558.0c	530 bc
	G.a.	P	10.6cd	15.7e	13.7b	163.3c	219.0bc	191.7c	211.6c	316.3d	264.3d	385.6d	551.0e	468.7e
Sour orange	Control	No P	7.3g	8.7fg	8.3d	68.6g	80.0g	74.7h	209.0c	146.6h	178.0g	285.0e	235.3g	260.3h
	Control	P	7.6g	9.3f	8.7cd	102.6f	53.0h	78.0h	282.3b	206.3g	244.7e	420.6c	268.6f	345.0f
	G.m.	No P	16.0a	16.6de	16.7a	165.3c	231.3b	198.3c	279.6b	392.6b	336.3b	442.3bc	640.6ab	541.7ab
	G.m.	P	16.0a	18.6cd	17.7a	122.3e	155.3e	139.0e	305.0a	492.3a	399.0a	442.6bc	666.2a	554.7a
	G.a.	No P	9.6ef	20.3bc	15.3b	168.0bc	254.0a	211.3b	307.0a	239.6f	273.7d	469.0b	514.0d	491.7d
	G.a.	P	12.6c	20.3bc	16.7a	180.3b	202.6c	191.7c	308.0a	348.3c	328.3b	500.9a	571.3c	536.3b

Control = No inoculation with mycorrhizae.
G.m. = Glomus macrocarpus.
G.a. = Glomus australe.

No. P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.

*m.m. = Root diameter in m.m.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

in roots with diameters 2 to 3 and 1 to 2 mm. Furthermore, seedlings treated with mycorrhizae fungi and received no phosphorus had visually more roots than the corresponding ones of unfertilized plants (control). Such effect was more remarkable in 2 to 3 and 1 to 2 m.m. roots since the increase was about twice or more.

Concerning mycorrhizae species, it is quite evident that root number of Cleopatra mandarin seedlings treated with Glomus australe was generally higher than those treated with Glomus macrocarpus fungi. This result confirms earlier report by Edrees (1982) who found a similar trend for Cleopatra mandarin seedlings with Glomus fasciculatus, Glomus macrocarpus, and Glomus mosseae fungi. The picture was nearly changed when sour orange plants were concerned.

Comparing fertilized plants and non inoculated with mycorrhizae fungi with those fertilized and inoculated, it is quite evident that mycorrhizae treatments enhanced noticeably the number of roots per plant than untreated ones. Moreover, Glomus australe fungi were generally most promising in this respect than Glomus macrocarpus in case of

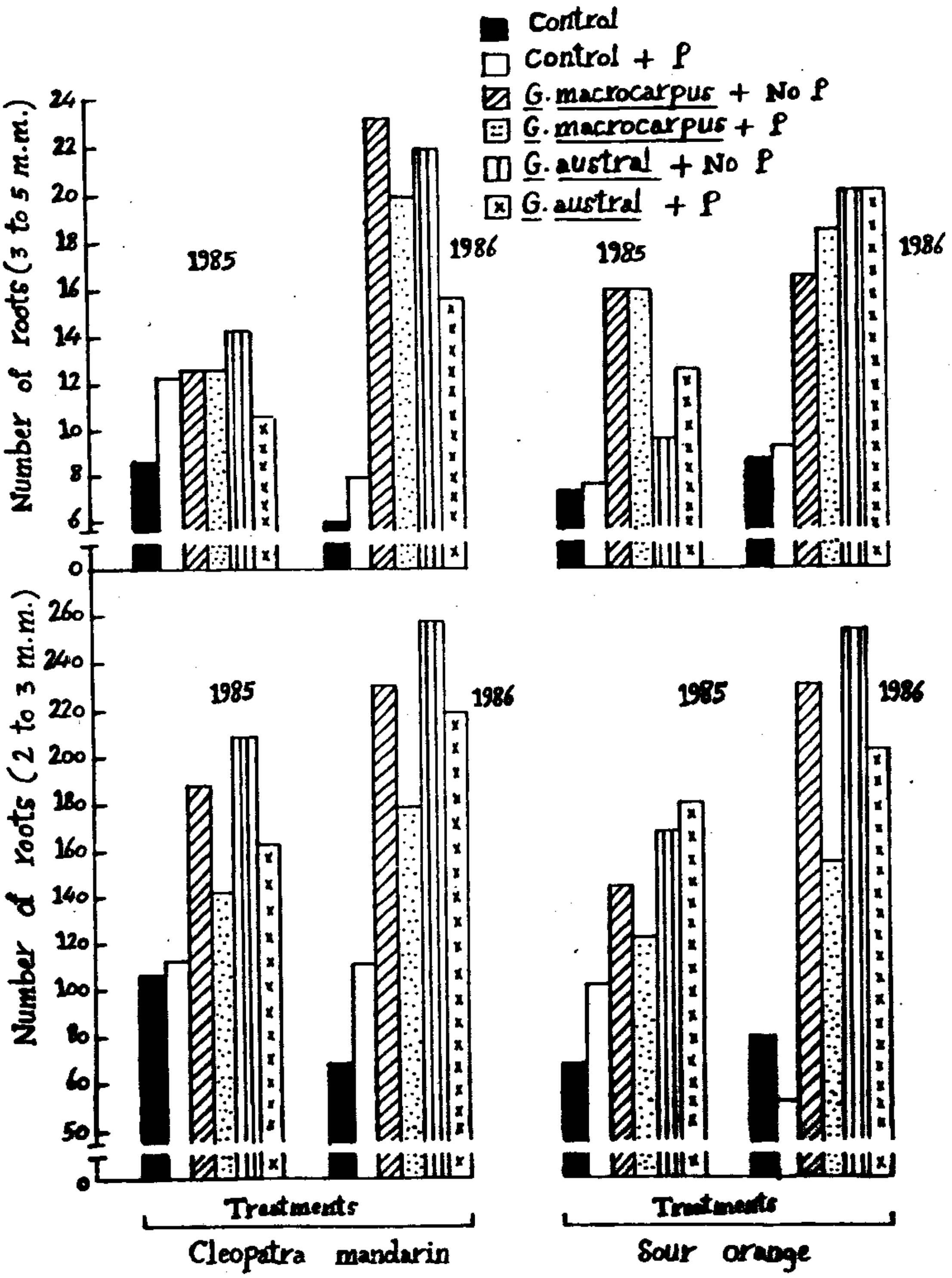


Fig (10) *Effect of rootstock, mycorrhizal fungi and phosphorus level on number of roots (3 to 5 m.m. and 2 to 3 m.m.) of Citrus Seedlings.*

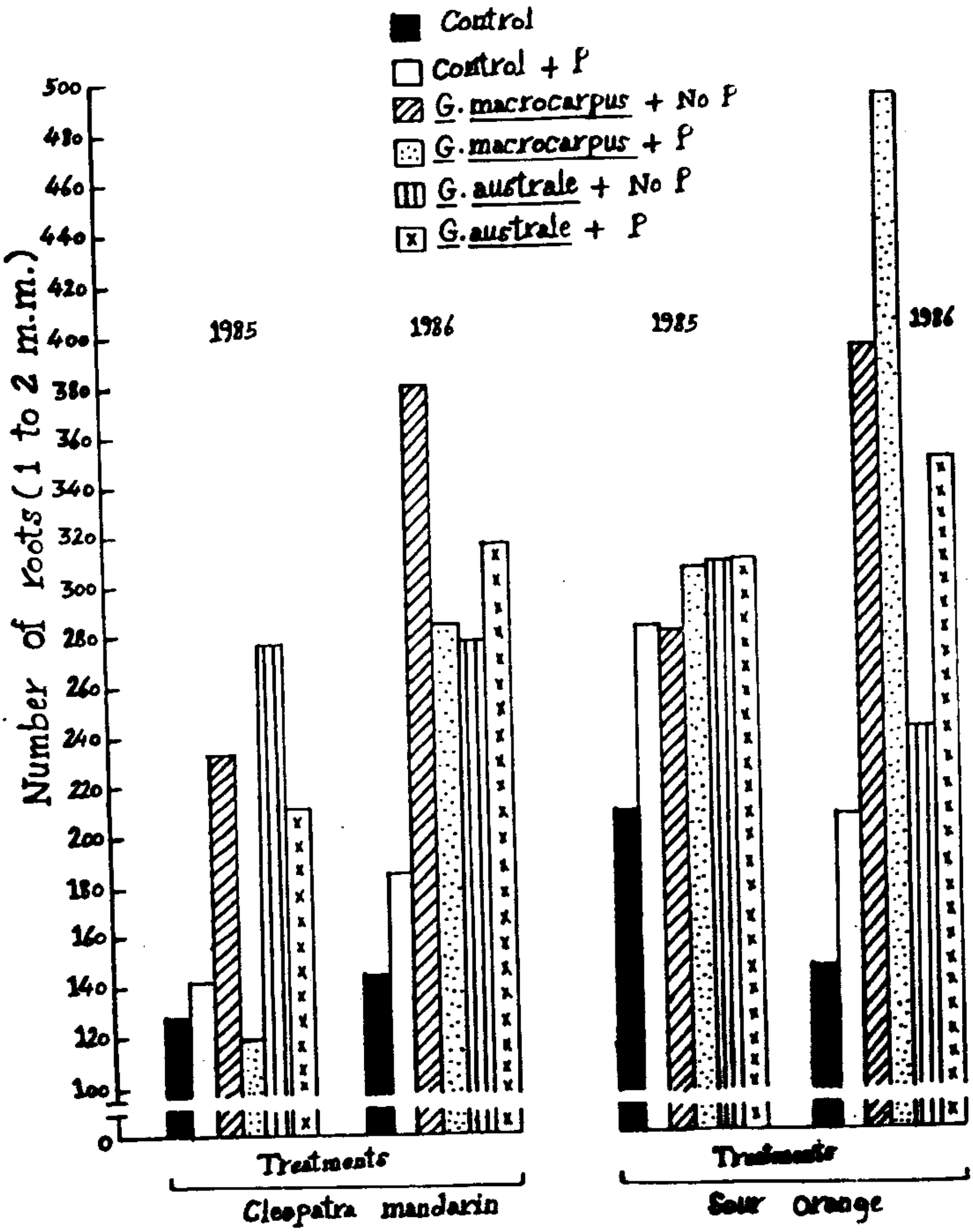


Fig (11) Effect of rootstock, mycorrhizal fungi and phosphorus level on number of roots (1 to 2 m.m.) of citrus seedlings.

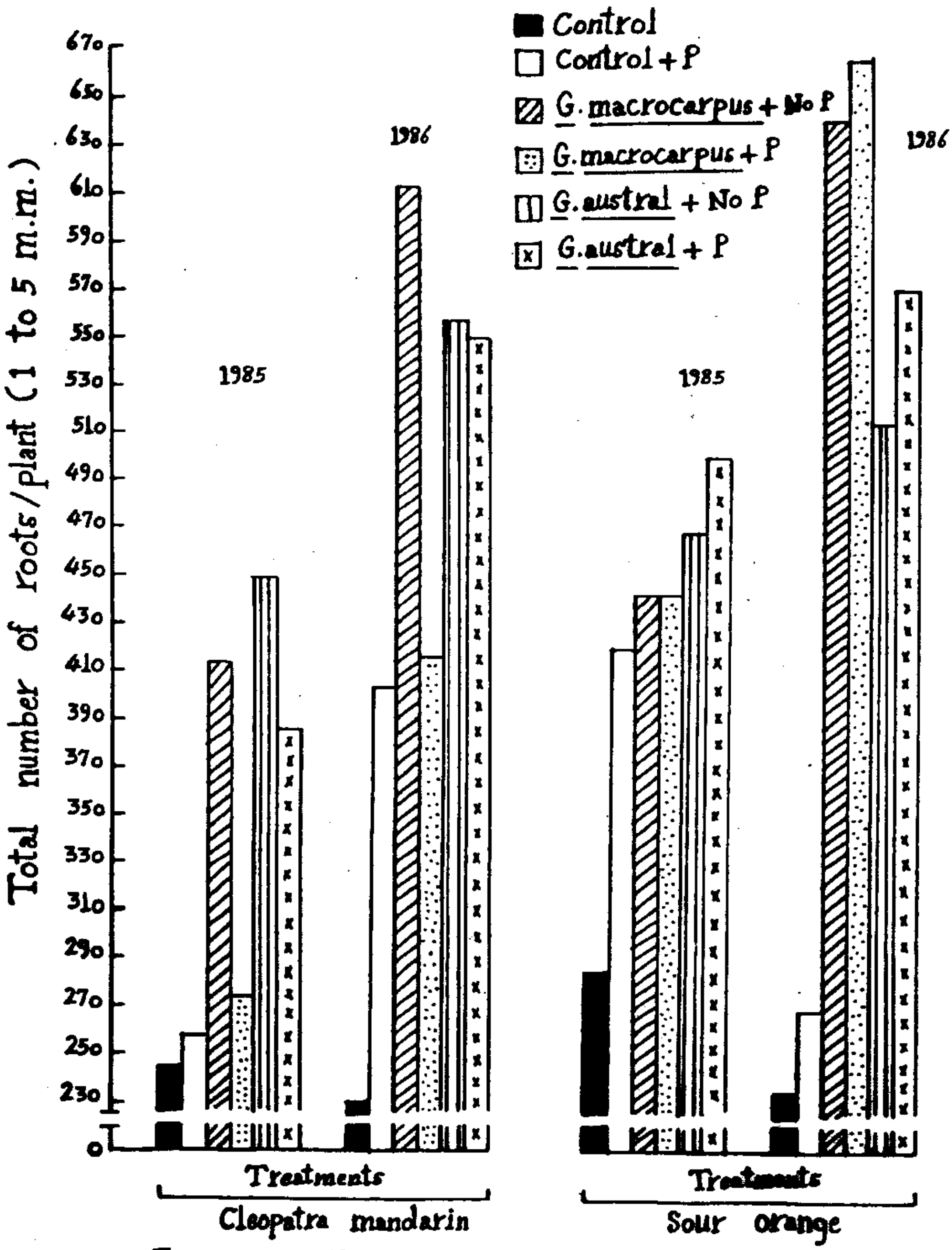


Fig (12) Effect of rootstock, mycorrhizal fungi and phosphorus level on total number of roots of citrus seedlings.

Cleopatra mandarin seedlings. The reverse was true when sour orange plants were considered.

Regarding total number of roots, it is found that adding phosphorus to control plants caused a significant increase in total number of roots in both rootstocks used. Meanwhile, inoculating citrus seedlings of both rootstocks with mycorrhizae fungi increased total number of roots significantly than the analogous ones of non inoculated plants. Such results are in agreement with those of Schenck and Tucker (1974) on citrus seedlings with Glomus calospora and Endogone macrocarpa fungi, and Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin seedlings with Glomus fasciculatus fungi.

Specific effect :

As for specific effect it is intersting to notice from Table (7-b) that sour ornage seedlings had the highest number of roots of 1-2 m.m. in diameter as well as total number of roots per seedling than the corresponding ones of Cleopatra mandarin. The opposite was true when 3-5 and 2-3 m.m. roots were considered.

Table (7-b): Specific effect of rootstock, mycorrhizal fungi, and phosphorus level on root distribution of citrus seedlings.

Treatments	Number of roots of different diameters											
	3-5 m.m.*			2-3 m.m.*			1-2 m.m.*			Total		
	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
1. Rootstock												
C.m.	11.9a	15.9a	13.9a	154.0a	176.2a	165.1a	182.5b	264.9b	223.7b	348.3b	445.8b	397.1b
S.o.	11.6a	15.7a	13.7a	134.6b	162.7b	148.7a	281.8a	304.3a	293.1a	426.8a	482.7a	454.8a
2. Mycorrhizae												
Control	9.0c	8.0b	8.5c	98.0c	80.8c	89.4c	191.0c	170.9c	181.0c	305.0c	259.8c	282.4c
G.m.	14.3a	19.8a	17.1a	154.5b	194.1b	174.3b	229.5b	387.4a	308.5a	393.4b	584.5a	489.0b
G.a.	11.8b	19.6a	15.7b	180.3a	233.5a	206.9a	276.0a	295.5b	285.8b	464.3a	548.6b	506.5a
3. Phosphorus												
No P	11.4a	16.2a	13.8a	151.2a	185.6a	168.4a	235.9a	263.7b	249.8b	392.8a	475.0a	433.9a
P	12.0a	15.3a	13.7a	137.3b	153.3b	145.3b	228.4a	305.6a	267.0a	382.3b	463.1b	422.7b

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.
S.o. = Sour orange.
C.m. = Cleopatra mandarin.
*m.m.= Root diameter in m.m.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

Regarding specific effect of mycorrhizae, it is found that inoculated seedlings with the two species of mycorrhizae had the highest number of roots as compared to the non inoculated ones (control). Meanwhile, the data also disclosed that Glomus macrocarpus fungi surpassed significantly Glomus australe in the number of both 3-5 and 1-2 m.m. roots. The reverse was true when 2-3 m.m. roots and total number of roots were concerned. Similar results were found by Edrees (1982) on Cleopatra mandarin seedlings with Glomus fasciculatus, Glomus macrocarpus, and Glomus mosseae fungi.

Considering specific effect of phosphorus level it is quite evident that unfertilized plants gave higher number of 2-3 m.m. roots as well as total number of roots in respect of fertilized ones. The difference between them was significant. In contrast, fertilized plants gave a slight increase in number of 3-5 m.m. roots than the unfertilized ones. Such increase was more remarkable when 1-2 m.m. roots were considered (as average of two seasons).

The interaction :

As regard to the interaction (average of two seasons) between rootstock and mycorrhizae, it is obvious from Table (7-c) that Cleopatra mandarin seedlings with Glomus australe fungi had higher number of 2-3 m.m., 1-2 m.m., and total number of roots than the analogous ones of Glomus macrocarpus fungi with the same rootstock and the reverse with the number of 3-5 m.m. roots. Moreover, sour orange seedlings with Glomus macrocarpus fungi had the highest number of 3-5 m.m., 1-2 m.m., and total roots as compared with the same rootstock with Glomus australe fungi in this respect and the picture was changed when number of the 2-3 m.m. roots was concerned.

Concerning the interaction between rootstock and phosphorus level, it is clear that Cleopatra mandarin seedlings with no phosphorus fertilization gave a significant increase in the number of 3-5 m.m., 2-3 m.m., 1-2 m.m., and total roots as compared to fertilized plants. The opposite was true when 3-5 m.m., 1-2m.m., and total number of roots of sour orange seedlings were considered.

Moreover, the interaction (average of two seasons) between mycorrhizae and phosphorus level, as presented

Table (7-c): The interaction between rootstock, mycorrhizal fungi, and phosphorus level on root distribution of citrus seedlings (Average of two seasons).

Treatments	Number of roots of different diameters							
	3-5 m.m*		2-3 m.m.*		1-2 m.m. *		Total	
1. Rootstock x mycorrhizae								
Rootstock / Mycorrhizae	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.
Control	8.8e	8.3e	102.8e	76.1f	150.8f	211.1e	264.4f	302.4e
G.m.	17.3a	16.9bc	180.0c	168.6d	249.5d	367.4a	429.9d	548.0a
G.a.	15.7d	16.0cd	212.6a	201.3b	270.8c	300.8b	499.0c	513.9b
2. Rootstock x phosphorus								
Rootstock / phosphorus	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.	C.m.	S.o.
No P	14.6a	13.1c	175.6a	161.2b	237.2c	262.5b	427.3b	431.1b
P	13.3bc	14.1b	154.7b	136.1c	210.2d	373.7a	367.0c	478.5a
3. Mycorrhizae x phosphorus								
Phosphorus / Mycorrhizae	No P	P	No P	P	No P	P	No P	P
Control	7.7d	9.4c	83.9e	95.0d	157.5e	204.4d	249.0e	315.8d
G.m.	17.3a	16.8a	198.9b	149.7c	316.5a	300.4b	527.8a	465.1c
G.a.	16.6a	14.9b	220.8a	191.3b	275.5c	296.1b	510.6b	502.3b

* m.m. = Root diameter in m.m.
Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.
C.m. = Cleopatra mandarin.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.
S.o. = Sour orange.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

in Table (7-c) showed that the inoculation with either Glomus macrocarpus or Glomus australe fungi and unfertilization of citrus seedlings caused higher values of the number 3-5 m.m., 2-3 m.m., 1-2 m.m., and total roots as compared with the analogous ones of fertilized mycorrhizal plants.

4.6. Leaf minerals content of citrus seedling rootstocks :

Leaf minerals content of citrus seedling rootstocks before transplanting are shown in Table (8-a). It is obvious that in both seasons leaf N, Ca, and Zn contents of sour orange seedlings were higher than those of Cleopatra mandarin. On the contrary, leaf K and Mg contents of Cleopatra mandarin seedlings took the other way around hence, higher amounts of K and Mg generally existed in leaves of Cleopatra mandarin than those of sour orange. Nevertheless, leaf P content of both citrus rootstocks was nearly the same.

Furthermore, leaf minerals content of the two citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization are presented in Table (8-b).

Table (8-a) : Leaf minerals content of citrus seedlings before transplanting.

Rootstock	Elements concentrations in dry leaf as(%)										as ppm	
	N		P		K		Ca		Mg		Zn	
	85	86	85	86	85	86	85	86	85	86	85	86
Cleopatra madnarin	2.48	2.40	0.12	0.11	1.15	1.28	3.73	3.12	0.41	0.51	100	112
Sour Orange	2.53	2.48	0.11	0.11	0.94	0.97	3.74	3.60	0.51	0.34	168	182

Table (8-b): Leaf minerals content of two citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization.

Treatments			Elements concentration in dry leaf as (%)															as (ppm)		
			N			P			K			Ca			Mg			Zn		
Rootstock	Mycorrhizae	Phosphorus	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
Cleopatra mandarin	Control	No P	1.92g	2.06g	1.99g	0.114f	0.118c	0.116g	1.46g	2.38c	1.93gh	3.56a	3.19bc	3.38b	0.33g	0.37ef	0.35f	63	156	110
	Control	P	1.97g	2.80de	2.39f	0.132e	0.129c	0.131f	1.88e	2.06de	1.97fg	3.64a	3.52ab	3.58ab	0.44ef	0.53d	0.49e	52	286	169
	G.m.	No P	3.82a	3.80a	3.81a	0.170d	0.182ab	0.176d	1.40 g	2.30c	1.85h	3.12b	2.86cd	2.99c	0.76cd	1.06ab	0.91bc	70	52	61
	G.m.	P	2.69ef	3.43b	3.06cd	0.225a	0.185ab	0.206a	1.37g	1.95e	1.66i	2.76bc	2.64de	2.70d	0.70d	0.85c	0.78d	155	38	97
	G.a.	No P	3.14bcd	3.50ab	3.32b	0.222a	0.173b	0.198b	1.96de	2.26c	2.12de	2.32de	2.42ef	2.37e	0.97a	1.12a	1.03a	197	100	149
	G.a.	P	3.16bc	3.23bc	3.20bc	0.194bc	0.184ab	0.189c	2.01cd	2.35c	2.19d	2.64cd	2.86cd	2.75cd	0.84bc	0.85c	0.85cd	116	137	127
Sour orange	Control	No P	2.00g	2.20fg	2.10g	0.126ef	0.123c	0.125f	1.69f	2.61b	2.16de	2.64cd	2.64de	2.66d	0.38fg	0.32f	0.35f	334	422	378
	Control	P	2.45f	2.55ef	2.50f	0.131e	0.134c	0.133f	2.10bc	2.01de	2.06ef	3.60a	3.85a	3.73a	0.47e	0.48de	0.48e	221	410	316
	G.m.	No P	3.40b	3.20bc	3.30b	0.153d	0.170b	0.164e	1.93de	2.78ab	2.36c	2.12ef	2.47def	2.30e	0.98a	1.06ab	1.03a	106	64	85
	G.m.	P	2.74e	2.73de	2.74e	0.182c	0.182ab	0.182cd	2.02cd	2.18cd	2.11de	2.04ef	2.42ef	2.23ef	0.81bc	0.85c	0.83d	74	60	67
	G.a.	No P	2.92cde	3.03cd	2.98d	0.206b	0.198a	0.202ab	2.18b	2.83a	2.51b	1.84f	2.08f	1.96f	1.03a	1.01ab	1.03a	46	32	39
	G.a.	P	2.88de	3.03cd	2.96de	0.190c	0.184ab	0.188c	2.62a	2.65ab	2.64a	2.56cd	2.86cd	2.71d	0.87b	0.96bc	0.94b	72	36	54

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

Regarding leaf N content, it is quite evident that in both rootstocks control plants fertilized with phosphorus had statistically higher values of leaf N content than those of unfertilized ones. Moreover, mycorrhizal plants of both rootstocks had higher values of leaf N content than the corresponding ones of control plants. These results confirm earlier reports by Finn (1942) on ectomycorrhizae, Read and Stribley (1973) on blueberry plants with *Ericoid* endomycorrhizae, Menge *et al*., (1980) on avocado seedlings with *Glomus fasciculatus*, and Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin seedlings with *Glomus fasciculatus* fungi.

In addition, under no P fertilization for both rootstocks inoculated plants with *Glomus macrocarpus* fungi were higher in leaf N content as compared with those treated with *Glomus australe* fungi. The difference was generally significant. However, the picture was changed to the reverse when inocuhated plants with *Glomus australe* fungi were fertilized with phosphorus. In other words, seedlings treated with *Glomus australe* and fertilized with P contained higher leaf N than the analogous ones of those inoculated with *Glomus macrocarpus* fungi. Similar leaf P content than those of unfertilized ones. Meanwhile, mycorrhizal seedlings of both rootstocks had higher levels of leaf P compared with nonmycorrhizal ones. Such results are in agreement with those of Finn (1942) on ectomycorrhizae, Gerdemann (1968) on vesicular arbuscular mycorrhizae, Read and Stribley (1973) report on Blueberry plants with *Ericoid* endomycorrhizae fungi, Lambert *et al*., (1979 a, b) on soybean, corn and peach seedlings with mycorrhizae, Krikun and Levy (1980) on rough lemon and sour orange with *Glomus mosseae* fungi, Menge *et al*., (1980) on avocado seedlings and Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin seedlings with *Glomus fasciculatus* fungi.

By all means, in both rootstocks, *Glomus australe* fungi for unfertilized seedlings were more promising than *Glomus macrocarpus* fungi in this respect. The same result was obtained when fertilized

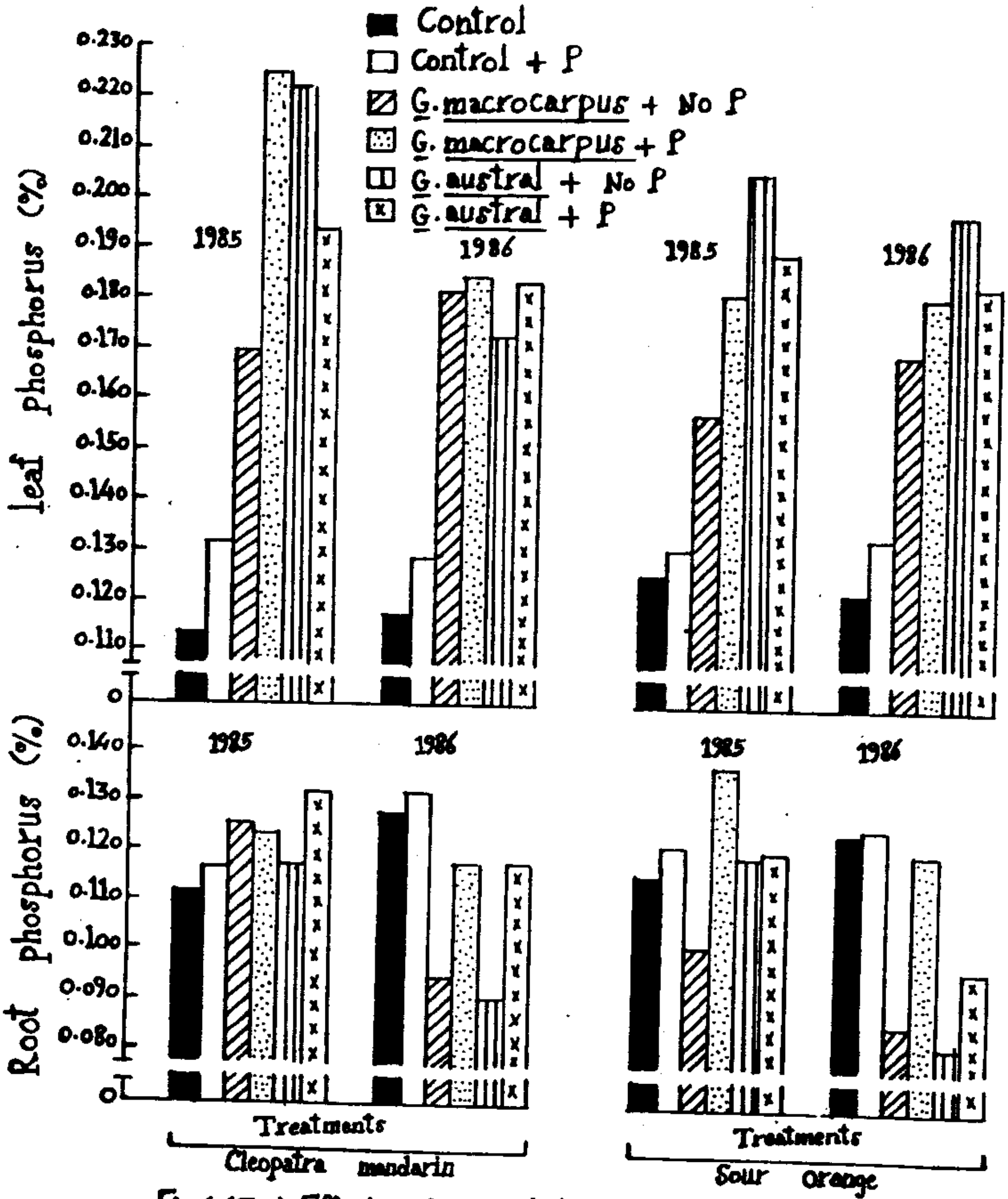


Fig (13) Effect of rootstock, mycorrhizal fungi and phosphorus level on phosphorus content of Citrus leaves and roots seedlings.

seedlings of Cleopatra mandarin were concerned.

Referring to leaf K content, it is obvious that control Cleopatra mandarin seedlings and fertilized with P developed leaves with higher amounts of K than those of unfertilized ones. Sour orange plants showed an opposite trend in this concern. At all events, the differences were insignificent. Moreover, mycorrhizal seedlings of both citrus rootstocks surpassed nonmycorrhizal ones in leaf K content. Such results was noticed in both fertilized and unfertilized seedlings. Similar results were found by Finn (1942) with ectomycorrhizae. Anyway, in both rootstocks, either unfertilized or fertilized seedlings and inoculated with *Glomus australe* fungi had leaves with higher levels of K content than the corresponding ones treated with *Glomus macrocarpus* fungi. These differences were significant.

So far as leaf Ca content was concerned, it is interesting to notice that in both rootstocks control seedlings received P were higher in leaf Ca content than the analogous ones of unfertilized control plants. The significant increase was noticed only in sour orange seedlings. Meanwhile, inoculating seedlings with mycorrhizae fungi caused a significant decrease in leaf Ca content as compared with the corresponding ones of non-inoculated seedlings. Such result was true in both fertilized and unfertilized plants. These findings confirm those reported by Lambert _et al_., (1979 b) on peach seedlings with mycorrhizae, Krikun and Levy (1980) on rough lemon and sour orange with _Glomus mosseae_ fungi, and Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin seedlings with _Glomus fasciculatus_ fungi.

Beside, data indicated also that unfertilized plants received _Glomus australe_ depressed profoundly leaf Ca content than those received _Glomus macrocarpus_ fungi. The reverse was true when fertilized seedlings were considered. That was clear in both rootstocks used in this study.

As for leaf Mg content, it is interesting to notice from Table (8-b) that adding phosphorus to control plants of both stocks raised up leaf Mg content significantly over unfertilized ones. On the other hand, inoculating seedlings with mycorrhizae species resulted in a remarkable increase in leaf Mg content than non-inoculated plants. Similar results were found by Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin seedlings with <u>Glomus fasciculatus</u> fungi.

In this sphere, higher levels of leaf Mg content were observed in plants inoculated with <u>Glomus australe</u> fungi as compared with those treated with <u>Glomus macrocarpus</u> fungi. Moreover, data indicated that applying phosphorus to inoculated plants decreased leaf Mg content than those of unfertilized ones. Such decrease was statistically significant.

In regard to leaf Zn content , it is clear that the effect of phosphorus on leaf Zn content of control plants varied according to the rootstocks used. In this respect, while phosphorus increased leaf Zn content of Cleopatra mandarin plants over unfertilized control ones, it had an opposite effect in sour orange seedlings. On the other side, mycorrhizae treatments decreased leaf Zn content of both rootstocks when compared with untreated plants. Similar findings were obtained by Lambert <u>et al</u>., (1979a) working on soybean and corn plants with mycorrhizae, Lambert <u>et al</u>., (1979b) on peach seedlings with mycorrhizae, and Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin seedlings with *Glomus fasciculatus* fungi. The contrary to these results were reported by Mosse (1973) on plant growth response to vesicular arbuscular mycorrhizae in soil with additional phosphate, and Menge *et al*., (1980) on avocado seedlings with *Glomus fasciculatus* fungi. The differences in these results could be attributed to the possible interaction between mycorrhizae fungi and the physical and chemical soil factors such as temperature (Harely, 1969, and Marx *et al*.,1970) or soil moisture (Muttiah, 1972) on ectomycorrhizae, or soil fertility (Hayman, 1982) or organic matter, cation exchange capacity, and soil P, Cu, Mn, and Zn contents (Menge *et al*.,1982) on Troyer citrange seedlings with *Glomus fasciculatus* fungi.

Concerning mycorrhizae species, while *Glomus australe* fungi surpassed *Glomus macrocarpus* in their effect on leaf Zn content of Cleopatra mandarin, it took the other way around in case of sour orange seedlings. Moreover, applying phosphorus to inoculated plants did not give a clear effect on leaf Zn content since there were fluctuated results. Similar results were found by Menge *et al*., (1978) working on Brazilian sour orange and Troyer citrange seedlings with *Glomus fasciculatus* fungi.

Specific effect :

Specific effect of rootstock, mycorrhizal fungi, and phosphorus level on leaf minerals content of citrus seedling rootstocks is presented in Table (8-c).

Concerning specific effect of rootstock it is quite evident that leaves of sour orange stock contained lower amounts of N and Ca and higher levels of K and Zn, than Cleopatra mandarin leaves. On the other hand, leaf P and Mg contents were similar between the two used stocks.

In regard to specific effect of mycorrhizae species, it is found that mycorrhizae increased leaf N, P, K, and Mg contents and decreased leaf Ca and Zn contents as compared with the control. By all means, Glomus australe fungi were more effective in increasing leaf P, K, and Mg contents than Glomus macrocarpus mycorrhizae. Such effect was not statistically significant in case of leaf N and Ca contents.

Considering specific effect of phosphorus, it is obvious that applying phosphorus to citrus root-

Table (8-c): Specific effect of rootstock, mycorrhizal fungi, and phosphorus level on leaf minerals content of citrus seedling rootstocks.

Treatments	Elements concentration in dry leaf as (%)															as (ppm)		
	N			P			K			Ca			Mg			Zn		
	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
1. Rootstock																		
C.m.	2.78a	3.14a	2.96a	0.176a	0.162a	0.169a	1.68b	2.22b	1.95b	3.01a	2.92a	2.97a	0.68b	0.80a	0.74a	109	128	119
S.o.	2.73a	2.79b	2.76b	0.166b	0.166a	0.166a	2.10a	2.51a	2.31a	2.47b	2.72b	2.60b	0.76a	0.78a	0.77a	142	171	157
2. Mycorrhizae																		
Control	2.08b	2.40b	2.24b	0.126c	0.126c	0.126c	1.79b	2.27b	2.03b	3.37a	3.30a	3.34a	0.41c	0.43b	0.42c	167	319	243
G.m.	3.16a	3.29a	3.23a	0.184b	0.180a	0.182b	1.68c	2.30b	1.99b	2.51b	2.60b	2.56b	0.82b	0.96a	0.89b	101	54	78
G.a.	3.03a	3.20a	3.12a	0.203a	0.185a	0.194a	2.20a	2.53a	2.37a	2.34b	2.56b	2.45b	0.93a	0.99a	0.96a	108	76	92
3. Phosphorus																		
No P	2.87a	2.97a	2.92a	0.166b	0.161a	0.164b	1.72b	2.23a	1.98b	2.61b	2.61b	2.61b	0.74a	0.33a	0.79a	140	138	139
P	2.65b	2.96a	2.81b	0.176a	0.167a	0.172a	2.00a	2.20b	2.10a	2.87a	3.03a	2.95a	0.69b	0.76b	0.73b	115	116	116

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.
S.O. = Sour orange.
C.m. = Cleopatra mandarin.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

stocks used in this study increased leaf P, K, and Ca contents and decreased leaf N, Mg, and Zn contents as compared with unfertilized plants. The difference, however, was so high to be significant.

4.7. Root minerals content :

Root minerals content before transplanting of citrus rootstock seedlings is presented in Table (9-a). It is found that sour orange seedlings had roots with higher levels of N, Ca, and Zn as compared with those of Cleopatra mandarin. On the other hand, root K, and Mg contents took the other way around. However, Cleopatra mandarin and sour orange seedlings were nearly more or less similar in their values of root P content.

Concerning root minerals content of the two citrus seedling rootstocks as influenced by mycorrhizal fungi inoculation and phosphorus fertilization it is shown in Table (9-b) that in both rootstocks control plants fertilized with phosphorus surpassed slightly in their values of root nitrogen the corresponding ones of unfertilized seedlings. Such differences were insignificant. On the other hand, mycorrhizae fungi treatments obviously increased

Table (9-a) : Root minerals content of citrus seedlings before transplanting.

Rootstock	N 85	N 86	P 85	P 86	K 85	K 86	Ca 85	Ca 86	Mg 85	Mg 86	Zn 85	Zn 86
	Elements concentration in dry roots as (%)										as(ppm)	
Cleopatra mandarin	1.25	1.44	0.08	0.08	1.06	1.03	1.70	2.29	0.66	0.54	62	62
Sour Orange	1.41	1.78	0.08	0.08	0.62	0.63	3.09	2.52	0.73	0.40	80	80

Table (9-b): Root minerals content of two citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization.

Rootstock	Mycorrhizae	Phosphorus	N 85	N 86	N Mean	P 85	P 86	P Mean	K 85	K 86	K Mean	Ca 85	Ca 86	Ca Mean	Mg 85	Mg 86	Mg Mean	Zn 85	Zn 86	Zn Mean
			Elements concentration in dry roots as (%)															as (ppm)		
Cleopatra mandarin	Control	No P	1.21d	1.30d	1.26e	0.112e	0.128ab	0.120b	1.13e	1.15de	1.08ef	2.25cd	2.57a	2.41b	1.24b	1.38b	1.32a	156	62	109
	Control	P	1.25d	1.31cd	1.28e	0.117de	0.132a	0.126ab	0.85g	0.91f	0.89g	2.29bc	2.63a	2.46ab	1.15cd	1.17cd	1.16bc	285	52	169
	G.m.	No P	1.33cd	1.56bed	1.45cd	0.126bc	0.095c	0.111c	1.29d	1.16de	1.23d	1.56h	1.76c	1.66f	1.03e	1.01de	1.03de	52	70	61
	G.m.	P	1.66b	1.75ab	1.71abc	0.124bcd	0.118b	0.121b	0.85g	1.38ab	1.12ef	2.00ef	2.09b	2.05cd	1.11d	1.06cde	1.09cd	38	154	96
	G.a.	No P	1.65b	1.56bcd	1.61bcd	0.118cde	0.091cd	0.105c	1.29d	1.28cd	1.29c	1.88f	1.98b	1.93de	0.70h	0.80f	0.75g	100	196	148
	G.a.	P	1.65b	1.86a	1.76ab	0.132ab	0.118b	0.125ab	0.98f	1.10e	1.04f	1.84fg	1.98b	1.91e	0.89g	1.01de	0.91f	136	116	126
Sour orange	Control	No P	1.28d	1.30d	1.29e	0.116de	0.125ab	0.121b	1.08e	1.18de	1.13e	2.48a	2.64a	2.56a	1.30a	1.49a	1.40a	420	334	377
	Control	P	1.49bcd	1.33cd	1.41de	0.122cd	0.126ab	0.124ab	1.48bc	1.20cd	1.34bc	2.44ab	2.64a	2.54a	1.19bc	1.22bc	1.21b	409	220	315
	G.m.	No P	1.57bc	1.60abc	1.59bcd	0.102f	0.087cd	0.095d	1.44c	1.35abc	1.40b	1.88f	1.87bc	1.88e	0.94fg	0.96ef	0.95ef	65	106	86
	G.m.	P	1.76b	1.80ab	1.78ab	0.138a	0.121ab	0.130a	0.153b	1.45a	1.49a	2.08de	2.09b	2.09c	0.89g	0.80f	0.85fg	61	74	68
	G.a.	No P	1.62b	1.53bcd	1.58bcd	0.120cde	0.083d	0.102cd	1.28d	1.25cde	1.27cd	2.12de	2.09b	2.11c	0.96f	0.90ef	0.93f	33	46	40
	G.a.	P	2.13a	1.63ab	1.93a	0.121cde	0.098c	0.110c	1.73a	1.30bcd	1.52a	1.68gh	1.75c	1.72f	1.21b	1.22bc	1.22b	36	72	54

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P= No phosphorus fertilization.
P= Phosphorus applied as superphosphate.

Means followed by the same letter, with each column, are not significantly different from each other at 1% level.

root N content as compared with control plants of both rootstocks. Similar results were found by Finn (1942) who found that plants with ectomycorrhizae contain more nitrogen than nonmycorrhizal plants, as well as Read and Stribly (1973), they reached the same result working on Blueberry roots with Ericoid mycorrhizal fungi. Moreover, seedlings inoculated with either Glomus macrocarpus or Glomus australe and fertilized with phosphorus were highest in root N content in respect of inoculated plants and unfertilized. Generally, seedlings inoculated with Glomus australe had roots with higher amounts of N than those treated with Glomus macrocarpus mycorrhizae.

As for root P content of both citrus rootstocks used in this study, it is well noticed from Table (9-b) and Fig.(13) that fertilized control seedlings increased P level slightly in their roots than unfertilized ones. Treating seedlings of both citrus rootstocks with mycorrhizae species caused a general decrease in root P content as compared with control plants. These results agree with that reported by Read and Stribly (1973) on Blueberry roots with Ericoid mycorrhizal fungi. Furthermore, seedlings inoculated with mycorrhizae and fertilized with phosphorus developed roots with higher amounts of root P content than those treated with mycorrhizae and unfertilized. This result confirm that reported by Lambert _et_ _al_., (1979a) who found similar results with bean and corn mycorrhizal plants and fertilized with different phosphorus levels.

Comparing mycorrhizae species and their effect on root P content, it is obvious that seedlings treated with _Glomus_ _macrocarpus_ were mostly higher in root P content as compared with the analogous ones of those inoculated with _Glomus_ _australe_.

A glance to data of root K content show that roots of Cleopatra mandarin seedlings fertilized with phosphorus contained lower amounts of K than unfertilized control plants. The picture was changed to the reverse when sour orange seedlings were put in consideration. Moreover, seedlings of both rootstocks inoculated with mycorrhizae fungi were higher in their values of root K content than the analogous ones of control plants. Applying phosphorus to inoculated plants caused a reduction in root K content of Cleopatra mandarin as compared with those inoculated with the same specie of mycorrhizae and unfertilized. The reverse was noticed when sour ornage seedlings were concerned. Such results indicate the differences between citrus rootstocks in this respect. Similar results were found by Finn (1942) who reached the same results with ectomycorrhizae.

Furthermore, Glomus macrocarpus fungi was more effective in increasing root K content than Glomus australe. Such result was clear in the case of sour orange rootstock.

Considering root Ca content, it is quite evident that in control plants, adding phosphorus to seedlings had no effect on root Ca content since the difference between unfertilized control plants and those only fertilized with phosphorus was so small to reach the significant level. On the other side, plants inoculated with mycorrhizae fungi had roots with lower amounts of root Ca as compared with the corresponding ones of control plants. Meanwhile, applying phosphorus to inoculated plants with Glomus macrocarpus fungi significantly increased root Ca content in respect of inoculated and unfertilized seedlings. The opposite was true when Glomus australe treatments were concerned. This tendency is in close agreement with the findings of Lambert *et al.*, (1979b) who showed that calcium content was lower in peach mycorrhizal seedlings than the nonmycorrhizal seedlings.

Referring to root Mg content, it is found that in both rootstocks, phosphorus fertilization to citrus seedlings decreased root Mg content of control plants than those of unfertilized control ones. In addition, mycorrhizae treatments decreased markedly root Mg content as compared with control plants. Applying phosphorus to inoculated plants with *Glomus australe* fungi caused an increase in root Mg level than those of inoculated with the same species of mycorrhizae and unfertilized seedlings. Such effect was not clear in case of *Glomus macrocarpus* fungi. Similar results were obtained by Menge *et al.*, (1978) when applied phosphorus as superphosphate to Brazilian sour orange and Troyer citrange seedlings inoculated with *Glomus fasciculatus* fungi. Also Lambert *et al.*, (1979b) showed that mycorrhizal peach seedlings gave lower values of Mg content than nonmycorrhizal plants.

Considering root Zn content, data clearly showed that control Cleopatra mandarin seedlings fertilized with phosphorus were higher in their values than the unfertilized ones. However, sour orange seedlings took the other way around in this respect. On the other hand, mycorrhizae treatments decreased root Zn content as compared with control plants. Moreover, phosphorus fertilization combined with mycorrhizae fungi caused oscillation results in root Zn content. Therefore, while Cleopatra mandarin seedlings inoculated with *Glomus macrocarpus* and fertilized had roots with highest levels of Zn as compared with inoculated and unfertilized plants, the opposite was noticed in sour orange rootstock. The reverse was true in case of *Glomus australe* fungi. In other words, *Glomus macrocarpus* fungi when added together with phosphorus induced a decrease in root Zn content of sour orange seedlings in respect of inoculated and unfertilized ones whereas *Glomus australe* gave opposite picture in this respect. This finding is in agreement with that of Menge *et al.*, (1978) when they applied phosphorus as superphosphate to Brazilian sour orange and Troyer citrange seedlings inoculated with *Glomus fasciculatus* fungi. Moreover, Lambert *et al.*, (1979a) found that phosphorus fertilization reduced Zn and Cu concentrations in mycorrhizal bean and corn plants than nonmycorrhizal plants. Similarly Lambert et la., (1979b) showed similar result on mycorrhizal peach seedlings.

Specific effect :

Specific effect of rootstock, mycorrhizal fungi and phosphorus level is presented in Table (9-c).

It is clear that roots of sour orange seedlings contained higher amounts of N, K, Ca, Mg, and Zn as compared with those of Cleopatra mandarin. However, the significance in case of root N content was lacking. On the other hand, Cleopatra mandarin seedlings had roots with higher amounts of P than roots of sour orange seedlings. The difference was significant.

In regard to specific effect of mycorrhizae, it is obvious that mycorrhizae fungi decreased root P, Ca, Mg, and Zn contents and increased N, and K contents when compared with uninoculated seedlings (control). In addition, Glomus australe fungi resulted in highest effect on root N and Zn

Table (9-c): Specific effect of rootstock, mycorrhizal fungi and phosphorus level on root minerals content of citrus seedlings.

Treatments	Elements concentration in dry roots as (%)															Mn as (ppm)		
	N			P			K			Ca			Mg					
	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
1. Rootstock																		
C.m.	1.46b	1.56a	1.51a	0.122a	0.114a	0.118a	1.05b	1.17b	1.11b	1.97b	2.17a	2.07b	1.02b	1.08a	1.05b	128	108	118
S.o.	1.66a	1.53a	1.60a	0.120a	0.107b	0.114b	1.42a	1.29a	1.36a	2.11a	2.18a	2.15a	1.09a	1.10a	1.10a	171	142	157
2. Mycorrhizae																		
Control	1.31c	1.31b	1.31b	0.117b	0.128a	0.123a	1.11b	1.11c	1.11b	2.37a	2.62a	2.50a	1.22a	1.32a	1.27a	318	167	243
G.m.	1.58b	1.68a	1.63a	0.123a	0.106b	0.115b	1.28a	1.34a	1.31a	1.88b	1.98b	1.93b	1.00b	0.96b	0.98b	54	101	78
G.a.	1.79a	1.65a	1.72a	0.123a	0.098c	0.111b	1.32a	1.23b	1.28a	1.88b	1.98b	1.93b	0.94c	0.99b	0.97b	76	108	92
3. Phosphorus																		
No P	1.45b	1.48b	1.47b	0.116b	0.102b	0.109b	1.23a	1.23a	1.23a	2.03a	2.15a	2.09a	1.03b	1.09a	1.06a	138	136	137
P	1.67a	1.62a	1.65a	0.126a	0.119a	0.123a	1.24a	1.23a	1.24a	2.06a	2.20a	2.13a	1.08a	1.08a	1.08a	161	115	138

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.
S.o. = Sour orange.
C.m. = Cleopatra mandarin.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

contents and lowest effect on root P, K, Ca, and Mg. Nevertheless, the difference between the two species of mycorrhizae in relation to root minerals content was statistically insignificant. Similar results were obtained by Menge and Zentmyer (1977) who mentioned that Glomus fasciculatus enhanced the uptake of P, Zn, Cu, and N more than did Glomus calospora of Avocado seedlings.

Considering specific effect of phosphorus, data obviously showed that phosphorus fertilization increased root N and P contents whereas it had no effect on the other studied minerals i.e. K, Ca, Mg, and Zn where values of these nutrients were more or less statistically similar.

4.8. Leaf chlorophyll and carotene contents of citrus seedlings :

Leaf chlorophyll and carotene contents of Cleopatra mandarin and sour orange seedlings before transplanting are disclosed in Table (10-a). It is clear that in both seasons leaf chlorophyll A, B, and total as well as carotene contents of sour orange were higher than that of the corresponding ones of Cleopatra mandarin seedlings.

Table (10-a) : Leaf chlorophyll and carotene contents of two citrus seedling rootstocks before transplanting.

Rootstock	Chlorophyll (A)		Chlorophyll (B)		Total (A+B)		Carotene	
	(mg./100g leaf fresh weight)							
	85	86	85	86	85	86	85	86
Cleopatra mandarin	83.0	82.5	35.9	36.7	118.9	119.2	73.5	73.0
Sour orange	143.3	150.5	79.9	82.0	223.2	232.5	162.9	135.9

Table (10-b): Leaf chlorophyll and carotene contents of two citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization.

Treatments			Chlorophyll (A)			Chlorophyll (B)			Total (A+B)			Carotene		
			(mg./100g leaf fresh weight)											
			85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
Rootstock	Mycorrhizae	Phosphorus												
Cleopatra mandarin	Control	No P	61.5g	62.6g	61.81h	35.0h	69.0d	51.99e	96.5f	131.5f	114.00e	61.3e	57.0f	59.15f
	Control	P	63.1g	81.3e	72.21g	40.9g	84.0c	62.44d	103.9f	165.4de	134.65d	63.5de	79.6e	71.55e
	G.m.	No P	99.9bc	92.7b	96.30c	61.1ab	94.2b	77.63b	161.0b	186.8ab	173.90b	98.6a	95.4bc	97.00ab
	G.m.	P	97.2c	83.5de	90.35d	51.1e	93.3b	72.19c	148.3c	176.8bcd	162.55c	95.5a	87.5d	91.50cd
	G.a.	No P	103.1b	95.5b	99.30ab	62.4a	101.2a	81.83a	165.5ab	196.8a	181.15a	95.3a	101.8a	98.55a
	G.a.	P	82.5e	85.0cd	83.72e	52.5e	95.0b	73.73c	134.9d	180.0bc	157.45c	86.6c	90.3cd	88.45d
Sour orange	Control	No P	75.5f	75.5f	75.54f	50.1e	78.3c	64.22d	125.7e	153.9e	139.80d	67.2d	79.3e	73.25e
	Control	P	59.8g	63.5g	61.66h	44.9f	62.9d	53.90e	104.7f	126.4f	115.55e	53.0f	51.1f	52.05g
	G.m.	No P	92.8d	103.0a	97.91abc	56.6d	93.4b	75.36bc	150.1c	196.4a	173.25b	80.1c	91.5cd	85.80d
	G.m.	P	92.2d	101.1	96.65bc	57.2cd	93.3b	75.22bc	149.4c	194.4a	171.90b	95.9a	98.4ab	9715ab
	G.a.	No P	111.8a	88.0c	99.90a	59.1bc	85.1c	73.11c	170.9a	173.1cd	172.00b	89.6b	78.4e	84.00d
	G.a.	P	98.0c	87.8c	92.89d	62.0a	101.2a	81.59a	160.0b	189.0ab	174.50b	96.0a	92.6bcd	94.30bc

NO P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

Moreover, Leaf chlorophyll and carotene contents of the two citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization are shown in Table (10-b) and graphically illustrated in Fig. (14).

It is found that fertilized control seedlings of Cleopatra mandarin had leaves with higher amounts of chlorophyll and carotene as compared with unfertilized check plants. The differences were generally significant. The picture was changed to the opposite as sour orange rootstock was considered.

In addition, mycorrhizal fungi treatments increased visually leaf chlorophyll and carotene contents of both citrus rootstocks in respect of the analogous ones of control plants. The difference between inoculated and unfertilized plants and unfertilized control seedlings, in most cases, were obviously significant. Similar results were found by Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin seedlings with Glomus fasciculatus fungi.

Moreover, data also clearly showed that applying phosphorus to inoculated mycorrhizal Cleopatra mandarin

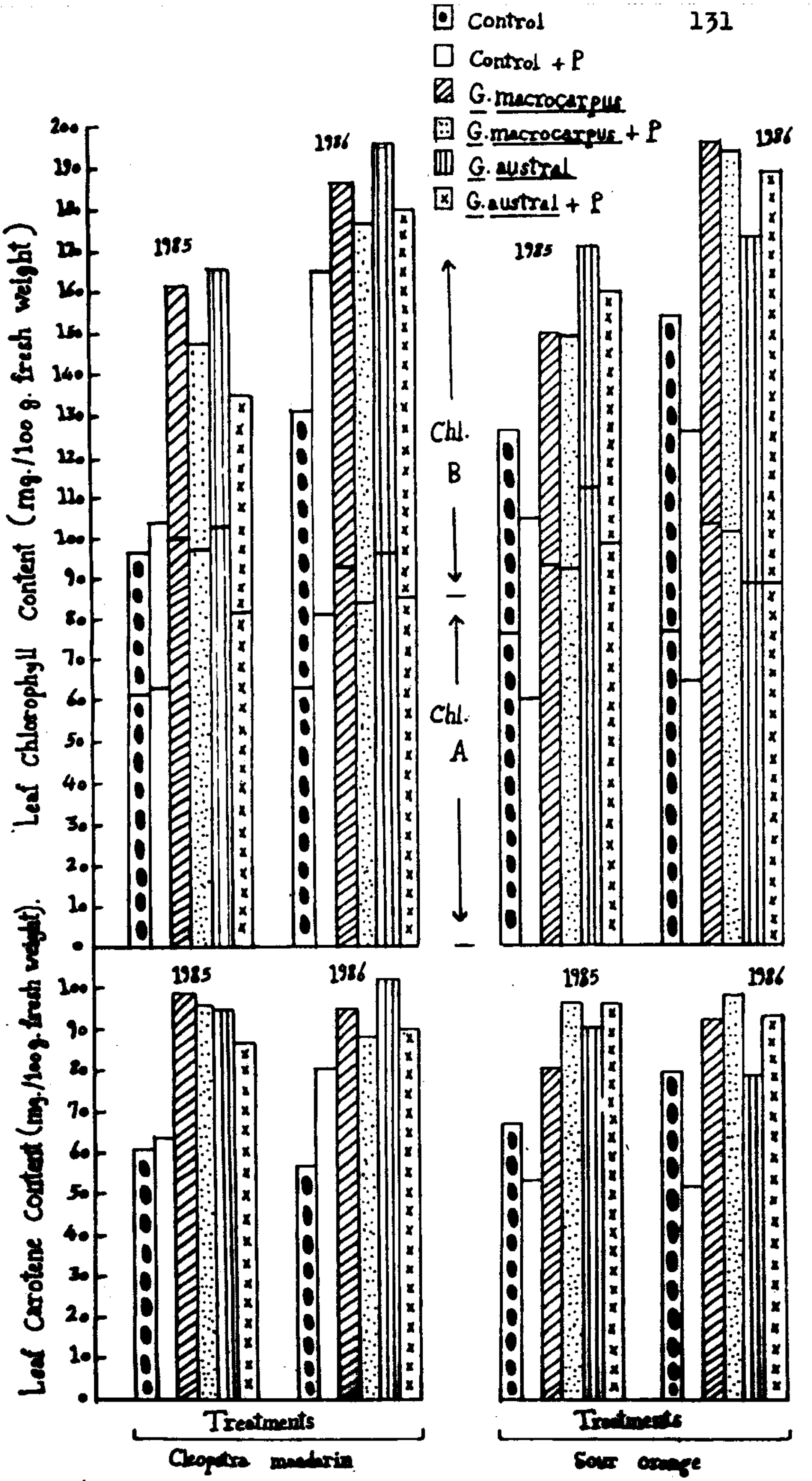


Fig (14) Effect of rootstock, mycorrhizal fungi and phosphorus level on chlorophyll and Carotene Contents of citrus seedlings.

seedlings resulted a remarkable reduction in leaf chlorophyll and carotene contents below those seedlings treated with mycorrhizae solely. Such result was slightly noticed in leaf chlorophyll (A) of sour orange plants. Nevertheless, sour orange seedlings inoculated and fertilized developed leaves with higher amounts of chlorophyll (B) and carotene when compared with those ones inoculated with mycorrhizae and deprived of phosphorus fertilizer.

Meanwhile, Glomus australe fungi increased leaf chlorophyll (B) and total chlorophyll levels as compared with Glomus macrocarpus fungi and in the same time decreased leaf chlorophyll (A) and carotene contents for both citrus rootstocks used.

Specific effect :

Specific effect of rootstock, mycorrhizal fungi, and phosphorus level on leaf chlorophyll and carotene contents of citrus seedlings is presented in Table (10-c).

Concerning specific effect of rootstock it is clear that sour orange rootstock had leaves with

Table (10-c): Specific effect of rootstock, mycorrhizal fungi, and phosphorus level on leaf chlorophyll and carotene contents of citrus seedlings.

Treatments	Chlorophyll (A)			Chlorophyll (B)			Total (A+B)			Carotene		
	(mg./100g leaf fresh weight)											
	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
1. Rootstock												
C.m.	84.5b	83.4b	83.95b	50.5b	89.5a	70.0a	135.0b	172.9a	153.95b	82.6a	85.3a	83.95a
S.o.	88.4a	86.5a	87.45a	55.1a	85.7b	70.40a	143.4a	172.2a	157.80a	80.3b	81.9b	81.10b
2. Mycorrhizae												
Control	65.0c	70.7c	67.65c	42.7c	73.6b	58.15c	107.7c	144.3b	126.0b	61.3b	66.8b	64.05c
G.m.	95.5b	95.1a	95.30a	56.7b	93.5a	75.10b	152.2b	188.6a	170.4a	92.5a	93.2a	92.85a
G.a.	98.8a	89.1b	93.95b	59.0a	95.6a	77.30a	157.8a	184.7a	171.25a	90.6a	90.8a	90.7b
3. Phosphorus												
No P	90.8a	86.2a	88.50a	54.2a	86.9a	70.55a	144.9a	173.1a	159.0a	82.0a	83.9a	82.95a
P	82.1b	83.7b	82.90b	51.4b	88.3a	69.85a	133.5b	172.0a	152.75b	80.9a	83.3a	82.10a

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.
S.o. = Sour orange.
C.m. = Cleopatra mandarin.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

higher amounts of chlorophyll (A) and total chlorophyll and lowest level of carotene as compared with analogous ones of Cleopatra mandarin. Significant differences were obvious. However, leaf chlorophyll (B) was not statistically affected with rootstock since the values were more or less similar.

As for specific effect of mycorrhizae, it is quite evident that mycorrhizae species increased significantly leaf chlorophyll and carotene contents. On the other hand, Glomus macrocarpus fungi surpassed Glomus australe in its effect on leaf chlorophyll (A) and carotene on one hand and decreased leaf chlorophyll (B) and total chlorophyll on the other. For all that, no significant difference was noticed between the two species of mycorrhizae used on leaf total chlorophyll. Similar results were found by Edrees (1982).

Referring to the specific effect of phosphorus, it is found that adding phosphorus to citrus seedlings failed to increase leaf chlorophyll and carotene contents over the control. Nevertheless, significant differences were lacking in leaf chorophyll (B) and carotene.

4.9. Leaf sugars and stem total carbohydrates contents of citrus seedlings :

Leaf sugars and stem total carbohydrates of citrus seedlings before transplanting are tabulated in Table (11-a) . It is clear that sour orange seedlings contained higher leaf reducing, non-reducing and total sugars as well as stem total carbohydrates as compared with those of Cleopatra mandarin seedlings.

In addition, leaf sugars and stem total carbohydrates contents of two citrus seedling rootstocks as influenced by mycorrhizal fungi inoculation and phosphorus fertilization are shown in Table (11-b). and Fig. (15) . It is obvious that control Cleopatra mandarin seedlings and unfertilized had leaves with higher amounts of reducing sugars and lower percentages of non-reducing and total sugars as compared with control and fertilized ones. On the other haad, control sour orange seedlings showed that adding phosphorus to these seedlings resulted in an increase in leaf reducing sugars as well as a reduction in leaf non reducing and total sugars.

Furthermore, mycorrhizae fungi treatments for Cleopatra mandarin decreased only reducing sugars in

Table (11-a) : Leaf sugars and stem total carbohydrates of citrus seedlings before transplanting.

Rootstock	Leaf sugars: Reducing 85	Reducing 86	Non-reducing 85	Non-reducing 86	Total 85	Total 86	Stem total carbohydrates 85	Stem total carbohydrates 86
	% of dry material							
Cleopatra mandarin	0.51	0.57	1.19	1.23	1.70	1.80	19.90	21.58
Sour orange	0.81	0.83	1.37	1.36	2.18	2.19	25.08	26.64

Table (11-b): Leaf sugars and stem total carbohydrates of two citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization.

Treatments			Leaf sugars: Reducing			Non-reducing			Total			Stem total Carbohydrates		
			% of dry material											
Rootstock	Mycorrhizae	Phosphorus	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
Cleopatra mandarin	Control	No P	1.17a	0.95abc	1.07ab	0.30g	0.32f	0.31i	1.47de	1.27e	1.37e	28.88cd	33.75a	31.32abc
	Control	P	0.86efg	0.73c	0.80de	0.91bc	0.89bc	0.90c	1.77c	1.62cd	1.70b	19.90f	32.41a	26.25cd
	G.m.	No P	0.76h	0.83bc	0.79de	0.77d	0.76cd	0.77de	1.53de	1.58cd	1.56bcd	19.90f	31.08a	26.46cd
	G.m.	P	1.00cd	1.00ab	1.00abc	0.56f	0.78bcd	0.66fg	1.56de	1.78bc	1.67b	27.61cde	30.25a	28.93bcd
	G.a.	No P	1.02c	0.99ab	1.01abc	0.39g	0.51e	0.45h	1.41e	1.50d	1.46de	25.04e	21.58a	23.31d
	G.a.	P	0.93de	0.87abc	0.90cde	0.54f	0.65de	0.59g	1.47de	1.52d	1.50cde	36.59a	31.91a	34.26a
Sour orange	Control	No P	0.78h	0.79bc	0.79de	1.21a	1.25a	1.23a	1.99ab	2.04a	2.02a	30.17bc	33.91a	32.05ab
	Control	P	1.11ab	1.07a	1.10a	0.76de	0.84bc	0.80cde	1.78bc	1.91ab	1.89a	30.01bcd	25.08a	28.05bcd
	G.m.	No P	1.05bc	0.84bc	0.95bc	0.98b	1.16a	1.07b	2.03a	2.00a	2.02a	29.85bcd	31.58a	30.72abc
	G.m.	P	0.84fgh	0.77bc	0.80de	0.79cd	0.89bc	0.81cde	1.62d	1.66cd	1.64bc	26.64de	33.91a	30.28abc
	G.a.	No P	0.80gh	0.74c	0.77e	0.73def	0.93b	0.83cd	1.53de	1.67cd	1.60bc	32.30b	29.91a	31.11abc
	G.a.	P	0.88ef	0.93abc	0.91cd	0.61ef	0.81bcd	0.71ef	1.49de	1.74bc	1.62bcd	38.52a	28.41a	33.47ab

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No. P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

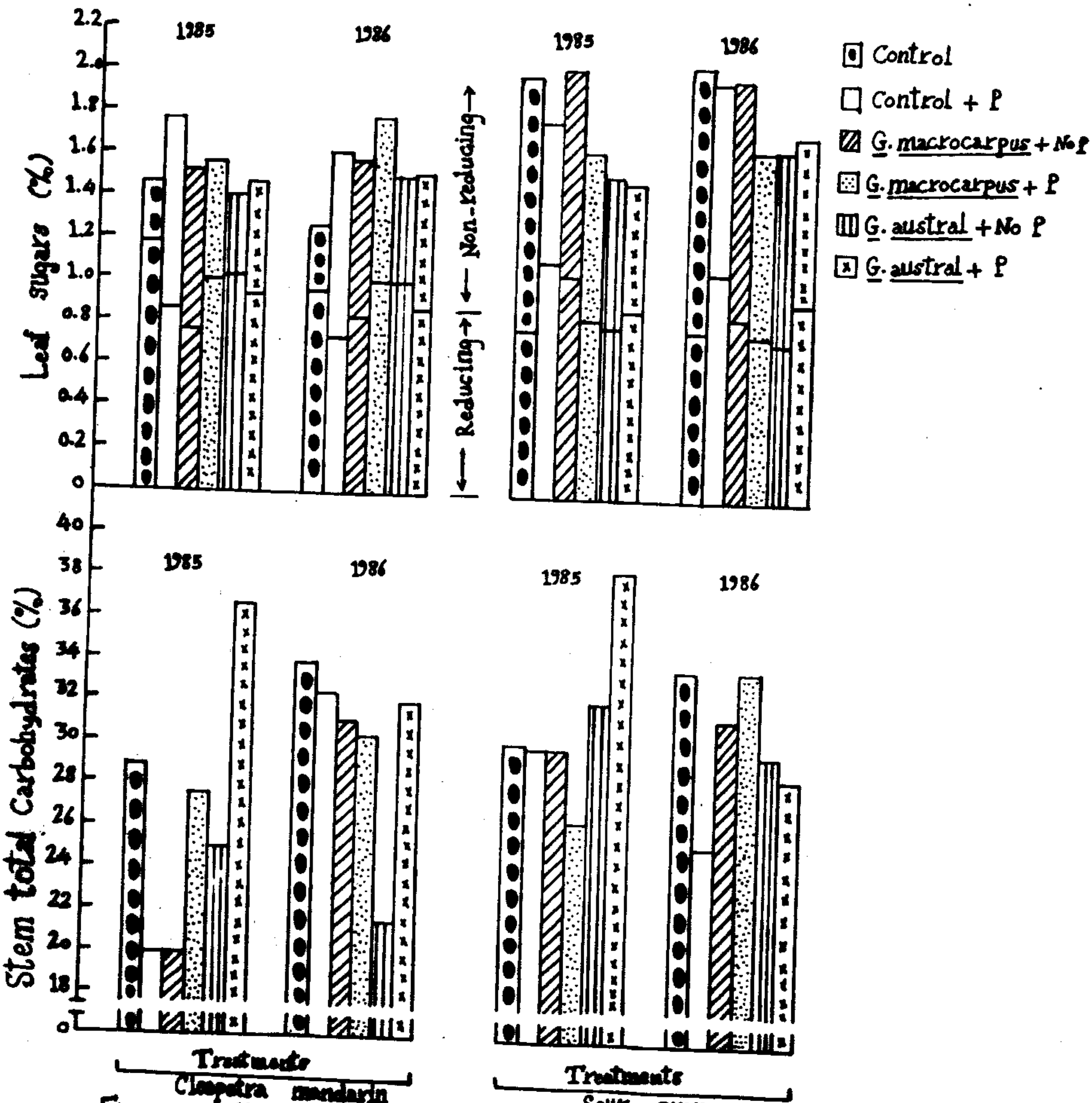


Fig (15) Effect of rootstock, mycorrhizal fungi and Phosphorus level on leaf sugars and stem total Carbohydrates of citrus seedlings.

leaves as compared with corresponding plants deprived from phosphorus fertilization whereas in control P fertilized plants they increased only leaf reducing sugars. However, mycorrhizae treatments for sour orange seedlings caused a general reduction in leaf reducing, non reducing and total sugars in respect of the corresponding ones of either unfertilized or fertilized control plants.

In regard to the effect of mycorrhizae species on leaf sugars of both citrus rootstocks used, it is found that Glomus macrocarpus fungi were more promising in increasing leaf non reducing and total sugars than Glomus australe fungi. That was true in both P fertilized and unfertilized plants. Unfortunately, in both stocks, no clear trend was noticed in explaining the effect of mycorrhizae species on leaf reducing sugar since fluctuated results were obtained.

Referring to stem total carbohydrates, it is quite evident that applying phosphorus to control plants of both citrus rootstocks used induced a decrease in stem total carbohydrates as compared with unfertilized control seedlings. Moreover, inoculating fertilized seedlings with mycorrhizae increased stem carbohydrates as compared with the analogous ones of fertilized and non-inoculated plants. Such results were observed by Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin seedlings with Glomus fasciculatus fungi. On the contrary, incoculating mycorrhizae for P unfertilized plants caused a decrease in stem total carbohydrates when compared with unfertilized check seedlings. Similar results were found by Peuss (1958) working on tabacco plants with vesicular arbuscular mycorrhizae, Harley (1969) on Endogone and Ectotrophic mycorrhizae in axenic culture, and Furlan and Fortin (1973) on onion plants with Endogone calospora fungi.

Specific effect :

Specific effect of rootstock, mycorrhizal fungi, and phosphorus level on leaf sugars and stem total carbohydrates of citrus seedlings is disclosed in Table (11-c).

Considering rootstock, it is found that sour orange seedlings had higher percentages of leaf non reducing and total sugars as well as stem total carbohydrates in comparison with those of Cleopatra mandarin. However, a slight decrease in leaf reducing

Table (11-c): Specific effect of rootstock, mycorrhizal fungi, and phosphorus level on leaf sugars and stem total carbohydrates of citrus seedlings.

Treatments	Leaf sugars									Stem total Carbohydrates		
	Reducing			Non-reducing			Total					
	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
1. Roostatock												
C.m.	0.96a	0.90a	0.93a	0.58b	0.65b	0.62b	1.54b	1.55b	1.55b	26.32b	30.17a	28.25b
S.o.	0.91b	0.86a	0.89a	0.85a	0.98a	0.92a	1.76a	1.84a	1.80a	31.42a	30.47a	30.95a
2. Mycorrhizae												
Control	0.99a	0.89a	0.94a	0.79a	0.82ab	0.81a	1.78a	1.71a	1.75a	27.50b	31.29a	29.40a
G.m.	0.91b	0.86a	0.89a	0.78a	0.90a	0.84a	1.69a	1.76a	1.73a	26.00b	31.71a	28.86a
G.a.	0.91b	0.86a	0.89a	0.57b	0.75b	0.66b	1.48b	1.61b	1.55b	33.12a	27.96a	30.54a
3. Phosphorus												
No P	0.93a	0.86a	0.90a	0.73a	0.82a	0.78a	1.66a	1.68a	1.67a	27.69b	30.31a	29.00a
P	0.94a	0.90a	0.92a	0.69a	0.73b	0.71b	1.63a	1.71a	1.67a	30.05a	30.33a	30.19a

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.
S.o. = Sour orange.
C.m. = Cleopatra mandarin.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

sugars of sour orange seedlings was noticed when compared with those of Cleopatra mandarin. In this respect, the significant difference was lacking. Similar results were found by Edrees (1982) on rough lemon, sour orange, and Cleopatra mandarin seedlings with Glomus fasciculatus.

In regard to mycorrhizae, it is clear that Glomus australe fungi decreased visually leaf non-reducing and total sugars and slightly reducing sugars than the control. Moreover, such fungi species increased insignificantly stem total carbohydrates over the control. On the other hand, Glomus macrocarpus treatments decreased slightly leaf reducing and total sugars as well as stem total carbohydrates as compared with the control.

Concerning specific effect of phosphorus, it is clear that although phosphorus application decreased significantly leaf non-reducing sugars, it had no statistical effect on leaf reducing and total sugars as well as stem total carbohydrates.

4.10. **Leaf nitrogen fractions :**

Leaf nitrogen fractions content before transplanting of citrus seedling rootstocks are presented in Table (12-a). It is clear that sour orange leaf contained higher amounts of crystalloid - N and ammonium - N and lower levels of soluble -N , rest - N and nitrates than those of Cleopatra mandarin.

Meanwhile, leaf nitrogen fractions content of both citrus seedling rootstocks as affected by mycorrhizal fungi inoculation and phosphorus fertilization are shown in Table (12-b). It is obvious that control plants of Cleopatra mandarin fertilized with phosphorus had leaves with higher amounts of soluble nitrogen, crystalloid nitrogen and ammonium nitrogen and lower level of rest nitrogen and nitrates than the corresponding ones of unfertilized control seedlings. On the other hand, data of sour orange indicated that fertilized control plants as compared with unfertilized control ones had leaves containing higher amounts of soluble nitrogen and crystalloid nitrogen and lower contents of rest nitrogen, ammonium nitrogen and nitrates.

Table (12-a) : Leaf nitrogen fractions content before transplanting of citrus seedling rootstocks.

Rootstock	Soluble-N 85	Soluble-N 86	Crystalloid-N 85	Crystalloid-N 86	Rest - N 85	Rest - N 86	Ammonium-N 85	Ammonium-N 86	Nitrate 85	Nitrate 86
Cleopatra mandarin	0.533	0.530	0.258	0.261	0.295	0.269	0.117	0.118	0.077	0.080
Sour orange	0.539	0.516	0.302	0.304	0.237	0.212	0.133	0.133	0.051	0.050

Table (12-b): Leaf nitrogen fractions content of two citrus seedling rootstocks as affected by endomycorrhizal fungi inoculation and phosphorus fertilization.

Rootstock	Mycorrhizae	Phosphorus	Soluble nitrogen 85	Soluble nitrogen 86	Soluble nitrogen Mean	Crystalloid nitrogen 85	Crystalloid nitrogen 86	Crystalloid nitrogen Mean	Rest nitrogen 85	Rest nitrogen 86	Rest nitrogen Mean	Ammonium nitrogen 85	Ammonium nitrogen 86	Ammonium nitrogen Mean	Nitrate 85	Nitrate 86	Nitrate Mean
Cleopatra mandarin	Control	No P	0.550d	0.395d	0.473d	0.309ef	0.240e	0.275e	0.241b	0.154b	0.198b	0.088d	0.049c	0.069e	0.068c	0.049d	0.058c
	Control	P	0.613a	0.415c	0.515a	0.373abc	0.266d	0.320b	0240b	0.149bc	0.195b	0.118a	0.058b	0.088a	0.040e	0.019g	0.030h
	G.m.	No P	0.561cd	0.427c	0.495bc	0.317e	0.269d	0.294d	0.243b	0.157b	0.201b	0.098c	0.069a	0.084b	0.020h	0.039e	0.030h
	G.m.	P	0.518ef	0.338f	0.429f	0.258g	0.152g	0.205g	0.260a	0.186a	0.224a	0.049g	0.058b	0.054h	0.098b	0.029f	0.064b
	G.a.	No P	0.550d	0.427c	0.489c	0.379ab	0.304b	0.342a	0.200de	0.123de	0.162ef	0.097c	0.059b	0.079c	0.058d	0.059c	0.059c
	G.a.	P	0.550d	0.387de	0.469d	0.352cd	0.249e	0.301cd	0.197de	0.137cd	0.168de	0.088d	0.058b	0.073d	0.058d	0.069b	0.064b
Sour orange	Control	No P	0.490g	0.378e	0.434f	0.289f	0.220f	0.255f	0.200de	0.157b	0.179c	0.0b9e	0.048c	0.059g	0.103a	0.078a	0.091a
	Control	P	0.556cd	0.449b	0.503b	0.358bcd	0.340a	0.349a	0.198de	0.109ef	0.154f	0.088d	0.019fg	0.054h	0.058d	0.030f	0.045e
	G.m.	No P	0.570bc	0.478a	0.524a	0.344d	0.301b	0.323b	0.226c	0.177a	0.202b	0.058f	0.029e	0.044i	0.038f	0.059c	0.049d
	G.m.	P	0.527e	0.346b	0.437ef	0.318e	0.212f	0.265ef	0.209d	0.134d	0.172cd	0.098c	0.039d	0.059g	0.039ef	0.039e	0.039f
	G.a.	No P	0.582b	0.415c	0.499bc	0.390a	0.301b	0.347a	0.192e	0.114ef	0.154f	0.108b	0.018g	0.064f	0.029g	0.038e	0.034g
	G.a.	P	0.498fg	0.389de	0.444e	0.335de	0.283c	0.310bc	0.163f	0.106f	0.135g	0.108b	0.020f	0.064f	0.029g	0.048d	0.039f

Control = No inoculation with mycorrhizae.
G.m. = Glomus macrocarpus.
G.a. = Glomus australe.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

As for mycorrhizae fungi treatments were concerned, it is clear that inoculated and P fertilized plants developed leaves with higher amounts of soluble nitrogen, crystalloid nitrogen and ammonium nitrogen as well as lower levels of nitrates in respect of those of unfertilized control ones. Concerning leaf rest nitrogen, it is obvious that the effect of mycorrhizae depend upon the species itself used. In this respect, while Glomus macrocarpus fungi increased leaf rest nitrogen of unfertilized plants, Glomus australe on the other side, decreased leaf rest nitrogen than non inoculated and P unfertilized plants. Such results were clear in both rootstocks used.

Inoculating fertilized plants of Cleopatra mandarin with mycorrhizae resulted in a decrease in leaf soluble nitrogen, crystalloid nitrogen and ammonium nitrogen and an increase in leaf nitrate as compard with the analogous ones of fertilized control plants.

Regarding sour orange, it is found that treating P fertilized seedlings with mycorrhizae fungi decreased leaf contents of soluble nitrogen, crystalloid nitrogen and nitrates and increased leaf ammonium nitrogen as compared with the analogous fertilized control ones. The effect of mycorrhizae fungi species combined with phosphorus fertilizer on leaf rest nitrogen did not give a clear trend. In this sphere, while Glomus macrocarpus fungi increased leaf rest nitrogen, Glomus australe took the other way around. Generally, similar results were found by Mac-Donald and Lewis (1978) regarding the role of Glomus mosseae fungi in N uptake and metabolism in plants, Pate (1980) concerning the inorganic N transported from root to shoots by xylem sap in the woody plants. Also Nemec and Meridith (1981) reported that endomycorrhizae fungi caused increased amino acids levels in leaves of citrus rootstocks which indicate an involvement in N metabolism comparing with non-mycorrhizal plants, and Edrees (1982), on rough lemon, sour orange, and Cleopatra mandarin seedlings with Glomus fasciculatus fungi.

Specific effect :

Table (12-c) involved the specific effect of rootstock, mycorrhizal fungi, and phosphorus level on leaf nitrogen fractions content of citrus seedlings.

Table (12-c): Specific effect of rootstock, mycorrhizal fungi, and phosphorus level on leaf nitrogen fractions content of citrus seedlings.

Treatments	Leaf nitrogen fractions (%)														
	Soluble nitrogen			Crystalloid nitrogen			Rest nitrogen			Ammonium nitrogen			Nitrate		
	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean	85	86	Mean
1. Rootstock															
C.m.	0.56a	0.40a	0.480a	0.33a	0.25b	0.29b	0.23a	0.15a	0.190a	0.090a	0.06a	0.075a	0.06a	0.04b	0.05a
S.o.	0.54b	0.41a	0.475b	0.34a	0.28a	0.31a	0.20b	0.13b	0.165b	0.086b	0.03b	0.059b	0.05b	0.05a	0.05a
2. Mycorrhizae															
Control	0.55a	0.41a	0.48a	0.33b	0.27b	0.300b	0.22b	0.14b	0.180b	0.09b	0.04b	0.065b	0.07a	0.04b	0.055a
G.m.	0.54a	0.40a	0.47a	0.31c	0.23c	0.270c	0.24a	0.16a	0.200a	0.08c	0.05a	0.065b	0.05b	0.04b	0.045b
G.a.	0.55a	0.41a	0.48a	0.36a	0.29a	0.325a	0.19c	0.12c	0.155c	0.10a	0.04b	0.070a	0.04c	0.05a	0.045b
3. Phosphorus															
No P	0.55a	0.42a	0.485a	0.34a	0.27a	0.305a	0.22a	0.15a	0.185a	0.087b	0.05a	0.069b	0.05a	0.05a	0.050a
P	0.54a	0.39b	0.465b	0.33a	0.25b	0.290a	0.21a	0.14a	0.175b	0.092a	0.05a	0.071a	0.05a	0.04b	0.045b

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.
S.o. = Sour orange.
C.m. = Cleopatra mandarin.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

Regarding specific effect of rootstock it is interesting to notice that higher amounts of soluble nitrogen, rest nitrogen, and ammonium nitrogen existed in leaves of Cleopatra mandarin seedlings than those of sour orange. The reverse was true as leaf crystalloid nitrogen was concerned. In addition, no statistical effect of rootstock on leaf nitrate content was observed since values were more or less similar.

Furthermore, data of specific effect of mycorrhizae indicated that Glomus macrocarpus fungi as compared with the control significantly decreased leaf crystalloid nitrogen and nitrate contents as well as increased leaf rest nitrogen, simultaneously. Moreover, the obtained results showed that Glomus macrocarpus fungi had no statistical effect on leaf soluble nitrogen and ammonium nitrogen when compared with the control. Meanwhile, Glomus australe significantly increased leaf crystalloid nitrogen and ammonium nitrogen whereas it decreased leaf rest nitrogen and nitrate contents. For all that, Glomus australe fungi had no effect on leaf soluble nitrogen content .

Furthermore, specific effect of phosphorus clearly showed that seedlings received phosphorus failed significantly to produce leaves with higher contents of soluble nitrogen, rest nitrogen, and nitrate. Nevertheless, the picture was completely changed to the reverse when leaf ammonium nitrogen was concerned. Beside, the values of crystalloid nitrogen of P fertilized and unfertilized plants were statistically simillar.

4.11. Root nitrogen fractions :

Root nitrogen fractions content before transplanting of citrus seedling rootstocks are presented in Table (13-a). It is clear that roots of sour orange seedlings as compared with those of Cleopatra mandarin contained higher amounts of soluble - N, Crystalloid - N, and nitrate as well as lower levels of rest - N, and ammonium nitrogen.

Moreover, roots nitrogen fractions of two citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization are disclosed in Table (13-b). It is found that in Cleopatra mandarin, control seedlings fertilized with phosphorus gave higher amounts of root soluble nitrogen, rest nitrogen and nitrate and

Table (13-a) : Root nitrogen fractions content of citrus seedlings before transplanting.

Rootstock	Soluble-N 85	Soluble-N 86	Crystalloid-N 85	Crystalloid-N 86	Rest-N 85	Rest-N 86	Ammonium-N 85	Ammonium-N 86	Nitrate 85	Nitrate 86
Cleopatra mandarin	0.427	0.409	0.172	0.180	0.255	0.229	0.107	0.108	0.029	0.042
Sour Orange	0.518	0.501	0.318	0.321	0.201	0.180	0.067	0.076	0.048	0.058

Table (13-b): Root nitrogen fractions content of two citrus seedling rootstocks as affected by endomycorrhizal fungi inoculation and phosphorus fertilization.

Rootstock	Mycorrhizae	Phosphorus	Soluble nitrogen 85	Soluble nitrogen 86	Soluble nitrogen Mean	Crystalloid nitrogen 85	Crystalloid nitrogen 86	Crystalloid nitrogen Mean	Rest nitrogen 85	Rest nitrogen 86	Rest nitrogen Mean	Ammonium nitrogen 85	Ammonium nitrogen 86	Ammonium nitrogen Mean	Nitrate 85	Nitrate 86	Nitrate Mean
Cleopatra mandarin	Control	No P	0.481fg	0.858e	0.470fg	0.347cd	0.392a	0.370d	0.134f	0.066g	0.100f	0.186a	0.137a	0.162a	0.39g	0.038d	0.039h
	Control	P	0.498e	0.473bc	0.486e	0.329de	0.353c	0.341e	0.169d	0.120d	0.145c	0.108d	0.108d	0.109e	0.49f	0.039cd	0.044g
	G.m.	No P	0.498e	0.459de	0.479ef	0.295fg	0.309de	0.303g	0.203a	0.146b	0.175a	0.088e	0.117c	0.103f	0.89b	0.041c	0.065c
	G.m.	P	0.495ef	0.381h	0.439i	0.312ef	0.246f	0.280hi	0.183c	0.134c	0.159b	0.078f	0.108d	0.093g	0.088b	0.048b	0.069b
	G.a.	No P	0.642a	0.510a	0.576a	0.436a	0.378b	0.407a	0.206a	0.131cd	0.169a	0.087e	0.119b	0.103f	0.088b	0.038d	0.063d
	G.a.	P	0.490ef	0.418g	0.455h	0.335de	0.298e	0.317f	0.155e	0.120d	0.138cd	0.088e	0.087f	0.088h	0.109a	0.040cd	0.075a
Sour orange	Control	No P	0.559c	0.47bcd	0.516c	0.390b	0.380ab	0.385bc	0.169d	0.092f	0.131de	0.137b	0.117c	0.127b	0.048f	0.049b	0.049f
	Control	P	0.470gh	0.384h	0.427j	0.284g	0.261f	0.273i	0.186bc	0.123d	0.155b	0.117c	0.098e	0.108e	0.058e	0.029e	0.044g
	G.m.	No P	0.467h	0.464cde	0.466g	0.278g	0.306e	0.292gh	0.189bc	0.157a	0.173a	0.078f	0.098e	0.089gh	0.070c	0.077a	0.074a
	G.m.	P	0.530d	0.478b	0.504d	0.372bc	0.378b	0.375cd	0.157e	0.100ef	0.129e	0.118c	0.138a	0.128b	0.067d	0.040cd	0.054e
	G.a.	No P	0.621b	0.481b	0.552b	0.424a	0.378b	0.391b	0.197ab	0.123d	0.160b	0.117c	0.108d	0.113d	0.021h	0.039cd	0.030i
	G.a.	P	0.558c	0.435f	0.497d	0.378b	0.322d	0.351e	0.180cd	0.106e	0.143c	0.118c	0.118bc	0.118c	0.087b	0.039cd	0.064cd

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

lower amounts of crystalloid nitrogen and ammonium nitrogen contents as compared with unfertilized ones. The differences were almost statistically significant. Regarding sour orange seedlings, it is quite evident that adding phosphorus to control plants in respect of unfertilized ones caused a reduction in root soluble nitrogen, crystalloid nitrogen, ammonium nitrogen, and nitrate contents and an increase in rest nitrogen. The significant difference was observed in all nitrogen fractions.

Referring to inoculated seedlings of Cleopatra mandarin and unfertilized, it is obvious that mycorrhizae treatments increased root soluble - N, rest - N, and nitrate values over the analogous ones of non inoculated plants. Such results confirmed the findings of Baltruschat and Schonbeck (1975) on vesicular arbuscular mycorrhizae.

On other point of view, mycorrhizae decreased root ammonium nitrogen in respect of non-inoculated plants. Furthermore, the effect of mycorrhizae on root crystalloid nitrogen varied according to the species used. In this respect, while Glomus macrocarpus fungi decreased root crystalloid nitrogen, Glomus australe fungi gave an opposite effect. This result may be reterieved that some nitrogen fractions were transported from roots to shoots by xylem sap in plants according to Pate (1980).

Concerning sour orange seedlings, it is quite evident that control P fertilized plants as compared with control unfertilized ones produced roots with lower levels of soluble nitrogen, crystalloid nitrogen, ammonium nitrogen, and nitrate as well as higher amounts of rest nitrogen. The differences were significant.

Furthermore, inoculated plants showed that treating seedlings with Glomus macrocarpus and deprived of phosphorus fertilizer gave roots with lower amounts of soluble nitrogen, crystalloid nitrogen and ammonium nitrogen and higher level of rest nitrogen. The same seedlings but inoculated with Glomus australe gave another results. In this respect, those treated plants produced roots with higher contents of soluble nitrogen, crystalloid nitrogen, and rest nitrogen. Root ammonium nitrogen and nitrate levels showed the opposite trend. Moreover, applying phosphorus to inoculated plants increased markedly root soluble nitrogen, crystalloid nitrogen, ammonium nitrogen, and nitrate contents and decreased root rest nitrogen level in respect of the corresponding ones of non-inoculated and fertilized plants. Similar results were found by Coxwell and Johnson (1985) on Pittasporum tobira plants with Glomus mosseae fungi.

Specific effect :

As shown in Table (13-c) specific effect of rootstock indicated that roots of sour orange were higher in soluble nitrogen and lower in nitrate content when compared with those of Cleopatra mandarin. However, rootstock had no effect on root crystalloid nitrogen, and ammonium nitrogen. The significant differences between the two rootstocks used were nil.

Moreover, specific effect of mycorrhizae showed that Glomus australe fungi raised up the values of root soluble nitrogen, crystalloid nitrogen, rest nitrogen, and nitrate contents and dropped down ammonium nitrogen values in comparison with the control.

On the other hand, Glomus macrocarpus fungi

Table (13-c): Specific effect of rootstock, mycorrhizal fungi, and phosphorus level on root nitrogen fractions content of citrus seedlings.

Treatments	Root nitrogen fractions (%) Soluble nitrogen 85	86	Mean	Crystalloid nitrogen 85	86	Mean	Rest nitrogen 85	86	Mean	Ammonium nitrogen 85	86	Mean	Nitrate 85	86	Mean
1. Rootstock															
C.m.	0.52b	0.45a	0.485b	0.34a	0.33a	0.335a	0.18a	0.12a	0.150a	0.11a	0.11a	0.110a	0.08a	0.04b	0.060a
S.o.	0.53a	0.45a	0.490a	0.35a	0.34a	0.345a	0.18a	0.12a	0.150a	0.11a	0.11a	0.110a	0.06b	0.05a	0.055b
2. Mycorrhizae															
Control	0.50b	0.45b	0.475b	0.34b	0.35a	0.345b	0.17b	0.10c	0.135c	0.14a	0.12a	0.130a	0.05b	0.04b	0.045c
G.m.	0.50b	0.45b	0.475b	0.32c	0.31b	0.315c	0.18a	0.14a	0.160a	0.09c	0.12a	0.105b	0.08a	0.05a	0.065a
G.a.	0.58a	0.46a	0.520a	0.39a	0.40a	0.395a	0.18a	0.12b	0.150b	0.10b	0.11b	0.105b	0.08a	0.04b	0.060b
3. Phosphorus															
No P	0.55a	0.47a	0.510a	0.36a	0.35a	0.355a	0.18a	0.12a	0.150a	0.12a	0.12a	0.120a	0.06b	0.05a	0.055b
P	0.51b	0.43b	0.470b	0.34b	0.31b	0.325b	0.17b	0.12a	0.145b	0.11b	0.11b	0.110b	0.12a	0.04b	0.080a

Control = No inoculation with mycorrhizae.
G.m. = Glomus macrocarpus.
G.a. = Glomus australe.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.
S.o. = Sour orange.
C.m. = Cleopatra mandarin.

Means followed by the same letter, within each column, are not significantly different from each other at 1% level.

as compared with the control caused an increment in root rest nitrogen and nitrate contents whereas it induced a negative effect on root crystalloid nitrogen, and ammonium nitrogen. Such fungi species did not affect root soluble nitrogen content, hence no significant difference was noticed between treated seedlings and the control.

Furthermore, specific effect of phosphorus clearly showed that applying phosphorus to citrus seedlings decreased their root solble nitrogen, crystalloid nitrogen, rest nitrogen, and ammonium nitrogen contents. Beside, phosphorus fertilizer increased root nitrate content over the control. The difference between fertilized and unfertilized plants in all root nitrogen fractions were obviously significant.

4.12. Plant amino acids content :

4.12.a. Leaf amino acids :

Leaf amino acids content of two citrus seedling rootstocks as affected by endomycorrhizal fungi inoculation and phosphorus fertilization during 1986 season is shown in Table (14-a). It is obvious that in both

Table (14-a): Leaf amino acids content of two citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization during 1986 season.

Treatments			Amino acids content (mg./100g.dry leaves)														
Root-stock	Mycorrhizae	Phos-phorus	Leucine & isoleucine	Phenylalanine	Valine	Methionine	Tyrosine	Proline	Alanine & Glutamic	Threonine	Hydroxy-proline	Glysine	Serine	Arginine	Histidine	Lysine	Total
Cleopatra mandarin	Control	No P	20.2	4.9	1.9	5.5	2.3	9.5	2.6	1.0	12.1	1.4	5.1	1.0	1.1	0.0	68.6
	Control	P	20.2	6.0	.2.4	8.8	2.9	13.1	3.6	1.7	13.8	1.8	6.8	1.7	1.2	0.0	84.0
	G.m.	No P	25.0	6.0	2.4	7.4	1.9	21.4	3.6	1.7	14.8	1.6	4.8	1.3	0.0	0.0	91.9
	G.m.	P	28.6	5.2	2.0	1.6	1.0	14.3	0.7	0.3	3.6	0.5	1.7	0.3	0.0	0.0	59.8
	G.a.	No P	21.4	5.2	2.1	6.0	1.9	19.1	4.5	1.9	15.5	1.7	5.5	1.7	1.4	0.0	87.9
	G.a.	P	21.4	5.2	1.2	6.6	2.1	14.3	3.6	1.2	10.5	1.4	4.8	1.4	0.8	3.1	77.6
Sour orange	Control	No P	17.9	4.5	1.4	5.4	1.8	15.5	2.5	0.7	7.1	1.0	3.3	1.0	1.7	0.0	63.8
	Control	P	23.0	5.2	1.7	5.5	2.0	14.3	3.6	1.2	8.8	1.3	5.1	1.2	1.3	0.0	74.2
	G.m.	No P	25.5	4.5	2.1	8.8	2.1	21.1	2.5	1.4	11.2	1.4	4.1	2.0	0.0	0.0	36.7
	G.m.	P	7.1	1.2	1.0	2.4	0.7	33.3	1.0	1.0	9.6	0.7	3.3	1.0	0.0	0.0	62.3
	G.a.	No P	25.0	4.5	2.9	7.4	3.1	16.7	4.1	1.4	11.2	1.4	7.1	1.7	2.0	0.0	88.5
	G.a.	P	17.9	4.5	1.2	5.7	1.4	26.2	2.5	0.7	8.8	0.7	2.6	1.0	0.0	0.0	73.2

Control = no inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.

rootstocks, fertilized control seedlings as compared with those of unfertilized control ones had leaves with higher amounts of the different amino acids under study except leucine and Isoleucine for Cleopatra mandarin and Histidine for sour orange. However, Lysine amino acid in leaves of both P fertilized and unfertilized control seedlings was nil. Moreover, leaf total amino acids of fertilized control plants was higher than the analogous ones of unfertilized control.

Concerning mycorrhizae treatments, data clearly showed that in plants of both citrus rootstocks inoculated and unfertilized in respect of unfertilized control ones were more rich in leaf amino acids content except Tyrosine and Serine in leaves of Cleopatra mandarin. Moreover, leaves of plants inoculated with Glomus macrocarpus fungi and unfertilized of both rootstocks were completely void of Lysine and Histidine. Generally, mycorrhizae treatments increased profoundly amino acids content than the control. These results confirm those reported by Mac-Donald and Lewis (1978) working on the role of Glomus mosseae fungi in N uptake or metobolism in plants, and Nemec and Meridith (1981) on citrus rootstocks with vesicular arbuscular mycorrhizae.

Comparing the two species of mycorrhizae under study, it is found that Glomus macrocarpus fungi increased leaf Leucine and Isoleucine, Phenyl Alanine, Methionine, and Proline amino acids than Glomus australe. The vice versa was obtained when leaf Alanine + Glutamic , Threonine, Hydroxy Proline, Glysine, Serine, Arginine, and Histidine amino acids of Cleopatra mandarin rootstock were considered. Meanwhile, Glomus australe fungi for sour orange plants surpassed Glomus macrocarpus in increasing leaf content of Valine, Tyrosine, Alanine + Glutamic, and serine amino acids.

Referring to inoculated and P fertilized seedlings as well as non-inoculated and fertilized ones, it is well noticed that in Cleopatra mandarin mycorrhizae increased leaf Leucine and Isoleucine, and Proline amino acids whereas in sour orange such effect was only observed in case of leaf Proline and Hydroxy Proline amino acids. The picture was completely changed to the reverse when other amino acids studied were put in consideration. Beside, data showed also that applying phosphorus to inoculated plants decreased leaf total amino acids as compared with the analogous ones of inoculated but deprived of phosphorus. In the same time, the present study disclosed that Leucine and Isoleucine, Proline, and Hydroxy Proline amino acids were dominent in leaves of citrus rootstocks than the other amino acids studied. On the other hand, leaf Valine, Tyrosine, Threonine, Glysine, Arginine, and Histidine amino acids took the other way around in this respect. Other amino acids were in between in their values. Similar results were found by Bowen and Theodorou (1973) on Pinus radiata seedlings with ectomycorrhizae, Nemec and Meridith (1981) working on citrus rootstocks with endomycorrhizal fungus, and Coxwell and Johnson (1985) report on Pittasporum tobira plants with Glomus mosseae fungi.

4.12.b **Root amino acids content :**

Root amino acids content of two citrus seedling rootstocks as affected by endomycorrhizal fungi inoculation and phosphorus fertilization are presented in Table (14-b). It is quite evident that in Cleopatra mandarin, fertilized control seedlings as comapared with unfertilized control ones had higher values of root Valine, Methionine, Tyrosine, Proline, Alanine + Glutamic acid, and Glysine. On

Table (14-b): Root amino acids content of two citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization during 1986 season.

Root-stock	Mycorrhizae	Phosphorus	Leucine & isoleucine	Phenylalanine	Valine	Methionine	Tyrosine	Proline	Alanine & Glutamic	Threonine	Hydroxyproline	Glysine	Serine	Arginine	Histidine	Lysine	Total
			Amino acids content (mg./100g.dry roots)														
Cleopatra mandarin	Control	No P	21.4	5.2	1.2	6.7	1.9	38.3	3.1	1.7	10.5	1.2	4.8	1.2	1.2	0.0	98.4
	Control	P	14.3	5.2	1.7	8.8	3.1	42.9	4.0	1.7	10.5	1.4	4.8	1.2	0.0	0.0	99.6
	G.m.	No P	24.5	6.0	1.7	8.8	2.1	38.3	3.6	1.0	11.9	1.7	4.8	1.7	0.0	0.0	106.1
	G.m.	P	28.6	6.0	7.4	11.0	11.2	47.6	6.9	1.7	10.5	1.7	6.4	1.9	1.7	0.0	142.6
	G.a.	No P	24.4	4.5	1.7	8.8	2.1	42.9	3.6	0.7	11.9	1.4	4.8	1.7	0.0	0.0	108.0
	G.a.	P	21.4	6.0	2.4	8.8	3.1	38.3	4.5	1.4	10.5	1.4	5.7	1.7	0.0	0.0	105.2
Sour orange	Control	No P	21.4	4.5	1.7	5.5	2.1	16.7	3.1	1.7	10.5	1.4	4.8	0.0	0.0	0.0	73.4
	Control	P	21.4	6.0	1.2	6.7	2.1	16.7	3.1	1.7	10.5	1.2	4.8	1.0	0.0	0.0	76.4
	G.m.	No P	24.5	6.0	1.9	8.8	3.1	14.3	2.6	1.0	11.9	1.8	5.5	1.0	0.0	0.0	82.4
	G.m.	P	36.2	6.0	2.4	8.8	4.5	23.8	3.1	1.7	13.8	1.9	4.8	1.7	1.7	0.0	110.4
	G.a.	No P	21.4	3.1	2.4	8.8	2.6	14.82	3.6	1.2	10.5	1.7	5.5	1.2	0.0	0.0	76.8
	G.a.	P	21.4	6.0	1.7	6.7	2.1	16.7	4.0	0.7	10.5	1.4	4.8	1.2	1.2	0.0	78.4

Control = no inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.

the contrary, such seedlings had lowest value of root Leucine and Isoleucine content. However, other studied amino acids in roots of both fertilized and unfertilized control plants were more or less similar in their values. Generally, Lysine in roots of these seedlings was lacking.

On the other hand, fertilized control plants of sour orange were higher in their root values of Phenyl Alanine, Methionine, and Arginine in respect of unfertilized ones. The vice versa was noticed when Valine, and Glysine were concerned. The other amino acids under study were at comparable values.

Furthermore, in both rootstocks inoculated. seedlings with mycorrhizae and unfertilized developed roots with higher amounts of Leucine and Isoleucine, Phenylalanine, Valine, Methionine, Tyrosine, Alanine and Glutamic, Hydroxy Proline, Glysine and Arginine as compared with the corresponding ones of non inoculated plants. The reverse was true in case of Threonine acid. In addition, such seedlings failed completely to build up Histidine and Lysine in their roots. Generally, mycorrhizae treatments increased profoundly root total amino acids content than the nonmycorrhizal seedlings. Similar results were obtained by Krupa *et al*., (1973) and the same author and Bränströn (1974) on *Pinus sylvestris* with *suillus variegatus* fungi, and Baltruschat and Schonbeck (1975) findings on vesicular arbuscular mycorrhizal fungi studies.

In both rootstocks, inoculated and phosphorus fertilized seedlings were more rich in root Leucine and Isoleucine, Valine, Methionine, Glysine, and Arginine. Such seedlings, mainly those inoculated with *Glomus australe* fungi, had roots with lower amounts of Proline and Thremnine amino acids for Cleopatra mandarin and Threonine for sour orange.

Furthermore, values of Hydroxy Proline for Cleopatra mandarin as well as Phenyl Alanine and Serine for sour orange were more or less similar.

Concerning total amino acids, it is clear that applying phosphorus for control plants of both citrus rootstocks increased root total amino acids over unfertilized control ones. Moreover, mycorrhizae treatments for both rootstocks greatly increased root total amino acids over the corresponding ones of the control. Similar results were found by

Hacskaylo (1971) report on ectomycorrhizae, Bowen and Theodorou (1973) on Pinus radiata seedlings with ectomycorrhizae, and Coxwell and Johnson (1985) on Pittosporum tobira plants with Glomus mosseae fungi.

In this sphere, seedlings inoculated with Glomus macrocarpus fungi were higher in their values of root total amino acids as compared with those ones treated with Glomus australe mycorrhizae.

Furthermore, data disclosed also that Leucine and Isoleucine, Proline, and Hydroxy Proline existed in roots of citrus seedlings with higher amounts whereas Valine, Threonine, Glysine, Arginine, and Histidine amino acids were the least in roots. The other amino acids lied in between.

4.13 Leaf Cytokinins content :

The leaf cytokinins content of two citrus seedling rootstocks as affected by endomycorrhizal fungi inoculation and phosphorus fertilization are shown in Table (15) and graphically illustrated in Figs. (16, 17, 18, and 19). It is interesting to notice that in June, Cleopatra mandarin unfertilized

Table (15): Leaf cytokinins content of two seedling rootstocks of citrus as affected by endomycorrhizal fungi inoculation and phosphorus fertilization during 1986 season.

			Leaf Cytokinins content (ppm./25g. fresh weight)																					
			June											September										
			RF																					
Root-stock	Mycorrhizae	Phos-phorus	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	Total	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	Total
Cleopatra mandarin	Control	No P	6.6	9.6	9.2	8.5	7.1	9.5	12.1	9.6	5.9	4.8	82.9	2.6	4.6	3.7	2.6	5.2	3.4	5.6	1.7	1.8	3.4	34.6
	Control	P	6.2	7.2	5.8	8.9	6.5	8.4	6.8	6.3	7.7	3.0	63.8	5.8	6.1	5.3	4.7	4.5	3.8	2.7	5.2	3.8	4.3	46.2
	G.m.	No P	14.0	13.5	14.3	11.8	11.2	14.2	12.8	13.4	14.7	15.1	145.0	7.1	4.4	5.7	5.9	6.5	4.0	4.0	4.2	4.3	7.1	53.2
	G.m.	P	10.7	12.2	12.6	12.6	20.0	10.7	13.1	12.0	10.5	10.5	124.9	8.8	8.9	10.1	6.0	5.8	5.4	6.1	9.1	7.3	9.4	76.9
	G.a.	No P	12.7	11.7	12.8	13.8	11.0	9.3	9.6	13.8	14.1	14.9	123.7	6.8	7.5	8.2	7.1	7.7	6.1	7.3	8.0	11.3	7.2	77.2
	G.a.	P	9.4	13.4	12.9	14.0	12.7	11.5	10.7	12.3	10.4	10.5	117.8	8.8	10.0	7.5	9.0	8.1	7.9	8.2	11.3	10.4	3.5	89.7
Sour orange	Control	No P	7.2	7.0	7.7	6.0	6.3	7.5	12.1	6.3	7.0	6.8	75.1	3.3	4.8	3.7	2.4	1.3	3.4	6.3	5.7	6.2	6.4	43.5
	Control	P	6.8	6.2	6.4	8.9	7.0	4.9	5.4	6.5	7.2	6.0	65.3	4.5	5.1	3.3	5.9	2.0	3.0	2.3	2.9	3.9	1.6	34.5
	G.m.	No P	13.2	13.0	11.5	12.5	14.2	13.0	12.3	11.4	11.7	13.3	126.1	9.8	10.2	10.0	11.4	6.9	7.1	7.3	7.3	7.7	8.5	86.2
	G.m.	P	11.0	19.8	14.8	13.6	17.2	14.5	14.0	14.0	15.3	14.2	148.4	5.5	7.0	5.9	6.6	5.3	4.7	4.7	6.1	7.3	6.3	59.4
	G.a.	No p	10.5	15.2	14.2	13.2	12.3	13.7	15.0	15.5	14.1	13.7	137.4	4.3	3.8	2.7	3.0	3.0	5.4	5.2	6.2	5.0	4.2	42.8
	G.a.	P	11.0	11.4	14.7	13.0	14.9	11.8	12.7	9.7	9.7	13.5	122.4	9.1	7.3	6.3	5.8	7.9	5.1	6.6	7.3	6.9	7.5	69.8

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.

No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.

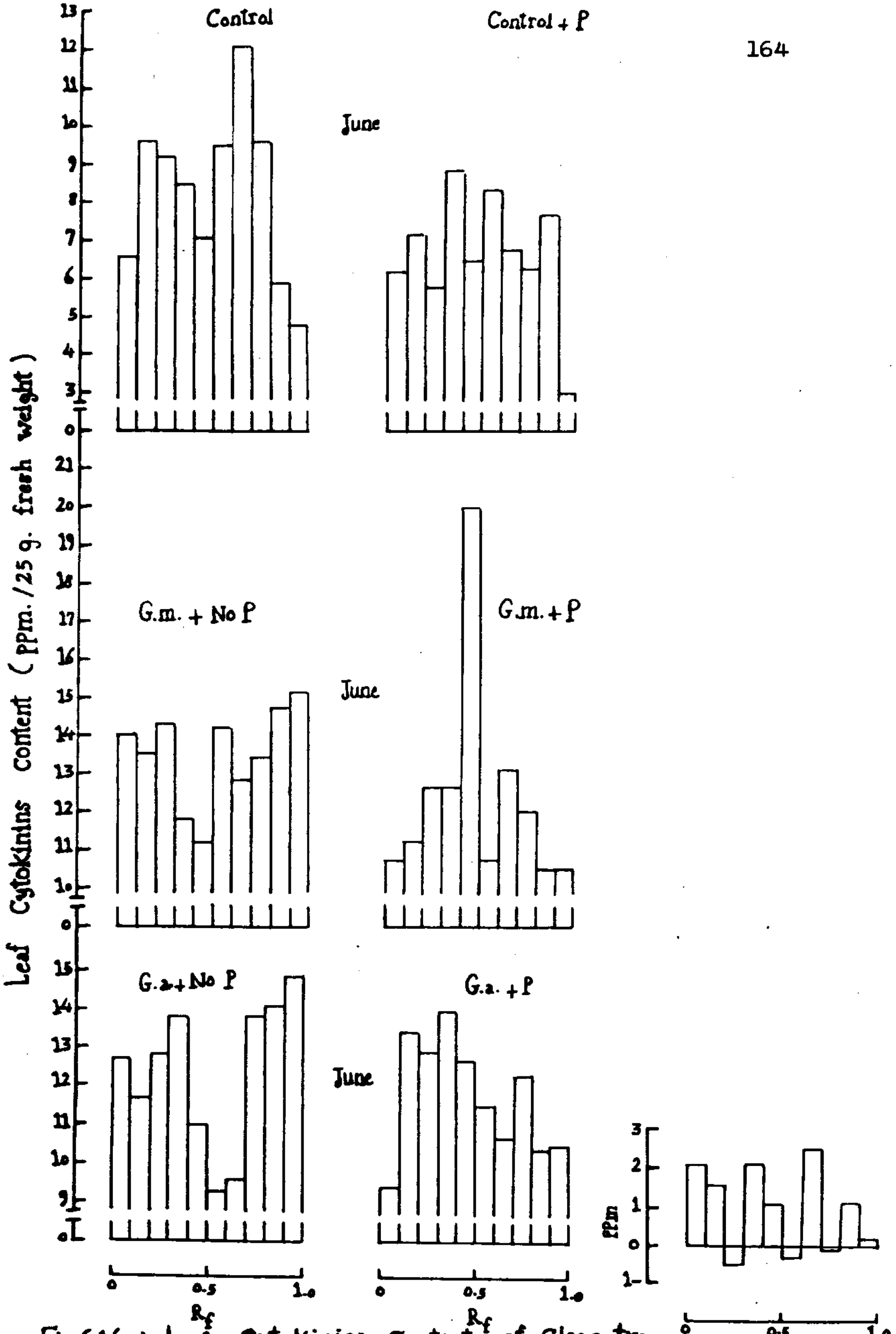


Fig (16) : Leaf Cytokinins Content of Cleopatra mandarin seedlings as affected by endomycorrhizal fungi and phosphorus level (June, 1986 Season).

Kinetin standard (10 p.p.m.)

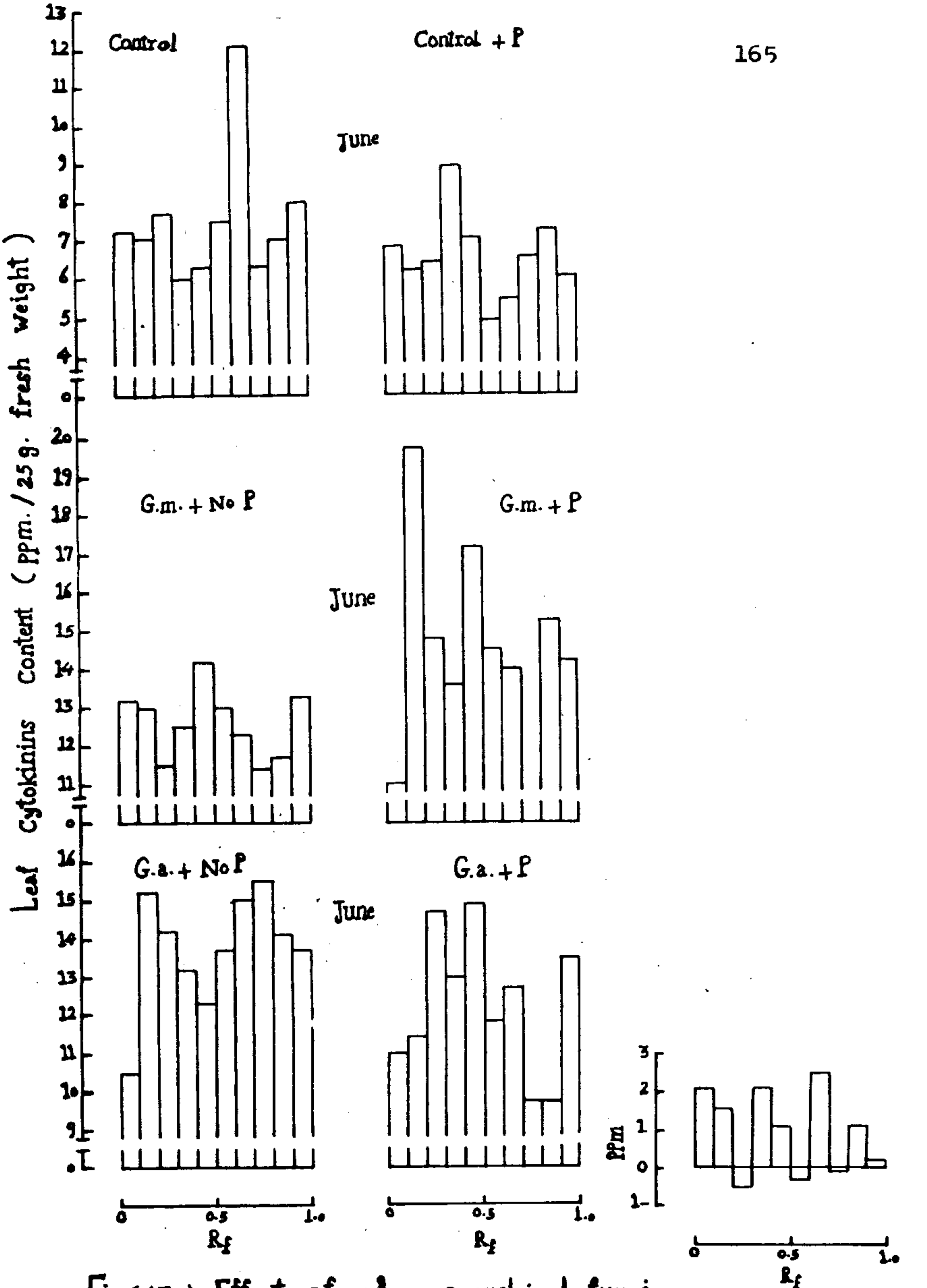


Fig (17): Effect of endomycorrhizal fungi and phosphorus level on leaf cytokinins content of sour orange seedlings (June, 1986 season).

Kinetin standard (10 p.p.m.)

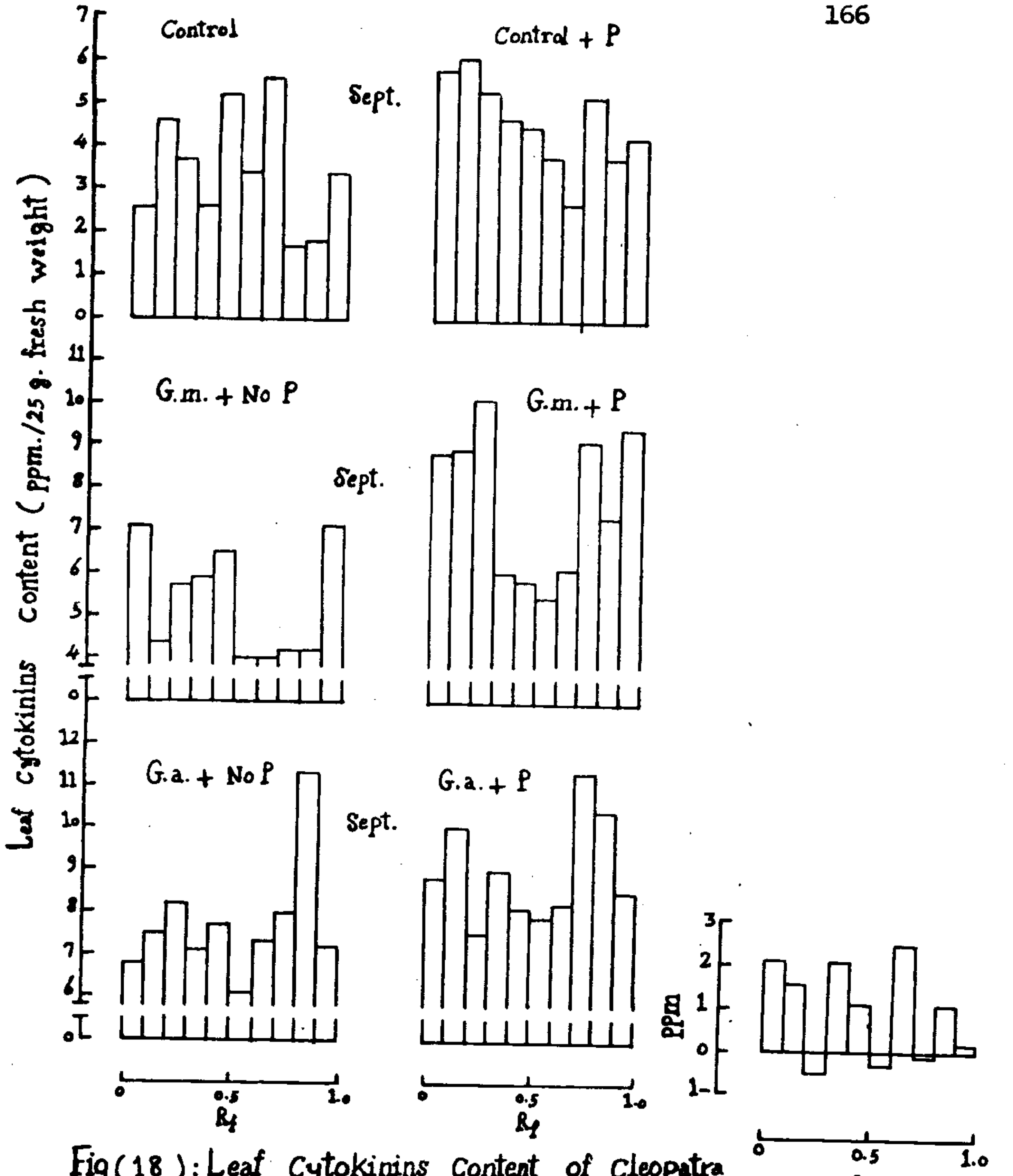


Fig (18): Leaf Cytokinins Content of Cleopatra mandarin seedlings in relation to endomycorrhizal fungi and phosphorus level (September, 1986 season).

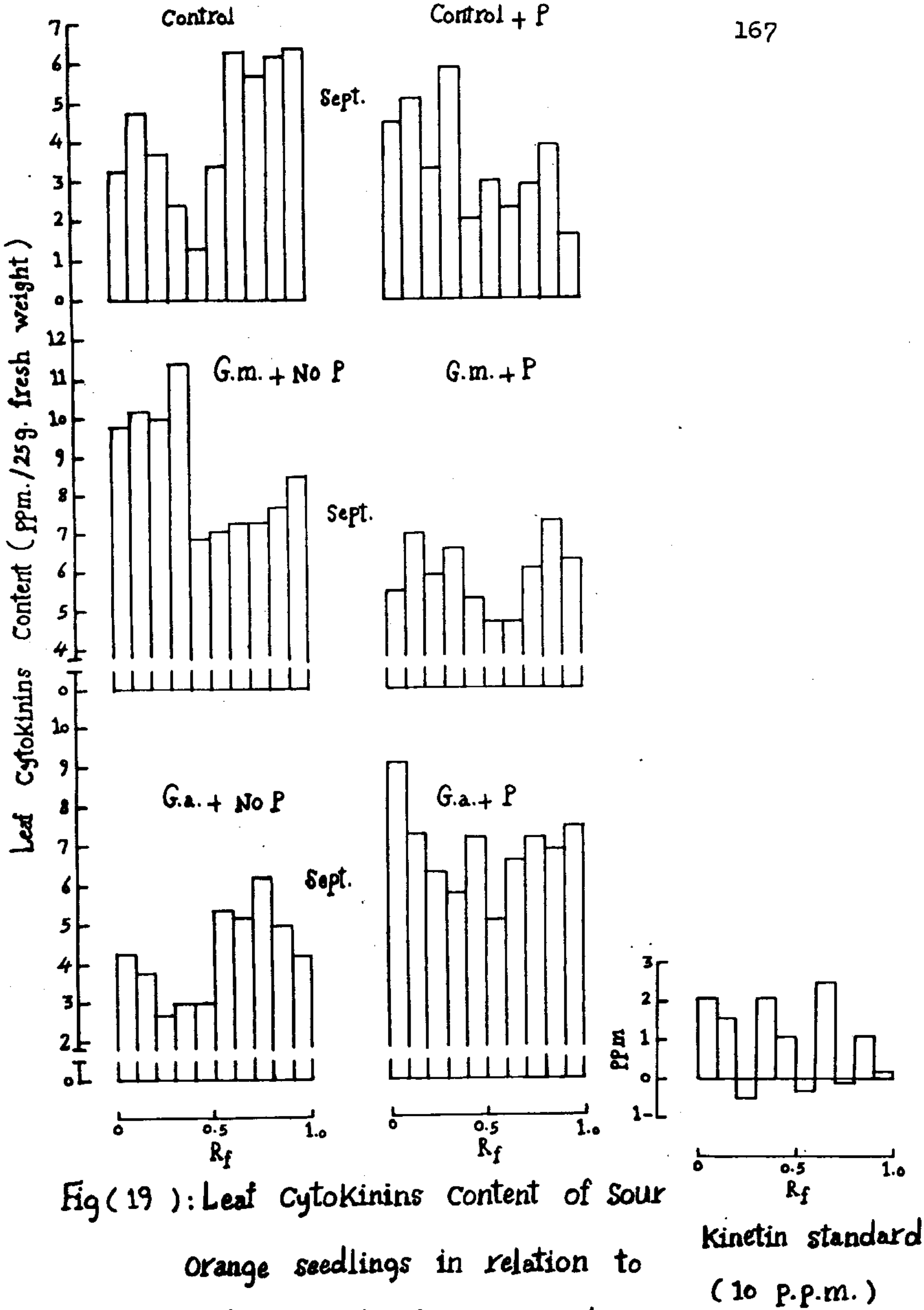


Fig (19): Leaf cytokinins content of sour orange seedlings in relation to endomycorrhizal fungi and phosphorus level (September, 1986 Season).

control seedlings borne leaves with high values of cytokinins under most Rf segments. Nevertheless, in September the picture was changed to the reverse.

On the other hand, sour orange seedlings gave the same trend but not as clear as in Cleopatra mandarin. In other words, data of leaf cytokinins of control plants somewhat fluctuated under various Rfs.

As for mycorrhizae treatments for unfertilized seedlings of Cleopatra mandarin it is remarkable that mycorrhizae species used in this study increased leaf cytokinins content under different Rfs. over unfertilized ones. That was true in both June and September leaf samples.

Concerning sour orange rootstock, data disclosed the same effect of Cleopatra mandarin in this respect in June but in the leaf sample, of September, such effect was fluctuated mainly in those seedlings inoculated with <u>Glomus australe</u> . These results are in agreement with those reported by Levisohn (1956) on forest tree seedlings with mycorrhizae, Slankis (1973) who reached similar results on ectomycorrhizae, and Edrees (1982) on sour orange seedlings with Glomus fasciculatus fungi.

Comparing inoculated and fertilized seedlings with those non inoculated and fertilized ones, it is found that in both rootstocks as well as in both leaf samples in June and September, mycorrhizae treatments increased noticeably leaf cytokinins content over those of control ones.

Considering total leaf cytokinins content, it is clear that applying phosphorus for either control or inoculated Cleopatra mandarin seedlings decreased visually leaf cytokinins content in June as compared with the analogous ones of unfertilized plants. The opposite was true when leaves were sampled in September.

However, as sour orange seedlings were concerned, regardless of leaf sample in June of seedlings inoculated with Glomus macrocarpus fungi and leaf sample in September of plants treated with Glomus australe , it is quite evident that in both leaf samples in June and September phosphorus fertilizer decreased leaf total cytokinins content.

Considering mycorrhizae species used in this study it is found that seedlings of Cleopatra mandarin rootstock inoculated with Glomus macrocarpus fungi gave leaves with higher amounts of total cytokinins content in June in respect of those treated with Glomus australe mycorrhizae. Such result was observed only in unfertilized sour orange plants. In September, the picture was changed to the reverse, hence Glomus macrocarpus failed to surpass Glomus australe in increasing leaf total cytokinins content. That was not true in case of those seedlings fertilized with phosphorus.

Moreover, the change in leaf total cytokinins content indicated that in both citrus rootstocks cytokinins started with the highest amounts in June then decreased visually in September. Such trend was almost noticed in all treatments used. These results confirm an earlier report by Devlin (1972) who mentioned that not only do cytokinin promote division but they also induce cell enlargement. This may explain the higher values of leaf cytokinins content of citrus seedlings during June after the start of the growth cycle. This tendency is in close agreement with the results obtained by Edrees (1982) who worked on sour orange seedlings with Glomus fasciculatus fungi.

4.14. Effect on soil properties :

Comparing soil available macro-elements (after the termination of the experiment) for two citrus seedling rootstocks as affected by endomycorrhizal fungi inoculation and phosphorus fertilization (Average of two seasons), Table (16) indicate that applying phosphorus to the soil planted with Cleopatra mandarin control seedlings increased available N whereas it decreased the other nutrients determined in the soil as compared with those of unfertilized control. On the other side, such treatment for sour orange caused a decrease in soil available N, P, and Ca contents. These may be attributed to the influence of the increase in the root growth and distribution which absorbed larger amounts of N, P, and Ca elements under P fertilization according to Bziava (1966), Atkinson (1974), Krasnoshtan (1975), and Atkinson and Wilson (1980). Nevertheless, soil K content was increased while Mg remained constant.

Comparing inoculated and unfertilized soil with non inoculated and unfertilized one, data of soil for Cleopatra mandarin disclosed that soil treated with Glomus macrocarpus fungi increased its contents of available, N, P, and Ca whereas K and Mg were decreased. Glomus australe on the other hand, Table (16): Soil available macro-elements (at the termination of the experiment) under two citrus seedling rootstocks as influenced by endomycorrhizal fungi inoculation and phosphorus fertilization (Average of two seasons).

Treatments			Available macro-elements of soil (mg./100g. dry weight)				
Root-stock	Mycorrhizae	Phos-phorus	N	P	K	Ca	Mg
Cleopatra mandarin	Control	No P	6.3	0.017	0.64	1.80	1.71
	Control	P	7.7	0.016	0.39	0.85	1.64
	G.m.	No P	8.5	0.020	0.39	1.90	0.92
	G.m.	P	12.1	0.033	0.76	3.40	1.05
	G.a.	No P	7.1	0.013	1.42	2.40	1.79
	G.a.	P	7.7	0.022	0.36	0.95	0.93
Sour orange	Control	No P	8.2	0.019	0.39	1.80	0.57
	Control	P	6.6	0.014	0.63	0.60	0.57
	G.m.	No P	9.3	0.042	0.62	2.10	1.43
	G.m.	P	9.3	0.019	0.39	1.90	0.43
	G.a.	No P	6.3	0.024	1.18	2.75	0.93
	G.a.	P	7.6	0.024	0.47	1.40	0.99

Control = No inoculation with mycorrhizae.
G.m. = *Glomus macrocarpus*.
G.a. = *Glomus australe*.
No P = No phosphorus fertilization.
P = Phosphorus applied as superphosphate.

increased soil available nutrients studied except P.

As for sour orange, it is quite evident that soil inoculated with Glomus macrocarpus fungi and unfertilized contained higher amounts of available N, P, K, Ca, and Mg nutrients as compared with those of the control. Regardless of soil N content, such effect was noticed when the soil was treated with Glomus australe mycorrhizae. This may be attributed to the influence of the physical and chemical soil factors on the mycorrhizal fungi growth such as soil temperature according to Harely (1969), and Marx et al., (1970) on Pisolithus tinctorus fungi, and Slankis (1974) on Suillus variegatus and Paxillus involutus fungi, or soil moisture availability according to Muttiah (1972) on Cencoccum graniforme fungi, or soil fertility according to Hayman (1982) on vesicular arbuscular mycorrhizae. Also Menge et al., (1982) found similar results on Troyer citrange with Glomus fasciculatus fungi.

Referring to soil fertilized with phosphorus and inoculated with Glomus macrocarpus fungi, data clearly showed that in both citrus rootstocks, soil contained higher amounts of available N, P, and Ca as well as lower levels of Mg in respect of that fertilized only with phosphorus but uninoculated with mycorrhizae. Moreover, the effect of such fungi on soil available K content differed due to the citrus rootstock used. In this concern, while Glomus macrocarpus increased soil K content under Cleopatra mandarin, the opposite was true for sour orange.

Meanwhile, soil fertilized and treated with Glomus australe mycorrhizae for both citrus rootstocks as compared with fertilized soil only, the available N, P, and Ca increased whereas K content decreased. In fact, there was a variability in soil Mg content. In this sphere, while soil of Cleopatra mandarin decreased in its content of Mg, it increased under sour orange seedlings. Similar results were found by Hayman (1982) on soil fertility with vesicular arbuscular mycorrhizae, also Menge et al., (1982) on Troyer citrange with Glomus fasciculatus fungi in various mineral soils, and Biermann and Linderman (1983) on the effect of phosphorus fertilizer establishment and host growth response to vesicular arbuscular mycorrhizae.

4.15. **Conclusion :**

Finally, it is worthy to conclude that inoculating citrus seedlings grown in sterelized soil with a suitable endomycorrhizal fungi generally enhances vegetative growth, root growth and distribution, and chemical constituents of both Cleopatra mandarin and sour orange seedlings. Furthermore, Glomus australe fungi and no phosphorus fertilization for Cleopatra mandarin seedlings and Glomus macrocarpus fungi and no phosphorus fertilization for sour orange seedlings gave the best results of seedlings growth.

Therefore, Glomus macrocarpus or Glomus australe fungi could be used as bio-fertilization for citrus seedlings in fumigated clay loam soil for producing good seedlings free from diseases.