RESULTS AND DISCUSSION

O°C for 72 hours. The methanol being changed every 24 as described by Daniel and George (1972).

The combined methanolic extract was transformed into aqueos phase by evaporating methanol at 30 ± 2 °C under vacuum. It was then diluted to a known volume and determinations were carried out as follows:

3.7.1. Total soluble phenols:

Total soluble phenols were determined by using Folin & Denis coloremetric method A.O.A.C, 1965 at 730 mμ wave length. The concentration was calculated from a standard curve of pyrogallol as mg per 100 grams dry weight.

3.7.2. Total endogenous gibberellins:-

The biological test of the hypocotyl seedling length of lettuce seeds as described by Frankland and Waring (1960) was utilized. Gibberellins were firstly separated according to George-Martin *et al.* (1969). These compounds were estimated in both fraction II (ether fraction) and fraction III (n-butyl fraction) as previously adopted by Badr *et al.*, 1971 and Gamal, 1979) as modified by Martin *et al.* (1982). The sum of gibberellic compounds concentration was calculated as μg GA per gram dry weight.

3.7.3. Total extractable indoles:-

P-dimethylamino benzaldehyde test as modified by Selim *et al.* (1978) to obtain a stable pink colour was used. They were estimated coloremetrically at 530 mμ. The concentration was calculated as mg indole acetic acid per 100 grams dry weight.

3.7.4. Total amino acids:

The ninhydrin coloremetric method as described by Rosein (1957) and modified by Selim *et al.* (1978) was used. The concentration of amino acid was calculated as mg glutamic acid per 100 grams dry weight.

3.7.5. Total soluble sugars:

Total soluble sugars was determined coloremetrically by the method of Smith *et al.* (1956), and the concnetration was calcualted as mg glucose per 100 grams dry weight.

3.8. Seedling growth:-

At the end of growing seasons (i.e. mid-September) in both seasons, seedlings (6-month-old) were subjected to the following measurements; seedling length, root length, number of feeder roots per seedling and average number of leaves per seedling.

After above measurements seedlings were washed with water to remove any residues, then cut to separate the tops from the roots for every Citrus rootstock under study, then oven dried at 70 °C until constant weight.

Top fresh weight, root fresh weight, seedling fresh weight, top dry weight, root dry weight and top dry weight/root dry weight were recorded for all Citrus rootstocks.

Seedling growth was recorded as a base for the following measurements:-

3.8.1. Seedling length (cm).

3.8.2. Root length (cm).

3.8.3. Number of feeder roots.

3.8.4. Number of leaves /seedling.

3.8.5. Top fresh weight (g).

3.8.6. Root fresh weight (g).

3.8.7. Seedling fresh weight (g).

3.8.8. Top dry weight (g).

3.8.9. Root dry weight (g).

3.8.10. Top : Root ratio (top dry weight/root dry weight).

Data recorded in both seasons were subjected to analysis of variance according to (Snedecor and Cochran, 1972). The significant differences among means were determined by Duncan's multiple range test (Duncan, 1955)..

3.9. Seed and leaf morphology:-

a- Seed and leaf macro morphology:-

Seed and leaf samples from each citrus rootstock under this study were washed by water to remove any residues and wiped by a damp cloth to become ready for morphological measurements as follows:-

I- Shape of seed and leaf:-

Shape of seed and leaf was determined by using characterized expressions for similar extended simple shapes which had been suggested by the taxonomical society and had depended on a geometric appearance by Radford *et al (*1974).

II- Seed and leaf colour:-

Seed and leaf colour were determined according to different known colours and their different degrees.

III- Size of seed and leaf:-

Size of seed and leaf had been classified as follows:-

1- Seed length (cm) had been used as grades for size:

S = small (1 cm or less)

L = Large (more than 1 cm)

2- Leaf area (cm^2) had been measured by the use of a planimeter as grades for size:

S = small (24 cm^2 or less)

L = Large (more than 24 cm)

b- Seed and leaf surface scan:-

Scanning electron microscope (SEM) JEOL-JXA-840 Electron PROBE Micro-Analyzer (*) had been used to survey seed and leaf samples of studied citrus rootstock.

Seed and leaf samples of citrus rootstock under this study were condcucted as follows:

The sputter coating procedure:

Edwards England S 150 A (*) sputter coating had been used to coating samples with golden layer before being viewed in the SEM that make surface of samples very reflective.

Therefore, we can obtain on the SEM to give a large number of Figs. for samples surface at different magnifications.

(*) Electron Microscope Unit, Service Central Lab., National Research Centre (N.R.C.) Dokki, Giza, Egypt.

4. RESULTS AND DISCUSSIONS

4.1. Vegetative growth:-

Table (1) and Figs. (1 and 2) show the vegetative growth of Balady sour orange, Cleopatra mandarin, *Citrus volkameriana,* rough lemon, Rangpur lime and Troyer citrange rootstocks under the experimental conditions. It is clear that trees of studied rootstocks in the most cases varied significantly in their values of tree height and canopy circumference in both seasons 2000 and 2001.

4.1.1. Tree height:-

It appeared from Table (1) and Fig. (1) that in both seasons 2000 and 2001, *Citrus volkameriana* rootstock proved to be the tallest ones, followed by rough lemon and Cleopatra mandarin rootstocks, which were similar in their values from the statistical stand point. Besides, Rangpur lime rootstock took statistically intermediate place in this respect. While, Troyer citrange and Balady sour orange rootstocks were statistically the shortest ones and similar in their values from the statistical stand point.

These findings are in partial agreement with those mentioned by Atawia (1992) who found that *Citrus volkameriana* rootstock proved to be the tallest ones compared with those of the other citrus rootstocks under study.

4.2.1. Canopy circumference:-

It is easy to notice from Table (1) and Fig. (2) that in both seasons 2000 and 2001, *Citrus volkameriana* rootstock had the widest canopy. While, canopy of Rangpur lime and Troyer citrange rootstocks were statistically the most narrow ones and similar in their values from the statistically stand point. Moreover, Cleopatra mandarin, Balady sour

Table (1): Vegetative growth of some citrus rootstocks.

Rootstock	Plant height (m)		Canopy circumference (m)	
	Season 2000	Season 2001	Season 2000	Season 2001
Balady sour orange	3.75 d	4.00 d	3.96 b	4.10 b
Cleopatra mandarin	5.73 b	6.00 b	4.00 b	4.12 b
Volkamer lemon	6.40 a	6.70 a	4.31 a	4.48 a
Rough lemon	6.00 b	6.22 b	4.01 b	4.06 b
Rangpur lime	5.30 c	5.54 c	2.95 c	3.01 c
Troyer citrange	3.70 d	3.93 d	3.00 c	3.12 c

Means within a column followed by the same letter (s) are not statistically different at 5 % level by Duncan's multiple range test.

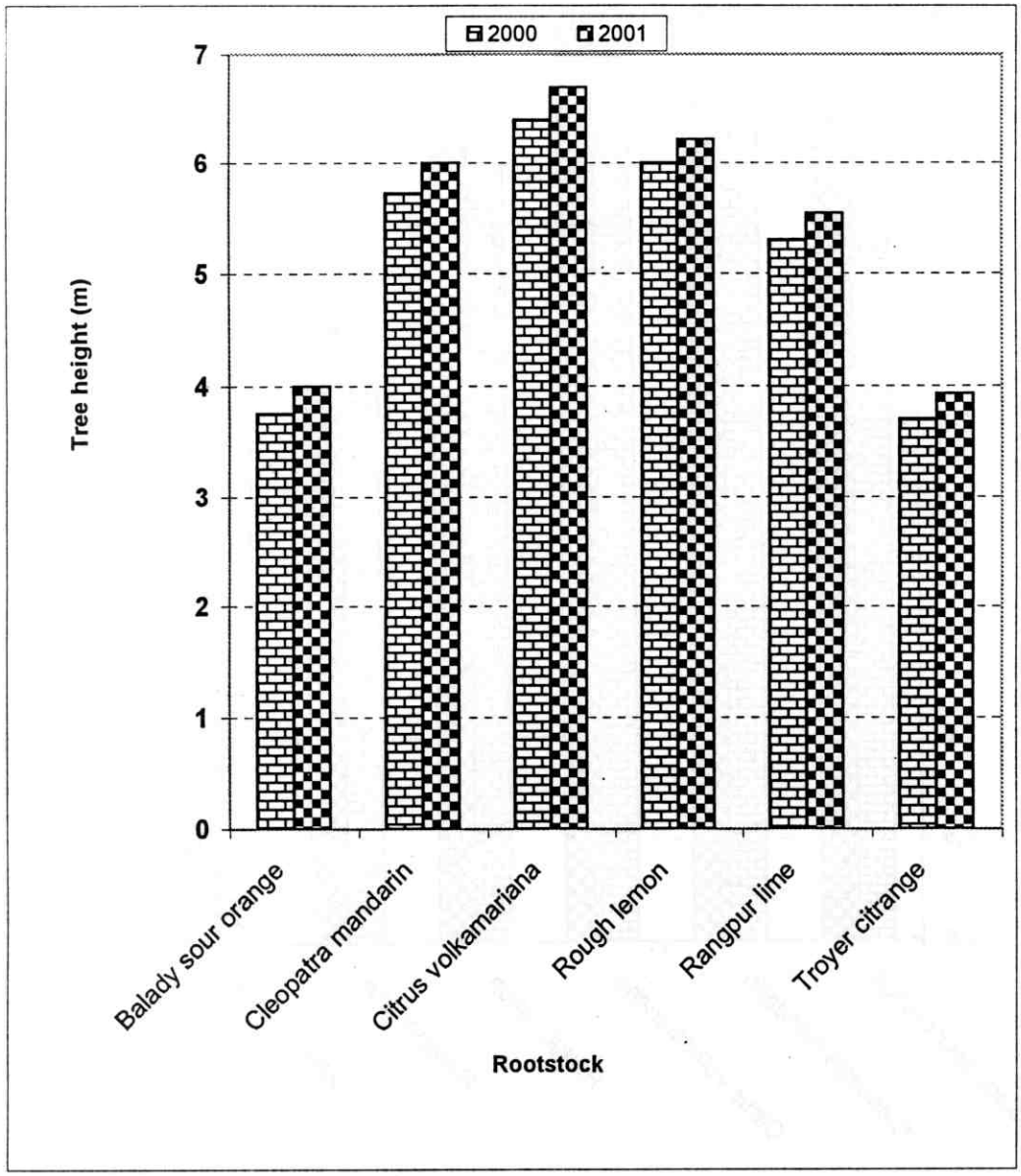

Fig. (1): Tree height of some citrus rootstocks.

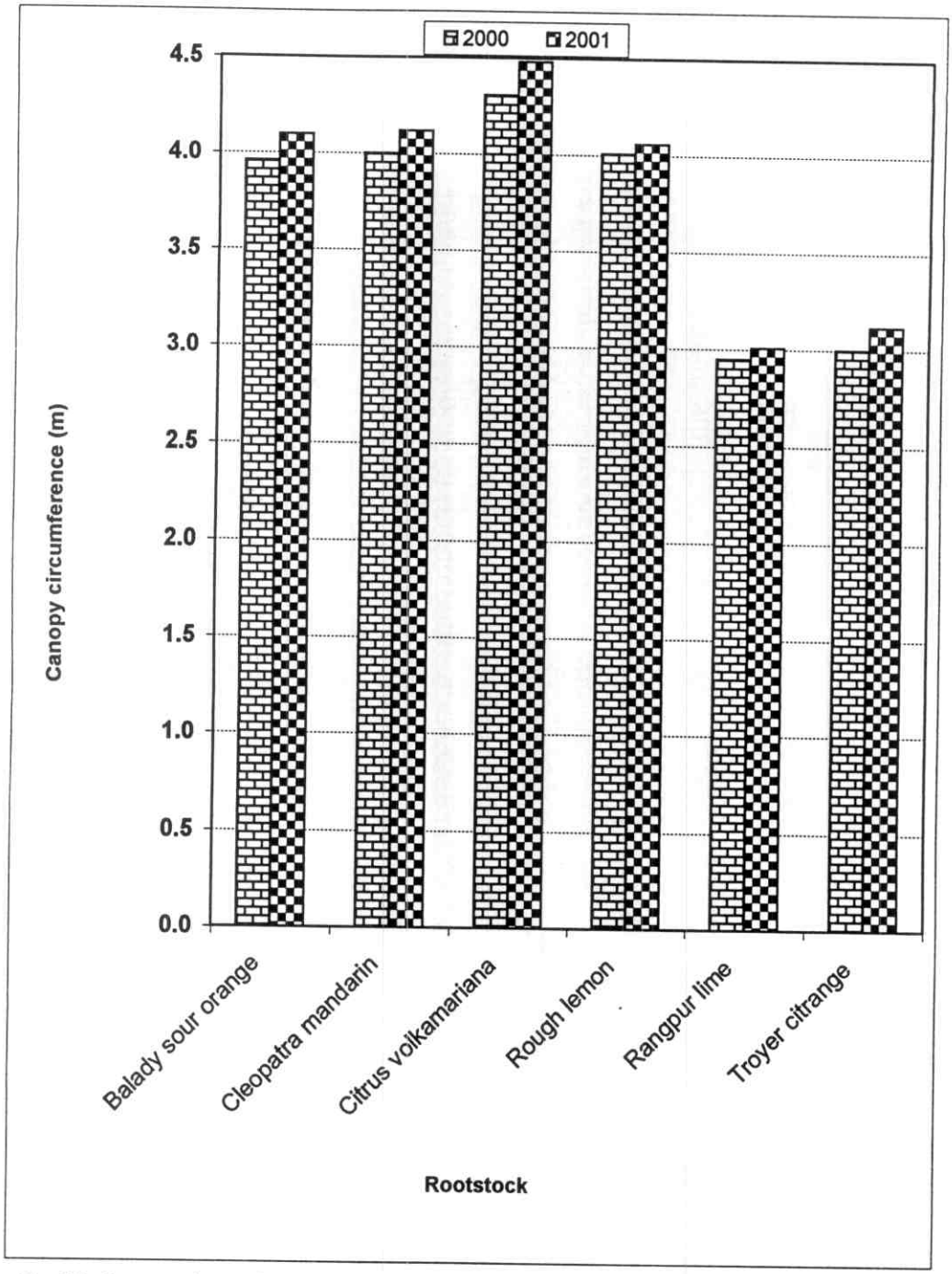

Fig. (2): Canopy circumference of some citrus rootstocks.

orange and rough lemon rootstocks took intermediate values in this respect.

These results are in partial agreement with those mentioned by Atawia (1992) who found that *Citrus volkameriana* rootstock had the widest canopy compared with the other citrus rootstocks under study.

4.2. Tree fruiting :-

Table (2) and Figs. (3 and 4) show the tree fruiting of some citrus rootstocks, Balady sour orange, Cleopatra mandarin, *Citrus volkameriana,* rough lemon, Rangpur lime and Troyer citrange. It is quite clear that in both seasons 2000 and 2001 studied citrus rootstocks varied significantly in their values of yield kg per tree and number of fruits per tree.

4.2.1. Yield kg per tree:

It is quite evident for Table (2) and Fig. (3) that in both seasons 2000 and 2001, Cleopatra mandarin rootstock showed severe alternate bearing. The trees were carrying a full load of crop in season 2001, while, the other way around in season 2000 because the trees were in the on year in the second seasons 2001 and it were in the off year during the first season 2000.

Moreover, it is clear from Table (1) and Fig. (3) that yield kg per tree of studied citrus rootstocks varied significantly in both seasons 2000 and 2001.

In the first season 2000, *Citrus volkameriana* rootstock produced the highest yield kg per tree. Meanwhile, Troyer citrange rootstock produced the lowest yield kg per tree. Besides, rough lemon, Balady sour orange, Cleopatra mandarin (in the off year) and Rangpur lime rootstocks, were intermediate in this respect.

Table (2): Tree fruiting of some citrus rootstocks.

Rootstock	Yield kg/tree		No. of fruit/tree	
	Season 2000	Season 2001	Season 2000	Season 2001
Balady sour orange	22.86 bc	29.91 c	163 c	220 d
Cleopatra mandarin	19.49 cd	37.40 b	214 ab	406 a
Volkamer lemon	30.82 a	45.66 a	245 a	363 ab
Rough lemon	27.11 ab	37.71 b	190 bc	285 c
Rangpur lime	17.03 cd	24.92 c	208 ab	332 b
Troyer citrange	14.70 d	16.04 d	201 bc	219 d

Means within a column followed by the same letter (s) are not statistically different at 5 % level by Duncan's multiple range test.

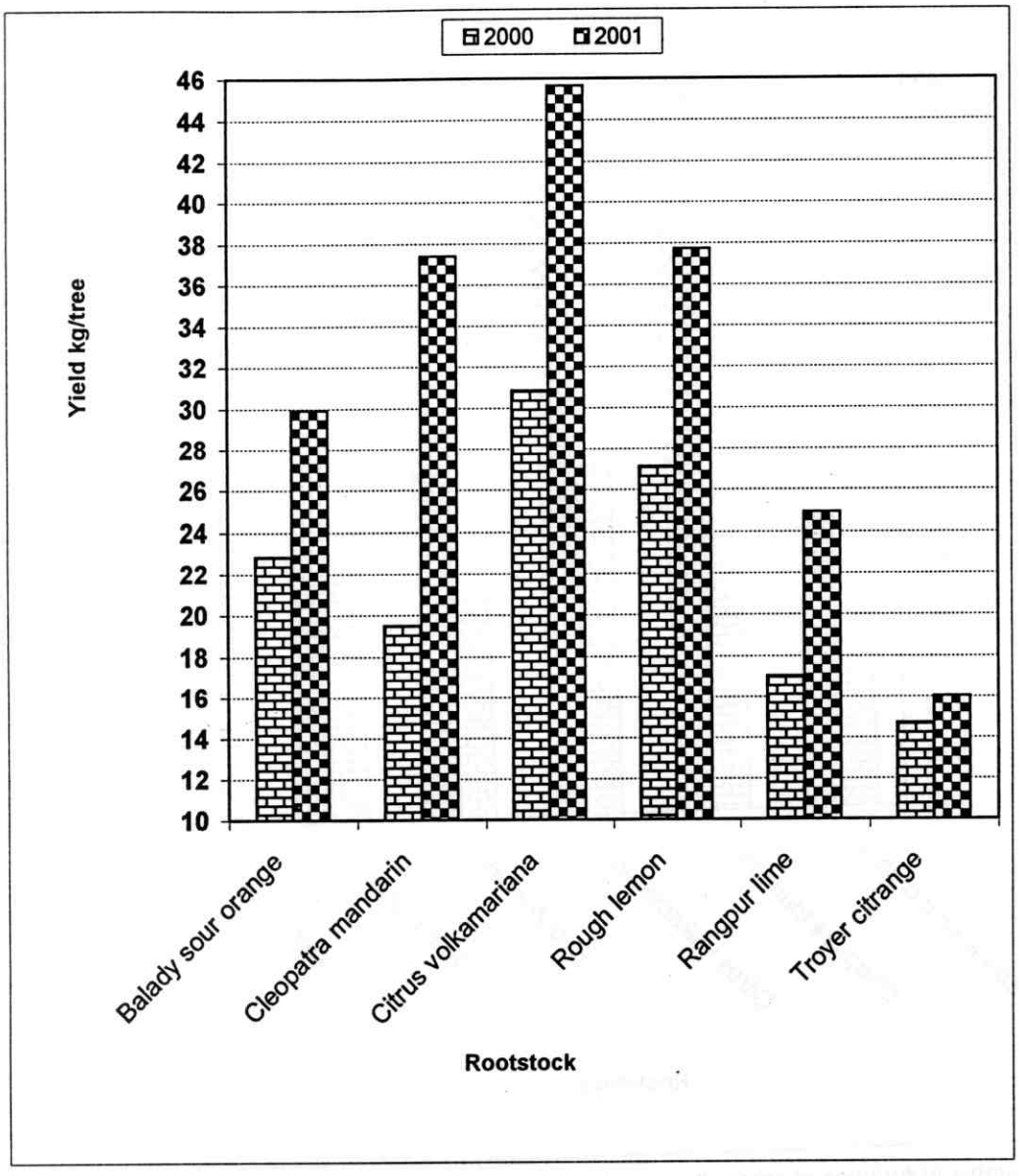

Fig. (3): Yield kg/tree of some citrus rootstocks.

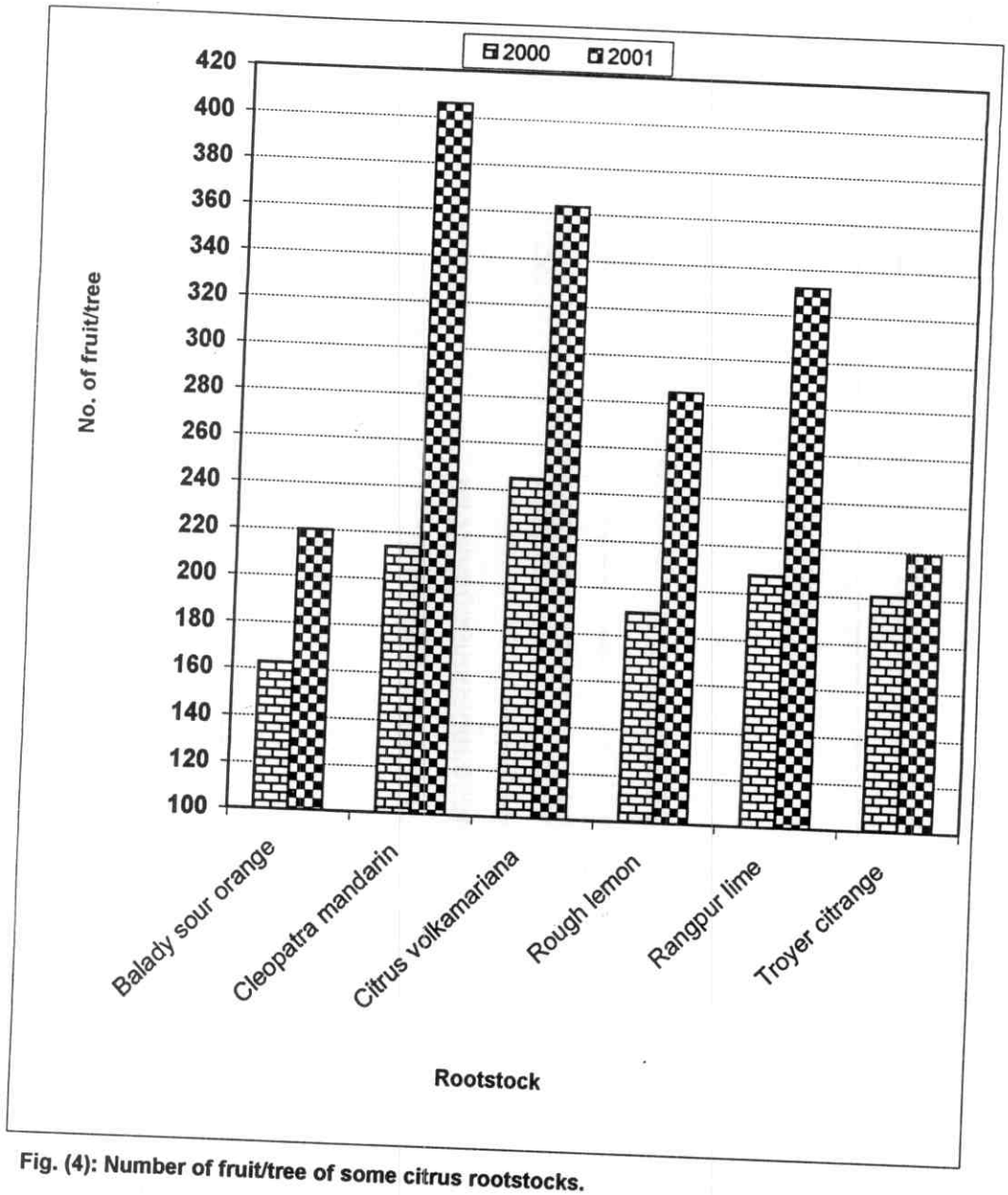

Fig. (4): Number of fruit/tree of some citrus rootstocks.

In the second season (2001) *Citrus volkameriana* rootstock produced the highest yield followed by rough lemon and Cleopatra mandarin (in the on year) rootstocks which were similar in their values from the statistical stand point, while, Balady sour orange and Rangpur lime rootstocks took statistically intermediate place in this respect. On the other hand, Troyer citrange rootstock produced the lowest yield.

In general, it is easy to notice from both seasons 2000 and 2001 that *Citrus volkameriana* produced the highest yield followed by rough lemon and Cleopatra mandarin (in the on year) rootstocks. While, Balady sour orange, Cleopatra mandarin (in off year) and Rangpur lime rootstocks took intermediate place in this respect. On the other hand, Troyer citrange rootstock produced the lowest yield.

These results are in partial agreement with those mentioned by Atawia (1992) who reported that *Citrus volkameriana* rootstock had significantly the highest yield kg per tree compared with the other citrus rootstocks during the study. Also, Aubert and Vullin (1997) who confirmed that *Citrus volkameriana* rootstock produced the highest yield kg per tree over those of the other citrus rootstocks tested.

On the other hand, these results are in contrast with those mentioned by Khamis *et al.* (1984) who mentioned that Cleopatra mandarin rootstock in the on year was the most productive rootstock of yield kg per tree compared with the other citrus rootstocks during the first season but in the second season Balady sour orange was the most productive rootstock of yield kg per tree because Cleopatra mandarin rootstock was in the off year.

4.2.2. Number of fruits per tree:-

It is clear from Table (2) and Fig. (4) that in 2000 and 2001 seasons Cleopatra mandarin rootstock showed severe alternate bearing of number of fruits per tree. The trees were carrying the lowest number of fruits in season 2000, while, carrying the highest number of fruits in season 2001 because the trees were in the off year in season 2000 and in the on year in season 2001. Furthermore, it is quite clear from Table (2) and Fig. (4) that number of fruits per tree of studied citrus rootstocks varied significantly in both seasons 2000 and 2001.

In the first season (2000) *Citrus volkameriana* rootstock produced the highest number of fruits per tree followed by Cleopatra mandarin (in the off year), Rangpur lime, Troyer citrange and rough lemon rootstocks which were intermediate in this respect. On the other hand, Balady sour orange rootstock produced the lowest number of fruit per tree.

In the second season (2001), Cleopatra mandarin rootstock was in the on year, so produced the highest number of fruits per tree followed by *Citrus volkameriana* and Rangpur lime rootstocks which were similar in their values from the statistical stand point. Besides, rough lemon rootstock took statistically intermediate place in this respect. On the other hand, Balady sour orange and Troyer citrange rootstocks produced the lowest number of fruits per tree and were similar in their values from the statistical stand point.

In general, it is clear from both seasons 2000 and 2001 that *Citrus volkameriana* and Cleopatra mandarin rootstocks had the highest number of fruits per tree and were similar in their values from the statistical stand point, followed by Rangpur lime rootstock. Besides, rough lemon took statistically intermediate place in this respect. On the other hand, Troyer

citrange and Balady sour orange rootstock had the lowest number of fruits per tree.

These results are in partial agreement with those mentioned by Khamis *et al.* (1984) who mentioned that Cleopatra mandarin rootstock produced the highest number of fruits compared with the other citrus rootstocks under this study. Whereas, Balady, Spanish and Brazilian sour orange produced the lowest number of fruits per tree compared with the other rootstocks. As well as, Atawia (1992) who reported that *Citrus volkameriana* rootstock born the highest number of fruits compared with the other citrus rootstocks under study. While, rough lemon, trifoliate orange and Balady sour orange had the lowest number of fruits per tree.

Moreover, Aubert and Vullin (1997) who found that sour orange and trifoliate orange rootstocks had higher number of fruits per tree compared with Troyer citrange, *Citrus volkameriana, Citrus macrophylla* rootstocks.

4.3. Seed yield:-

Table (3) and Figs. (5 and 6) show the tree yield of seeds of Balady sour orange, Cleopatra mandarin, *Citrus volkameriana,* rough lemon, Rangpur lime and Troyer citrange rootstocks. It is clear that tree yield of seeds of studied citrus rootstocks in the most cases varied significantly in their values of number of seeds per fruits and tree yield of seeds as kg per tree in both seasons 2000 and 2001.

4.3.1. Number of seeds per fruit:-

It is clear from Table (3) and Fig. (5) that in both seasons 2000 and 2001 fruits of Balady sour orange rootstock had significantly the highest number of seeds, followed by those of *Citrus volkameriana* and Troyer citrange rootstocks which were statistically similar in their values of

Table (3): Tree yield of seeds of some citrus rootstocks.

Rootstock	No. of seeds/fruit		Tree yield of seeds (Kg)	
	Season 2000	Season 2001	Season 2000	Season 2001
Balady sour orange	32 a	31 a	1.09 b	1.43 a
Cleopatra mandarin	16 c	15 c	0.47 c	0.84 b
Volkamer lemon	22 b	22 b	0.42 c	0.63 c
Rough lemon	13 c	13 c	0.21 d	0.32 d
Rangpur lime	14 c	14 c	0.16 d	0.25 d
Troyer citrange	23 b	24 b	1.30 a	1.52 a

Means within a column followed by the same letter (s) are not statistically different at 5 % level by Duncan's multiple range test.

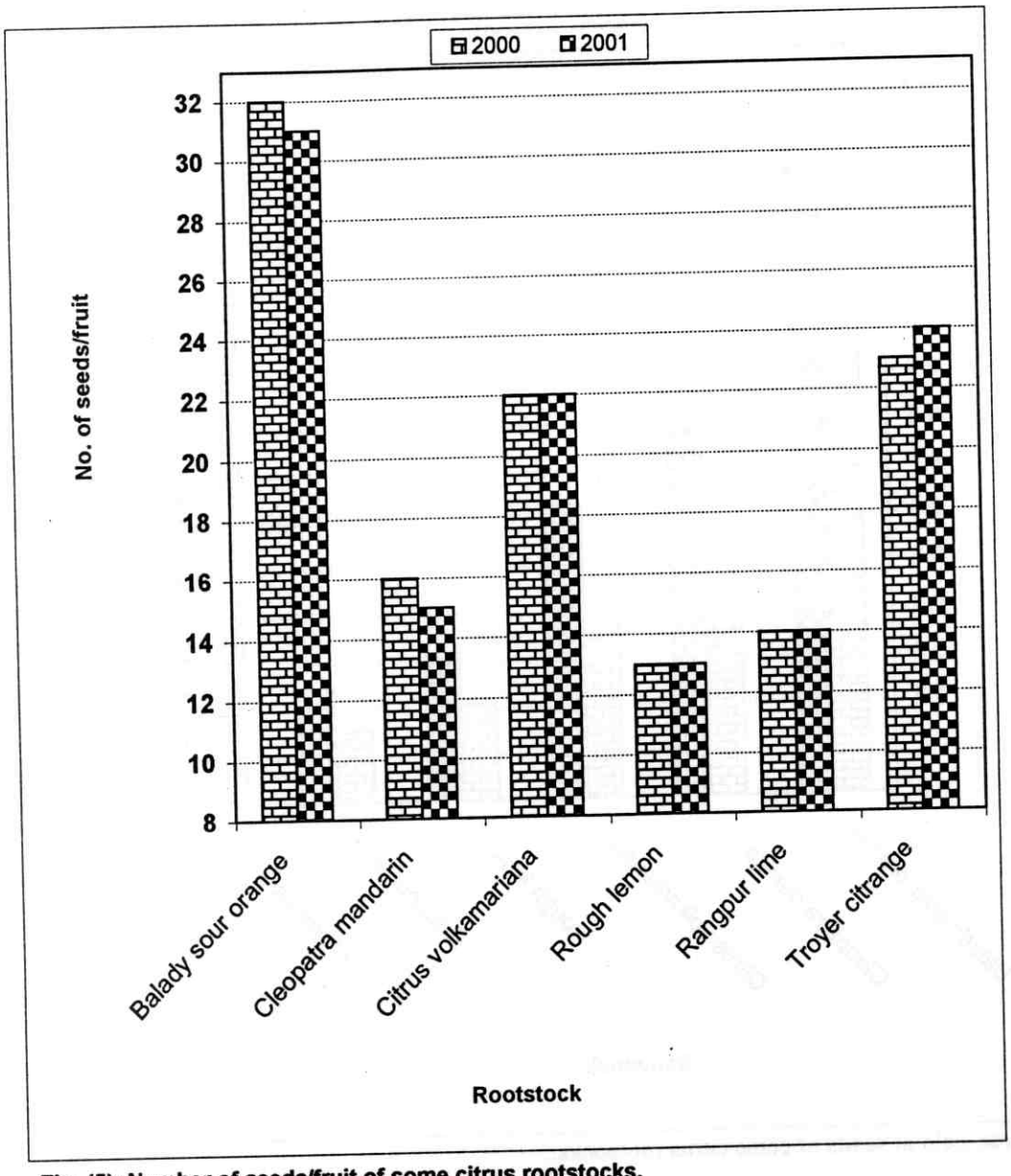

Fig. (5): Number of seeds/fruit of some citrus rootstocks.

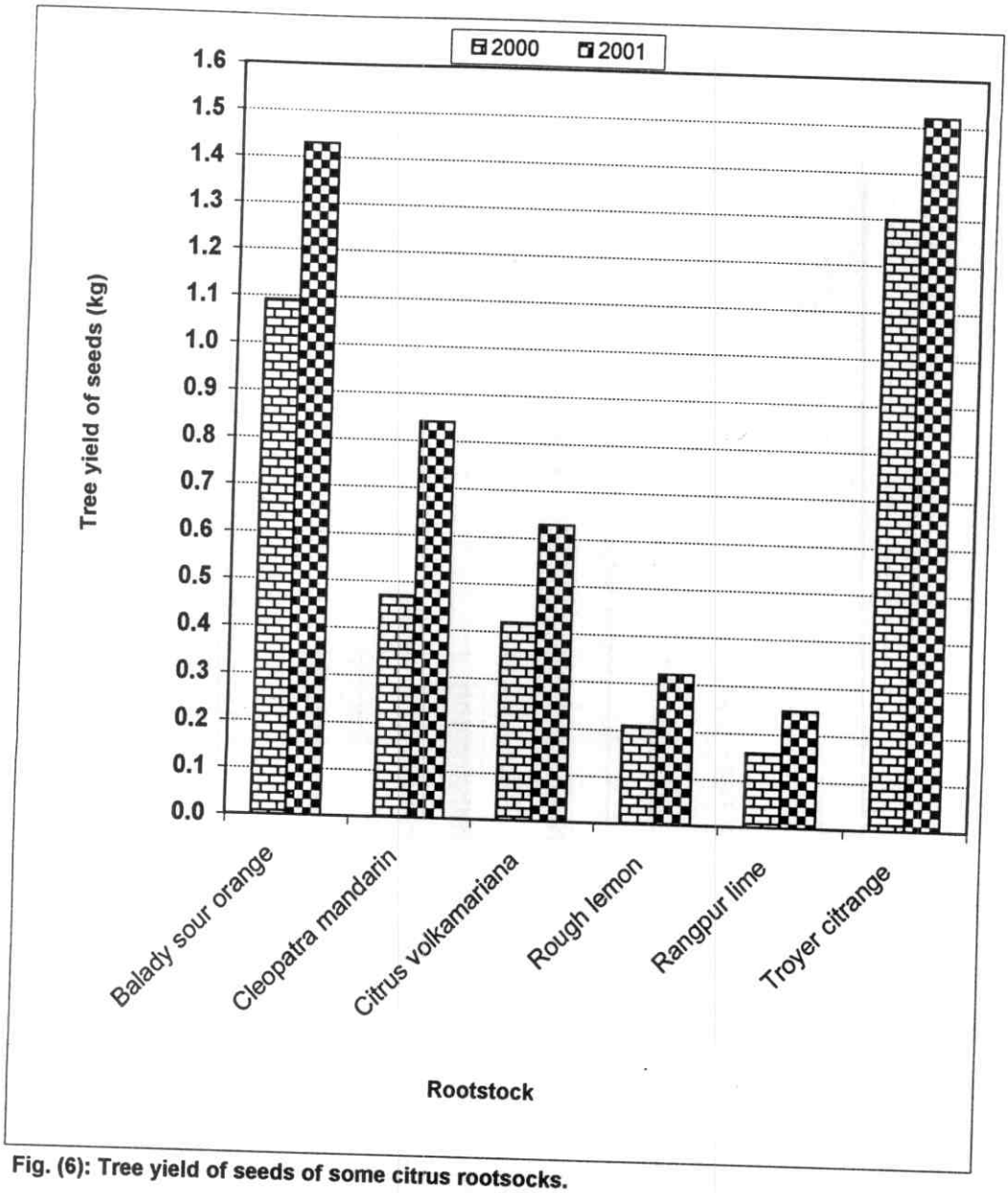

Fig. (6): Tree yield of seeds of some citrus rootsocks.

number of seeds per fruit and were statistically intermediate in this respect. Other studied citrus rootstocks, Cleopatra mandarin, Rangpur lime and rough lemon had statistically similar in their values of number of seeds per fruit and were the lowest numbers.

These results are in partial agreement with those mentioned by Plat and Optiz (1973) who reported that fruits of sour orange rootstock had the highest number of seeds compared with the other citrus rootstock which was rough lemon rootstock.

In addition, Khamis *et al.* (1984) who found that Spanish sour orange rootstock had the highest average number of seeds per fruit compared with the other citrus rootstocks under this study. Whereas, Cleopatra mandarin rootstock had the lowest number of seeds per fruit compared with the other citrus rootstocks under study.

As well as, Atawia (1992) who mentioned that fruit of Balady sour orange rootstock had significantly the highest number of seeds compared with the other citrus rootstocks of this study.

On the other hand, Gravina (1989) reported that *Citrus macrophylla* fruits had the highest average number of seeds compared with other rootstocks, sour orange, Troyer citrange, Carrizo citrange, Swingle citrumelo, *Citrus volkameriana, Citrus taiwanica* and *Citrus amblecarpa.*

4.3.2. Tree yield of seeds:-

It is obvious from Table (3) and Fig. (6) that in both seasons 2000 and 2001 tree yield of seeds of Balady sour orange, Cleopatra mandarin, *Citrus volkameriana,* rough lemon, Rangpur lime and Troyer citrange rootstocks varied significantly.

In the first season (2000), Troyer citrange rootstock produced the highest yield of seeds kg per tree, followed by Balady sour orange rootstock. Moreover, Cleopatra mandarin (in the off year) and *Citrus volkameriana* rootstocks came statistically intermediate in this respect and were similar in their values of tree yield of seeds kg per tree. On the other hand, Rangpur lime and rough lemon rootstocks produced the lowest yield of seeds kg per tree and had statistically similar values from the statistically stand point.

In the second season (2001), Balady sour orange and Troyer citrange rootstocks produced the highest yield of seeds kg per tree and were statistically similar in their values of tree yield of seeds, followed by Cleopatra mandarin rootstock (in the on year). Besides, *Citrus volkameriana* had statistically intermediate place in this respect. Meanwhile, Rangpur lime and rough lemon rootstocks produced the lowest yield of seeds kg per tree and were statistically similar in their values of tree yield of seeds.

In general, it is easy to notice from both seasons 2000 and 2001 that Troyer citrange rootstock produced the highest yield of seeds kg per tree, followed by Balady sour orange rootstock. Moreover, Cleopatra mandarin and *Citrus volkameriana* rootstocks had statistically intermediate place in tree yield of seeds (kg). While, Rangpur lime and rough lemon rootstocks produced the lowest yield of seeds as kg per tree and were statistically similar in their values of tree yield of seeds.

These results are in partial agreement with those mentioned by Atawia (1992) who reported that Balady sour orange rootstock had the highest potentiality in seed productions as compared with studied rootstocks, *Citrus volkameriana,* Rangpur lime, rough lemon, trifoliate orange. Meanwhile, Rangpur lime rootstock had the lowest yield of seed

production compared with the other rootstocks under study. Also, Khamis *et al.* (1984) reported in the second season then Cleopatra mandarin rootstock in the off year that Balady sour orange rootstock produced the highest quantity of seeds, compared with the other citrus rootstocks. Meanwhile, rough lemon and Brazilian sour orange rootstocks produced the least quantity of seeds. Moreover, Aubert and Vullin (1997) confirmed that trees of Troyer citrange rootstock produced yield of seeds higher than that of sour orange and *Citrus volkameriana* rootstocks.

These results are contrast with those mentioned by Khamis *et al.* (1984) who found that Cleopatra mandarin rootstock was the most productive rootstocks of seeds (in the on year), compared with the other citrus rootstocks. That is in the first season which Cleopatra mandarin rootstock in the on year.

4.4. Leaf fresh weight, dry weight and dry matter percentage:-

Table (4) and Figs. (7-9) show the leaf fresh weight, dry weight and dry matter percentage in leaf of some citrus rootstocks, Balady sour orange, Cleopatra mandarin, *Citrus volkameriana,* rough lemon, Rangpur lime and Troyer citrange. It is clear that in both seasons 2000 and 2001, studied citrus rootstocks varied significantly in their values of leaf fresh weight, dry weight and dry matter percentage.

4.4.1. Leaf fresh weight:-

It is appeared from Table (4) and Fig. (7) that in both seasons 2000 and 2001, rough lemon and Balady sour orange rootstocks had the highest values of leaf fresh weight and were similar in their values from the statistical stand point. Besides, *Citrus volkameriana* rootstock took statistically intermediate place in this respect. On the other hand, Troyer citrange, Rangpur lime and Cleopatra mandarin rootstocks had the lowest

Table (4): Leaf fresh weight, dry weight and dry matter percentage in leaf of some citrus rootstocks.

Rootstock	Leaf fresh weight (mg)		Leaf dry weight (mg)		Dry matter (%)	
	Season 2000	Season 2001	Season 2000	Season 2001	Season 2000	Season 2001
Balady sour orange	584 a	587 a	190 a	187 a	32.52 c	31.86 c
Cleopatra mandarin	385 c	390 c	104 f	141 d	27.02 e	36.18 ab
Volkamer lemon	446 b	453 b	178 b	173 b	39.95 a	38.20 a
Rough lemon	606 a	611 a	156 c	150 c	25.73 e	24.54 e
Rangpur lime	393 c	397 c	143 d	140 d	36.52 b	35.46 b
Troyer citrange	407 c	409 c	120 e	117 e	29.65 d	28.60 d

Means within a column followed by the same letters are not statistically different at 5 % level by Duncan's multiple range test.

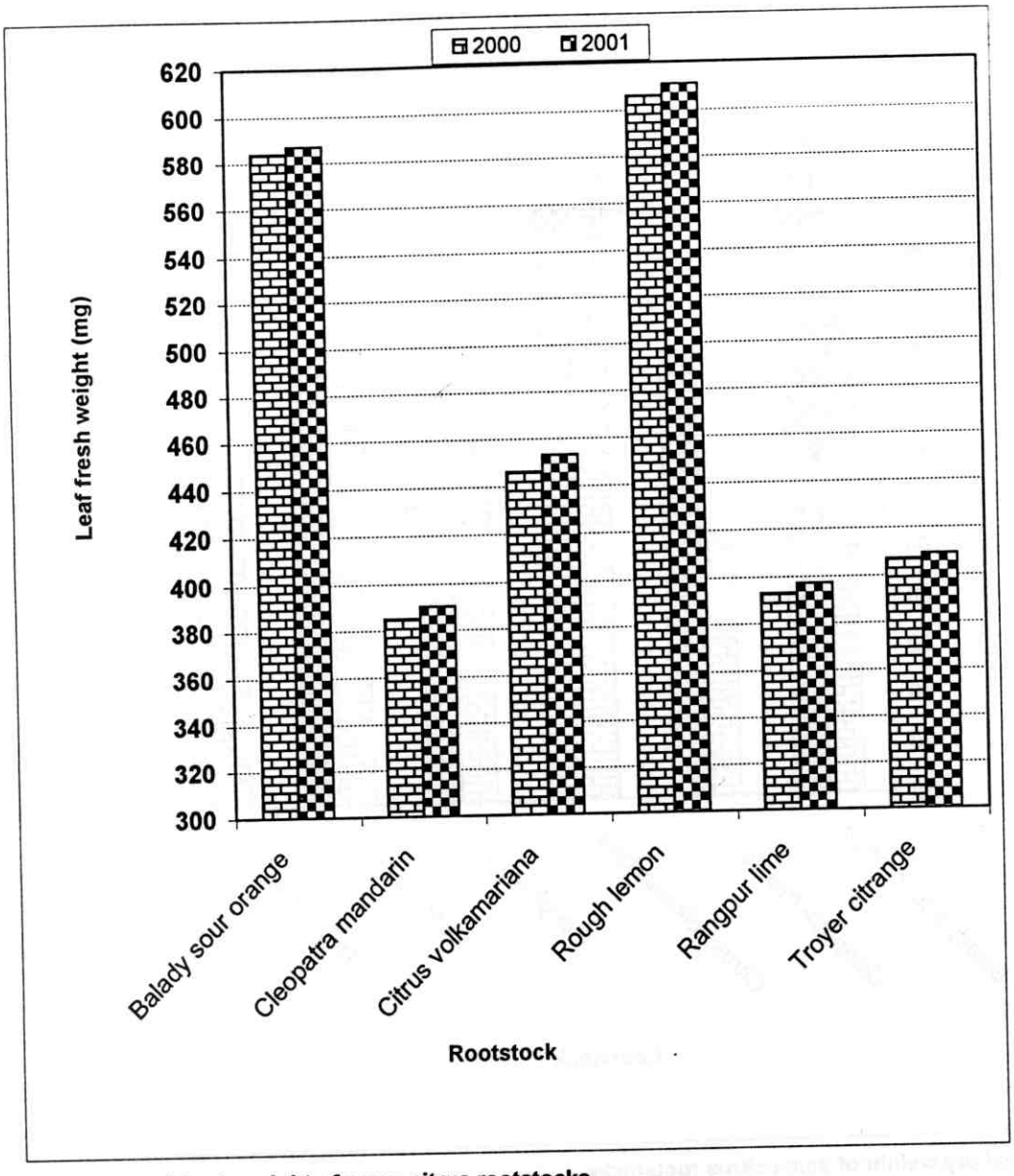

Fig. (7): Leaf fresh weight of some citrus rootstocks.

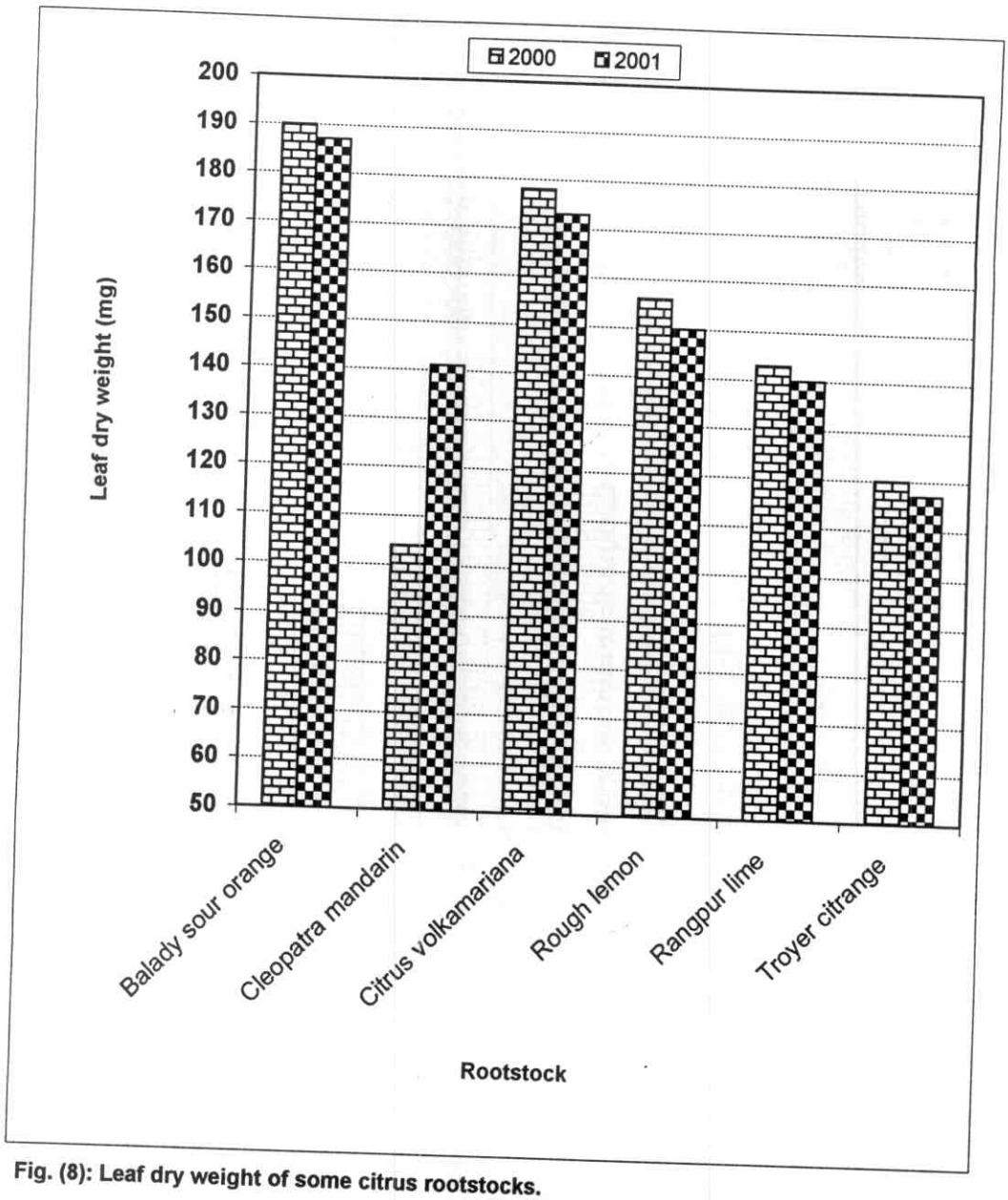

Fig. (8): Leaf dry weight of some citrus rootstocks.

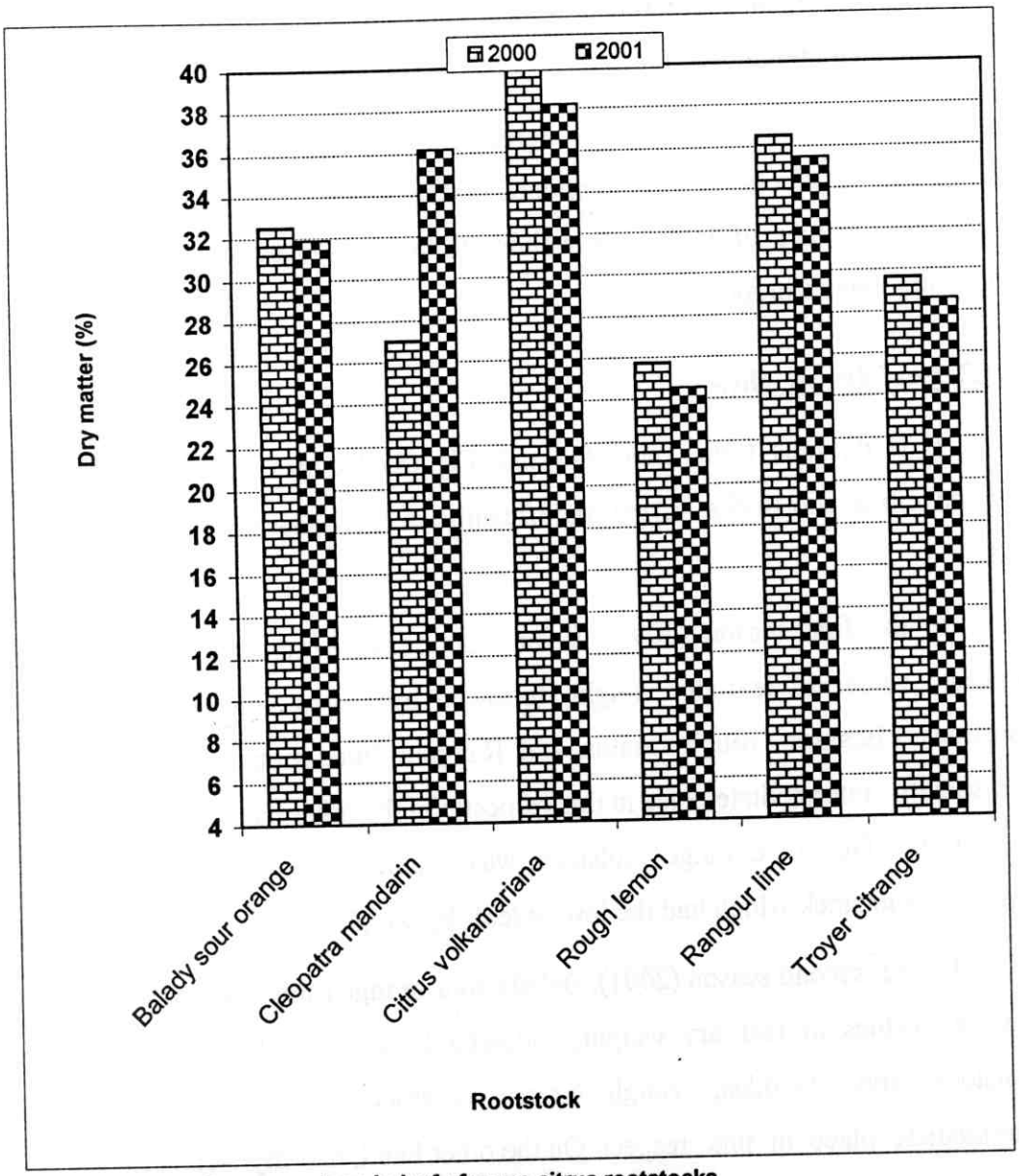

Fig. (9): Dry matter percentage in leaf of some citrus rootstocks.

values of leaf fresh weight and were similar in their values from the statistical stand point.

These results are in partial agreement with those mentioned by Mougheith *et al.* (1979) who mentioned that rough lemon rootstocks had the highest values of leaf fresh weight, followed by sour orange and Cleopatra mandarin rootstocks.

4.4.2. Leaf dry weight:-

It is obvious from Table (4) and Fig. (8) that leaf dry weight of studied citrus rootstocks varied significantly in both seasons 2000 and 2001.

In the first season (2000), Balady sour orange rootstock had the highest values of leaf dry weight, followed by *Citrus volkameriana* rootstock. Besides, rough lemon and Rangpur lime rootstocks took statistically intermediate place in this respect. On the other hand, leaf dry weight of Troyer citrange rootstock was heavier than of Cleopatra mandarin rootstock which had the lowest leaf dry weight.

In the second season (2001), Balady sour orange rootstock had the highest values of leaf dry weight, followed by *Citrus volkameriana* rootstock too. Besides, rough lemon rootstock took statistically intermediate place in this respect. On the other hand, leaf dry weight of Cleopatra mandarin and Rangpur rootstocks was similar in their values from statistical stand point and heavier than that of Troyer citrange rootstock which had the lowest values of leaf dry weight.

In general, it is easy to notice from both seasons 2000 and 2001 that Balady sour orange rootstock had the highest values of leaf dry weight, followed by *Citrus volkameriana* and rough lemon rootstocks. Besides, Rangpur lime and Cleopatra mandarin (in the on year) rootstock

were intermediate in this respect. While, Troyer citrange and Cleopatra mandarin (in the off year) rootstocks had the lowest values of leaf dry weight.

These results are in partial agreement with those mentioned by Atawia (1992) who confirmed that Balady sour orange rootstock had the highest values of leaf dry weight, followed by *Citrus volkameriana*, rough lemon, Rangpur lime rootstocks and trifoliate orange rootstocks which had the lowest weight of leaf dry weight.

4.4.3. Leaf dry matter percentage:-

It is easy to notice from Table (4) and Fig. (9) that leaf dry matter percentage of studied citrus rootstocks varied significantly in both seasons 2000 and 2001.

In the first season (2000), *Citrus volkameriana* rootstock had the highest values of leaf dry matter percentage, followed by Rangpur lime rootstock. Besides, Balady sour orange and Troyer citrange rootstocks took statistically intermediate place in this respect. On the other hand, Cleopatra mandarin (in the off year) and rough lemon rootstocks had the lowest values of leaf dry matter percentage which were similar in their values from the statistically stand point.

In the second season (2001), *Citrus volkameriana* and Cleopatra mandarin (in the on year) rootstocks had the highest values of leaf dry matter percentage and were similar in their values from the statistically stand point, followed by Rangpur lime rootstock. Besides, Balady sour orange and Troyer citrange rootstock took statistically intermediate place in this respect. On the other hand, rough lemon rootstock had the lowest values of leaf dry matter percentage.

In general, it is easy to notice from both seasons 2000 and 2001 that *Citrus volkameriana* and Cleopatra mandarin (in the on year) rootstocks had the highest values of dry matter percentage. While, rough lemon and Cleopatra mandarin (in the off year) rootstocks had the lowest values of dry matter percentage. Besides, other rootstocks; Balady sour orange, Rangpur lime and Troyer citrange rootstocks were intermediate in this respect.

These results are in partial agreement with those mentioned by Khamis *et al.* (1984) who found that Balady sour orange had the highest value of dry matter. While, rough lemon and Cleopatra mandarin rootstocks had the lowest values leaf dry matter percentage.

4.5. Leaf nutrient content:

Table (5) and Figs. (10-12) show nitrogen, phosphorus and potassium content in dry leaves of Balady sour orange, Cleopatra mandarin, *Citrus volkameriana,* rough lemon, Rangpur lime and Troyer citrange rootstocks.

It is clear that in both seasons 2000 and 2001 studied citrus rootstocks varied significantly in their values of nitrogen, phosphors and potassium content.

4.5.1.Nitrogen:-

It appeared from Table (5) and Fig. (10) that nitrogen content in dry leaves of studied citrus rootstocks varied significantly in both seasons 2000 and 2001.

In the first season (2000), leaves of *Citrus volkameriana* and Balady sour orange rootstocks were the richest ones in their nitrogen content and similar in their values from the statistical stand point.

Table (5): Nitrogen, phosphorus and potassium content in dry leaves of some citrus rootstocks.

Rootstock	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	Season 2000	Season 2001	Season 2000	Season 2001	Season 2000	Season 2001
Balady sour orange	2.82 a	2.69 b	0.19 a	0.19 a	0.48 b	0.48 b
Cleopatra mandarin	2.37 b	2.21 d	0.13 cd	0.12 d	0.40 d	0.39 e
Volkamer lemon	2.95 a	2.87 a	0.18 a	0.17 b	0.49 b	0.47 bc
Rough lemon	2.45 b	2.38 c	0.14 c	0.13 d	0.58 a	0.57 a
Rangpur lime	2.43 b	2.35 cd	0.16 b	0.15 c	0.46 c	0.45 d
Troyer citrange	2.52 b	2.45 c	0.12 d	0.13 d	0.49 b	0.46 c

Means within a column followed by the same letter (s) are not statistically different at 5 % level by Duncan's multiple range test.

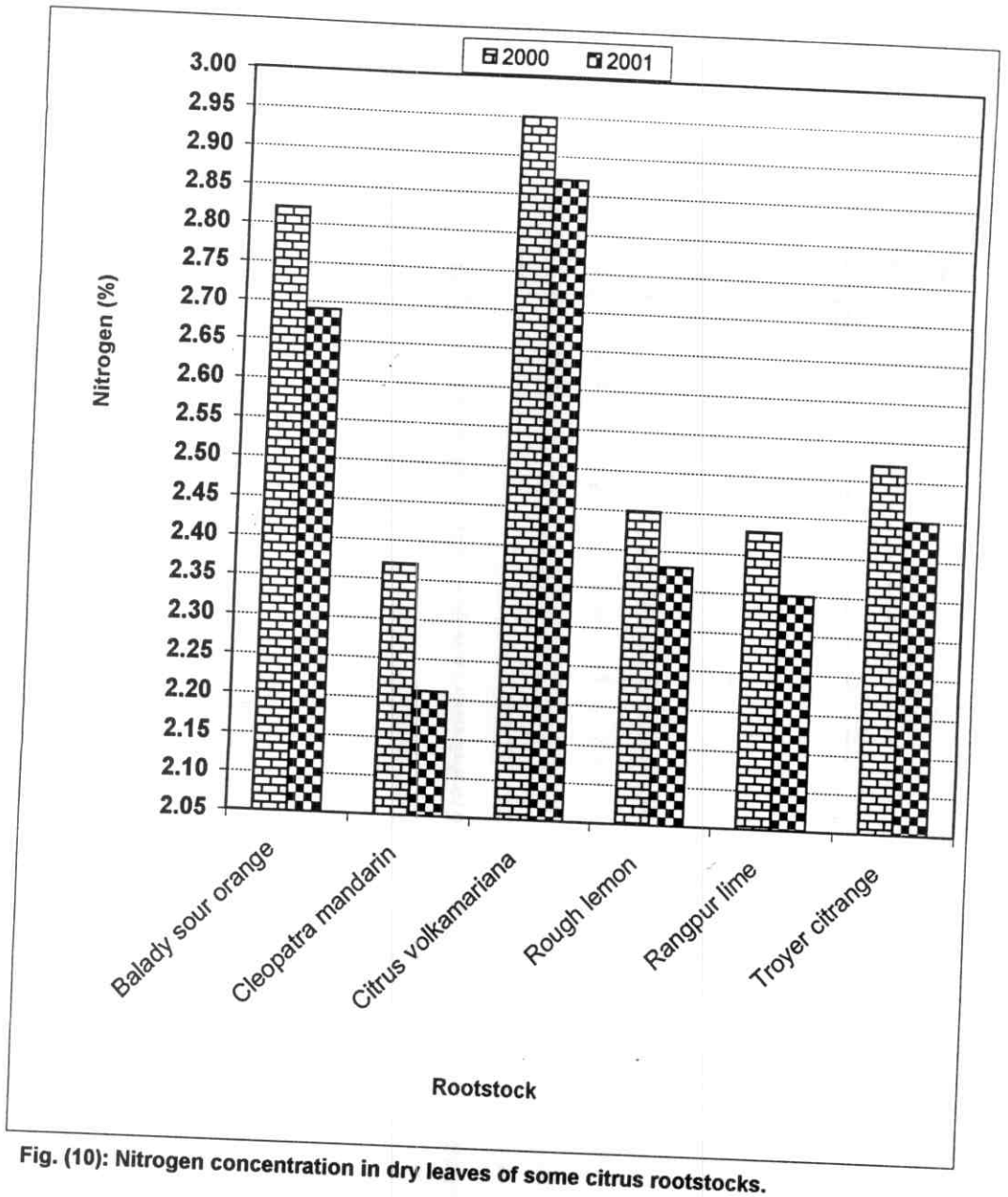

Fig. (10): Nitrogen concentration in dry leaves of some citrus rootstocks.

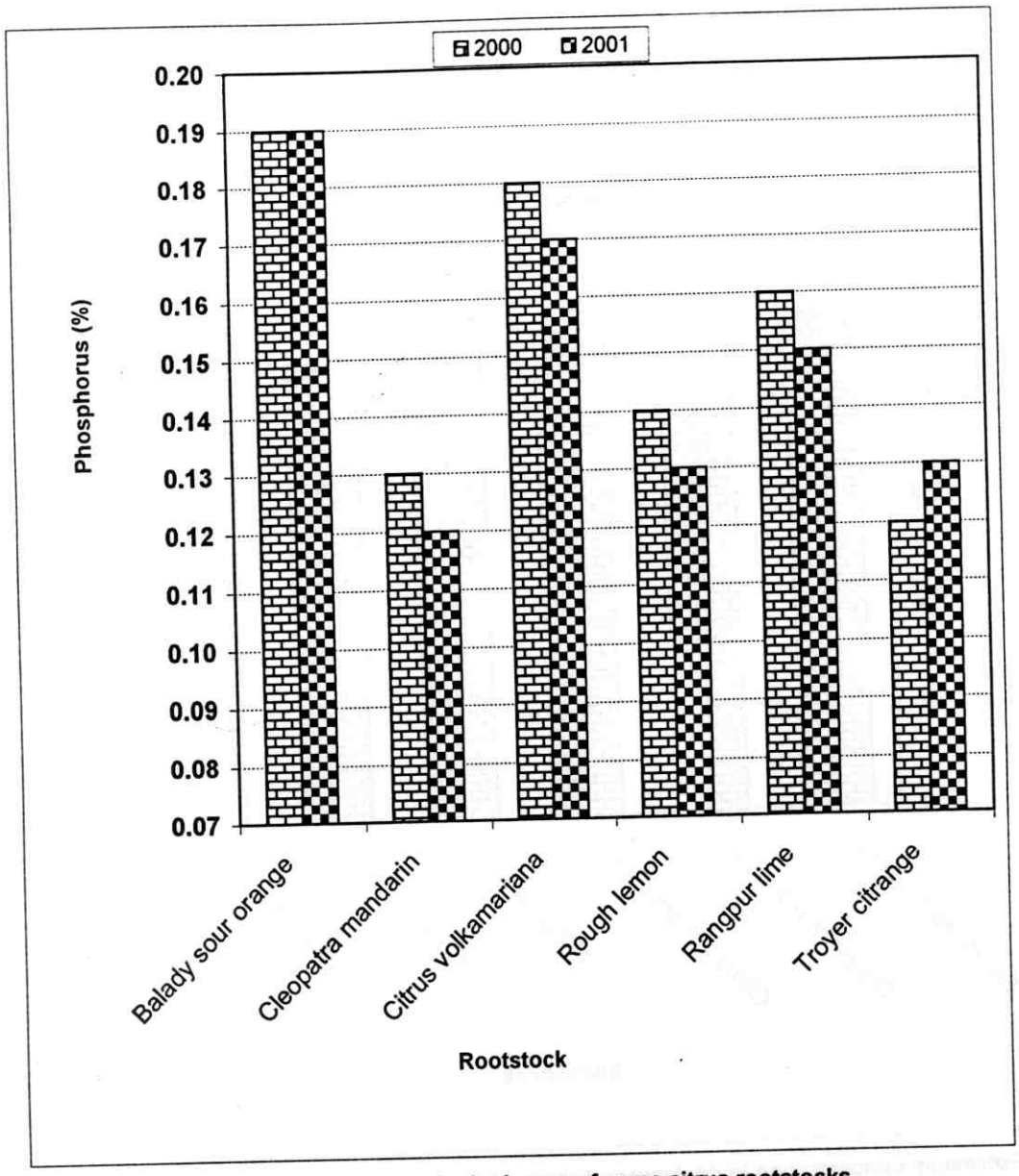

Fig. (11): Phosphorus concentration in dry leaves of some citrus rootstocks.

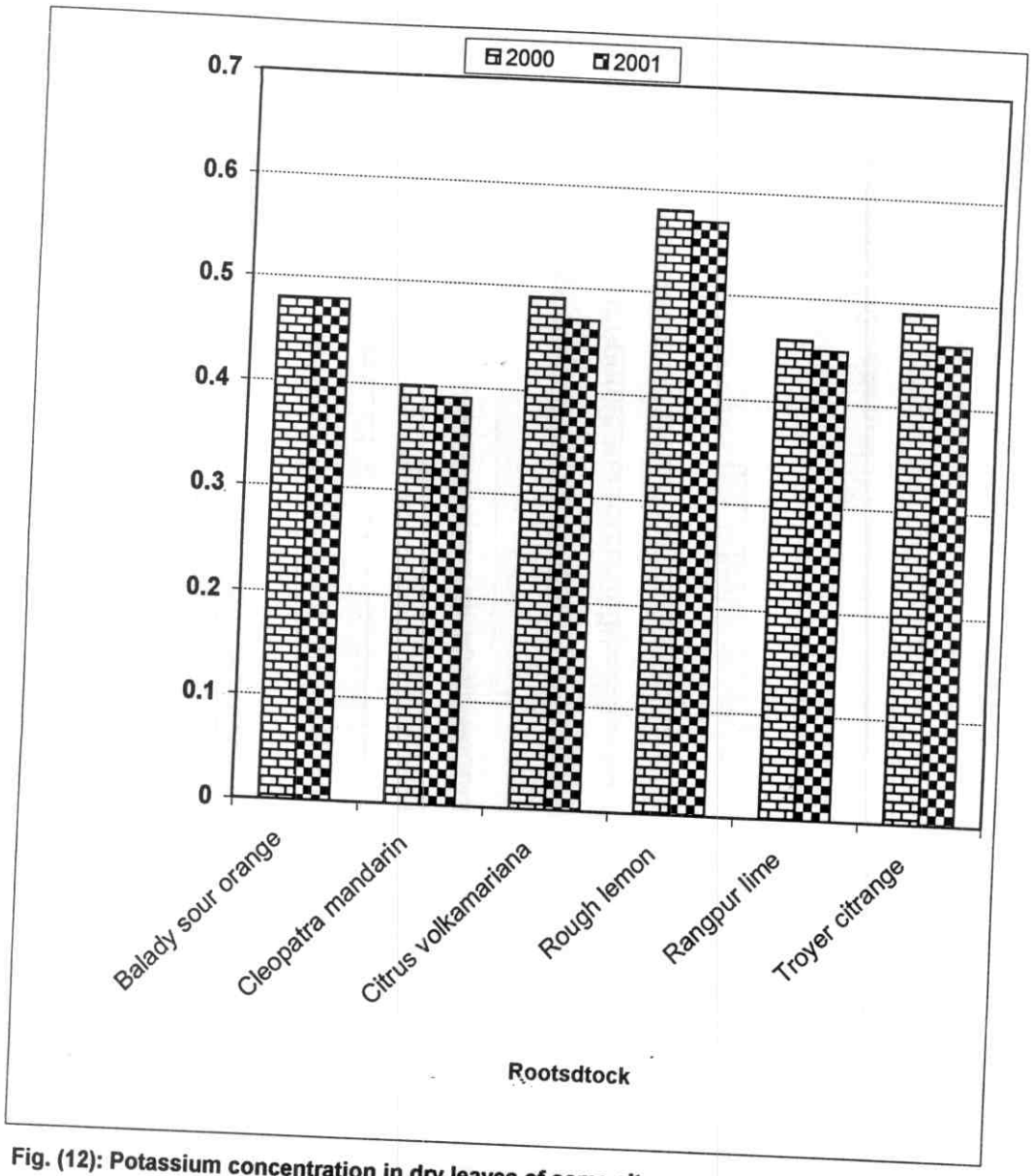

Fig. (12): Potassium concentration in dry leaves of some citrus rootstocks.

Moreover, Troyer citrange, rough lemon, Rangpur lime and Cleopatra mandarin had statistically similar values of leaf nitrogen content.

In the second season (2001), leaves of *Citrus volkameriana* rootstock were the richest ones in their nitrogen content followed by those of Balady sour orange rootstock. Besides, leaves of Troyer citrange, rough lemon and Rangpur lime rootstocks were statistically intermediate in this respect. On the other hand, leaves of Cleopatra mandarin rootstock were the poorest ones in their nitrogen content compared with the other rootstocks from the statistical stand point.

In general, it is easy to notice from both seasons 2000 and 2001 that leaves of *Citrus volkameriana* rootstock were the richest ones in their nitrogen content, followed by those of Balady sour orange rootstock. Besides, leaves of Troyer citrange, rough lemon, Rangpur lime rootstocks were intermediate in this respect. On the other hand, leaves of Cleopatra mandarin rootstocks were the poorest in their nitrogen content compared with the other citrus rootstocks.

These results are in partial agreement with those mentioned by Khamis *et al.* (1984) who reported that leaves of Balady sour orange rootstock were highest one in their nitrogen content. While, leaves of Cleopatra mandarin rootstock was the lowest in their nitrogen content compared with other rootstocks under study.

As well as, these results are in partial agreement with those mentioned by Atawia (1992) who confirmed that leaves of *Citrus volkameriana* rootstock were the richest ones in their nitrogen content. Moreover, studied citrus rootstocks, Rangpur lime, rough lemon and trifoliate orange had statistically similar values of leaf nitrogen content and were the lowest in their values of nitrogen content.

On the other hand, Hassaballa (1975) found that leaves of Orlando tangelo rootstock were the highest ones compared with other eleven tested rootstocks in the mean percentage of N in dry weight of the tops.

4.5.2. Phosphorus:-

It is obvious from Table (5) and Fig. (11) that phosphorus content in dry leaves of studied citrus rootstocks varied significantly in both seasons 2000 and 2001.

In the first season (2000), leaves of Balady sour orange and *Citrus volkameriana* rootstocks had the highest values of phosphorus content and were statistically similar values, followed by those of Rangpur lime rootstock. Whereas, leaves of Troyer citrange rootstock took the other way around. Moreover, leaves of rough lemon and Cleopatra mandarin rootstocks had similar values of phosphorus content and took statistically intermediate place in this respect.

In the second season (2001), leaves of Balady sour orange rootstock had the highest values of phosphorus content, followed by those of *Citrus volkameriana* rootstock. While, leaves of Cleopatra mandarin, rough lemon and Troyer citrange rootstocks were the lowest values of phosphorus content and statistically similar in their values. Besides, leaves of Rangpur lime rootstock took statistically intermediate place in this respect.

Anyhow, it is obvious from both seasons 2000 and 2001 that leaves of Balady sour orange rootstock had the highest values of phosphorus content, followed by those of *Citrus volkameriana* rootstock. Moreover, leaves of Rangpur lime rootstock took intermediate place in this respect. Meanwhile, leaves of other rootstocks, Cleopatra mandarin, rough lemon,

Moreover, Troyer citrange, rough lemon, Rangpur lime and Cleopatra mandarin had statistically similar values of leaf nitrogen content.

In the second season (2001), leaves of *Citrus volkameriana* rootstock were the richest ones in their nitrogen content followed by those of Balady sour orange rootstock. Besides, leaves of Troyer citrange, rough lemon and Rangpur lime rootstocks were statistically intermediate in this respect. On the other hand, leaves of Cleopatra mandarin rootstock were the poorest ones in their nitrogen content compared with the other rootstocks from the statistical stand point.

In general, it is easy to notice from both seasons 2000 and 2001 that leaves of *Citrus volkameriana* rootstock were the richest ones in their nitrogen content, followed by those of Balady sour orange rootstock. Besides, leaves of Troyer citrange, rough lemon, Rangpur lime rootstocks were intermediate in this respect. On the other hand, leaves of Cleopatra mandarin rootstocks were the poorest in their nitrogen content compared with the other citrus rootstocks.

These results are in partial agreement with those mentioned by Khamis *et al.* (1984) who reported that leaves of Balady sour orange rootstock were highest one in their nitrogen content. While, leaves of Cleopatra mandarin rootstock was the lowest in their nitrogen content compared with other rootstocks under study.

As well as, these results are in partial agreement with those mentioned by Atawia (1992) who confirmed that leaves of *Citrus volkameriana* rootstock were the richest ones in their nitrogen content. Moreover, studied citrus rootstocks, Rangpur lime, rough lemon and trifoliate orange had statistically similar values of leaf nitrogen content and were the lowest in their values of nitrogen content.

On the other hand, Hassaballa (1975) found that leaves of Orlando tangelo rootstock were the highest ones compared with other eleven tested rootstocks in the mean percentage of N in dry weight of the tops.

4.5.2. Phosphorus:-

It is obvious from Table (5) and Fig. (11) that phosphorus content in dry leaves of studied citrus rootstocks varied significantly in both seasons 2000 and 2001.

In the first season (2000), leaves of Balady sour orange and *Citrus volkameriana* rootstocks had the highest values of phosphorus content and were statistically similar values, followed by those of Rangpur lime rootstock. Whereas, leaves of Troyer citrange rootstock took the other way around. Moreover, leaves of rough lemon and Cleopatra mandarin rootstocks had similar values of phosphorus content and took statistically intermediate place in this respect.

In the second season (2001), leaves of Balady sour orange rootstock had the highest values of phosphorus content, followed by those of *Citrus volkameriana* rootstock. While, leaves of Cleopatra mandarin, rough lemon and Troyer citrange rootstocks were the lowest values of phosphorus content and statistically similar in their values. Besides, leaves of Rangpur lime rootstock took statistically intermediate place in this respect.

Anyhow, it is obvious from both seasons 2000 and 2001 that leaves of Balady sour orange rootstock had the highest values of phosphorus content, followed by those of *Citrus volkameriana* rootstock. Moreover, leaves of Rangpur lime rootstock took intermediate place in this respect. Meanwhile, leaves of other rootstocks, Cleopatra mandarin, rough lemon,

Troyer citrange had similar values in their content of phosphorus and were the lowest in this respect.

These results are in partial agreement with those mentioned by Hassaballa (1975) who found that the mean percentage of P in dry weight of tops was the lowest in Troyer citrange rootstock. Also, Khamis *et al.* (1984) mentioned that Cleopatra mandarin rootstock was the lowest in content of P in dry leaves compared with the other citrus rootstocks under study.

However, these results are contrast with those mentioned by Atawia (1992) who noticed that the highest values of phosphorus content in dry leaves were observed in *Citrus volkameriana* and Rangpur lime rootstocks which had statistically similar values of phosphorus content compared with the other citrus rootstocks.

4.5.3. Potassium:-

It is clear from Table (5) and Fig. (12) that in both seasons 2000 and 2001, potassium content in dry leaves of studied citrus rootstocks varied significantly in their values.

In both seasons 2000 and 2001, the highest leaf potassium content was observed with rough lemon rootstock, followed by Balady sour orange, *Citrus volkameriana,* and Troyer citrange rootstocks. Moreover, Rangpur lime had statistically intermediate place in this respect. While, the lowest values of potassium content were observed with Cleopatra mandarin rootstocks.

These results are in partial agreement with those mentioned by Khamis *et al.* (1984) who mentioned that rough lemon rootstock had the highest values of leaf potassium content, compared with the other citrus rootstocks. While, Cleopatra mandarin rootstock had the lowest

values of leaves potassium content. Also, Atawia (1992) noticed that the highest leaf potassium content was observed with rough lemon rootstock compared with the other citrus rootstocks under study.

On the other hand, these results are contrast with those mentioned by Hassaballa (1975) who found that Cleopatra mandarin, sour orange and Troyer citrange rootstocks had the highest values of leaf potassium content and were statistically similar in their values.

4.5.4 Calcium:-

Table (6) and Figs. (13 and 14) show calcium and magnesium content in dry leaves of Balady sour orange, Cleopatra mandarin, *Citrus volkameriana,* rough lemon, Rangpur lime and Troyer citrange rootstocks. It is clear that in both seasons 2000 and 2001 studied citrus rootstocks varied significantly in their values of calcium and magnesium content.

In both seasons 2000 and 2001, leaves of *Citrus volkameriana* rootstock were the richest ones in their values of calcium content. Whereas, leaves of Cleopatra mandarin rootstock took the other way around. Other studied citrus rootstocks were intermediate in this respect.

It is easy to arrange the evaluated citrus rootstocks in this respect in a descending order as follows: *Citrus volkameriana,* Rangpur lime, rough lemon, Balady sour orange and finally Cleopatra mandarin rootstocks.

These results are in partial agreement with those mentioned by Atawia (1992) who reported that *Citrus volkameriana* rootstock was the highest ones in their values of calcium content in their leaves. On the other hand, leaves of Balady sour orange and trifoliate orange rootstocks recorded the lowest values of calcium. Moreover, Rangpur lime and rough lemon rootstocks recorded in between values.

Table (6): Calcium and magnesium content in dry leaves of some citrus rootstocks.

Rootstock	Calcium (%)		Magnesium (%)	
	Season 2000	Season 2001	Season 2000	Season 2001
Balady sour orange	3.31 e	3.27 e	0.44 b	0.43 b
Cleopatra mandarin	3.10 f	3.05 f	0.37 c	0.35 c
Volkamer lemon	3.52 a	3.46 a	0.52 a	0.50 a
Rough lemon	3.40 c	3.34 c	0.37 c	0.34 cd
Rangpur lime	3.43 b	3.38 b	0.36 cd	0.35 c
Troyer citrange	3.34 d	3.30 d	0.35 d	0.33 d

Means within a column followed by the same letter (s) are not statistically different at 5 % level by Duncan's multiple range test.

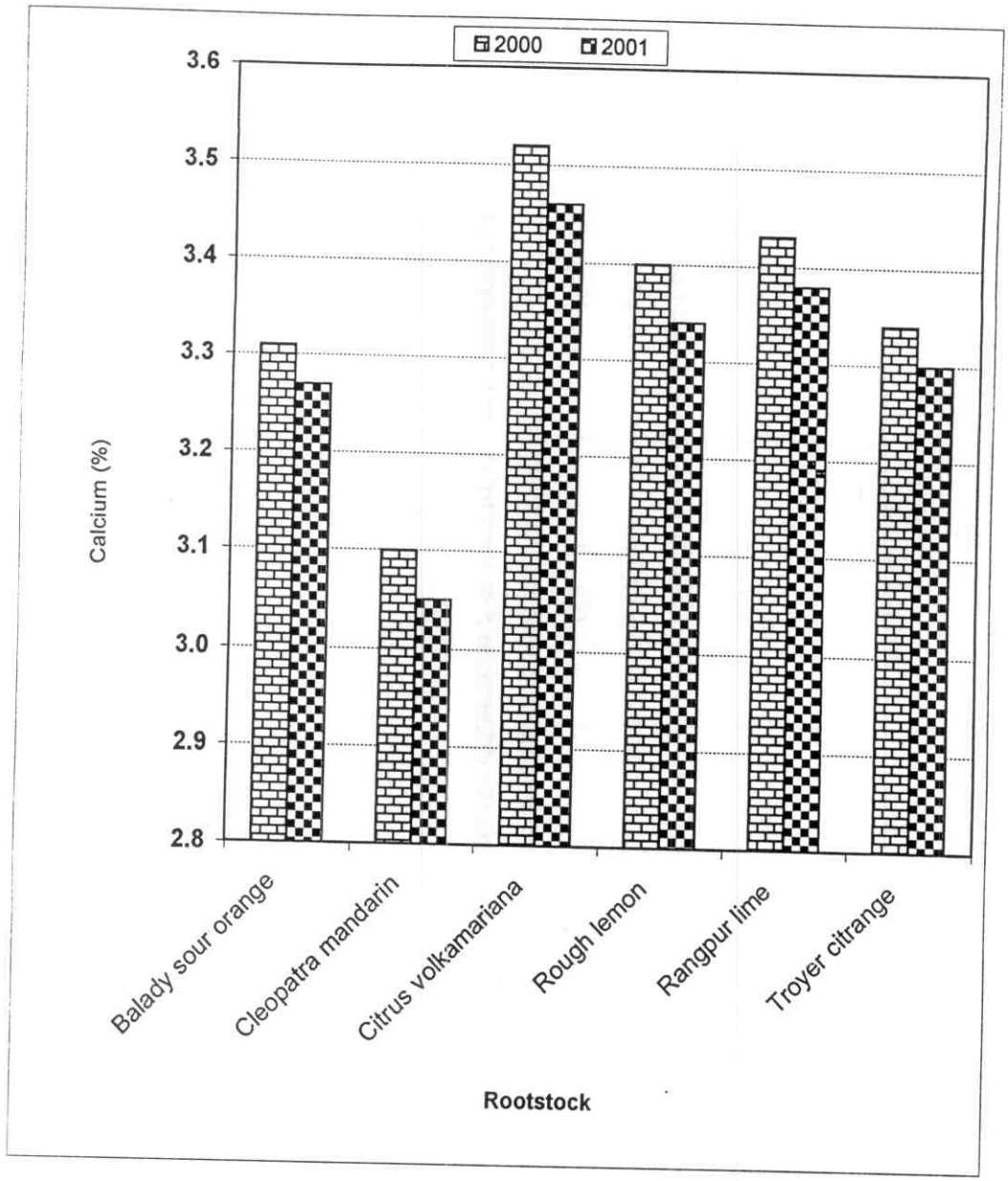

Fig. (13): Calcium concentration in dry leaves of some citrus rootstocks.

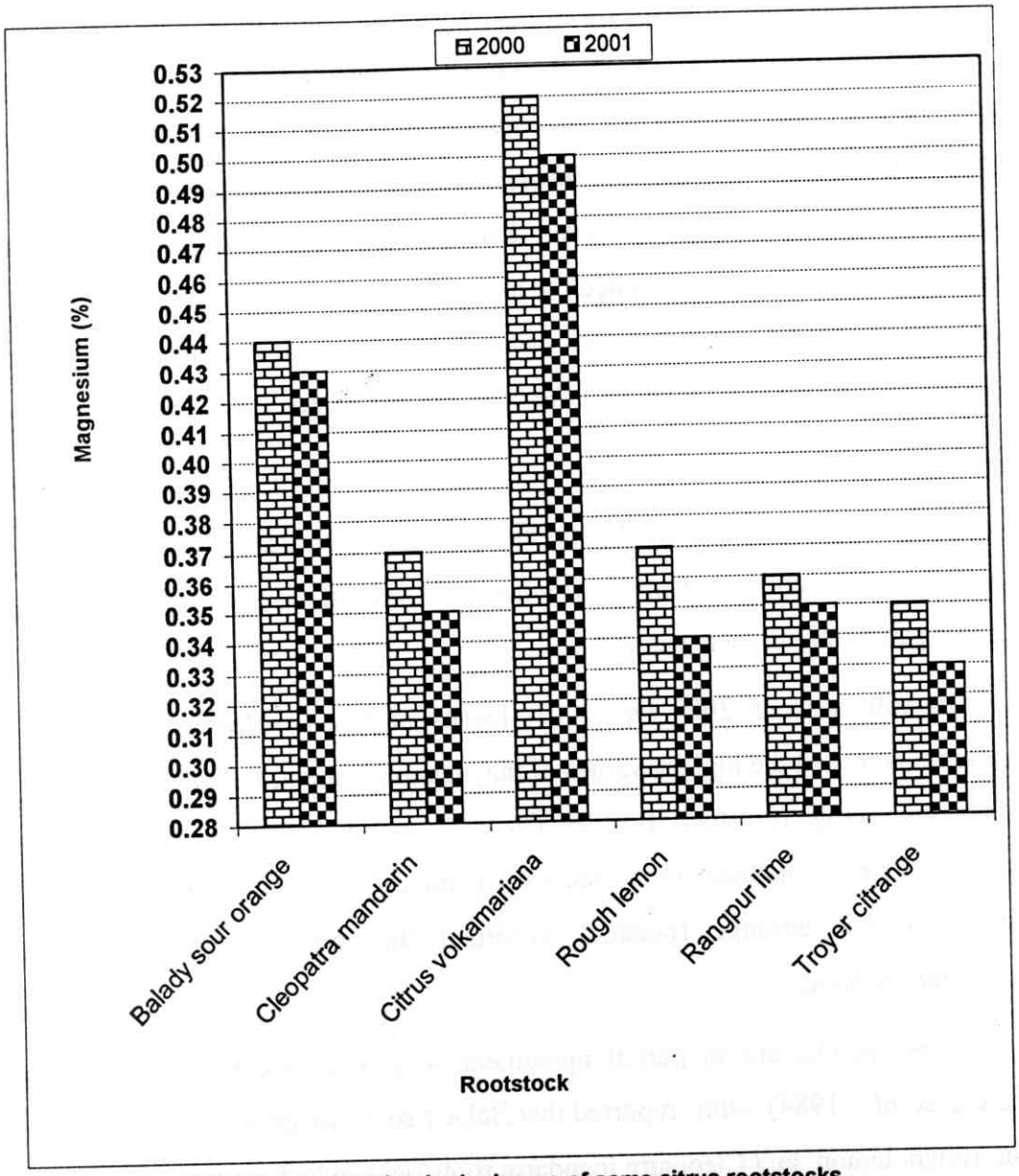

Fig. (14): Magnesium concentration in dry leaves of some citrus rootstocks.

On the other hand, these results are in contrast with those mentioned by Hassaballa (1975) who reported that Cleopatra mandarin rootstock had the highest values of calcium content, compared with the other rootstocks. While, *Citrus volkameriana* rootstock had the lowest values of calcium content. However, Khamis *et al.* (1984) found that Balady sour orange rootstocks had the highest values of calcium content. While, Cleopatra mandarin rootstock had the lowest content of calcium in dry weight of leaves compared with the other citrus rootstocks.

4.5.5. Magnesium:-

It is obvious from table (6) and Fig. (14) that in both seasons 2000 and 2001 magnesium content in dry leaves of studied citrus rootstocks varied significantly in their values.

In both seasons 2000 and 2001, leaves of *Citrus volkameriana* rootstock recorded the highest values of magnesium content, followed by Balady sour orange rootstock. Besides, Cleopatra mandarin, rough lemon, Rangpur lime rootstocks took statistically intermediate place in this respect. Troyer citrange rootstock recorded the lowest values of magnesium content.

These results are in partial agreement with those mentioned by Khamis *et al.* (1984) who reported that Balady sour orange was higher than rough lemon and Cleopatra mandarin rootstocks in leaf magnesium content. Also, Atawia (1992) mentioned that *Citrus volkameriana* rootstock was the richest in leaf magnesium content compared with the other studied citrus rootstocks which had statistically similar values.

On the other hand, these results disagree with those mentioned by Hassaballa (1975) who found that Troyer citrange rootstock had the

highest values of magnesium content compared with the other citrus rootstocks under study.

The aforementioned results of leaf nutrient content of different citrus rootstocks revealed that *Citrus volkameriana* rootstock had high capacity of nutrient uptake as compared with Balady sour orange, Cleopatra mandarin, rough lemon, Rangpur lime and Troyer citrange rootstocks.

This may give another explanation for the vigorous growth of *Citrus volkameriana* as compared with Balady sour orange, Cleopatra mandarin, rough lemon, Rangpur lime and Troyer citrange rootstocks.

4.6. Seed characteristics:

Table (7) and Figs. (15-18) show the seed characteristics of Balady sour orange, Cleopatra mandarin, *Citrus volkameriana*, rough lemon, Rangpur lime and Troyer citrange rootstocks. It is clear that seeds of studied Citrus rootstocks in the most cases varied significantly in their values of seed weight, seed polyembryony, seed germination and seed rate in both seasons 2000 and 2001.

4.6.1. Seed weight:-

It is quite evident from Table (7) and Fig. (15) that in both seasons 2000 and 2001 seeds of Troyer citrange rootstock was the heaviest ones, followed by Balady sour orange rootstock. Besides, seeds of Cleopatra mandarin rootstock took intermediate place in this respect. Meanwhile, rough lemon, *Citrus volkameriana* and Rangpur lime rootstocks were the least ones in their weight.

These results are in partial agreement with those mentioned by Atawia (1992) who reported that trifoliate orange and Balady sour orange rootstocks had the heaviest seeds compared with Rangpur lime, rough

Table (7): Seed characteristics of seeds of some citrus rootstocks.

Rootstock	Seed weight {100 seed (g)}		Seed polyembryony (%)		Seed germination (%)		Germination rate (%)	
	Season 2000	Season 2001	Season 2000	Season 2001	Season 2000	Season 2001	Season 2000	Season 2001
Balady sour orange	20.81 b	21.00 b	96.31 ab	96.02 ab	59.02 cd	58.70 cd	0.29 bc	0.29 bc
Cleopatra mandarin	13.59 c	13.71 c	90.59 cd	90.21 cd	55.07 de	54.29 de	0.25 c	0.24 cd
Volkamer lemon	7.78 de	7.86 de	88.45 d	88.20 d	73.14 a	73.00 a	0.40 a	0.39 a
Rough lemon	8.29 d	8.40 d	94.30 bc	94.06 bc	65.41 bc	64.87 bc	0.32 b	0.31 b
Rangpur lime	5.38 e	5.46 e	83.80 e	83.49 e	70.93 ab	70.13 ab	0.39 a	0.38 a
Troyer citrange	28.21 a	28.83 a	99.72 a	99.51 a	50.50 e	50.72 e	0.24 c	0.23 d

Means within a column followed by the same letter (s) are not statistically different at 5 % level by Duncan's multiple range test.

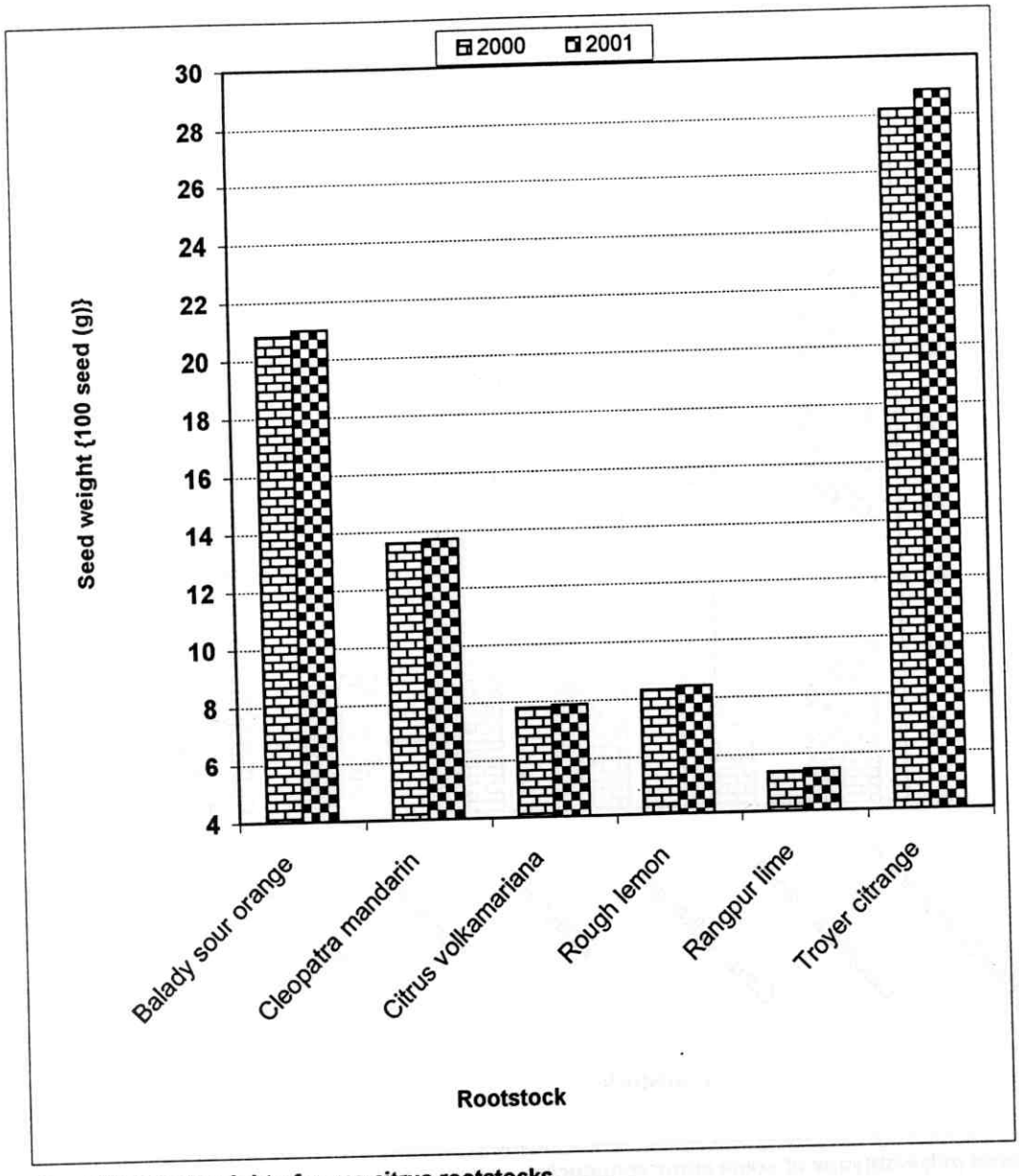

Fig. (15): Seed weight of some citrus rootstocks.

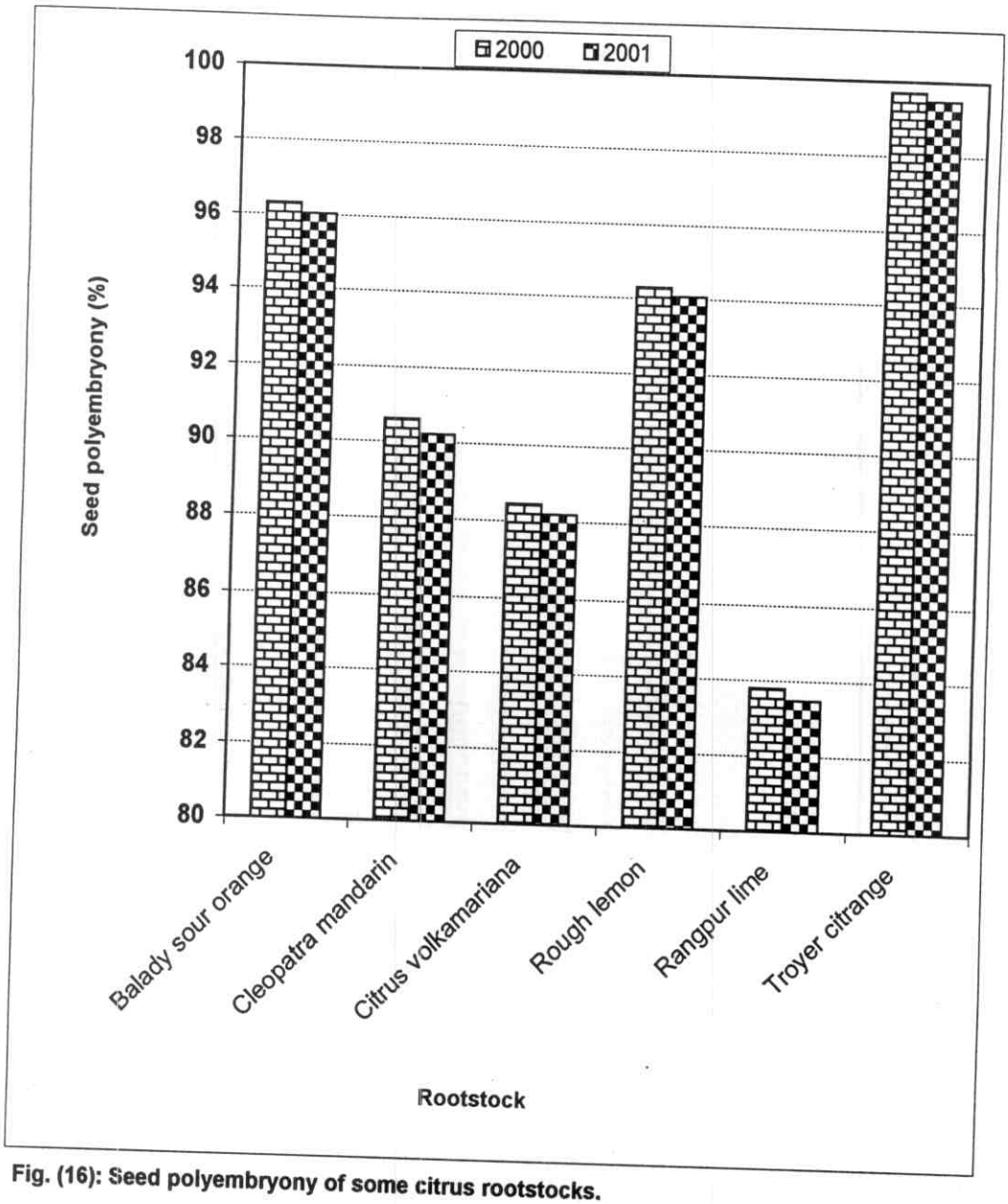

Fig. (16): Seed polyembryony of some citrus rootstocks.

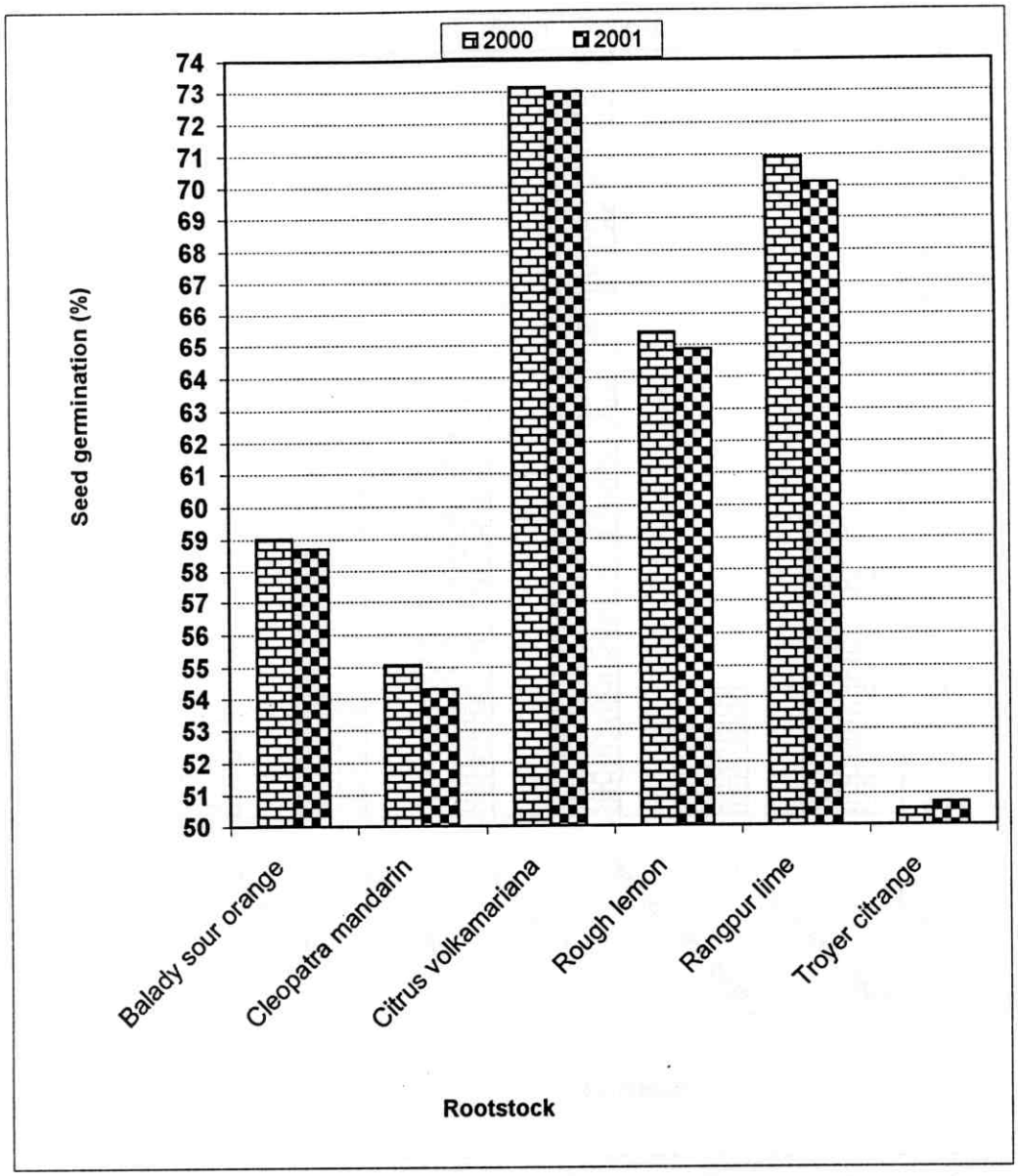

Fig. (17): Seed germination of some citrus rootstocks.

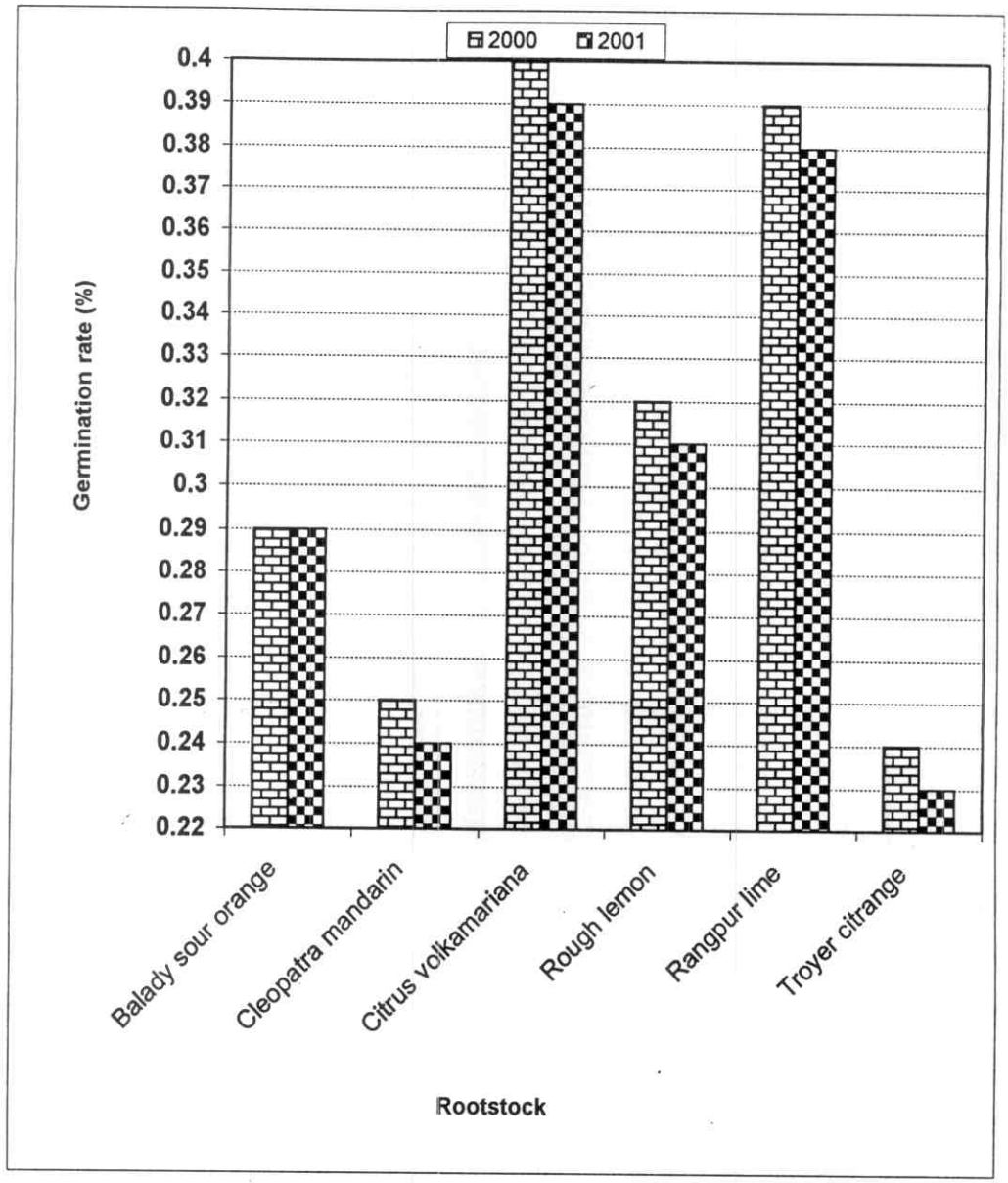

Fig. (18): Germination rate of some citrus rootstocks.

lemon and *Citrus volkameriana* rootstock. Whereas, seed weight of Rangpur lime rootstock took the other way around. Also, Gravina (1989) and Khalil (1999) found that detectable differences were observed in seed weight and uniformity of citrus rootstocks, Troyer citrange, *Citrus volkameriana,* Balady lime, Rashidi lime, sour orange, Carrizo citrange, Swingle citrumelo, *Citrus amblycarpa, Citrus macrophylla* and *Citrus taiwanica* which had the highest average seed weight.

4.6.2. Seed polyembryony:-

It is quite clear from Table (7) and Fig. (16) that in both seasons 2000 and 2001 seeds of Troyer citrange rootstock were highly polyembryonic, followed by those of Balady sour orange rootstock. While, seeds of Rangpur lime rootstock were the lowest polyembryonic seeds compared with those of other citrus rootstocks under study. Besides, seeds of rough lemon, Cleopatra mandarin and *Citrus volkameriana* rootstock took intermediate place in this respect.

These results are in partial agreement with those mentioned by Atawia (1992) who reported that seeds of rough lemon and Balady sour orange rootstocks were higher polyembryonic than *Citrus volkameriana* rootstock while Rangpur lime rootstock had lower percentage of polyembryony

4.6.3. Seed germination:-

It is obvious from Table (7) and Fig. (17) that in both seasons 2000 and 2001 seeds of *Citrus volkameriana* had significantly the highest percentage of seed germination, followed by Rangpur lime rootstock. Meanwhile, seeds of Cleopatra mandarin and Troyer citrange rootstocks had significantly the lowest percentage of germination compared with the other citrus rootstocks under study and were significantly similar in their

values of germination percentage from the statistical stand point. Moreover, seeds of rough lemon and Balady sour orange rootstocks took intermediate place in their values of germination percentage and were significantly similar in their values from the statistical stand point.

These results are in partial agreement with those mentioned by Atawia (1992) who noticed that the highest percentages of seed germination were observed with *Citrus volkameriana* rootstock, followed by Rangpur lime rootstock. Moreover, seeds of rough lemon and Balady sour orange rootstocks were intermediate in this respect. While, trifoliate orange rootstock showed the lowest seed germination percentage.

On the other hand, these results are contrast with those mentioned by Khamis *et al* (1984) who reported that seedling yield/100 seeds of Cleopatra mandarin rootstock was the highest compared with other citrus rootstocks.

However, Eshuys (1985) confirmed that germination percentage was 35 % for seeds of all citrus rootstocks under his study.

But, Simbson and Panggabean (1986) found that the highest germination percentage was 93 % for seeds of sour orange rootstock.

Moreover, Yousif *et al* (1989) who established that germination percentage of sour orange seeds was 83 %.

4.6.4. Germination rate:

It is clear from Table (7) and Fig. (18) that in both seasons 2000 and 2001 seeds of *Citrus volkameriana* and Rangpur rootstocks germinated significantly with the highest rates compared with those of other citrus rootstocks under the study and were statistically similar in their values of germination rate. While, seeds of Cleopatra mandarin and Troyer citrange rootstocks germinated significantly with the lowest rates

compared with those of other rootstocks under the study. Moreover, seeds of rough lemon and Balady sour orange rootstocks took intermediate place in this respect.

These results are in partial agreement with those mentioned by Atawia (1992) who reported that seeds of *Citrus volkameriana* rootstock germinated with the highest rates as compared with those of other rootstocks tested.

4.7. Seed content of organic substances:-

Table (8) and Figs. (19-21) show the seed content of total soluble phenols, total endogenous gibberellins and total extractable indoles of some citrus rootstocks; Balady sour orange, Cleopatra mandarin, *Citrus volkameriana,* rough lemon and Rangpur lime in both seasons 2000 and 2001. It is clear that seed content of total soluble phenols, total endogenous gibberellins and total extractable indoles of citrus rootstocks under study in the most cases varied significantly in their values in both seasons 2000 and 2001.

4.7.1. Total soluble phenols:-

It is quite evident from Table (8) and Fig. (19) that in both seasons 2000 and 2001 seeds of Troyer citrange rootstock contained significantly the highest concentration of total soluble phenols, followed by those of Cleopatra mandarin rootstock. Besides, seeds of Balady sour orange, rough lemon and Rangpur lime rootstocks took significantly intermediate place in their concentration of total soluble phenols. While, *Citrus volkameriana* rootstock contained significantly the lowest concentration of total soluble phenols.

With no exceptions, these results are in partial agreement with mentioned by Kilany (1980) who found that seeds of Cleopatra mandarin

Table (8): Seed content of total soluble phenols, total endogenous gibberellins and total extractable indoles of some citrus rootstocks..

Rootstock	Phenols mg/100 g dry weight		Gibberellin µg GA/g dry weight		Indoles mg/100 g dry weight	
	Season 2000	Season 2001	Season 2000	Season 2001	Season 2000	Season 2001
Balady sour orange	4.91 c	5.00 c	1.25 c	1.23 c	3.25 b	3.20 c
Cleopatra mandarin	5.81 b	5.89 b	0.80 e	0.74 e	3.00 c	3.02 d
Volkamer lemon	2.72 e	2.77 e	1.47 a	1.44 a	4.28 a	4.17 a
Rough lemon	3.40 d	3.46 d	1.29 b	1.27 bc	3.28 b	3.30 b
Rangpur lime	3.41 d	3.43 d	1.30 b	1.32 b	3.30 b	3.25 bc
Troyer citrange	6.33 a	6.39 a	0.91 d	0.87 d	3.02 c	3.04 d

Means within a column followed by the same letter (s) are not statistically different at 5 % level by Duncan's multiple range test.

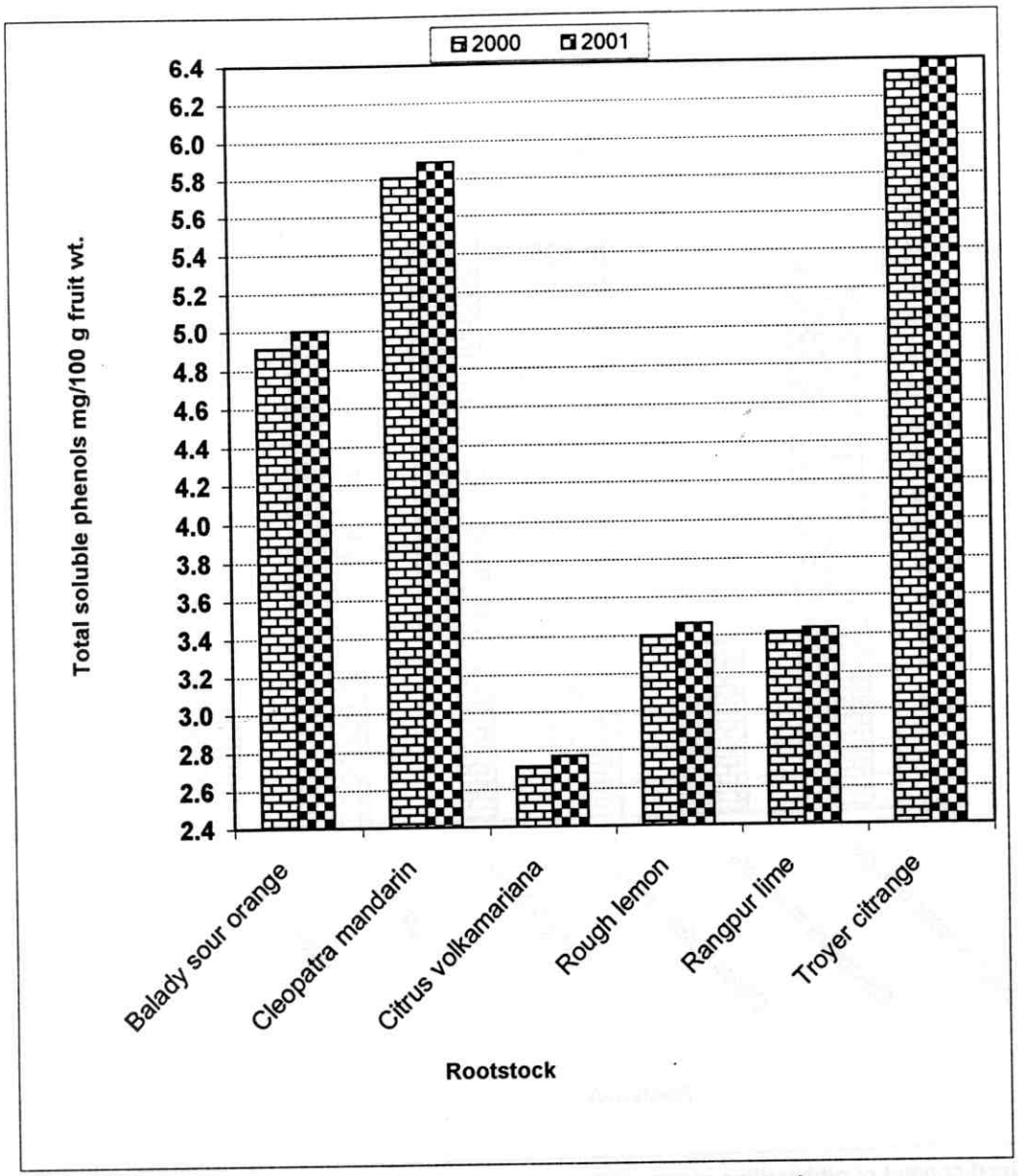

Fig. (19): Seed content of total soluble phenols of some citrus rootstocks.

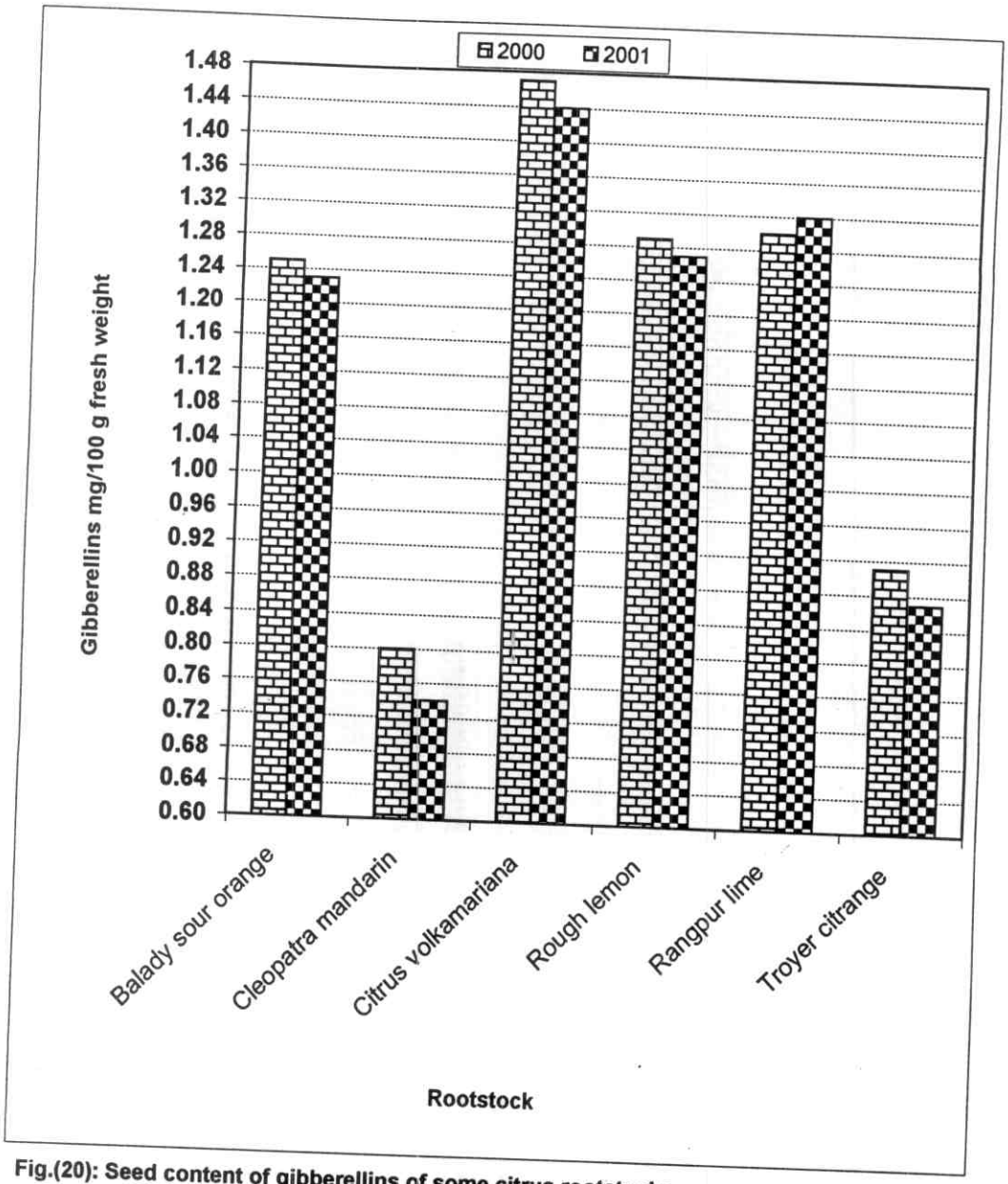

Fig.(20): Seed content of gibberellins of some citrus rootstocks.

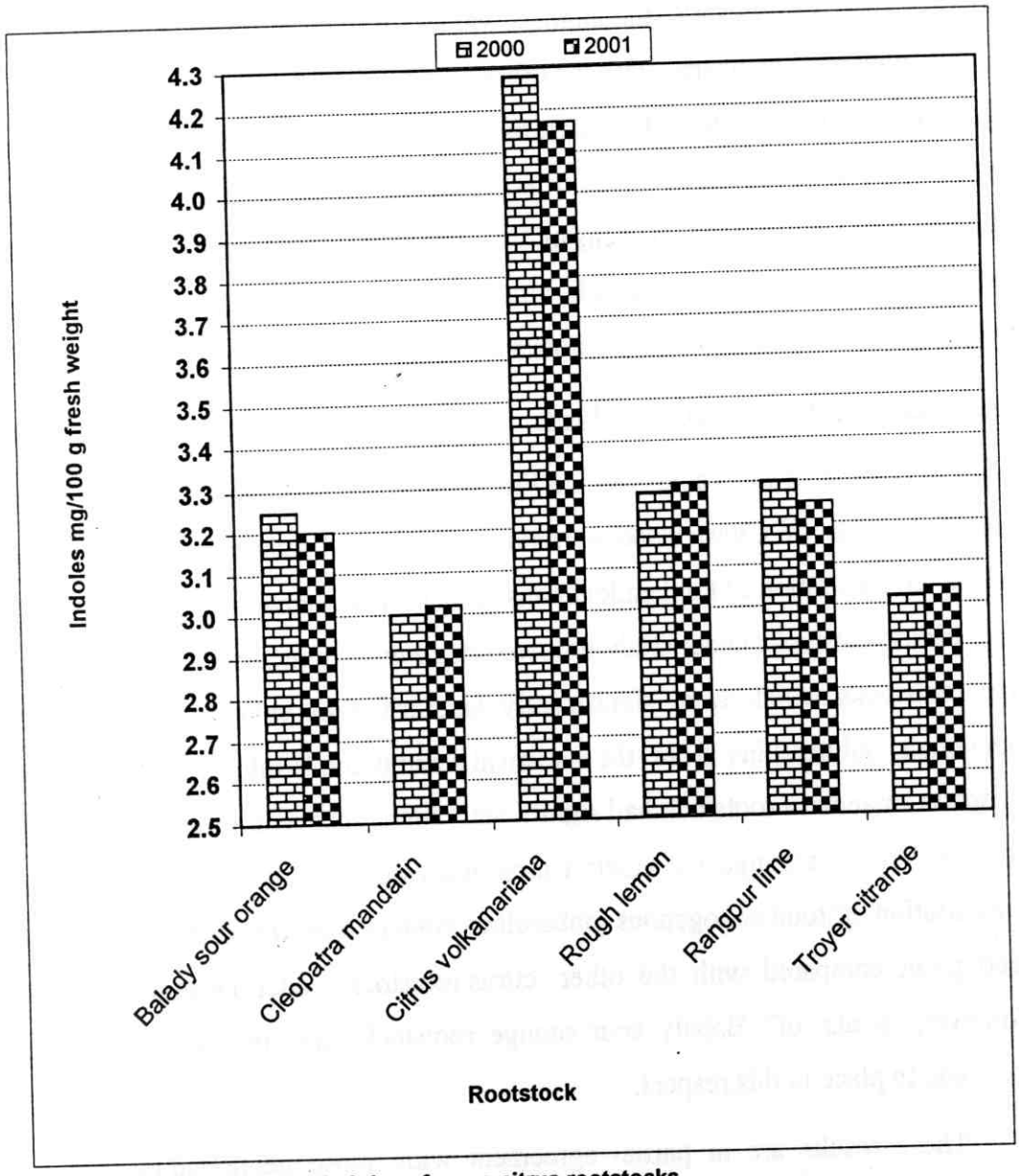

Fig. (21): Seed content of indoles of some citrus rootstocks.

rootstock had significantly the highest values of their content of total soluble phenols, compared with the other citrus rootstocks. While, seeds of Rangpur lime rootstock had significantly the lowest values in this respect compared with the other Citrus rootstocks under the study. Also, Atawia (1992) confirmed that seeds of *Citrus volkameriana* rootstock had statistically the least content of total soluble phenols compounds compared with the other citrus rootstocks under the study.

4.7.2. Total endogenous gibberellins:-

It is clear from Table (8) and Fig. (20) that in both seasons 2000 and 2001 seeds of *Citrus volkameriana* rootstock had significantly the highest concentration of total endogenous gibberellins compared with the other citrus rootstocks under study followed by rough lemon and Rangpur lime rootstocks which were significantly similar in their values of total endogenous gibberellins from the statistical stand point. While, seeds of Cleopatra mandarin rootstock had significantly higher concentration than those of Troyer citrange rootstock which were significantly the lowest concentration of total endogenous gibberellins content from the statistical stand point compared with the other citrus rootstocks under the study. Moreover, seeds of Balady sour orange rootstock had significantly intermediate place in this respect.

These results are in partial agreement with those mentioned by Kilany (1980) who confirmed that seeds of Rangpur lime rootstock had significantly the highest concentration of total endogenous gibberellins content compared with other citrus rootstocks. Meanwhile, seeds of Cleopatra mandarin rootstock had significantly the lowest concentration of total endogenous gibberellins content compared with the other citrus rootstocks. Also, Atawia (1992) found that seeds of *Citrus*

volkameriana rootstock contained significantly the highest concentration of total endogenous gibberellins.

Gibberellins appear to play a role in seed germination at two different stages of germination. In the first stage, it has been suggested that gibberellins act on the initial stage of enzyme induction in their transcription from the chromosomes. A later stage in which gibberellin is effective in the activation of enzymes involving the food mobilizing system.

4.7.3. Total extrable indoles:-

It is quite clear form Table (8) and Fig. (21) that in both seasons 2000 and 2001 seeds of *Citrus volkameriana* rootstock had significantly the highest concentration of total extractable indoles content. While, those of Cleopatra mandarin and Troyer citrange rootstocks had significantly the lowest concentration of total extractable indoles content. Moreover, seeds of Balady sour orange, rough lemon and Rangpur lime rootstocks took significantly intermediate place and were similar in their values from the statistical stand point.

These results are in partial agreement with those mentioned by Atawia (1992) who reported that seeds of *Citrus volkameriana* rootstock had the highest concentration of extractable indoles.

However, these results are in contrast with those mentioned by Kilany (1980) who found that seeds of Cleopatra mandarin rootstocks had significantly the highest level of total extractable indoles content. While, those of Rangpur lime rootstock contained significantly the least content of total extractable indoles.

Table (9) and Fig. (22 and 23) show the seed content of total soluble sugars and total amino acid of some citrus rootstocks, Balady sour

Table (9): Seed content of total soluble sugars and total amino acids of some citrus rootstocks.

Rootstock	Sugars mg/100 g dry weight		Amino acids mg/100 g dry weight	
	Season 2000	Season 2001	Season 2000	Season 2001
Balady sour orange	148.78 e	165.12 e	14.98 f	15.73 f
Cleopatra mandarin	133.23 f	145.07 f	16.21 e	16.98 e
Volkamer lemon	219.71 a	210.31 a	21.90 a	22.95 a
Rough lemon	179.71 d	184.15 d	20.23 c	20.41 c
Rangpur lime	187.10 c	190.05 c	21.01 b	21.46 b
Troyer citrange	210.23 b	205.87 b	17.38 d	18.04 d

Means within a column followed by the same letter (s) are not statistically different at 5 % level by Duncan's multiple range test.

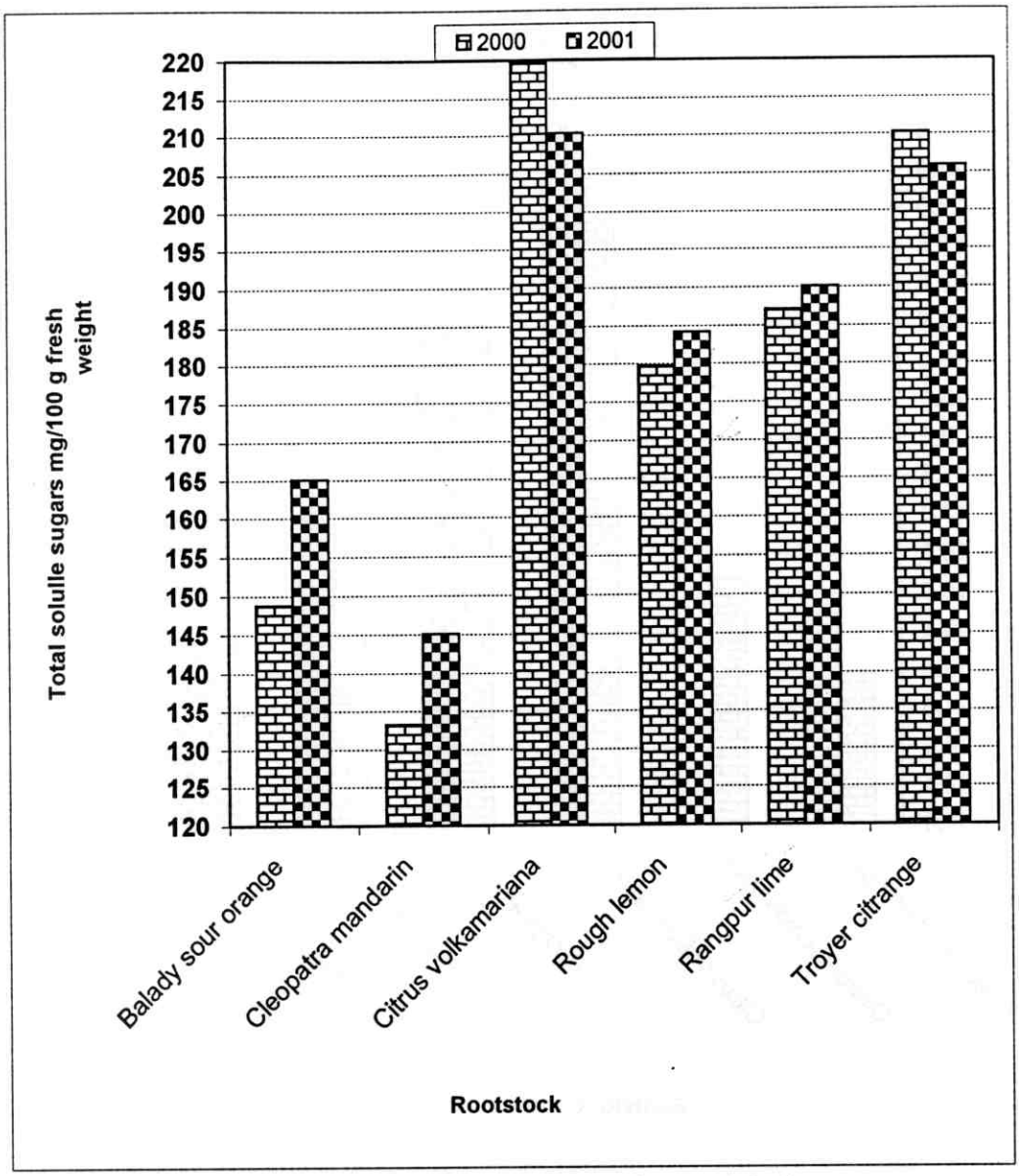

Fig. (22): Seed content of total soluble sugars of some citrus rootstocks.

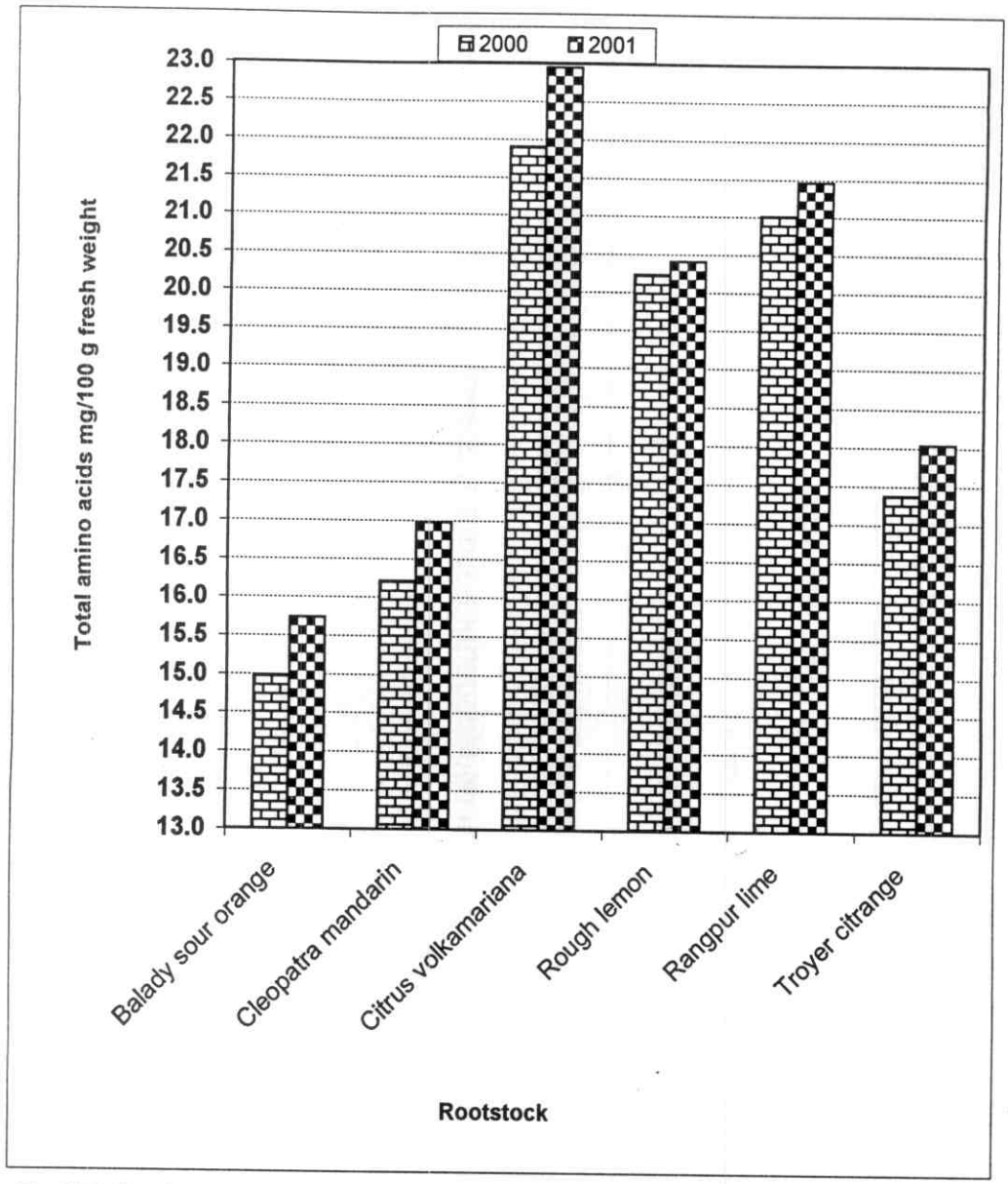

Fig. (23): Seed content of total amino acids of some citrus rootstocks.

orange, Cleopatra mandarin, *Citrus volkameriana*, rough lemon, Rangpur lime and Troyer citrange in both seasons 2000 and 2001. It is clear that seed content of total soluble sugars and total amino acid of citrus rootstock under study in the most cases varied significantly in their values in both seasons 2000 and 2001.

4.7.4. Total soluble sugars:-

It is easy to notice from Table (9) and Fig. (22) that in both seasons 2000 and 2001 seeds of *Citrus volkameriana* rootstock had significantly the highest content of total soluble sugars compared with the other citrus rootstocks under study. Meanwhile, those of Cleopatra mandarin rootstock had significantly the lowest content. It is easy to arranged the other rootstocks in seed content of total soluble sugars between *Citrus volkameriana* and Cleopatra mandarin rootstocks in a descending order as follows: Troyer citrange, Rangpur lime, rough lemon and finally Balady sour orange rootstocks.

These results are in partial agreement with those mentioned by Atawia (1992) who confirmed that seeds of *Citrus volkameriana* rootstock had the highest total soluble content compared with the other citrus rootstocks. However, Kilany (1980) found that seeds of Cleopatra mandarin rootstock had significantly the highest content of total soluble sugars compared with those of other citrus rootstocks tested.

4.7.5. Total amino acids:-

It is quite evident from Table (9) and Fig. (23) that in both seasons 2000 and 2001 seeds of *Citrus volkameriana* rootstock had significantly the highest concentration of total amino acids. Meanwhile, seeds of Cleopatra mandarin rootstocks had significantly the least concentration of total amino acids, between them it is easy to arrange the other seeds of

citrus rootstocks under study in their values of total amino acids in a descending order as follows: Rangpur lime, rough lemon, Troyer citrange and finally Balady sour orange rootstocks.

These results are in partial agreement with those mentioned by Kilany (1980) who noticed that seeds of Rangpur lime rootstock had the significant highest content of total amino acids compared with other rootstocks. While, those of Cleopatra mandarin and sour orange rootstocks had the least content of total amino acids. Also, Atawia (1992) found that seeds of *Citrus volkameriana* rootstock were the richest ones in their content of total amino acids compared with other citrus rootstocks under the study. Meanwhile, Balady sour orange took the other way around.

4.8. Seedling growth:-

Tables (10-12) and Figs. (24-33) show the seedling growth of some citrus rootstocks, Balady sour orange, Cleopatra mandarin, *Citrus volkameriana* , rough lemon, Rangpur lime and Troyer citrange. It is clear that seedlings of studied citrus rootstocks in the most cases varied significantly in their values of seedling height, root length, number of leaves per seedling, number of feeder roots, top fresh weight, root fresh weight, seedling fresh weight, top dry weight, root dry weight and top: root ratio in both seasons 2000 and 2001.

4.8.1. Seedling height:-

It is evident from Table (10) and Fig. (24) that in both seasons 2000 and 2001 seedlings of rough lemon rootstock were significantly the longest ones, followed by seedlings of Rangpur lime rootstock. While, seedlings of Cleopatra mandarin and Troyer citrange rootstocks were significantly the shortest ones and were similar in their values from the

Table (10): Seedling length, root length, number of leaves per seedling and number of feeder roots of some citrus rootstocks.

Rootstock	Seedling length (cm)		Root length (cm)		No. of feeder roots		No. of leaves/seedling	
	Season 2000	Season 2001	Season 2000	Season 2001	Season 2000	Season 2001	Season 2000	Season 2001
Balady sour orange	18.2 c	19.0 c	12.2 e	13.0 e	1.35 c	1.31 c	16.7 a	17.4 a
Cleopatra mandarin	14.9 d	15.8 d	15.3 d	16.6 d	1.49 bc	1.43 bc	14.8 bc	15.5 bc
Volkamer lemon	19.3 c	20.1 c	30.4 a	31.8 a	1.60 ab	1.55 ab	15.7 ab	16.0 b
Rough lemon	28.2 a	29.4 a	24.1 b	25.7 b	1.70 a	1.64 a	14.0 c	14.4 c
Rangpur lime	22.7 b	23.6 b	18.3 c	19.5 c	1.40 c	1.36 c	14.4 bc	15.1 bc
Troyer citrange	16.3 d	17.0 d	9.5 f	10.7 f	1.45 bc	1.41 bc	10.2 d	10.4 d

Means within a column followed by the same letter (s) are not statistically different at 5 % level by Duncan's multiple range test.

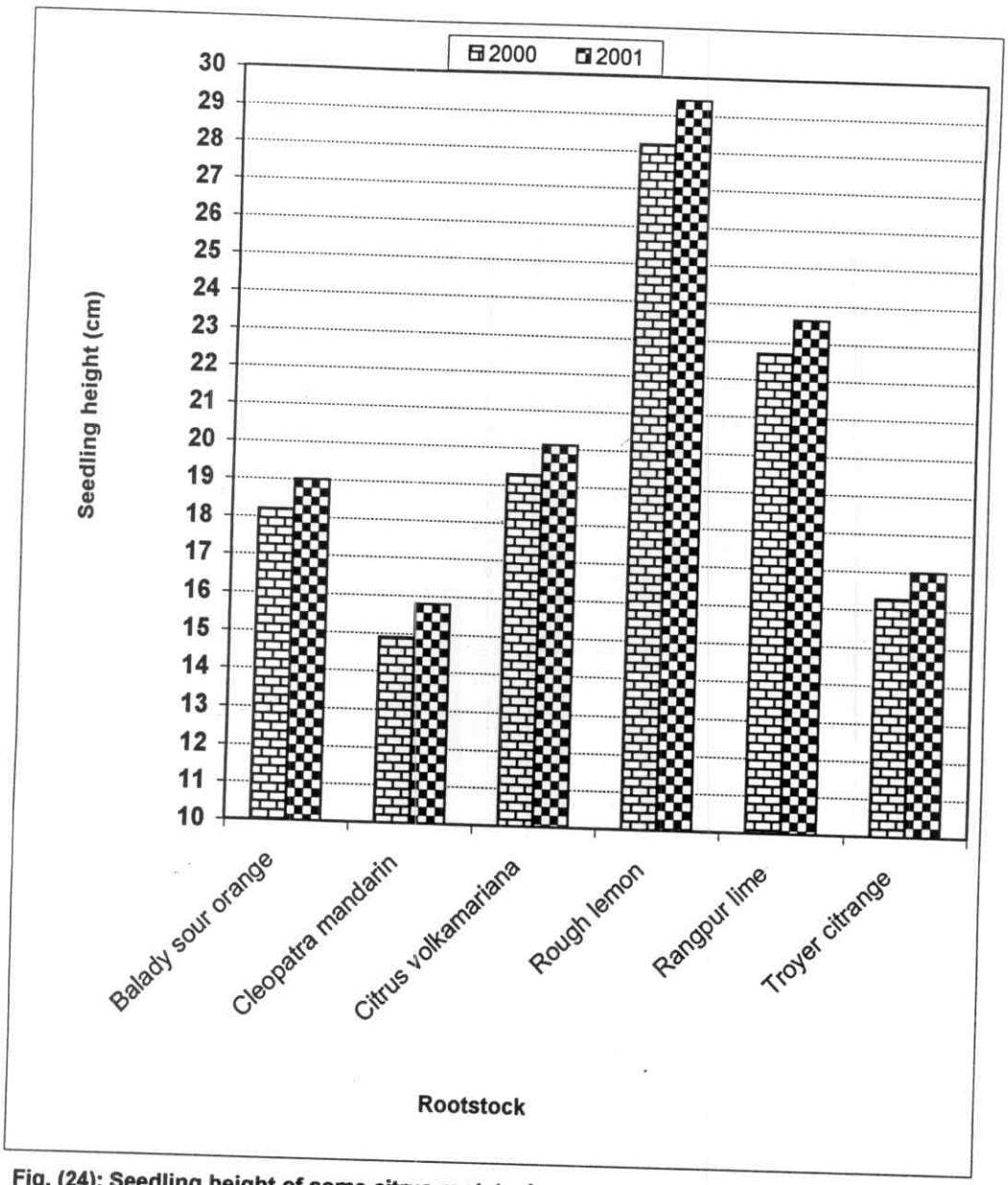

Fig. (24): Seedling height of some citrus rootstocks.

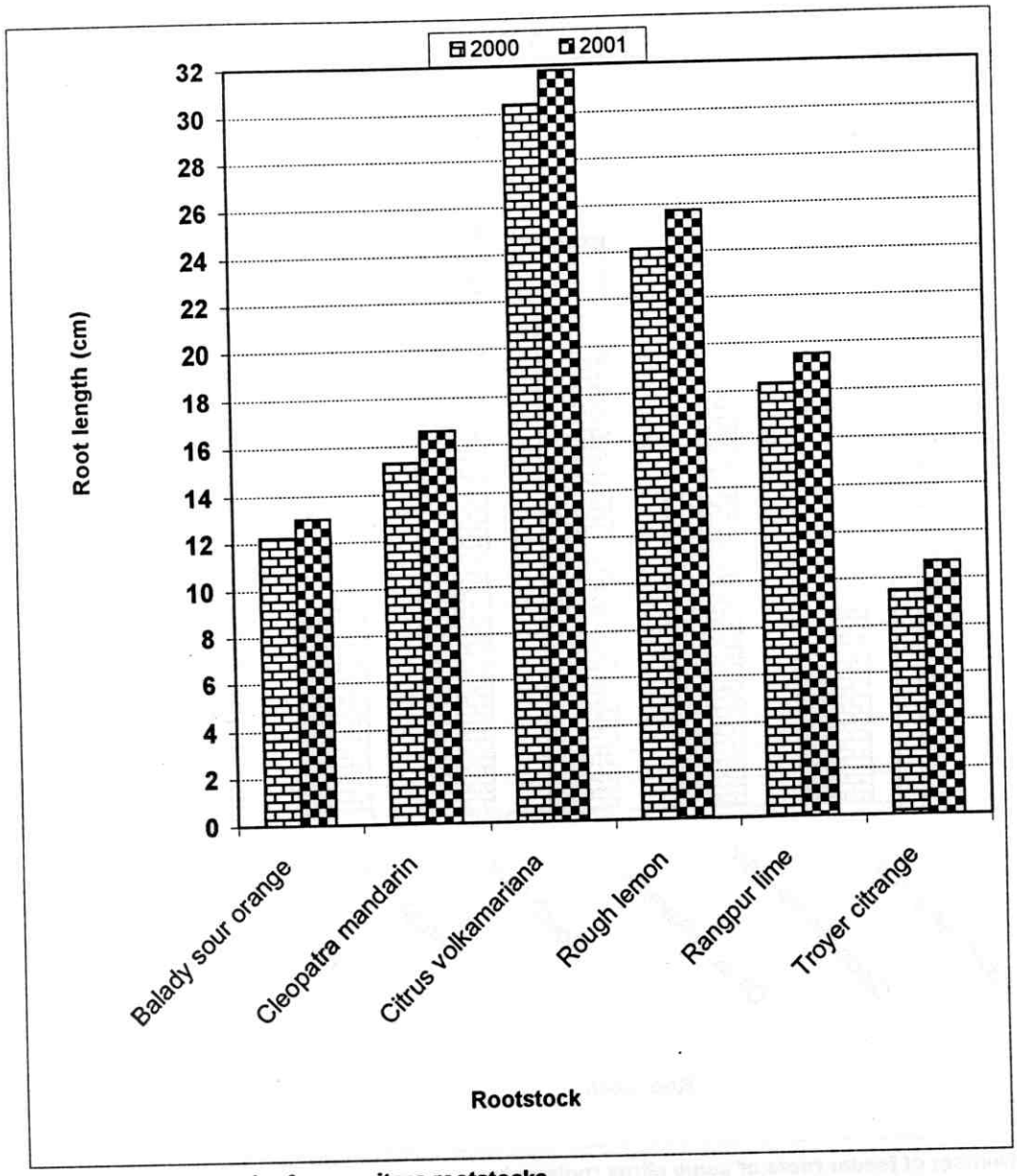

Fig. (25): Root length of some citrus rootstocks.

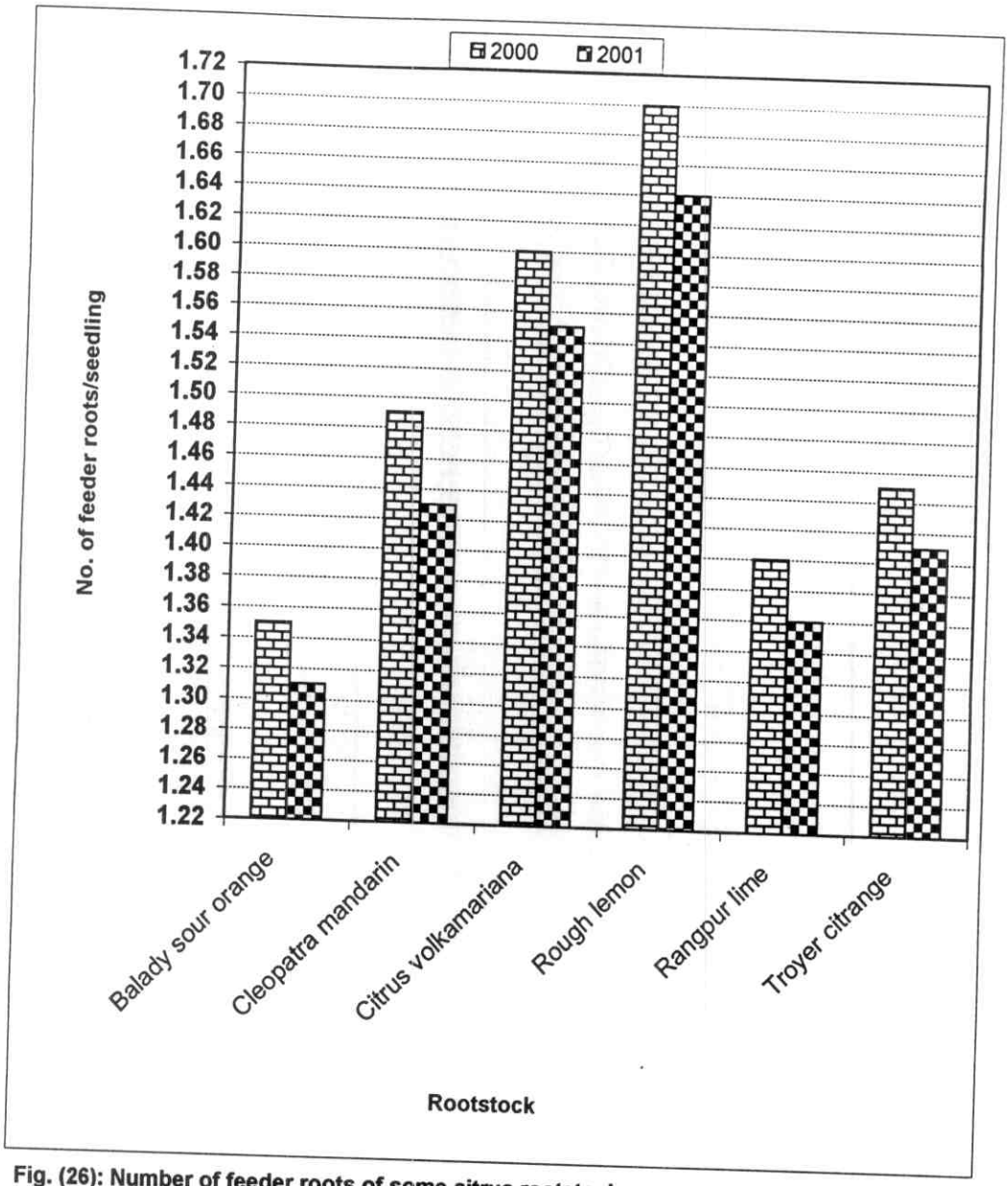

Fig. (26): Number of feeder roots of some citrus rootstocks.

order as follows: rough lemon, Rangpur lime, Cleopatra mandarin and Troyer citrange rootstock seedlings.

These results are in partial agreement with those mentioned by Toyed (1985) who found that rough lemon seedlings had significantly the longest primary roots compared with the other tested rootstock seedlings. Also, Atawia (1992) who found that *Citrus volkameriana* rootstock seedlings had the longest roots compared with the other rootstock seedlings.

4.8.3. Number of feeder roots:-

It is easy to notice from Table (10) and Fig. (26) that in bot seasons 2000 and 2001 seedlings of rough lemon and *Citrus volkameriana* had significantly the highest number of feeder roots and were similar in the their values of number of feeder roots from the statistical stand point. Meanwhile, those of Balady sour orange and Rangpur lime rootstocks had significantly the lowest number of feeder roots. Besides, other rootstock seedlings, Cleopatra mandarin and Troyer citrange came in between in this respect.

These results are in partial agreement with those mentioned by Tayde (1985) who reported that rough lemon rootstock seedlings had the highest number of fibrous roots. Also, Atawia (1992) who found that number of feeder roots of *Citrus volkameriana* rootstock seedlings were the highest compared with the other rootstock seedlings.

4.8.4. Number of leaves per seedling:-

It is quite clear from Table (10) and Fig. (27) that in both seasons 2000 and 2001 seedlings of Balady sour orange had significantly the highest number of leaves per seedling, followed by *Citrus volkameriana* seedlings. While, seedlings of Troyer citrange rootstock had significantly

the lowest number of leaves per seedling. Moreover, Cleopatra mandarin, Rangpur lime and rough lemon rootstock seedlings were significantly intermediate in this respect.

These results are in contrast with those mentioned by Atawia (1992) who reported that seedling of Balady sour orange, *Citrus volkameriana* , Rangpur lime and rough lemon had statistically similar number of leaves per seedling.

4.8.5. Top fresh weight:-

It is quite evident from Table (11) and Fig. (28) that in both seasons 2000 and 2001 seedlings of *Citrus volkameriana* rootstock had significantly the heaviest top fresh weight, followed by those of Balady sour orange and rough lemon rootstocks. While, seedlings of Troyer citrange rootstock took significantly the other way around. Besides, Cleopatra mandarin and Rangpur lime rootstock seedlings took significantly intermediate place in their top fresh weight.

These results are in partial agreement with those mentioned by Hassaballa (1975) who reported that seedlings of Troyer citrange rootstock were significantly the lowest in top fresh weight. On the other hand, these results are in contrast with those mentioned by Hassaballa (1975) who confirmed that *Citrus volkameriana*, Balady sour orange, Cleopatra mandarin and Rangpur lime rootstock seedlings were significantly intermediate in top fresh weight compared with other rootstock seedlings under the study.

4.8.6. Root fresh weight:-

It is quite easy to notice from Table (11) and Fig. (29) that in both seasons seedlings of *Citrus volkameriana* and Balady sour orange

Table (11): Top, root and seedling fresh weight of some citrus rootstocks.

Rootstock	Top fresh weight (g)		Root fresh weight (g)		Seedling fresh weight (g)	
	Season 2000	Season 2001	Season 2000	Season 2001	Season 2000	Season 2001
Balady sour orange	5.53 b	5.48 b	2.76 a	2.71 b	8.29 b	8.19 b
Cleopatra mandarin	4.38 c	4.43 c	1.65 c	1.68 e	6.03 d	6.11 d
Volkamer lemon	5.72 a	5.78 a	2.95 a	3.00 a	8.67 a	8.78 a
Rough lemon	5.47 b	5.43 b	1.98 b	1.95 d	7.45 c	7.38 c
Rangpur lime	3.81 d	3.75 d	2.14 b	2.12 c	5.95 d	5.87 d
Troyer citrange	2.00 e	1.97 e	1.85 b	1.83 d	3.85 e	3.80 e

Means within a column followed by the same letter (s) are not statistically different at 5 % level by Duncan's multiple range test.

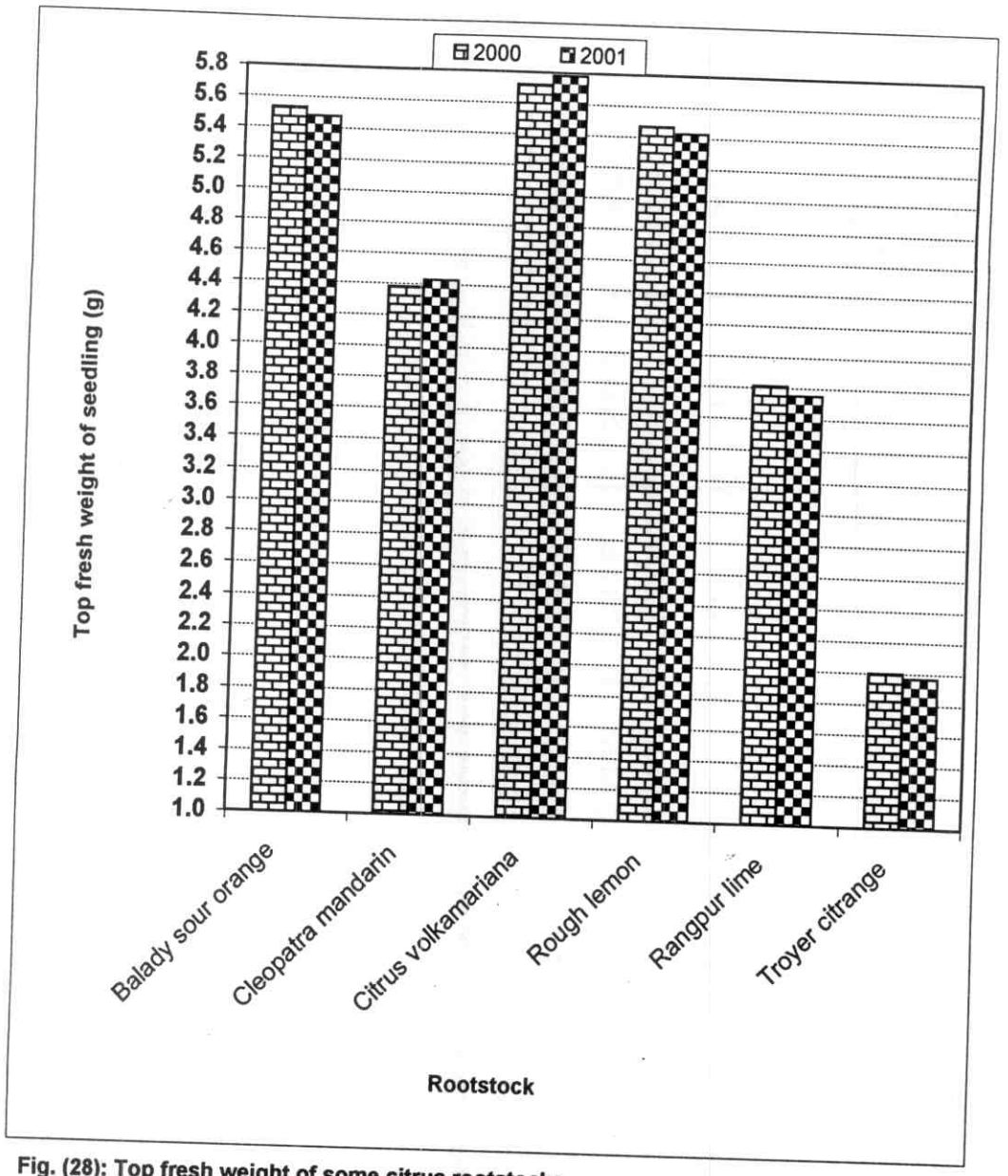

Fig. (28): Top fresh weight of some citrus rootstocks.

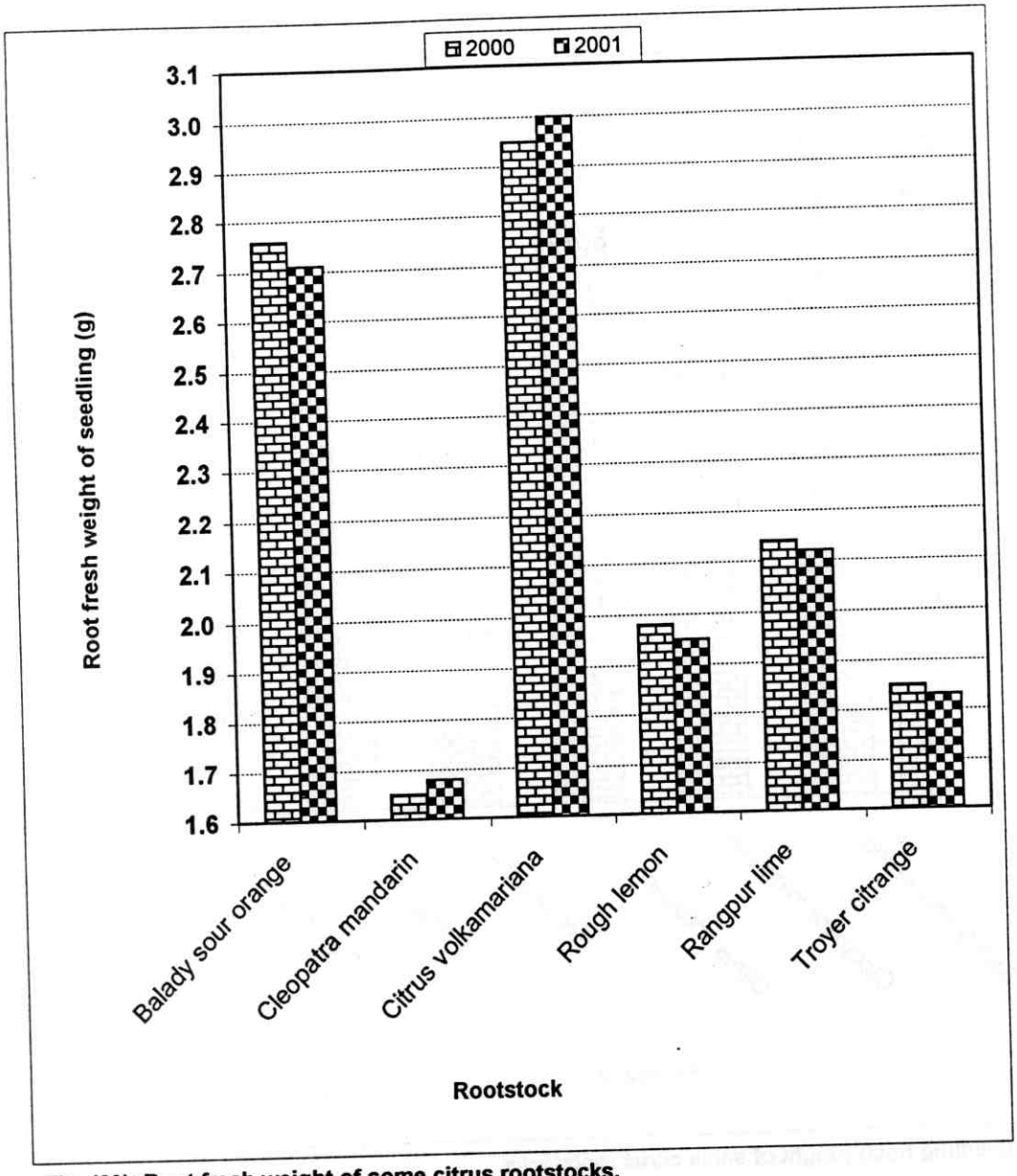

Fig. (29): Root fresh weight of some citrus rootstocks.

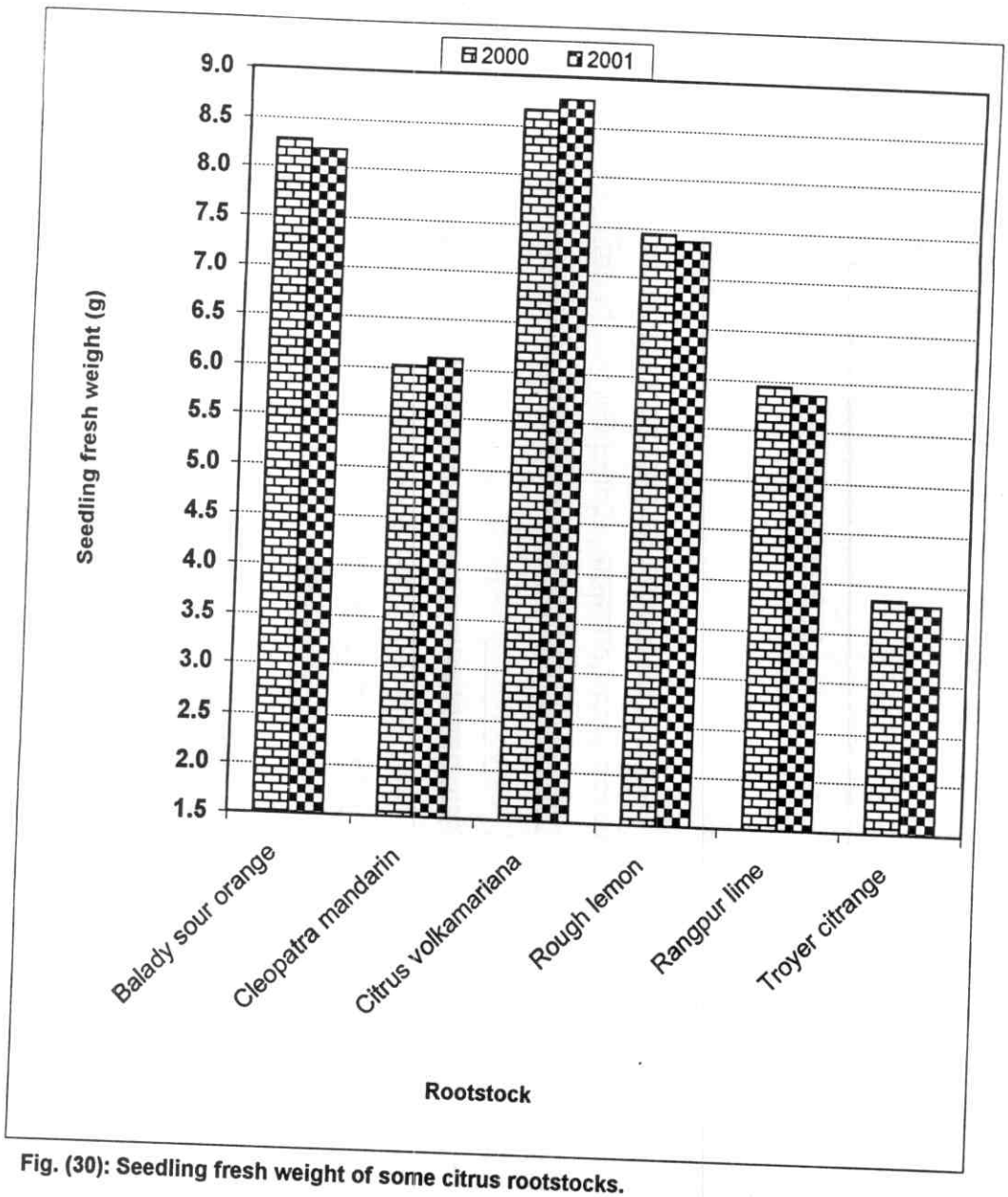

Fig. (30): Seedling fresh weight of some citrus rootstocks.

rootstocks had the heaviest root fresh weight compared with those of the other rootstocks under study and were statistically similar in their values. While, seedlings of Cleopatra mandarin had significantly the least root fresh weight compared with those of the other citrus rootstock seedlings under study. Moreover, seedlings of Rangpur lime, rough lemon and Troyer citrange took significantly intermediate place and were statistically similar in their values of root fresh weight.

These results are in partial agreement with those mentioned by Hassaballa (1975) who found that seedlings of Cleopatra mandarin rootstock had the least values of root fresh weight. However, he mentioned that seedlings of *Citrus volkameriana,* sour orange, Rangpur lime and Troyer citrange rootstock were significantly intermediate in root fresh weight and were similar in their values from the statistical stand point.

4.8.7 Seedling fresh weight:-

It is quite clear that from Table (11) and fig. (30) that in both seasons 2000 and 2001 seedlings of *Citrus volkameriana* rootstock had significantly the heaviest values of seedling fresh weight, followed by those of Balady sour orange rootstock. Besides, seedlings of rough lemon rootstock took significantly intermediate place in their values of seedling fresh weight. On the other hand, seedlings of Cleopatra mandarin, Rangpur lime and Troyer citrange rootstocks were significantly the least values of seedling fresh weight.

These results are in partial agreement with those mentioned by Hassaballa (1975) who noticed that seedlings of Troyer citrange rootstock had significantly the lowest values of their seedling fresh weight. However, he mentioned that seedlings of *Citrus volkameriana,* sour orange, Rangpur lime and Cleopatra mandarin rootstocks were

significantly intermediate in seedling fresh weight and were statistically similar in their values from the statistical point.

4.8.8. Top dry weight:-

It is easy to notice from Table (12) and Fig. (31) that seedlings of *Citrus volkameriana* and Balady sour orange rootstocks had significantly the heaviest values of top dry weight compared with the other rootstock seedlings under study and were statistically similar in their values of top dry weight, followed by those of rough lemon rootstock. While, seedlings of Cleopatra mandarin and Rangpur lime rootstocks were heavier than those of Troyer citrange rootstock which were significantly the lowest values of their top dry weight.

These results are in partial agreement with those mentioned by Hassaballa (1975) who found that seedlings of Troyer citrange rootstock were significantly the lowest values of top dry weight. Also, Atawia (1992) reported that seedlings of *Citrus volkameriana* rootstock were significantly, the heaviest ones in seedling top dry weight compared with the other rootstocks.

As well as, these results are contrast with those mentioned by Hassaballah (1975) who established that seedlings of *Citrus volkameriana*, sour orange, Rangpur lime and Cleopatra mandarin rootstocks were significantly intermediate in top dry weight and were statistically similar in their values from the statistical stand point.

On the other hand, these results are contrast with those mentioned by El-Shazly (1996) who found that *Citrus macrophylla* rootstock seedling, the lowest values of dry matter compared with the other rootstock seedlings under study.

Table (12): Top dry weight, root dry weight and top: root ratio of some citrus rootstock seedlings.

Rootstock	Top dry weight (g)		Root dry weight (g)		Top : Root ratio	
	Season 2000	Season 2001	Season 2000	Season 2001	Season 2000	Season 2001
Balady sour orange	2.26 a	2.24 a	1.01 b	1.03 b	2.24 b	2.18 b
Cleopatra mandarin	1.60 c	1.58 c	0.58 d	0.57 d	2.77 a	2.80 a
Volkamer lemon	2.35 a	2.30 a	1.24 a	1.20 a	1.90 cd	1.92 bc
Rough lemon	2.09 b	2.07 b	1.00 b	0.99 b	2.10 bc	2.08 bc
Rangpur lime	1.48 c	1.45 d	0.81 c	0.80 c	1.83 d	1.82 c
Troyer citrange	0.90 d	0.91 e	0.83 c	0.79 c	1.08 e	1.15 d

Means within a column followed by the same letter (s) are not statistically different at 5 % level by Duncan's multiple range test.

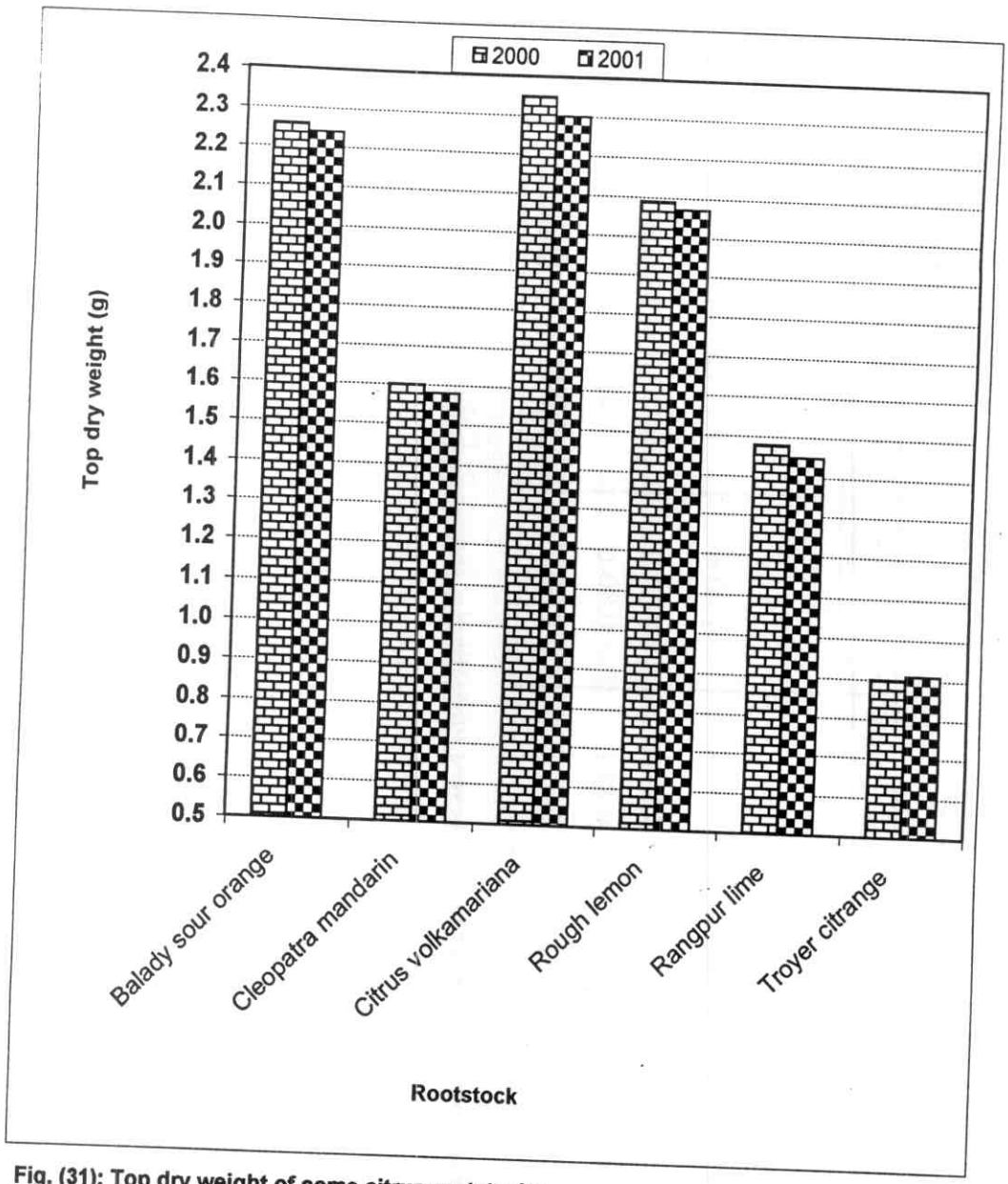

Fig. (31): Top dry weight of some citrus rootstocks.

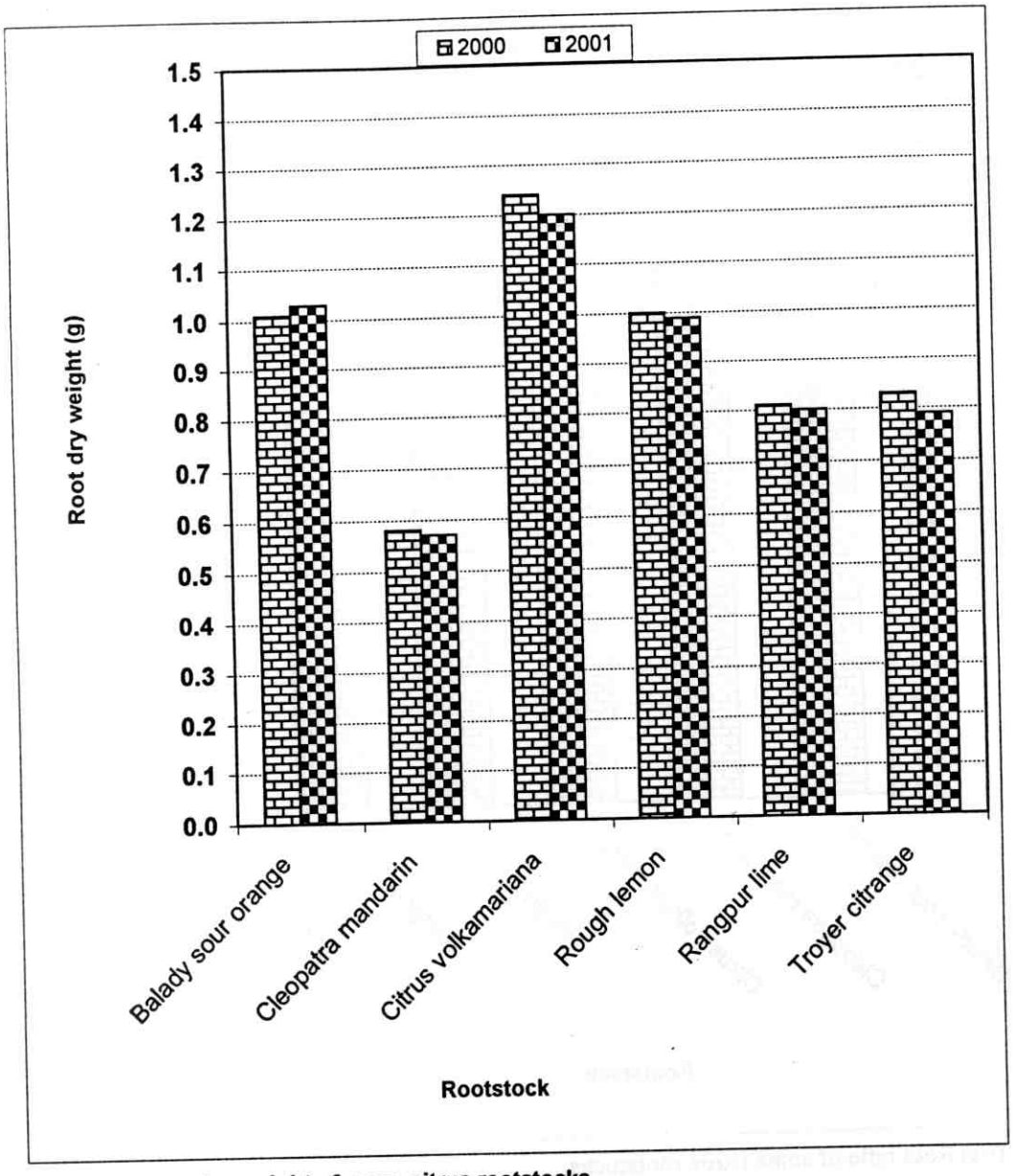

Fig. (32): Root dry weight of some citrus rootstocks.

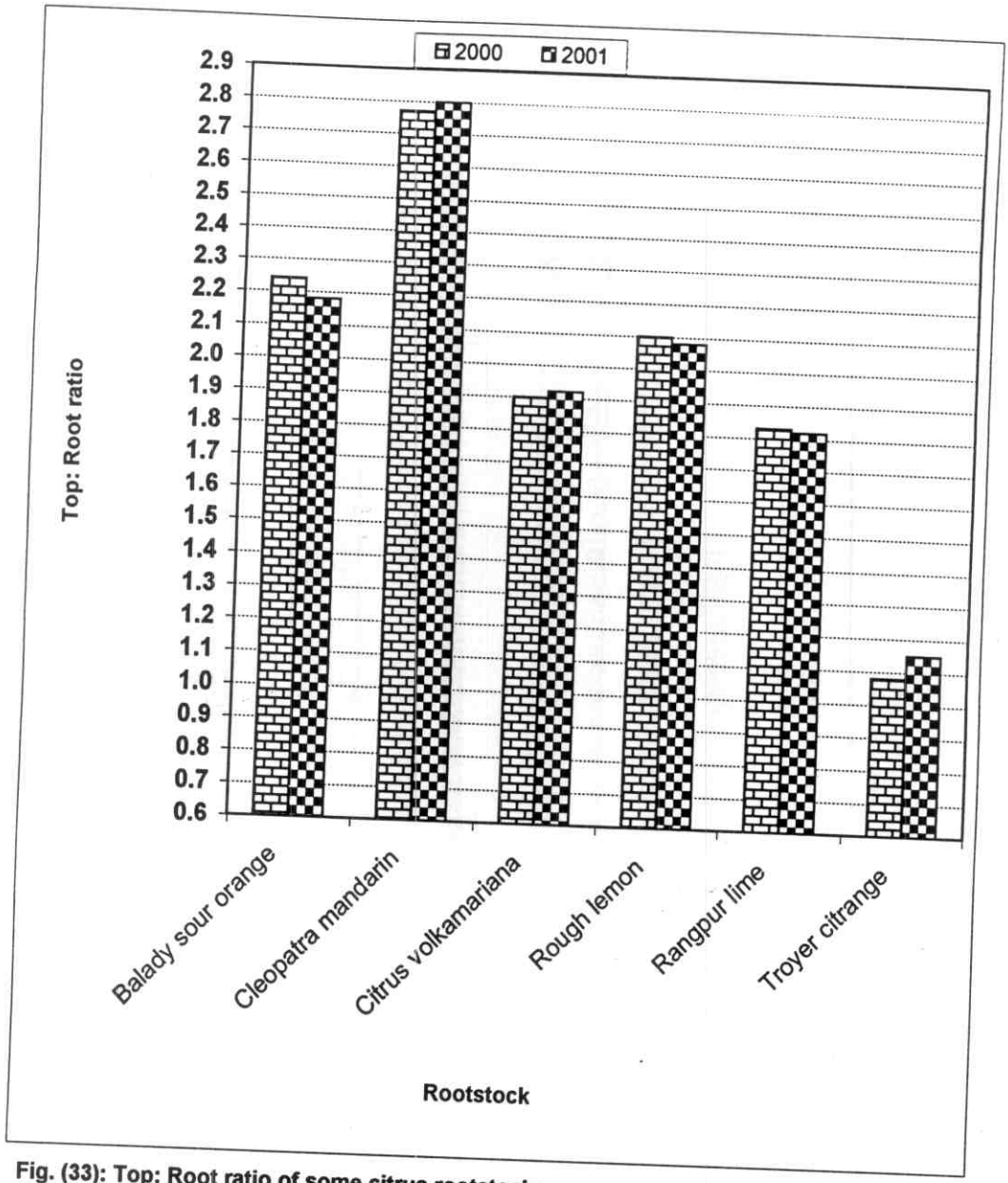

Fig. (33): Top: Root ratio of some citrus rootstocks.

4.8.9. Root dry weight:-

It is clear from Table (12) and Fig. (32) that in both seasons 2000 and 2001 seedlings of *Citrus volkameriana* gave significantly the highest values of root dry weight compared with those of the other rootstock seedlings under the study. Besides, seedlings of Balady sour orange and rough lemon rootstocks had intermediate values of dry root weight and were statistically similar in their values. While, seedlings of Troyer citrange and Rangpur lime rootstocks were statistically similar in their values of dry root weight and heavier than those of Cleopatra mandarin rootstock which had significantly the lowest values of dry root weight compared with the other rootstock seedlings under study.

These results are in partial agreement with those mentioned by Hassaballa (1975), and Atawia (1992) they reported that seedlings of *Citrus volkameriana* gave the highest values of dry root weight. Meanwhile, Cleopatra mandarin rootstock seedlings had the lowest values of root dry weight.

4.8.10. Top: Root ratio:

It is obvious from Table (12) and Fig. (33) that in both seasons 2000 and 2001 the highest top: root ratios of rootstock seedlings were noticed with Cleopatra mandarin, followed by Balady sour orange, rough lemon and *Citrus volkameriana* seedlings. Meanwhile, seedlings of Rangpur lime rootstock had higher top: root ratio than those of Troyer citrange rootstock which were significantly the lowest values of top: root ratio compared with the other rootstock seedlings under study.

These results are in partial agreement with those mentioned by Hassaballa (1975) who reported that seedlings of Cleopatra mandarin rootstock had the highest top/root ratio (dry weight basis), compared with

the other rootstock seedlings. While, seedlings of Troyer citrange rootstock had the lowest values of top/root ratio compared with the other rootstocks under study.

On the other hand, these results are in contrast with those mentioned by Atawia (1992) who found that the highest top: root ratios belonged to seedlings of rough lemon and *Citrus volkameriana* rootstocks, respectively.

4.9. Seed morphology:-

a- Seed macro morphology

Table (13) and Figs. (34-39) show the macro morphological aspects of six *Citrus* rootstock seeds. It was found that all rootstock seeds were easy to differentiate them according to their shape, colour and size.

I- Shape of seed:-

It is clear from Table (13) and Figs (34-39) that the shape of seeds in the studied citrus rootstocks was found to be as follows:

1. Obovate : (one taxon) as in *Citrus aurantium* (sour orange)Fig. (34).
2. Oval-ovate: (one taxon) as in *Citrus reshni* (Cleopatra mandarin). Fig. (35).
3. Ellipsoid: (two taxa) as in *Citrus volkameriana* (Volkamer lemon) and *Citrus limonia* (Rangpur lime) Figs. (36 and 38).
4. Ovoid: (one taxon) as in *Citrus jambhiri* (rough lemon) Fig. (37).
5. Oval-ovate to oblong-ovate: (one taxon) as in *Citrus sinensis x Poncirus trifoliata* (Troyer citrange) Fig. (39).

II- Seed colour:-

It is quite clear from Table (13) and Figs. (34-39) that the colour of seed in the studied citrus rootstocks is either shiny creamy (one taxon) as

Table (13): The macro morphological aspects of six *Citrus* rootstock seeds.

Rootstock	Shape	Colour	Size (cm)		
			Length	Width	Grade (*)
***Citrus aurantium*, L.** **Balady sour orange**	Obovate	Shiny creamy	1.40	0.70	L
***Citrus reshni*, Hort. Ex. Tanaka** **Cleopatra mandarin**	Oval-Ovate	Creamy	1.00	0.50	S
Citrus volkameriana **Volkamer lemon**	Ellipsoid	Creamy	1.20	0.45	L
***Citrus jambhiri*, Lush** **Rough lemon**	Ovoid	Creamy	1.00	0.55	S
***Citrus limonia*, Osbeck** **Rangpur lime**	Ellipsoid	Creamy	0.95	0.50	S
Citrus sinensis x Poncirus trifoliata **Troyer citrange**	Oval-Ovate to oblong-ovate	Yellowish brown	1.50	0.90	L

(*) Grade for length S = small (1 cm or less)
L = Large (more than 1 cm)

in *Citrus aurantium* (sour orange) Fig. (34), creamy (four taxa) as in *Citrus reshni* (Cleopatra mandarin), *Citrus volkameriana* (Volkamer lemon), *Citrus jambhiri* (rough lemon) and *Citrus limonia* (Rangpur lime) Figs. (35-38) or yellowish brown (one taxon) as in *Citrus sinensis x Poncirus trifoliata* (Troyer citrange) Fig. (39).

III- Size of seed:-

It is obvious from table (13) and Figs (34-39) that the size of seed in the studied taxa was classified into either small and large grade as follows:

1- Small-sized seeds: 1 cm or less (three taxa) as in *Citrus reshni* (Cleopatra mandarin), *Citrus jambhiri* (rough lemon) and *Citrus limonia* (Rangpr lime) Figs.(35, 37 and 38).

2- Large-sized seeds: more than 1 cm (three taxa) as in *Citrus aurantium* (sour orange), *Citrus volkameriana* (Volkamer lemon) and *Citrus sinensis x Poncirus trifoliata* (Troyer citrange) Figs. (34, 36 and 39).

b-Seed surface scan aspects:

Table (14) and Figs. (40-51) show the different surface scan aspects of six *Citrus* rootstock seeds. It is clear that seeds of the studied Citrus rootstocks varied in their general features such as surface scan, surface texture, anticlinal walls and periclinal walls.

I- Surface scan:-

It is quite clear from Table (14) and Figs. (40-51) that the surface scan of the studied citrus rootstock seeds was performed showing five sculpute types (colliculate, tuberculate-ruminate, striate-tuberculat, rugose to reticulate-foveate and double reticulate associated with rounded bodies) as follows:-

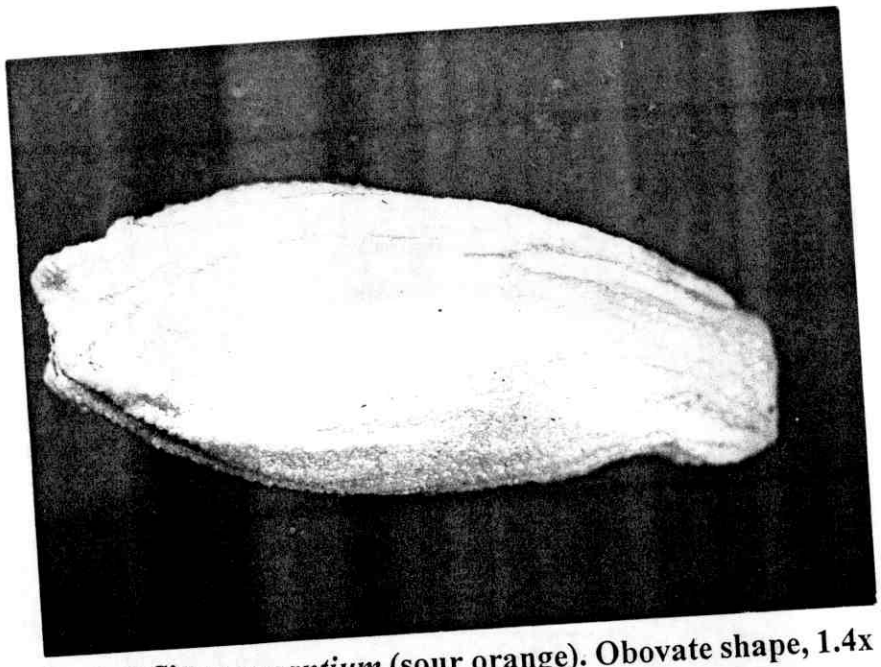

Fig. (34). Seed of *Citrus aurantium* (sour orange). Obovate shape, 1.4x 0.7 cm (L x W) dimensions, shiny creamy colour and large-sized (X = 25 Zoom = 0.66)

Fig. (35). Seed of *Citrus reshni* (Cleopatra mandarin). Oval-ovate shape, 1.0x 0.5 cm (L x W) dimensions, creamy colour and small-sized (X = 25 Zoom = 1.00)

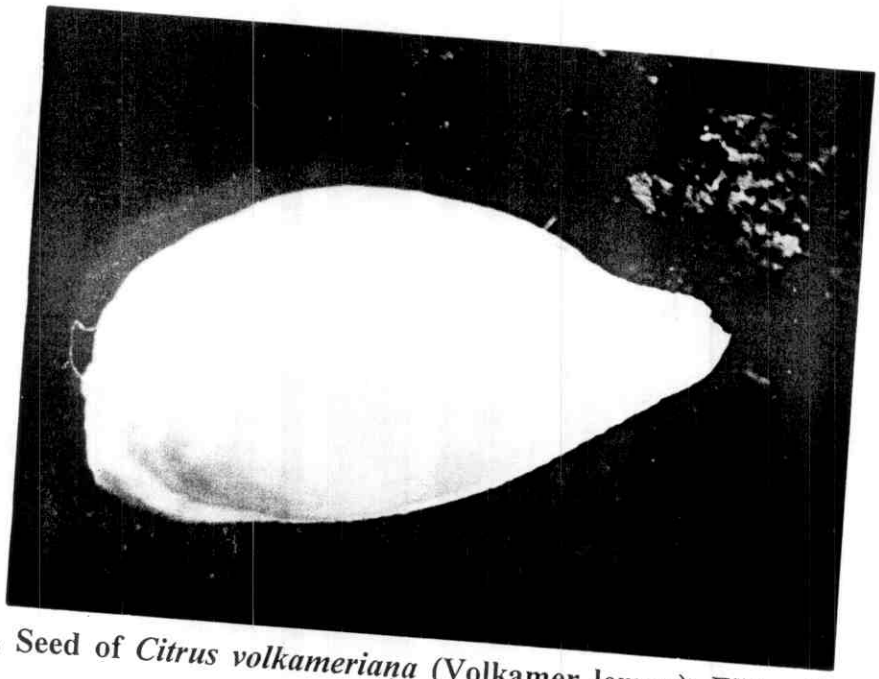

Fig. (36). Seed of *Citrus volkameriana* (Volkamer lemon). Ellipsoid shape, 1.2x 0.45 cm (L x W) dimensions, creamy colour and large-sized (X = 25 Zoom = 1.00)

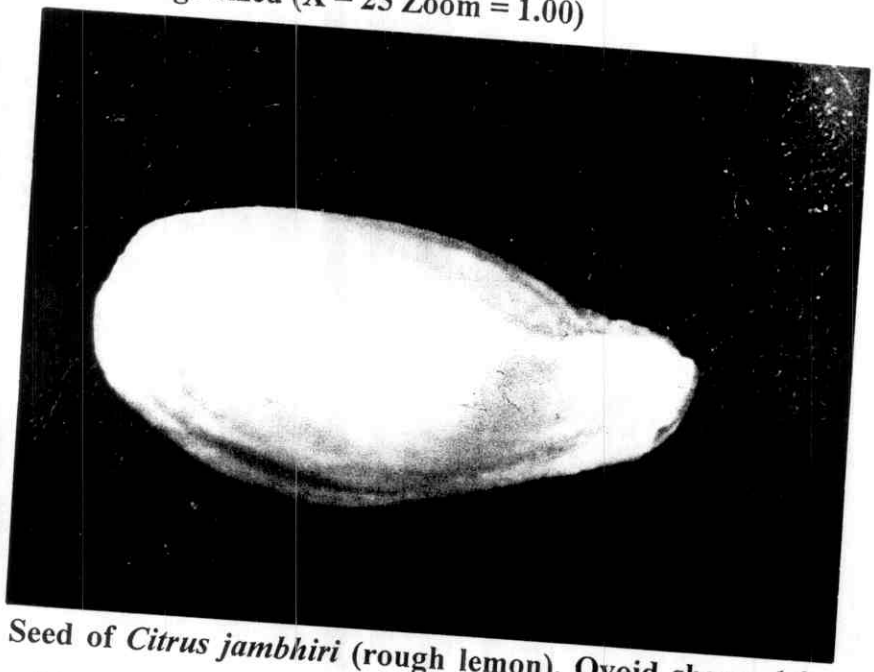

Fig. (37). Seed of *Citrus jambhiri* (rough lemon). Ovoid shape, 1.0x 0.55 cm (L x W) dimensions, creamy colour and small-sized (X = 25 Zoom = 1.00).

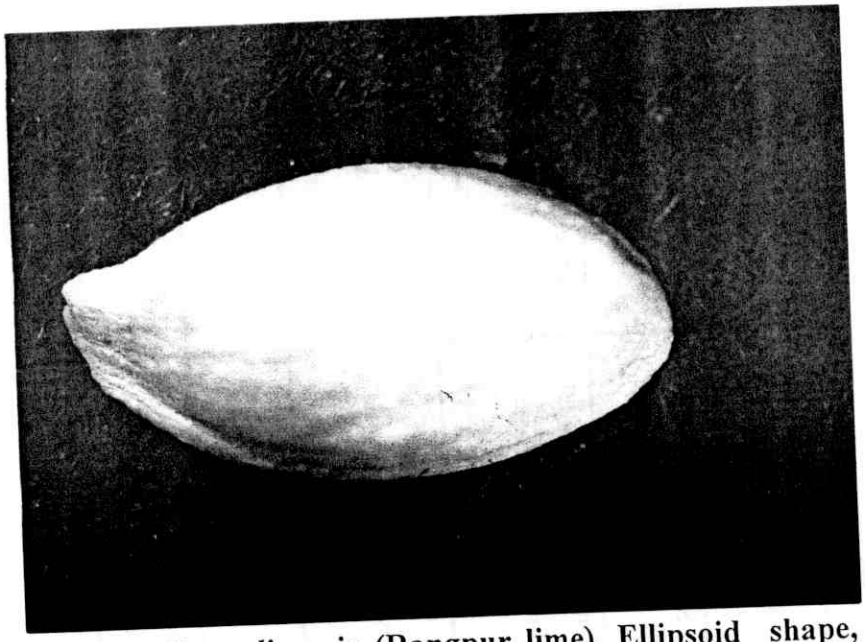

Fig. (38). Seed of *Citrus limonia* (Rangpur lime). Ellipsoid shape, 0.95 x 0.50 cm (L x W) dimensions, creamy colour and small-sized (X = 25 Zoom = 1.25)

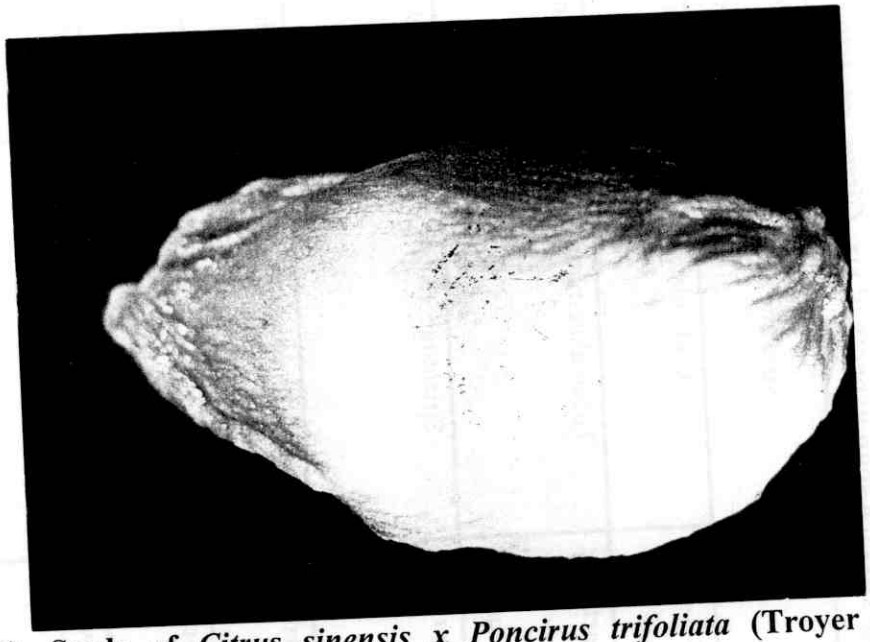

Fig. (39). Seeds of *Citrus sinensis x Poncirus trifoliata* (Troyer citrange). Oval-ovate to oblong-ovate shape, 1.5x 0.9 cm (L x W) dimensions, yellowish brown colour and large-sized (X = 25 Zoom = 0.66)

Table (14): The surface scan aspects of six *Citrus* rootstock seeds under this study.

Rootstock	Surface scan	Surface Texture	Anticlinal walls	Periclinal walls
Citrus aurantium, L. **Balady sour orange**	Colliculate	Rigid	Shallow depressed	Elevated with small rounded bodies
Citrus reshni, **Hort. Ex. Tanaka Cleopatra mandarin**	Tuberculate-ruminate	Smooth	In some zones very shallow while in others is raised	Very clear to be raised with some irregular elevations
Citrus volkameriana **Volkamer lemon**	Striate-tuberculate	Wavy	Perform regular grooves in between periclinal walls	Tuberculate elevate associated with some papilia
Citrus jambhiri, **Lush Rough lemon**	Rugose to retculate-foveate	Smooth and shiny	Depressed	Sharply raised
Citrus limonia, **Osbeck Rangpur lime**	Double reticulate associated with rounded bodies	Rigid	Sharply raised accompanied with rounded bodies	Depressed
Citrus sinensis x Poncirus trifoliata **Troyer citrange**	Colliculate	Smooth and dull	Shallow depressed	Elevated with large rounded bodies

1- Colliculate: (two taxa), i.e. with rounded broad elevation closely spaced covering as in *Citrus aurantium* (sour orange) and *Citrus sinensis x poncirus trifoliata* (Troyer citrange). Figs. (40 and 50).

2- Tuberculate-ruminate : (one taxon), i.e. with small smooth rounded projection or knobs and penetrated by irregular channles giving an eroded appearance and running in different directions, as in *Citrus reshni* (Cleopatra mandarin) Fig. (42).

3- Striate-tuberculate: (one taxon), i.e. marked with a series of fine narrow parallel bands and with small smooth rounded projections or knobs, as in *Citrus volkameriana* (Volkamer lemon) Fig. (44).

4- Rugose to reticulate-foveate: (one taxon), i.e. wrinkled, intermediate between reticulate and foveat, the irrigular elevation making up the wrinkles and running mostly in one direction, with a raised network of narrow and sharply angled lines frequently presenting a geometric appearance, each area or depression out-lined by the reticulum being an interspace and pitted as in *Citrus jambhiri* (rough lemon) Fig. (46).

5- Double reticulate associated with rounded bodies: (one taxon), i.e. with double raised network of narrow and sharply angles lines frequently presenting geometric appearance, each area or depression out-lined by the reticulum being an inetrspace and associated with rounded bodies, as in *Citrus limonia* (Rangpur lime) Fig. (48).

II- Surface texture:-

It is clear from Table (14) and Figs (40-51) that the surface texture of citrus rootstock seeds under this study was classified into five texture types (smooth, smooth and shiny, smooth and dull, rigid and wavy) as follows:-

1- Smooth: (one taxon) as in *Citrus reshni* (Cleopatra mandarin) Fig. (42).

2- Smooth and shiny: (one taxon) as in *Citrus jambhiri* (rough lemon) Fig. (46).

3- Smooth and dull: (one taxon) as in *Citrus sinensis x Poncirus trifoliata* (Troyer citrange) Fig. (50).

4- Rigid: (two taxa) as in *Citrus aurantium* (sour orange) and *Citrus limonia* (Rangpur lime) Figs. (40 and 48).

5- Wavy: (one taxon) as in *Citrus volkameriana* (Volkamer lemon) Fig. (44).

III- Anticlinal walls:-

It is easy to notice from Table (14) and Figs (40-51) that the anticlinal walls of citrus rootstock seeds under this study were performed as five sculpture types as follows:-

1- Shallow depressed: (two taxa) as in *Citrus aurantium* (sour orange) and *Citrus sinensis x Poncirus trifoliata* (Troyer citrange) Figs. (41 and 51).

2- In some zones very shallow while in others is raised: (one taxon) as in *Citrus reshni* (Cleopatra mandarin) Fig. (43).

3- Perform regular grooves in between periclinal walls : (one taxon) as in *Citrus volkameriana* (Volkamer lemon) Fig. (45).

4- Depressed: (one taxon) as in *Citrus jambhiri* (rough lemon) Fig. (47).

5- Sharply raised accompanied with rounded bodies: (one taxon) as in *Citrus liomina* (Rangpur lime) Fig. (49).

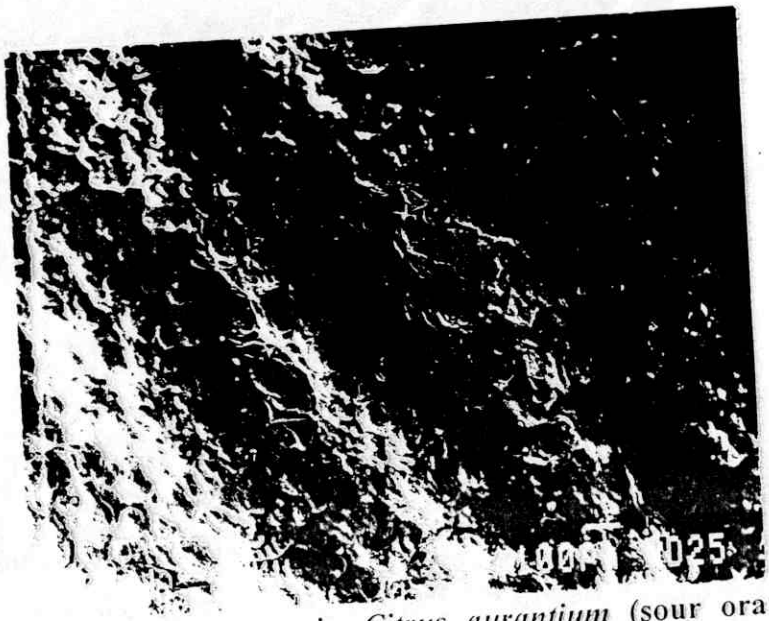

Fig. (40): Seed surface scan in *Citrus aurantium* (sour orange). Seulpture type is colliculate and surface texture is rigid (X = 50).

Fig. (41): Seed anticlinal and periclinal walls in *Citrus aurantium* (sour orange). Anticlinal wall is shallow depressed and periclinal wall is elevated with small rounded bodies (X = 150).

Fig. (42): Seed surface scan in *Citrus reshni* (Cleopatra mandarin). Sculpture type is tuberculate-ruminate and surface texture is smooth (X = 250).

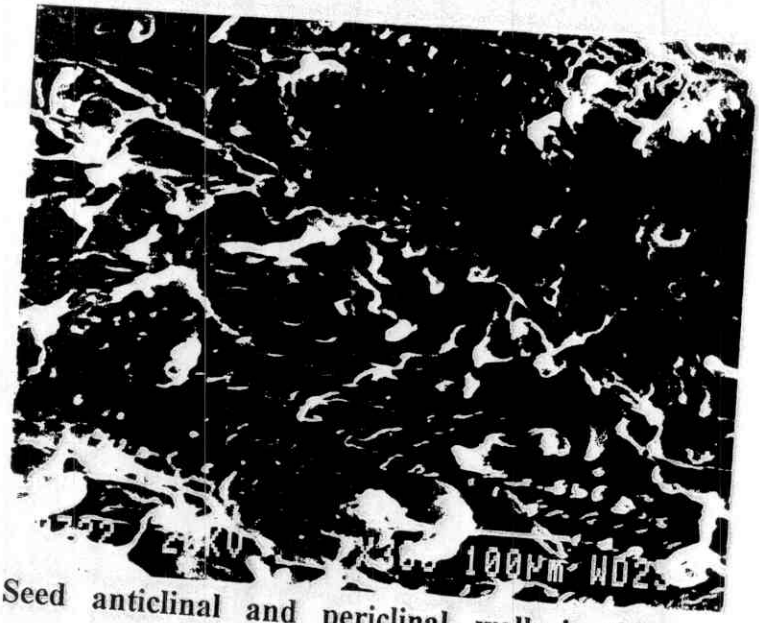

Fig. (43): Seed anticlinal and periclinal walls in *Citrus reshni* (Cleopatra mandarin). Anticlinal wall is in some zones very shallow while in the others is raised and periclinal wall is very clear to be raised with some irregular elevation (X = 300).

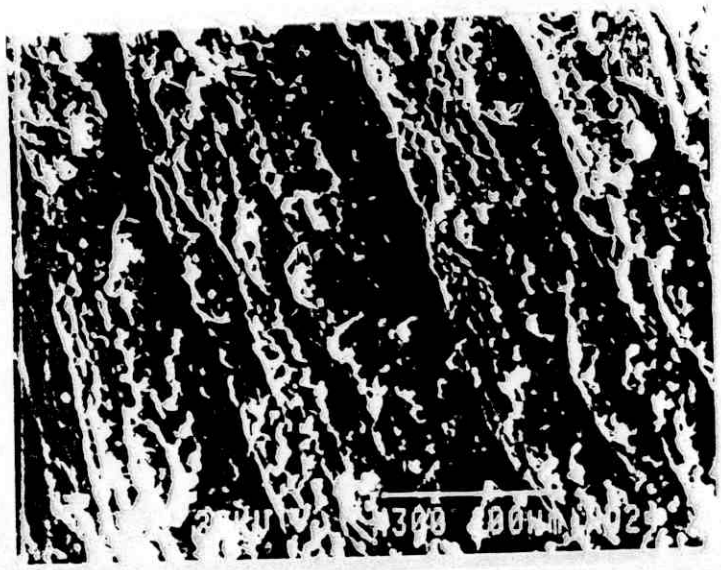

Fig. (44): Seed surface scan in *Citrus volkameriana* (Volkamer lemon). Sculpture type is striate-tuberculate and surface texture is wavy (X = 300).

Fig. (45): Seed anticlinal and periclinal walls in *Citrus volkameriana* (Volkamer lemon). Anticlinal wall perform regular grooves in between periclinal walls and periclinal wall is tuberculate elevate associated with some papilia (X = 400).

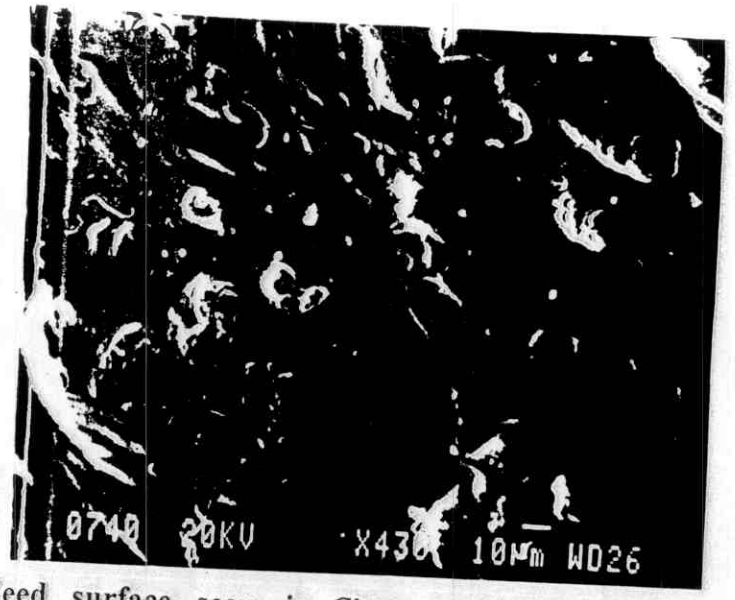

Fig. (46): Seed surface scan in *Citrus jambhiri* (rough lemon). Sculpture type is rugose to reticulate-foveate and surface texture is smooth and shiny (X = 430).

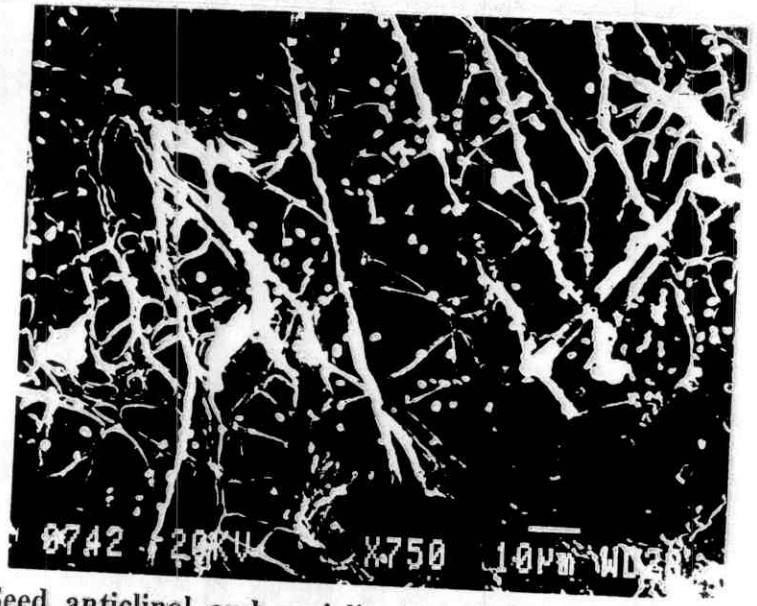

Fig. (47): Seed anticlinal and periclinal walls in *Citrus jambhiri* (rough lemon). Anticlinal wall is depressed and periclinal wall is sharply raised (X = 750).

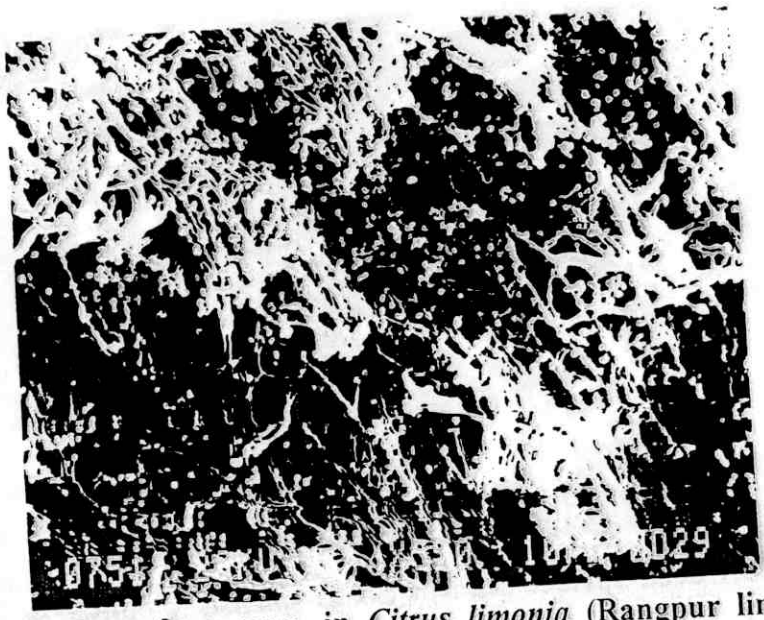

Fig. (48): Seed surface scan in *Citrus limonia* (Rangpur lime). Sculpture type is double reticulate associated with rounded bodies and surface texture is rigid (X = 550).

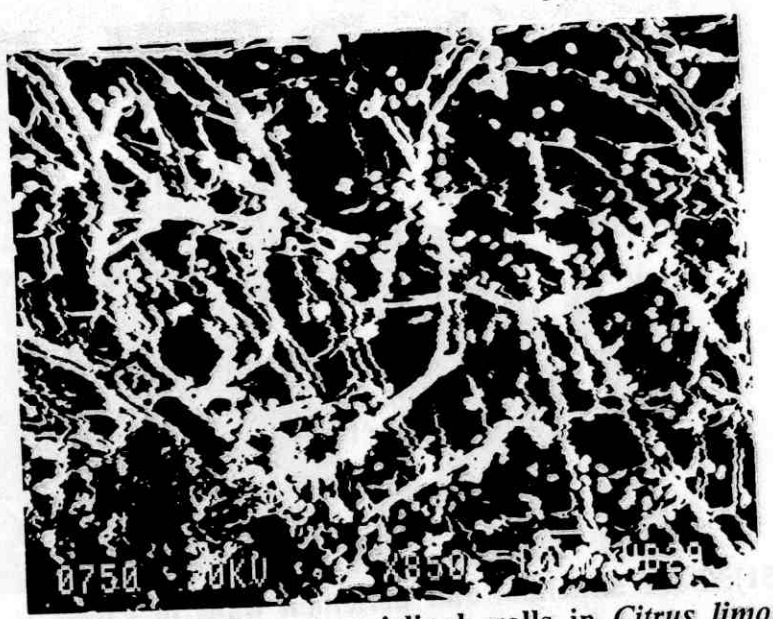

Fig. (49): Seed anticlinal and periclinal walls in *Citrus limonia* (Rangpur lime). Anticlinal wall is sharply raised accompanied with rounded bodies and periclinal wall is depressed (X = 850).

Fig. (50): Seed surface scan in *Citrus sinensis x Ponscirus trifoliata* (Troyer citrange). Sculpture type is colliculate and surface texture is smooth and dull (X = 300).

Fig. (51): Seed anticlinal and periclinal walls in *Citrus sinensis x Poncirus trifoliate* (Troyer citrange). Anticlinal wall is shallow depressed and periclinal wall is elevated with large rounded bodies (X = 450).

IV- Periclinal walls:-

It is obvious from Table (14) and Figs (40-51) that the periclinal walls of the studied taxa seeds were classified into six sculputure types (elevated with small rounded bodies, very clear to be raised with some irregular elevations, tuberculate elevate associated with some papilia, sharply raised, depressed, and elevated with large rounded bodies) as the next:-

1. Elevate with small rounded bodies: (one taxon) as in *Citrus aurantium* (sour orange) Fig. (41).
2. Very clear to be raised with some irregular elevation: (one taxon) as in *Citrus reshni* (Cleopatra mandarin) Fig. (43).
3. Tuberculate elevate associated with some paplilia: (one taxon) as in *Citrus volkamriana* (Volkamer lemon) Fig. (45).
4. Sharply raised: (one taxon) as in *Citrus jambhiri* (rough lemon) Fig. (47).
5. Depressed: (one taxon) as in *Citrus limonia* (Rangpur lime) Fig. (49).
6. Elevated with large rounded bodies: (one taxon) as in *Citurs sinensis x Poncirus trifoliata* (Troyer citrange) Fig. (51).

V-Seed artificial key:-

It is clear from Table (14) and Figs (40 -51) that all rootstock seeds under this study were easily differentiated according to their surface scan, , anticlinal walls and periclinal walls. So, it is easy to make an artificial key for them as follows:-

1- Artificial key based on seed surface scan:-

A. Seed surface scan

a_1. Colliculate

b_1. Rigid — *C. aurantium* (sour orange)

b_2. Smooth and dull — *C. sinensis x P. trifoliata* (Troyer citrange)

a_2. Tuberculate–ruminate — *C.reshni* (Cleopatra mandarin)

a_3. Striate- tuberculate — *C.Volkameriana* (Volkamer lemon)

a_4. Rugose to retculate-fovate — *C. Jambhiri* (rough lemon)

a_5.Double retculate associated with rounded bodies — *C. limonia* (Rangpur lime)

2- Artificial key based on seed periclinal walls :-

B. Seed periclinal walls:

b_1. Elevated with small rounded bodies — *C. aurantium* (sour orange)

b_2.Raised with some irregular elevations — *C.reshni* (Cleopatra mandarin)

b_3. Tuberculate elevate associated with some papillia — *C.Volkameriana* (Volkamer lemon)

b_4. Sharply raised — *C. Jambhiri* (rough lemon)

b_5.Depressed — *C. limonia* (Rangpur lime)

b_6. Elevated with large rounded bodies. — *C. sinensis x P. trifoliata* (Troyer citrange)

3- Artificial key based on seed anticlinal walls :-

C. Seed anticlinal walls:

c_1. Shallow depressed

a_1.Elevated with small rounded bodies *C. aurantium* (sour orange)

irregular elevations

a_2. Elevated with *C. sinensis x P. trifoliata* (Troyer citrange)

large rounded bodies

c_2. In some zone very shallow *C.reshni* (Cleopatra mandarin)

c_3.Perform regular grooves *C.Volkameriana* (Volkamer lemon)

c_4. Depressed *C. Jambhiri* (rough lemon)

c_5- Sharply raised *C. limonia* (Rangur lime)

4.10. Leaf morhology:-

a- Leaf macro morphology:-

Table (15) and Figs (52-63) show the macro morphological aspects of six *Citrus* rootstock leaves. It was found that all rootstock leaves were easy to differentiate them according to their shape, colour and size.

I- Shape of leaf:-

It is clear from Table (15) and figs. (52-63) that the shape of leaves in the *citrus* rootstocks under this study was found to be as follows:-

1- Widely-ellipitic: (one taxon) as in *Citrus aurantium* (sour orange) Fig. (52).

2- Narrowly-ovate: (one taxon) as in *Citrus reshni* (Cleopatra mandarin) Fig. (54).

3- Oblong: (one taxon) as in *Citrus volkameriana* (Volkamer lemon) Fig. (56).

4- Widely-ovate: (one taxon) as in *Citrus jambhiri* (rough lemon) Fig. (58).

5- Obovate: (one taxon) as in *Citrus limonia* (Rangpur lime) Fig. (60).

Table (15): The macro morphological aspects of six *Citrus* rootstock leaves.

Rootstock	Shape	Colour	Size			
			Length (cm)	Width (cm)	Area (cm^2)	Grade (*)
Citrus aurantium, L. Balady sour orange	Widely-ellipitic	Shiny dark green	9.00	4.50	26.36	L
Citrus reshni, Hort. Ex. Tanaka Cleopatra mandarin	Narrowly ovate	Green	6.70	3.50	16.05	S
Citrus volkameriana Volkamer lemon	Oblong	Shiny green	10.50	4.70	33.20	L
Citrus jambhiri, Lush Rough lemon	Widely-ovate	Green	8.00	4.40	24.60	L
Citrus limonia, Osbeck Rangpur lime	Obovate	Shiny green	5.70	2.50	11.20	S
Citrus sinensis x Poncirus trifoliata Troyer citrange		Shiny green	4.40 (**) 2.50 2.50	2.70 (**) 1.50 1.50	14.00 (***)	S

(*) Grade for area **S = small (24 cm^2 or less)**
L = Large (more than 24 cm^2)
(**) Length or width for one leaf only.
(***) Total area for three leaves.

6- Trifoliate : (one taxon) as in *Citrus sinensis x poncirus trifoliata* (Troyer citrange) Fig. (62).

II- Leaf colour:

It is quite clear from Table (15) and Figs. (52-63) that the colour of leaf in the citrus rootstock leaves under this study is either shiny dark green (one taxon) as in *Citrus aurantium* (sour orange) Fig. (52), green (two taxa) as in *Citrus reshni* (Cleopatra mandarin) and *Citrus jambhiri* (rough lemon) Figs (54 and 58) or shiny green (3 taxa) as in *Citrus volkameriana* (Volkamer lemon), *Citrus limonia* (Rangpur lime) and *Citrus sinensis x Poncirus trifoliata* (Troyer citrange) Figs. (56, 60 and 62).

III- Size of leaf:

It is obvious from Table (15) and Figs. (52-63) that the size of leaf in the taxa under this study was classified into small and large grades as follows:

1- Small-sized leaves:- 24 cm or less (three taxa) as in *Citrus reshni* (Cleopatra mandarin), *Citrus limonia* (Rangpur lime) and *Citrus sinensis x Poncirus trifoliate* (Troyer citrange) Figs. (54, 60 and 62).

2- Large-sized leaves: more than 24 cm (three taxa) as in *Citrus aurantium* (sour orange), *Citrus volkameriana* (Volkamer lemon) and *Citrus jambhiri* (rough lemon) Figs. (52, 56 and 58).

b- Leaf surface scan:

Figs. (64 and 65) show types of stomatal complex in some Citrus rootstocks under this study. It was found that rootstock leaves were easy to differentiate them according to their type of stomatal complex.

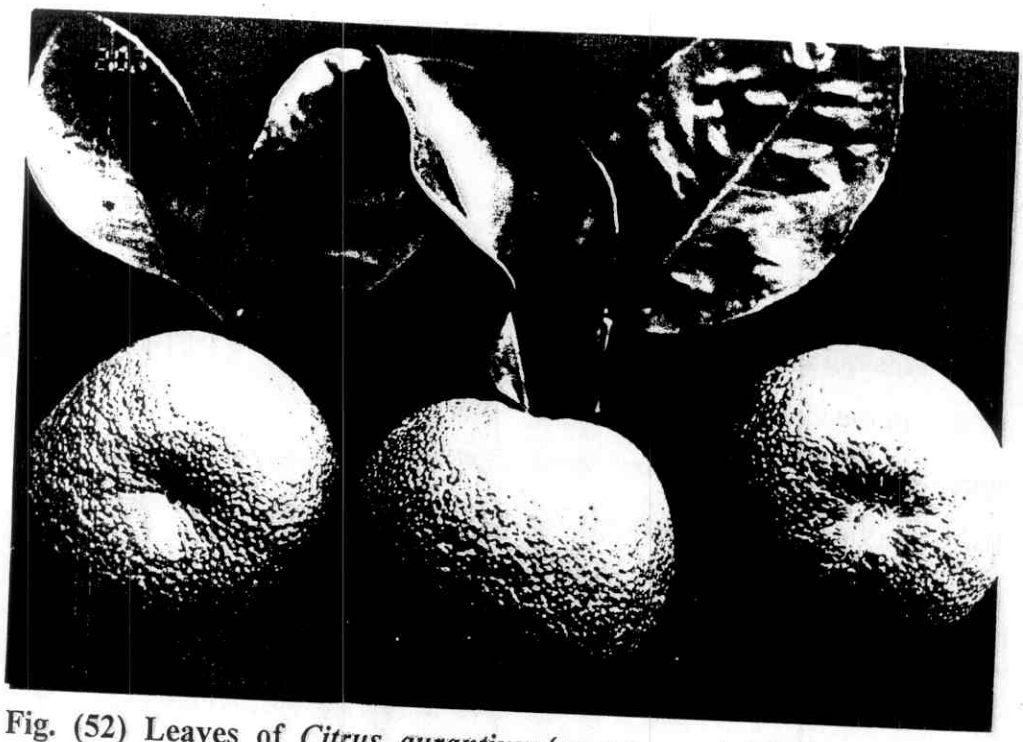

Fig. (52) Leaves of *Citrus aurantium* (sour orange). Widely-ellipitic shape, 9 x 4.5 cm (L XW) in dimensions, shiny dark green colour and large-sized. (X = 1/ 2)

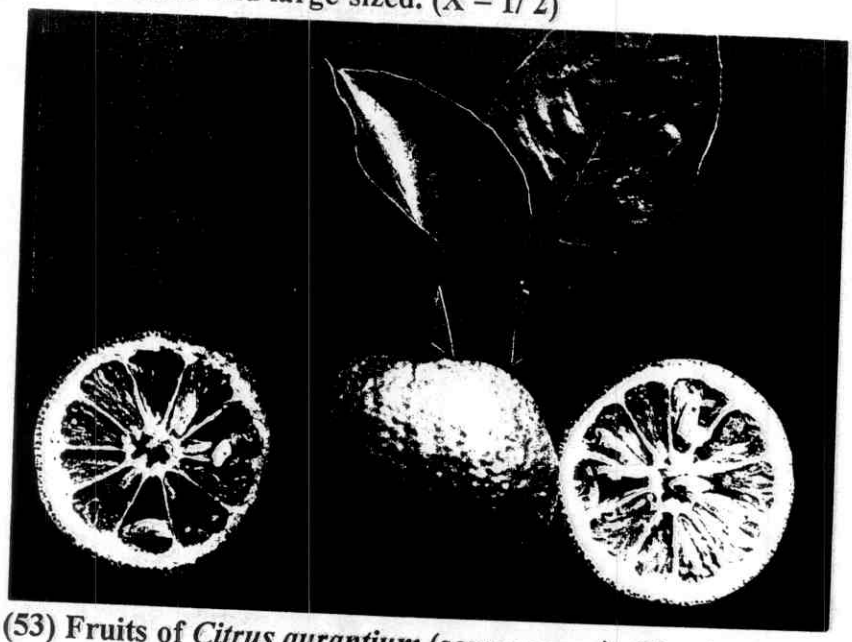

Fig. (53) Fruits of *Citrus aurantium* (sour orange). (X = 1/ 2)

Fig. (54) Leaves of *Citrus reshni* (Cleopatra mandarin). Narrow-ovate shape, 6.7 x 3.5 cm (L XW) in dimensions, green colour and small-sized. (X = 2/ 3)

Fig. (55) Fruits of *Citrus reshni* (Cleopatra mandarin). (X = 1/ 2)

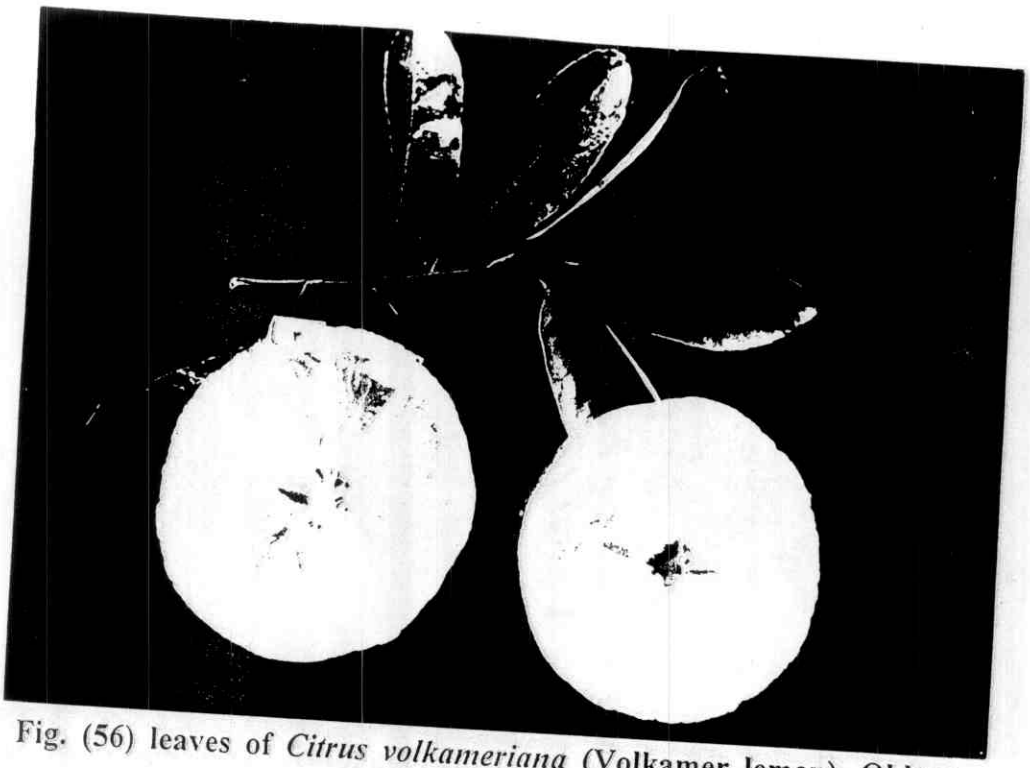

Fig. (56) leaves of *Citrus volkameriana* (Volkamer lemon). Oblong shape, 10.5 x 4.7 cm (L XW) in dimensions, shiny green colour and large-sized. (X = 1/ 2)

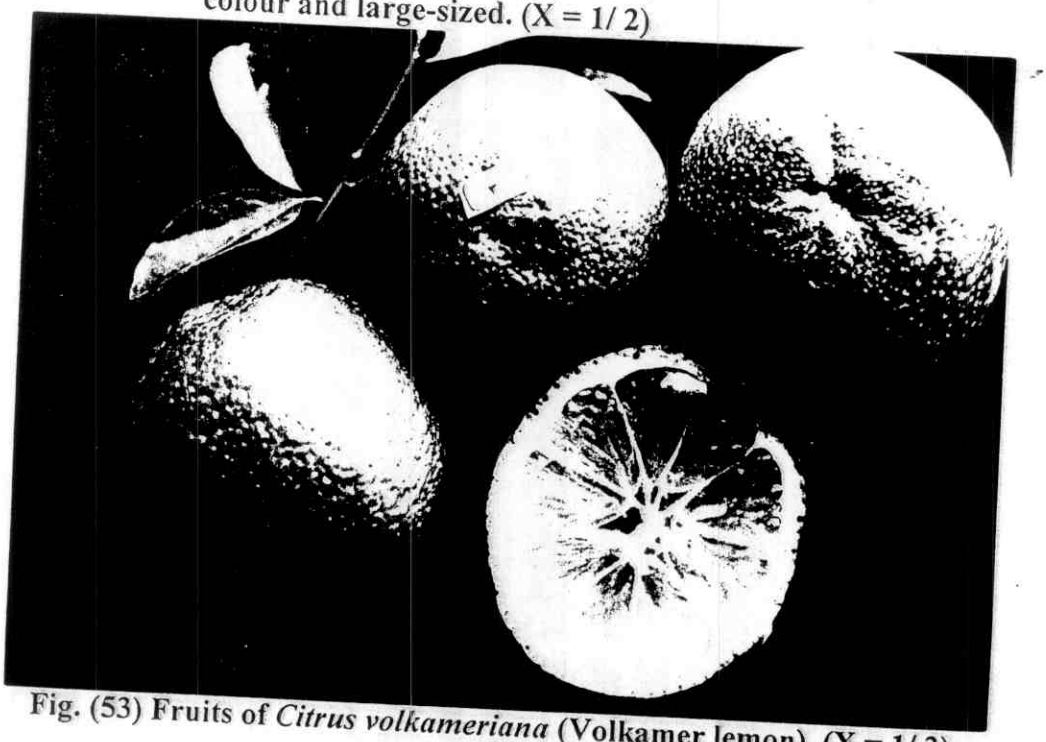

Fig. (53) Fruits of *Citrus volkameriana* (Volkamer lemon). (X = 1/ 2)

Fig. (58) Leaf of *Citrus jambhiri* (rough lemon). Widely-ovate shape, 8 x 4.4 cm (L XW) in dimensions, green colour and large-sized.(X = 1)

Fig. (59) Fruits of *Citrus jambhiri* (rough lemon). (X = 1/ 2)

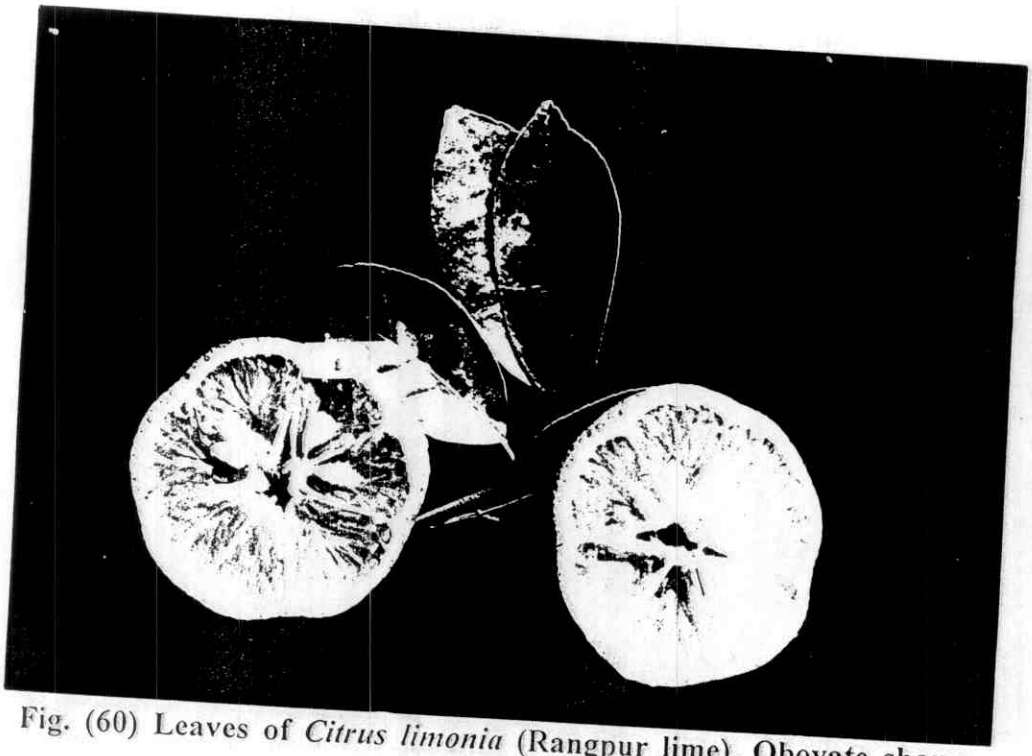

Fig. (60) Leaves of *Citrus limonia* (Rangpur lime). Obovate shape, 5.7 x 2.5 cm (L XW) in dimensions, shiny green colour and small-sized. (X = 2/3)

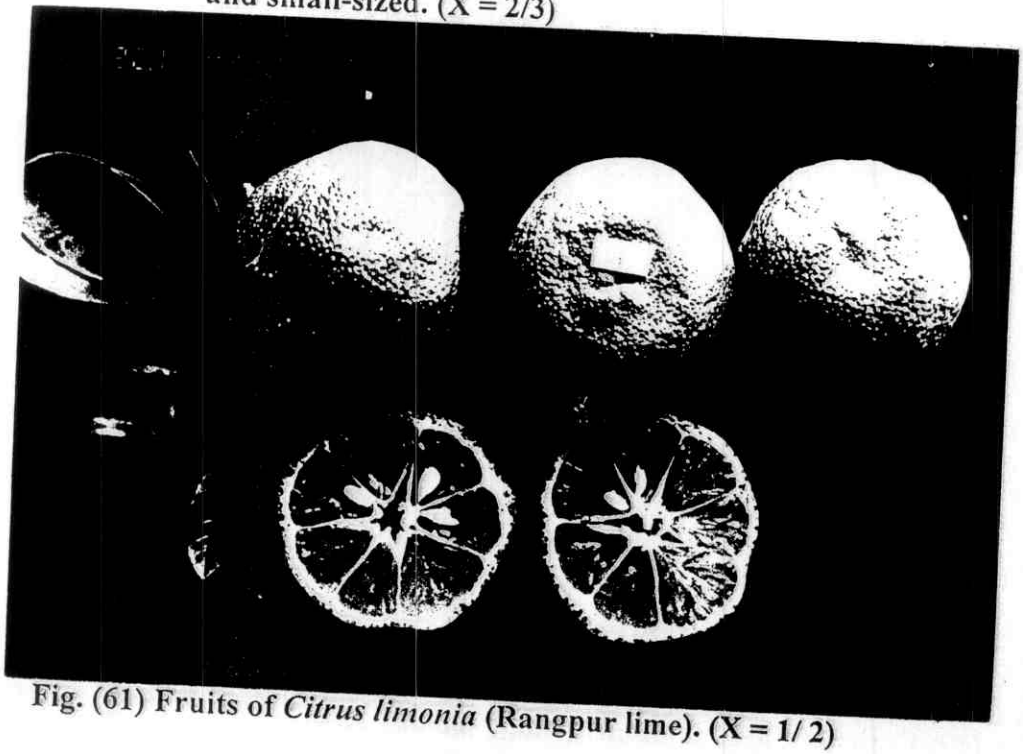

Fig. (61) Fruits of *Citrus limonia* (Rangpur lime). (X = 1/ 2)

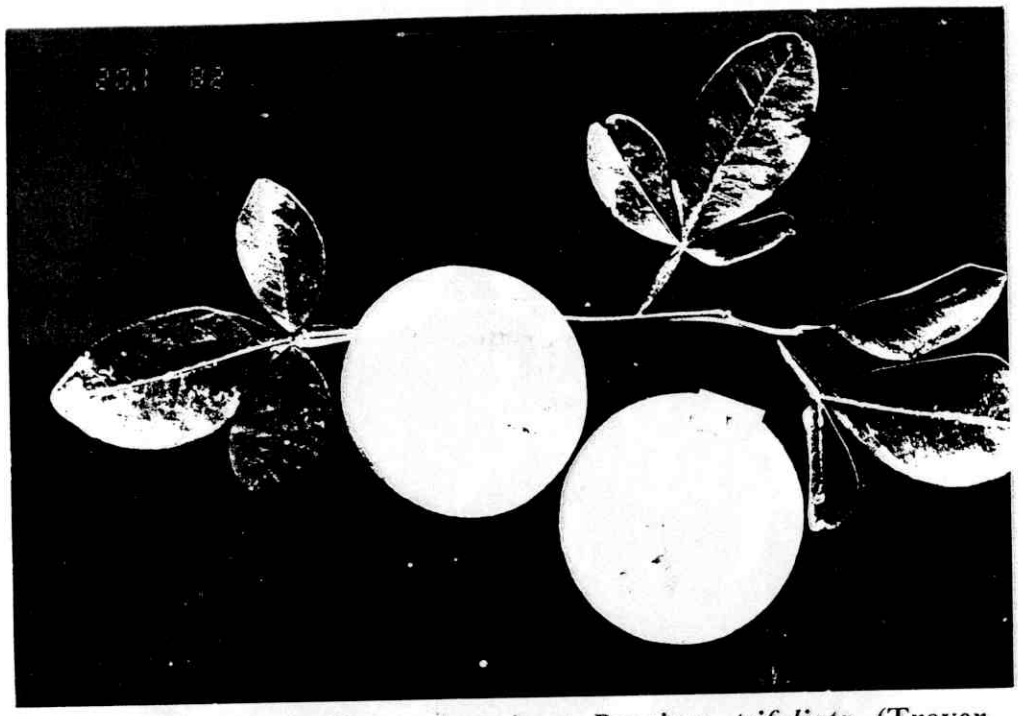

Fig. (62) Leaf of *Citrus sinensis x Poncirus trifoliata* (Troyer citrange). Ovate trifoliate-shape, (4.4 x 2.7, 2.5 x 1.5 and 2.5 x 1.5 cm (L XW) in dimensions, shiny green colour and small-sized. (X = 1/ 2)

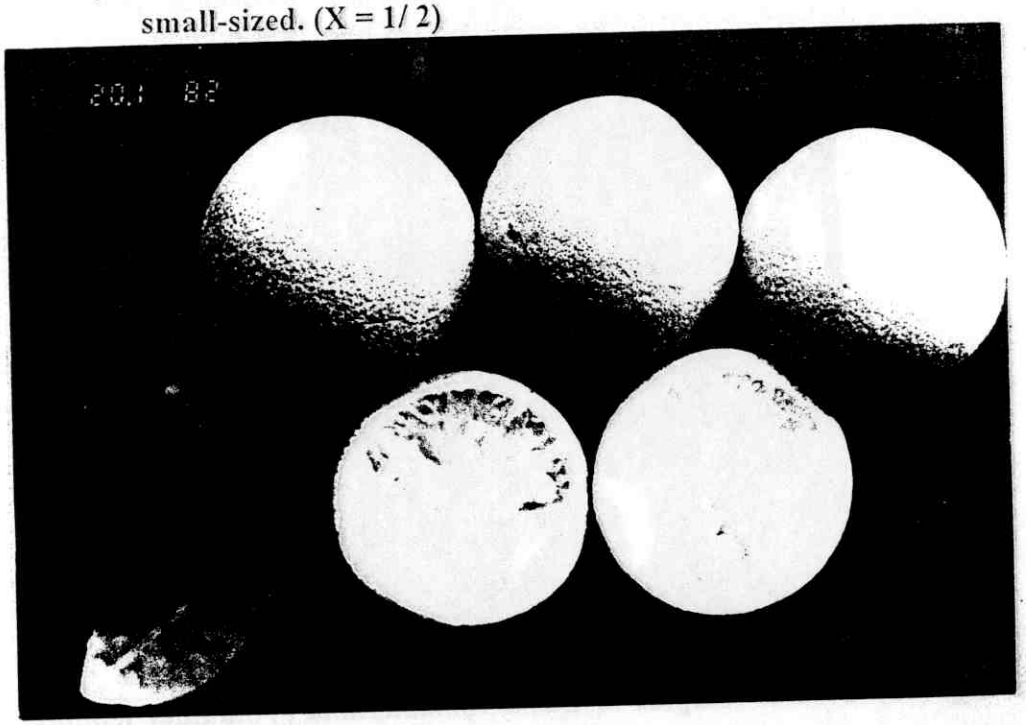

Fig. (63) Fruits of *Citrus sinensis x Poncirus trifoliata* (Troyer citrange). (X = 1/ 2)

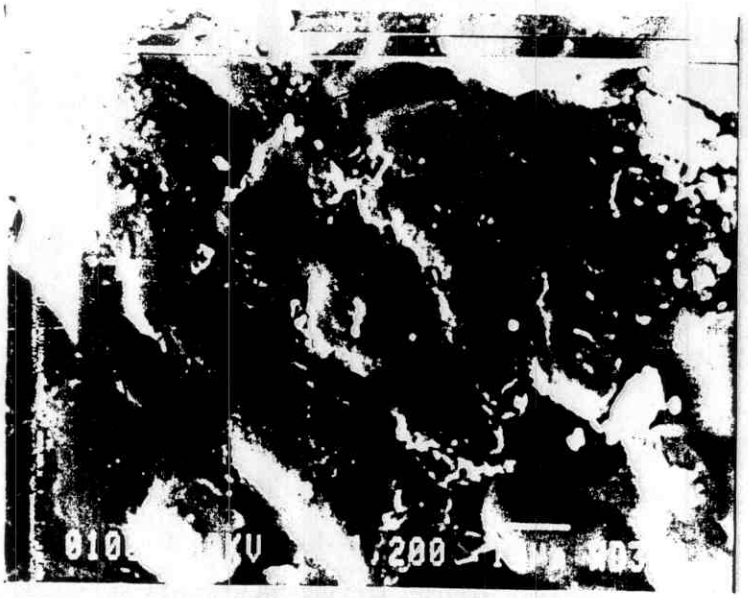

Fig. (64). Stomal complex in *Citrus aurantium* (sour orange) leaf (X = 1200).

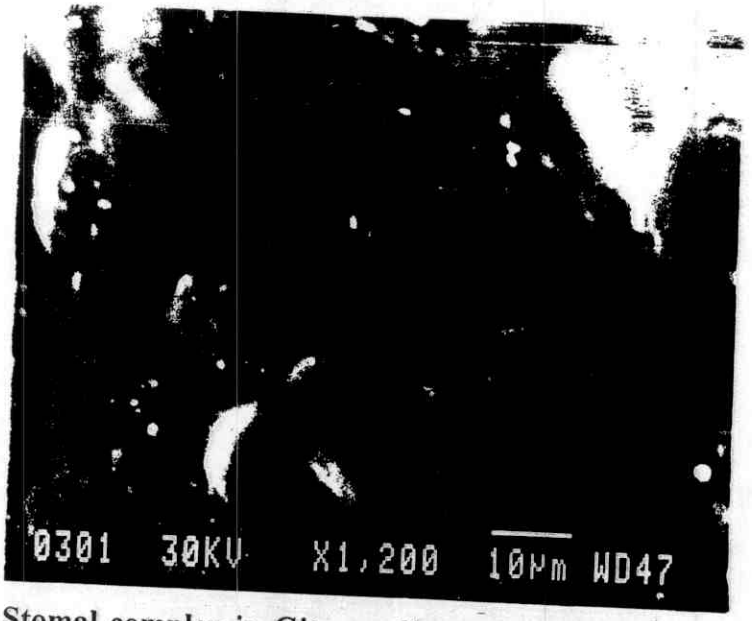

Fig. (65). Stomal complex in *Citrus volkameriana* (Volkamer lemon) leaf (X = 1200).

Fig. (66). Stomal complex in *Citrus limonia* (Rangpur lime) leaf (X = 1200).

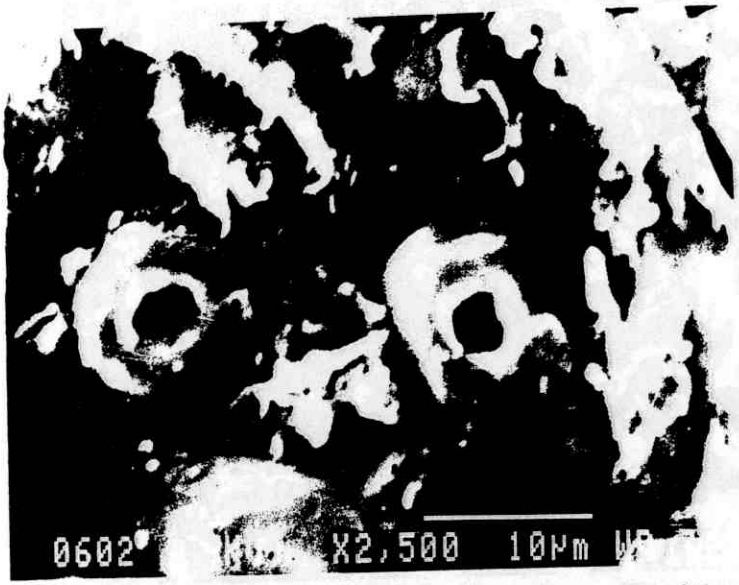

Fig. (67). Stomal complex in *Citrus sinensis x Poncirus trifoliata* (Troyer citrange) leaf. (X = 2500)

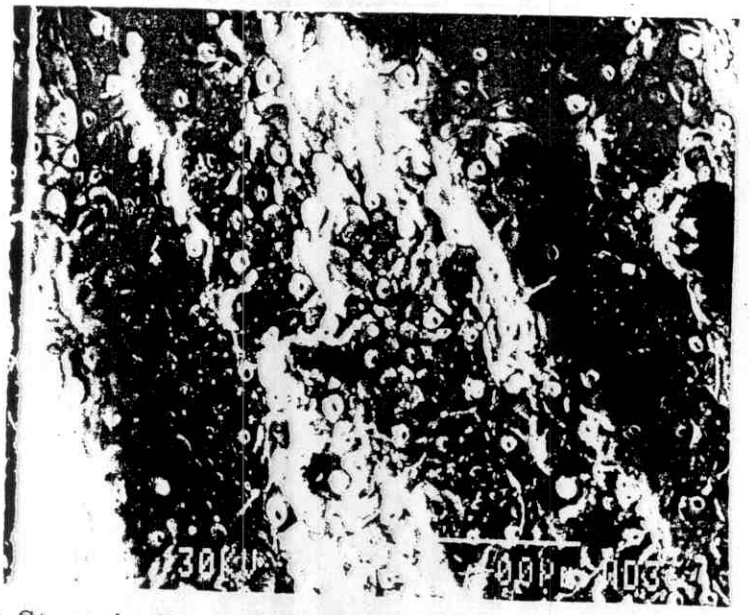

Fig. (68). Stoma in *Citrus volkameriana* (Volkamer lemon) leaf.

(X = 300)

Fig. (69). Stoma in *Citrus limonia* (Rangpur lime) leaf. (X = 300)

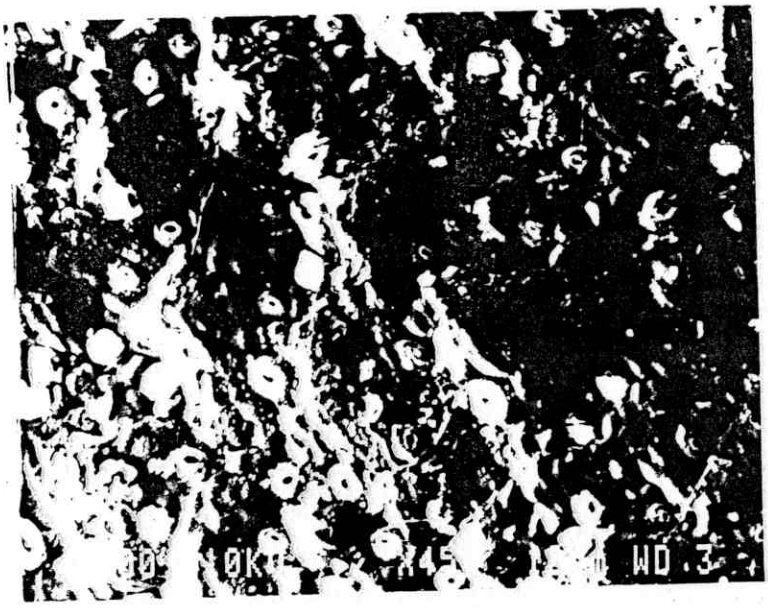

Fig. (70). Stoma in *Citrus sinensis x Poncrius trifoliata* (Troyer citrange) leaf. (X = 1200)