RESULTS AND DISCUSSION

IV. RESULTS AND DISCUSSION

IV.I. Experiment, I "Fruitful trees"

In this regard specific effect of two studied factors viz Citrus spp / cv (Balady lime; Valencia orange and Washington navel orange) and irrigation water resource (well water and reclaimed Cairo sewage effluent), as well as interaction effect of their combinations were evaluated regarding the response of the different measurements of the fruitful trees of the aforesaid three Citrus spp / cv as follows:

IV. I. I. Vegetative growth:

The average shoot (length & diameter); number of leaves per shoot and average leaf area of spring flushed shoots, as well as the tree canopy volume were the five investigated growth measurements in this concern. Data obtained during both 2001-02 and 2002-03 experimental seasons are presented in **Table (8).**

IV. I. I. 1. Shoot length:

A. Specific effect:

Regarding the specific effect of irrigation water resource, it is quite evident that the sewage irrigated fruitful citrus trees had statistically the tallest shoots as compared to the analogous ones of those irrigated with well water. Such trend was true during both 2001 - 02 and 2002 - 03 experimental seasons.

This result is in agreement with the findings of **Paliwal** ***et al*;(1998).**

As for the specific effect of Citrus spp / cv **Table (8)** shows obviously that Balady lime had always the longest shoots (10.4 & 10.6 cm) followed by Valencia orange (8.5 & 8.6 cm) and Washington navel orange (7.5 & 7.7 cm.) during 1^{st} and 2^{nd} seasons respectively. Differences between Balady lime and two orange cultivars were significant during both 2001 - 02 & 2002 - 03 experimental seasons. However, Valencia orange tended to induce longer shoots than Washington navel orange, but difference between two orange cultivars was significant during second season only.

This may be attributed mainly to that the average shoot length is an inheritable characteristic closely related to the genotype of the botanical species or cultivar itself.

B. Interaction effect:

Concerning the interaction effect of different combinations between two studied factors (irrigation water resource & Citrus spp / cv.), **Table (8)** displays that the specific effect of each investigated factor was directly reflected on its combinations. Anyhow, the tallest shoots were always in closed relationship to the sewage irrigated Balady lime trees which ranked statistically 1^{st} during both 2001 - 02 and 2002 - 03 experimental seasons. On the contrary, the shortest shoots were markedly coupled with the well water irrigated Washington navel orange trees. Meanwhile, other combinations were in between the aforesaid two extremes, however Valencia orange trees and Balady lime trees irrigated with sewage and well water respectively, beside sewage irrigated Washington navel orange trees tended obviously to induce significantly longer shoots than well water irrigated Valencia orange trees. Such trend was true during both experimental seasons.

IV. I. I. 2. Shoot diameter:

A. Specific effect:

Regarding the mature spring flushed shoots of three Citrus spp / cv under study in response to the specific effect of irrigation water resource, **Table (8)** shows that trend was not coincident with that previously discussed for its length. Herein, the well water irrigated trees tended relatively to induce thicker shoots than the analogous ones of sewage irrigated trees. However, difference was significant during the second 2002 - 03 experimental seasons only.

As for the specific effect of Citrus spp / cv it was quite evident that the response was less pronounced than that previously detected with shoot length. Anyhow, both Balady lime and Valencia orange cultivars induced shoots had significantly the same diameter from one hand but relatively thicker than those of Washington navel orange from the other. The trend of response was true during both seasons.

B. Interaction effect:

Referring the interaction effect of different combinations between two studied factors (Citrus spp / cv and irrigation water resource), **Table (8)** shows that, however the variations were not so acute but it could be noticed that the well water irrigated Balady lime trees induced generally the thickest shoots (2.28 & 2.24 mm.) during 1st and 2nd seasons, respectively. On the contrary, Washington navel orange trees showed the thinnest shoots, irrespective of the irrigation water used. In addition, other combinations were in between the aforesaid two extremes.

The conflict in trends of response to irrigation water resource between average length of mature spring flushed shoot and its diameter may be logically explained on such fact that the further elongation of shoots results in more depletion of synthetic substances (especially carbohydrates). While with the retarted elongated shoots the reverse was true, where more accumulated carbohydrates will be certainly took place and reflected positively on shoots diameter, especially when the number of developed leaves per each shoot was constant with two cases as will be discussed later with the following characteristic.

The obtained results regarding the effect of sewage effluent on stem / shoot diameter goes partially with the earlier findings of **Brister and Schultz, (1981)** on forest trees; **Maurer *et al.*, (1995-a)** on grapefruit and **Maurer and Davies (1993 a &b)** on young grapefruit transplants.

IV.I.I.3. Number of leaves per shoot:

A. Specific effect:

Concerning the specific effect of irrigation water resource on number of leaves per shoot of fruitful citrus trees (Balady lime; Valencia orange and Washington navel orange), data presented in **Table (8)** showed that differences during both seasons were completely absent from the statistical point of view.

Nevertheless, **Table (8)** shows obviously that the specific effect of Citrus spp/cv was clearly observed. Hence, the Balady lime trees induced significantly the greatest number of leaves as compared to either Valencia and Washington navel orange cultivars. On the other hand, both orange cvs induced significantly shoots had statistically the same number of leaves. Such trend was true during both seasons of study.

B. Interaction effect:

With regard to the interaction effect, it could noticed clearly that the sewage irrigated Balady lime trees induced shoots had significantly the greatest number of leaves per each (9.6) during the two experimental seasons. However, the well water irrigated Balady lime trees ranked statistically second. On the other hand, Valencia and Washington navel orange cultivars were equally the same in this concern, where they had shoots of the same number of leaves per each from the statistical standpoint, irrespective of the water irrigation used.

The obtained results may be attributed to such fact that the number of leaves per the mature shoot is an inheritable characteristic for each species or cultivar characterized by its relative constancy.

IV. I. I. 4. Average leaf area:

A. Specific effect:

With regard to the specific effect of irrigation water resource, **Table (8)** shows that the response was so obvious, where the sewage irrigated trees induced leaves with leaf area approximately two folds much more than those of the well water irrigated trees.

As for the specific effect of Citrus spp / cv., it is quite evident that the widest area was significantly in concomitant to leaves of Washington navel orange, descendingly followed by those of Valencia orange, while Balady lime ranked statistically the inferior in this respect.

B. Interaction effect:

It was quite clear that the pronounced response to specific effect of each investigated factor (water resource & Citrus spp / cv.) was reflected obviously on their combinations. Hence, the greatest leaf area was significantly always in concomitant to sewage irrigated Washington navel orange trees descendingly followed by those of Valencia orange trees irrigated with sewage effluent and Balady lime trees supplied with the same water resource during both seasons. On the other hand, average leaf area of three citrus cultivars irrigated with well water showed significantly the least values, where they did not significantly differ as compared each other during two seasons. However, well water irrigated Valencia orange trees exhibited the smallest leaf area but the reduction didn't reach level of significance as compared to those of both Balady lime and Washington navel orange trees irrigated with the same water resource.

The obtained results goes in the line with the finding of **Paliwal** ***et al,*** **(1998)** on Hardwickia binata regarding the stimulation effect of using sewage effluent on leaf area.

IV. I. I. 5. Tree canopy volume:

A. Specific effect:

Referring the specific effect of water resource, it was quite evident as shown from **Table (8)** that the sewage irrigated citrus trees characterized by their huge canopy volume i.e, 79.6 and 92.6 cubic meter during 1^{st} & 2^{nd} seasons, respectively. However, well water irrigated trees had moderate canopy volume (34.9 & 38.8 m^3) during both seasons. This may be attributed to the higher level of same nutrient elements especially N, as shown from **Table (4)**

Referring the specific effect of Citrus spp/cv, **Table (8)** shows that Balady lime trees had statistically the greatest canopy volume (74.9 & 90.3 m^3) while the opposite was true with Valencia orange which showed the smallest one (38.2 & 42.1 m^3) during 1^{st} and 2^{nd} seasons, respectively. In addition, Washington navel orange trees were in between in this concern (58.7 & 64.8 m^3) during two seasons.

B. Interaction effect:

It was so worthy to be noticed that the specific effect of each investigated factor (irrigation water resource & Citrus spp / cv.) was reflected directly on tree canopy volume of their combinations. Herein, sewage irrigated Balady lime trees surpassed statistically the analogous ones of other combinations, where former one exhibited canopy volume of 108.8 and 132.4 cubic meters during 1^{st} and 2^{nd} 2001 - 02 & 2002 - 03 experimental seasons, respectively, followed significantly in descending order by sewage irrigated Washington navel orange trees (81.8 & 91.5 m^3); Valencia orange trees irrigated with sewage effluent (48.4 & 54.0 m^3); Balady lime trees irrigated with well water (41.0 & 48.1 m^3) and irrigated trees with well water for both orange cultivars i.e., Washington navel orange (35.6 & 38.1 m^3) and Valencia orange (28.0 & 30.3 m^3) during 1st 2nd seasons, respectively.

The obtained results concerning the response of different vegetative growth measurements are in congeniality with the trends previously detected by several investigators on various fruit crops. **Omran *et al.*, (1988)** on navel orange; **Maurer and Davies,(1993-a&b)**; on citrus seedlings; **Paliwal *et al.*, (1998)** on Hardwickia binata and **Parsons et al., (2001-b)** on Hamline orange and Orlando Tangelo.

IV. I. II. Leaf chemical analysis:

IV. I. II. 1. Leaf photosynthetic pigments content:

In this regard leaf chlorophyll "A"; "B"; "A+B" contents and "A:B ratio" as influenced by specific effect of two studied factors (irrigation water resource & Citrus spp / cv.) and interaction effects of their combinations were investigated. Data obtained during both seasons are presented in **Table (9).**

IV. I. II. 1. 1. Leaf chlorophyll (A) content:

A-Specific effect:

Regarding the specific effect of irrigation water resource, **Table (9)** displays that leaves of sewage irrigated citrus trees were statistically richest in their chlorophyll "A" content as compared to those of well water irrigated ones during both seasons.

Table (8): Vegetative growth measurements of fruitful citrus trees in response to specific and interaction effects of species / cultivar (Balady lime / B. L. ;Valencia orange / V. O. and Washington navel orange / W. N. O) ; irrigation water resource (sewage & well) and their combinations during two consecutive 2001 - 02 & 2002 - 03 experimental seasons.

Citrus spp/cvs / Water resource	Shoot length (cm)				Shoot diameter (mm)				Number of leaves / shoot				Leaf area (cm^2) in spring cycle				Tree canopy volume (m^3)			
	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*
2001-02 season																				
Sewage	11.8 a	9.2 b	8.7 bc	**9.9 A**	2.07 bc	2.12 bc	2.05 bc	**2.10 A**	9.6 a	6.1 c	6.4 c	**7.4 A**	13.2 c	19.8 b	23.5 a	**18.8 A**	108.8 a	48.4 c	81.8 b	**79.6 A**
Well	9.1 b	7.7 c	6.4 d	**7.7 B**	2.28 a	2.18 ab	2.02 c	**2.15 A**	8.1 b	7.1 bc	6.4 c	**7.2 A**	10.1 d	8.8 d	10.7 d	**9.9 B**	41.0 d	28.0 f	35.6 e	**34.9 B**
Mean**	**10.4 A**	**8.5 B**	**7.5 B**		**2.16 A**	**2.15 A**	**2.04 A**		**8.9 A**	**6.6 B**	**6.4 B**		**11.7 C**	**14.3 B**	**17.1 A**		**74.9 A**	**38.2 C**	**58.7 B**	
2002 - 03 season																				
Sewage	12.1 a	9.5 b	9.0 b	**10.2 A**	2.00 bc	2.10 ab	1.90 bc	**2.00 B**	9.0 a	6.0 c	6.5 c	**7.4 A**	13.0 c	20.1 b	22.7 a	**18.6 A**	132.4 a	54.0 c	91.5 b	**92.6 A**
Well	9.1 b	7.7 c	6.5 d	**7.8 B**	2.24 a	2.20 ab	2.10 ab	**2.15 A**	8.4 b	7.1 c	6.4 c	**7.3 A**	10.3 d	9.0 d	10.2 d	**9.9 B**	48.1 d	30.3 f	38.1 e	**38.8 B**
Mean**	**10.6 A**	**8.6 B**	7.7 C		**2.14 A**	**2.11 A**	**2.02 B**		**9.0 A**	**6.5 B**	**6.6 B**		**11.6 C**	**14.6 B**	**16.5 A**		**90.3 A**	**42.1 C**	**64.8 B**	

* and ** refer to specific effect of water resource and citurs spp/cvs, respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level, where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations, respectively.

As for the specific effect of Citrus spp/cv, it was quite evident that Valencia orange cultivar had statistically the poorest leaves in their chlorophyll "A" content. However, both Balady lime and Washington navel orange were significantly richer and had equally the same chlorophyll "A" content.

B- Interaction effect:

Leaves of both Balady lime and Valencia orange trees irrigated with sewage water had the statistically the highest chlorophyll "A" content, while the reverse was true with the well water irrigated Valencia orange trees which

was statistically the inferior in this concern. In addition, three other combinations were in between the aforesaid two extremes, with a noticeable tendency pointed out that two combinations of Washington navel orange i. e., irrigated with either sewage or well water were statistically richer and ranked respectively $2^{\underline{nd}}$ & $3^{\underline{rd}}$ after the superior category. Such trend was true during both 2001- 02 & 2002- 03 seasons.

IV. I. II. 1. 2. Leaf chlorophyll "B" content:

A. Specific effect:

Regarding the specific effect of irrigation water resource, **Table (9)** displays that irrigation with well water resulted in increasing leaf chlorophyll "B" content. However, difference between sewage effluent and well water was significant during $1^{\underline{st}}$ season only.

Nevertheless leaf chlorophyll "B" content respond specifically to Citrus spp / cv, where Washington navel orange was statistically the superior, descendingly followed by

Valencia orange and Balady lime which came 2nd and 3rd from the statistical stand point during both experimental seasons.

B-Interaction effect:

It is quite clear as shown from **Table (9)** that the richest leaf chlorophyll "B" content was significantly in closed relationship to the well water irrigated Washington navel orange trees followed by the Valencia orange trees irrigated with the same water resource, however difference between both two superior combinations didn't reach level of significance during 2nd 2002-03 experimental season. On the contrary sewage irrigated Balady lime trees were statistically the inferior as their leaf chlorophyll "B" content was concerned during both experimental seasons. In addition, other combinations were in between the aforesaid two extremes.

IV. I. II. 1. 3. Leaf chlorophyll "A+B" content:

A-Specific effect:

Referring the specific effect of irrigation water resource, **Table (9)** displays that difference between sewage effluent and well water was not so considerable to reach level of significance during two experimental seasons. However, leaves of irrigated citrus trees with sewage effluent tended slightly to be richer than the analogous ones of well water irrigated ones.

The present results could be explained logically depending upon the unparalleled trends of both chlorophyll kinds (A&B) in response to water resource, where each took an opposite trend to that detected with the other.

As for the specific effect of Citrus spp / cv., it could be noticed that however variances were not so pronounced, but Washington navel orange leaves tended to be richer than those of either Valencia orange or Balady lime cultivars, especially during 1st season where differences were significant.

B-Interaction effect:

However, difference in leaf chlorophyll "A+B" content were not so acute and didn't follow a firm trend during both seasons. On the other hand, it could be generally concluded that trees of both Balady lime and Valencia orange cvs irrigated with well water had statistically the poorest leaves in their chlorophyll (A+B) content. On the contrary, other combinations had statistically richer leaves, but sewage irrigated trees of Valencia orange were to great extent the superior especially as compared to both combinations of Balady lime and Washington navel orange trees irrigated with sewage effluent and well water during 1st and 2nd seasons, respectively.

IV. I. II. 1. 4. Leaf chlorophyll (A : B ratio):

A-Specific effect:

With regard to specific effect of water resource, tabulated data in **Table (9)** displayed that leaves of sewage irrigated citrus trees had significantly higher ratio between chlorophyll A and B.

As for the specific effect of Citrus spp / cv on leaf chlorophyll A: B ratio, it was quite clear that Balady lime cv had significantly the highest value as compared to both orange cultivars (Valencia & Washington navel orange). On the other hand, difference between two orange cultivars was so slight to reach level of significance during both seasons.

B-Interaction effect:

Regarding the leaf chlorophyll A:B ratio as influenced by the different treatments (combinations between two water resources and 3 Citrus spp / cvs), **Table (9)** displays that the sewage irrigated Balady lime trees had statistically the highest value during both seasons. On the contrary, the least chlorophyll A:B ratio was exhibited by leaves of the well water irrigated trees for both orange cultivars. In addition, other combinations were in between the aforesaid two extremes.

Obtained results pertaining the response of chlorophyll A:B ratio to the different combinations reflect the unparalleled trends of response for each chlorophyll kind to a given treatment , especially as both superior and inferior combinations were concerned.

The response to the irrigation water resource and the positive effect of sewage effluent was supported by the findings of **Zekri and Koo,(1993)** on fruitful citrus trees (Hamlin orange; Valencia orange and Orlando Tangelo) budded on different citrus rootstocks and **El-Said,(1999)** on mandarin trees, as well as **Basiouny,(1984)** on Peach trees. All reported that reclaimed municipal wastewater effluent resulted in visually greener leaves.

Table (9): Leaf chlorophyll (A & B) of fruitful citrus trees in response to specific and interaction effects of species /cultivar (Balady lime / B. L ; Valencia orange / V. O. and Washington navel orange / W. N. O.); irrigation water resource (sewage & well) and their combinations during two consecutive 2001 - 02 & 2002 - 03 experimental seasons.

Citrus spp/cvs / Water resource	Chl. A mg / 100 g F.Wt.				Chl. B mg / 100 g F.Wt.				Chls. (A+B) mg / 100 g F.Wt.				Chl. A : B ratio			
	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*
2001-02 season																
Sewage	209.7 a	209.5 a	191.7 b	**203.6 A**	22.1 f	33.1 e	44.6 c	**33.2 B**	231.7 b	242.6 a	236.3 ab	**236.9 A**	9.6 a	6.4 b	4.3 c	**6.7 A**
Well	166.7 d	153.0 e	184.4 c	**168.0 B**	36.0 d	49.3 b	56.3 a	**47.2 A**	202.7 c	202.3 c	240.7 a	**215.2 A**	4.6 c	3.2 d	3.3 d	**3.7 B**
Mean**	**188.2 A**	**181.2 B**	**188.1 A**		**29.1 C**	**41.2 B**	**50.5 A**		**217.2 B**	**224.0 B**	**238.5 A**		**7.1 A**	**4.8 B**	**3.8 B**	
2002 - 03 season																
Sewage	220.3 a	209.8 a	191.4 b	**207.2 A**	29.2 c	41.2 b	39.6 b	**36.7 A**	249.5 a	250.9 a	231.0 ab	**243.8 A**	7.6 a	5.1 b	4.8 c	**5.8 A**
Well	158.2 d	143.5 e	175.3 c	**159.0 B**	35.9 b	47.1 a	51.2 a	**44.7 A**	194.1 c	193.9 c	226.4 b	**204.8 A**	4.4 c	3.0 d	3.5 d	**3.7 B**
Mean**	**189.3 A**	**176.6 B**	**183.4 A**		**32.6 C**	**44.1 B**	**55.4 A**		**221.8 A**	**222.4 A**	**228.7 A**		**6.0 A**	**4.1 B**	**4.2 B**	

* and ** refer to specific effect of water resource and citurs spp/cvs., respectively. Values within each column or row followed by the same letter / s did'nt significantly differ at 5 % level, where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations, respectively.

IV. I. II. 2. Leaf total phenols; indoles and free amino acids contents:

In this regard leaf total phenolic; indolic components and free amino acids in response to specific and interaction effects of irrigation water resource, Citrus spp / cvs and their combinations were investigated during second season (2002-03). Data obtained are presented in **Table (10).**

Total phenolic compounds:

A. Specific effect:

As for the specific effect of irrigation water resource, **Table (10)** displays that the sewage irrigated trees had significantly the richest leaves in their total phenols content. The increase was about one fold higher than the analogous one of irrigated trees with well water.

Regarding the specific effect of Citrus spp / cv, it was quite evident that Washington navel orange had the richest leaves, descendingly followed by Balady lime and Valencia orange. Differences were pronounced and significant as leaves content of three Citrus spp / cvs were compared each other.

B. Interaction effect:

Data obtained revealed that sewage irrigated trees of both Washington navel orange and Balady lime had significantly the richest leaves in their total phenolic compounds. The reverse was true with the well water irrigated trees of Balady lime. In Addition, other combinations were in between the aforesaid two extremes with a variable tendency of variance between them.

This result may be due to the more pronounced effect of water resource from one hand and the higher sensitivity of Balady lime that corresponded to the strong tolerance of Valencia orange to irrigation water resource from the other side.

Total indolic compounds:

A. Specific effect:

It is quite evident as shown from **Table (10)** that the response of leaf indoles content to the specific effect of either irrigation water resource or Citrus spp / cv followed an opposite trend to that previously detected with phenolic compounds. Herein, sewage effluent as an irrigation water resource reduced total indoles. On the other hand, leaves of Valencia orange were statistically the richest.

B. Interaction effects:

Irrigated Valencia orange trees with well water had significantly the richest leaves in their total indoles content. On the contrary the least leaf indoles level was in concomitant to the sewage irrigated trees of Balady lime. Other combinations were in between the aforesaid two extremes.

Total free amino acids content:

A. Specific effect:

With regard to the specific effect of water resource, it could be noticed that sewage effluent reduced obviously leaf total free amino acids content.

Nevertheless, leaf total free amino acids content respond significantly to Citrus spp/cvs, where Valencia orange was the richest, followed significantly in a descending order by Balady lime and Washington navel orange, respectively.

B. Interaction effect:

Data obtained revealed that the specific effect of each investigated factor reflected directly on their combinations. Herein, the well water irrigated trees of both Valencia orange and Balady lime had significantly the richest leaves in their total free amino acids content. On the contrary irrigated trees with sewage effluent "especially Balady lime & Washington navel orange" were generally the inferiors.

The present result regarding the effect of irrigation water resource on total free amino acids content were conflected to that previously mentioned by **El-Said,(1999)** on mandarin; **Hossni and EL-Tarrass,(1997)** on Vicia faba and **Narwal *et al.*, (1990)** on Maize, all reported that sewage effluent increased total free amino acids content.

IV.I.II.3.Leaf catalase and peroxidase enzymes activities:

The influence of both irrigation water resource (sewage & well) and estimated duration expended through determination (advancement of determination time in seconds) and their combinations on catalase and peroxidase enzymes

Table (10): Leaf total phenols; indoles and free amino acids contents of fruitful citrus trees in response to specific and interaction effects of species / cultivar (Balady lime / B. L. ; Valencia orange / V. O. and Washington navel orange / W. N. O.) ; water resource (sewage & well) and their combinations during second experimental 2002-03 season.

Citrus spp/cvs / Water resource	Phenols mg /100g				Indoles mg / 100g				Free amino acids mg /100g			
	B. L.	**V. O.**	**W. N. O.**	**Mean***	**B. L.**	**V. O.**	**W. N. O.**	**Mean***	**B. L.**	**V. O.**	**W. N. O.**	**Mean***
					2002-03 season							
Sewage	34.4 a	15.9 bc	38.5 a	**29.6 A**	255.7 d	402.0 b	351.3 c	**336.3 B**	938.0 c	1148.3 b	909.3 c	**998.6 B**
Well	8.0 d	11.9 cd	19.8 b	**13.2 B**	362.0 c	532.9 a	431.3 b	**442.1 A**	1360.7 a	1373.0 a	974.9 c	**1236.2 A**
Mean**	**21.2 B**	**13.9 C**	**29.1 A**		**308.8 C**	**467.7 A**	**391.3 B**		**1149.3 B**	**1261.0 A**	**942.1 C**	

* and ** refer to specific effect of water resource and citurs spp/cvs., respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level, where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations, respectively.

activities in leaves of fruitful Balady lime; Valencia and Washington navel orange trees during 2nd experimental season (2002 - 03) was investigated. Data obtained are presented in **Table (11).**

Catalase activity:

A. Specific effect:

With regard to catalase activity in response to irrigation water resource, **Table (11)** displays that the trend varied from one Citrus spp/cv to another. Anyhow, with Balady lime cv the rate of activity was significantly depressed in leaves of sewage effluent irrigated trees as compared to that of the well water irrigated trees. However, with both Valencia and Washington navel orange cultivars the trend took the other way around, where leaves of sewage effluent irrigated trees characterized significantly by their higher catalase activity.

Nevertheless, the rate of catalse activity was increased with advancement of estimated time expended through determination process i.e, up to 90 seconds. However, such trend was detected with three Citrus spp/cvs i.e., Balady lime; Valencia orange and Washington navel orange, but the increase was more pronounced with Washington navel orange and Balady lime where differences were significant. Meanwhile, with Valencia orange differences were too little to reach level of significance.

B. Interaction effect:

Table (11) reveals that leaves of Balady lime irrigated trees with well water showed significantly higher catalse activity than those of sewage irrigated trees, regardless of time spent through duration of determination process. Moreover, differences in catalase activity of well water irrigated trees of Balady lime through the whole duration of determination were too small to be considered from the statistical standpoint. However, Balady lime leaves of sewage irrigated trees showed statistically the least rate of catalse activity either at 0.0 or after 15 seconds when compared to values of its activity at more advanced times.

Meanwhile, with Valencia and Washington navel orange cultivars, the reverse was true, where the activity was significantly higher in leaves of their sewage effluent irrigated trees. Herein, the highest activity was always in concomitant to sewage irrigated trees after 90 seconds, but catalse activity in leaves of their well water irrigated trees, especially either at 0.0 or after 15 seconds were statistically the inferior.

Peroxidase activity:

A. Specific effect:

As for the specific effect of irrigation water resource on leaf peroxidase activity, **Table (11)** displays obviously that the variations were too slight to be taken into consideration. Herein, activity rate in leaves of a given Citrus spp/cv didn't response to irrigation water resource.

Nevertheless, peroxidase activity was gradually increased with advancement of determination time up to 300 seconds. Differences were significant especially as the most advanced reading of activity i.e, later one after 300 seconds was compared to the those of the first three readings i.e, after

0.0; 60 and 120 seconds. Such trend was true with the three Citrus spp / cvs

B. Interaction effect:

Table (11) shows that the more pronounced response of peroxidase activity to advancement of estimated times through determination process more than that resulted by irrigation water resource was reflected directly on the response to their combinations. Anyhow, the highest rate of peroxidase activity was significantly in closed relationship to both reading (values) recorded after 240 and 300 seconds, on leaves of three Citrus spp / cvs, regardless of irrigation water resource. On the contrary, the least activity of peroxidase activity was recorded at 0.0 seconds spent for Balady lime and / or 0.0 / 60 for both two orange cultivars. Differences between the superior and inferior combinations between irrigation water resource and duration estimated through determination process were significant for 3 Citrus spp / cvs

The present results regarding the peroxidase activity is in general agreement with the findings of **Zhao *et al.*, (1998)** on seedlings of various cultivars belonging to some Citrus spp, who reported that there was no obvious correlation between peroxidase activity and (GA : ABA) ratio i.e active growth and aging. However, findings of other investigators didn't agree with the present trend of peroxidase viz **El-Said, (1999)** on mandarin trees and **Van and Clijsters, (1990)** on different higher plants who reported that peroxidase induction considered as a general response to uptake of some toxic amounts of metals like as Cd; Ni; Pb Cu and Zn.

Table(11): **Catalasae and peroxidase enzymes activities of Balady lime; Valencia orange and Washington navel orange fruitful trees in response to specific and interaction effects of advancement of determination time; irrigation water resource (sewage & well) and their combinations during second experimental season (2002 - 03).**

A. Catalase activity

Time (Sc)	Balady lime			Valencia orange			Washington navl orange		
	Sewage	Well	Mean*	Sewage	Well	Mean*	Sewage	Well	Mean*
0	0.5199 d	0.6776 a	**0.5987 C**	0.7627 a	0.6412 b	**0.702 A**	0.7846 c	0.5864 f	**0.6855 C**
15	0.5621 cd	0.6746 a	**0.6184 B**	0.7791 a	0.6467 b	**0.7129 A**	0.8157 bc	0.6152 de	**0.7155 B**
30	0.5982 bc	0.6921 a	**0.6451 A**	0.779 a	0.6477 b	**0.71335 A**	0.8334 ab	0.6313 de	**0.7324 AB**
45	0.6127 bc	0.693 a	**0.6529 A**	0.7827 a	0.6642 b	**0.7234 A**	0.8522 ab	0.6521 d	**0.7521 A**
60	0.6048 bc	0.6785 a	**0.6416 A**	0.7896 a	0.6706 b	**0.7301 A**	0.869 a	0.6618 d	**0.7654 A**
75	0.6153 bc	0.6917 a	**0.6535 A**	0.7892 a	0.6755 b	**0.7324 A**	0.8783 a	0.6659 d	**0.7721 A**
90	0.615 b	0.6933 a	**0.6542 A**	0.7929 a	0.6727 b	**0.7328 A**	0.8792 a	0.6662 d	**0.7727 A**
Mean **	**0.5897 B**	**0.6858 A**		**0.7822 A**	**0.6598 B**		**0.8446 A**	**0.6397 B**	

B. Peroxidase activity

Time (Sc)	Balady lime			Valencia orange			Washington navl orange		
	Sewage	Well	Mean*	Sewage	Well	Mean*	Sewage	Well	Mean*
0	0.4030 de	0.3381 f	**0.3706 E**	0.3940 d	0.4520 bc	**0.4230 D**	0.3672 d	0.4281 c	**0.3977 d**
60	0.4273 cde	0.3773 ef	**0.4023 DE**	0.4267 cd	0.4632 abc	**0.4449 CD**	0.4367 c	0.4544 c	**0.4456 c**
120	0.4498 bcd	0.4301 cde	**0.4400 CD**	0.4553 bc	0.4724 abc	**0.4638 BC**	0.5453 ab	0.5111 b	**0.5282 b**
180	0.4576 bc	0.4596 bc	**0.4586 BC**	0.4810 ab	0.4845 ab	**0.4827 ABC**	0.5749 a	0.5456 ab	**0.5602 ab**
240	0.4873 ab	0.4890 ab	**0.4881 AB**	0.4900 ab	0.4950 ab	**0.4925 AB**	0.5820 a	0.5731 a	**0.5775 a**
300	0.4953 ab	0.5137 a	**0.5045 A**	0.5162 a	0.5044 ab	**0.5103 A**	0.5929 a	0.5924 a	**0.5926 a**
Mean **	**0.4534 A**	**0.4346 A**		**0.4605 A**	**0.4786 A**		**0.5165 A**	**0.5175 A**	

* and ** refer to specific effect of advancment of determination time and water resource , respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level, where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations, respectively.

IV. I. II. 4. Some endogenous growth substances (phytohoromnes) contents in leaves of fruitful citrus trees:

In this regard leaves GA_3, IAA and ABA contents of mature fruitful Balady lime, Valencia orange and Washington naval orange as influenced by irrigation water resources (sewage, El-Gabal Al-Asfar farm and well water Quesna) were investigated during the 1st experimental season (2001- 02), where data obtained are presented in **Table (12).**

As for the response of GA_3, it is quite clear that an obvious difference was resulted. Herein, the irrigated citrus trees with sewage effluent showed an increase as compared to the analogous ones of those irrigated with well water. Such increase varied from one citrus species / cultivar to another, where it was more pronounced with Balady lime trees, (about 3 folds) and moderately with Valencia orange (about 1.5 times), while with the second orange cultivar (Washington naval orange) the variance was too slight to be taken into consideration.

Referring the response of IAA, **Table (12)** shows that the trend of response to irrigation water resource took the other way around as compared to the above mentioned discussed one with GA_3. The difference in variance due to the irrigation water resource had nearly the same rate with a relative tendency to be more pronounced with both Balady lime and Washington naval orange where the reduction in IAA exhibited by sewage water showed approximately one third of IAA values of those in leaves of well water irrigated trees. However, with the

Washington naval orange the decrease in leaf IAA content of sewage irrigated trees was about one half as compared to those of well water irrigated ones.

Concerning the ABA content, it was quite clear that it followed typically the same trend previously detected with leaf IAA level. On the other hand, the rate of reduction in leaf ABA content resulted by irrigation with sewage ranged about nearly one half of the corresponding level of well water irrigated trees of the three citrus species / cultivars under study.

As for the different ratios between the three endogenous growth substances in response to irrigation water resource for three citrus species / cultivars, **Table (12)** shows a noticeable variances as ratio of each two components was discussed separately. Anyhow, the GA_3 : IAA ratio shows that sewage water resulted in an obvious increase from one hand, but the rate of increase was more pronounced with Balady lime trees (about 8.0 times) than those exhibited in Valencia and Washington naval orange cvs i,e, were 2.25 and 3.0 times, respectively.

This trend may be attributed to the two conflicted trends of response for both GA_3 and IAA, where an increase was found with former one (GA_3) in sewage irrigated trees but the opposite was true with the latter one (IAA), as previously discussed.

Table (12) shows that the ratio between either GA_3 or IAA from one hand and the ABA from the other were clearly respond to irrigation water resource. However, the ratio was increased obviously with GA_3: ABA ratio due to using sewage for irrigation while with IAA: ABA ratio it was slightly decreased, regardless of the citrus species / cultivars. On the other hand, the increase in GA_3 : ABA ratio in leaves of sewage irrigated Balady lime trees was more pronounced than those found with two sweet orange cultivars.

The obtained results regarding the conflicted trends of response for both GA_3: ABA and IAA:ABA ratios to water resource could be logically explained depending upon two conflicted trends detected regarding the response of GA_3 and IAA to water resource where each followed its own opposite trend as previously discussed.

The present results regarding the response of both GA_3 and ABA to irrigation water resource is in harmony with that found by **El-Said, (1999)** on mandarin trees, however the trend of IAA partially disagreed our findings.

IV. I. II. 5. Leaf mineral composition:

In this respect leaf N; P; K; Mg; Fe; Mn; Zn; Cu; Na; Pb and Ni contents of some citrus cultivars (fruitful trees) in response to specific effect of irrigation water resource and Citrus spp/cv as well as interaction effects of their combinations were investigated. Data obtained during both experimental 2001- 02 and 2002- 03 seasons are presented in **Tables (13); (14)** and **(15).**

Table(12): Some endogenous growth substances (phytohormones) contents in young leaves of recently spring flushed shoots of Balady lime, Valencia orange and Washington navel orange trees as influenced by irrigation water resources during the first experimental season. (2001 - 02).

Citrus spp/cvs	Water resource	mg / 100 g F. Wt.					
		GA_3	IAA	ABA	GA_3 : IAA	GA_3:ABA	IAA:ABA
Balady lime	sewage effluent	211.31	0.33	0.22	640.33	960.50	1.50
	well water	77.69	0.99	0.56	78.47	138.24	1.76
Valencia orange	sewage effluent	8.41	0.45	0.32	18.69	26.45	1.42
	well water	6.96	0.84	0.57	8.32	12.30	1.48
W. navel orange	sewage effluent	11.25	0.93	0.13	12.05	88.55	7.35
	well water	11.05	2.90	0.31	3.81	35.19	9.24

IV. I. II. 5. 1. Leaf macro nutrients content:

Leaf nitrogen content:

A. Specific effect:

With regard to specific effect of irrigation water resource, data obtained during both seasons as shown in **Table (13),** displayed obviously that fruitful citrus trees irrigated with sewage effluent had significantly higher leaves N % as compared to those of well water irrigated trees.

As for the specific effect of Citrus spp / cv., it was quite evident that the richest leaf N content was always in significant concomitant to Balady lime trees. On the contrary Valencia orange cv had the poorest leaves N content. Meanwhile Washington navel cv orange was in between. Differences between three Citrus spp / cvs were significant as compared each other during both experimental 2001- 02 and 2002- 03 seasons.

B-Interaction effect:

Table (13) displays obviously that the specific effect of each investigated factor (water resource & Citrus spp /cv) reflected directly on their possible combinations. Herein, the more pronounced effect of sewage as an irrigation resource associated with the superiority of Balady lime led to the superiority of sewage irrigated Balady lime trees, where the richest leaves N content were significantly in closed relationship to such combination. On the contrary, both combinations of well water irrigated Valencia and Washington navel orange trees had significantly the poorest leaves N %, especially such combination of former orange cultivar (Valencia) which was the inferior during both experimental seasons from the statistical point of view during both experimental seasons. In addition other combinations were in between the aforesaid two extremes, however both combinations of sewage effluent irrigated trees of both orange cultivars had significantly richer leaves than other members of such intermediate category.

Leaf phosphorus content:

A. Specific effect:

Referring the specific effect of investigated factors, **Table (13)** shows that leaf P % followed typically the same trends previously detected with nitrogen level. Herein, sewage increased significantly leaf P % as compared to well water. On the other hand, leaf P % respond specifically to Citrus spp / cv, where Balady lime leaves were significantly the richest, descendingly followed by Valencia and Washington navel orange cultivars, respectively.

B-Interaction effect:

The specific effect of both investigated factors (water resource & Citrus spp / cvs) was reflected on interaction effect of their combinations. Herein, sewage irrigated trees of both Balady lime and Valencia orange had statistically the richest leaves in their P content. The superiority of the aforesaid two combinations i.e, (B.L. X sewage) and (V.O. X sewage) was true during two seasons, however former one exhibited a relative tendency to be richer, especially in 1st season where difference was significant. On the contrary, well water irrigated trees of both orange cultivars were statistically the inferior during both seasons. Other combinations were in between the aforesaid two extremes.

Leaf potassium content:

A. Specific effect:

With regard to specific effect of irrigation water resource, **Table (13)** shows that using sewage effluent for irrigation increased significantly leaf K % as compared to well water. On the other hand, Valencia orange cv was significantly the richest as leaf K % in response to specific effect of Citrus spp / cv was concerned. Such trends of response to specific effect of either water resource or Citrus spp /cv were true during both experimental seasons.

B. Interaction effect:

Table (13) displays that the more pronounced response of leaf K % to specific effect of irrigation water resource rather than that of Citrus spp / cv reflected obviously on their various combinations. Herein, the sewage irrigated trees of three citrus cultivars exceeded significantly the analogous three ones of well water irrigated trees of three citrus cvs However, sewage irrigated Valencia orange trees were the superior either data of each season or an average of two seasons were concerned. On the other hand, well water irrigated trees of 3 Citrus spp / cvs were the inferior and didn't significantly differ as compared each other during two seasons of study.

Leaf magnesium content:

A. Specific effect:

As for the specific effect of water resource, **Table (13)** shows that sewage irrigated citrus trees had significantly the richest leaves Mg %. However, Balady lime was significantly the richest followed in descending order by Valencia and Washington navel orange cultivars as the specific effect of Citrus spp / cv was concerned. Taking into consideration that difference between two orange cultivars did not reach level of significance during both seasons of study.

B. Interaction effect:

Table (13) displays that variances in leaf Mg % due to interaction effect of different combinations between two studied factors were obviously detected. Herein, the sewage irrigated Balady lime trees had significantly the richest leaves in their Mg content.

Meanwhile, leaves of sewage irrigated orange trees (Valencia & Washington navel orange cvs) ranked statistically 2^{nd} either data of each season or an average of two seasons were concerned. Difference between two members (combinations) of 2^{nd} category was significantly absent in 1^{st} season but in 2^{nd} season Valencia leaves were significantly richer. On the contrary the least Mg % was significantly in closed relationship to well water irrigated Washington navel orange trees. In addition, other combinations were in between.

The obtained results regarding the specific effect of irrigation water resource could be explained logically depending upon the water chemical analysis of two resources (sewage & well water), where sewage contained higher levels of the previously discussed macro nutrient elements (N; P; K and Mg). Moreover, the increase in leaf N; P; K and Mg contents of sewage irrigated trees supported the previously findings of **Esteller *et al.*, (1994)** on irrigation citrus trees with wastewater (found that wastewater increased leaf N content); **Lapena *et al.*, (1995)** on young orange transplants irrigated with wastewater (an increase in leaf N; K; Cl; B and Na content). **Maurer *et al.*, (1995-b)** on March grapefruit trees (25 years old), found that the wastewater irrigated groves had trees significantly richer in their leaves K content and optimum leaf P; Mg; Cu; Mn and Zn contents. **Reboll *et al.*, (2000)** studied the effect of wastewater as an alternative water resource on nutritional status of young citrus trees, they found that leaf N content was in optimal nutrition rate and consequently fertilizer rate could be practically lowered without affecting nutritional status when reclaimed wastewater used for irrigation. In addition **Paranichianakis *et al.*,(2000)** studied the effect of reclaimed wastewater on nutrition of Sultanina grapevines grafted on different rootstocks, they found that irrigation with reclaimed water was sufficient to cover, Mg; K and p requirements.

IV. I. II. 5.2. Leaf micro nutrients content:

Data obtained during both 2001- 02 and 2002 - 03 experimental seasons regarding the response of leaf Fe; Mn; Zn

Table (13): Leaf N; P; K and Mg content of fruitful citrus trees in response to specific and interaction effects of species / cultivar (Balady lime / B. L.; Valencia orange / V. O. and Washington navel orange / W. N. O.); irrigation water resource (sewage & well) and their combinations during two consecutive 2001 - 02 & 2002 - 03 experimental seasons.

Citrus spp/cvs / Water resource	N %				P %				K %				Mg %			
	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*
2001- 02 season																
Sewage	3.04 a	2.48 b	2.53 b	**2.68 A**	0.263 a	0.203 b	0.172 c	**0.213 A**	1.26 a	1.30 a	1.13 b	**1.23 A**	0.447 a	0.324 bc	0.337 b	**0.369 A**
Well	2.33 c	2.17 d	2.33 c	**2.28 B**	0.113 d	0.088 e	0.077 e	**0.092 B**	0.94 c	0.96 c	0.90 c	**0.93 B**	0.318 c	0.271 d	0.202 e	**0.264 B**
Mean**	**2.68 A**	**2.33 C**	**2.43 B**		**0.188 A**	**0.145 B**	**0.125 C**		**1.10 A**	**1.13 A**	**1.02 B**		**0.383 A**	**0.298 B**	**0.269 B**	
2002 - 03 season																
Sewage	2.94 a	2.61 b	2.66 b	**2.73 A**	0.208 a	0.201 a	0.177 b	**0.195 A**	1.14 b	1.17 a	1.14 b	**1.15 A**	0.346 a	0.338 b	0.322 c	**0.335 A**
Well	2.43 c	2.24 e	2.35 d	**2.34 B**	0.103 c	0.077 d	0.083 d	**0.088 B**	0.99 c	0.98 c	0.98 c	**0.98 B**	0.305 d	0.226 e	0.169 f	**0.233 B**
Mean**	**2.69 A**	**2.43 C**	**2.51 B**		**0.155 A**	**0.139 B**	**0.130 B**		**1.06 B**	**1.08 A**	**1.06 B**		**0.326 A**	**0.282 B**	**0.245 C**	

* and ** refer to specific effect of water resource and citurs spp/cvs, respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level, where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations,respectively.

and Cu contents to specific and interaction effects of irrigation water resource, fruitful Citrus spp / cv and their combinations are presented in **Table (14).**

Leaf iron content:

A. Specific effect:

With regard to specific effect of irrigation water resource, it is quite clear that the sewage effluent irrigated trees had significantly the richest leaf Fe content as compared to those irrigated with well water. The increase reached approximately two folds during both seasons.

Nevertheless, the response to specific effect of Citrus spp / cv revealed that Valencia orange cv was significantly the richest, descendingly followed by Washington navel orange and Balady lime as their leaf Fe content was concerned. Differences between three Citrus spp / cv were significant during both experimental seasons.

B. Interaction effect:

Table (14) shows that the specific effect of either irrigation water resource or Citrus spp / cv was reflected directly on interaction effect of their possible combinations. Hence, the sewage effluent irrigated trees of Valencia orange exhibited statistically the highest leaf Fe content i.e, 205 and 220 ppm

during 1^{st} and 2^{nd} seasons, respectively. Moreover sewage effluent, irrigated trees of both Washington navel orange and Balady lime descendingly ranked 2^{nd} and 3^{rd} orders, respectively as their leaves Fe content were concerned from the statistical standpoint. On the contrary, Balady lime trees subjected to well water irrigation had the least leaf Fe content especially either data of 2nd season or an average of two seasons were concerned.

Leaf manganese content:

A. Specific effect:

Leaf Mn content followed typically the same trend previously detected with leaf Fe content pertaining the specific effect of irrigation water resource. However, rate of difference was relatively less pronounced with leaf Mn content. On the other hand, the trend of response to the specific effect of Citrus spp / cv was relatively modified as compared to the aforesaid one discussed for leaf Fe content. Herein, although the Balady lime was still relatively the poorest as its leaves Mn content was concerned, but two sweet orange cultivars alternately changed their ranks. In other words, Washington navel orange was statistically the richest followed in descending order by Valencia orange and Balady lime, however difference between two later Citrus spp / cv didn't reach level of significance during both seasons.

B. Interaction effect:

Table (14) reveals obviously that sewage effluent irrigated trees of Washington navel orange had significantly the richest leaves in their Mn content i.e, 22.6 and 25.2 ppm during 1st and 2nd seasons respectively. On the contrary the least leaf Mn content was always in significant concomitant to the lime well water irrigated Balady lime trees i.e, 11.7 and 11.2 ppm during 1st and 2nd seasons respectively. In addition, other combinations were in between the above mentioned two extremes.

Leaf zinc content:

A-Specific effect:

Table (14) shows obviously that leaf Zn content in response to specific effect of water resource followed the same trend previously detected with both leaf Fe and Mn contents. However, the trend of response to Citrus spp / cv took the other way around, where Balady lime was statistically the richest as its leaves Zn content was concerned. On the other hand, leaves of both orange cultivars had not only lower zinc level below the analogous one of Balady lime but also both were equally the same from the statistical point of view.

B. Interaction effect:

It is quite evident as shown from tabulated data in **Table (14)** that the Balady lime trees irrigated with sewage effluent had statistically the richest leaf Zn content i.e, 106.5 and 99.0 ppm during 1^{st} and 2^{nd} seasons respectively. On the contrary, well water irrigated trees of three Citrus spp /cv had the least leaf Zn content, especially as an average of two seasons was concerned, however the well water irrigated trees of Washington navel and Valencia orange cvs were statistically the inferior during 1^{st} and 2^{nd} seasons, respectively.

Leaf Copper content:

A. Specific effect:

With regard to specific effect of water irrigation resource it is quite clear as shown from **Table (14)** that the trend was similar to that previously detected with leaf Fe; Mn and Zn content. Meanwhile, the response to the specific effect of Citrus spp / cv was to great extent coincident to that previously detected with leaf Zn content. Herein, Balady lime cv was the superior followed statistically by Washington navel orange while Valencia orange was the inferior. Differences were significant with comparing 3 Citrus spp / cvs each other during both seasons except when compared Balady lime to Washington navel orange during 2nd season where difference was not significant.

B. Interaction effect:

Table (14) reveals that Balady lime trees irrigated with sewage effluent surpassed statistically other investigated combinations (water resource X Citrus spp / cv) as their leaves Cu content was concerned. The reverse was true with two combinations representing well water irrigated trees of both sweet orange cultivars, where the least leaf Cu content was exhibited by those of Washington navel and Valencia during 1st and 2nd seasons for former and later cultivars, respectively. In addition, other combinations were in between the aforesaid two extremes.

The present results regarding the effect of sewage effluent on different leaf micronutrient elements content are in congeniality with the findings of several investigators. Finding of **Abd El-Naim and El-Awady, (1989)** on citrus trees grown in sandy soil gave support to our result regarding the increase in leaves Fe; Mn; Zn and Cu contents of sewage irrigated trees of 3 Citrus spp / cvs under study, where they reported that Zn;

Cu; Mn; and Fe elements increased in sewage water irrigated soil. Moreover, **Zekri and Koo, (1990)** on Hamlin orange reported that leaf Fe level was increased in municipal wastewater irrigated trees than those irrigated with well water. However, the same authers indicated that leaf Mn and Zn contents of municipal wastewater irrigated Hamlin trees were decreased than the analogous ones of well water irrigated ones.

Leaf sodium and some heavy metals content:

In this regard leaf Na; Pb, and Ni content of fruitful citrus trees in response to specific and interaction effects of water resource; Citrus spp / cvs and their combinations were investigated. Data obtained during both 2001- 02 and 2002- 03 experimental seasons are presented in **Table (15).**

Leaf Na content:

A. Specific effect:

With regard to specific effect of investigated factors, data obtained revealed that leaf Na content respond specifically to each factor. Herein, sewage effluent increased it significantly as compared to well water. On the other hand, Baldy lime leaves were statistically the richest as the specific effect of Citrus spp/cv was concerned. However, leaves of Valencia orange were relatively richer in their Na content as compared to those of Washington navel orange, but differences between two orange cvs didn't reach level of significance during both experimental seasons.

Table (14): Leaf Fe; Mn; Zn and Cu content of fruitful citrus trees in response to specific and interaction effects of species / cultivar (Balady lime / B. L.; Valencia orange / V. O. and Washington navel orange / W. N. O.); irrigation water resource (sewage & well) and their combinations during two consecutive 2001 - 02 & 2002 - 03 experimental seasons.

Citrus spp/cvs	Fe ppm				Mn ppm				Zn ppm				Cu ppm			
Water resource	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*
2001-02 season																
Sewage	114.0 c	205.0 a	127.0 b	**148.7 A**	18.7 c	16.5 d	22.6 a	**19.3 A**	106.5 a	50.5 c	60.5 b	**72.5 A**	32.5 a	23.4 c	32.2 b	**29.4 A**
Well	81.0 d	65.0 e	79.0 d	**75.0 B**	11.7 f	14.8 e	20.2 b	**15.7 B**	42.0 e	45.0 d	37.5 f	**41.5 B**	17.6 d	16.8 e	13.2 f	**15.9 B**
Mean**	**97.5 C**	**135.0 A**	**103.0 B**		**15.2 B**	**15.7 B**	**21.4 A**		**74.3 A**	**47.8 B**	**49.0 B**		**25.1 A**	**20.1 C**	**22.7 B**	
2002 - 03 season																
Sewage	144.0 c	220.0 a	169.0 b	**177.7 A**	22.2 b	21.3 c	25.2 a	**22.9 A**	99.0 a	62.0 b	62.0 b	**74.3 A**	32.3 a	23.1 c	31.6 b	**29.0 A**
Well	58.0 f	134.0 d	79.0 e	**90.3 B**	11.2 e	17.8 d	21.6 c	**16.9 B**	48.0 d	46.0 e	50.0 c	**48.0 B**	19.0 d	15.7 f	16.8 e	**17.2 B**
Mean**	**101.0 C**	**177.0 A**	**124.0 B**		**16.7 B**	**19.6 B**	**23.4 A**		**73.5 A**	**54.0 B**	**56.0 B**		**25.7 A**	**19.4 B**	**24.2 A**	

* and ** refer to specific effect of water resource and citurs spp / cvs. respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level , where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations.respectively.

B. Interaction effect:

It was quite clear that leaves of sewage irrigated Balady lime trees were statistically the richest in their Na content. Other combinations had not only lower Na content, but also they had equally the same Na level from statistical standpoint with few exceptions i.e., well water irrigated trees of Washington navel orange.

The increase in leaf Na content of sewage irrigated citrus trees of 3 spp/cv detected in our study is supported by different publications dealing with findings of **Koo and Zekri, (1989)** on orange; **Maurer and Davies, (1993-a&b)** on grapefruit, all demonstrated that using municipal wastewater in irrigation increased leaf Na content.

A. Leaf lead content:

Specific effect:

Application of sewage effluent for irrigation increased leaf Pb content as compared to those subjected to irrigation with well water. On the other hand, Balady lime followed by Washington navel orange cv characterized by their potentiality to accumulate higher rate of lead in their leaves, while Valencia orange was the inferior in this regard.

B. Interaction effect:

Balady lime and Washington navel orange trees irrigated with sewage effluent had statistically the highest Pb level in their leaves. While, the least leaf Pb content was always in concomitant to well water irrigated Valencia orange trees. In addition other combinations were in between.

Leaf Nickel content

A. Specific effect:

The response to specific effect of irrigation water resource exhibited that leaves of sewage irrigated citrus trees had significantly higher Ni content than those of well water irrigation. As for the specific effect of Citrus spp / cv. **Table (15)** shows that Washington navel orange cv was statistically the richest in leaf Ni content. Moreover, Balady lime and Valencia orange had leaves with a comparable Ni level from statistical point of view either data of each season or an average of two seasons were concerned.

B. Interaction effect:

Table (15) displays that the highest leaf Ni content was significantly coupled with sewage irrigated Washington navel orange trees during both seasons. On the contrary, the least leaf Ni content was markedly in closed relationship to the well water irrigated trees of both Valencia orange and Balady lime cvs The inferiority of the aforesaid two combinations of well water resource was true during both seasons.

In additions, other combinations were in between the aforesaid two extremes.

The results obtained regarding the increase in leaf Ni and Pb due to sewage effluent is in harmony with the findings of **Omran *et al.*, (1985)** on navel orange ; **Abd El-Naim and El-Awady,(1989)** on citrus trees; **Abd El-Sabour ,(1995) on orange and Hussein *et al.*, (1999)** on date palm trees, all demonstrated that municipal wastewater increased Cd; Ni and Pb content.

Table (15): Leaf sodium and some heavy metals (Pb & Ni) contents of fruitful citrus trees in response to specific and interaction effects of species / cultivar (Balady lime / B. L.; Valencia orange / V. O. and Washington navel orange / W. N. O.); irrigation water resource (sewage & well) and their combinations during two consecutive 2001 - 02 & 2002 - 03 experimental seasons.

Water resource \ Citrus spp/cvs	Na %				Pb ppm				Ni ppm			
	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*
2001 - 02 season												
Sewage	0.971 a	0.669 b	0.677 b	**0.772 A**	2.10 a	1.92 b	2.01 ab	**2.01 A**	4.89 c	5.95 b	9.83 a	**6.89 A**
Well	0.695 b	0.610 b	0.441 c	**0.582 B**	1.60 c	1.29 e	1.50 d	**1.46 B**	2.86 f	3.68 e	4.72 d	**3.75 B**
Mean**	**0.833 A**	**0.640 B**	**0.559 B**		**1.85 A**	**1.60 B**	**1.75 AB**		**3.87. B**	**4.81 B**	**7.27 A**	
2002 - 03 season												
Sewage	0.589 a	0.573 a	0.349 c	**0.503 A**	1.90 a	1.60 c	1.70 b	**1.80 A**	6.30 b	5.28 c	6.60 a	**6.40 A**
Well	0.477 b	0.413 b	0.318 c	**0.403 B**	1.60 c	1.30 e	1.40 d	**1.44 B**	2.60 e	2.60 e	4.20 c	**4.37 B**
Mean**	**0.533 A**	**0.493 A**	**0.334 B**		**1.80 A**	**1.45 B**	**1.55 B**		**4.45 B**	**3.90 B**	**5.40 A**	

* and ** refer to specific effect of water resource and citurs spp / cvs, respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level, where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations, respectively.

IV. I. III. Flowering measurements:

In this regard inflorescences (number & type); flower nature (normal & aborted) and pollen grains viability in response to irrigation water resource for three Citrus spp / cvs under study were concerned. Data obtained are presented in **Tables (16) and (17).**

IV. I. III. 1. Number of inflorescences and their types:

In this respect total number of both woody and leafy inflorescences, as well as percentage of leafy inflorescences in response to water resource were investigated during second season (2002-03)

Number of inflorescences:

Table (16 - A) reveals that swage irrigated trees of each Citrus spp/cv had statistically greater number of inflorescences as each cv was compared separately to the analogous one of well water irrigated trees. The increase was more pronounced with both Baldy lime and Valencia orange, where the total number of inflorescences induced by their sewage irrigated trees reached approximately two folds much more than those of well water irrigated ones. Meanwhile, with Washington navel orange rate of increase was relatively lower and reached about 50 % only.

As for the influence of irrigation water resource on inflorescences type, it is quite evident as shown form tabulated data in **Table (16-A)** that the woody inflorescences were the unique type produced by Balady lime cv However, both types (woody & leafy) were presented for two orange cultivars.

Anyhow, the leafy inflorescences % respond obviously to water resource, where it was significantly increased in well water irrigated trees of both Valencia and Washington navel orange. The well water irrigated trees leafy inflorescences % was two and three times much higher than the analogous ones of sewage irrigated trees for Valencia and Washington navel orange cvs, respectively.

The present result regarding the absence of leafy inflorescence in Balady lime may be attributed to the inheritable characteristics of such Citrus spp However, the increase exhibited by sewage effluent in total number of inflorescence may be attributed to the higher nutrient element contents in such water resource, which reflected positively on growth and consequently on total number of produced inflorescences. However, the higher % of leafy inflorescences in well water-irrigated trees than the sewage irrigated ones attributed mainly to the higher depleted rate of synthetic materials (mainly carbohydrates) in the sewage irrigated trees.

IV. I. III. 2. Flowers nature:

With regard to flowers nature of Balady lime cv expressed as normal flowers % in its woody (leafless) inflorescences in response to water irrigation resource, Table **(16-B)** displays obviously that sewage irrigated Balady lime trees exhibited significantly higher normal flowers% particularly as both categories of large and intermediate flowers sizes were concerned. Such trend was true for two flowering waves (March 10^{th} & April 3^{rd}) as normal flowers % of both large and medium flowers induced by either sewage irrigated Balady trees or well water irrigated ones were compared each other. However, the small flowers of Balady lime were completely upnormal for both flowering waves.

Referring the effect of irrigation water resource on flowers nature expressed as normal flowers % of both sweet orange cultivars (Valencia and Washington navel orange) **Table (16-C)** displays that the response varied not only from one cultivar to another but also both inflorescence types and category of flowers size each reflects its own role in this respect. Anyhow, the large flowers of both Valencia and Washington navel cultivars didn't respond to irrigation water resources, where aborted flowers were approximately absent (100% normal flowers), irrespective of inflorescence type. Meanwhile, with the second flowers category (medium size) the trend of response to irrigation water resource were typically coincident for two orange cultivars, where the sewage irrigated trees exhibited 100 % normal flower corresponding to 100 % upnormal flowers for the well water irrigated trees, regardless of inflorescence type of both orange cultivars. Moreover, with the small flowers the trend of response to irrigation water resource varied greatly from one cultivar to another. Herein, neither irrigation water resource nor inflorescence type had any effect on flowers nature of Valencia orange cv., where normal flowers were completely absent in its small flowers. While, the small flowers of Washington navel orange cultivar in response to irrigation water resource followed typically the same trend previously detected with those of medium size category for two orange cvs Herein, normality was 100 % in flowers of sewage irrigated Washington navel orange trees but 100 % absent with those of well water irrigated ones, regardless of inflorescence type.

The shift in response of flowers normality to irrigation water resource, which linked with the flower size as large and small sized flowers may be attributed to some internal factors like as nutritional reasons and balance of some endogenous hormones. So, advanced investigations are needed in this concern.

IV. I. III. 3. Pollen grains viability:

Pollen grains viability of both Baldy lime and Valencia orange in response to irrigation water resource; Citrus spp and their combinations were investigated during both 2001 - 02 and 2002 - 03 seasons. Data estimated as a percentage of germinated grains during two experimental seasons are presented in **Table (17).**

A. Specific effect:

With regard to specific effect of irrigation water resource, it was quite clear that sewage effluent decreased relatively germination %. Difference was significant during both experimental seasons. However, the trend of response to specific effect of Citrus spp was not firm during both seasons where pollen grains of Valencia orange showed significantly higher germination % than Balady lime in 1st season, but the reverse was true during 2nd season. Such conflict in response to Citrus spp may be due to the environmental condition prevailed either before flowering or at sampling date (full bloom) of flowers materials needed through two seasons of study.

Table (16): Inflorescences (total number & type) and flower nature of Balady lime; Valencia orange and Washington navel orange cvs as influenced by irrigation water resource during full bloom stage* of 2002- 03 experimental season.

A: Total number and type of Inflorescences

Citrus spp/cvs / Water resource	Total inflorescences number			Leafy infloresecences %		
	B. L.	V. O.	W. N. O.	B. L.	V. O.	W. N. O.
Sewage water	273.3 a	114.3 a	120.7 a	0.0	31.7 b	20.1 b
Well Water	124.0 b	55.0 b	85.3 b	0.0	57.5 a	57.8 a

B: Flowers nature of Balady lime (woody inflorescences at two flowering waves)

flowerind date & flower size / Water resource	Normal flowers %					
	March 10th			April 3rd		
	Flower size			Flower size		
	large	medium	small	large	medium	small
Sewage water	68.3 a	43.3 a	0.0	93.8 a	51.8 a	0.0
Well Water	48.8 b	11.5 b	0.0	55.8 b	10.8 b	0.0

: Flowers nature of Valencia orange and Washington navel orange cvs. (leafy & woody / leafless inflorescence

Citrus spp. / cv. & flower size / Water resource	Inflorescence type	Normal flowrs %					
		Valencia orange			Washington navel orange		
		Large	medium	small	Large	medium	small
Sewage water	leafy	100 a	100 a	0	100 a	100 a	100 a
	leafless	100 a	100 a	0	100 a	100 a	100 a
Well Water	leafy	100 a	0 b	0	100 a	0 b	0 b
	leafless	96 a	0 b	0	100 a	0 b	0 b

* Data of both inflorescences and flowers maesurments were recorded once at full bloom of each citrus cultivar sexecpt flowere nature of Balady lime (twice at two flowering waves).

** Data of each flowering characteristic were statistically analysed separately for every Citrus spp. / cv. and each flower category. So means within each column followed by the same letter did'nt significantly differ at 5 % level.

B. Interaction effect:

However, no specific trend could be detected during both seasons, but it could be generally noticed that germination % of the sewage irrigated trees for both lime and Valencia orange exhibited statistically the same value from one hand and ranked last from the other.

The decrease in pollen grains viability (germination %)in sewage irrigated trees (Balady lime and Valencia orange cvs) goes in line with findings of **Munzuroglu and Gur, (2000)** on apple, who demonstrated that presence of heavy metals stunted germination % of pollen grains and retarded tube growth.

IV. I. IV. Productivity measurements :

In this regard fruit retention; preharvest drop; yield (number & weight of mature fruits per either the whole tree or one cubic meter of its canopy) and fruit quality (physical; chemical properties and mineral compositions of both fruit peel and pulp) were investigated in response to specific and interaction effects of irrigation water resource; Citrus spp / cvs and their combinations.

IV. I. IV. 1. Fruit retention and preharvest drop:

Periodical changes in fruit retention% along their development (June; August and October) as well as their preharvest drop in response to irrigation water resource; Citrus spp / cvs and their combinations were investigated.

Table(17): **Pollen grains viability of Balady lime and Valencia orange trees grown in El-Gabal Al-Asfar and Quesna as influenced by irrigation water resource (sewage & well) in the first and second regions, respectively during two consecutive 2001 - 02 & 2002 - 03 experimental seasons.**

Citrus spp/cvs / Water resource	Pollen grains germination %		
	Balady lime	Valencia orange	Mean*
2001- 02 season			
Sewage	10.41 b	12.89 b	11.65 B
Well	11.13 b	16.94 a	14.35 A
Mean**	**10.77 B**	**14.91 A**	
2002- 03 season			
Sewage	14.53 bc	12.53 c	**13.53 B**
Well	18.47 a	15.54 b	**17.00 A**
Mean**	**16.50 A**	**14.03 B**	

* and ** refer to specific effect of water resource and citurs spp / cvs, respectively. Values within each column or row followed by the same letter / s did'nt significantly differ at 5 % level, where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations, respectively.

Data obtained during both 2001-02 and 2002-03 experimental seasons are presented in **Table (18).**

A. Specific effect:

With regard to specific effect of irrigation water resource, **Table (18)** shows that fruit retention % was decreased by sewage effluent as compared to well water. Differences were more pronounced and reached significance level at both earlier dates of measuring i.e., June and August, while at the last date (October) difference didn't reach level of significance. Such trend was true during both experimental seasons.

As for the specific effect of Citrus spp / cvs , it was clear that the trend of response was not typically the same as the periodical readings of fruit retention %at June ;August and October were concerned. On the other hand, it could be detected that Valencia orange cv showed generally the least values of fruit retention % at 3 measuring dates. However, the differences were more pronounced and reached level of significance at both June and August especially as compared to the corresponding values of Balady lime and Washington navel orange during both 2001- 02 and 2002 - 03 experimental seasons.

In addition with regard to preharvest drop as influenced by irrigation water resource, **Table (18)** reveals that the trend of response took the other way around as compared to that previously detected with fruit retention%. Herein, sewage irrigated trees ehibited higher percentage of preharvest drop as compared to that of water irrigated trees. Differences were significant during 2nd seasons only.

Nevertheless, the response of preharvest drop to specific effect of Citrus spp / cv was not firm during both seasons. Whereas, Balady lime showed the highest value of preharvest drop during 1st season, while Washington navel orange ranked 1st during 2nd season from the statistical standpoint. However, it could be generally concluded the Valencia orange showed the least preharvest drop %, especially as compared to Balady lime and Washington navel orange during 1st and 2nd seasons, respectively.

B. Interaction effect:

With regard to the interaction effect of various combinations between two investigated factors i.e, irrigation water resource and Citrus spp / cvs on periodical fruit retention %, it is quite clear as shown from **Table (18)** that a considerable differences were detected from one side and reflected the specific effect of each factor from the other. Hence, the highest fruits retention % was always in concomitant to the well irrigated Balady lime trees at three measuring dates (June; August and October) from the statistical point of view during two experimental seasons. On the contrary, the least value of fruit retention percentage was generally in closed relationship to Valencia orange trees irrigated with sewage effluent at three measuring dates during two seasons. In addition, other combinations were in between the aforesaid two extremes with some tendency of variances between four members (combinations) of such intermediate category, especially as data of each measuring date were compared to the analogous ones of two other dates.

Referring, the preharvest drop %, **Table (18)** displays that the trend of response to interaction effect between two investigated factors (water resource & Citrus spp / cvs) was not firm during the two seasons of study. Anyhow, during 1st season the highest preharvest drop % was exhibited by the well water irrigated Balady lime trees. However, in 2nd season sewage irrigated Washington navel orange trees showed statistically the highest preharvest drop %. In other words, it could be concluded that both combinations of well water irrigated Balady lime trees and sewage effluent irrigated Washington navel trees exhibited generally the greatest preharvest drop % as an average of two seasons was concerned. On the contrary, the least preharvest drop % was generally related to Valencia orange trees regardless of irrigation water resource, especially either data of 2nd season or an average of two seasons were concerned. In addition, other combinations were in between.

The obtained result regarding the reduction in fruit retention and increase in preharvest drop exhibited by using sewage effluent for irrigation may be due to the phytotoxic effect of presence of some elements in the municipal wastewater (probably Zn and Ni), **Berti and Jacobs, (1996)**.

IV. I. IV. 2. Yield:

In this regard yield expressed as weight (Kg) and number of fruits per either an individual whole tree or one cubic meter of tree canopy volume in response to the irrigation

Table (18) Fruit retention and preharvest drop of fruitful citrus trees in response to specific and interaction effects of species / cultivar (Balady lime / B. L.; Valencia orange / V. O. and Washington navel orange / W. N. O.); irrigation water resource (sewage & well) and their combinations during two consecutive 2001 - 02 & 2002 - 03 experimental seasons.

Citrus spp /cvs / Water resource	Fruit retention (June) %				Fruit retention (August) %				Fruit retention (October) %				Preharvest drop *** %			
	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*
2001 - 02 season																
Sewage	6.90 b	2.96 d	4.87 c	**4.91 B**	1.83 bc	1.54 c	2.30 bc	**1.89 B**	1.19 ab	1.02 b	1.47 ab	**1.23 A**	0.64 bc	0.90 b	0.83 bc	**0.79 A**
well	9.64 a	4.57 c	5.30 bc	**6.50 A**	3.49 a	2.42 b	2.13 bc	**2.68 A**	1.86 a	1.52 ab	1.58 ab	**1.65 A**	1.63 a	0.52 c	0.52 c	**0.89 A**
Mean**	**8.27 A**	**3.77 C**	**5.09 B**		**2.66 A**	**1.98 B**	**2.22 AB**		**1.53 A**	**1.27 A**	**1.53 A**		**1.14 A**	**0.71 B**	**0.68 B**	
2002 - 03 season																
Sewage	4.22 bc	3.75 c	4.87 b	**4.28 B**	2.60 b	1.67 d	1.83 d	**2.03 B**	2.16 b	1.39 d	1.47 d	**1.67 A**	0.44 cd	0.27 d	1.36 a	**0.69 A**
well	6.77 a	3.71 c	5.90 a	**5.46 A**	3.32 a	1.80 d	2.38 c	**2.50 A**	2.53 a	1.44 d	1.74 c	**1.90 A**	0.69 b	0.36 d	0.58 bc	**0.25 B**
Mean**	**5.50 A**	**3.73 B**	**5.43 A**		**2.96 A**	**1.73 B**	**2.10 AB**		**2.35 A**	**1.42 B**	**1.60 B**		**0.57 AB**	**0.32 B**	**0.97 A**	

* and ** refer to specific effect of water resource and citurs spp / cvs, respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level, where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations,respectively.

*** Data recorded in October; December and March for B.L.; W. N.O. and V.O. respectively.

water resource used (sewage effluent and well water) were investigated. Data obtained during both 2001 - 02 and 2002 - 03 experimental seasons are presented in **Table (19).**

With regard to the yield per the whole individual tree, data obtained during both seasons exhibited that two opposite trends were detected. Herein, with Balady lime cv yield per tree expressed either as weight in Kg or number of fruits, was increased significantly by sewage effluent as compared to the well water irrigated trees. Meanwhile, the trend took the other way around with two orange cultivars, where well water irrigated trees of Valencia and Washington navel orange cultivars produced significantly higher yield per tree rather than the analogous ones irrigated with sewage effluent,(regardless of yield per tree was expressed as either weight or number of harvested fruits). Both trends were true during two 2001 - 02 and 2002 - 03 experimental seasons for three Citrus spp / cvs under study.

Nevertheless, as yield was estimated either as weight or number of harvested fruits per one cubic meter of tree canopy volume, **Table (19)** shows that three Citrus spp / cvs followed the same trend. Hence, the well water irrigated trees of three citrus cultivars under study surpassed statistically the analogous ones of sewage irrigated trees in this concern. Such trend was true during both experimental seasons.

These results regarding the reduction in yield exhibited by sewage effluent comparing to well water especially when cropping was estimated per either cubic meter of tree canopy for three Citrus spp / cvs or per the whole tree for both orange cultivars (regardless of yield was expressed as weight or number of harvested fruits) may be attributed to the presence of specific constituents in sewage water effluent as shown from **Table (4)**. Moreover, the increase of yield per tree of Valencia and Washington navel orange cvs exhibited by using well water for irrigation may be mainly due to the paralleled change in leafy inflorescence % from one hand, and not dependent upon the total number of inflorescences from the other as has been discussed previously in flowering measurements.

However, the unique exception in this regard i.e, the increase in yield of Balady lime trees irrigated with swage effluent when it was estimated as Kg & N° of harvested fruits per the whole tree which may be explained by the obvious increase exhibited by using sewage for irrigation in tree canopy volume of Balady lime cv rather than in those of two orange cultivars. So the conflict between yield per either the whole tree of Balady lime per one cubic meter of its canopy volume could be logically discussed on the fact that sewage irrigated Balady lime trees had a huge canopy size from one hand associated with the absent effect of irrigation water resource on its inflorescence type from the other.

IV. I. IV. 3. Fruit quality:

IV. I. IV. 3. 1. Fruit physical properties:

In this regard average fruit weight (g); peel / rind thickness (mm.); fruit shape index (polar diameter / height: equatorial diameter / width) and fruit juice % (by weight) were the four fruit physical properties investigated in response to water resource; Citrus spp / cvs and their combinations. Data

Table (19) Yield of (Balady lime / B. L.; Valencia orange / V. O. and Washington navel orange / W. N. O.) trees grown in El-Gabal Al-Asfar and Quesna as influenced by irrigation water resource (sewage and well water) in the 1st and 2nd region, respectively during two consecutive 2001 - 02 & 2002 - 03 experimental seasons.

Citrus spp / cvs \ Water resource	yield expressed as: Kg / tree			Number of fruits / per tree			Kg / m^3 canopy volume			No. of fruits per (m^3) of canopy		
	B. L.	V. O.	W.N. O.	B. L.	V. O.	W.N. O.	B. L.	V. O.	W.N. O.	B. L.	V. O.	W.N. O.
2001 - 02 season												
'Sewage*	91.9 a	14.2 b	23.3 b	2800 a	88 b	114 a	0.85 b	0.30 b	0.29 b	25.79 b	1.97 b	1.41 b
'Well**	68.2 b	26.5 a	24.9 a	2140 b	136 a	116 a	1.71 a	1.11 a	0.72 a	53.36 a	5.140 a	3.37 a
2002 / 2003 seaon												
'Sewage*	94.2 a	16.4 b	25.3 b	2700 a	108 b	119 b	0.70 b	0.30 b	0.30 b	20.42 b	2.00 b	1.32 b
'Well**	66.0 b	25.3 a	49.8 a	2240 b	180 a	215 a	1.44 a	0.86 a	1.34 a	48.16 a	6.00 a	5.78 a

* and ** refer to (El-Gabal Al-Asfar) and (Quesna) regions irrigated with sewag and well water, respectively. Means within the same column followed by the same letter / s for a given character during each season were not significantly differ at 5 % level.

obtained during both 2001 - 02 and 2002 - 03 experimental seasons are presented in **Table (20).**

Average fruit weight:

A. Specific effect:

With regard to specific effect of water resource, **Table (20)** shows that well water irrigated trees induced significantly heavier fruit than those of sewage irrigated ones as average weight per each was concerned during both seasons of study. However, as the specific effect of fruit spp / cvs was concerned, it was quite evident that Washington navel orange had significantly the heaviest fruit, descendingly followed by Valencia orange and Balady lime.

B.Interaction effect:

The heaviest fruits in their average weight per each was always in significant concomitant to well water irrigated trees of Washington navel orange followed statistically in descending order by those of sewage irrigated trees of Washington navel orange; well water irrigated trees of Valencia orange; Valencia orange trees irrigated with sewage effluent and Balady lime fruits of either sewage or well water irrigated trees. Difference, were significant during both seasons.

The increase in average fruit weight associated with increasing yield may be due to either the desired balance of nutrients elements ratio or presence of an element or elements at higher level than the permissible rate. So further study is needed to throw some light about the real reason / s in this concern.

Fruit rind / peel thickness:

Tabulated data in **Table (20)** pointed out that differences in fruit peel thickness due to specific effect of irrigation water resource were to slight to reach level of significance during both seasons of study. However, as specific effect of Citrus spp / cvs was concerned differences were more pronounced. Whereas, the thickest peel was significantly in closed relationship to Washington navel orange followed in descending order by Valencia orange and Balady lime which ranked statistically the inferior.

B. Interaction effect:

Table (20) reveals that the more pronounced effect of Citrus spp / cv from one hand and the approximately absence of response to water irrigation water resource from the other on fruit rind thickness both were reflected on the interaction effect of their combinations. Herein, the thickest peel was always in concomitant to Washington navel orange (regardless of irrigation water resource), descendingly followed by Valencia orange and Balady lime. Such trend was true during both seasons and differences were significant, irrespective of the water resource used.

Fruit shape index (polar: equatorial dimensions):

A. Specific effect:

Data presented in **Table (20)** showed clearly that no obvious response to specific effect of irrigation water resource was detected regarding the fruit shape index. Since, variance in fruit shape index was too few to be taken into consideration during both seasons of study. Meanwhile, the trend of response to specific effect of Citrus spp / cvs showed relatively an obvious tendency that Baldy lime fruit had moderately oblonged shape fruits as compared to those of both orange cultivars which tended to be approximately round. Differences in fruit shape values were significant; especially as Baldy lime fruits were compared to the Valencia orange fruits during or both seasons of study.

A. Interaction effect:

Table (20) shows that Balady lime fruits had oblonged shape while both orange cultivars (Valencia & Washington navel orange) produced rounded fruits, irrespective of water resource.

Fruit juice percentage (by weight):

A. Specific effect:

It is quite evident that the fruit juice % didn't significantly respond to water resource. Since, variance was not so enough to be taken into consideration from the statistical point of view. On the other hand the response to Citrus spp / cvs was more pronounced, where Valencia orange cultivar had significantly the most juicy fruits followed in descending order by Balady lime and Washington navel orange fruits. Differences between three Citrus cultivars were significant as compared each other during two seasons of study except with comparing Balady lime with Washington navel orange during 1st season, where both were statistically similar.

B. Interaction effect:

Table (20) reveals that fruits of Valencia orange trees irrigated with sewage effluent were statistically the juiciest ones, followed by those of the same orange cultivar irrigated with well water which ranked statistically 2nd during both seasons of study. On the contrary, the least fruit juice % was usually in closed relationship to Washington navel orange irrespective of irrigation water resource. In addition, other combinations i.e, Balady lime trees irrigated with either sewage effluent or well water were in between the aforesaid two extremes. Differences were significant as combinations of each category were compared to members of two other categories.

The present result regarding the response of fruit peel thickness to water resource is in agreement with finding of Maurer et al., (1995-a) on grapefruit who found that no difference was detected. However the response of fruit rind to Citrus spp /cv may be attributed the inheritable characteristics of each species or cultivar itself. Moreover, the conflict in the present trend regarding the effect of irrigation water resource on average fruit weight from one hand and detected trend exhibited by several investigators [**Omran, (1988); Koo and Zekri, (1989); Zekri and Koo, (1990) and Zekri and Koo, (1994)**] may be attributed to the increased (crowdness) of tree canopy and consequently its efficiency per each unit assimilation leaves area. In addition the result of both fruit shape index and fruit juice percentage to irrigation water resource may be attributed the paralleled response of both fruit dimension from one hand, and the own inheritable characteristics of each citrus cultivar regarding the second measure (juice stat) from the others.

Table (20): Fruit physical properties of fruitful citrus trees in response to specific and interaction effects of species / cultivar (Balady lime / B. L.; Valencia orange / V. O. and Washington navel orange / W. N. O.); irrigation water resource (sewage & well) and their combinations during two consecutive 2001 - 02 & 2002 - 03 experimental seasons.

Water resource \ Citrus spp/cvs	Fruit weight (g)				Peel thickness (mm)				Fruit Shape index				Juice percentage by weight			
	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*
2001 - 02 season																
Sewage	33.0 d	165.0 c	205.0 b	**134.3 B**	2.03 c	4.17 b	4.69 a	**3.60 A**	1.10 a	1.00 b	1.05 b	**1.02 A**	45.5 c	53.0 a	42.0 cd	**46.8 A**
well	32.0 d	192.0 b	219.0 a	**147.6 A**	2.20 c	4.30 b	4.80 a	**3.77 A**	1.10 a	1.00 b	1.05 b	**1.05 A**	44.7 c	49.5 b	41.0 d	**45.1 A**
Mean**	**32.0 C**	**178.5 B**	**212.0 A**		**2.10 B**	**4.23 A**	**4.75 A**		**1.10 AB**	**1.00 C**	**1.05 BC**		**45.3 B**	**51.3 A**	**41.5 B**	
2002 - 03 season																
Sewage	34.9 d	151.0 c	194.2 b	**126.7 A**	1.8 c	3.6 b	4.7 a	**3.4 A**	1.1 a	1.0 b	1.0 b	**1.0 A**	46.4 c	55.8 a	40.6 d	**47.6 A**
well	29.5 d	170.0 c	233.0 a	**144.2 A**	1.8 c	3.9 b	4.8 a	**3.5 A**	1.1 a	1.0 b	1.0 b	**1.0 A**	42.0 d	52.6 b	39.5 d	**44.7 A**
Mean**	**32.2 C**	**160.5 B**	**213.6 A**		**1.8 C**	**3.8 B**	**4.8 A**		**1.1 A**	**1.0 B**	**1.0 B**		**44.2 B**	**54.2 A**	**40.0 C**	

* and ** refer to specific effect of water resource and citurs spp / cvs, respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level , where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations,respectively.

IV. I. IV. 3. 2. Fruit chemical properties:

In this regard fruit juice total soluble solids percentage (TSS); total acidity; TSS / acid ratio and vitamin C (ascorbic acid) contents in response to specific and interaction effects of water resource; Citrus spp / cvs and their combinations were the investigated fruit chemical properties. Data obtained during both seasons are presented in **Table (21).**

Fruit total soluble solids (TSS) %:

A. Specific effect:

Referring the specific effect of irrigation water resource, it is quite evident as shown from tabulated data in **Table (21)** that well water increased significantly fruit juice TSS % as compared to sewage water effluent during both experimental seasons.

As for the specific effect of Citrus spp / cvs, **Table (21)** displays obviously that Valencia orange fruits had significantly the highest TSS % followed statistically in a descending order by Washington navel orange and Balady lime. Differences between three citrus cultivars were significant as compared each other during two seasons.

B. Interaction effect:

Table (21) displays that specific effect of each investigated factor (water resource and Citrus spp / cvs) was reflected directly on their combinations. Herein, Valencia orange fruits of well water irrigated trees had significantly the richest juice TSS % during two seasons of study. On the contrary, Balady lime fruits produced by sewage irrigated trees were statistically the inferior as their juice TSS % was concerned. In addition, other combinations were in between the aforesaid two extremes with an obvious tendency indicated that Valencia orange fruits of sewage irrigated trees were statistically the richest member in such intermediate category.

Fruit juice total acidity:

A. Specific effect:

Concerning the fruit juice total acidity % in relation to specific effects of irrigation water resource, it is quite clear that sewage effluent decreased it significantly during both seasons.

Nevertheless, the response to specific effect of Citrus spp / cvs was more pronounced where Balady lime fruits had statistically the richest juice acidity content i.e, 6.79 and 6.83 % during 1st and 2nd seasons, respectively. On the contrary, Washington navel orange had statistically the least juice acidity i.e, 0.76 and 0.82 % during 1st and 2nd seasons, respectively. Moreover, Valencia orange cv was intermediate (about1.20 %).

B. Interaction effect:

Table (21) reveals obviously that specific effect of each investigated factor was reflected directly on its own combinations. Herein, well water irrigated trees of Balady lime had statistically the richest fruits in their juice acidity content, followed statistically by Balady lime trees irrigated with sewage effluent. On the contrary Washington navel orange fruits of sewage irrigated trees were statistically the inferior (the poorest in their juice acidity). In addition, other combinations were in between with a noticeable tendency pointed out that Washington navel orange trees irrigated with well water was significantly the poorest member of this intermediate category. Such trend was true during both seasons of study.

Fruit juice TSS / Acid ratio:

A. Specific effect :

With regard to specific effect of water resource, **Table (21)** displays that TSS / acid ratio was decreased significantly by well water. On the other hand, the trend of response to specific effect of Citrus spp / cvs exhibited that Washington navel orange fruit had the greatest TSS / acid ratio significantly followed in a descending order by Valencia orange and Balady lime which ranked statistically last. Such trend of response was true during both seasons and it could be logically explained on that fact of the highest total acidity of Baldy lime associated with lowest TSS value of its fruit juice from one hand corresponding to the opposite values of both total acidity and TSS % in Washington navel orange cv.

B. Interaction effect:

Table (21) shows that fruit juice TSS / acid ratio of sewage irrigated Washington navel orange trees had significantly the highest value. However, Balady lime fruits irrespective of water resource used for irrigation were statistically the inferior. In addition, Valencia orange fruits were intermediate, regardless of water resource. The absence of significance between pair combinations of each Citrus spp / cvs when compared each other, especially of Balady lime and Valencia orange reflect the unparalleled rate of response for both components (TSS & acidity) to any of investigated factor. In other words, differences between fruit juice TSS / acid ratio of two Balady lime combinations (well water irrigated trees or sewage effluent irrigated ones) and also those of Valencia orange (regardless of water resource) could be mainly attributed to the unparalleled rates of response in two chemical constituents to specific effect of water resource as both combinations of each Citrus spp / cvs (B. L. & V. O.) were separately compared each other.

Fruit juice ascorbic acid (Vitamin C) content:

A. Specific effect:

Data in **Table (21)** displays that fruit juice Vitamin C "ascorbic acid" content responds specifically to irrigation water resource. Hence, well water irrigated trees induced fruits had significantly higher ascorbic acid level as compared to those of sewage effluent irrigated trees during both seasons of study. On the other hand, fruits of both orange cultivars not only had significantly richer juice than Balady lime fruits but also were the same from statistical point of view as their vitamin C content was compared during the two seasons of study regarding the response to specific effect of Citrus spp / cvs .

B. Interaction effect:

Table (21) reveals that well water irrigated trees of both orange cultivars (Valencia and Washington navel) induced fruits with the richest juice Vitamin C content from statistical point of view during both seasons.

On the contrary, Baldy lime fruits especially those of sewage effluent irrigated trees were the poorest in their Vitamin C content. In addition, other combinations were in between the aforesaid two extremes.

Our data regarding the influence of sewage effluent are in agreement with the findings of **Koo and Zekri, (1985)** on orange and **Davies and Maurer, (1993)** on some Citrus spp, who demonstrated that the municipal wastewater decreased both fruit juice TSS and acidity. Moreover the reduction exhibited in fruit juice TSS; acidity and TSS / acid ratio due to irrigation with sewage effluent is supported by **Zekri and Koo, (1993)** and **Koo and Zekri, (1994)** on some sweet orange cultivars.

IV. I. IV. 4. Fruit peel and pulp mineral composition:

In this regard fruit peel and pulp N; P; K; Mg; Fe; Mn; Zn; Cu; Na; Pb and Ni contents in response to specific and interaction effects of irrigation water resource; Citrus spp / cv and their combinations were investigated. Data obtained during both experimental seasons of 2001 - 02 and 2002 - 03 are presented in **Tables (22); (23); (24); (25); (26) and (27).**

Fruit peel and pulp nitrogen content:

A. Specific effect:

With regard to specific of irrigation water resource on fruit peel and pulp N%, **Tables (22) and (23)** display that

Table (21): Fruit chemical properties of fruitful citrus trees in response to specific and interaction effects of species / cultivar (Balady lime / B. L; Valencia orange / V. O. and Washington navel orange / W. N. O.); irrigation water resource (sewage & well) and their combinations during two consecutive 2001 - 02 & 2002 - 03 experimental seasons.

Citrus spp/cvs / Water resource	TSS				Acidity				TSS \ Acid ratio				Ascorbic acid mg /100 ml			
	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*
2001 - 02 season																
Sewage	7.40 d	11.00 b	10.00 c	**9.45 B**	6.05 b	1.16 c	0.63 e	**2.61 B**	1.22 d	9.50 c	15.85 a	**8.86 A**	22.00 f	37.20 c	32.50 d	**30.60 B**
well	9.00 c	12.10 a	10.10 c	**10.40 A**	7.53 a	1.29 c	0.89 d	**3.24 A**	1.20 d	9.40 c	11.34 b	**7.31 B**	28.80 e	42.20 b	48.30 a	**39.80 A**
Mean**	**8.20 C**	**11.55 A**	**10.05 B**		**6.79 A**	**1.22 B**	**0.76 C**		**1.21 C**	**9.45 B**	**13.95 A**		**25.40 B**	**36.70 A**	**40.40 A**	
2002 - 03 season																
Sewage	7.80 e	10.70 bc	10.50 c	**9.67 B**	6.46 b	1.15 d	0.71 f	**2.77 B**	1.21 d	9.30 c	14.80 a	**8.43 A**	19.00 e	33.60 c	35.40 b	**29.30 B**
well	9.30 d	12.60 a	10.80 b	**10.90 A**	7.19 a	1.30 c	0.94 e	**3.14 A**	1.29 d	9.71 c	11.49 b	**7.49 A**	23.80 d	42.70 a	41.30 a	**35.93 A**
Mean**	**8.55 C**	**11.65 A**	**10.65 B**		**6.83 A**	**1.23 B**	**0.82 C**		**1.25 C**	**9.50 B**	**13.15 A**		**21.40 C**	**38.20 A**	**38.35 A**	

* and ** refer to specific effect of water resource and citurs spp / cvs, respectively. Values within each column or row followed by the same letter / s did'nt significantly differ at 5 % level , where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations,respectively.

sewage effluent increased significantly N content as compared to well water during both experimental seasons.

As for the specific effect of Citrus spp / cv, data obtained exhibited that Balady lime was statistically the richest as N% of its fruit peel and pulp was concerned. However, two sweet orange cultivars i.e, Valencia and Washington navel were to great extent similar from statistical standpoint, except in 1st season (2001 - 02) where Valencia had richer peel but Washington navel was richer as fruit pulp was concerned.

B. Interaction effect:

Tables (22) and **(23)** show that sewage effluent irrigated trees of Balady lime had statistically the richest fruits in their rind and pulp N %. On the contrary, the poorest fruits in their peel and pulp N contents were always in concomitant to those of well water irrigated Washington navel orange trees. In addition, other combinations were in between with a noticeable tendency pointed out that sewage irrigated trees of Washington navel orange induced fruits had relatively higher peel and pulp N%.

The obtained results regarding the higher peel and pulp N% in fruits of sewage irrigated trees rather than the analogous ones of well water irrigated trees may be attributed to the relative higher N content in sewage effluent than in well water as shown from **Table (4).**

Fruit peel and pulp phosphorus contents:

A. Specific effect:

It is quite evident that the responses of fruit peel and pulp P % to the specific effect of two investigated factors (water resource & Citrus spp / cvs) followed to great extent the same trends previously detected with nitrogen content. Herein, sewage irrigated trees exceeded statistically the well water irrigated ones. Moreover, Balady lime was richer and Washington navel orange was the poorest in this concern. However, differences between three Citrus spp / cvs were relatively less pronounced, especially Balady lime and Valencia orange which didn't significantly differ when compared each other regarding their fruit peel and pulp P % during two seasons of study.

B. Interaction effect:

Concerning the interaction effect of different combinations between two investigated factors on fruit peel and pulp P %, **Tables (22) and (23)** show that differences were relatively light, especially in fruit pulp. However, it could be noticed that sewage irrigated trees of Balady lime and to great extent Valencia orange induced fruits had statistically the highest peel and pulp P level, while the reverse was found with well water irrigated Washington navel orange trees which showed the least P level in their fruit peel and pulp. In addition, other combinations were in between the aforesaid two extremes.

These results could be logically explained depending upon the higher P level of sewage effluent from one hand and the superiority of Balady lime and Valencia orange over Washington navel orange regarding their potentiality for P absorption from the other.

Besides, the increase in P pulp due to using sewage effluent is in partial agreement with **Meheriuk and Neilsen, (1991)** on apples.

Fruit peel and pulp potassium content:

A. Specific effect:

Data obtained during both seasons as shown from **Tables (22) and (23)** declared that the response followed typically the same trend previously found with N and P % regarding the specific effect of irrigation water resource. Herein, the sewage effluent increased significantly both peel and pulp K %. However, with the specific effect of Citrus spp / cvs the trend was generally the same which declared the superiority of both Balady lime and Valencia orange corresponded to the inferiority of Washington navel orange.

B. Interaction effect:

Referring the interaction effect, tabulated data in **Tables (22) and (23)** reveal that sewage irrigated trees of both Balady lime and Valencia orange produced fruits had statistically the highest peel and pulp K contents, especially as an average of two seasons was concerned. The reverse was true with Washington navel orange trees irrigated with well water, where the least fruit peel and pulp K % was found. In addition, other combinations were in between the aforesaid two extremes.

These results could be logically discussed on the fact that sewage effluent contained obviously higher K than well water as shown in **Table (4)**.

Moreover, finding of **Meheriuk and Neilsen, (1991)** on apple cv McIntoch gives support to our result regarding the increase if fruit K content exhibited by using municipal wastewater for irrigation

Fruit peel and pulp magnesium content:

A. Specific effect:

However, the trends of response to specific effect of two investigated factors were not so firm as those previously discussed with N; P; and K %, but it could be generally noticed that sewage effluent increased Mg level in most cases. Moreover, Washington navel orange fruits were the inferior regarding their peel and pulp Mg content.

B. Interaction effect:

Generally, it could be safely concluded that Balady lime fruits of sewage irrigated trees had significantly the richest peel and pulp Mg %. On the contrary, well water irrigated trees of Washington navel orange induced fruits of the least peel and pulp Mg %. In addition, other combinations were in between with a noticeable tendency of variance between members of such intermediate category which reflected the uncoincident trends of response for both fruit peel and pulp even to the same combination not only from one season to another but also as Mg content of either fruit peel or fruit pulp were concerned.

Table (22): Fruit peel N; P; K and Mg content of fruitful citrus trees in response to specific and interaction effects of species / cultivar (Balady lime / B. L.; Valencia orange / V. O. and Washington navel orange / W. N. O.); irrigation water resource (sewage & well) and their combinations during two consecutive 2001 - 02 & 2002 - 03 experimental seasons.

Citrus spp / cvs / Water resource	N %				P %				K %				Mg %			
	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*
2001 - 02 season																
Sewage	2.56 a	1.65 c	2.08 b	**2.10 A**	0.112 a.	0.098 ab	0.088 bc	**0.099 A**	0.890 a	0.820 b	0.780 c	**0.83 A**	0.263 a	0.247 b	0.181 c	**0.230 A**
well	1.52 d	1.40 e	1.53 d	**1.48 B**	0.070 cd	0.083 bcd	0.065 d	**0.073 B**	0.700 d	0.680 d	0.570 e	**0.65 B**	0.152 d	0.128 e	0.050 f	**0.110 B**
Mean**	**2.04 A**	**1.53 C**	**1.81 B**		**0.091 A**	**0.091 ·A**	**0.077 B**		**0.795 A**	**0.750 A**	**0.675 B**		**0.208 A**	**0.188 A**	**0.115 B**	
2002 - 03 season																
Sewage	2.27 a	1.77 c	2.06 b	**2.03 A**	0.135 a	0.112 b	0.082 c	**0.110 A**	0.930 a	0.940 a	0.890 b	**0.92 A**	0.264 a	0.220 d	0.169 e	**0.218 A**
well	1.48 e	1.62 d	1.44 e	**1.51 B**	0.063 de	0.069 cd	0.048 e	**0.060 B**	0.730 c	0.610 d	0.640 d	**0.66 B**	0.252 b	0.230 c	0.156 f	**0.213 A**
Mean**	**1.88 A**	**1.70 B**	**1.75 B**		**0.099 A**	**0.091 A**	**0.065 B**		**0.830 A**	**0.775 AB**	**0.765 B**		**0.258 A**	**0.225 B**	**0.163 C**	

* and ** refer to specific effect of water resource and citurs spp / cvs, respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level , where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations, respectively.

Table (23): Fruit pulp N; P; K and Mg content of fruitful citrus trees in response to specific and interaction effects of species / cultivar (Balady lime / B. L.; Valencia orange / V. O. and Washington navel orange / W. N. O.); irrigation water resource (sewage & well) and their combinations during two consecutive2001 - 02 & 2002 - 03 experimental seasons.

Water resource \ Citrus spp / cvs	N %				P %				K %				Mg %			
	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*
2001 - 02 season																
Sewage	1.37 ab	1.38 ab	1.31 a	**1.35 A**	0.076 a	0.076 a	0.072 ab	**0.075 A**	0.881 a	0.860 a	0.720 b	**0.820 A**	0.237 a	0.177 b	0.059 d	**0.121 A**
well	1.07 c	1.05 c	0.96 c	**1.03 B**	0.065 ab	0.065 ab	0.055 b	**0.062 A**	0.574 d	0.652 c	0.503 e	**0.576 B**	0.126 c	0.043 e	0.036 f	**0.068 B**
Mean**	**1.22 A**	**1.22 A**	**1.14 B**		**0.071 A**	**0.071 A**	**0.064 A**		**0.728 A**	**0.756 A**	**0.612 B**		**0.182 A**	**0.110 B**	**0.048 C**	
2002 - 03 season																
Sewage	1.58 a	1.39 b	1.41 b	**1.46 A**	0.074 ab	0.081 a	0.059 bc	**0.071 A**	0.822 b	0.869 a	0.790 c	**0.827 A**	0.210 a	0.120 d	0.139 b	**0.156 A**
well	1.10 c	1.12 c	1.02 d	**1.08 B**	0.053 cd	0.057 bc	0.038 d	**0.049 B**	0.638 d	0.776 c	0.576 e	**0.663 B**	0.125 c	0.120 d	0.104 e	**0.116 B**
Mean**	**1.34 A**	**1.26 B**	**1.22 B**		**0.064 A**	**0.069 A**	**0.049 B**		**0.730 A**	**0.823 A**	**0.683 B**		**0.168 A**	**0.120 B**	**0.121 B**	

* and ** refer to specific effect of water resource and citurs spp / cvs, respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level, where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations, respectively.

Theses results may be attributed to the less pronounced differences in Mg content of both irrigation with water resource. In addition, the increase in fruit peel and pulp Mg content resulted by irrigation with sewage goes in line of **Meheriuk and Nielsen, (1991)** on McItntoch apple cv.

Fruit peel and pulp iron content:

A. Specific effect:

With regard to specific effect of irrigation water resource, **Tables (24) and (25)** show that sewage effluent increased significantly Fe content in both peel and pulp of different Citrus spp / cv under study. However, the trend of response to Citrus spp / cvs indicated that Valencia orange had statistically the highest fruit peel and pulp Fe content, while both Balady lime and Washington navel orange were to great extent the same as their fruit peel and pulp Fe content were concerned in most cases during both seasons of study.

B. Interaction effect:

Data obtained during both seasons revealed obviously that the highest fruit peel and pulp Fe content was significantly always in concomitant to such combination represented the sewage effluent irrigated trees of Valencia orange. On the contrary, the least fruit peel and pulp Fe content was markedly in closed relationship to Washington navel orange trees irrigated with well water, The inferiority of such combination was significant during both seasons for both fruit peel and pulp with the unique exception that peel of Balady lime fruits was statistically the poorest in its Fe content under irrigation with sewage effluent in the 1st 2001- 02experimental season. In addition other combination were in between.

Fruit peel and pulp manganese content:

A. Specific effect:

Referring the specific effect of water resource on fruit peel and pulp Mn content, data obtained during both seasons as shown in **Tables (24) and (25)** indicate that the variance in most cases was too slight to reach level of significance. Such trend was true during both seasons for fruit pulp, but in 2nd season only for fruit peel. However, in 1st season fruit peel Mn content increased significantly by sewage effluent.

As for the specific effect of Citrus spp / cvs, it could be noticed that Washington navel orange had statistically the richest fruit peel Mn content, while the reverse was tree for Valencia orange especially in 2nd season. On the other hand, the response of fruit pulp Mn content to specific effect of Citrus spp / cv followed the same trend of fruit peel pertaining the inferiority of Valencia orange and superiority of Washington navel orange. However, difference between Baldy lime and Washington navel orange didn't reach level of significance during both seasons of study.

B. Interaction effect:

Nevertheless, the trend of response to interaction effect of two investigated factors was not so firm for Mn content of both fruit rind and pulp. However, it could be generally concluded that fruit rind of Washington navel orange trees irrigated with sewage effluent was statistically the richest in this concern. On the other hand the richest fruit pulp in its Mn content was in closed relationship to sewage irrigated Balady lime trees, especially as an average of two seasons was concerned. In addition, other combinations didi,nt follow specific firm trend during both seasons.

Fruit peel and pulp zinc content:

A. Specific effect:

Concerning the specific effect of irrigation water resource, tabulated data in **Tables (24)** and **(25)** declared that sewage irrigated trees had statistically the richest fruits in their peel and pulp Zn contents as compared to those of well water irrigated ones.

As for the specific effect of Citrus spp / cvs, it is quite clear to be noticed that Balady lime fruits were statistically the richest as their fruit peel and pulp Zn contents were concerned during both seasons. However, the two orange cultivars were nearly the same, especially during 2^{nd} season or as an average of two seasons were concerned.

B. Interaction effect:

Data obtained during both seasons displayed that Balady lime trees irrigated with sewage effluent induced statistically the richest fruits in their peel and pulp Zn content. On the contrary, well water irrigated trees of both orange cultivars induced in most cases fruits with the least Zn level in their peels and pulps during both seasons. Other combinations were in between the aforesaid two extremes.

Fruit peel and pulp copper content:

A. Specific effect:

With regard to specific effect of water resource, it is quite evident as shown from **Tables (24) and (25)** that irrigation with sewage effluent increased significantly fruit peel and pulp Cu content. Meanwhile, the response to specific effect of Citrus spp / cvs exhibited that fruit peel and pulp of Balady lime were the richest in their Cu content. While the reverse was true with Valencia orange. Differences between three Citrus spp / cvs were significant as they were compared each other during two seasons, except when peel Cu content of Valencia and Washington navel orange fruits were compared during 1st season, where difference didn't reach level of significance.

B. Interaction effect:

Referring the response to interaction effect of various combinations between two investigated factors (water resource and Citrus spp / cvs), tabulated data in **Tables (24) and (25)** revealed that fruit peel and pulp of Balady lime trees irrigated with sewage effluent were statistically the richest in their Cu content. On the contrary, the least Cu level was usually in concomitant to fruit peel and pulp of Valencia orange trees supplied with well water during two seasons of study. In addition, other combinations were in between.

The increase in fruit peel and pulp Cu content of sewage irrigated trees as observed from the present study is in agreement with finding of **Hamad, (1993)** on some vegetable crops, who pointed out that higher accumulation of Cu in fruits of irrigated plants with sewage may constitute a real problem.

Table (24): Fruit peel Fe; Mn; Zn and Cu content of fruitful citrus trees in response to specific and interaction effects of species / cultivar (Balady lime / B. L.; Valencia orange / V. O. and Washington navel orange / W. N. O.); irrigation water resource (sewage & well) and their combinations during two consecutive 2001 - 02 & 2002 - 03 experimental seasons.

Water resource \ Citrus spp/cvs	Fe ppm				Mn ppm				Zn ppm				Cu ppm			
	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*	B. L.	V. O.	W.N.O.	Mean*
2001 - 02 season																
Sewage	53.3 d	109.6 a	82.8 b	**81.9 A**	14.30 b	13.30 c	20.30 a	**15.97 A**	45.0 a	41.5 b	38.5 c	**41.7 A**	25.61 a	18.86 c	23.14 b	**22.54 A**
well	47.5 e	76.4 c	37.2 f	**53.7 B**	10.80 f	12.00 d	11.70 e	**11.50 B**	42.5 b	38.0 c	35.0 d	**38.5 B**	13.95 d	8.15 e	13.26 d	**11.79 B**
Mean**	**50.4 C**	**93.0 A**	**60.0 B**		**12.55 B**	**12.65 B**	**16.00 A**		**43.8 A**	**39.9 B**	**36.8 c**		**19.78 A**	**13.51 C**	**18.20 B**	
2002 - 03 season																
Sewage	105.8 b	129.8 a	82.1 c	**105.9 A**	8.89 b	7.14 d	11.63 a	**9.22 A**	38.0 a	33.0 b	33.5 b	**34.8 A**	17.86 a	12.97 b	13.11 b	**14.65 A**
well	52.2 f	64.8 d	57.8 e	**58.3 B**	9.12 b	7.47 c	9.10 b	**8.56 A**	33.0 b	27.0 c	28.0 c	**29.3 B**	10.56 cd	9.96 d	9.66 d	**10.06 B**
Mean**	**79.0 B**	**97.3 A**	**70.0 B**		**9.00 B**	**7.30 C**	**10.37 A**		**35.5 A**	**30.0 B**	**30.8 B**		**14.21 A**	**11.47 B**	**11.39 B**	

* and ** refer to specific effect of water resource and citurs spp / cvs, respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level, where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations, respectively.

Table (25): **Fruit pulp Fe; Mn; Zn and Cu content of fruitful citrus trees in response to specific and interaction effects of species/ cultivar (Balady lime/B. L; Valencia orange/V. O. and Washington navel orange/W. N. O.); irrigation water resource (sewage & well) and their combinations during two consecutive 2001-02 & 2002-03 experimental seasons.**

Citrus spp/cvs / Water resource	Fe ppm				Mn ppm				Zn ppm				Cu ppm			
	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*
2001-02 season																
Sewage	31.0 d	59.0 a	39.0 c	**43.0 A**	12.00 a	8.00 d	11.00 b	**10.30 A**	48.0 a	35.5 c	39.5 b	**41.0 A**	15.35 a	9.21 c	12.48 b	**12.35 A**
well	30.0 d	44.0 b	21.0 e	**31.7 B**	10.00 c	8.00 d	11.00 b	**9.66 A**	39.0 b	33.0 d	35.0 cd	**35.8 B**	6.68 d	6.47 d	8.76 c	**7.30 B**
Mean**	**30.5 B**	**51.5 A**	**30.0 B**		**11.00 A**	**8.00 B**	**11.00 A**		**43.5 A**	**34.3 B**	**37.3 B**		**11.02 A**	**7.84 C**	**10.62 B**	
2002-03 season																
Sewage	52.0 d	82.0 a	60.0 b	**64.7 A**	8.00 a	6.00 b	8.00 a	**7.33 A**	47.0 a	31.5 b	33.0 b	**37.2 A**	11.96 a	9.93 b	9.76 b	**10.55 A**
well	55.0 c	52.0 d	46.0 e	**51.0 B**	8.00 a	6.00 b	7.00 ab	**7.00 A**	27.0 cd	26.0 d	28.5 c	**27.2 B**	7.59 c	6.13 d	7.45 c	**7.06 B**
Mean**	**53.5 B**	**67.0 A**	**53.0 B**		**8.00 A**	**6.00 B**	**7.50 A**		**37.0 A**	**28.8 B**	**30.8 B**		**9.78 A**	**8.03 C**	**8.59 B**	

* and ** refer to specific effect of water resource and citurs spp/cvs, respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level, where capital and small letters were used for distinguishing berween means of specific and interaction effects of investigated factors and their combinations, respectively.

Fruit Peel and pulp sodium content:

A. Specific effect:

Fruit peel and pulp Na content respond significantly to the irrigation water resource. Herein, **Tables (26) and (27)** show that sewage irrigated trees had richest fruits in their peel and pulp Na content. Differences were significant as compared to the analogous ones of well water irrigated trees during both 2001- 02 and 2002 - 03 seasons.

Nevertheless, the specific effect of Citrus spp/cvs indicated that Balady lime was the richest, while Washington navel orange had the least fruit peel and pulp Na content. Differences were significant, especially as both Balady lime and Washington navel orange were compared each other during two seasons of study. Valencia orange was intermediate, however it didn't significantly when its peel and pulp Na contents were compared to those of Balady lime during two seasons and Washington navel orange during 2nd season only, respectively.

B. Interaction effect:

Tables (26) and (27) show that fruit peel and pulp of sewage irrigated trees for both Balady lime and Valencia orange had statistically the highest Na level. However, both the superior combination didn't significantly differ as their fruit peel Na content was compared during two seasons, but with their pulp Na content Balady lime surpassed statistically Valencia orange during both seasons. On the contrary, the least Na content was generally coupled with fruit peel and pulp of

Washington navel orange trees irrigated with well water. In addition, other combinations were in between.

This result is in general agreement with the findings of **Meheriuk and Neilsen, (1991)** on McIntoch apple cultivar regarding the increase in fruit Na exhibited by using municipal wastewater for irrigation.

Fruit peel and pulp lead content:

A. Specific effect:

With regard to specific effect of irrigation water resource on fruit peel and pulp Pb content, it is quite evident as shown from **Tables (26) and (27)** that sewage irrigated trees exhibited statistically higher level than those of well water irrigated trees during both experimental seasons.

Referring the to response specific effect of Citrus spp / cvs, two opposite trends were detected for both fruit peel and pulp. Herein, with fruit peel the highest Pb level was markedly coupled with Balady lime from statistical standpoint. Meanwhile, the highest fruit pulp Pb content was significantly detected by Washington navel orange. In other words, Balady lime fruits characterized by the highest peel Pb level and lowest pulp Pb content, while the reverse was true for Washington navel orange fruits where they showed the least and highest Pb levels in their peel and pulp, respectively. In addition, Valencia orange was intermediate in this concern.

B. Interaction effect:

Specific effect of both investigated factors as shown from **Tables (26) and (27)** reflected obviously on interaction effect of their combinations. Hence, sewage irrigated trees of Balady lime induced fruits with the highest peel Pb content, while the highest fruit pulp Pb level was significantly coupled with Washington navel orange trees irrigated with sewage effluent. On the contrary, the least lead level was generally in closed relationship to well water irrigated trees of three Citrus spp / cvs, especially Valencia orange during second season, where its fruits were statistically the inferior as both peel and pulp Pb were concerned.

The findings of **Aboulroos *et al.*, (1989)** on orange fruits and maize; **Hamad *et al.*, (1993)** on tomato; **Darwish *et al.*, (1997)** on some Citrus spp and **Hussein *et al.*, (1999)** on palm trees gave support to our findings regarding the increase exhibited in fruits of sewage irrigated trees.

Fruit peel and pulp Nickel content:

A. Specific effect:

It is quite clear that fruit peel and pulp Ni content respond significantly to irrigation water resource. Hence, the sewage irrigated citrus trees exceeded statistically the well water irrigated ones as their fruit peel and pulp Ni content was concerned during both experimental seasons.

Nevertheless, the response to specific of Citrus spp / cv was relatively less pronounced as compared to that of water resource. However, it could be generally concluded that Washington navel orange had higher level. On the contrary Balady lime was the inferior while Valencia was in between. Differences were significant especially as both Balady lime and

Washington navel orange were compared each other during two experimental seasons.

B. Interaction effect:

The highest fruit Ni level was always in significant concomitant to both fruit peel and pulp of Washington navel orange trees irrigated with sewage effluent. On the contrary, the least Ni content was markedly coupled with Balady lime fruits of well water-irrigated trees. In addition, other combinations were in between.

The present result regarding the increase in fruit peel and pulp Ni content of sewage irrigated citrus trees is in harmony with the findings of **Aboulroos *et al.*, (1989)** on maize and orange; **Hamad, (1993)** on some vegetable crops and **Hussein *et al.*, (1999)** on date palm, all demonstrated an obvious increase in fruits of municipal wastewater irrigated plants.

Table (26): Fruit peel sodium and some heavy metals (Pb & Ni) content of fruitful citrus trees in response to specific and interaction effects of species/cultivar (Balady lime/B. L.; Valencia orange/V. O. and Washington navel orange/W. N. O); irrigation water resource (sewage & well) and their combinations during two consecutive 2001 - 02 & 2002 - 03 experimental seasons.

Citrus spp/cvs / Water resource	Na %				Pb ppm				Ni ppm			
	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*
2001 - 02 season												
Sewage	0.573 a	0.589 a	0.477 b	**0.546 A**	1.44 a	1.33 b	1.24 c	**1.34 A**	2.23 c	2.50 b	2.60 a	**2.37 A**
well	0.413 c	0.349 d	0.332 e	**0.365 B**	1.00 d	0.99 d	1.00 d	**0.99 B**	1.68 d	1.73 d	1.73 d	**1.71 B**
Mean**	**0.493 A**	**0.469 A**	**0.405 B**		**1.22 A**	**1.16 B**	**1.12 C**		**1.95 B**	**2.12 A**	**2.17 A**	
2002 - 03 season												
Sewage	0.569 a	0.600 a	0.465 b	**0.545 A**	1.44 a	1.30 b	1.20 c	**1.31 A**	2.77 b	2.50 c	3.11 a	**2.79 A**
well	0.438 b	0.374 b	0.357 b	**0.390 B**	1.00 d	0.87 e	0.94 d	**0.94 B**	1.54 e	2.03 d	2.08 d	**1.88 B**
Mean**	**0.504 A**	**0.487 A**	**0.411 B**		**1.22 A**	**1.09 B**	**1.07 B**		**2.16 B**	**2.27 AB**	**2.59 A**	

* and ** refer to specific effect of water resource and citurs spp/cvs, respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level, where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations, respectively.

Table (27): **Fruit pulp sodium and some heavy metals (Pb & Ni) contents of fruitful citrus trees in response to specific and interaction effects of species/cultivar (Balady lime/B. L.; Valencia orange/V. O. and Washington navel orange/W. N. O.); and irrigation water resource (sewage & well) and their combinations during two consecutive 2001-02 & 2002-03 experimental seasons.**

Citrus spp/cvs / Waterre source	Na %				Pb ppm				Ni ppm			
	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*	B. L.	V. O.	W. N. O.	Mean*
2001-02 season												
Sewage	0.542 a	0.418 b	0.288 e	**0.416 A**	1.13 c	1.20 b	1.44 a	**1.26 A**	2.07 c	2.14 b	2.29 a	**2.17 A**
well	0.319 d	0.344 c	0.218 f	**0.294 B**	1.00 d	1.08 cd	1.00 d	**1.03 B**	1.17 e	1.34 d	1.31 d	**1.27 B**
Mean**	**0.431 A**	**0.381 B**	**0.253 C**		**1.07 C**	**1.14 B**	**1.22 A**		**1.62 B**	**1.74 A**	**1.80 A**	
2002-03 season												
Sewage	0.527 a	0.425 b	0.412 b	**0.455 A**	1.14 b	1.01 c	1.79 a	**1.31 A**	2.24 b	2.18 b	2.92 a	**2.45 A**
well	0.347 c	0.330 c	0.265 d	**0.314 B**	0.89 de	0.85 e	0.91 de	**0.88 B**	1.34 c	1.40 c	1.35 c	**1.36 B**
Mean**	**0.437 A**	**0.378 B**	**0.339 B**		**1.01 B**	**0.93 B**	**1.35 A**		**1.79 B**	**1.79 B**	**2.13 A**	

* and ** refer to specific effect of water resource and citurs spp / cvs, respectively. Values within each column or row followed by the same letter / s didn't significantly differ at 5 % level, where capital and small letters were used for distingushing berween means of specific and interaction effects of investigated factors and their combinations,respectively.

IV. II. Second experiment ("Potted Valencia nursery trees "transplants")

In this respect factorial experiment was conducted on two year old Valencia orange nursery trees (transplants) budded on three rootstocks namely: Volkameriana, rough lemon and Cleopatra mandarin grown in pots contained virgin sandy soil brought from two regions (EL-Gabal Al-Asfar and Dahshour) and irrigated with either primary treated sewage effluent or fresh water. The response to specific effect of water resource; citrus rootstocks used and soil sites (regions), as well as interaction effect of different combinations between three investigated factors was evaluated through the following vegetative growth and chemical measurements.

IV. II. I. Vegetative growth measurements:

In this regard nursery tree (transplant) height; scion diameter; number of leaves average leaf area; root length; dry weight of different plant organs (leaves, shoot, root and total plant weight) and top root ratio were investigated. Data obtained during both seasons are presented in **Tables (28)** and **(29)**.

Nursery tree (transplant) height:

A. Specific effect:

With regard to specific effect of irrigation water resource, **Table (28)** displays obviously that the sewage effluent irrigated nursery trees (transplants) were significantly taller than those of fresh water irrigated ones. Meanwhile, the specific effect of soil site was approximately absent, where transplant height of Valencia orange grown in two soil sites was equally the same.

As for the specific effect of citrus rootstocks used, it is quite evident that Valencia orange nursery trees (transplants) transplants on Volkameriana were significantly the tallest, descendingly followed by those on rough lemon. On the contrary Valencia orange budded on Cleopatra mandarin were statistically the shortest ones. Differences between three citrus rootstocks were significant as compared each other during both experimental seasons.

B. Interaction effect:

With regard to the response of nursery tree (transplant) height to interaction effect of three investigated factors (water resource X rootstock X soil site), **Table (28)** displays that the tallest Valencia orange nursery trees (transplants) were significantly coupled to both combinations represented those budded on Volkameriana and irrigated with sewage effluent when grown in either El-Gabal Al-Asfar or Dahshour soil which ranked statistically 1st and 2nd, respectively. On the contrary, the shortest nursery trees (transplants) were markedly in closed relationship to the fresh water irrigated ones budded on Cleopatra mandarin rootstock grown in either El-Gabal Al-Asfar or Dahshour soils, as well as those on rough lemon grown in Dahshour soil and supplied with fresh water. Such trend was true during both experimental seasons. In addition, other combinations were in between the aforesaid two extremes.

Scion diameter:

A. Specific effect:

With respect to specific effect of water resource, it is quite clear as shown from **Table (28)** that scion diameter of sewage irrigated Valencia orange nursery trees (transplants) was significantly thicker than that of fresh water irrigated ones during both seasons of study.

Referring the specific effect of citrus rootstock used, data obtained during both seasons exhibited that budded trees on Volkameriana rootstock had the thickest scion as compared to those on either rough lemon or Cleopatra mandarin rootstocks. Meanwhile, difference between both rough lemon and Cleopatra mandarin was too few to be taken into consideration from the statistical point of view during both experimental seasons.

Concerning the specific effect of sandy soil site, tabulated data in **Table (28)** displays that the response was completely absent, where scion diameter of nursery trees (transplants) grown in either El-Gabal Al-Asfar or Dahshour sites was equally the same during two seasons of study.

B. Interaction effect:

The response to interaction effect of various combinations between three investigated factors exhibited that the thickest scion was always insignificant concomitant to the budded Valencia orange nursery trees (transplants) on Volkameriana and irrigated with primary treated sewage effluent, regardless of site from which growing medium (soil) was brought. Such trend reflects the more pronounced effect of both citrus rootstock and irrigation water resource associated with the absence of the soil site effect. On the contrary, the thinnest scion diameter of Valencia orange nursery trees (transplants) was generally in closed relationship to those budded on rough lemon, irrigated with fresh water and grown in Dahshour soil, beside such fresh water irrigated nursery trees (transplants) on Cleopatra mandarin, regardless of soil site. In addition, other combinations were in between with some tendency of relative variance as members of such category compared either each other or to the aforesaid combinations of the superior and inferior categories during both seasons of study.

Average number of leaves per nursery trees (transplants):

A. Specific effect:

Table (28) shows obviously the superiority of primary treated sewage effluent over fresh water as the specific effect of water resource used for irrigation was concerned. Difference was significant during both seasons of study. On the other hand the superiority of Volkameriana rootstock was significantly observed as compared to two other ones used for budding. Cleopatra mandarin was the inferior, while rough lemon was intermediate. Differences were significant as three citrus rootstocks were compared each other during two seasons of study.

Referring the specific effect of soil site, it was quite clear that variance was completely absent from statistical point of view during both seasons of study.

B. Interaction effect:

The superiority of sewage effluent over fresh water and Volkameriana over rough lemon and Cleopatra mandarin as specific effect of both irrigation water resource and citrus rootstocks were respectively concerned reflected directly on the differential twelve investigated combinations of (3 rootstocks X 2 water resources X 2 soil sites). Herein, the Valencia orange trees budded on Volkameriana rootstocks, subjected to irrigation with sewage effluent and grown in El-Gabal Al-Asfar soil, exhibited statistically the greatest number of leaves per each individual transplant. On the contrary, the fewest number of leaves per transplant was related to both combinations representative of fresh water irrigated trees budded on Cleopatra mandarin, and grown in either El-Gabal Al-Asfar or Dahshour soil, especially in former soil region. The inferiority of the aforesaid two combinations (Valencia orange nursery trees (transplants) + fresh water in soils of both sites) was significant as compared to other investigated combinations during both seasons of study. In addition, other combinations were in between the aforesaid two extremes during two seasons.

Average leaf area:

A. Specific effect

Concerning the specific effect of irrigation water resource on average leaf area, **Table (28)** reveals that sewage irrigated transplants had significantly larger leaf area. However, the specific effects of two other investigated factors i.e, citrus rootstocks and soil site were completely absent from the statistical standpoint during two seasons.

B. Interaction effects:

Regarding the response of average leaf area to interaction effect of different combinations between three investigated factors, (3 rootstocks X 2 water resources X 2 soil sites), **Table (28)** discloses that the greatest leaf area was usually coupled with the swage irrigated Valencia orange nursery trees (transplants) budded on either Volkameriana or rough lemon rootstocks, regardless of sites from which soil was brought. Such trend was true either data of each season or an average of two seasons were concerned. Moreover, the analogous combination of those budded on Cleopatra mandarin and irrigated with sewage effluent (regardless of soils site) ranked second, especially as an average of two seasons was concerned. On the contrary, the smallest leaf area was closely related to three combinations representative of the fresh water irrigated nursery trees (transplants) i.e, those grown in either El-Gabal Al-Asfar soil (budded on Volkameriana and Cleopatra mandarin) or in Dahshour soil (budded on rough lemon). However, three other combinations of fresh water irrigated transplants showed relatively intermediated leaf area.

Average root length:

A. Specific effect:

Regarding the specific effect of irrigation water resource, **Table (28)** discloses that response of root length followed an opposite trend to that previously detected for the aforesaid four growth measurements. Herein, sewage effluent depressed the penetration of root system and produced shorter roots than those of fresh water irrigated transplants. Meanwhile, trees budded on Volkameriana had significantly the longest roots, descendingly followed statistically by those on rough lemon and Cleopatra mandarin. In addition, specific effect of soil was more pronounced for such parameter, where nursery trees (transplants) grown in El-Gabal Al-Asfar soil exhibited statistically longer roots than those in Dahshour soil during both seasons.

B. Interaction effect:

With regard to the interaction effect, **Table (28)** displays obviously that the most penetrated root system (deepest / longest) was always in significant concomitant to the fresh water irrigated Valencia orange nursery trees (transplants) budded on either Volkameriana or rough lemon rootstocks and grown in El-Gabal Al-Asfar soil during both experimental seasons.

On the contrary, the shortest roots were generally coupled with sewage irrigated Valencia orange nursery trees (transplants) budded on either Cleopatra mandarin or rough lemon and grown in both soil sites or Dahshour site during 1^{st} and 2^{nd} seasons, respectively.

In addition other combinations were in between the aforesaid two extremes during two seasons of study.

Shoot dry weight:

In this regard shoots dry weight per each individual transplant in response to specific and interaction effects of three investigated factors (water resource; citrus rootstocks and soil site) and their combinations were studied.

Table (28): Plant height; scion diameter; number of leaves / plant; average leaf area and root length of Valencia orange nursery trees (transplants) as influenced by specific and interaction effects of water resource; citrus rootstock and soil region during two successive experimental 2000 -02 and 2001- 03 seasons.

Water &soil	Rootstocks	Plant height (cm)				Scion diameter (mm)				Number of leaves per plant				Average leaf area(cm²)				Root length(cm)			
		Vol.	R. I.	C. m	M *	Vol.	R. I.	C. m	M *	Vol.	R. I.	C. m	M *	Vol.	R. I.	C. m	M *	Vol.	R. I.	C. m	M *
2000 - 02 season																					
Sewage	El-Gabal (S_1)	86.5 a	61.3 e	64.6 d	70.5 A	7.73 a	5.82 c	5.23 d	6.34 A	89.47 a	42.97 de	39.27 f	55.53 A	25.6 ab	26.7 a	25.1 ab	25.4 A	18.5 def	17.6 ef	16.0 f	17.9 B
	Dahshour (S_2)	81.9 b	69.6 c	59.2 f		7.61 a	5.21 d	6.44 b		61.13 b	60.43 b	39.93 ef		27.5 a	25.3 ab	22.1 c		20.3 bcd	18.3 def	16.6 f	
Fresh	El-Gabal (S_1)	58.2 fg	58.2 fg	53.8 h	56.80 B	5.90 bc	5.25 d	5.24 d	5.42 B	48.33 c	33.08 g	16.70 l	34.29 B	17.1 d	22.0 c	18.4 d	19.6 B	26.3 a	25.4 a	22.0 bc	22.4 A
	Dahshour (S_2)	66.0 d	48.9 l	56.2 g		6.21 bc	5.16 d	4.78 d		45.05 d	37.91 f	24.67 h		19.3 d	17.4 d	23.1 bc		22.6 b	20.0 cde	18.1 def	
Mean **(Rootstock)		73.1 A	59.5 B	58.4 C		6.86 A	5.36 B	5.42 B		61.00 A	43.60 B	30.14 C		22.4 A	22.6 A	22.2 A		22.0 A	20.4 B	18.2 C	
Mean *** El-Gab. (S_1); Dahs.(S_2)		S_1= 63.8 A		S_2= 63.6 A		S_1= 5.86 A		S_2= 5.90 A		S_1= 22.3 A		S_2= 22.46 A		S_1= 22.5 A		S_2= 22.5 A		S_1=20.9 A		S_2= 19.3 B	
2001- 03 season																					
Sewage	El-Gabal (S_1)	92.1 a	65.8 d	66.2 d	72.4 A	8.10 a	5.63 de	5.37 de	6.54 A	65.20 a	43.00 de	44.40 de	50.09 A	26.1 a	24.5 b	22.7 c	24.1 A	18.5 e	19.9 de	18.3 e	18.5 B
	Dahshour (S_2)	84.1 b	63.7 e	62.6 e		7.83 a	6.53 b	5.80 cde		65.07 a	45.60 cd	37.27 f		25.8 ab	24.9 ab	20.3 de		21.3 cd	16.3 f	16.6 f	
Fresh	El-Gabal (S_1)	62.3 e	60.2 f	55.2 h	60.8 B	5.97 bcd	5.70 cde	5.33 de	5.51 B	45.13 d	41.53 e	26.47 h	40.32 B	16.4 g	21.6 cd	19.0 ef	19.8 B	25.0 ab	26.5 a	21.6 c	22.9 A
	Dahshour (S_2)	71.2 c	57.6 g	58.5 g		6.37 bc	4.53 f	5.13 ef		48.93 bc	49.83 b	30.00 g		20.5 d	18.6 f	22.9 c		23.5 b	21.2 cd	20.0 cde	
Mean **(Rootstock)		77.4 A	61.8 B	60.6 C		7.07 A	5.60 B	5.41 B		56.08 A	44.99 B	34.53 C		22.2 A	22.4 A	21.2 A		22.1 A	21.0 B	19.1 C	
Mean *** El-Gab. (S_1); Dahs.(S_2)		S_1= 66.9 A		S_2= 66.3 A		S_1= 6.02 A		S_2= 6.03 A		S_1= 44.3 A		S_2= 46.1 A		S_1= 21.7 A		S_2= 22.2 A		S_1= 21.62 A		S_2= 19.8 B	

*; ** and *** refer to specific effect of water resource ; citrus rootstock and soil region, respectively. Whereas means within each row or column followed by the same letter/s are not significantly different at 5 % level , capital letters were used for distinguishing means of each investigated factor, while small ones for means of interaction(their combinations.)

Data obtained during both 2000-02 and 2001-03 experimental seasons are presented in **Table (29).**

A. Specific effect:

Referring the specific effect of irrigation water resource, **Table (29)** reveals that Valencia orange nursery trees (transplants) irrigated with sewage effluent had statistically heavier shoots than the analogous ones irrigated with fresh water during both seasons of study.

Referring the specific effect of citrus rootstocks, it is quite evident that the heaviest shoots dry weight were significantly in closed relationship to Valencia orange nursery trees (transplants) budded on Volkameriana, descendingly followed by those on rough lemon and Cleopatra mandarin. Differences between three rootstocks were significant as compared each other during two seasons of study.

Concerning the specific effect of soil site, **Table (29)** displays that difference between two soil sites were so slight to reach level of significance, where shoots dry weight of Valencia orange nursery trees (transplants) grown in both Dahshour and El- Gabal Al-Asfar soils were of comparable weight.

B. Interaction effect:

Data obtained during both seasons displayed that specific effect of each investigated factor was directly reflected on their interaction effect. Herein, the heaviest shoots dry weight of Valencia orange transplants were significantly coupled with those budded on Volkameriana, irrigated with sewage effluent and grown in pots filled with soil brought from El-Gabal Al-Asfar region. Moreover, those on the same rootstock (Volkameriana) grown in soil of Dahshour region and subjected to irrigation with sewage effluent ranked statistically second during both seasons of study. On the contrary, the lightest shoot dry weight was always in concomitant to fresh water irrigated Valencia orange nursery trees (transplants) budded on Cleopatra mandarin, grown in El-Gabal Al-Asfar soil when supplied with fresh water. In addition, other combinations were in between the aforesaid two extremes.

Leaves dry weight:

A. Specific effect:

Table (29) shows that the leaves dry weight followed typically the same trends previously detected with the shoots dry weight regarding the response to specific effect of three investigated factors. Herein, the leaves dry weight was significantly increased by sewage effluent irrigated Valencia orange nursery trees (transplants) from one hand and those budded on Volkameriana rootstock from the other as the specific effect of water resource and citrus rootstock were concerned, respectively. However, the variance due to soil site was too small to be taken into consideration from the statistical standpoint.

B. Interaction effect:

Table (29) reveals obviously that the heaviest leaves dry weight was significantly in closed relationship to the sewage irrigated Valencia orange trees budded on

Volkameriana rootstock and grown in bags filled with El-Gabal Al-Asfar soil. Meanwhile, those on the same rootstock and irrigated with the same irrigation water resource but grown in the other soil (Dahshour soil) ranked statistically 2nd. On the contrary, the lightest leaves dry weight was markedly in closed relationship to fresh water irrigated Valencia orange trees budded on Cleopatra mandarin, regardless of soil site. In addition, other combinations were in between the aforesaid two extremes.

Root system dry weight:

A. Specific effect:

With regard to specific effect of irrigation water resource, **Table (29)** displays that the trend of response took the other way around to that previously detected with both shoots and leaves dry weight. Herein, fresh water irrigated nursery trees (transplants) exhibited statistically heavier root system dry weight as compared to those irrigated with sewage effluent during both experimental seasons.

As for the specific effect of citrus rootstock, it is quite clear that root system dry weight followed typically the same trend previously detected with either shoots or leaves dry weight. Whereas, the heaviest roots dry weight was closely linked with the nursery trees (transplants) budded on Volkameriana. The opposite was found with those on Cleopatra mandarin, while those on rough lemon were in between. Differences between three citrus rootstocks were significant as compared each other during two seasons of study.

Referring the response to soil site, **Table (29)** shows that variance was too few to be taken into consideration.

B. Interaction effect:

It is quite clear as shown from **Table (29)** that the interaction effect of various combinations between three investigated factors was a real reflection of their specific effect. So, the heaviest root system dry weight was markedly coupled with the fresh water irrigated trees budded on Volkameriana and grown in El-Gabal Al-Asfar soil. Moreover, combination representing the fresh water irrigated trees budded on Volkameriana and grown in Dahshour soil ranked statistically second as their root system dry weight was concerned during both experimental seasons.

On the other contrary, the least root system dry weight was obviously correlated to the sewage irrigated nursery trees (transplants) budded on Cleopatra mandarin, especially those grown in pots filled with Dahshour soil. In addition, other combinations were in between with a noticeable tendency pointed out that those of fresh water irrigated nursery trees (transplants) budded on rough lemon and grown in El-Gabal Al-Asfar soil had significantly heavier roots dry weight as compared to the combinations of such intermediate category.

The conflicted trends detected in the present results regarding the response of both above and underground systems dry weight in response to specific effect of irrigation water resource may be attributed to the variance in depletion rates of photosynthetic substances (especially carbohydrates) exhausted in growth process of the above ground system (shoots &

leaves) under two irrigation water resources. So, the higher vigorous growth exhibited in the aboveground system of the sewage irrigated transplants required higher depletion rate in carbohydrates. However, the reverse was found with the fresh water irrigated nursery trees (transplants) which characterized by their relative lower shoots and leaves dry weight which reflected in less depletion rate in photosynthetic substances and consequently relative higher accumulation rate of carbohydrates which certainly should be reflected positively in growth of the underground system (roots).

Total plant dry weight:

A. Specific effect:

The response of total plant dry weight to specific effect of irrigation water resource followed similar trend to that previously detected with shoots and leaves dry weights. Herein, the sewage irrigated transplants had significantly heavier total plant dry weight as compared to the fresh water irrigated ones during both seasons of study.

Nevertheless, the trend of response to citrus rootstock was also generally similar to that previously discussed with two plant organs of the aboveground system (shoots & leaves). Whereas, the total plant dry weight of Valencia orange nursery trees (transplants) budded on Volkameriana was significantly the heaviest. On the contrary budded nursery trees (transplants) on Cleopatra mandarin were the inferiors, while those on rough lemon were intermediate. Differences between three citrus rootstocks were significant during both seasons of study.

Referring the response to soil site, **Table (29)** reveals that differences were not so enough to be significant as the total plant dry weight was concerned during both seasons of study.

B. Interaction effect:

The heaviest total plant dry weight of Valencia orange nursery trees (transplants) was always in concomitant to the sewage effluent irrigated ones, budded on Volkameriana and grown in El-Gabal Al-Asfar soil. Moreover, the sewage irrigated nursery trees (transplants) budded on volkameriana and grown in Dahshour soil ranked statistically second during both seasons of study. On the contrary the lightest nursery trees (transplants) dry weight were the fresh water irrigated ones, budded on Cleopatra mandarin and grown in El-Gabal Al-Asfar soil. In addition, other combinations were in between the aforesaid two extremes.

The less pronounced variances in total plant dry weight regarding the response to irrigation water resource as compared to that exhibited in both aboveground and underground systems could be explained logically by the unparalleled trends of two systems as previously discussed.

Top : root ratio:

A. Specific effect:

Table (29) displays that top / root ratio of Valencia orange nursery trees (transplants) respond specifically to both irrigation water resource and citrus rootstocks, while the response to soil site was less pronounced and variance didn't reach level of significance. Anyhow, sewage effluent increased significantly the top / root ratio than fresh water during both experimental seasons. This result could be logically explained depending upon the unparalleled trends of response for both top (shoot &leaves) and root to the irrigation water resource. Whereas the aboveground system (shoots and leaves) increased by using sewage effluent for irrigation, while the reverse was found with the root system.

As for the specific effect of citrus rootstock, it was quite evident that Valencia orange nursery trees (transplants) budded on Volkameriana had statistically the greatest top / root ratio. The reverse was true with those on Cleopatra mandarin, while those budded on rough lemon were intermediate. Differences among three citrus rootstocks were significant as compared each other during both seasons, except in 2nd season when rough lemon was compared to Cleopatra mandarin, where variance didn't reach level of significance.

Interaction effect:

The greatest value of top /root ratio was always in significant concomitant to such combination representative of the sewage irrigated nursery trees (transplants) budded on Volkameriana rootstock and grown in El-Gabal Al-Asfar soil. Moreover, three combinations of sewage effluent irrigated nursery trees (transplants) grown in Dahshour soil (regardless of citrus rootstocks used) ranked generally second, especially as an average of two seasons for each case was concerned. On the contrary, the least top /root ratio was markedly related to two combinations of fresh water irrigated transplants, budded grown in El-Gabal Al-Asfar and Dahshour soils, respectively. In addition, other combinations were in between the aforesaid two extremes.

The present results regarding the response of height; scion diameter; number of leaves; leaf area; and dry weight of (shoots; leaves, total plant) to irrigation water resource go generally with previously discussed trends with different vegetative growth parameters of fruitfull citrus trees (experiment, I). Whereas, the presence of higher levels of some nutrient elements particularly N in sewage effluent could be considered as the real reasons for its stimulative effect in this concern.

However, the response to citrus rootstocks goes partially with the findings of **Salem, *et al.,* (1994)** and **Kojima *et al.,* (1995).**

In addition, the absence of variations in response to soil regions may be attributed to the slight differences between two investigated soil sites.

IV. II. II. Leaf chemical analysis:

IV. II. II 1. Leaf photosynthetic pigments content:

In this respect leaf chlorophyll (A); chlorophyll (B); chlorophyll (A+B) and chlorophyll A:B ratio of Valencia orange nursery trees (transplants) as influenced by specific and interaction effects of three investigated factors i.e, irrigation water resource; citrus rootstock; soil site and their combinations were studied. Data obtained during both 2000-02 and 2001-03 experimental seasons are presented in **Table (30).**

Table (29): Shoots; leaves; roots; total plant dry weight and top : root ratio of Valencia orange nursery trees (transplants) as influenced by specific and interaction effects of water resource; citrus rootstock and soil region during two successive experimental 2000 - 02 and 2001- 03 seasons.

Water &soil \ Rootstocks		Shoots D. Wt. Vol.	Shoots D. Wt. R. I.	Shoots D. Wt. C.m	Shoots D. Wt. M *	Leaves D. Wt. Vol.	Leaves D. Wt. R. I.	Leaves D. Wt. C.m	Leaves D. Wt. M *	Root D. Wt. Vol.	Root D. Wt. R. I.	Root D. Wt. C.m	Root D. Wt. M *	Total plant D. Wt. Vol.	Total plant D. Wt. R. I.	Total plant D. Wt. C.m	Total plant D. Wt. M *	Top : root ratio Vol.	Top : root ratio R. I.	Top : root ratio C.m	Top : root ratio M *
2000 - 02 season																					
Sewage	El-Gabal (S_1)	31.29 a	15.12 ef	14.55 f	**18.94 A**	17.91 a	7.46 de	7.89 d	**10.66 A**	18.16 c	13.90 f	15.44 e	**15.50 B**	67.37 a	36.48 f	37.86 e	**45.11 A**	2.71 a	1.62 d	1.45 e	**1.89 A**
	Dahshour (S_2)	23.71 b	15.79 d	13.18 h		10.56 c	13.31 b	6.80 f		19.67 b	14.10 f	11.60 g		54.15 b	43.20 c	31.58 g		1.74 c	2.06 b	1.72 c	
Fresh	El-Gabal (S_1)	15.48 de	15.14 ef	8.92 j	**13.48 B**	7.22 ef	5.76 g	3.51 j	**5.65 B**	21.47 a	19.45 b	14.18 f	**18.24 A**	44.16 c	40.36 d	26.61 h	**37.37 B**	1.06 g	1.07 g	0.88 l	**1.04 B**
	Dahshour (S_2)	17.09 c	10.33 l	13.89 g		7.36 e	5.26 h	4.79 l		19.45 b	16.61 d	18.29 c		43.91 c	32.20 g	37.97 ef		1.26 f	0.94 h	1.02 g	
Mean **(Rootstock)		**21.89 A**	**14.10 B**	**12.63 C**		**10.76 A**	**7.95 B**	**5.75 C**		**19.69 A**	**16.02 B**	**14.88 C**		**52.40 A**	**38.06 B**	**33.26 C**		**1.69 A**	**1.37 B**	**1.27 C**	
Mean *** El-Gab. (S_1); Dahs.(S_2)		16.75 A		15.66 A		S_1= 8.3 A		S_2= 8.0 A		S_1= 17.10 A		S_2= 16.62 A		S_1= 42.14 A		S_2= 40.34 A		S_1= 1.47 A		S_2= 1.46 A	
2001- 03 season																					
Sewage	El-Gabal (S_1)	30.57 a	16.21 d	16.74 d	**20.27 A**	14.70 a	7.80 e	8.23 d	**9.64 A**	18.23 d	14.20 h	15.23 g	**15.50 B**	66.00 a	38.21 e	39.98 d	**45.82 A**	2.62 a	1.69 d	1.65 d	**1.93 A**
	Dahshour (S_2)	26.68 b	16.64 d	14.80 e		11.00 b	9.43 c	6.67 f		20.23 b	14.27 h	11.10 j		57.82 b	40.34 d	32.57 f		1.86 c	1.86 c	1.93 b	
Fresh	El-Gabal (S_1)	16.78 d	14.18 ef	8.62 g	**14.14 B**	6.73 f	5.27 g	4.17 i	**5.42 B**	20.90 a	18.97 c	13.67 l	**17.60 A**	44.41 c	38.42 e	26.45 h	**37.17 B**	1.13 f	1.03 g	0.94 h	**1.10 B**
	Dahshour (S_2)	18.85 c	10.21 f	16.20 d		7.67 e	4.63 h	4.07 i		18.30 b	15.97 f	17.83 e		44.82 c	30.81 g	38.10 e		1.45 e	0.93 h	1.14 f	
Mean **(Rootstock)		**23.22 A**	**14.31 B**	**14.09 C**		**10.70 A**	**6.80 B**	**5.80 C**		**19.42 A**	**15.85 B**	**14.46 C**		**53.26 A**	**36.95 B**	**34.28 C**		**1.76 A**	**1.37 B**	**1.41 B**	
Mean *** El-Gab. (S_1); Dahs.(S_2)		S_1= 17.18 A		S_2= 17.23 A		S_1= 7.82 A		S_2= 7.25 A		S_1= 16.80 A		S_2= 16.28 A		S_1= 42.25 A		S_2= 40.74 A		S_1= 1.51 A		S_2= 1.52 A	

* ; ** and *** refer to specific effect of water resource ; citrus rootstock and soil region, respectively. Whereas means within each row or column followed by the same letter/s are not significantly different at 5 % level , capital letters were used for distinguishing means of each investigated factor, while small ones for means of interaction(their combinations.)

IV. II. II 1. 1. Chlorophyll (A) content:

A. Specific effect:

With regard to specific effect of irrigation water resource, it was quite evident that leaves of sewage effluent irrigated Valencia orange nursery trees (transplants) were statistically the richest in their chlorophyll (A) content as compared to the analogous ones of fresh water irrigated nursery trees (transplants) during both experimental seasons.

Referring the specific effect of citrus rootstocks, **Table (30)** reveals that the response was less pronounced, where differences between three rootstocks didn't reach level of significance, especially during 2nd experimental season. However, leaves of Valencia orange nursery trees (transplants) budded on Cleopatra mandarin tended relatively to be the poorest especially during 1st season, where the reduction was significant with comparing to those on two other rootstocks.

Concerning the specific effect of soil site, **Table (30)** shows that variance in leaf chlorophyll (A) content of Valencia orange nursery trees (transplants) grown in soils brought from two sites were too few to be taken into consideration.

B. Interaction effect:

Table (30) displays that the more pronounced response to specific effect of irrigation water resource than specific effect of two other investigated factors reflected directly on interaction effect of their different combinations.. Anyhow, the highest leaf chlorophyll (A) content was always in significant relationship to the sewage irrigated Valencia orange trees budded on either Volkameriana or rough lemon and grown in El-Gabal Al-Asfar followed by those on Cleopatra mandarin in the same soil site and irrigated with sewage effluent, as well as those supplied with sewage effluent on either Volkameriana or rough lemon in Dahshour soil.

On the contrary, the least leaf chlorophyll (A) content was coupled to nursery trees (transplants) of the three combinations representative of the fresh water irrigated ones budded on rough lemon; Cleopatra mandarin or Volkameriana grown in El-Gabal Al-Asfar and Dahshour soils for those of the two former rootstocks and later one, respectively.

In addition, other combinations were in between the aforesaid two extremes.

I. IV. II. 1. 2. Chlorophyll (B) content:

A. Specific effect:

Table (30) shows that the variance due to specific effect of irrigation water resource was too few to be considered, where both sewage effluent and fresh water irrigated trees did not significantly differ as their leaf chlorophyll (B) content was concerned during both experimental seasons.

As for the specific effect of citrus rootstock, it is quite clear to be noticed that the budded nursery trees (transplants) on Cleopatra mandarin had the poorest leaves in their chlorophyll (B) content, especially as compared to the analogous ones on two other rootstocks (Volkameriana &

rough lemon) and Volkameriana only during 1st and 2nd seasons, respectively.

In addition, difference in leaf chlorophyll (B) content due to specific effect of soil site was too slight to be considered.

B. Interaction effect:

Table (30) reveals that however the trend of response was not firm during both seasons from one hand, but it could be generally noticed that the sewage effluent irrigated nursery trees (transplants) budded on either Volkameriana or rough lemon had statistically richer leaves in their chlorophyll (B) content regardless of soil site. Such trend was true especially as an average of two seasons was concerned. Moreover, other combinations followed in most cases two conflicted tends during two seasons of study viz three combinations of fresh water irrigated nursery trees (transplants) grown in Dahshour soil (regardless of rootstock used) were significantly the poorest in 1st season but the reverse was true during 2nd season.

IV. II. II. 1. 3. Leaf chlorophyll (A+B) content:

A. Specific effect:

Regarding the specific effect of irrigation water resource, **Table (30)** reveals that the sewage effluent irrigated Valencia orange nursery trees (transplants) had significantly richer leaves in their (A+B) chlorophyll contents as compared to those irrigated with fresh water.

Referring the response to citrus rootstock used, data obtained during both experimental seasons revealed that leaves of budded Valencia orange nursery trees (transplants) on Volkameriana rootstock were statistically the richest in their (A+B) chlorophyll content. On the contrary, budded nursery trees (transplants) on Cleopatra mandarin had the poorest leaves chlorophyll (A+B). However, the reduction was significant as compared to those budded on either Volkameriana during two seasons or on rough lemon during 1st season only.

Concerning the specific effect of soil site, **Table (30)** displays that no considerable variance could be detected between two soil sites from the statistical point of view during two seasons of study.

B. Interaction effect:

Tabulated data in **Table (30)** exhibited that the sewage effluent irrigated Valencia orange budded on either Volkameriana or rough lemon rootstocks and grown in El-Gabal Al-Asfar soils had statistically the richest leaves in their chlorophyll (A+B). The superiority of the aforesaid two combinations over other investigated ones was significant during both 2000 - 02 and 2001- 03 experimental seasons.

On the contrary fresh water irrigated nursery trees (transplants) budded on rough lemon either grown in El-Gabal Al-Asfar or Dahshour soil had statistically the poorest leaves in their chlorophyll (A+B). Besides fresh water irrigated trees budded on either Cleopatra mandarin or Volkameriana rootstock and grown in El-Gabal Al-Asfar and Dahshour soils, respectively showed also the least chlorophyll (A+B) contents.

In addition, other combinations were in between the aforesaid two extremes.

These results go generally with the findings of **Basiouny, (1984)** on peach; **Zekri and Koo,(1993)** of fruit full citrus trees, and **El-said,(1999),** on mandarin trees, all demonstrated that irrigation with municipal wastewater increased leaf chlorophyll contents.

However, the specific effect of rootstock may be attributed to the potentiality of both rootstock for absorption some nutrient elements at higher rates than others.

IV. II. II. 1. 4. Leaf chlorophyll (A): (B) ratio:

A. Specific effect:

With regard to the specific effect of irrigation water resource, it is quite clear that the sewage effluent irrigated Valencia orange nursery trees (transplants) had leaves characterized by their higher chlorophyll (A): (B) ratio as compared to the analogous ones of fresh water irrigated. This may be due to the paralleled response of both chlorophyll kinds to the irrigation water resource.

Nevertheless, the leaf chlorophyll (A): (B) ratio followed nearly the same trend previously detected with total chlorophyll (A+B) content. Herein, the nursery trees (transplants) budded on Volkameriana rootstock showed significantly the highest leaf chlorophyll (A): (B), ratio while the reverse was true with those on Cleopatra mandarin. Differences were significant as Volkameriana compared to either rough lemon or Cleopatra mandarin during two seasons, while rough lemon exceeded statistically Cleopatra mandarin during first season only.

Referring to the specific effect of the soil site, **Table (30)** displays that the leaf chlorophyll (A): (B) ratio of the Valencia orange nursery trees (transplants) grown in both El–Gabal Al–Asfar and Dahshour soils didn't significantly differ.

B. Interaction Effect:

Table (30) reveals that neither specific nor firm trend could be detected regarding the response of leaf chlorophyll (A): (B) ratio to the interaction effect of various combinations between three investigated factors. However, it could be generally observed that the various combinations of sewage effluent irrigated nursery trees (transplants) had higher leaf chlorophyll (A): (B) ratio as compared to those of fresh water irrigation regardless of rootstock used and soil site during both experimental seasons. This result could be generally discussed on the fact depending upon the more pronounced response to specific effect of irrigation water resource than those of two investigated factors.

The present results regarding leaf chlorophyll content as affected by sewage water were on line with findings of **El-Said, (1999)** on Balady mandarin and **Basiouny, (1984)** on Peach.

IV. II. II. 2. Leaf mineral composition:

In his regard leaf N; P;K; Mg; Fe; Mn; Zn; Cu; Na; Pb and Ni contents of Valencia orange transplants as influenced by specific and interaction effects of irrigation water resource; citrus rootstocks used; soil site and their combinations were investigated. Data obtained during both 2000-02 and 2001-03 experimental seasons are presented in **Tables (31) ; (32)** and **(33).**

Table (30): Chlorophyll A& B in leaves of Valencia orange nursery trees (transplants) as influenced by specific and interaction effects of water resource; citrus rootstock and soil region during two successive experimental 2000 -02 and 2001- 03 seasons.

Water &soil \ Rootstocks		Chl. A mg \ 100 g f. Wt.				Chl. B mg \ 100 g f. Wt.				Chl. (A+B) mg \ 100 g f. Wt.				Chl. A : B ratio			
		Vol	R. l.	C.m	M *	Vol	R. l.	C.m	M *	Vol	R. l.	C.m	M *	Vol	R. l.	C.m	M *
2000 - 02 season																	
Sewage	El-Gabal (S_1)	226.4 a	224.7 a	197.1 bc	202.6 A	49.1 a	47.0 ab	43.1 bc	44.3 A	275.3 a	271.7 a	240.2 b	246.3 A	5.8 a	4.8 b	4.2 bc	4.7 A
	Dahshour (S_2)	206.3 b	187.8 c	173.1 d		42.5 bc	45.1 ab	38.8 cd		249.0 ab	233.0 bc	208.5 c		6.0 a	4.0 c	3.5 f	
Fresh	El-Gabal (S_1)	126.0 e	110.6 fg	112.7 fg	126.8 B	36.6 de	33.4 ef	30.2 f	32.0 A	165.9 d	144.0 d	142.8 d	148.4 B	4.5 b	3.8 df	3.4 f	3.9 B
	Dahshour (S_2)	113.5 efg	174.4 g	123.4 ef		31.0 f	29.0 f	31.6 ef		144.4 d	138.5 d	155.0 d		4.2 bc	3.9 df	3.7 d	
Mean **(Rootstock)		168.1 A	174.4 A	151.6 B		39.8 A	38.6 A	35.9 B		208.7 A	196.8 B	186.6 C		5.1 A	4.1 B	3.7 C	
Mean *** El-Gab. (S_1); Dahs.(S_2)		S_1= 166.3 A		S_2= 210.8 A		S_1= 39.9 A		S_2= 36.3 A		S_1= 206.7 A		S_2= 188.1 B		S_1= 4.4 A		S_2= 4.2 A	
2001- 03 season																	
Sewage	El-Gabal (S_1)	213.5 a	224.6 a	207.2 ab	206.6 A	47.6 a	35.6 abcd	37.7 abcd	37.3 A	261.0 a	260.0 a	248.3 ab	244.4 A	6.3 b	5.7 bc	4.5 d	5.5 A
	Dahshour (S_2)	204.1 bc	204.7 abc	185.5 c		42.2 abc	36.7 abcd	24.0 d		246.3 ab	241.2 a	209.5 c		8.1 a	2.8 g	5.4 c	
Fresh	El-Gabal (S_1)	125.8 d	102.2 e	127.1 d	118.3 B	43.8 ab	29.9 bcd	29.3 cd	39.6 A	169.5 d	132.1 e	156.3 d	154.8 B	2.9 fg	3.7 e	4.7 d	3.2 B
	Dahshour (S_2)	104.5 e	125.2 d	124.8 d		48.0 a	44.8 a	41.8 ab		152.4 d	152.2 d	166.5 d		2.3 h	2.8 g	3.0 f	
Mean **(Rootstock)		162.0 A	164.2 A	161.2 A		45.4 A	36.8 B	33.2 B		207.3 A	196.4 B	195.2 B		4.9 A	3.8 B	3.2 C	
Mean *** El-Gab. (S_1); Dahs.(S_2)		S_1= 165.5 A		S_2= 160 A		S_1= 37.3 A		S_2= 39.6 A		S_1= 201.2 A		S_2= 200.0 A		S_1= 4.6 A		S_2= 4.2 A	

*; ** and *** refer to specific effect of water resource ; citrus rootstock and soil region, respectively. Whereas means within each row or column followed by the same letter/s are not significantly different at 5 % level , capital letters were used for distinguishing means of each investigated factor, while small ones for means of interaction (their combinations.)

IV. II. II. 2. 1. Leaf Macro Nutrients Content:

Leaf Nitrogen Content:

A. Specific Effect:

Concerning the specific effect of irrigation water resource, **Table (31)** reveals that sewage effluent irrigated nursery trees (transplants) of Valencia orange had significantly richer leaves N content as compared to those of fresh water irrigated ones during both experimental seasons.

As for the specific effect of citrus rootstock used, data obtained during both seasons declared that the response was less pronounced as compared to that previously detected with irrigation water resource. Hence, budded nursery trees (transplants) on Volkameriana were significantly richer as their leaves N % compared to the analogous ones on either rough lemon or Cleopatra mandarin rootstocks. On the other hand, rough lemon and Cleopatra mandarin did not significantly differ in this regard.

Nevertheless, **Table (31)** displays that N % of Valencia orange nursery trees (transplants) grown in El – Gabal Al – Asfar soil tended relatively to be higher than those in Dahshour soil. Difference was significant during first season only.

B. Interaction effect:

With regard to the interaction effect, **Table (31)** shows that although the trend was not firm during both seasons, it could be generally observed that sewage irrigated nursery trees (transplants) budded on either Volkameriana or Cleopatra mandarin had significantly the richest leaves N% irrespective of soil site. Such trend was true especially with those on Volkameriana during both seasons, either data of each season or an average of two seasons were concerned, while those budded on Cleopatra mandarin ranked significantly second except nursery trees (transplants) grown in El–Gabal Al–Asfar, which came first during the second season only.

On the contrary, the poorest leaves N% were the fresh water irrigated nursery trees (transplants) grown in Dahshour soil, either budded on rough lemon or Cleopatra mandarin. In addition, other combinations were in between.

The present results regarding the specific effect of water resource goes with the findings of **Koo and Zekri;(1989)** on citrus; **Esteller *et al.*, (1994)** on citrus trees and **Lapena *et al.*,(1995)** on young citrus trees, all pointed out the leaves of wastewater irrigated plants had higher N content than those irrigated with either well or fresh water.

However, the response to citrus rootstock partially agreed the findings of **Banuls *et al.*, (1990)** on clementine budded on two rootstock who reported that the pattern of N accumulation an different plant organs was influenced by rootstock kind regarding the rootstock ability for N transport from roots to leaves of scion. **Salem *et al.*, (1994), Wu *et al.*, (1998) Marathe *et al.*, (2000) and Moeen-Ud-Din *et al.*, (2001)** all found that leaf N content of different citrus scions was greatly affected by rootstock which-seemed to be an inherent nutrient absorption characteristic of a particular rootstock.

Leaf Phosphorus Content:

A. Specific effect:

The response to specific effect of irrigation water resource was obviously clear. Herein, the sewage irrigated nursery trees (transplants) had statistically richer leaves phosphorus content i.e., about 2.5 folds much more than those of fresh water irrigated ones during two seasons.

As for the specific effect of citrus rootstock, **Table (31)** shows that the differences were relatively lower. Anyhow, budded nursery trees (transplants) on rough lemon had leaves significantly richer in their P % than those on either Volkameriana during two seasons or Cleopatra mandarin in second and second season only.

Referring the specific effect of soil site, it could be noticed relatively differences between two sires. Herein, transplants grown in soil brought from Dahshour region had richer leaves P % than those in El-Gabal Al-Asfar. However, differences was significant during 2^nd^ season only.

B. Interaction effect:

Data obtained during both seasons declared that the more pronounced effect of water irrigation resource and the relative influence of soil site were reflected directly on the interaction effect of different combinations between three investigated factors. Herein, the sewage irrigated nursery trees (transplants) especially those grown in Dahshour soil exhibited significantly the highest leaf P %, regardless of citrus rootstock during both seasons. However, those in El-Gabal Al-Asfar soil supplied with the same irrigation water exhibited also their superiority during the second season only. On the contrary, the fresh water irrigated nursery trees (transplants) budded on three citrus rootstocks (especially Cleopatra mandarin rootstock) and grown in El-Gabal Al-Asfar soil were statistically the inferior during both experimental seasons of study.

The obtained results regarding the increase in leaf P content of sewage irrigated trees goes in the line with the findings of **Koo and Zekri,(1989)** on citrus, **Maurer *et al.*, (1995-a)** on grapefruit trees and **Paranichianakis *et al.*,(2000)** on grapevines, all reported that wastewater increased leaf P %.

As for the specific effect of rootstock, obtained results is supported by the findings of **Wu *et al.*, (1998); Marathe *et al.*, (2000) and Moeen-Ud-Din *et al.*, (2001)**, all reported that nutrient uptake and consequently scion contents (leaves mineral composition) is an inherent nutrient absorption characteristic of a particular rootstock.

Leaf potassium content:

A. Specific effect:

The specific effect of irrigation water resource on leaf K % of Valencia orange nursery trees (transplants) was quite clear. Hence, the sewage irrigated nursery trees (transplants) surpassed statistically the fresh water irrigated ones during both experimental seasons.

As for the specific effect of citrus rootstock used, **Table (31)** displays that Valencia budded on rough lemon rootstock tended relatively to be richer in their leaf K % than those on two other rootstocks. However, differences was significant during first season only, while in second season three citrus rootstocks were equally the same in this concern.

Referring the specific effect of soil site, **Table (31)** reveals that no firm trend was detected during both seasons. Herein, in first season growing nursery trees (transplants) in El-Gabal Al-Asfar soil were significantly richer while in second season both soil sites were statistically the same.

B. Interaction effect:

Data obtained during both experimental seasons displayed that the richest leaves K content were always in concomitant to the sewage irrigated nursery trees (transplants) budded on rough lemon rootstock and grown in either El-Gabal Al-Asfar soil (during first season) or two soil sites during second season. Moreover the sewage irrigated nursery trees (transplants) budded on two other rootstocks (Volkameriana and Cleopatra mandarin) in most cases ranked statistically second regardless of the site from which soil was brought during two seasons of study. On the contrary, the least leaf K % was generally in closed relationship to the fresh water irrigated nursery trees (transplants) neither rootstock nor soil site were concerned. However, those in Dahshour soil tended relatively to be the poorest especially those on either Volkameraina or rough lemon during two seasons.

The trend of response to water resource detected in the present study gives supported to the earlier findings of **Lapena** ***et al.*, (1995)** on young seedlings of orange; **Maurer** ***et al.*, (1995-a&b)** on grapefruit and **Paranichianakis** ***et al.*,(2000)**.

However, the present results obtained regarding the response citrus rootstock are in general agreement with the findings of **Salem** ***et al.*****,(1994)** on Valencia orange; **Araujo** ***et al.*****,(1998)** on some citrus species; **Wu** ***et al.*****,(1998)** on orange, **Marathe** ***et al.*****,(2000)** on citrus and **Moeen-Ud-Din et al.,(2001)** on citrus, all reported a considerable variations in nutrient uptake depending upon the rootstock used.

Leaf magnesium content:

A. Specific effect:

Regarding the specific effect of irrigation water resource it is quite evident that sewage effluent irrigated nursery trees (transplants) surpassed statistically the fresh water irrigated ones as their leaves Mg content was concerned during both experimental seasons.

Nevertheless, the specific effect of citrus rootstock was completely absent from the statistical point of view during both seasons. Besides, both soil sites (El-Gabal Al-Asfar and Dahshour regions) did not significantly differ as their influence on leaf Mg content was concerned during experimental seasons.

B. Interaction effect:

Table (31) shows that however trend of response to interaction effect was not so firm during both seasons but it could be noticed that the sewage irrigated nursery trees (transplants), especially those budded on either Cleopatra mandarin or rough lemon rootstocks had richer leaves Mg content. The superiority of the aforesaid four combinations over the other investigated ones was true during both seasons with two exceptions i.e., : 1st dealing with sewage irrigated nursery trees (transplants) budded on Volkameriana in two soils, while 2nd representing fresh water irrigated nursery trees (transplants) on Cleopatra mandarin in Dahshour soil where both didn't significantly differ than the superior ones during 1st season and two seasons for the 1st and 2nd exceptions, respectively. On the contrary, the least leaf Mg % was always in concomitant to those combinations representing the fresh water irrigated nursery trees (transplants) budded on either Volkameriana rootstock (grown in two soil sites) or rough lemon grown in El-Gabal Al-Asfar soil during both experimental seasons.

The present trend of leaf Mg content as influenced by water resource is in agreement with **Maurer *et al.*,(1995-a) and Paranichianakis *et al.*, (2000).** However, the absent of influence on leaf Mg due to citrus rootstock is in agreement with **Salem *et al.*, (1994)** but in disagreement with the findings of **Araujo *et al.*, (1998) ; Wu *et al.*, (1998)** and **Marathe *et al*,(2000)**

IV. II. II. 2. 2. Leaf micro nutrients content:

Leaf iron content:

A. Specific effect:

With regard to specific effect of irrigation water resource, **Table (32)** displays obviously that the sewage irrigated Valencia orange nursery trees (transplants) had significantly higher leaf Fe content as compared to those irrigated with fresh water during both experimental seasons.

Table (31) Leaf N; P; K and mg contents in Valencia orange nursery trees (transplants) as influenced by specific and interaction effects of water resource; citrus rootstock and soil region during two successive experimental 2000 -02 and 2001- 03 seasons.

Water &soil \ Rootstocks		N %				P %				k %				Mg %			
		Vol	R. l.	C.m.	M *	Vol	R. l.	C.m.	M *	Vol	R. l.	C.m.	M *	Vol	R. l.	C.m.	M *
2000 - 02 season																	
Sewage	El-Gabal (S_1)	2.91 a	2.64 b	2.66 b	2.69 A	0.217 bc	0.223 b	0.205 cd	0.222 A	1.12 bc	1.45 a	1.17 b	1.17 A	0.184 ab	0.216 a	0.215 a	0.194 A
	Dahshour (S_2)	2.69 b	2.61 b	2.60 b		0.195 d	0.234 ab	0.258 a		1.11 bc	1.07 c	1.10 bc		0.197 a	0.146 bc	0.208 a	
Fresh	El-Gabal (S_1)	1.95 cd	1.93 cd	2.02 c	1.89 B	0.089 f	0.078 f	0.058 g	0.085 B	0.78 d	1.04 c	0.77 d	0.77 B	0.111 c	0.121 c	0.138 c	0.130 B
	Dahshour (S_2)	1.91 c	1.71 f	1.81 de		0.086 f	0.094 ef	0.104 e		0.63 e	0.67 e	0.71 de		0.124 c	0.146 bc	0.140 bc	
Mean **(Rootstock)		2.37 A	2.22 B	2.27 B		0.147 B	0.157 A	0.156 A		0.91 B	1.06 A	0.94 B		0.154 A	0.157 A	0.175 A	
Mean *** El-Gab. (S_1); Dahs.(S_2)		S_1=2.35 A		S_2=2.22 B		S_1=0.145 A		S_2=0.162 A		S_1=1.06 A		S_2=0.88 B		S_1=0.164 A		S_2=0.160 A	
2001- 03 season																	
Sewage	El-Gabal (S_1)	2.78 a	2.52 c	2.78 a	2.68 A	0.249 ab	0.229 ab	0.199 b	0.238 A	1.19 b	1.27 a	1.15 b	1.19 A	0.170 bc	0.190 ab	0.221 a	0.185 A
	Dahshour (S_2)	2.83 a	2.54 c	2.61 b		0.230 ab	0.275 a	0.243 ab		1.19 b	1.31 a	1.03 c		0.169 bc	0.172 bc	0.188 ab	
Fresh	El-Gabal (S_1)	2.04 d	2.00 de	1.93 e	1.95 B	0.092 cd	0.113 cd	0.059 d	0.099 B	0.71 de	0.70 de	0.74 d	0.70 B	0.122 d	0.110 d	0.140 cd	0.130 B
	Dahshour (S_2)	2.04 d	1.87 ef	1.79 f		0.086 cd	0.120 c	0.121 c		0.68 de	0.64 e	0.73 d		0.128 cd	0.132 cd	0.145 bcd	
Mean **(Rootstock)		2.42 A	2.23 B	2.28 B		0.164 B	0.184 A	0.156 B		0.94 A	0.98 A	0.91 A		0.147 A	0.151 A	0.174 A	
Mean *** El-Gab. (S_1); Dahs.(S_2)		S_1 = 2.34 A		S_2 = 2.28 A		S_1 = 0.157 B		S_2 = 0.179 A		S_1 = 0.96 A		S_2 = 0.93 A		S_1 = 0.159 A		S_2 = 0.156 A	

* ; ** and *** refer to specific effect of water resource ; citrus rootstock and soil region, respectively. Whereas means within each row or column followed by the same letter/s are not significantly different at 5 % level , capital letters were used for distinguishing means of each investigated factor, while small ones for means of interaction (their combinations.)

Referring the specific effect of citrus rootstock, it is quite evident that Valencia nursery trees (transplants) budded on rough lemon rootstock were statistically the richest in their leaves Fe content during both experimental seasons of study. However, those on Volkameriana were the poorest, while budded nursery trees (transplants) on Cleopatra mandarin were intermediate in this concern. Differences between three rootstocks were significant as compared each other during both seasons of study.

Nevertheless, leaf Fe content respond specifically to soil site, where nursery trees (transplants) grown in El-Gabal Al-Asfar had significantly richer leaves Fe content as compared to the analogous ones grown in Dahshour soil during two seasons of study.

B. Interaction effect:

Concerning the interaction effect of different combinations between three investigated factors (irrigation water resource, citrus rootstock and soil site), **Table (32)** reveals that the sewage effluent irrigated Valencia orange nursery trees (transplants) budded on rough lemon rootstock and grown un El-Gabal Al-Asfar soil were statistically the richest in their leaves Fe content during both 2000-02 and 2001-03 experimental seasons. Moreover, those budded on Cleopatra mandarin and irrigated with sewage effluent in Dahshour soil ranked statistically second during both experimental seasons in this concern.

On the contrary, fresh water irrigated nursery trees (transplants) grown in Dahshour soil were statistically the inferior, regardless of citrus rootstocks on which they were budded during both experimental seasons. In addition, other combinations were in between.

The trend of response to water resource detected in the present study is in agreement with that obtained by **Abd-El-Naim and El-Awady, (1989)** who concluded that leaf Fe content increased in irrigated citrus trees with sewage effluent.

However, the response to rootstock goes in line of **Salem** *et al.*, **(1994)** on orange; **Wu** *et al.*, **(1998)** on orange and **Marathe** *et al.*, **(2000)** on citrus, all reported that Fe level was in closed relationship to rootstock.

Leaf manganese content:

A. Specific effect

Regarding the specific effect of irrigation water resource, tabulated data in **Table (32)** revealed that leaf Mn content followed typically the same trend previously detected with iron. Hence, the sewage irrigated nursery trees (transplants) had statistically richer leaves in their Mn content as compared to those irrigated with fresh water.

Concerning the specific effect of citrus rootstock used, **Table (32)** reveals that budded nursery trees (transplants) on rough lemon were the richest, while those on Volkameriana had the poorest leaves Mn content. In addition, Cleopatra mandarin was intermediate, however it didn't significantly differ as compared to Volkameriana rootstock during both seasons.

Referring the soil site, both regions didn't significantly differ during two seasons.

B. Interaction effect:

Data obtained during both seasons revealed obviously that the richest leaves Mn content were significantly in closed relationship to the sewage irrigated nursery trees (transplants) budded on rough lemon and grown in El-Gabal Al-Asfar soil. However, those budded on Cleopatra mandarin and irrigated with sewage effluent ranked statistically second when grown in Dahshour soil during both experimental seasons. On the contrary, the least leaf Mn content was markedly coupled to both combinations representing the fresh water irrigated nursery trees (transplants) budded on either Cleopatra mandarin or Volkameriana when grown in El-Gabal Al-Asfar and Dahshour soils, respectively during two seasons of study.

In addition, other combinations were in between the aforesaid two extremes with tendency of variance as members of such intermediate category compared each other during both experimental seasons of study.

This result goes in line with that previously found by **Abd El-Naim and El-Awady ,(1989)** on citrus regarding the increasing effect of irrigation with sewage effluent on leaf Mn content.

Meanwhile, the findings of **Salem *et al.*, (1994); Wu *et al.*, (1998) and Marathe *et al.*, ((2000)** gave support to the present result regarding the effect of rootstock on leaf Mn content.

Leaf zinc content:

A. Specific effect:

Table (32) displays that the Leaf Zn content in response to the specific effect of irrigation water resource followed typically the same trend previously detected with both Fe and Mn. Herein, sewage irrigated nursery trees (transplants) were significantly richer in their leaf Zn content as compared to those irrigated with fresh water during both experimental seasons.

As for the specific effect of citrus rootstock used, **Table (32)** displays that Volkameriana rootstock increased significantly leaf Zn level as compared to either rough lemon or Cleopatra mandarin, where both were equally the same from the statistical point of view in two seasons of study.

Referring the specific effect of soil site, it is quite evident as shown from tabulated data in **Table (32)** that nursery trees (transplants) grown in El-Gabal Al-Asfar soil were statistically richer than those in Dahshour soil as their leaves Zn content was concerned during both experimental seasons.

B. Interaction effect:

Table (32) displays obviously that the sewage irrigated Valencia orange nursery trees (transplants) budded on Volkameriana rootstock and grown in El-Gabal Al-Asfar soil had statistically the richest leaves Zn content. However, those on Cleopatra mandarin grown in the same soil and supplied with the same irrigation water ranked statistically the 2^{nd} during both experimental seasons.

On the contrary, the least leaf Zn content was significantly coupled with those irrigated with fresh water and grown in Dahshour soil, especially when budded on either Volkameriana or rough lemon during two seasons of study. Moreover, other combinations were in between the aforesaid two extremes.

The present result regarding the influence of water resource on leaf Zn content is supported by **Abd El- Naim and El-Awady, (1989)** on citrus trees. On the other hand, **Salem *et al.*, (1994)** and **Marathe *et al* ., (2000)** pointed out an obvious response to rootstock as leaf Zn of citrus was concerned.

Leaf copper content:

A. Specific effect:

Table (32) shows that leaf Cu content respond specifically to the irrigation water resource. Herein, the sewage effluent irrigated nursery trees (transplants) had significantly richer leaves Cu content i.e, (20.1 & 20.9) and (11.6 & 12.3) ppm for the sewage and fresh water irrigated nursery trees (transplants), respectively during both experimental seasons.

As for the specific effect of citrus rootstock used, **Table (32)** shows that budded nursery trees (transplants) on Volkameriana were the richest in their leaf Cu content as compared to the analogous ones on two other rootstocks during both experimental seasons from statistical point of view. However, leaves of nursery trees (transplants) on Cleopatra mandarin tended to be richer than those on rough lemon, but difference was significant during second season only.

As for the specific effect of soil site, obtained data revealed that leaves of growing nursery trees (transplants) in El-Gabal Al-Asfar soil were significantly richer than the analogous ones in Dahshour soil during two seasons.

B.Interaction effect:

Data obtained during both experimental seasons displayed obviously that the sewage irrigated nursery trees (transplants) budded on volkameriana and grown in El-Gabal Al-Asfar soil had statistically the richest leaves Cu content followed by those budded on Cleopatra mandarin supplied by sewage effluent and grown in the same soil. Differences between the aforesaid two superior combinations from one side and other combinations from the other were significant during both experimental seasons. On the contrary, the least Cu content was generally in closed relationship to the fresh water irrigated nursery trees (transplants), however those grown in El-Gabal Al-Asfar either budded on Volkameriana or rough lemon, beside those on later rootstock and grown in Dahshour soil were statistically the inferior during both experimental seasons. In addition, other combinations were in between the aforesaid two extremes.

The trend of response detected in the present study regarding the effect of irrigation water resource on leaf Cu content goes in line with that found by **Abd El- Naim and El-Awady. (1989).**

However, the response to citrus rootstock is in agreement with findings of **Alva and Chen, (1995) and Wu** ***et al.,*** **(1998),** but in disagreement with **Marathe** ***et al*** **., (2000)** who found that there is no difference due to rootstock.

Leaf sodium and some heavy metals contents:

In this regard leaf Na; Pb and Ni contents of Valencia orange transplants in response to irrigation water resource; citrus rootstocks used for budding and soil site were investigated. Data obtained during both 2000-02 and 2001-03 experimental seasons are presented in **Table (33).**

Leaf sodium content:

A. Specific effect:

Table (33) shows obviously that leaf Na content responds significantly to the irrigation water resource. Hence, the swage effluent irrigated nursery trees (transplants) were significantly richer in their leaves Na content as compared to those irrigated with fresh water during both experimental seasons.

As for the specific effect of citrus rootstock used, it could be noticed clearly that budded nursery trees (transplants) on rough lemon exhibited statistically the highest leaf Na content. However, those on either Volkameriana or Cleopatra mandarin were statistically similar as compared each other during both seasons of study.

Referring the specific effect of soil site, difference was completely absent from statistical point of view during both seasons.

Table (32): Leaf Fe; Mn; Zn and Cu in Valencia orange nursery trees (transplants) as influenced by specific and interaction effects of water resource; citrus rootstock and soil region during two successive experimental 2000 -02 and 2001- 03 seasons.

Water &soil	Rootstocks	Fe ppm Vol	Fe ppm R. l.	Fe ppm C.m.	Fe ppm M *	Mn ppm Vol	Mn ppm R. l.	Mn ppm C.m.	Mn ppm M *	Zn ppm Vol	Zn ppm R. l.	Zn ppm C.m.	Zn ppm M *	Cu ppm Vol	Cu ppm R. l.	Cu ppm C.m.	Cu ppm M *
2000 - 02 season																	
Sewage	El-Gabal(S_1)	167.0 c	222.5 a	135.5 d	165.1 A	42.9 c	52.8 a	40.2 d	43.3 A	66.2 a	40.4 c	43.9 d	44.2 A	36.4 a	16.0 de	18.4 b	20.1 A
	Dahshour (S_2)	108.6 e	161.8 c	195.3 b		33.6 e	44.2 c	46.3 b		37.8 b	36.1 e	40.5 c		17.8 bc	15.2 e	17.0 cd	
Fresh	El-Gabal (S_1)	86.7 f	82.5 f	73.3 g	61.6 B	30.5 f	26.3 gh	20.9 I	25.3 B	34.3 f	30.4 g	26.9 I	26.9 B	10.0 g	8.1 h	13.0 f	11.6 B
	Dahshour (S_2)	41.0 h	40.8 h	45.0 h		20.6 I	28.0 fg	25.3 h		22.8 c	18.5 k	28.7 h		12.8 f	12.6 f	12.9 f	
Mean **(Rootstock)		100.8 C	126.9 A	112.3 B		31.9 B	37.8 A	33.2 AB		40.3 A	31.4 B	35.0 B		19.3 A	13.0 B	15.3 B	
Mean *** El-Gab. (S_1); Dahs.(S_2)		S_1=127.9 A		S_2=98.8 B		S_1=35.6 A		S_2=33.0 A		S_1=40.4 A		S_2=30.7 B		S_1=17.0 A		S_2=14.7 B	
2001 - 03 season																	
Sewage	El-Gabal (S_1)	156.8 c	205.5 a	130.5 e	153.1 A	44.5 d	57.4 a	45.0 d	47.7 A	58.5 a	38.9 d	45.0 b	41.7 A	32.4 a	17.4 d	21.3 b	20.9 A
	Dahshour (S_2)	98.3 f	146.9 d	180.8 b		40.4 e	47.5 c	51.5 b		34.8 e	30.7 f	42.5 c		19.0 c	15.1 e	20.1 bc	
Fresh	El-Gabal (S_1)	82.0 g	74.7 gh	71.5 h	61.1 B	35.0 f	28.1 h	19.2 j	27.4 B	26.6 g	21.9 h	20.9 hi	21.4 B	11.9 fgh	11.4 gh	13.3 f	12.3 B
	Dahshour (S_2)	50.9 I	45.3 ij	42.4 j		23.8 I	31.8 g	26.2 h		19.5 I	19.1 I	20.6 hi		12.8 fg	11.1 h	13.1 f	
Mean **(Rootstock)		97.0 C	118.1 A	106.3 B		35.9 B	41.2 A	35.5 B		34.9 A	27.7 B	32.3 B		19.0 A	13.8 B	17.0 A	
Mean *** El-Gab. (S_1); Dahs.(S_2)		S_1=120.3 A		S_2=94.3 B		S_1= 38.2 A		S_2=36.9 A		S_1=35.3 A		S_2=27.9 B		S_1=17.9 A		S_2=15.2 B	

* ; ** and *** refer to specific effect of water resource ; citrus rootstock and soil region, respectively. Whereas means within each row or column followed by the same letter/s are not significantly different at 5 % level , capital letters were used for distinguishing means of each investigated factor, while small ones for means of interaction(their combinations.)

B. Interaction effect:

Table (33) shows obviously that the sewage irrigated nursery trees (transplants) budded on rough lemon and grown in Dahshour soil had statistically the richest leaves Na %, followed by three combinations of sewage irrigated transplants grown in El- Gabal Al-Asfar, irrespective of citrus rootstock, where these three combinations ranked statistically 2nd from one hand and were equally the same as their leaves Na % was compared to each other during both experimental seasons from the other.

On the contrary, leaves of budded nursery trees (transplants) on Cleopatra mandarin and irrigated with fresh water in Dahshour soil exhibited statistically the least leaf Na % during both seasons. In addition, other combinations were in between with a relative tendency of variance.

The higher leaf Na content exhibited by the sewage effluent irrigated transplants is supported by the earlier findings of **Koo and Zekri, (1989) and Lapena *et al.*,(1995)** .

Meanwhile, the effect of rootstock on Na accumulation in leaves of scion was in general agreement with the findings of several investigators who studied the ability of rootstock root system to absorb Na under salinity conditions.

Leaf lead content:

A. Specific effect:

Concerning the response of leaf Pb content to specific effect of water resource, **Table (33)** reveals that the sewage irrigated Valencia orange transplants had leaves contained significantly higher lead. The increase was approximately two folds much higher than those of fresh water irrigated nursery trees (transplants) during two seasons i.e., (3.93 & 3.64) and (1.53 & 1.5) ppm for the sewage effluent and fresh water irrigated nursery trees (transplants), respectively.

As for the specific effect of citrus rootstock used, it was quite evident that Volkameriana rootstock increased significantly leaves Pb content of Valencia orange scion as compared to two other investigated rootstocks (rough lemon and Cleopatra mandarin) during both seasons. On the other hand, leaves Pb content of budded nursery trees (transplants) on rough lemon tended to be decreased as compared to those on Cleopatra mandarin, however difference was significant during 2nd season only.

Regarding the specific effect of soil site, **Table (33)** displays that the difference was too slight to reach level of significance, however level tended slightly to be increased in El-Gabal Al-Asfar soil during two seasons .

B. Interaction effect:

Table (33) reveals that the more pronounced response to either irrigation water resource or citrus rootstock rather than soil site reflected obviously on interaction effect of different combinations between the investigated three factors. Herein, the highest leaf Pb content was always in significant concomitant to the sewage irrigated nursery trees (transplants) budded on Volkameriana rootstock (regardless of soil site). Moreover, sewage irrigated transplants budded on Cleopatra mandarin and grown in El-Gabal Al-Asfar soil ranked second especially as an average of two seasons was concerned , however, the reduction below the superior combination was not significant during 2nd season . On the contrary, fresh water irrigated nursery trees (transplants) budded on rough lemon rootstock (regardless of soil site) showed statistically the least leaf Pb content during both seasons of study. In addition, other combinations were in between, however those of sewage irrigation included in such intermediate category tended to be richer in their leaves Pb content during both seasons.

Leaf nickel content:

A. Specific effect:

With regard to specific effect of irrigation water resource on leaf Ni content, **Table (33)** displays that sewage effluent resulted in increasing it significantly i.e, about 3 folds much higher than fresh water. Herein, leaf Ni content during both seasons for the sewage effluent and fresh water irrigated nursery trees (transplants) was (3.398 & 3.256) and (1.077 & 1.167) ppm, respectively.

Referring the specific effect of citrus rootstocks used, **Table (33)** reveals that Volkameriana rootstock increased significantly leaf Ni content as compared to two other investigated ones during both seasons. However, both rough lemon and Cleopatra mandarin were equally the same from statistical point of view as their effect on leaves Ni content was concerned during both experimental seasons.

As for the specific effect of soil site, it is quite clear that Valencia orange nursery trees (transplants) in El-Gabal Al-

Asfar soil were significantly richer in their leaves Ni content as compared to those grown in Dahshour soil during both seasons.

B. Interaction effect:

Table (33) shows that leaves of sewage irrigated Valencia orange nursery trees (transplants) budded on Volkameriana and grown in El-Gabal Al-Asfar soil had statistically the highest Ni level i.e, 6.735 and 6.507 ppm during first and second seasons, respectively. Moreover, nursery trees (transplants) on the same rootstock and water resource but grown in Dahshour soil ranked statistically second i.e, 4.695 and 4.419 ppm during first and second seasons, respectively. On the contrary, the fresh water irrigated nursery trees (transplants) grown in Dahshour soil and budded on either rough lemon or Volkameriana rootstocks had statistically the least leaf Ni content during both seasons.

Such result concerning the variance due to either irrigation water resource or citrus rootstock could be logically explained depending upon the fact that sewage effluent containing higher Na; Pb and Ni levels than those in fresh water from one hand, and differences in some biological characteristics (especially selectivity of root to absorb) from the other. Herein, the obtained results declared the great variance in selectivity of three rootstocks, where both Volkameriana and Cleopatra mandarin surpassed rough lemon regarding their potentiality for Na absorption, while the reverse was true for their selectivity regarding Pb and Ni absorption, where rough lemon and Cleopatra mandarin rootstocks had higher selectivity in this concern.

The present results regarding the increase in leaf Pb and Ni contents of sewage irrigated nursery trees (transplants) are in general agreement with the findings of **Aboulroos *et al.*, (1989)** on (maize and orange) and **Hamad, (1993)** on some vegetable crops. However, the variance due to rootstocks may be attributed to the biochemical characteristics of various rootstocks regarding their ability to absorb different elements.

V. II. III. Residual effect of irrigation water resource used on some soil physical and chemical properties:

V. II. III. 1. Soil physical properties:

In this respect, percentage of different particle size (corse; fine sand; silt; clay and soil texture) of virgin soil of two regions under study (Dahshour and El-Gabel Al-Asfar) as influenced by the irrigation water resource along the 2nd 2001-03 experimental season was concerned. Tabulated data in **Table (34-A)** declared a noticeable response however such influence varied from one characteristic to another. Herein, the coarse sand % was slightly decreased after different irrigation treatments. The reduction was relatively greater in the sewage irrigated virgin soil of two soil sites (Dahshour & El-Gabal Al-Asfar).

Nevertheless, the fine sand % was also slightly decreased in virgin soil of two sites by using water from two resources for irrigation. However, the rate of reduction was relatively higher in fresh water irrigated soil of two sites.

Table (33): Leaf sodium and some heavy metals (Pb and Ni) contents in Valencia orange nursery trees (transplants) as influenced by specific and interaction effects of water resource; citrus rootstock and soil region during two successive experimental 2000 - 02 and 2001 - 03 seasons.

Water &soil	Rootstocks	Na % Vol.	Na % R. l.	Na % C.m.	Na % M *	Pb ppm Vol.	Pb ppm R. l.	Pb ppm C.m.	Pb ppm M *	Ni ppm Vol.	Ni ppm R. l.	Ni ppm C.m.	Ni ppm M *
2000 - 02 season													
Sewage	El-Gabal (S_1)	0.224 cd	0.240 bc	0.242 bc	0.250 A	4.575 a	3.400 d	3.950 bc	3.933 A	6.735 a	2.110 c	2.165 c	3.398 A
	Dahshour (S_2)	0.207 de	0.403 a	0.184 ef		4.395 ab	3.625 cd	3.650 cd		4.695 b	2.230 c	2.455 c	
Fresh	El-Gabal (S_1)	0.170 fg	0.145 g	0.179 f	0.152 B	2.068 e	1.365 gh	1.600 fg	1.528 B	1.063 de	1.283 d	1.345 d	1.077 B
	Dahshour (S_2)	0.152 g	0.153 fg	0.116 h		1.575 fg	1.350 gh	1.212 h		0.815 f	0.583 ef.	1.375 d	
Mean **(Rootstock)		0.188 B	0.235 A	0.180 B		3.153 A	2.435 B	2.603 B		3.327 A	1.552 B	1.835 B	
Mean *** El-Gab. (S_1); Dahs.(S_2)		S_1=0.199 A		S_2=0.202 A		S_1=2.826 A		S_2=2.635 A		S_1=2.450 A		S_2=2.025 B	
2001- 03 season													
Sewage	El-Gabal (S_1)	0.237 b	0.233 b	0.233 b	0.241 A	4.472 a	3.243 b	4.090 a	3.640 A	6.507 a	2.255 c	2.056 d	3.256 A
	Dahshour (S_2)	0.203 bc	0.365 a	0.176 cd		4.550 a	2.543 c	2.959 bc		4.419 b	2.130 c	2.170 c	
Fresh	El-Gabal (S_1)	0.145 de	0.138 e	0.173 cd	0.145 B	1.678 d	1.271 d	1.530 d	1.500 B	1.143 de	1.344 d	1.211 de	1.167 B
	Dahshour (S_2)	0.142 de	0.150 de	0.121 e		1.470 d	1.450 d	1.586 d		1.058 de	0.907 e	1.339 d	
Mean **(Rootstock)		0.182 B	0.221 A	0.176 B		3.043 A	2.104 C	2.541 B		3.282 A	1.659 B	1.694 B	
Mean *** El-Gab. (S_1); Dahs.(S_2)		S_1=0.193 A		S_2=0 .193 A		S_1=2.714 A		S_2=2.426 A		S_1=2.419 A		S_2=2.004 B	

* ; ** and *** refer to specific effect of water resource ; citrus rootstock and soil region, respectively. Whereas means within each row or column followed by the same letter/s are not significantly different at 5 % level , capital letters are used for distinguishing means of each investigated factor, while small ones for means of interaction(their combinations.)

As for the response of smaller particles (silt and clay) the trend took the other way around as compared to that previously detected with both corse and fine sands. Consequently, a considerable increase in both silt and clay particles was exhibited in soils of two sites when irrigated with sewage effluent; however the change exhibited by irrigation with fresh water was so slight or completely absent.

As for the available rates of some nutrient elements and heavy metals in soil extract (ppm) of virgin soil in response to irrigation water resource, data obtained during the second 2001-03 season are presented in **Table (34- B).** It is quite clear that the response varied from one element to another. Anyhow., N; P; K; Mg; Cu; Fe; Mn; Zn; and Pb were increased in irrigated soil especially those supplied with sewage effluent, while the increase in fresh water irrigated ones was too slight or in some cases completely absent.

As for the changes in electrical conductivity (EC); sodium adsorption ratio (SAR); Anions and cations of virgin soil used from two sites (EL-Gabal Al-Asfar and Dahshour regions) as influenced by irrigation water resource, data obtained during second 2001- 03 season are presented in **Table (34-C).**

The changes in EC in response to water resource varied from one site to another. Herein, EL-Gabal Al- Asfar soil its EC was nearly remained constant at the end of experimental season, regardless of the irrigation water resource. However, with Dahshour soil its EC was greatly reduced by irrigation with both sewage effluent and fresh water, but the rate of reduction was more pronounced with using fresh water than sewage effluent.

This result regarding the two conflicted trends of response to irrigation water resources for two soil sites may be attributed to the variance in salinity levels in virgin soil of two sites (which tended to be obviously higher in Dahshour site). So irrigation resulted in higher rate of leaching for the solving salines in Dahshour soil.

As for the changes in SAR, **Table (34-C)** reveals that two opposite trends were detected. Hence, in EL-Gabal Al-Asfar soil its SAR increased from 3.2 to 5.1 after irrigation with sewage affluent but was still constant after irrigation with fresh water. However, in Dahshour soil the trend took the other way around, where SAR was greatly decreased from 9.3 in virgin soil to 6.7 and 4.3 after irrigation with sewage effluent and fresh water, respectively.

Nevertheless, the changes in HCO_3 of two soil sites due to irrigation with two water resources exhibited that a considerable reduction was observed in sewage irrigated soil of two sites, while the fresh water didn't affect it in two sites. However, Cl level showed severe rate of reduction in Dahshour soil (decreased from 32.97 to 13.8and 3.96 after irrigation with sewage effluent and fresh water, respectively). The changes in Cl of El-Gabal Al-Asfar soil exhibited an obvious decrease after irrigation with fresh water, but sewage effluent didn't influence it. The influence of irrigation water resource on SO_4 level as shown from **Table (34-C)** pointed out that no considerable changes were detected in El-Gabal Al-Asfar, regardless of water resource. However, in Dahshour soil a noticeable reduction in soil level was detected particularly in the fresh water irrigated Dahshour soil.

With regard to changes in some cations i. e., Ca; Mg; Na and K, **Table (34-C)** reveals that the response varied from one cation to another. Anyhow, Ca was still constant in El-Gabal Al-Asfar soil after irrigation with two water resources, while in Dahshour soil it was obviously decreased, especially after irrigation with fresh water. Magnesium was increased by two irrigation water resources in two soil sites, except in fresh water irrigated Dahshour soil where it was slightly decreased.

In addition, Na level didn't change in El-Gabal Al-Asfar soil, but it was severely reduced in Dahshour soil after irrigation with either sewage effluent or fresh water, especially later one (decreased from 35.64 to 7.8 meq. / L.).

The trend of response for potassium showed a considerable reduction in El-Gabal Al-Asfar soil (regardless of water resource), while in Dahshour soil the level was still constant after irrigation with any of two water resources.

The obtained results regarding the changes in both soil physical and chemical characteristics exhibited after irrigation with sewage and fresh water go partially with the findings of **El-Nashar, (1985); Allam, (1986); Zekri and Koo, (1990); Abdel Aal *et al.*, (1991); Badawy and Helal, (1997) and El-Gala *et al.*, (2003).**

Table(34) Changes in physical and chemical properties of virgin soil brought from (El- Gabal Al- Asfar and Dashour regions) after irrigation with sewage effluent and well water during the second experimental season 2001-03.

A. Soil physical properties

Soil site	Irrigation water	Particle size				texture
		coarse sand %	Fine sand %	silt %	caly %	
EL Gabal Al Asfar	no irrigated virgin soil	96.2	1.60	1.20	1.00	sandy
	sewage	94.6	1.54	2.42	1.44	sandy
	fresh	96.2	1.34	1.46	1.00	sandy
Dahshour	no irrigated virgin soil	92.6	2.80	2.40	2.20	sandy
	sewage	92.2	2.75	2.65	2.40	sandy
	fresh	92.5	2.65	2.40	2.36	sandy

B - Available nutrient and heavy elements (mg/L)

Soil site	Irrigation water	N	P	K	Mg	Cu	fe	Mn	Zn	Ni	Pb
EL Gabal Al Asfar	no irrigated virgin soil	12	0.02	50	24	0.40	3	0.01	0.20	0.30	0.37
	sewage	120	0.36	89.7	38.86	0.83	7.57	0.07	1.28	0.41	1.50
	fresh	5.1	0.21	109.2	25.61	0.55	3.07	0.04	0.21	0.25	0.70
Dahshour	no irrigated virgin soil	18.8	0.07	73.3	27.92	0.19	4.07	0.01	0.32	0.28	0.41
	sewage	138.9	0.23	78	30.25	0.63	5.32	0.06	1.02	0.41	1.30
	fresh	11.2	0.03	124	27.6	0.20	3.23	0.04	0.31	0.28	0.60

C- Some chemical constituents

Soil site	Irrigation water	Ec	SAR	Anions meq/l				Cations meq/l			
				CO_3^{--}	HCO_3^{--}	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
EL Gabal Al Asfar	no irrigated virgin soil	1.08	3.2	0	1.95	3.88	5.06	4.81	0.29	5.00	0.79
	sewage	1	5.1	0	1.04	3.96	5	4.6	1.15	6.49	0.30
	fresh	1.02	3	0	1.8	1.98	5.9	5.15	1.27	5.33	0.25
Dahshour	no irrigated virgin soil	4.3	9.3	0	1.94	32.97	14.99	11.33	1.78	35.64	0.25
	sewage	2	6.7	0	1.04	13.8	10	10.2	2.34	12.95	0.30
	fresh	1	4.3	0	1.85	3.96	7.8	7.8	1.23	7.8	0.25