RESULTS AND DISCUSSION

IV- RESULTS AND DISCUSSION

IV.I- First Experiment: Effect of irrigation regimes:

In this regard specific and interaction effects of three factors i.e., a) irrigation regime (rewatering at 25 %, 50 % and 75 % depletion of the available water); b) geographical direction (north & south) c) and/or fruit status (sound & creased), as well as their combinations were investigated pertaining the response of fruit qualities, (physical & chemical properties); creasing incidence and nutritional status (leaf & fruit rind mineral compositions) of Tanarif orange trees were the investigated characteristics during both 2002/2003 & 2003/2004 experimental seasons.

IV.I.1-Fruit quality:

Data obtained during both experimental seasons regarding the specific and interaction effects of different available soil water levels, fruit status (sound & creased) and geographical direction of fruit localities towards north or south, as well as their combinations on both physical and chemical properties of Tanarif fruits are presented in **Tables (3); (4); (5); (6); (7) and (8)**.

IV.I.1.A- Fruit physical properties:

Average fruit weight; size; dimensions (polar & equatorial diameters); fruit rind thickness, rind weight and fruit juice weight, volume of Tanarif fruits were investigated in response to specific and interaction effects of different available soil water levels, geographical (north & south) directions and fruit status (sound & creased) as well as their combinations. Data obtained during both seasons are presented in **Tables (3, 4, 5 and 6)**.

Average fruit weight (g) and size (cm^3):

Data obtained during both 2002/2003 & 2003/2004 experimental seasons are presented in **Table (3)**.

A- Specific effect:

Referring the specific effect of irrigation regime i.e., the depleted available soil water % at which rewatering was carried out, it is quite clear to be noticed the negative relationship between both fruit weight and fruit size parameters from one hand and the percentage of depleted available water from the other. Hence, the weight and size of fruit was continuously decreased with raising the limit of irrigation regime (percentage of depleted available water). Anyhow, Tanarif trees subjected to the irrigation regime at 25 % depleted A. W. had significantly the highest values of weight and size, while the reverse was true with those irrigated after 75 % depletion of A.W. Moreover, irrigation after 50 % of A. W. were in between, whereas, differences were significant during both seasons.

The present results are in agreement with those found by **Krome *et al.*, (1970)** on Tahiti lime; **Abd El-Meesih *et al.*, (1977)** on Washington navel orange, **Swellem (1986)** on Valencia orange trees and **Abd- El- Metaal (1990)** in some citrus trees who reported that highest fruit weight was obtained from trees receiving the highest number of irrigation during the growth seasons. Moreover, **Sepaskhah and Kashefipour (1994)** on sweet lime and **Ali & Gobran (2002)** on Washington navel orange trees, reported that the maximum fruit weight of both sweet lime and Washington navel orange fruits resulted at higher water application.

As for the specific effect of fruits localities across the tree periphery towards both northern and southern geographical direction, **Table (3)** shows obviously that fruits of northern half of tree canopy had significantly higher values in both average fruit weight and size as compared to those of the southern hemisphere during the two seasons of study. These results could be confirmed with that reported by **Fatma (2003)** on Hamlin cultivar. She found that northern half of tree canopy induced fruits significantly higher in their average fruit weight and size as compared to those of southern limbs.

Regarding the specific effect of fruit status (sound & creased), it is so clear that sound Tanarif fruits had heavier average fruit weight and size as compared to those of creased fruits during both seasons of study. Such results are in general agreement with the findings of **Miller (1945)** who stated that small mature fruits were more subjected to creasing than large a ones. **Salama (1979) and Fatma (2003)** reported that values of fruit weight and volume were less in cracked Balady orange fruit and Hamlin orange fruits than sound ones, respectively.

B- Interaction effect:

With respect to the interaction effect of various combinations between three investigated factors i.e., different available soil water levels x geographical direction (northern & southern) and fruit status (sound & creased) during both 2002/2003 and 2003/2004 seasons on both fruit weight and size, **Table (3)** displays that each investigated factor reflected its own specific effect on the interaction effect of their combinations. Hence, the heaviest fruits with the largest size were coupled with those fruits situated within the northern limbs of Tanarif trees irrigated after depletion of 25 % available water. The superiority of those sound fruits borne on northern scaffolds of Tanarif trees irrigated after depletion of 25% available water over other investigated combinations pertaining their average fresh weight and size was more pronounced during both seasons with the unique exception viz with comparison to those fruits of the northern limbs regardless of irrigation regime during two seasons. Moreover, Tanarif fruits (sound & creased) of trees irrigated after depletion of 50 % and/or 75 % available water and borne on the northern branches which ranked statistically second after the superior combination. Contrary to that, creased fruits situated on southern side of Tanarif trees irrigated after depletion of 75 % available water were statistically the lightest during 1st and 2nd seasons of study. In addition, other combinations were in between.

Fruit dimensions (polar & equatorial diameters):

A- Specific effect:

Referring the response of fruit dimensions i.e., fruit height (polar diameter) and fruit width (equatorial diameter) to specific effect of different depleted available soil water levels (25, 50 & 75 %), at which irrigation was carried out, data obtained during both seasons as shown from **Table (4)** pointed out that both fruit dimension followed the same trend. In this regard, reducing the available soil moisture significantly decreased fruit dimensions. There were significant differences between the treatment after depletion of 25 % A. W. (wet treatment) and both of treatments 50 %

Table (3): Average fruit weight and size of sweet orange "Tanarif" cv. in response to specific and interaction effects of irrigation regime, geographical direction, fruit status and their combinations in Feb. sampled during the two successive 2002/2003 and 2003/2004 seasons.

Treatments / Direction and fruit status	Fruit weight (g.)				Mean *	Fruit size (cm^3)				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	185.3a	182.5ab	172.8bc	170.8cd	**177.8A**	186.0a	184.8a	173.8b-d	171.5c-e	**179.0A**
Irrigation after depletion of 50 % available water	181.8ab	179.0a-c	171.5cd	170.0cd	**175.6B**	183.3a	181.8ab	172.3c-e	170.8c-e	**177.0B**
Irrigation after depletion of 75 % available water	178.3a-c	176.0a-c	172.8bc	162.5d	**172.4C**	180.8ab	178.3a-c	167.3de	165.0e	**172.8C**
Mean (direction)**	**180.5A**		**170.0B**			**182.5A**		**170.1B**		
Mean* (fruit status)**	**Sou. 177.0A**		**Cre. 173.5B**			**Sou. 177.2A**		**Cre. 175.3B**		
2003/2004 season										
Irrigation after depletion of 25 % available water	182.8a	179.5a	171.8b	167.5bc	**175.4A**	188.3a	181.8b	175.8c	170.5cd	**179.1A**
Irrigation after depletion of 50 % available water	167.3bc	163.0c	156.5d	151.3d-f	**159.5B**	173.3c	166.0d	160.3e	154.0fg	**163.4B**
Irrigation after depletion of 75 % available water	154.0de	150.0ef	146.3f	141.0g	**147.8C**	158.3ef	152.3g	150.8g	143.8h	**151.3C**
Mean (direction)**	**166.1A**		**155.7B**			**170.0A**		**159.2B**		
Mean* (fruit status)**	**Sou. 163.1A**		**Cre. 158.7B**			**Sou. 167.8A**		**Cre. 161.4B**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

A. W. and 75 % A.W. (dry treatments) in the two seasons of study. The prementioned results are supported by several workers, **Hilgeman (1951), Beutel (1965), Hilgeman and Sharples (1970), Swellem (1986) and Abd El-Metaal (1990).**

Regarding the response of fruit dimensions i.e., fruit height (polar diameter) and fruit width (equatorial diameter) to specific effect of geographical direction towards which the fruits carrier branches were directed, data obtained during both seasons as shown from **Table (4)** pointed out that both fruit dimension followed the same trend and significantly influenced by the geographical direction, whereas Tanarif fruits borne on limbs towards the north had an obvious taller height and width over those facing the opposite direction (south) during both seasons of study. The detected trend regarding the specific effect of geographical direction on fruit polar diameter goes generally in the line of that found by **Fatma (2003)** on Hamlin orange.

Concerning the specific effect of fruit status (sound & creased), data obtained in **Table (4)** showed that creased fruits induced the lowest values of both polar and equatorial diameters as compared with sound fruits during 2002/2003 and 2003/2004 seasons. These results are confirmed by those reported by **Salama (1979) and Diab (1982)**. They found that values of the fruit dimensions (height & width) were less in cracked Balady orange than sound fruits.

B- Interaction effect:

With respect to the response of fruit dimensions to interaction effect of differential investigated combinations between 3 irrigation regimes i.e., after depletion of (25, 50 and 75 % available soil water), 2 directions (north & south) and 2 fruit status (sound & creased), data in **Table (4)** displayed that both sound & creased fruits from northern direction and irrigation after depletion 25 % A.W. generally showed the greatest fruit dimensions i.e., fruit height (polar diameter) and fruit width (equatorial diameter) during the 1st and 2nd seasons of study.

Contrary to that, creased fruits of Tanarif trees x southern direction and irrigation after depletion of 75 % A.W. had statistically the least values of both fruit height & width during the two seasons of study. Moreover, other combinations were in between the aforesaid two extremes.

Fruit rind thickness (mm) and weight (g):

In this regard fruit peel thickness and rind weight of Tanarif orange in response to specific and interaction effects of different depleted available soil water levels (25, 50 and 75 %), geographical direction (north & south) and/or fruit status (sound & creased) as well as their combinations were investigated. Data obtained during both 2002/2003 & 2003/2004 experimental seasons are presented in **Table (5)**.

A- Specific effect:

Concerning the specific effect of available soil water levels treatments (irrigation regime) on both rind thickness and weight, the recorded data in **Table (5)** clearly show that both parameters followed typically the same trend in both seasons. It is quite clear to be noticed the positive relationship between both rind thickness and weight parameters from one hand and percentage of depleted available soil water at which rewatering was carried out from the other. Hence, the thicker rind thickness (mm) and heavier rind weight (g) was obtained by the dry irrigation. The

Table (4): Average fruit polar diameter (cm) and fruit equatorial diameter (cm) of sweet orange "Tanarif" cv. in response to specific and interaction effects of irrigation regime, geographical direction, fruit status and their combinations in Feb. sampled during the two successive 2002/2003 and 2003/2004 seasons.

Treatments / Direction and fruit status	Fruit polar diameter (cm)				Mean *	Fruit equatorial diameter (cm)				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	5.37a	5.34ab	5.30a-c	5.21c	**5.31A**	5.41a	5.35ab	5.39a	5.22cd	**5.34A**
Irrigation after depletion of 50 % available water	5.25bc	5.19c	5.24bc	5.18c	**5.22B**	5.40a	5.29a-c	5.27bc	5.12de	**5.27B**
Irrigation after depletion of 75 % available water	5.25bc	5.25bc	4.94d	4.83e	**5.07C**	5.19cd	5.07ef	5.02ef	4.97f	**5.06C**
Mean (direction)**	**5.27A**		**5.12B**			**5.28A**		**5.16B**		
Mean* (fruit status)**	**Sou. 5.23A**		**Cre. 5.17B**			**Sou. 5.28A**		**Cre. 5.17B**		
2003/2004 season										
Irrigation after depletion of 25 % available water	5.70a	5.62ab	5.59bc	5.47d-f	**5.56A**	5.90a	5.75b	5.92a	5.74b	**5.83A**
Irrigation after depletion of 50 % available water	5.49d-f	5.42ef	5.55b-d	5.40fg	**5.50B**	5.69bc	5.58cd	5.67bc	5.57cd	**5.63B**
Irrigation after depletion of 75 % available water	5.51c-e	5.31gh	5.40fg	5.29h	**5.38C**	5.66bc	5.53d	5.59cd	5.47d	**5.56C**
Mean (direction)**	**5.51A**		**5.45B**			**5.69A**		**5.66B**		
Mean* (fruit status)**	**Sou. 5.54A**		**Cre. 5.42B**			**Sou. 5.74A**		**Cre. 5.61B**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

obtained data show that the Tanarif trees irrigated after depletion 25 % A.W. gave the thinner rind and lighter weight as compared with the other treatments (after depleted 50 & 75 %, respectively) during the two season of study. Generally, it can be concluded that dry soil moisture treatment increased rind thickness and weight than both medium and wet soil moisture treatments, the differences was significantly. These results are in line with findings of **Abd El-Messih *et al.*, (1977), Hilgeman (1977), Swellem (1986), Abd El-Metaal (1990), Ali and Gobran (2002)**. They reported that the thicker and heavier rind obtained by the dry irrigation treatment.

On the other hand, **El-Nockrashy *et al.*, (1966-b)** found that no-marked difference in rind thickness of Valencia orange fruits in respect to different levels of soil moisture.

Meanwhile, the Tanarif fruit rind thickness and weight were significantly responded to the specific effect of geographical direction towards which the fruits carrier branches were directed. Hence, the fruits of the southern half of tree periphery had the thickest and heaviest rind as compared to those of the northern canopy side. Differences were significant during both seasons. This result was in harmony with the findings of **Fatma (2003)**. She reported that fruits of the southern limbs characterized by their thicker and heavier rind as compared to those of the opposite side of tree and differences were significant.

With regard to specific relationship between Tanarif fruit status (sound or creased) and its rind thickness and rind weight, **Table (5)** shows that the creased fruit characterized by its thinner and lighter weight rind, while the reverse was observed with the sound fruits, which showed thicker, and heavier rind. Such trend was true during both seasons of study and differences in both rind thickness and rind weight were significant. This result was in line with the findings of **Hass (1950), Jones *et al.*, (1967), El-Nokrashy (1969), Salama (1979), Diab (1982) and Fatma (2003)**. They reported that peel of creased and cracked navel orange, Balady and Hamlin orange fruits had thinner rind than that of sound ones.

B- Interaction effect:

As for the interaction effect of various combinations between the three investigated factors (irrigation regime, geographical direction and fruit status), **Table (5)** shows that the trend of response was so firm from one hand and reflected directly the specific effect of each investigated factor from the other side. In this regard, it was quite evident to be noticed that the thickest and heaviest rind of Tanarif fruit were statistically coupled with the sound fruits situated within the southern tree hemispheres and irrigation after depletion of 75 % A.W. Followed statistically with those of the sound fruits carried on the northern limbs of irrigated trees after depletion of 75 % A.W. during the study. Moreover, the thinnest and lightest rind weight was always in closed relationship to the sound & creased Tanarif fruits born on northern side of tree canopy and irrigated trees after depletion of 25 % A.W. Such trend was true during both 2002/2003 & 2003/2004 seasons and differences between the various investigated combinations (3 irrigation regime x 2 geographical directions x 2 fruit status) were significant during both seasons of study. In addition, other combinations were in between the aforesaid two extremes.

Table (5): Average rind thickness (mm) and rind weight (g) of sweet orange "Tanarif" cv. in response to specific and interaction effects of irrigation regime, geographical direction, fruit status and their combinations in Feb. sampled during the two successive 2002/2003 and 2003/2004 seasons.

Treatments \ Direction and fruit status	Rind thickness (mm)				Mean *	Rind weight (g)				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	4.10g	3.38h	5.10c-e	4.75d-f	**4.33C**	42.75cd	38.00e	43.50b-d	39.75de	**41.00C**
Irrigation after depletion of 50 % available water	4.68ef	4.30fg	5.78ab	5.53bc	**5.07B**	43.00b-d	38.50e	45.75a-c	44.50a-c	**42.94B**
Irrigation after depletion of 75 % available water	5.28b-d	5.13c-e	6.25a	5.85ab	**5.63A**	44.75a-c	43.25b-d	48.25a	47.00ab	**45.81A**
Mean (direction)**	**4.48B**		**5.54A**			**41.71B**		**44.79A**		
Mean* (fruit status)**	**Sou. 5.20A**		**Cre. 4.82B**			**Sou. 44.67A**		**Cre. 41.83B**		
2003/2004 season										
Irrigation after depletion of 25 % available water	4.53bc	3.93d	4.73b	4.23cd	**4.35C**	45.25d-f	24.15g	46.25c-e	43.75fg	**44.35C**
Irrigation after depletion of 50 % available water	4.88b	4.50bc	5.18ab	4.80b	**4.84B**	47.75bc	44.00e-g	47.75bc	46.00c-f	**46.38B**
Irrigation after depletion of 75 % available water	5.13ab	4.90b	5.70a	4.90b	**5.16A**	48.75ab	47.00b-d	50.25a	48.75ab	**48.69A**
Mean (direction)**	**4.65B**		**4.92A**			**45.53B**		**47.13A**		
Mean* (fruit status)**	**Sou. 5.02A**		**Cre. 4.54B**			**Sou. 47.66A**		**Cre. 44.98B**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

Fruit juice weight (g) and volume (cm^3):

The average juice weight and volume per fruit in response to specific effect of irrigation regime, geographical direction, fruit status as well as interaction effect of their combinations were investigated. Data obtained during both 2002/2003 and 2003/2004 experimental seasons are presented in **Table (6)**.

A- Specific effect:

Referring the specific effect of irrigation regime on both juice weight and volume/fruit, it is quite evident as shown from **Table (6)** to be noticed that both parameters were continuously decreased with decreasing of available soil water % at which rewatering was applied. Such trend was true during both seasons for two concerned parameters and differences were significant when compared each other. These results agree with those of **El-Nokrashy (1966-b), Swellem (1986) Abd El-Metaal (1990)** who found that the dry irrigation treatment produced fruits with low juice volume.

In addition, **Krome *et al.*, (1970)** on Tahiti lime and **Ali & Gobran (2002)** on Washington navel orange. They found that wet soil moisture treatment surpassed significantly both medium and dry soil moisture treatment.

Concerning the Tanarif fruit juice weight (g) and volume (cm^3) in response to specific effect of geographical direction of the fruits bearer scaffolds, **Table (6)** declares that fruits situated across the southern limbs of Tanarif tree periphery had significantly higher value of both juice parameters i.e., weight (g) and volume (cm^3) as compared to those of fruits borne on the northern side. Such trend was true during both 2002/2003 and 2003/2004 experimental seasons.

These results agree with those of **Fatma (2003)** she found that fruit juice (weight & volume) of the southern limbs characterized by their abundant juice as compared to those of the opposite side of tree and differences was significant of Hamlin orange cv.

As for the specific effect of fruit status (sound & creased) on both juice weight (g) and volume (cm^3) it could be noticed from data in **Table (6)** that sound fruits resulted in a significant increase in both juice weight (g) and volume (cm^3) /fruit than creased fruits during the two seasons of study.

These results were in generally agreement with those of **Diab (1982),** who pointed out that sound fruit contained higher juice weight and juice percentage per fruit weight than creased fruit of Balady orange, Shamouti and Hamlin fruits.

B- Interaction effect:

Table (6) indicates a significant variance due to the interaction effect of various combinations between irrigation regimes; geographical direction and fruit status on both juice weight and volume/fruit. Anyhow, the heaviest juice weight (g) and highest volume (cm^3) of juice/fruit were always in closed relationship to sound fruits born on the southern limbs of Tanarif tree irrigated after depleted 25 % A.W. Meanwhile, the reverse was found with creased fruits produced by Tanarif trees irrigated after depleted 75 % A.W. and situated across the northern side of the periphery during the study. Moreover, other combinations were in between the aforesaid two extremes. Such trend was true during both 2002/2003 & 2003/2004 experimental seasons and differences between all the abovementioned categories were significant.

Table (6): Average fruit juice weight (g) and fruit juice volume (cm3) of sweet orange "Tanarif" cv. in response to specific and interaction effects of irrigation regime, geographical direction, fruit status and their combinations in Feb. sampled during the two successive 2002/2003 and 2003/2004 seasons.

Treatments \ Direction and fruit status	Fruit juice weight (g)				Mean *	Fruit juice volume (cm3)				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	60.00a-c	58.00bc	65.00a	61.75ab	**61.19A**	58.00a-d	55.75b-e	61.50a	59.25a-c	**58.63A**
Irrigation after depletion of 50 % available water	58.00bc	56.75bc	62.75ab	60.75a-c	**59.56B**	54.50c-e	53.00de	60.75ab	56.00b-e	**56.06B**
Irrigation after depletion of 75 % available water	57.75bc	55.25c	60.50a-c	58.25bc	**57.94C**	54.50c-e	52.00e	57.25a-e	55.75b-e	**54.81C**
Mean (direction)**	**57.63B**		**61.50A**			**54.58B**		**58.42A**		
Mean* (fruit status)**	**Sou. 60.67A**		**Cre. 58.46B**			**Sou. 57.71A**		**Sou. 55.29B**		
2003/2004 season										
Irrigation after depletion of 25 % available water	62.00ab	55.75cd	64.25a	61.00ab	**60.75A**	55.75bc	52.50c-e	60.25a	57.25ab	**56.44A**
Irrigation after depletion of 50 % available water	55.75cd	51.50de	58.50bc	55.25cd	**55.25B**	55.50bc	52.00c-e	53.50b-d	50.25fg	**52.81B**
Irrigation after depletion of 75 % available water	53.25d	48.25e	54.25cd	50.75de	**51.63C**	48.75ef	44.50g	52.25c-e	47.25fg	**48.19C**
Mean (direction)**	**54.42B**		**57.33A**			**51.50B**		**53.46A**		
Mean* (fruit status)**	**Sou. 58.00A**		**Cre. 53.75B**			**Sou. 54.33A**		**Cre. 50.63B**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.
Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

IV.I.1.B- Fruit chemical properties:

In this respect, fruit juice TSS and acidity percentage, as well as TSS/acid ratio, besides vitamin C of Tanarif orange cultivar were the investigated fruit chemical characteristics in response to specific and interaction effects of three studied factors (irrigation regime; geographical direction and fruit status) and their combinations during both 2002/2003 and 2003/2004 experimental seasons, data obtained are presented in **Tables (7) and (8)**.

Fruit juice total soluble solids percentage (TSS %):

A- Specific effect:

Referring the specific effect of irrigation regime, **Table (7)** reveals that irrigated Tanarif orange trees after 75 % depletion of available water had statistically the highest value in total soluble solids percentage, while the reverse was true with those irrigated after 25 % A. W. depletion. Moreover, irrigation regime after 50 % A.W. depletion was in between. Differences were significant as three irrigation regimes were compared each other during both 2002/2003 & 2003/2004 seasons. The results of this study are in line with **El-Nokrashy *et al*., (1966-b) and Abd El-Metaal (1990)** on orange. **Naguib (1978)** mentioned that prolonged the drought period increased total soluble solids in the juice of Balady orange fruit. This may be attributed to moisture content of fruit was much lower in the unirrigated trees for long period, so the TSS content was relatively high. **Ali & Gobran (2002)** on Washington navel orange, found that the values of TSS were decreased by increasing soil moisture level.

Concerning the Tanarif fruit juice total soluble solids content in response to specific effect of geographical direction of the fruit bearer scaffold, **Table (7)** declares that fruits situated across the southern side of tree periphery had significantly higher juice TSS % as compared to those of the northern side. Such trend was true during both 2002/2003 and 2003/2004 experimental seasons. These results were in agreement with those of **Fatma (2003)**, she mentioned that fruits of the southern branches were the richest in their juice TSS content.

With respect to the specific effect of fruit status (sound & creased), **Table (7)** shows that sound fruits exhibited statistically the highest value of total soluble solids percentage as compared to creased fruits. However, differences were significant with fruit status. Such trend was true during 1^{st} and 2^{nd} experimental seasons. These results were confirmed with that of **Jones *et al.*, (1967), El-Nokrashy (1969), Diab (1982) and Fatma (2003)**. They pointed out that non-creased citrus fruits were higher in fruit juice TSS %.

B- Interaction effect:

Table (7) reveals that Tanarif fruit juice TSS % responded obviously to the interaction effect of various combinations between irrigation regimes x geographical direction x fruit status. Anyhow, the highest fruit juice TSS % was always in closed relationship to such sound fruits situated across both the northern and southern sides of the tree periphery of Tanarif trees irrigated after depletion of 75 % A.W. during the two seasons of study. Meanwhile, the reverse was found with the creased fruits on such limbs directed towards the north of Tanarif trees irrigated after depletion 25 % A.W. Moreover, other combinations were in between the aforesaid two extremes.

Fruit juice total acidity percentage:

A- Specific effect:

As for the response of Tanarif fruit juice total acidity to the specific effect of irrigation regime on Tanarif fruit juice total acidity %, the trend as shown from **Table (7)** took the other way around as compared to that previously detected with the fruit juice TSS %. Hence, the total acidity % was continuously increased with raising the limit of irrigation regime (percentage of depleted A.W.). In the same time differences between acidity values in Tanarif fruit juice of the trees in three treatments (25 %, 50 % & 75% A.W.) were significant. However, reports in the literature on the effect of irrigation on acidity of fruit juice are variable. **Hilgeman and Sharples (1970)** working on Valencia orange trees, **Koo *et al.*, (1974)** working on lemon trees, **Abd El-Messih *et al.*, (1977)** working on Washington navel orange, **Levy *et al.*, (1978)** working on grapefruit, **Moreshet *et al.*, (1983)** working on citrus trees and **Ali & Gobran (2002)** working on Washington navel orange, they found that the acidity was increased by decreasing number of irrigation (dry soil moisture treatments), which agree with the results of the present study. While **Swellem (1986)** working on Valencia orange, found that the highest acidity was obtained by the wet treatment.

Referring the response of Tanarif fruit juice total acidity (%) to specific effect of geographical direction the trend as shown from **Table (7)** took the other way around as compared to that previously detected with the fruit juice TSS

%, Hence, the north situated fruits exhibited relatively higher acidity % over those of the southern limbs. Differences were significant during 1st and 2nd seasons.

The present results regarding fruit juice acidity as affected by geographical direction goes in line with those previously reported by **Fatma (2003)** working on Hamlin orange.

Nevertheless, **Table (7)** shows that fruit status exhibited also its specific effect on fruit juice total acidity %, whereas the Tanarif sound fruits exhibited statistically the highest value of total acidity % as compared to creased fruits. Such trend was true during 1st and 2nd seasons of study. These results were confirmed by those of **Jones *et al.*, (1967), El-Nokrashy (1969) and Diab (1982)**. They pointed out that the non-creased citrus fruits had higher value of total acidity % in the fruit juice.

B- Interaction effect:

Regarding fruit juice acidity of Tanarif fruits as influenced by interaction effect of various combinations between three investigated factors (irrigation regime x geographical direction x fruit status), **Table (7)** displays that differences were noticeably less pronounced as compared to those exhibited in juice TSS %. On the other hand, it could be generally observed the superiority of sound fruits located across both northern and southern branches of Tanarif trees irrigated after depletion of 75 % A.W. pertaining the higher level of their juice acidity during both 2002/2003 and 2003/2004 seasons. The opposite was found by creased fruits of Tanarif trees irrigated after depletion of 25 % A.W., especially those facing the geographical north direction. Moreover, other combinations were in between the aforesaid two extents.

Table (7): Average fruit juice TSS (%) and fruit juice acidity (%) of sweet orange "Tanarif" cv. in response to specific and interaction effects of irrigation regime, geographical direction, fruit status and their combinations in Feb. sampled during the two successive 2002/2003 and 2003/2004 seasons.

Treatments / Direction and fruit status	Fruit juice TSS (%)				Mean *	Fruit juice acidity (%)				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	11.60e	10.50g	12.40d	11.50ef	**11.50C**	1.08b-d	1.02c-e	1.02c-e	0.98e	**1.02C**
Irrigation after depletion of 50 % available water	12.50cd	11.00fg	13.00a-c	12.40d	**12.23B**	1.12ab	1.05b-e	1.06b-e	1.02c-e	**1.06B**
Irrigation after depletion of 75 % available water	13.10ab	11.71e	13.50a	12.70b-d	**12.75A**	1.15a	1.05b-e	1.09a-c	1.04b-e	**1.08A**
Mean (direction)**	**11.74B**		**12.58A**			**1.08A**		**1.04B**		
Mean* (fruit status)**	**Sou. 12.68A**		**Cre. 11.64B**			**Sou. 1.09A**		**Cre. 1.03B**		
2003/2004 season										
Irrigation after depletion of 25 % available water	12.70cd	11.20f	13.10bc	12.50de	**12.38C**	1.02cd	0.97de	0.99d	0.95ef	**0.98C**
Irrigation after depletion of 50 % available water	13.00b-d	12.00e	13.50b	12.70cd	**12.80B**	1.02cd	1.02cd	1.01cd	0.96ef	**1.00B**
Irrigation after depletion of 75 % available water	14.10a	12.50de	14.50a	13.20bc	**13.57A**	1.10a	1.06ab	1.07ab	0.98e	**1.05A**
Mean (direction)**	**12.58B**		**13.25A**			**1.03A**		**1.00B**		
Mean* (fruit status)**	**Sou. 13.48A**		**Cre. 12.35B**			**Sou. 1.04A**		**Cre. 0.99B**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

Fruit juice TSS/acid ratio:

A- Specific effect:

Concerning the specific effect of irrigation regime on fruit juice TSS/acid ratio in Tanarif orange cultivar, data presented in **Table (8)** display that the average values in the first and second seasons increased by irrigation after depletion of 75 % A.W. In addition, irrigation after depletion of 25 % or of 50 % A.W. greatly decreased the fruit juice TSS/acid ratio during the study. **Abd El-Metaal (1990)** on citrus found that the average values of fruit juice TSS/acid ratio increased by decreasing the number of irrigation.

As for the specific effect of geographical direction (north & south), **Table (8)** shows that the situated fruits on southern sides of tree periphery had statistically higher TSS/acid ratio as compared to those located within the northern direction during both seasons of study. The obtained result is in general agreement with the findings of **Fatma (2003)** who found that TSS/acid ratio of fruits situated in southern branches were the richest.

Regarding the specific effect of fruit status (sound & creased), data in **Table (8)** showed that juice of sound fruits had higher TSS/acid ratio than did creased one. These results were in disagreement with those of **Jones *et al.*, (1967), Salama (1979) and Diab (1982)** they found that the juice of creased orange fruit contained higher soluble solids to acid ratio than that of sound fruits.

B- Interaction effect:

Obtained data in **Table (8)** during both seasons revealed that the specific effects of three investigated factors (irrigation regime, geographical directions and fruit status) on the interaction effect of their combinations. Hence, the highest value was always in concomitant to the fruits (sound) of the southern limbs of irrigated Tanarif trees after depletion of 75 % available water. The reverse was true with the creased fruits on northern limbs of Tanarif trees after depletion of 25 % A.W. limb, which had seemed to be the inferior. In addition, other combinations were in between the aforesaid two extremes.

Fruit juice ascorbic acid (V.C.) content:

Vitamin C content as mg ascorbic acid per 100 ml juice was investigated regarding the response to specific and interaction effects of irrigation regime, geographical direction of fruit carrier branches and fruit status as well as their combinations. Data obtained during both 2002/2003 and 2003/2004 seasons are tabulated in **Table (8)**.

A- Specific effect:

Referring the specific effect of irrigation regime (irrigation after depletion of 25, 50 and 75 % A.W.), on vitamin C content **Table (8)** reveals that Tanarif trees irrigated after depletion of 75 % A.W. were significantly higher in their fruit juice V.C. content followed in a decreasing order by both depletion of 50 % A.W. and 25 % A.W. The results agree with those of **El-Nokrashy *et al.*, (1966-b)** on orange, **El-Kassas (1972)** on Balady orange and

Abd El-Metaal (1990) on citrus, they found that V.C. content in fruit juice of the orange trees was increased by decreasing number of irrigation. While, **Abd El-Messih *et al.*, (1977)** working on Washington navel orange trees and **Swellem (1986)** working on Valencia orange trees found that the moderate level irrigation gave the highest V.C. content.

Regarding the specific effect of geographical direction, **Table (8)** reveals that Tanarif fruits situated towards the north were significantly higher in their fruit juice vitamin "C" content as compared to those of opposite side (south) during the two seasons of study. The obtained result is in general agreement with the finding of **Fatma (2003)**.

With respect to the specific effect of fruit status (sound & creased) it is clear from **Table (8)** that sound fruit of Tanarif orange juice contained higher value of ascorbic acid content than did creased one. These results were confirmed with that **Jones *et al.*, (1967), El-Nokrashy (1969) and Diab (1982).** They pointed out that the non-creased citrus fruits had higher vitamin C value in their juice as compared with creased one.

B- Interaction effect:

As for the interaction effect of various combinations between irrigation regimes x geographical directions x fruit status, **Table (8)** shows that the highest vitamin "C" content was coupled with sound Tanarif fruits on the northern side of trees irrigated after depletion of 75% A.W. Contrary to that the least V.C. level was detected by creased Tanarif fruits, especially those facing the south direction of trees irrigated after depletion of 25 % A.W. during both seasons of study.

Table (8): Average TSS/acid ratio and fruit juice V. C. mg/100g. of sweet orange "Tanarif" cv. in response to specific and interaction effects of irrigation regime, geographical direction, fruit status and their combinations in Feb. sampled during the two successive 2002/2003 and 2003/2004 seasons.

Treatments / Direction and fruit status	TSS/acid ratio				Mean *	Fruit juice V. C. mg/100g.				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	10.75c-e	10.31e	12.17ab	11.73a-c	**11.24C**	43.03f	40.58g	39.00gh	36.94h	**39.89C**
Irrigation after depletion of 50 % available water	11.17b-e	10.51de	12.30a	12.19ab	**11.54B**	49.75bc	47.65cd	49.00c	44.23ef	**47.66B**
Irrigation after depletion of 75 % available water	11.41a-d	11.20b-e	12.42a	12.23ab	**11.82A**	54.25a	52.11a	49.75bc	46.28de	**50.60A**
Mean (direction)**	**10.89B**		**12.17A**			**47.90A**		**44.20B**		
Mean* (fruit status)**	**Sou. 11.70A**		**Cre. 11.36B**			**Sou. 46.35A**		**Cre. 45.75B**		
2003/2004 season										
Irrigation after depletion of 25 % available water	12.40bc	11.58c	13.24ab	13.11ab	**12.58C**	49.75cd	45.98ef	48.00c-e	43.94f	**46.92C**
Irrigation after depletion of 50 % available water	12.74b	11.79c	13.37ab	13.24ab	**12.79B**	52.62b	49.44cd	50.25c	47.58de	**49.97B**
Irrigation after depletion of 75 % available water	12.87ab	11.79c	13.60a	13.44a	**12.93A**	55.75a	54.25ab	54.52a	48.73cd	**53.31A**
Mean (direction)**	**12.20B**		**13.33A**			**51.30A**		**48.84B**		
Mean* (fruit status)**	**Sou. 13.04A**		**Cre. 12.49B**			**Sou. 51.82A**		**Cre. 48.32B**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

IV.I.2- Creasing incidence in Tanarif fruits as related to irrigation regime, localities towards north & south direction and fruit status:

In this regard level of creasing incidence (expressed as a percentage of creased fruits) in Tanarif fruits in response to specific and interaction effects of irrigation regime (irrigation after depletion of 25, 50 & 75 % A.W.) and geographical direction (north & south) were periodically determined (4 times) along their developmental stages from the last week of November till harvesting date February 28th during 1st and 2nd seasons of study. Data obtained during both 2002/2003 & 2003/2004 experimental seasons are presented in **Table (9)**.

A- Specific effect:

Referring the specific effect of irrigation regime i.e., (irrigation after depletion of 25, 50 & 75 % A. W.) the depleted available soil water percentage at which rewatering was carried out, it is quite clear to be noticed the negative relationship between creasing percentage from one hand and the percentage of depleted available water from the other. Hence, the creasing percentage was continuously decreased with raising the limit of irrigation regime (percentage of depleted available water). Anyhow, Tanarif trees subjected to the irrigation regime at 25 % depleted A.W. had significantly the highest percentage of creasing fruit, while the reverse was true with those irrigated after 75 % depletion of A.W. Moreover, irrigation after 50 % depletion of A.W. were in between. Differences were significant during the two seasons of study.

The abovementioned results agree with **Miller and Turnbull (1948) and Naguib (1978),** they found that more creasing percentage of fruits from irrigated than from un irrigated trees and **Grisson (1965-1966)** who mentioned that rind injury problems in citrus are probably nutritional complicated by water relation. Also, **Naguib (1978)** concluded that the highest irrigation rate was associated with highest creasing. In addition, **Ali & Gobran (2002)** found that soil moisture treatment increased significantly creasing percentage, while the lowest value of creasing percentage was observed at dry soil moisture treatment.

Concerning the specific effect of measuring date, data obtained during 2002/2003 & 2003/2004 seasons, it was so clear to be noticed that creasing incidence in Tanarif fruits was gradually increased with advancement of fruit development. However, such increase in level of creasing incidence took place gently throughout period of two successive earlier measuring dates (Nov. $25^{\underline{th}}$ & Dec. $25^{\underline{th}}$), but the rate of increase rose suddenly throughout Jan $25^{\underline{th}}$ & Feb. $28^{\underline{th}}$. However, differences between four measuring dates were significant as compared each other during two seasons of study.

With regard to specific effect of geographical direction of the fruits bearer branches towards either north or south, data obtained during both seasons as shown from **Table (9)** revealed that percentage of creased fruits on the northern limbs was significantly higher than on the southern ones. Such trend was true during both experimental 2002/2003 and 2003/2004 seasons.

The present results regarding the difference of geographical north and south directions may be mainly due to the direct influence of shading and flactuations exhibited in the relative humidity in both seasons of study. These results could be related to an increase in the relative humidity around the northern side of the tree, due to its isolation from the solar radiation on the eastern side.

These results were in line with **Coit and Hodgson (1919), Webber (1937), Webber and Batchelor (1948), Kuraoka (1962), El-Mahamoudi and Zorkani (1971), Diab (1982) and Fatma (2003).** They reported that the northern side of the tree usually isolated from the solar radiation. Moreover, the atmospheric humidity was relatively high and induces than rinds at the northern side. Hence, fruits creasing percentage in northern side was higher than in the fruits on other sides. In addition, **Smit, (1987)** reported that the most shaded fruits were worst affected.

B- Interaction effect:

As for the interaction effect of various combinations between three investigated factors i.e., irrigation regime x four measuring dates x two geographical direction (north & south) during both 2002/2003 & 2003/ 2004 seasons on fruit creasing percentage **Table (9)** displays that each investigated factor reflected its own specific effect on the interaction effect of their combinations. The highest percentage of creased fruits were statistically in closed relationship with the northern side of Tanarif trees that irrigated after depletion of 25 % A.W. during February 28$^{\underline{th}}$ measuring date. However, southern side of Tanarif trees irrigated after depletion of 75 % A.W. during 1$^{\underline{st}}$ & 2$^{\underline{nd}}$ seasons through measuring date of November 25$^{\underline{th}}$, showed the least creasing %. Such trend was true during both experimental seasons. In addition, other combinations are in between the aforesaid two extremes.

Table (9): Periodical changes in creasing % of sweet orange "Tanarif"cv. in response to specific and interaction effects of irrigation regime, measuring dates, geographical direction and their combinations during the two successive 2002/2003 and 2003/2004 seasons.

Treatments \ Fruit direction	Measuring dates of creasing percentage								Mean*
	November 25th		December 25th		January 25th		February 28th		
	North	South	North	South	North	South	North	South	
	2002/2003 season								
Irrigation after depletion of 25 % available water	16.06d-g	7.41hi	20.26c-e	9.95g-I	24.56c	13.51f-h	49.67a	21.73c-e	**20.39A**
Irrigation after depletion of 50 % available water	11.78f-h	3.95i	15.63e-g	6.83hi	22.47cd	10.89gh	34.80b	16.67d-g	**15.38B**
Irrigation after depletion of 75 % available water	6.84hi	3.37i	10.03g-I	6.88hi	17.90d-f	10.92gh	24.65c	17.84d-f	**12.30C**
Mean (dates)**	**8.23D**		**11.59C**		**16.71B**		**27.56A**		
Mean * (g. direction)**	**North 21.22A**				**South 10.83B**				
	2003/2004 season								
Irrigation after depletion of 25 % available water	8.31f-h	5.39g-I	11.76d-f	7.35f-I	16.19cd	9.68e-h	36.55a	16.00cd	**13.90A**
Irrigation after depletion of 50 % available water	5.72g-I	6.03g-I	8.26f-h	6.88f-I	14.34c-e	10.07e-g	27.92b	17.11c	**12.04B**
Irrigation after depletion of 75 % available water	4.41hi	2.15i	5.89g-I	4.63g-I	9.03f-h	7.02f-I	19.48c	14.57c-e	**8.40C**
Mean (dates)**	**5.33D**		**7.46C**		**11.05B**		**21.94A**		
Mean * (g. direction)**	**North 13.99A**				**South 8.91B**				

*; ** and *** refer to specific effect means of irrigation regime, measuring date and geographical direction (N & S).

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

IV.I.3-Nutritional status (leaf and fruit rind mineral composition):

In this concern, leaf and fruit rind N; P; K; Ca; Mg; Fe; Mn; Zn and Cu contents of Tanarif orange cv. were investigated pertaining the response to specific effect of three investigated factors i.e., irrigation regime (after depletion of 25, 50, 75 % A.W.), fruit status regarding the creasing incidence (sound & creased) from which rind and adjacent leaves were sampled from either northern or southern sides (geographical direction) of tree canopy. Besides, interaction effect of various combinations between irrigation regime, geographical direction and fruit status were also concerned and data obtained during both 2002/2003 and 2003/2004 experimental seasons are presented in **Tables (10); (11); (12); (13); (14); (15); (16); (17) and (18)**.

Leaf and fruit rind nitrogen content (N %):

Data obtained during both 2002/2003 and 2003/2004 seasons are presented in **Table (10)**.

A- Specific effect:

Table (10) displays that leaf and fruit rind N % was responded specifically to each of the three investigated factors. Hence, irrigated Tanarif trees after 75 % depletion of available water had statistically the richest leaves and fruit rind in their N content, while the reverse was true with those irrigated after 25 % depletion of A.W. Moreover, irrigation regimes after 50 % A.W. depletion was in between. Differences were significant as three irrigation regimes were compared each other during 2002/2003 and 2003/2004 seasons. A similar observation has been reported by **Labanuskas *et al.*, (1966)** found that the uptake of N decreased by increasing irrigation treatments. Also, such results are in general agreement with those previously reported by **Gowda, (1998); Hassan (1998), Laze *et al.*, (1999) and Osman, (2004)** on olive regarding the influence of irrigation regime. In addition, **El-Tomi (1954), Koo *et al.*, (1974), Swellem (1986), Abd El-Metaal (1990) and Ali & Gobran (2002),** all found that, N content tended to increase by increasing soil moisture levels.

With regard to the specific effect of geographical direction (north & south), **Table (10)** displays that both leaves and fruit rind situated across the northern side of the tree periphery had significantly higher N % as compared to those of the southern side. Such trend was true during both 2002/2003 and 2003/2004 experimental seasons.

Concerning the specific effect of fruit status (sound or creased), it is quite evident that rind of creased fruits and leaves adjacent to them were richer in their N content. Such trend was true during both seasons of study and differences were significant. These results were in agreement with the known effect of nitrogen in producing thicker and rough rind of fruits (**Webber and Batchelor, 1948**). Orange fruit with thicker rind was not easily creased. **(Reitz and Koo, 1960 and Embleton *et al.*, 1973).**

Diab (1982) found that dried peel of creased Egyptian Balady orange fruit contained lower nitrogen than sound ones. In addition sound fruit and sound rind areas from creased fruit of Egyptian Balady orange contained the highest nitrogen than did sound Hamlin orange fruit rind, whereas sound Shamouti orange peel being intermediate.

Moreover, **Fatma (2003)** found that rind of creased fruits and leaves adjacent them were richer in their N content as compared to sound ones.

B- Interaction effect:

As for the interaction effect of various combinations between three studied factors involved in this study i.e., irrigation regime, geographical direction & fruit status, **Table (10)** shows that the response was representative of direct reflection of specific effect of each factor. Hence, with leaves the richest ones were those adjacent to creased fruits born on limbs towards the north side of Tanarif trees irrigated after depletion of 75 % available water, while the contrary was found with Tanarif sound fruits in south side of Tanarif trees irrigated after depletion of 25 % A.W. during the two seasons of study. In addition, other combinations were in between the abovementioned two extremes.

Leaf and fruit rind phosphorus content (P %):

A- Specific effect:

Referring the specific effect of irrigation regime treatments, it is quite clear the trend of response took the other way around as compared to that previously detected with phosphorus **(Table 11)**. Hence, the richest leaf P and fruit rind was always in concomitant to the irrigated Tanarif trees after depletion of 25 % A.W., while the reverse was true with those exposed to the reversed water stress (75 % A.W. depletion). Other regime (50 % A.W. depletion) was in between and differences were significant with comparing the three investigated irrigation regimes each other during both seasons of study. The results agree with those of **Lehav and Doichev (1983); El-Sammak (1984); Swellem (1986) and**

Table (10): Nitrogen content in leaf and fruit peel sampled from northern and southern sides of Tanarif orange trees periphery as affected by irrigation regime, geographical direction, fruit status and their combinations during both 2002/2003 and 2003/2004 seasons.

Treatments \ Direction and fruit status	N (%)									
	Leaf				Mean *	Rind				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	2.19e	2.39cd	2.17e	2.12e	**2.22C**	2.23fg	2.31d-f	2.00i	2.10hi	**2.16C**
Irrigation after depletion of 50 % available water	2.45c	2.52bc	2.32d	2.52bc	**2.45B**	2.36de	2.57c	2.13gh	2.26ef	**2.33B**
Irrigation after depletion of 75 % available water	2.63ab	2.70a	2.50bc	2.63ab	**2.62A**	2.54c	2.88a	2.41d	2.70b	**2.63A**
Mean (direction)**	**2.48A**		**2.38B**			**2.48A**		**2.27B**		
Mean* (fruit status)**	**Sou. 2.38B**		**Cre. 2.48A**			**Sou. 2.28B**		**Cre. 2.47A**		
2003/2004 season										
Irrigation after depletion of 25 % available water	2.23d	2.40c	2.25d	2.20d	**2.27C**	2.30f	2.61c	2.12h	2.20g	**2.31C**
Irrigation after depletion of 50 % available water	2.51bc	2.59b	2.40c	2.60b	**2.53B**	2.41de	2.48d	2.22g	2.28fg	**2.35B**
Irrigation after depletion of 75 % available water	2.75a	2.79a	2.55b	2.73a	**2.70A**	2.60c	2.90a	2.39e	2.78b	**2.67A**
Mean (direction)**	**2.55A**		**2.46B**			**2.55A**		**2.33B**		
Mean* (fruit status)**	**Sou. 2.45B**		**Cre. 2.55A**			**Sou. 2.34B**		**Cre. 2.54A**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

Abd El-Metaal (1990), who reported that the irrigation intervals were correlated negatively with phosphorus leaf content. On the contrary, **Hilgeman and Sharples (1957) and Labanuskas *et al.*, (1966)** found that irrigation did not affect phosphorus content in leaves. Also, the results are in un-congeniality with the findings of previously detected by **Zahran *et al.*, (1987); Nomir, (1994); Abd El-Samed, (1995); Hassan (1998); Gowda (1998); Laz *et al.*, (1999); Moustafa (2002) and Osman (2004)** regarding the effect of irrigation regime on olive P content.

Concerning the specific effect of geographical direction (north & south), **Table (11)** reveals that Tanarif leaves and fruit rind situated towards the north were significantly higher in their leaf and fruit rind phosphorus content as compared to those of the opposite side (south) during 2002/2003 and 2003/2004 experimental seasons.

With regard to the specific effect of fruit status (sound & creased) from which and the adjacent to it fruit peel and leaves were sampled, respectively for determining P contents, data obtained during both seasons as shown from **Table (11)** declared that both organs (leaf & peel), didn't follow the same trend. Since, leaf P didn't responded to fruit status during two seasons of study. However, with the fruit peel P % the response was more pronounced, whereas, the creased fruits had significantly the richest peel P content as compared to the sound fruits. This finding was in line with those obtained by **Erickson (1957); Salama (1979); Diab (1982) and Fatma (2003)**. They found that phosphorus was higher in cracked Washington Navel, Balady orange and Hamlin fruit rind than in sound one. **Webber and Batchelor (1948)** mentioned that excessive phosphorus might lead to creasing or "Crinkle rind" in orange fruits. In addition, **Fatma (2003)** found that both organs (leaf & peel) didn't follow the same trend. Since, leaf P didn`t respond to fruit status. However, with the fruit peel P % the response was more pronounced, were as the creased fruits had significantly the richest P content as compared to the normal fruits.

B- Interaction effect:

Referring the interaction effect of the differential combinations between three investigated variables (3 irrigation regime x 2 geographical directions x 2 fruit status), on both leaf and fruit peel P content, data obtained during both 2002/2003 and 2003/2004 seasons as shown from **Table (11)** revealed that specific effect of each investigated factor was directly reflected on its combinations. Hence, with leaves, the sampled ones from those adjacent to sound or creased fruits situated across the northern side of Tanarif trees irrigated of after depletion of 25 % A.W. had significantly higher leaf P content. The reverse was found with leaves and peel nearer to the sound fruits situated across the southern side of tree periphery irrigated after depletion 75 % A.W. during the study. Moreover, other combinations were in between.

Leaf and fruit rind potassium content (K %):

A- Specific effect:

Table (12) shows the leaf and fruit peel K % content of Tanarif cv. in response to specific effect of irrigation regime (after depletion of 25, 50 & 75 % A.W.), geographical direction (north & south) and fruit status (sound & creased) from which rind and the adjacent leaves

Table (11): Phosphorus content in leaf and fruit peel sampled from northern and southern sides of Tanarif orange trees periphery as affected by irrigation regime, geographical direction, fruit status and their combinations during both 2002/2003 and 2003/2004 seasons.

Treatments / Direction and fruit status	P (%)									
	Leaf				Mean *	Rind				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	0.24c	0.27a	0.24c	0.26ab	**0.25A**	0.18cd	0.25a	0.17de	0.19c	**0.20A**
Irrigation after depletion of 50 % available water	0.23c	0.25bc	0.22d	0.23d	**0.23B**	0.17ef	0.22b	0.16ef	0.17de	**0.18B**
Irrigation after depletion of 75 % available water	0.21d	0.22d	0.17e	0.22d	**0.21C**	0.19c	0.21b	0.12g	0.16ef	**0.17C**
Mean (direction)**	**0.24A**		**0.22B**			**0.20A**		**0.16B**		
Mean* (fruit status)**	**Sou. 0.22B**		**Cre. 0.24A**			**Sou. 0.17B**		**Cre. 0.20A**		
2003/2004 season										
Irrigation after depletion of 25 % available water	0.25c	0.28a	0.24c	0.26bc	**0.26A**	0.20c	0.25a	0.18d-f	0.19cd	**0.20A**
Irrigation after depletion of 50 % available water	0.25c	0.26bc	0.22d	0.23d	**0.24B**	0.17e-g	0.23b	0.16gh	0.18d-f	**0.19B**
Irrigation after depletion of 75 % available water	0.22d	0.23d	0.21e	0.22d	**0.22C**	0.16gh	0.22b	0.15h	0.17e-g	**0.17C**
Mean (direction)**	**0.25A**		**0.23B**			**0.20A**		**0.17B**		
Mean* (fruit status)**	**Sou. 0.23B**		**Cre. 0.25A**			**Sou. 0.17B**		**Cre. 0.21A**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.
Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

were sampled for determination during both 2002/2003 and 2003/2004 seasons. It is quite evident that, both plant organs (leaf & peel) followed typically the same trend of response which, was so firm and differences in K content were more pronounced. Hence, the irrigated trees after the lightest percentage of A.W. (25 %) had statistically the richest leaves and peel fruit pertaining their K content. Thus, irrigation regimes could be descendingly arranged as the rewatering after depletion of 25 % A. W. ranked first, then irrigation after depletion of 50 and 75 % A.W. In addition on the contrary, irrigated trees after depletion of 75 % A. W. had statistically the poorest leaf and fruit rind pertaining their K content. Reports in literature on the effect of irrigation on K content of tree leaves are available. **Koo *et al.*, (1974)** working on lemon fruit trees, **El-Sammak (1984)** working on Washington navel orange trees and **Abd El-Metaal (1990),** on some citrus trees, found that irrigation interval negatively correlated with leaf K content, while **Swellem (1986)** working on Valencia orange trees and **Ali & Gobran (2002)** on Washington navel orange found that K content was increased by increasing number of irrigation. Moreover, the present results regarding the influence of irrigation regime on leaf K % in magnitude with the findings of **Zahran *et al.*, (1987); Nomir, (1994); Abd El-Samed (1995); Hassan (1998) Laz *et al.*, (1999); Moustafa (2002) and Osman (2004)** on olive.

With respect to the specific effect of geographical direction on leaf and fruit rind K content, **Table (12)** show that northern limbs of Tanarif trees produced leaves and fruit rind characterized by their higher value of K content as compared to those leaves and fruit rind situated on southern side during the two seasons of study.

With regard to the specific effect of fruit status (sound & creased) from which rind and the adjacent leaves were sampled for determination during both seasons. It is quite evident to be noticed that both plant organs (leaf and rind) followed typically the same trend regarding the response to specific effect of fruit status. Anyhow, peel of creased fruits and the adjacent leaves characterized by their significant higher K content as compared to the analogous ones of the sound fruits. Such trend was true during both seasons for fruit peel and the adjacent leaves.

The present results regarding the influence of fruit status on the adjacent leaf and fruit peel K % is in magnitude with the findings of **Erickson (1957)** on Washington navel orange; **Salama (1979)** on Balady orange; **Diab (1982)** on citrus sp. **and Fatma (2003)** on Hamlin cv. They reported that potassium concentration in cracked fruit rind was higher than sound one.

In addition, the obtained results regarding K content as related to creasing incidence is in disagreement with the finding of **Embleton *et al.*, (1980)** who reported that higher K content reducing creasing incidence. However, findings of **Storey and Treeby (2000) and Storey *et al.*, (2002)** support our result, they mentioned that higher K : Ca ratio is a responsible for incidence of crease. The conflict in response of K content to creasing incidence shows that farther study is needed in this respect.

B- Interaction effect:

Table (12) reveals that leaf and fruit peel K content responded obviously to the interaction effect of various combinations between irrigation regimes x geographical direction x fruit status. Anyhow, the highest value of leaf and fruit rind K content was always in concomitant to both peel of creased fruits and leaves nearer to infected fruits situated in southern periphery limbs of Tanarif trees irrigated after 25 % depletion A.W. during the two seasons of study. On the contrary, peels of sound fruits and leaves nearer them of southern side of Tanarif trees irrigated after depletion of 75 % A.W. showed statistically the least K level during both seasons of study. Moreover, other combinations were in between.

Leaf and fruit rind calcium content (Ca %)

A- Specific effect:

With regard to specific effect of the different factors involved in this study i.e., irrigation regime, geographical direction and fruit status on the leaf and fruit rind Ca content from which fruit peel and nearer leaves were sampled, **Table (13)** displays a significant response to each investigated factor.

As for the specific effect of irrigation regime, data obtained in from **Table (13)** displayed that, irrigation after depletion of 25 % available water resulted significantly in the highest Ca content in both fruit peel and leaves nearer to them. In other words, leaf and fruit peel Ca content was significantly decreased with rising the percentage of available water depletion prior rewatering during two seasons of study. The present results are in agreement with the findings of **Nomir, (1994); Moustafa (2002) and Osman (2004)** on olive.

Table (12): Potassium content in leaf and fruit peel sampled from northern and southern sides of Tanarif orange trees periphery as affected by irrigation regime, geographical direction, fruit status and their combinations during both 2002/2003 and 2003/2004 seasons.

Treatments \ Direction and fruit status	K (%)									
	Leaf				Mean *	Rind				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	1.24d	1.26c	1.22e	1.31a	**1.26A**	1.88b	1.91b	1.64de	2.00a	**1.86A**
Irrigation after depletion of 50 % available water	1.24d	1.28b	1.18h	1.19gh	**1.22B**	1.73bc	1.76bc	1.61e	1.94a	**1.76B**
Irrigation after depletion of 75 % available water	1.20fg	1.24d	1.18h	1.21ef	**1.21C**	1.71cd	1.92a	1.52f	1.80b	**1.74C**
Mean (direction)**	**1.24A**		**1.22B**			**1.82A**		**1.75B**		
Mean* (fruit status)**	**Sou. 1.21B**		**Cre. 1.25A**			**Sou. 1.68B**		**Cre. 1.89A**		
2003/2004 season										
Irrigation after depletion of 25 % available water	1.27cd	1.30b	1.24e	1.33a	**1.29A**	1.82e	1.97bc	1.69f	2.10a	**1.90A**
Irrigation after depletion of 50 % available water	1.21f	1.28c	1.20f	1.26d	**1.24B**	1.87de	1.90c	1.66fg	2.03b	**1.87B**
Irrigation after depletion of 75 % available water	1.21f	1.27cd	1.20f	1.26d	**1.23C**	1.73f	1.87de	1.59g	1.94cd	**1.78C**
Mean (direction)**	**1.26A**		**1.24B**			**1.92A**		**1.78B**		
Mean* (fruit status)**	**Sou. 1.22B**		**Cre. 1.28A**			**Sou. 1.73B**		**Cre. 1.97A**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

With regard the specific effect of geographical direction (north & south), data in **Table (13)** revealed that the situated fruits and adjacent leaves to them across the southern side of the tree periphery had significantly richer fruit rind and adjacent leaves in their calcium content as compared to the analogous ones of northern side during both 2002/2003 and 2003/2004 seasons.

Concerning the leaf and fruit rind Ca content of Tanarif trees as influenced by specific effect of fruit status from which fruit peel and nearer leaves were sampled, **Table (13)** reveals that a significant response, hence, fruit peel of sound fruits and the nearer leaves to them were significantly richer in their Ca content as compared to the analogous ones of creased fruits. Such trend was true for both leaves and fruits rind in both seasons of study.

This might be attributed to the fact that calcium is one of cell walls and middle lamella constituents. Unfavorable factors such as drought or irregular irrigation change calcium compound from complicated state to simple and soluble form **(Marinos, 1962)**. Thus calcium content in the rind decrease and causing the deterioration of cell walls producing creasing.

The present result regarding the negative relationship between Ca content (leaf and fruit rind) and creasing incidence is typically coincided with findings of **Cutuli, (1968); Salama (1979); Diab (1982); Michael *et al.*, (2000); Storey and Treeby, (2000); Treeby *et al.*, (2000); Storey *et al.*, (2002) and Fatma (2003)**. They found that calcium content was significantly lower in cracked fruit peel as compared to sound one.

B- Interaction effect:

Concerning the interaction effect of various combinations between irrigation regime x geographical direction x fruit status on fruit rind and leaf Ca contents, **Table (13)** displays significant variations. Anyhow, the highest value of leaf and fruit rind Ca content were closely coupled to sound fruits and the adjacent leaves in south side of Tanarif trees irrigated after depletion of 25 % available water. The reverse was true with peel of creased fruits and leaves sampled nearer to those creased fruits in north side of Tanarif trees irrigated after depletion of 75 % A.W. during two seasons of study. In addition, other combinations were in between the aforesaid two extremes.

Leaf and fruit rind magnesium content (Mg %)

A- Specific effect:

As for the specific effect of irrigation regime, **Table (14)** displays that both leaf and fruit rind magnesium content reacted obviously during both 2002/2003 and 2003/2004 experimental seasons. Hence, a gradual reduction in both leaf and fruit peel magnesium content was detected with rising the percentage of available soil moisture depleted just before rewatering had been carried out. Such trend was true during both seasons and differences were significant as both leaf and fruit peel Mg content of a given irrigation regime were compared to the analogous ones of the two other irrigation systems. The present results are in agreement with the findings of **Zahran *et al.*, (1987); Nomir, (1994) and Moustafa (2002)** regarding the influence of soil moisture on olive leaf Mg content.

Table (13): Calcium content in leaf and fruit peel sampled from northern and southern sides of Tanarif orange trees periphery as affected by irrigation regime, geographical direction, fruit status and their combinations during both 2002/2003 and 2003/2004 seasons.

Treatments \ Direction and fruit status	Ca (%)									
	Leaf				Mean *	Rind				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	5.26b	4.90f	5.32a	4.95e	**5.11A**	3.27cd	3.24cd	3.75a	3.44b	**3.43A**
Irrigation after depletion of 50 % available water	4.96e	4.84g	5.12c	4.81g	**4.93B**	3.36bc	2.94cd	3.45b	2.93f	**3.17B**
Irrigation after depletion of 75 % available water	4.67h	4.25j	5.02d	4.51i	**4.61C**	3.07ef	2.65g	3.16de	2.93f	**2.95C**
Mean (direction)**	**4.81B**		**4.96A**			**3.09B**		**3.28A**		
Mean* (fruit status)**	**Sou. 5.06A**		**Cre. 4.71B**			**Sou. 3.34A**		**Cre. 3.02B**		
2003/2004 season										
Irrigation after depletion of 25 % available water	5.10b	4.94c	5.24a	4.93c	**5.05A**	3.60a	3.12cd	3.60a	3.15c	**3.37A**
Irrigation after depletion of 50 % available water	4.85c	4.70d	5.00bc	4.69d	**4.81B**	3.31b	2.87f	3.40b	2.90ef	**3.12B**
Irrigation after depletion of 75 % available water	4.57d	4.40e	4.95c	4.64d	**4.64C**	3.00de	2.55g	3.05cd	2.86f	**2.87C**
Mean (direction)**	**4.76B**		**4.91A**			**3.08B**		**3.16A**		
Mean* (fruit status)**	**Sou. 4.95A**		**Cre. 4.72B**			**Sou. 3.33A**		**Cre. 2.91B**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

Meanwhile, the Tanarif fruit peel and leaf Mg content was significantly responded to the specific effect of geographical direction towards which the fruits and leaves approached to their carrier branches were directed. Hence, the fruits peel and leaves of southern half of tree periphery had the highest value of both fruit peel and leaf Mg content as compared to those of the northern canopy side. Differences were significant during both seasons of study.

Nevertheless, as the specific effect of fruit status (sound & creased) was concerned, **Table (14)** shows that peel of creased fruits and leaves approached them were relatively richer in their Mg content as compared to the analogous ones of the sound fruits. However, differences were significant during the two seasons of study.

The obtained results regarding the positive correlation between Mg level (in both fruit peel and leaves) and creasing incidence goes generally with the findings of **Storey and Treeby, (2000) and Storey *et al.*, (2002)**. They demonstrated that rind of creased fruits had higher albedo Mg: Ca ratio.

B- Interaction effect:

Referring leaf and fruit rind Mg % as related to the interaction effect of various combinations between three irrigation regime (after depletion of 25, 50 & 75 % A.W.), two geographical direction (north & south) and two fruit status (sound & creased), **Table (14)** shows that however, variances were relatively less pronounced but it could be generally detected that rind of creased fruits and leaves adjacent them in southern side for Tanarif orange trees irrigation after depletion of 25 % A.W. were the richest in their Mg content. Such trend was true during both seasons for two plant organs in both seasons of study. On the contrary, peels of sound fruits and the nearer leaves to them

Table (14): Magnesium content in leaf and fruit peel sampled from northern and southern sides of Tanarif orange trees periphery as affected by irrigation regime, geographical direction, fruit status and their combinations during both 2002/2003 and 2003/2004 seasons.

Treatments \ Direction and fruit status	Mg (%)									
	Leaf				Mean *	Rind				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	0.48b-d	0.52ab	0.51ab	0.55a	**0.52A**	0.21de	0.34ab	0.33ab	0.36a	**0.31A**
Irrigation after depletion of 50 % available water	0.45cd	0.48b-d	0.47b-d	0.50bc	**0.48B**	0.18e	0.31a-c	0.28bc	0.31a-c	**0.27B**
Irrigation after depletion of 75 % available water	0.40e	0.45cd	0.43de	0.48b-d	**0.44C**	0.15e	0.25cd	0.25cd	0.31a-c	**0.24C**
Mean (direction)**	**0.46B**		**0.49A**			**0.24B**		**0.31A**		
Mean* (fruit status)**	**Sou. 046B**		**Cre. 0.50A**			**Sou. 0.23B**		**Cre. 0.31A**		
2003/2004 season										
Irrigation after depletion of 25 % available water	0.43c-f	0.47bc	0.49ab	0.52a	**0.48A**	0.19e	0.30a-c	0.31ab	0.34a	**0.29A**
Irrigation after depletion of 50 % available water	0.41d-f	0.44b-e	0.45b-d	0.48a-c	**0.45B**	0.17ef	0.29b-d	0.25cd	0.29b-d	**0.26B**
Irrigation after depletion of 75 % available water	0.38f	0.43c-f	0.39ef	0.43c-f	**0.41C**	0.14f	0.27b-d	0.24d	0.29b-d	**0.24C**
Mean (direction)**	**0.43B**		**0.46A**			**0.23B**		**0.30A**		
Mean* (fruit status)**	**Sou. 0.43B**		**Cre. 0.46A**			**Sou. 0.22B**		**Cre. 0.30A**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

in northern side of Tanarif trees irrigated after depletion of 75 % available water were the poorest in their Mg content. In addition, other combinations were in between the abovementioned two extents.

Leaf and fruit rind iron content (Fe ppm).

A- Specific effect:

Regarding the leaf and fruit peel Fe content of Tanarif cv. As affected by specific effect of three studied factors i.e., irrigation regime, geographical direction (north & south) and fruit status (sound & creased) from which rind and adhered to them leaves were sampled respectively, **Table (15)** displays that, leaf and fruit peel Fe ppm was gradually increased with increasing the percentage of available water depletion prior rewatering had been applied. Herein, irrigated Tanarif orange trees after depletion of 75 % available water had statistically the richest leaves and fruit peel Fe ppm content, while the reverse was true with those irrigated after 25 % A.W. depletion. Moreover, irrigation regime (after 50 % A.W. depletion) was in between. Differences, were significant as 3 irrigation regimes were compared each other during both 2002/2003 and 2003/2004 seasons.

The present results are in agreement with the findings of **Ali & Gobran (2002)** on Washington navel orange trees, **Nomir, (1994)** in persimmon and **Osman (2004)** on some olive cultivars, regarding the influence of soil moisture on leaf Fe content. They found that leaves of dry soil moisture treatment had the highest value of leaf Fe content.

As for the specific effect of geographical direction on the leaf and fruits bearer scaffolds, **Table (15)** declares that leaves and fruits situated across northern side of the tree periphery had significantly higher value of leaf and fruit peel Fe ppm contents as compared to those of the southern side. Such trend was true during 2002/2003 and 2003/2004 experimental seasons.

As for the specific effect of fruit status from which rind and adhered to them leaves were sampled respectively, **Table (15)** displays that fruit peel of sound fruits and nearer leaves to them were significantly richer in their Fe content as compared to the analogous ones of creased fruits. Such trend was true during both seasons of study.Present results of Fe content in response to fruit status are in agreement with finding of **Fatma(2003)** on Hamlin orange trees.

B- Interaction effect:

Concerning the interaction effect of various combinations between irrigation regime, geographical direction and fruit status on fruit rind and leaf Fe content, **Table (15)** displays significant variations. Anyhow, the highest leaf and fruit rind Fe content were closely coupled to sound fruits and the adjacent leaves in north side of Tanarif trees irrigated after depilation of 75 % A.W. The reverse was true with sampled fruit peel of creased fruits and leaves nearer to them for Tanarif trees irrigated after depletion of 25 % available water. In addition, other combinations were in between the aforesaid two extremes.

Table (15): Iron content in leaf and fruit peel sampled from northern and southern sides of Tanarif orange trees periphery as affected by irrigation regime, geographical direction, fruit status and their combinations during both 2002/2003 and 2003/2004 seasons.

Treatments \ Direction and fruit status	Fe (ppm)									
	Leaf				Mean *	Rind				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	320.0d	305.0f	311.5e	305.0f	**310.4C**	212.0e	194.8h	200.0g	190.0i	**199.2C**
Irrigation after depletion of 50 % available water	325.0c	310.0e	320.0d	310.0e	**316.3B**	224.0d	206.0f	210.0ef	201.3g	**210.3B**
Irrigation after depletion of 75 % available water	340.5a	325.0c	335.0b	322.5cd	**330.8A**	246.0b	240.0c	262.0a	247.0b	**248.8A**
Mean (direction)**	**320.9A**		**317.3B**			**220.5A**		**218.4B**		
Mean* (fruit status)**	**Sou. 325.3A**		**Cre. 312.9B**			**Sou. 225.7A**		**Cre. 213.2B**		
2003/2004 season										
Irrigation after depletion of 25 % available water	332.5bc	315.0ef	319.0de	305.0f	**319.0C**	226.0c	211.8de	218.0c-e	210.0e	**216.4C**
Irrigation after depletion of 50 % available water	335.0a-c	322.5c-e	328.0b-d	312.0ef	**324.4B**	227.0c	226.0c	217.0c-e	224.0cd	**223.5B**
Irrigation after depletion of 75 % available water	340.0ab	333.5a-c	333.50a-c	331.5bc	**337.5A**	252.0b	250.0b	267.0a	248.0b	**254.3A**
Mean (direction)**	**331.7A**		**321.5B**			**232.1A**		**230.7B**		
Mean* (fruit status)**	**Sou. 333.3A**		**Cre. 319.9B**			**Sou.234.5A**		**Cre. 228.3B**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

Leaf and fruit rind manganese content (Mn ppm).

A- Specific effect:

Regarding the specific effect of irrigation regime, geographical direction and fruit status on fruit peel and adjacent leaves Mn content, **Table (16)** clearly shows that fruit rind and leaves Mn content was gradually increased with increasing the percentage of available water depletion prior rewatering had been applied. Herein, irrigated Tanarif trees after 75 % depletion of available water had statistically the richest leaves and fruit rind Mn content, while the reverse was true with those irrigated after 25 % A.W. depletion. Moreover, irrigation regime after 50 % A.W. depletion were in between. Differences, were significant as three irrigation regimes were compared each other during both 2002/2003 and 2003/2004 seasons.

The present results regarding the influence of irrigation regime on both fruit rind and leaves adjacent to it on Mn content are in general agreement with that previously reported by **Ali & Gobran (2002)** on Washington navel orange, **Nomir, (1994)** in persimmon and **Osman (2004)** on some olive cultivars. They mentioned that leaves of dry soil moisture treatment had the highest value of leaf Mn content. However, **Moustafa, (2002)** found that Mn level didn't influence by soil moisture.

Meanwhile, the Tanarif fruit peel and leaves adjacent to it Mn content was significantly responded to the specific effect of geographical direction towards which fruits and nearer leaves carrier branches were directed. Hence, the fruits and leaves adjacent to it of the southern half of tree periphery had the highest value of fruit peel and leaf Mn content as compared to those of the northern canopy side. Differences were significant during both seasons.

Table (16) displays that leaf and fruit peel Mn contents responded obviously to the specific effect of fruit status from which rind and the adjacent leaves were analyzed. Anyhow, peel of sound fruit and leaves adjacent to it were statistically higher in their Mn content as compared to the analogous samples of creased fruits. Such trend was true during both seasons of study for two plant organs (fruit peel & leaf).

The obtained results regarding the influence of fruit status on fruit peel and leaves Mn content is in harmony with that found by **Fatma (2003)** on Hamlin orange cultivar.

B- Interaction effect:

Concerning the interaction effect of various combinations between 3 irrigation regimes (after depletion of 25 %, 50 % & 75 % A.W.), geographical direction (north & south) and fruit status (sound & creased), data obtained during both seasons as shown from **Table (16)** revealed that fruit peel of and sound fruits adjacent leaves situated in southern branches of irrigated Tanarif trees after depletion of 75 % A.W. were statistically the richest in their Mn content. However, rind of creased fruits and leaves nearer to them situated in northern limbs of Tanarif trees irrigated after depletion of 25 % A. W. exhibited the least Mn content. Such trend was true during both 2002/2003 and 2003/2004 seasons with both analyzed plant organs (leaves & fruit peel). In addition, other combinations were in between the aforesaid two extremes.

Table (16): Manganese content in leaf and fruit peel sampled from northern and southern sides of Tanarif orange trees periphery as affected by irrigation regime, geographical direction, fruit status and their combinations during both 2002/2003 and 2003/2004 seasons.

Treatments \ Direction and fruit status	Mn (ppm)									
	Leaf				Mean *	Rind				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	35.00e	31.25f	37.00c-e	35.50e	**34.69C**	27.00de	21.00f	30.00b-d	26.00e	**26.00C**
Irrigation after depletion of 50 % available water	39.75a-c	36.00de	41.00ab	39.25b-d	**39.00B**	31.00a-c	25.00e	32.00ab	28.00c-e	**29.00B**
Irrigation after depletion of 75 % available water	42.50ab	40.75ab	43.00a	40.00a-c	**41.56A**	33.00ab	27.00de	34.00a	30.00b-d	**31.00A**
Mean (direction)**	**37.54B**		**39.29A**			**27.33B**		**30.00A**		
Mean* (fruit status)**	**Sou. 39.71A**		**Cre. 37.13B**			**Sou. 31.17A**		**Cre. 26.17B**		
2003/2004 season										
Irrigation after depletion of 25 % available water	37.00ef	26.00g	46.00bc	37.00ef	**36.50C**	31.00c-e	25.00f	32.00b-d	29.00de	**29.25C**
Irrigation after depletion of 50 % available water	43.00cd	35.00f	49.00b	41.00de	**42.00B**	34.00a-c	28.00e	34.00a-c	30.00de	**31.50B**
Irrigation after depletion of 75 % available water	44.00cd	34.00f	54.00a	45.00b-d	**44.25A**	35.00ab	30.00de	36.00a	31.00c-e	**33.00A**
Mean (direction)**	**36.50B**		**45.33A**			**30.50B**		**32.00A**		
Mean* (fruit status)**	**Sou. 45.50A**		**Cre. 36.33B**			**Sou. 33.67A**		**Cre. 28.83B**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

Leaf and fruit rind zinc content (Zn ppm).

A- Specific effect:

Concerning the response of leaf and fruit rind zinc content to specific effect of three investigated factors (irrigation regime, geographical direction and fruit status), **Table (17)** reveals that the same trends previously discussed with iron and manganese were also detected for fruit rind leaf Zn content. Hence, a noticeable increase was linked with the Tanarif trees irrigated after depletion of 75 % available water. Variance was significant as fruit rind and leaf Zn content of irrigated trees after depletion of 75 % A.W. was compared to that of the analogous ones irrigated either after depletion of 25 or 50 % A.W. during both 2002/2003 and 2003/2004 experimental seasons.

This result is in agreement with the findings of **Labanuskas *et al.*, (1966)** who found that the uptake of Zn in Washington navel orange seedling was decreased by irrigation treatments. **Khalidy and Nayyal (1973)** working on Eureka lemon leaves found that the irrigation interval was negatively correlated with leaf Zn levels. In addition, **El-Morshedy and Haggag (1997)** reported that decreasing irrigation water increased leaf Zn content. Moreover, **Ali & Gobran (2002)** found that leaves of dry soil moisture treatment had the highest value of leaf Zn content of Washington navel orange trees.

As for the specific effect of fruits and adjacent leaves localities across the tree periphery towards both northern and southern direction, **Table (17)** shows obviously that fruit rind and adjacent leaves of northern half of tree canopy were richer in their zinc content as compared to those of the southern hemisphere during both seasons of study. Differences were significant during both seasons with either leaf or fruit rind.

Meanwhile, as the fruit status (sound and creased) and nearer leaves, it is quite clear that trend of response was so firmer and rind of sound fruits and leaves nearer to them were statistically richer than the analogous organs related to the creased fruits. Such trend was true during both 2002/2003 and 2003/2004 seasons.

Findings of **Fatma (2003)** gave support to trend of response detected from the present study concerning the specific effect of fruit status on Zn content.

B- Interaction effect:

The specific effect of each studied factors (irrigation regime, geographical direction and fruit status) was directly reflected on their combinations. So, the highest zinc level in both leaf and fruit rind was always in concomitant to peel of sound fruits and adjacent leaves born on the limbs towards the northern side of tree canopy of Tanarif trees irrigated after depletion of 75 % available water. The reverse was true with the rind of creased fruits and adjacent leaves located towards the southern side of Tanarif trees irrigated after depletion of 25 % A.W. during 1st and 2nd seasons. Moreover, other combinations were in between the aforesaid two extremes.

Table (17): content in leaf and fruit peel sampled from northern and southern sides of Tanarif orange trees periphery as affected by irrigation regime, geographical direction, fruit status and their combinations during both 2002/2003 and 2003/2004 seasons.

Treatments \ Direction and fruit status	Zn (ppm)									
	Leaf					Rind				
	North		South		Mean *	North		South		Mean *
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	68.00c	66.00cd	66.00cd	54.00f	**63.50C**	46.00ef	40.00g	44.00f	38.50g	**42.13C**
Irrigation after depletion of 50 % available water	74.00ab	72.00b	72.00b	60.00e	**69.50B**	52.00a-c	46.00ef	50.00b-d	44.00f	**48.00B**
Irrigation after depletion of 75 % available water	77.00a	75.00ab	75.00ab	63.00de	**72.50A**	55.00a	49.00c-e	53.00a-b	47.00d-f	**51.00A**
Mean (direction)**	**72.00A**		**65.00B**			**48.00A**		**46.08B**		
Mean* (fruit status)**	**Sou. 71.67A**		**Cre.65.33B**			**Sou. 50.0A**		**Cre. 44.08B**		
2003/2004 season										
Irrigation after depletion of 25 % available water	72.00b-d	68.00de	69.00c-e	58.00f	**66.75C**	47.00e	42.00fg	47.00e	40.00g	**44.00C**
Irrigation after depletion of 50 % available water	78.00ab	74.00a-d	75.00a-c	63.00ef	**72.50B**	53.00a-c	48.00de	52.00b-d	46.00ef	**49.75B**
Irrigation after depletion of 75 % available water	79.00a	76.00ab	79.00a	68.00de	**75.50A**	57.00a	50.00c-e	55.00ab	49.00c-e	**52.75A**
Mean (direction)**	**74.50A**		**68.67B**			**49.50A**		**48.17B**		
Mean* (fruit status)**	**Sou. 75.33A**		**Cre. 67.83B**			**Sou. 51.83A**		**Cre. 45.83B**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.
Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

Leaf and fruit rind cupper content (Cu ppm).

A- Specific effect:

Concerning the specific effect of irrigation regime, **Table (18)** displays that both fruit rind and adjacent leaves cupper content of Tanarif trees was gradually increased with increasing the percentage of available water depleted prior rewatering had been applied. Herein, irrigated Tanarif trees after depletion of 75 % of available water had statistically the richest fruit rind and adjacent leaves cupper content, while the reverse was true with those irrigated after 25 % A.W. depletion. Moreover, irrigation regime after 50 % A.W. depletion was in between. Differences were significant as three irrigation regimes were compared each other during both 2002/2003 and 2003/2004 seasons.

Such results are in general agreement with those previously reported by **Zahran *et al.*, (1987),** on some olive cultivars and **Nomir, (1994)** in persimmon leaves. They found that the reduction in soil moisture level caused an increase in concentration of Cu content.

Referring the response of fruit rind and adjacent leaves cupper content to the specific effect of geographical direction towards which the fruits and leaves carrier branches were directed, data obtained during both seasons as shown from **Table (18)** pointed out that Cu content in both fruit rind and nearer leaf followed the same trend. In this regard, fruit rind and leaf Cu contents were significantly influenced by the geographical direction, whereas, Tanarif fruits and adjacent leaves borne on limbs towards the south had the highest value of cupper content over those facing the opposite direction (north) during both seasons of study.

With regard to specific effect of fruit status (sound or creased) on leaf and fruit rind Cu content of Tanarif orange cv., data presented in **Table (18)** display that peels of creased fruits and leaves approached them were significantly richer in their Cu content as compared to the analogous ones of the sound fruits. Such trend was true during both seasons of study. In this concern, **Fatma (2003)** showed that peel of creased fruits and adjacent leaves contained higher level of Cu as compared to those of analogous ones of sound fruits. However, the increase in Cu content in most cases was in significant.

B- Interaction effect:

Table (18) displays that both leaf and fruit rind of creased fruits sampled from the southern side of tree canopy and irrigated after depletion of 75 % available water exhibited statistically the highest Cu level during both seasons of study.

The reverse was observed with both sound fruit rind and adjacent leaves situated in northern side of tree canopy which irrigated after depletion of 25 % available water in both seasons. In addition, other combinations were in between the aforesaid two extremes.

Table (18): Cupper content in leaf and fruit peel sampled from northern and southern sides of Tanarif orange trees periphery as affected by irrigation regime, geographical direction, fruit status and their combinations during both 2002/2003 and 2003/2004 seasons.

Treatments \ Direction and fruit status	Cu (ppm)									
	Leaf				Mean *	Rind				Mean *
	North		South			North		South		
	Sound	Creased	Sound	Creased		Sound	Creased	Sound	Creased	
2002/2003 season										
Irrigation after depletion of 25 % available water	10.80g	11.50f	12.30d	12.88c	**11.87C**	7.85j	8.00ij	8.80f	11.40c	**9.01C**
Irrigation after depletion of 50 % available water	11.40f	12.80c	12.90c	13.40b	**12.63B**	8.13hi	8.30h	9.40e	12.00b	**9.46B**
Irrigation after depletion of 75 % available water	11.90e	13.30b	13.45b	13.90a	**13.14A**	8.60g	8.80f	9.90d	12.50a	**9.95A**
Mean (direction)**	**11.95B**		**13.14A**			**8.28B**		**10.67A**		
Mean* (fruit status)**	**Sou. 12.13B**		**Cre. 12.96A**			**Sou. 8.78B**		**Cre. 10.17A**		
2003/2004 season										
Irrigation after depletion of 25 % available water	10.65h	12.00e	12.05e	12.80c	**11.88C**	7.81j	8.00i	8.69f	11.25c	**8.94C**
Irrigation after depletion of 50 % available water	11.10g	12.50d	12.75c	13.20b	**12.39B**	8.05i	8.26h	9.20e	11.82b	**9.33B**
Irrigation after depletion of 75 % available water	11.70f	13.10b	13.15b	13.65a	**12.90A**	8.45g	8.62f	9.75d	12.32a	**9.79A**
Mean (direction)**	**11.84B**		**12.93A**			**8.20B**		**10.50A**		
Mean* (fruit status)**	**Sou. 11.90B**		**Cre. 12.88A**			**Sou. 8.66B**		**Cre. 10.05A**		

*; ** and *** refer to specific means of irrigation regime, geographical direction (N & S) and fruit status (sound & creased), respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

IV.II- Second Experiment: Effect of (GA_3; P; K) foliar spray in combination with application date and geographical direction on Tanarif sweet orange cultivar:

In this regard specific and interaction of four investigated factors namely, a) foliar spray treatments (GA_3 at 40 ppm, GA_3 at 40 ppm + P at 200 ppm, GA_3 at 40 ppm + K_2SO_4 at 3 %, GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %) ; b) geographical direction (north & south); c) fruit status (sound & creased), d) date of application (June & July) as well as their combinations were investigated pertaining the response of fruit qualities, (physical & chemical properties); creasing incidence and nutritional status (leaf & rind mineral compositions) of Tanarif orange trees were investigated during both 2002/2003 & 2003/2004 experimental seasons.

IV.II.1-Fruit quality:

Data obtained during both experimental seasons 2002/2003 and 2003/2004 regarding the specific effect of four investigated factors involved in this study i.e., foliar spray treatments, geographical direction, fruit status and application date as well as interaction effect of their possible combinations are presented in **Tables (19); (20); (21); (22); (23) and (24).**

IV.II.1.A- Fruit physical properties:

Average fruit weight; size, dimensions (polar & equatorial diameters); fruit peel thickness, rind weight and fruit juice weight, volume, of Tanarif fruits were investigated in response to specific and interaction effects of different foliar spray treatments, geographical direction (north & south); fruit status (sound & creased) and date of application (June & July) as well as their combinations. Data obtained during both seasons are presented in **Tables (19); (20); (21) and (22)**.

Average fruit weight (g) and size (cm^3):

A- Specific effect:

Referring the specific effect of foliar spray treatments on fruit weight (g) and size (cm^3), it is clear from the present results in **Table (19)** that four foliar spray treatments increased significantly both fruit parameters, however they varied obviously in their effect during 2002/2003 and 2003/2004 experimental seasons. On the other hand, T_5 (GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %) resulted significantly the greatest value of both fruit weight and size followed in a descending order by T_2 (GA_3 at 40 ppm) foliar spray treatments. The T_4 (GA_3 at 40 ppm + K_2SO_4 at 3 %) came in the third class; meanwhile the T_3 (GA_3 at 40 ppm + P at 200ppm) appeared to be less effective than the abovementioned ones. These observations are in accordance with those obtained by **Franciosi and Ponce (1970)**, they reported that spraying Washington navel orange trees at the flower bud stage or at petal fall with 10, 100 or 1000 ppm GA produced larger fruits than the control and disagree with the findings of **Coggins and Hield (1958) and Deidda (1971),** they reported that GA did not affect orange fruit weight. Moreover, **Randhawa and Dhuria (1965)** on lime trees and **Jakson (1968)** on lemon trees, they included that GA increased fruit size. On the contrary, **Ashkenazy and**

Broch (1971) mentioned that spraying celementine trees with 25 to 30 ppm GA at flowering decreased fruit size.

In addition, **Goepfert *et al.*, (1987)** on Valencia orange, **Rabeh and Sweelam (1990)** on mandarin, **Sobral *et al.*, (2000)** on orange and **Ali and Gobran (2002)** on Washington navel orange trees indicated that potassium increased fruit weight and fruit size.

Concerning the specific effect of fruits localities across the tree periphery towards both northern and southern geographical direction, **Table (19)** shows obviously that fruits of northern half of tree canopy had significantly heavier fruit with larger size as compared to those of the southern hemisphere during the two seasons of study. These results are in general agreement with the findings of **Fatma (2003)** on Hamlin cultivar. She found that northern half of tree canopy induced fruits significantly higher in their average fruit weight and size as compared to those of southern limbs.

Regarding the specific effect of fruit status (sound & creased), it is so clear that sound Tanarif fruits had heavier fruit and larger size as compared to those of creased fruits during both seasons of study. These results were in disagreement with those of **Miller (1945)** who stated that small mature fruits were more subjected to creasing than large ones. **Salama (1979) and Fatma (2003)** reported that value of weight and volume less in cracked Balady orange fruits and Washington navel orange than sound ones, respectively.

As for the specific effect of application date (June & July) on fruit weight and size, it could be noticed from data in **Table (19)** that July application significantly effective to increase in both fruit weight and size than the June application during the two seasons of study.

B- Interaction effect:

Regarding the interaction effect of various combinations between four investigated factors i.e., foliar spray treatments, geographical direction, fruit status and date of application on both fruit weight and size, data obtained during both 2002/2003 and 2003/2004 seasons **Table (19)** displays that each investigated factor reflected its own specific effect on the interaction effect of their combinations. Hence, the heaviest fruit of the greatest size were coupled with those sound fruits situated within the northern limbs of Tanarif trees sprayed in July with the T_5 (GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %) during two seasons of study followed statistically by sound ones of southern side on sprayed trees with same treatment and date. Contrary to that, creased fruits borne on either southern or northern scaffolds of Tanarif trees sprayed with water (control) followed by these of T_3 (GA_3 at 40 ppm + P at 200 ppm) had statistically the lightest fresh weight and size during 1^{st} and 2^{nd} seasons of study. In addition, other combinations were in between the aforesaid to extremes.

Fruit dimensions (polar & equatorial diameters):

A- Specific effect:

Referring the response of fruit dimensions i.e., fruit height (polar diameter) and fruit width (equatorial diameter) to the specific effect of the four factors involved in this study i.e., foliar spray treatments with GA_3 solely or combined with P or K or P and K treatments, geographical direction (north & south), fruit status (sound & creased) and date of

Table (19): Average weight and size of Tanarif sweet orange fruits harvested in Feb. in response to specific and interaction effects of foliar spray with (GA_3 & combined with P/ and K), geographical direction, fruit status, dates of application and their combinations during two successive 2002/2003 and 2003/2004 seasons.

Spray treatments \ Direction, fruit status and application date	Fruit weight (g.)								Mean*	Fruit size (cm)								Mean*
	North				South					North				South				
	Sound		Creased		Sound		Creased			Sound		Creased		Sound		Creased		
	June	July	June	July	June	July	June	July		June	July	June	July	June	July	June	July	
2002/2003 season																		
T_1 water spray (control)	161.7k-m	168.0g-k	154.7m-o	166.0h-l	158.3l-n	163.0k-m	154.3m-o	158.7l-n	**160.6D**	164.7l-n	170.7i-m	164.7l-n	166.7k-n	164.7l-n	167.3k-n	162.3m-o	162.7m-o	**165.5D**
T_2 GA_3 40 ppm	172.7f-j	188.0ab	170.3f-k	186.3a-c	169.3f-k	189.7ab	165.0i-l	184.3a-d	**178.2B**	174.7g-k	191.0ab	172.0i-l	188.7a-d	172.7h-l	188.3a-d	168.7j-n	183.7b-f	**180.0B**
T_3 GA_3 40 ppm + P 200 ppm	152.0n-p	185.0a-d	149.7op	178.0c-f	146.7op	182.7b-e	145.7p	175.7e-g	**164.4C**	154.7o-q	183.7b-f	160.3n-p	181.0d-h	152.7pq	181.3d-h	151.3q	178.3e-l	**167.9C**
T_4 GA_3 40 ppm + 3 % K_2SO_4	166.3h-l	166.3h-l	164.3j-l	164.3j-l	168.3g-k	168.3g-k	165.0i-l	165.0i-l	**166.0C**	174.0g-k	174.0g-k	167.0k-n	167.0k-n	170.7i-m	170.7i-m	164.7l-n	164.7l-n	**169.1C**
T_5 GA_3 40 ppm + P 200 ppm + 3 % K_2SO_4	177.0d-g	193.0a	175.0e-h	188.7ab	174.0e-l	190.7ab	172.7f-j	184.7a-d	**182.0A**	184.3b-f	195.0a	177.3f-j	190.7a-c	182.0c-g	191.0ab	175.7f-k	186.7a-e	**185.3A**
Mean** (direction)	**171.4A**				**169.1B**					**175.1A**				**172.0B**				
Mean*** (fruit status)	**Sou. 172.1A**				**Cre. 168.4B**					**Sou. 175.4A**				**Cre. 171.7B**				
Mean**** (application date)	**June 163.2B**				**July 177.3A**					**June 168.0B**				**July 179.2A**				
2003/2004 season																		
T_1 water spray (control)	152.0e-l	161.0c-e	147.7h-k	155.0d-h	139.3kl	140.7j-l	135.0l	136.7l	**145.9D**	150.0i-l	156.7e-h	139.7m	140.0m	149.3j-l	152.0h-l	146.0l	136.7m	**146.3D**
T_2 GA_3 40 ppm	174.7ab	174.7ab	177.3a	177.3a	155.0d-h	155.0d-h	160.3c-e	160.3c-e	**166.8B**	171.7b	176.0ab	149.3j-l	176.0ab	169.7bc	172.7ab	147.7kl	161.3de	**165.6B**
T_3 GA_3 40 ppm + P 200 ppm	162.3cd	176.0a	161.3c-e	173.0ab	140.7j-l	162.0cd	134.7l	157.0d-g	**158.4C**	165.0cd	171.0b	148.3kl	155.0f-j	163.0d	171.7b	136.0m	151.0h-l	**157.6C**
T_4 GA_3 40 ppm + 3 % K_2SO_4	166.3bc	174.7ab	160.7c-e	166.7bc	148.7g-j	153.7d-l	145.3i-k	150.0f-l	**158.3C**	156.0e-l	163.3d	140.0m	162.0de	153.7g-k	172.0b	137.0m	159.0d-g	**155.4C**
T_5 GA_3 40 ppm + P 200 ppm + 3 % K_2SO_4	178.3a	181.0a	173.3ab	177.7a	159.3c-e	163.0cd	154.7d-h	158.3c-f	**168.2A**	164.7cd	178.3a	164.7cd	178.3a	172.0b	173.0ab	160.7d-f	160.7d-f	**169.1A**
Mean** (direction)	**168.6A**				**150.5B**					**160.3A**				**157.3B**				
Mean*** (fruit status)	**Sou. 160.9A**				**Cre. 158.1B**					**Sou. 165.1A**				**Cre. 152.5B**				
Mean**** (application date)	**June 156.3B**				**July 162.7A**					**June 154.2B**				**July 163.3A**				

*; **; *** and **** refer to specific effect values of foliar spray treatments; geographical direction; fruit status and application date, respectively.
Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

application (June & July). The specific effect of different foliar treatments, it is quite evident from data obtained from **Table (20)** that the four investigated foliar treatments significantly increased both dimensions as compared with control, but varied as they were compared each other. On the other hand, the T_5 (GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %) resulted significantly in the greatest values of both fruit height and diameter followed statistically in a decreasing order by the T_2 (GA_3 at 40 ppm) foliar spray treatments which ranked statistically second. Moreover, both T_3 (GA_3 at 40 ppm + P at 200 ppm) and T_4 (GA_3 at 40 ppm + K_2SO_4 at 3 %) foliar spray treatments came third and appeared to be less effective during 1st and 2nd seasons.

The present results are in agreement with those found by **Ibrahim *et al.*, (1994)** on Washington navel orange, **Kaur *et al.*, (1997)** on Kinnow mandarin and **Marzouk and Kassem (2002)** on Balady mandarin. They noticed that both fruit length and diameter exhibited the highest values of both fruit diameter after spraying with GA_3. Also, **El-Deeb (1989)** found that K_2SO_4 foliar sprays increased fruit dimensions (especially diameter) of both Washington navel orange and Valencia orange.

Concerning the response of fruit dimensions i.e., fruit height and width to specific effect of geographical direction towards which the fruits carrier branches were directed, data obtained during both seasons as shown from **Table (20)** pointed out that both fruit dimensions (height & width) was significantly influenced by the geographical direction, whereas Tanarif fruits born on limbs towards the north had an obvious taller height and width over those facing the opposite direction (south) during 1st and 2nd seasons of study. The results go partially with findings of **Fatma (2003)** on Hamlin cultivar.

With regard to the specific effect of fruit status (sound & creased), data obtained in **Table (20)** showed that sound

Tanarif fruits had longer height and width of fruits as compared with creased fruits during the two seasons of study. The present results regarding the effect of fruit status on fruit dimensions (polar & equatorial) in magnitude with findings of **Salama (1979)** and **Diab (1982)**. They pointed out that values of the fruit dimensions (height & width) were less in cracked Balady orange than sound fruits.

Regarding the specific effect of date of application (June & July) on fruit dimensions (polar & equatorial diameters) values, it could be noticed from data in **Table (20)** that July application date resulted in a significant increase in fruit dimensions than June application date during the study.

B- Interaction effect:

Table (20) indicates a significant variance due to interaction effect of various combinations between foliar spray treatments, geographical direction (north & south), fruit status (sound & creased) and date of application (June & July) on fruit dimensions (height and width). Data in **Table (20)** displayed that the trend of response was so firm with both fruit height and width. On the other hand, it could be generally noticed the superiority of both fruit dimensions of Tanarif trees, expressed as polar and equatorial diameters during 1st and 2nd seasons. Herein, sound fruits on the northern limbs of Tanarif trees sprayed with the T_5 (GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %) in July, induced fruits with the tallest height and width during 2002/2003 and 2003/2004 seasons. However, the opposite was found with creased fruits of southern limbs on Tanarif trees sprayed with water (control) regardless of date of application during the two seasons of study. In addition, other combinations were in between the aforesaid two extremes.

Table (20): Average polar diameter (cm) and equatorial diameter (cm) of Tanarif sweet orange fruits harvested in Feb. in response to specific and interaction effects of foliar spray with (GA_3 & combined with P/ and K), geographical direction, fruit status, dates of application and their combinations during two successive 2002/2003 and 2003/2004 seasons.

Direction, fruit status and application date / Spray treatments	Fruit polar diameter (cm)								Mean*	Fruit equatorial diameter (cm.)								Mean*
	North				South					North				South				
	Sound		Creased		Sound		Creased			Sound		Creased		Sound		Creased		
	June	July	June	July	June	July	June	July		June	July	June	July	June	July	June	July	
2002/2003 season																		
T_1 water spray (control)	6.51c-e	5.94n-p	6.35e-h	5.86op	6.15i-m	6.17h-l	5.91n-p	5.97no	**6.11D**	6.20l-o	6.30i-m	5.96p-r	6.06n-p	6.07n-p	6.07n-p	5.76r	5.82qr	**6.03D**
T_2 GA_3 40 ppm	6.46d-g	6.65bc	6.24h-j	6.49c-e	6.26hi	6.49c-e	6.06j-n	6.22h-j	**6.36B**	6.55e-h	6.92b	6.27i-n	6.85bc	6.37h-l	6.71c-e	6.23k-n	6.43f-k	**6.54B**
T_3 GA_3 40 ppm + P 200 ppm	6.44d-g	6.44d-g	6.18h-l	6.18h-l	6.18h-l	6.18h-l	5.77p	5.91n-p	**6.16C**	6.21l-o	6.46f-j	6.07n-p	6.26i-n	5.79qr	6.26j-n	5.52s	6.12m-p	**6.09C**
T_4 GA_3 40 ppm + 3 % K_2SO_4	6.21h-k	6.57cd	6.03k-o	6.22h-j	5.99m-o	6.35e-h	5.91n-p	6.30f-l	**6.20C**	6.45f-j	6.45f-j	6.26i-n	6.33h-m	5.99o-q	6.26j-n	6.12m-p	6.07n-p	**6.24C**
T_5 GA_3 40 ppm + P 200 ppm + 3 % K_2SO_4	6.76b	6.98a	6.48c-f	6.78b	6.23h-j	6.57cd	6.00l-o	6.29g-l	**6.51A**	6.86bc	7.15a	6.61d-g	6.92b	6.64d-f	6.76b-d	6.40g-l	6.48f-l	**6.73A**
Mean** (direction)	**6.39A**				**6.15B**					**6.47A**				**6.19B**				
Mean*** (fruit status)	**Sou. 6.38A**				**Cre. 6.16B**					**Sou. 6.40A**				**Cre. 6.26B**				
Mean**** (application date)	**June 6.21B**				**July 6.33A**					**June 6.23B**				**July 6.43A**				
2003/2004 season																		
T_1 water spray (control)	5.76l-n	6.15d-f	5.65n-p	5.69n-p	5.65n-p	6.02f-l	5.56pq	5.58pq	**5.76D**	6.03i-l	6.45b	5.73o	5.99j-m	5.85n	6.37bc	5.59op	5.93k-n	**5.99D**
T_2 GA_3 40 ppm	5.90i-k	6.35b	5.71m-o	6.14d-f	5.83k-m	6.35b	5.59o-q	6.01f-l	**5.99B**	6.37bc	6.46b	6.00j-m	6.19e-h	6.28c-e	6.43b	5.92l-n	6.08g-j	**6.22B**
T_3 GA_3 40 ppm + P 200 ppm	6.22c-e	6.22c-e	5.85kl	5.85kl	6.04f-h	6.04f-h	5.48q	5.74l-n	**5.93C**	6.06h-k	6.47b	5.95k-n	6.20e-g	6.04i-l	6.43b	5.66op	6.14f-l	**6.12C**
T_4 GA_3 40 ppm + 3 % K_2SO_4	6.14d-f	6.33bc	5.67n-p	6.12d-g	5.98h-j	6.20c-e	5.74l-n	5.99g-l	**6.03C**	6.06h-k	6.48b	5.89mn	6.23d-f	5.62op	6.35b-d	5.73o	6.15e-l	**6.06C**
T_5 GA_3 40 ppm + P 200 ppm + 3 % K_2SO_4	6.12d-g	6.52a	5.86j-l	6.21c-e	5.98hi	6.25b-d	5.76l-n	6.09e-h	**6.10A**	6.46b	6.70a	6.19e-h	6.37bc	6.43b	6.61a	6.08g-j	6.28c-e	**6.39A**
Mean** (direction)	**6.02A**				**5.89B**					**6.21A**				**6.10B**				
Mean*** (fruit status)	**Sou. 6.10A**				**Cre. 5.81B**					**Sou. 6.30A**				**Cre. 6.02B**				
Mean**** (application date)	**June 5.82B**				**July 6.09A**					**June 6.00B**				**July 6.32A**				

*; **; *** and **** refer to specific effect values of foliar spray treatments; geographical direction; fruit status and application date, respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

Fruit rind thickness (mm) and weight (g):

Concerning the specific and interaction effects of four investigated factors (foliar spray treatments; geographical direction; fruit status and date of application) as well as their combinations on rind thickness and its weight per fruit, data obtained during both 2002/2003 and 2003/2004 seasons are presented in **Table (21)**.

A- Specific effect:

With regard to specific effect of foliar spray treatments, data obtained during two seasons displayed that the response of both parameters peel (thickness and weight/fruit) followed typically the same trend. Whereas, the four investigated foliar spray treatments significantly varied in this concern as they were compared to control during 2002/2003 and 2003/2004 seasons. On the other hand, the T_5 (GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %) resulted significantly in the greatest values of both rind thickness and weight followed in decreasing order by T_4 (GA_3 at 40 ppm + K_2SO_4 at 3 %); T_3 (GA_3 at 40 ppm + P at 200 ppm) and T_2 (GA_3 at 40 ppm) foliar spray where three treatments ranked statistically 2nd from one hand and showed the same effectiveness from the other.

The present results are in agreement with those found by **Coggins (1968-69)** on Washington navel orange, **Gilfilian *et al.*, (1974) and Naguib (1978)** on Balady orange fruit, they reported that GA increased rind thickness and disagree with **Deidda (1971)** who mentioned that spraying Washington navel orange trees at full bloom with GA_3 reduced rind thickness. Regarding the effect of P foliar spray treatment as fruit peel thickness in magnitude with the findings of **Bauma (1961)** on Washington navel orange, **De-Viliers (1968-1969), Till *et al.*, (1969) and Lou and Yin (1986)**. They reported that P application increased the rind thickness. On the contrary, **Rosselet *et al.*, (1962) and Ogaki *et al.*, (1966)** reported that P application reduced rind thickness on orange and Unshiu fruits. Also, **Bar-Akiva *et al.*, (1968)** came to the same conclusion in grapefruit. In addition, the present result regarding the effect of potassium application on fruit peel thickness, corresponding literature indicated that potassium application increased peel thickness. In **(1966) Embleton and Jones** mentioned that increasing K level in orange and grapefruit generally increased thickness of the rind. In the same time, **Embleton *et al.*, (1967)** found that an increase of K level in the range of 0.3 to 1.7 % resulted in thicker and coarser textured rind that has subjected to delayed colour break and to more greening also. In addition **Goepfert *et al.*, (1987)** on Valencia orange , **Rabeh and Sweelam, (1990)** on mandarin, **Sobral *et al.*, (2000)** on orange and **Ali and Gobran (2002)** on Washington navel orange, they reported that potassium application increased rind thickness.

Concerning the specific effect of geographical direction (north & south) on both rind thickness and weight, it could be noticed from data in **Table (21)** that the fruits of the southern half of the tree periphery had the thickest and heaviest rind as compared to those of the northern canopy side. Differences were significant during 1st and. 2nd seasons of study. These results were in harmony with the findings of **Fatma (2003)**. She found that fruits of the southern limbs characterized by their abundant thickest and heaviest rind as compared to those of the opposite side of tree and differences were significant.

With regard to the specific relationship between Tanarif fruit status (sound and creased) and its rind thickness and rind weight, **Table (21)** shows that the creased fruit characterized by its thinner and lighter weight rind, while the reverse was observed with the sound fruits, which showed thicker, and heavier weight rind. Such trend was true during both seasons of study and differences in both rind thickness and rind weight were significant. This result was in line with the findings of **Hass (1950), Jones *et al.*, (1967), El-Nokrashy (1969), Salama (1979), Diab (1982) and Fatma (2003).** They reported that peel of the creased and cracked navel, Balady and Hamlin orange fruits were thinner than that of sound fruits.

Concerning the specific effect of application date (June and July), data as shown in **Table (21)** revealed that July application significantly increased both peel thickness and weight as compared to those fruits from June application during two seasons of study.

B- Interaction effect:

As for the interaction effect of various combinations between the four investigated factors (foliar spray treatments, geographical direction, fruit status and application date), **Table (21)** shows that the trend of response was so firm from one hand and reflected directly the specific effect of each investigated factor from the other side. In this regard, it was quite evident to be noticed that both thickest and heaviest rind of Tanarif fruit were statistically coupled with the sound fruits situated within the southern tree hemispheres of July sprayed trees with T_5 (GA_3

Table (21): Average of rind thickness (mm) and rind weight (g) of Tanarif sweet orange fruits harvested in Feb. in response to specific and interaction effects of foliar spray with (GA3 & combined with P/ and K), geographical direction, fruit status, dates of application and their combinations during two successive 2002/2003 and 2003/2004 seasons.

Direction, fruit status and application date / Spray treatments	Rind thickness (mm.)								Mean*	Rind weight (g.)								Mean*
	North				South					North				South				
	Sound		Creased		Sound		Creased			Sound		Creased		Sound		Creased		
	June	July	June	July	June	July	June	July		June	July	June	July	June	July	June	July	
2002/2003 season																		
T_1 water spray (control)	3.33i-o	3.67c-l	2.80p	2.80p	3.47g-m	3.80c-j	3.17l-p	3.17l-p	**3.28C**	41.33lm	46.67f-j	36.67n	42.00lm	44.00h-l	46.67f-j	39.00mn	43.33j-l	**42.46C**
T_2 GA_3 40 ppm	3.60d-m	4.00c-g	2.93n-p	3.53f-m	3.90c-h	4.13b-d	3.23k-p	3.76c-k	**3.64B**	46.33f-j	47.00e-j	44.33h-l	44.33h-l	48.67d-g	47.67d-g	44.67h-l	47.00e-j	**46.25B**
T_3 GA_3 40 ppm + P 200 ppm	3.60d-m	3.60d-m	2.83op	3.07m-p	3.80c-j	3.90c-h	3.13m-p	3.40h-n	**3.42B**	48.67d-g	48.67d-g	41.33lm	42.00lm	49.67d-g	49.67d-g	43.67i-l	47.00e-j	**46.34B**
T_4 GA_3 40 ppm + 3 % K_2SO_4	3.57e-m	3.83c-I	3.10m-p	3.30i-p	3.73c-k	4.20bc	3.27j-p	3.73c-k	**3.59B**	47.33e-I	47.33e-I	42.67kl	43.33j-l	46.00g-k	55.00ab	41.33lm	51.67b-d	**46.83B**
T_5 GA_3 40 ppm + P 200 ppm + 3 % K_2SO_4	4.10b-e	4.53b	3.77c-k	4.10b-e	4.70b	4.97a	4.03c-f	4.67b	**4.36A**	50.00d-f	53.67bc	46.33f-j	50.67c-e	52.00b-d	58.00a	47.67e-h	53.67bc	**51.50A**
Mean** (direction)	**3.50B**				**3.81A**					**45.53B**				**47.82A**				
Mean*** (fruit status)	**Sou. 3.92A**				**Cre. 3.39B**					**Sou. 48.72A**				**Cre. 44.63B**				
Mean**** (application date)	**June 3.50B**				**July 3.81A**					**June 45.08B**				**July 48.27A**				
2003/2004 season																		
T_1 water spray (control)	3.33m-p	3.90h-l	3.13p	3.33m-p	3.83h-m	4.33d-h	3.80i-n	3.80i-n	**3.68C**	39.00jk	43.00e-l	36.33k	39.67ij	44.67d-g	47.33b-d	39.00jk	43.00e-I	**41.50C**
T_2 GA_3 40 ppm	4.03g-k	4.17f-j	3.30n-p	3.43l-p	4.33b-h	4.60c-f	3.70j-o	4.07g-j	**3.95B**	42.33f-j	46.33de	39.33jk	43.67e-h	48.00b-d	49.67bc	42.00g-j	46.00dc	**44.67B**
T_3 GA_3 40 ppm + P 200 ppm	4.10g-j	4.10g-j	3.53k-p	3.53k-p	4.73b-d	4.73b-d	4.07g-j	4.07g-j	**4.11B**	44.67d-g	47.00cd	40.33h-j	42.33f-j	48.00b-d	50.33b	43.33e-h	43.67e-h	**44.96B**
T_4 GA_3 40 ppm + 3 % K_2SO_4	3.67j-o	4.23e-I	3.27op	3.67j-o	4.53c-g	4.77b-d	3.93h-l	4.67c-e	**4.09B**	43.33e-h	43.33e-h	42.00g-j	42.00g-j	50.00bc	50.00bc	45.67d-f	45.67d-f	**45.25B**
T_5 GA_3 40 ppm + P 200 ppm + 3 % K_2SO_4	4.87bc	5.00bc	4.80b-d	4.83b-d	5.20b	5.73a	4.90bc	4.87bc	**5.03A**	42.33f-j	45.67d-f	39.00jk	42.00g-j	50.33b	53.33a	45.67d-f	47.67b-d	**45.75A**
Mean** (direction)	**3.91B**				**4.43A**					**42.18B**				**46.67A**				
Mean*** (fruit status)	**Sou. 4.41A**				**Cre. 3.93B**					**Sou. 46.43A**				**Cre. 42.42B**				
Mean**** (application date)	**June 4.05B**				**July 4.29A**					**June 43.27B**				**July 45.58A**				

*; **; *** and **** refer to specific effect values of foliar spray treatments; geographical direction; fruit status and application date, respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %) during two seasons of study. Moreover, the thinnest and lightest rind weight was always in closed relationship to the creased Tanarif fruits borne on northern periphery side of water sprayed Tanarif trees, regardless of application date during 2002/2003 and 2003/2004 seasons. In addition, other combinations were in between the aforesaid two extremes.

Fruit juice weight (g) and volume (cm^3):

Data obtained regarding the specific effect of foliar spray treatments, geographical direction, fruit status and date of application, as well as interaction effect of their combinations on both juice weight and volume/fruit, are presented in **Table (22)**.

A- Specific effect:

Referring the specific effect of different spray treatments, obtained data exhibited that both juice weight (g) and volume (cm^3)/fruit followed typically the same trend of response. Anyhow, it was quite clear that all four investigated foliar spray treatments resulted in an obvious increase over control treatment in both juice weight (g) and volume (cm^3)/fruit during 1^{st} and 2^{nd} seasons.

Whereas, T_5 (GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %) foliar spray treatment ranked significantly first in this regard significantly, followed in a descending order by T_4 (GA_3 at 40 ppm + K_2SO_4 at 3 %). However, both the T_3 (GA_3 at 40 ppm + P at 200 ppm) and the T_2 (GA_3 at 40 ppm) came third class and appeared to be significantly less effective than the abovementioned two superior ones and showed the same effectiveness in both seasons of study. On the contrary, water spray (control) treatment exhibited the lowest values in this respect.

These results were in agreement with those of **Coggins and Hield (1958) and Naguib (1978),** they mentioned that GA treatment increased the juice percentage of Washington navel orange and some orange cultivars. On the other hand, **Coggins and Garber (1960)** reported that GA decreased the percentage of juice of Valencia orange fruits. **Gershtein (1973)** reported that GA had no determined effect on orange fruit quality. Moreover, **El-Deeb (1989)** found that K H_2PO_4 foliar spray increased fruit juice in both Washington navel orange and Valencia orange.

In addition, findings of **Goepfert *et al.*, (1987)** on Valencia orange, **Rabeh and Sweelam (1990)** on mandarin, **Sobral *et al.*, (2000)** on orange and **Ali & Gobran (2002)** on Washington navel orange, they indicated that potassium increased fruit juice.

Concerning the Tanarif fruit juice weight (g) and volume (cm^3) in response to specific effect of geographical direction (north & south) of the fruits bearer scaffolds, **Table (22)** declares that fruits situated across the southern side of tree periphery had significantly higher value of both juice weight (g) and volume (cm^3) as compared to those of the northern side. Such trend was true during 1st and 2nd seasons of study.

The observation are in accordance with those obtained by **Fatma (2003)** where, she pointed out that southern limbs of Hamlin trees produced fruits characterized by their abundant juice with heavier weight and greater volume as compared to those fruits borne on northern side of Hamlin orange trees.

With regard to the specific effect of fruit status (sound & creased) on both juice weight (g) and volume (cm^3) per

Tanarif fruit, it could be noticed from data in **Table (22)** that sound fruits resulted in a significant increase in both juice weight (g) and volume (cm^3) per fruit than creased fruits during 2002/2003 and 2003/2004 experimental seasons.

These results were in agreement with those of **Diab (1982)**, who mentioned that sound fruit contained higher juice weight and greater juice volume than creased fruit of Balady orange, Shamouti and Hamlin fruits.

Regarding the specific effect of the date of application (June & July) on both juice weight (g) and volume (cm^3)/fruit, it could be noticed from data in **Table (22)** that July application caused a significant increase in both juice weight and volume than June date of application during $1^{\underline{st}}$ and $2^{\underline{nd}}$ seasons of study.

B- Interaction effect :

As for the interaction effect of the four investigated factors i.e., foliar spray treatments, geographical direction (northern & southern), fruit status (sound & creased) and date of application (June & July) on both juice weight (g) and volume (cm^3), data obtained during both 2002/2003 and 2003/2004 seasons are presented in **Table (22)**. The combination of sound fruits of southern limbs foliar sprayed Tanarif trees in July with the T_5 (GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %); gave the heaviest Juice weight (g) and highest volume (cm^3) of juice/fruit. Meanwhile, the reverse was found with creased fruits produced from Tanarif trees sprayed with water (control) and situated across the northern side of the periphery regardless of application date during the two seasons of study. Moreover, other combinations were in between the aforesaid two extremes.

Table (22): Average juice weight (g) and juice volume (cm3) of Tanarif sweet orange fruits harvested in Feb. in response to specific and interaction effects of foliar spray with (GA_3 & combined with P/ and K), geographical direction, fruit status, dates of application and their combinations during two successive 2002/2003 and 2003/2004 seasons.

Direction, fruit status and application date / Spray treatments	Fruit juice weight (g.)								Mean*	Fruit juice volume (cm3)								Mean*
	North				South					North				South				
	Sound		Creased		Sound		Creased			Sound		Creased		Sound		Creased		
	June	July	June	July	June	July	June	July		June	July	June	July	June	July	June	July	
2002/2003 season																		
T_1 water spray (control)	51.67jk	57.00e-l	47.00l	51.67jk	55.00h-j	59.00d-h	51.67jk	55.00h-j	**53.50D**	50.00q-s	52.67l-r	47.33s	49.33q-s	54.33j-o	56.67f-l	49.67q-s	53.00k-q	**51.63D**
T_2 GA_3 40 ppm	53.00i-k	56.00g-j	49.67kl	52.67i-k	55.67g-j	60.67c-g	52.33i-k	56.67f-l	**54.59C**	56.00h-m	56.00h-m	48.67rs	49.67q-s	54.67i-o	58.67d-l	50.33p-s	56.33g-m	**53.79C**
T_3 GA_3 40 ppm + P 200 ppm	57.33e-l	57.33e-l	53.33i-k	53.33i-k	60.00d-h	60.00d-h	55.67g-j	55.67g-j	**56.58C**	51.33o-r	52.33m-r	51.67n-r	51.67n-r	58.00d-j	58.00d-j	55.00h-o	55.00h-o	**54.13C**
T_4 GA_3 40 ppm + 3 % K_2SO_4	60.67c-g	61.67b-e	55.67g-j	58.67d-h	62.67b-d	65.00a-c	58.33d-h	60.33c-g	**60.38B**	57.67d-j	59.00c-h	54.00j-p	55.67h-n	60.33b-g	62.67bc	57.00e-k	60.33b-g	**58.33B**
T_5 GA_3 40 ppm + P 200 ppm + 3 % K_2SO_4	60.67c-g	66.00ab	56.33g-j	61.33b-f	62.67b-d	68.00a	59.67d-h	66.00ab	**62.58A**	59.00c-h	64.00ab	54.67i-o	61.00b-e	60.67b-f	66.33a	58.00d-j	61.67b-d	**60.67A**
Mean** (direction)	**56.06B**				**59.00A**					**54.08B**				**57.33A**				
Mean*** (fruit status)	**Sou. 59.50A**				**Cre. 55.55B**					**Sou. 57.42A**				**Cre. 54.00B**				
Mean**** (application date)	**June 55.95B**				**July 59.10A**					**June 54.42B**				**July 57.00A**				
2003/2004 season																		
T_1 water spray (control)	50.00k	54.00j	44.67l	49.00k	55.00j	57.00ij	54.33j	55.33j	**52.42D**	49.00lm	51.33k-m	47.00m	48.33lm	54.33h-k	57.33f-j	52.00j-m	54.33h-k	**51.71D**
T_2 GA_3 40 ppm	54.33j	57.00i-j	53.00jk	56.00ij	57.67h-j	59.33g-i	57.00ij	57.67h-j	**46.50C**	54.00h-k	57.00g-k	50.00kl	52.00j-m	58.00e-i	60.33h-j	56.00g-k	59.00c-h	**55.79C**
T_3 GA_3 40 ppm + P 200 ppm	50.00k	53.50jk	56.00ij	57.00ij	61.00f-h	62.00e-g	60.00f-i	60.33f-i	**57.48C**	54.00h-k	56.00i-k	50.00kl	52.00j-m	60.25b-i	62.00a-h	59.00c-h	61.33b-g	**56.82C**
T_4 GA_3 40 ppm + 3 % K_2SO_4	61.00f-h	62.67c-g	60.00f-i	62.00e-g	64.00a-f	65.33a-c	62.00e-g	63.33b-g	**62.54B**	61.33b-g	63.33a-e	57.00g-k	59.67b-h	63.00a-f	65.33ab	61.67a-g	64.33a-d	**61.96B**
T_5 GA_3 40 ppm + P 200 ppm + 3 % K_2SO_4	66.67ab	67.33a	61.33e-h	62.33d-g	66.67ab	67.67a	63.33b-g	66.00a-d	**65.17A**	64.33a-d	65.00a-c	61.50a-g	63.00a-f	65.33ab	67.33a	62.33a-g	65.00a-c	**64.23A**
Mean** (direction)	**56.89B**				**60.75A**					**55.79B**				**60.41A**				
Mean*** (fruit status)	**Sou. 59.61A**				**Cre. 58.03B**					**Sou. 59.43A**				**Cre. 56.77B**				
Mean**** (application date)	**June 57.90B**				**July 59.74A**					**June 57.00B**				**July 59.20A**				

*; **; *** and **** refer to specific effect values of foliar spray treatments; geographical direction; fruit status and application date, respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

IV.II.I.B- Fruit chemical properties:

In this concern, fruit juice total soluble solids percentage (TSS %), total acidity, TSS/acid ratio and vitamin C content of Tanarif trees were the investigated fruit chemical properties in response to various spray treatments (GA_3 solely and/or combined with P or K), geographical direction (northern & southern), fruit status (sound & creased) and date of application (June & July) as well as their combinations during both 2002/2003 and 2003/2004 experimental seasons, data obtained are presented in **Tables (23) and (24)**.

Fruit juice total soluble solids percentage (TSS %):

A- Specific effect:

Referring the specific effect of different foliar spray treatments on TSS % of Tanarif fruits, data obtained in **Table (23)** showed that the four investigated foliar spray treatments significantly varied in this concern either they were compared each other or with water spray (control). On the other hand the T_5 (GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %) and T_4 (GA_3 at 40 ppm + K_2SO_4 at 3 %) treatments increased significantly TSS % over control, however the former treatment was statistically the superior. Meanwhile, both T_3 (GA_3 at 40 ppm + P at 200 ppm) and T_2 (GA_3 at 40 ppm) foliar spray treatments came third class and didn't significantly defect than water spray (control) during 1^{st} and 2^{nd} seasons of study. In this respect, **Coggins and Hield (1958)** reported that no significant differences in total soluble solids were detected by GA treatments on navel orange. On the other hand, **Coggins and Garber (1960)** mentioned that K GA decreased total soluble solids in

Valencia orange juice. Moreover, **Coggins (1968-1969)** reported that GA did not affect juice quality. In addition, **Naguib (1978)** found that total soluble solids in the juice of Balady orange fruits increased with GA treatments. In addition, **Lou and Yin (1986)** found that super phosphate decreased fruit juice total soluble solids. In addition, **Chu (1963)** on mandarin trees the TSS was increased with K application, while **Reese and Koo (1975-a)** on Hamlin, Pineapple and Valencia orange trees. They found that K application reduced the total soluble solids percentage. **Ali & Gobran (2002)** on Washington navel orange, sprayed potassium succeeded in enhancing fruit TSS than soil application or control treatments. On another point of view **Achilea *et al.*, (1999)** reported that accumulation of carbohydrates and organic acids is highly dependent on optimal photosynthesis and the intensity of which is related to potassium status in the plant.

Concerning the Tanarif fruit juice total soluble solids content in response to specific effect of geographical direction (north & south) of bearer scaffold, **Table (23)** declares that fruits situated across the southern side of tree periphery had significantly higher juice TSS % as compared to those of northern side. Such trend was true during both 1st and 2nd experimental seasons. These results were in agreement with those of **Fatma (2003).**

Referring the specific effect of fruit status (sound & creased), **Table (23)** shows that sound fruits exhibited statistically the highest value of total soluble solids percentage as compared to creased fruits. Differences were significant with fruit status during the two seasons of study. These results were confirmed with that of **Jones *et al.*, (1967), El-Nokrashy *et al.*, (1966-a) Diab (1982) and**

Fatma (2003). They mentioned that non creased (sound) citrus fruits were higher in TSS % in fruit juice.

As for the specific effect of the date of application (June & July) on fruit juice total soluble solids percentage, data in **Table (23)** pointed out that July application significantly increased TSS % in fruit juice as compared to June application during two seasons.

B- Interaction effect:

Concerning the interaction effect of various combinations between foliar spray treatments; geographical direction (north and south); fruit status (sound & creased) and date of application (June & July) on fruit juice total soluble solids % in Tanarif fruits, data presented in **Table (23)** showed obviously a variable response of Tanarif trees to the different combinations during two seasons of study. Anyhow, the highest fruit juice TSS % was always in closed relationship to such sound fruits of the southern limbs of Tanarif trees sprayed with the T_5 (GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %) in July. Meanwhile, the reverse was found with creased fruits of the northern tree hemispheres and sprayed with water regardless of application date. Such trend was true during both seasons of study. In addition, other combinations were in between the abovementioned two extremes.

Fruit juice total acidity percentage:

A- Specific effect:

Concerning the specific effect of the different factors involved in this study i.e., different foliar spray treatments; geographical direction, fruit status and date of application on fruit juice acidity percentage, data obtained in **Table (23)**, showed that fruit juice total acidity % was significantly affected by some foliar spray treatments in both seasons. Herein, foliar spray treatments with either T_5 (GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %) or T_4 (GA_3 at 40 ppm + K_2SO_4 at 3 %) resulted in an obvious increase over (control) treatment in fruit juice total acidity % on Tanarif fruit during two seasons.

However, both T_3 (GA_3 at 40 ppm + P at 200 ppm) and T_2 (GA_3 at 40 ppm) did not significantly very than control as compared to the other ones during the two seasons of study. On the other hand, the T_5 (GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %) foliar application treatment ranked statistically first in this regard, followed in a descending order by the T_4 (GA_3 at 40 ppm + K_2SO_4 at 3 %), while both GA_3 foliar spray solely or combined with P at 200 ppm (T_2 & T_3) beside control ranked third during both seasons of study.

The abovementioned results agree with **Coggins and Garber (1960)** who mentioned that spraying Valencia orange trees with K GA after full bloom increased total acidity and (H) ions of the fruit juice. On the other hand, **Coggins and Hield (1968)** on navel orange and **Deidda (1971)** on Washington navel orange reported that GA did not affect total acidity. In addition, fruit juice acidity as affected by P foliar spray was decreased in both Washington navel orange and Valencia orange **(El-Deeb, 1989)**. Moreover, **Bar-Akiva (1975)** on Valencia orange, found that potassium fertilization increased juice acidity while **Ali & Gobran (2002)** on Washington navel orange showed that potassium spray tended to be more effective in enhancing significantly fruit total acidity content than soil application or control treatments.

With respect to the response of specific effect of geographical direction on Tanarif fruit juice total acidity %, the response as shown from **Table (23)** took the same trend as compared to that previously noticed with the fruit juice total soluble solids percentage. Hence, the north situated fruits exhibited relatively higher acidity percentage over those of the southern limbs. Differences were significant during 2002/2003 and 2003/2004 seasons.

The present results regarding fruit juice acidity percentage as affected by geographical direction goes in line with those previously reported by **Fatma (2003).**

Referring the specific effect of fruit status (sound & creased) data in **Table (23)** shows that fruit status exhibited also its specific effect on fruit juice total acidity percentage, whereas, the Tanarif sound fruits exhibited statistically the highest value of total acidity percentage as compared to those creased fruits. Such trend was true during 1^{st} and 2^{nd} seasons of study. These results were confirmed with that of **Jones *et al*., (1967), El-Nokrashy (1969) Diab (1982)**. They reported that the sound citrus fruits had higher value of total acidity percentage in their fruit juice.

As for the specific effect of the date of application (June & July) on fruit juice total acidity percentage, data in **Table (23)** pointed out that July application significantly increased total acidity percentage in fruit juice as compared to June application during two seasons.

B- Interaction effect:

As for fruit juice acidity percentage of Tanarif fruits as influenced by interaction effect of various combinations between four investigated factors (foliar spray treatments; geographical direction; fruit status and date of application).

Table (23): Average juice TSS (%) and juice acidity (%) of Tanarif sweet orange fruits harvested in Feb. in response to specific and interaction effects of foliar spray with (GA_3 & combined with P/ and K), geographical direction, fruit status, dates of application and their combinations during two successive 2002/2003 and 2003/2004 seasons.

Direction, fruit status and application date / Spray treatments	Fruit juice TSS (%)								Mean*	Fruit juice acidity (%)								Mean*
	North				South					North				South				
	Sound		Creased		Sound		Creased			Sound		Creased		Sound		Creased		
	June	July	June	July	June	July	June	July		June	July	June	July	June	July	June	July	
2002/2003 season																		
T_1 water spray (control)	12.08h-l	12.23g-k	11.37mn	12.12h-l	12.72e-h	12.78fg	11.71j-l	13.01i-l	**12.25C**	0.83g-m	0.88d-k	0.82h-n	0.85f-m	0.89c-j	0.94b-f	0.81j-m	0.90c-h	**0.87C**
T_2 GA_3 40 ppm	12.21g-k	12.34f-j	11.95j-l	11.95j-l	12.10h-l	11.51b	13.64bc	11.57lm	**12.16C**	0.94b-f	0.96a-d	0.93c-f	0.93c-f	0.92d-f	0.82h-n	0.99ab	0.81j-m	**0.91C**
T_3 GA_3 40 ppm + P 200 ppm	12.02i-l	12.02i-l	11.76j-l	11.76j-l	12.22g-k	12.71e-h	14.14ab	12.36fg	**12.37C**	0.90c-h	0.90c-h	0.87e-k	0.87e-k	0.79lm	0.81j-m	0.80j-n	0.90c-h	**0.86C**
T_4 GA_3 40 ppm + 3 % K_2SO_4	12.24g-k	12.67e-l	11.83jk	12.14h-l	13.06de	13.28b-d	12.66e-l	12.97e	**12.61B**	0.97a-d	1.02a	0.94b-f	0.97a-d	0.94b-f	0.97a-d	0.91c-g	0.93c-f	**0.96B**
T_5 GA_3 40 ppm + P 200 ppm + 3 % K_2SO_4	13.18c-e	13.67bc	12.98e	13.17c-e	14.05b	14.26a	13.57b-d	13.91a-c	**13.60A**	1.03a	1.03a	0.94b-f	0.98a-c	0.98a-c	1.02a	0.92c-f	0.95a-e	**0.98A**
Mean** (direction)	**12.28B**				**12.91A**					**0.93A**				**0.90B**				
Mean*** (fruit status)	**Sou. 12.67A**				**Cre. 12.53B**					**Sou. 0.93A**				**Cre. 0.90B**				
Mean**** (application date)	**June 12.57B**				**July 12.62A**					**June 0.91B**				**July 0.92A**				
2003/2004 season																		
T_1 water spray (control)	11.63j-n	11.63j-n	11.10n	11.87h-m	12.17e-j	11.87h-m	11.40mn	12.33c-h	**11.75C**	0.83h-n	0.83h-n	0.82j-p	0.82j-p	0.81k-p	0.81k-p	0.77n-r	0.77n-r	**0.81C**
T_2 GA_3 40 ppm	11.43mn	12.07f-l	11.47l-n	11.43mn	11.87h-m	12.57c-g	11.97g-m	11.40mn	**11.78C**	0.84h-m	0.88e-j	0.80l-r	0.83h-n	0.81k-p	0.83i-o	0.74r	0.77n-r	**0.81C**
T_3 GA_3 40 ppm + P 200 ppm	11.43mn	11.93h-m	11.43mn	11.53k-n	13.30b	12.30d-l	11.67j-n	12.13e-k	**11.97C**	0.83h-n	0.85g-l	0.76p-r	0.80l-q	0.77n-r	0.81k-p	0.74qr	0.79m-r	**0.79C**
T_4 GA_3 40 ppm + 3 % K_2SO_4	11.70i-n	12.13e-k	11.40mn	11.87h-m	12.57c-g	12.87b-d	12.20e-j	12.53c-g	**12.16B**	0.94b-e	0.98ab	0.89d-h	0.91c-g	0.91c-g	0.94b-d	0.81k-p	0.87f-k	**0.91B**
T_5 GA_3 40 ppm + P 200 ppm + 3 % K_2SO_4	12.67c-f	12.70c-e	12.10e-k	12.67c-f	12.13e-k	13.93a	12.90bc	13.27b	**12.80A**	0.96a-c	1.00a	0.91c-g	0.93b-f	0.93b-f	0.98ab	0.90d-g	0.89d-l	**0.94A**
Mean** (direction)	**11.81B**				**12.37A**					**0.87A**				**0.83B**				
Mean*** (fruit status)	**Sou. 12.25A**				**Cre. 11.93B**					**Sou. 0.88A**				**Cre. 0.83B**				
Mean**** (application date)	**June 11.93B**				**July 12.25A**					**June 0.84B**				**July 0.86A**				

*; **; *** and **** refer to specific effect values of foliar spray treatments; geographical direction; fruit status and application date, respectively.

Values of either specific or interaction effect followed by the same capital or small letter/s, respectively are not significantly different at 5 % level

Table (23) displays that differences were noticeably less pronounced as compared to those exhibited in juice TSS %. On the other hand, it could be generally observed the superiority of sound fruits located across both the southern or northern branches of Tanarif trees sprayed with either T_4 (GA_3 at 40 ppm + K_2SO_4 at 3 %) or T_5 (GA_3 at 40 ppm + H_3PO_4 at 0.1 % + K_2SO_4 at 3 %) foliar spray treatment in July which had the highest value of total acidity % during two seasons of study. The reverse was true with creased fruits on southern limbs of treated trees with (GA_3 at 40 ppm) foliar spray in June, which seemed to be the inferior.

In addition, other combinations were in between the above- mentioned two extremes during 2002/2003 and 2003/2004 seasons.

Fruit juice TSS/acid ratio:

A- Specific effect:

Referring the specific effect of the different foliar spray treatments geographical direction, fruit status and date of application on TSS/acid ratio, **Table (24)**, clearly shows that TSS/acid ratio was significantly affected by different foliar spray treatments in both seasons. The third treatment (T_3) i.e., foliar spray with GA_3 40 ppm + P 200 ppm exhibited statistically the highest TSS/acid ratio during both experimental seasons, descending followed by control (water spray) which ranked statistically 2^{nd}. Moreover, both T_2 and T_5 i.e., foliar spray with either GA_3 40 ppm solely or (GA_3 40 ppm + P 200 ppm + K_2SO_4 3 %) had the same effectiveness from statistical point of view from one hand and ranked third from the other. On the contrary, the least TSS/acid ratio was always in closed relationship to the foliar application with (GA_3 40 ppm + + K_2SO_4 3 %) from the statistical standpoint. Such trend was true during both seasons of study. In this respect, **Coggins and Garber (1960)** found that spraying Valencia orange trees at full bloom with 37.5, 75, 150 and 300 ppm K GA increased TSS/acid ratio. **Kaur *et al.*, (1997)** mentioned that TSS/acid ratio of Kinnow mandarin fruits increased in all treatments with GA_3 at 15 and 20 ppm applied during bloom and fruit set compared with the control.

The present result regarding fruit juice TSS/acid ratio as affected by KH_2PO_4 goes in line with those previously reported by **El-Deeb (1989)** on Washington navel orange and Valencia orange. In addition, **Reese and Koo (1975-a)** on Hamlin, Pineapple and Valencia orange trees, found that K application reduced the TSS/acid ratio of fruit juice. Moreover, **Ali & Gobran (2002)** mentioned that, the effect of potassium spray treatment predominates the effect of soil application and control.

Concerning the specific effect of geographical direction (north & south), **Table (24)** shows that the situated fruits on southern sides of tree periphery had statistically higher TSS/acid ratio as compared to those located within the northern direction during both seasons of study. The obtained result is in general agreement with the findings of **Fatma (2003)**.

With respect to the specific effect of fruit status (sound & creased), data in **Table (24)** showed that juice of creased fruits was higher TSS/acid ratio than did sound one. This result may be pointed out that reached maturity earlier in creased fruit than did sound fruit. These results are in agreement with those of **Jones *et al.*, (1967), Salama (1979) and Diab (1982)** they found that the juice of creased and cracked orange fruit contained higher soluble solids to acid ratio than that of sound fruits.

Regarding the specific effect of the date of application (June & July) on TSS/acid ratio, data in **Table (24)** showed clearly that the TSS/acid ratio was slightly during 1^{st} and 2^{nd} seasons of study.

B- Interaction effect:

Obtained data during both seasons revealed that the specific effect of four investigated factors (foliar spray treatments; geographical direction; fruit status and date of application) had been reflected directly on the interaction effect of their combinations. Hence, the highest value of TSS/acid ratio was to great extent in concomitant to the fruits (sound & creased) of the southern limbs of sprayed Tanarif trees with T_3 i.e., GA_3 at 40 ppm + P 200 ppm in both June & July during 2002/2003 and 2003/2004 seasons. The reverse was true with the sound fruits on northern limbs of Tanarif trees sprayed with GA_3 at 40ppm + K_2SO_4 at 3 % in July which had seemed to be the inferior. In addition, other combinations are in between the aforesaid two extremes.

Fruit juice V.C. "ascorbic acid" content:

Vitamin C content as mg ascorbic acid/100 ml juice was investigated regarding the specific and interaction effects of different foliar spray treatments, geographical direction of fruit carrier branches, fruit status, date of application as well as their combinations. Data obtained during both 2002/2003 and 2003/2004 seasons are tabulated in **Table (24)**.

A- Specific effect:

Referring the specific effect of the different foliar spray treatments on ascorbic acid (V.C.) content, **Table (24)** reveals that all four investigated (GA_3 solely or combined with P or K) foliar spray treatments resulted in an obvious increase in values of ascorbic acid content during the two seasons of study. However, differences between four foliar spray treatments were significant as compared each other or with control (water spray) during 1st and 2nd seasons of study. On the other hand, the T_5 (GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %) foliar spray treatment ranked statistically first in this regard, followed in a descending order by the T_4 (GA_3 at 40 ppm + K_2SO_4 at 3 %). T_3 (GA_3 at 40 ppm + P at 200 ppm) foliar spray treatment which came 2nd and 3rd, respectively. Moreover, GA_3 at 40 ppm foliar spray treatment appeared to be less effective than the abovementioned treatments ones in both seasons of study. On the contrary, control (water spray) treatment exhibited the lowest value in this respect.

The obtained result is in general agreement with the findings of **Cutuli (1970), Embleton *et al.*, (1973), Salama (1979), Zhang and Yan (1987) and Marzouk and Kasem (2002)** gave a great support to the present result regarding the influence of GA_3 on juice ascorbic acid (V.C.) content. In addition, **Ali & Gobran (2002)** found that potassium spray treatment increased fruit ascorbic acid content on Washington navel orange trees than the other treatments used but the significant differences were nil.

Concerning the specific effect of geographical direction (north & south), **Table (24)** reveals that Tanarif fruits situated towards the north were significantly higher in their fruit juice ascorbic acid (V.C.) content as compared to those of opposite side (south) during 2002/2003 and 2003/2004 seasons of study. The obtained result is in general agreement with the findings of **Fatma (2003)**.

Concerning the specific effect of fruit status (sound & creased), it is clear from **Table (24)** that sound fruit of Tanarif orange juice contained higher value of ascorbic acid (vitamin C) content than did creased one. The results go in line with that of **Jones *et al.*, (1967), El-Nokrashy (1969) and Diab (1982).** They pointed out that the non-creased citrus fruits were higher in Vitamin "C" value in juice.

With respect to the specific effect of date of application (June & July), data in **Table (24)** showed clearly that fruits of July application had the highest value of juice ascorbic acid content as compared to those of June application during 2002/2003 and 2003/2004 seasons.

B- Interaction effect:

As for the interaction effect of different foliar spray treatments x geographical direction x fruit status and date of application combinations, **Table (24)** shows that the highest value of ascorbic acid (vitamin C) content was coupled with sound Tanarif fruits on the northern side of trees sprayed with T_5 (GA_3 at 40 ppm + P at 200 ppm + K_2SO_4 at 3 %), regardless of application date. In spite of sound fruits on the southern limbs of Tanarif trees sprayed with the T_4 and the T_5 in 1^{st} season ranked second, but differences between two categories were not significant during 1^{st} and 2^{nd} seasons. Contrary to that, the least V.C. level was detected by creased fruits facing the south direction of Tanarif trees sprayed with water in June application date during both seasons of study. Other combinations were in between.