EFFECT OF IRRIGATION LEVELS AND SPRAYING MEPIQUAT CHLORIDE ON GROWTH AND PRODUCTIVITY OF PEACH TREES

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ABSTRACT: To study the effect of rationalizing irrigation and mepiquat chloride foliar application on growth, productivity and fruit quality of Florida Brines peach trees grafted on Nimagard root stock and grown in sandy soil at a private orchard in El- Tahadi road, EL-Behera Governorate, Egypt. A trial in a split plot design has carried out through two successive seasons of 2018 and 2019. Three drip irrigation levels (100, 80 and 60 % of ETc) were in the main plot and mepiquat chloride foliar application by three levels (without, 150 and 300 ppm) in sub plot and all trees had fertilized by recommended doses. Results indicated that shoot length (cm) and number of leaves/shoot was not significantly affect by the three irrigation levels in both seasons. Reducing irrigation increased acidity of peach fruits and led to a significant reduction on leaf area (cm²), total chlorophyll contents, yield, fruit weight, flesh weight, seed weight, TSS and total sugars but no significant difference between irrigation by 80 or 60 % from calculated ETc except with yield and seed weight in both studied seasons. Number of leaves/shoot, yield either kg/tree or ton/feddan and fruit flesh thickness (cm) were not significantly affected by mepiquat chloride foliar application at all concentrations in both seasons. The highest fruit TSS and the lowest shoot length (cm), leaf length and width (cm), leaf area (cm²) and total fruit acidity were obtained from peach trees treated by mepiquat chloride foliar application at 300 ppm but by mepiquat chloride foliar application at 150ppm achieved the highest increase in fruit weight (gr), flesh weight (gr) and fruit total sugars in both seasons. Additionally, the obtained data from the interaction between irrigation levels and mepiquat chloride foliar application showed that mepiquat chloride foliar application made the decrease in irrigation level gave no significantly reduction in shoot length, leaf length and width (cm), leaf area (cm²) especially with concentration 150 ppm and with 300 ppm on leaf total chlorophyll contents. However, this interaction failed to show a clear trend on others studied parameters in both seasons. In addition, peach leaf anatomy has affected by foliar application with mepiquat chloride at 150 ppm and 300 ppm where a prominent increase in thickness of lamina of leaf blade more than those of unsprayed ones (control) has found. Finally, irrigated peach trees by 60% of calculated ETc led to the highest water saving and gave the highest productivity of irrigation water where every used m³ water gave (4.83 & 5.33 kg peach fruits).

Key words: Rationalizing irrigation, mepiquat chloride, Florida Brines cv., water use efficiency, leaf anatomy, leaf blade lamina.

INTRODUCTION

Water availability is a considerable constraint for agriculture and the improvement of water use efficiency (units of product per unit of water) in agricultural sector is an importance issue, with environmental and economic implications. Extensive irrigation from farmers and limited water resources in addition, to the requirements of expansion in the agricultural area to meet the population increase make this problem more difficult. Irrigation is an important limiting factor of crop yield, because it participates with others plant environment factors, which effect on plant growth. The availability of sufficient amount of ground moisture helps facilitate the nutrients necessary for growth and productivity. Consequently, any degree of water stress may produce deleterious effects on growth and yield of the crop (Saif et al., 2003).

To address this problem, many researchers have sought to study the effect of irrigation rationalization on the growth and productivity of many fruit trees. Johnson et al., (1992) studied the possibility of reducing the amount of irrigation water without affecting the tree performance in California. The...
greatest irrigation water saving in treatment regulated deficit irrigation (RDI), irrigated at 100% of ETc only during stage III of fruit growth and 25% of the rest of the growing season caused the higher water use efficiency values in this treatment (Abrisqueta et al., 2010). Pliakoni and Nanos (2010) studied the effect of deficit irrigation with 50% of Etc on “Royal Glory” peach and “Caldesi 2000” nectarine trees and the results showed an increase in total soluble solid (TSS) with higher acidity than fruit from control trees. Moreover, Rufat et al., (2010) whose study irrigation restriction of 28% Etc during stage III of peach trees, which led to a clear yield reduction in comparison with T1 (100%Etc). They revealed that this results may be due to a direct effect on fruit weight but gave an increase in total soluble solids and soluble sugar with 30% Etc. Additionally, decreased water amount applied by using irrigation regime from75% up to 25% of field capacity led to significantly decreased in average leaf area (cm²) of Ne plus Ultra almond as compared with control which was irrigated with 100% of field capacity (Mohy, 2011). Besides, Khattab et al., (2011) indicated that chlorophyll a, b and carotenoids of pomegranate trees increased with high irrigation rate. Ominna and El- Hajagrey (2014) studied the effect of irrigation by three levels (60, 80, 100% of calculated ETc) on yield, fruit quality and some leaf parameters of peach trees. They indicated that irrigation by 80% of ETc under surface ultra-low drip 1.0 l/h irrigation system gave the best results on tree yield and fruit quality, except fruit volume, fruit length, T.S.S. and total acidity percentage where the highest significant values had obtained with this treatment under Gr surface drip 4 l/h. irrigation systems. Sheren et al., (2017) were found that the best number of leaves per shoot, leaf area, total chlorophyll content, total yield, cluster weight, cluster length and width, berry dimensions, weight and volume of 100 berries, soluble solids content (SSC), sugar contents in berries Juice obtained from irrigation vineyard trees at 100% of calculated ETc by sub surface drip irrigation system. On the other side, 80% water amount under a sub-surface drip irrigation system gave the lowest total acidity in both seasons. Control of tree growth limits exposed surface of the plant it may reduce water loss. This can be obtaining by over-pruning but it may be effect on flowering by reducing number of remaining flower buds. This can be achieved by using foliar application with one of growth retardant from their substances PIX (Mepiquat chloride). PIX (Mepiquat chloride) is a systemic plant growth regulator, extensively used in cotton production for the last two decades (Hake et al., 1991 & Reddy et al., 1993). PIX treated cotton plants tended to be shorter and narrower with thick and smaller leaves (Gausman et al., 1979). A study on five years old ‘Le Conte’ pear trees had carried in two types of soil. some plant growth retardants such as, Paclobutrazol (Cultar) sprayed at 200 and 300 ppm, Mepiquat chloride at 150 and 250 ppm, Succinic acid at 150 and 300 ppm and control. Results indicated that Mepiquat chloride in both concentrations increased chlorophyll content and reduced the rate of vegetative growth by decreasing shoot length, leaf area besides and improved fruit quality (Hanaa and samia, 2014).

The aim of this work is study the effect of rationalizing irrigation and mepiquat chloride foliar application on growth, productivity and fruit quality of Florida Brines cv. peach trees grafted on Namagard rootstock and grown in sandy soil.

**MATERIALS AND METHODS**

This study was conducted during two successive seasons 2018 and 2019 in a private orchard in El-Tahadi road, EL-Behara Governorate, Egypt to study the effect of rationalizing irrigation and mepiquat chloride foliar application on growth, productivity and fruit quality of Florida Brines cv. peach trees grafted on Namagard root stock and grown in sandy soil. Fifty four trees were 5-years old uniform in vigor, planted at 3 x 5 meters were received all requirements from essential elements as the recommendation of the ministry of agriculture and all pests and diseases were controlled. Initial some physical and chemical properties were determined according to A.O.A.C. (2005) and recorded as in Table (1).

| Particle size distribution % | Texture soil | Eo/dsm | PH | Soluble cation meq/L | Soluble Anions meq/L |
|-----------------------------|--------------|--------|----|---------------------|---------------------|
| Sand 90.98 Silt 5.85 Clay 2.22 | Sandy | 1.26 | 7.75 | Ca** 1.54 | Mg** 1.45 | Na+ 8.98 | K+ 0.63 | Cl- 1.56 | HCO3- 8.25 | SO4- 2.79 |

A spilt plot design with two factors and three replicates had used for each treatment and every replicate has represented by two as follow: - The main factor were the three irrigation water levels (100, 80 and 60 %) of the calculated applied water.
- Sub main factor is three levels of mepiquat chloride as a foliar application (control, 150 and 300 ppm).

Water irrigation sample were determined before the beginning of experiment according to A.O.A.C. (2005) and all data had tabulated in Table (2).

Table 2. Some chemical analysis of irrigation water

| Characteristics | Ef/dsm | PH | Ca** | Mg** | Na⁺ | K⁺ | Cl⁻ | HCO₃⁻ | SO₄²⁻ |
|-----------------|--------|----|------|------|-----|----|-----|-------|-------|
| values          | 1.23   | 6.77 | 3.54 | 3.65 | 6.98 | 0.35 | -   | 2.85  | 6.55  | 2.90  |

Irrigation requirements:

Irrigation water requirements for peach trees had calculated according to the local weather station data at El-Beharia Governorate, belonged to the Central Laboratory for Agricultural Climate (C.L.A.C.), Ministry of Agriculture and Land Reclamation.

Crop water use was calculated through the evapotranspiration method (ETc = ETo x Kc x Kr (Allen et al., 1998), where Kc is a coefficient to adjust for the difference between the orchard and ETo and Kr adjusts for ground cover. ETo was obtained from local weather station data at El-Beharia Governorate.

Water requirements (WR) of the peach orchard were calculated on daily basis through the relationship of the simplified water budget WR = ETc – Er, where Er stands for effective rainfall (Dastane, 1974).

From calculated water requirements the amount of irrigation water as treatments (100, 80 and 60% calculated as in (Table 3).

Table 3. Amount of irrigation water m³/tree and m³/ feddan as treatments (100, 80 and 60%)

| Irrigation levels | irrigation water m³/tree/season | irrigation water m³/feddan/season |
|-------------------|---------------------------------|-----------------------------------|
|                   | 2018               | 2019               | 2018              | 2019              |
| 100% of calculated ETc | 11.20345          | 11.06001           | 3136.966          | 3096.803          |
| 80% of calculated ETc   | 8.962759          | 8.848008           | 2509.573          | 2477.442          |
| 60% of calculated ETc   | 6.722069          | 6.636006           | 1882.179          | 1858.082          |

The following parameters had recorded:

Vegetative growth measurements: In the first June of the two seasons, shoot length (cm), number of leaves per shoot, leaf length (cm) and width (W) were measured and leaf area (cm²) was calculated LA = 0.70 (L x W) - 1.06 according to (Ahmed and Morsy 1999). Average total chlorophyll content has measured using a chlorophyll meter SPAD 502. Leaf samples had collected from the middle portion of the current season growth and fresh weight was record. Washed by distilled water and dried in oven at 70 °C until constant weight. Dry weight was record and the percentage of dry matter has calculated as follows:

\[ \text{Dry matter} \% = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100 \]

Yield: At harvesting time in early May in two seasons fruit yield as Weight in (kg) per tree has recorded.

Yield:

- Fruit chemical characteristics: Total soluble solids percentage (TSS) has measured in fruit juice by hand refractometer. Total acidity percentage in fruit juice as malice acid, total and reducing sugar contents were determined according to A.O.A.C (2005) and non-reducing sugars was calculated.

Anatomical study: The anatomical studies had carried out only in the second season (2018) to follow the changes occurring in peach leaf tissues as affected by foliar application with mepiquat chloride treatments. Samples of all treatments had taken from the third leaf of the chosen shoots after 15 days from the second date of foliar application. Microtechnique procedures given by Nassar and El-Sahhar (1998). Specimens had killed and fixed for at least 48 h in FAA (10 ml formalin, 5 ml glacial acetic acid and 85 ml ethyl alcohol 70%). The selected materials were washed in 50% ethyl alcohol, dehydrated in normal butyl alcohol series, embedded in paraffin wax of 56 °C melting point, Sectioned to a thickness of 20 microns, double stained with safranin and light green, cleared in xylene and mounted in canada balsam. Sections were examined to detect fruit weight (g), flesh weight (g), seed weight (g) and flesh thickness (cm).

- Fruit physical characteristics: Samples of twenty fruits had taken from each replicate for measuring
histological manifestations of the chosen treatments and photomicrographed. To studies the effect of treatments on peach leaf structure some measurements i.e. (midvein thick., lamina thick., upper epidermis thick., lower epidermis thick., palisade tissue thick., spongy tissue thick, midvein bundle length, midvein bundle width, number of xylem vessels/bundle and diameter of xylem vessels/bundle) were estimated.

**Productivity of irrigation water (PIW, kg/m³).** Productivity of irrigation water (PIW) was calculated by the following equation according to (Ali et al., 2007). PIW=Y/Wa Where: PIW: Productivity of irrigation water (kg fruits /m³ of water), Y: fruit yield (kg/fed.) and Wa: Water applied to the field (m³)

**Statistical analysis:** The obtained data of all seasons has subjected to analysis of variance according to Snedecor and Cochran (1980). The means had differentiated using Duncan multiple range test at 5% level (Duncan, 1955).

### RESULTS AND DISCUSSIONS

#### Vegetative growth parameters

It is clear from data in Table (4) that shoot length (cm) and number of leaves per shoot was not significantly affected by the three irrigation levels applied in both seasons.

Regarding to mepiquat chloride foliar application effect on shoot length (cm) number of leaves was affected significantly by different concentrations in both seasons. In addition, mepiquat chloride foliar application at 300 ppm produced the lowest shoot length (cm) comparing with the second concentration 150 ppm or without mepiquat chloride foliar application. But, number of leaves per shoot was not significantly affected by mepiquat chloride foliar application in both seasons.

| Irrigation treatments | Mepiquat chloride treatments | Shoot length (cm) | Number of leaves per shoot |
|-----------------------|-----------------------------|-------------------|---------------------------|
|                       |                             | Control 150 ppm  | Control 300 ppm  | Mean          | Control 150 ppm | Control 300 ppm | Mean          |
| 100 ETC               |                             | 24.00 a           | 19.33 b           | 18.0 bc       | 20.44 A         | 25.67 a           | 24.00 a       | 23.33 a       | 24.33 A       |
| 80 ETC                |                             | 23.67 a           | 18.67 b           | 17.6 bc       | 20.00 A         | 24.67 a           | 23.33 a       | 23.00 a       | 23.67 A       |
| 60 ETC                |                             | 23.67 a           | 19.33 b           | 16.67 c       | 19.89 A         | 24.33 a           | 23.33 a       | 23.00 a       | 23.56 A       |
| Mean                  |                             | 23.78 A           | 19.11 B           | 17.44 C       | 24.89 A         | 23.55 A           | 23.11 A       |

Means with the same letter(s) in each column or row are not significantly different at 5% level.

Additionally, the obtained data from the interaction between irrigation levels and mepiquat chloride foliar application showed that mepiquat chloride foliar application made the decrease in irrigation level gave no significantly reduction in shoot length especially with concentration 150 ppm. However, number of leaves per shoot was not significantly affected by the interaction between irrigation levels and mepiquat chloride foliar application in both seasons.

Data in Table (5) revealed that leaf length and width (cm) significantly affected by the three irrigation levels applied but no significant difference between irrigation by 80 or 60 % from calculated ETc in both seasons in this respect.

Furthermore, mepiquat chloride foliar application effect on leaf length and width (cm) significantly affected by different concentrations in both seasons. Mepiquat chloride foliar application at 300 ppm produced the lowest leaf length and width (7.5, 7.74 and 2.51, 2.06 cm) comparing with the highest values (12.17, 12.41 and 2.30, 2.85 cm) obtained from without mepiquat chloride foliar application (control) in 2018 and 2019 seasons, respectively.

Although, the highest values of peach leaf length and width obtained from trees irrigated with 100% of calculated ETc without mepiquat chloride foliar application but mepiquat chloride foliar application made the decrease in irrigation level gave no significantly reduction in leaf length and width in both seasons.

On the contrary, data in Table (6) indicated that leaf area (cm²) and total chlorophyll contents significantly affected by the three irrigation levels applied but no significant difference between irrigation by 80 or 60 % from calculated ETc in both seasons in this respect.
Table 5. Effect of irrigation levels, foliar application of mepiquat chloride and their interaction on width and length of peach leaves during 2018 and 2019 seasons

| Irrigation treatments | Mepequat chloride treatments | Leaf width (cm)        | Leaf length (cm)        |
|-----------------------|-----------------------------|------------------------|------------------------|
|                       |                             | Control 150 ppm | 300 ppm | Mean     | Control 150 ppm | 300 ppm | Mean     |
| 100 ETC               |                             | 3.33a        | 2.93b   | 2.77b    | 3.01A         | 13.00a   | 9.00e    | 8.00d    | 10.00A   |
| 80 ETC                |                             | 3.30a        | 2.53c   | 2.40c    | 2.75B         | 12.00b   | 8.04d    | 7.50de   | 9.17B    |
| 60 ETC                |                             | 3.28a        | 2.51c   | 2.37c    | 2.72B         | 11.50b   | 8.04d    | 7.00e    | 8.83B    |
| Mean                  |                             | 3.30a        | 2.66B   | 2.51C    | 12.17A        | 8.33B    | 7.50C    |           |          |
| 100 ETC               |                             | 2.88a        | 2.48b   | 2.32b    | 2.56A         | 13.24a   | 9.24c    | 8.24d    | 10.24A   |
| 80 ETC                |                             | 2.85a        | 2.08c   | 1.95c    | 2.30B         | 12.24b   | 8.24d    | 7.74de   | 9.41B    |
| 60 ETC                |                             | 2.83a        | 2.06c   | 1.92c    | 2.27B         | 11.74b   | 8.24d    | 7.24e    | 9.07B    |
| Mean                  |                             | 2.85A        | 2.21B   | 2.06C    | 12.41A        | 8.57B    | 7.74C    |           |          |

Means with the same letter (s) in each column or row are not significantly different at 5% level.

Table 6. Effect of irrigation levels, foliar application of mepiquat chloride and their interaction on leaf area (cm²) and Total chlorophyll of peach leaves during 2018 and 2019 seasons

| Irrigation treatments | Mepequat chloride treatments | Leaf area (cm²) | Total chlorophyll |
|-----------------------|-----------------------------|-----------------|------------------|
|                       |                             | Control 150 ppm | 300 ppm | Mean | Control 150 ppm | 300 ppm | Mean |
| 100 ETC               |                             | 29.33a        | 17.44c   | 14.47d  | 20.42A       | 36.80de  | 39.17c  | 48.23a  | 41.40A  |
| 80 ETC                |                             | 26.65b        | 13.1de   | 11.55e  | 17.10B       | 36.40de  | 37.8d   | 44.13b  | 39.46B  |
| 60 ETC                |                             | 25.31b        | 13.0de   | 10.53e  | 16.29B       | 35.53e   | 37.0e   | 43.50b  | 38.67B  |
| Mean                  |                             | 27.10A        | 14.52B   | 12.18C  | 16.29B       | 35.53e   | 37.0e   | 43.50b  | 38.67B  |
| 100 ETC               |                             | 25.71a        | 15.01c   | 12.34d  | 17.69A       | 38.60de  | 40.97c  | 50.03a  | 43.20A  |
| 80 ETC                |                             | 23.34ab       | 10.9de   | 9.51e   | 14.59B       | 38.20de  | 39.6d   | 45.93b  | 41.26B  |
| 60 ETC                |                             | 22.15b        | 10.9de   | 8.64e   | 13.88B       | 37.33e   | 38.8d   | 45.30b  | 40.47B  |
| Mean                  |                             | 23.73A        | 12.26B   | 10.16C  | 13.88B       | 37.33e   | 38.8d   | 45.30b  | 40.47B  |

Means with the same letter (s) in each column or row are not significantly different at 5% level.

On the other hand, the highest values of peach leaf area (29.33 and 25.71 cm²) obtained from trees irrigated with 100% of calculated ETc without mepiquat chloride foliar application but mepiquat chloride foliar application at 300 ppm with irrigation level 100 % of calculated ETc achieved the highest total chlorophyll contents (48.23 and 50.03 SPAD value) in the first and second seasons respectively. Besides, mepiquat chloride foliar application made decrease irrigation level gave no significantly reduction in leaf area in both seasons.

The reduction in some vegetative growth by decreasing water amount may be due to the effect of disability in irrigation on plant biological processes as solving nutrients. These data are agree with the findings by (Mohy, 2011) who reported that decreased water amount applied by using irrigation regime from 75% up to 25% of field capacity led to significantly decreased in average leaf area (cm²) of Ne plus Ultra almond as compared with control which was irrigated with 100% of field capacity. Khattab et al., (2011) indicated that chlorophyll a, b and carotenoids of pomegranate trees increased with high irrigation rate. Sheren et al., (2017) were found that the best number of leaves per shoot, leaf area and total chlorophyll content of grape trees obtained from irrigation vineyard trees at 100% of calculated ETc by sub surface drip irrigation system.

Besides, reduction of some vegetative growth parameters of peach trees treated by mepiquat

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chloride foliar application due to mepiquat chloride mode of action as a growth retardants in inhibiting growth. These results in same way of the findings by leaves (Gaustamn et al., 1979) whose reported that PIX treated cotton plants tended to be shorter and narrower with thick and smaller. Moreover, a study on five years old 'Le Conte' pear trees was carried in two types of soil. some plant growth retardants such as, Paclobutrazol (Cultar) sprayed at 200 and 300 ppm, Mepiquat chloride at 150 and 250 ppm, Succinic acid at 150 and300 ppm and control. Results indicated that Mepiquat chloride in both concentrations increased chlorophyll content and reduced the rate of vegetative growth by decreasing shoot length and leaf area besides (Hanaa and samia, 2014).

Yield (kg/ tree) and (ton/ feddan)

Regarding to data in Table (7) irrigated peach trees by three levels significantly affected on yield (kg/ tree) and (ton/ feddan) in both studied seasons. In addition, the lowest yield (32.49, 35.39 kg/ tree and 9.10, 9.91 ton/ feddan) obtained from peach trees irrigated by 60% of calculated ETc compared with the highest yield (45.20, 48.10 kg/ tree and 12.66, 13.47 ton/ feddan) obtained from peach trees irrigated by 100% of calculated ETc in 2018 and 2019 seasons respectively.

It is clear from data in the same table that yield either kg/ tree or ton/ feddan was not significantly affected by mepiquat chloride foliar application at all concentrations in both seasons.

Table 7. Effect of irrigation levels, foliar application of mepiquat chloride and their interaction on yield kg/tree and ton/feddan of peach trees during 2018 and 2019 seasons

| Irrigation treatments | Mepiquat chloride treatments | Yield kg/tree | Yield ton/feddan |
|-----------------------|-----------------------------|---------------|-----------------|
|                       | Control         | 150 ppm       | 300 ppm       | Mean    | 150 ppm       | 300 ppm       | Mean  |
| 100 ETC               | 44.53a          | 46.20a        | 44.87a        | 45.20A  | 12.47a        | 12.94a        | 12.66a |
| 80 ETC                | 37.78b          | 43.82c        | 39.03b        | 37.21B  | 10.58b        | 9.75c         | 10.42B |
| 60 ETC                | 31.40d          | 33.76c        | 32.36c        | 32.49C  | 8.79d         | 9.44c         | 9.10C  |
| Mean                  | 37.90A          | 41.25A        | 38.74A        | 38.94A  | 10.61A        | 10.71A        | 10.85A |

Means with the same letter(s) in each column or row are not significantly different at 5% level.

On the other hand, the highest values of yield (44.53, 47.43 kg/tree and 12.94, 13.28 ton/feddan) obtained from trees irrigated with 100% of calculated ETc without mepiquat chloride foliar application in the first and second seasons respectively. Besides, mepiquat chloride foliar applications failed in decrease the effect of reduce irrigation level on peach trees yield in both seasons.

On my opinion the reduction in yield due to the effect of reducing irrigation which led to less vegetative growth and its effect on reducing photosynthesis and carbohydrate accumulation. As the findings by Rufat et al., (2010) whose study irrigation restriction of 28% Etc during stage III of peach trees which led to a clear yield reduction in comparison with T1 (100%Etc). Onimina and El-Hagarey (2014) they were indicated that irrigation by 80% of ETc under surface ultra-low drip 1.0 l/h irrigation system gave the best results on tree yield. Sheren et al., (2017) were found that the best total yield obtained from irrigation vineyard trees at 100% of calculated ETc by sub surface drip irrigation system.

I think that non-significant differences between mepequat chloride foliar applications at two using concentrations and control on yield may be due to the role of this treatment in increasing leaf chlorophyll contents which led to an increase in photosynthis and carbohydrate accumulation. This opinion is agree with the results by Hanaa and samia, 2014 whose indicated that mepiquat chloride in both concentrations increased chlorophyll content.

**Fruit physical properties**

Peach fruit physical properties (fruit weight, flesh weight, thickness and seed weight “g”) as affected by irrigation levels, mepiquat chloride foliar application and the interaction between them recorded in Tables (8 and 9).

Data in Table (8) indicated that fruit weight significantly affected by the three irrigation levels applied but no significant difference between irrigation by 80 or 60 % from calculated ETc. Nevertheless, data of flesh thickness did not show any significant differences between the three irrigation levels in both seasons in this respect.
Regarding to fruit weight as affected by mepiquat chloride foliar application we found significant differences between the three using concentrations in both seasons in this respect. Mepiquat chloride foliar application at 150 ppm produced the highest fruit weight (84.74 and 85.9 g) but no significant differences between data obtained from without mepiquat chloride foliar application (control) or mepiquat chloride foliar application at 300 ppm 2018 and 2019 seasons respectively. No significant differences between without mepiquat chloride foliar application (control) and mepiquat chloride foliar application either at 150 or at 300 ppm in both studied seasons.

### Table 8. Effect of irrigation levels, foliar application of mepiquat chloride and their interaction on fruit weight and flesh thickness of peach during 2018 and 2019 seasons

| Irrigation treatments | Mepiquat chloride treatments | 2018 Fruit weight (g) | 2018 Flesh thickness (cm) | 2019 Fruit weight (g) | 2019 Flesh thickness (cm) |
|-----------------------|-----------------------------|-----------------------|--------------------------|-----------------------|--------------------------|
|                       |                            | Control 150 ppm | 300 ppm | Mean | Control 150 ppm | 300 ppm | Mean | Control 150 ppm | 300 ppm | Mean |
| 100 ETC               |                            | 82.13bc          | 91.67a | 87.0ab | 86.93A          | 1.56a       | 1.49a | 1.46a | 1.50A |
| 80 ETC               |                            | 76.7cde          | 82.5bc | 76.8cde | 78.64B          | 1.41a       | 1.58a | 1.49a | 1.49A |
| 60 ETC               |                            | 72.70e           | 80.1cd | 74.6de | 75.80B          | 1.38a       | 1.40a | 1.41a | 1.40A |
| Mean                 |                            | 77.18B           | 84.74A | 79.46B | 1.45A           | 1.49A       | 1.45A | 1.45A | 1.45A |

Means with the same letter(s) in each column or row are not significantly different at 5% level.

However, the highest values of peach fruit weight (91.67 and 92.81 g) obtained from trees irrigated with 100% of calculated ETc with mepiquat chloride foliar application at 150 ppm in the first and second season respectively. Besides, the interaction between mepiquat chloride foliar application at (without, 150 and 300 ppm) and irrigate peach trees by the three studied levels (100, 80 and 60% of calculated ETc) failed to achieve any significant in fruit flesh thickness in both studied seasons.

In addition to, data in Table (9) revealed that although fruit flesh weight significantly affected by the three irrigation levels applied but no significant difference between irrigation by 80 or 60 % from calculated ETc. Besides, data of seed weight significantly affected by the three irrigation levels and seed weight decreased by decrease irrigation where the highest seed weight (5.13 and 4.83 g) obtained from trees irrigated by 100% of calculated ETc in 2018 and 2019 seasons respectively.

### Table 9. Effect of irrigation levels, foliar application of mepiquat chloride and their interaction on flesh and seed weight of peach fruits during 2018 and 2019 seasons

| Irrigation treatments | Mepiquat chloride treatments | 2018 Fruit flesh weight (g) | 2018 Seed weight (g) | 2019 Fruit flesh weight (g) | 2019 Seed weight (g) |
|-----------------------|-----------------------------|-----------------------------|--------------------|-----------------------------|----------------------|
|                       |                            | Control 150 ppm | 300 ppm | Mean | Control 150 ppm | 300 ppm | Mean | Control 150 ppm | 300 ppm | Mean |
| 100 ETC               |                            | 67.80bc          | 86.70a | 81.9ab | 81.80A          | 5.33a       | 5.00ab | 5.07a | 5.13A |
| 80 ETC               |                            | 72.1cde          | 78.3bc | 72.4cd | 74.24B          | 4.58bc      | 4.23cd | 4.40cd | 4.40B |
| 60 ETC               |                            | 68.60e           | 76.1bc | 70.3de | 71.67B          | 4.13d       | 4.00d | 4.23cd | 4.13C |
| Mean                 |                            | 72.49B           | 80.33A | 74.88B | 4.68A           | 4.41B       | 4.58AB | 4.58AB | 4.58AB |
| 2019                  |                            | 78.24bc          | 88.11a | 83.4ab | 83.42A          | 5.03a       | 4.70ab | 4.77a | 4.83A |
| 80 ETC               |                            | 73.5cde          | 79.7bc | 73.8cd | 75.68B          | 4.28bc      | 3.93cd | 4.10cd | 4.11B |
| 60 ETC               |                            | 70.04e           | 77.5bcd | 71.8de | 73.11B          | 3.83d       | 3.70d | 3.97cd | 3.83C |
| Mean                 |                            | 73.93B           | 81.8A | 76.32B | 4.38A           | 4.11B       | 4.3AB | 4.3AB | 4.3AB |

Means with the same letter(s) in each column or row are not significantly different at 5% level.
However, the highest values of peach fruit flesh weight (86.70 and 88.11 g) obtained from trees irrigated with 100% of calculated ETc with mepiquat chloride foliar application at 150 ppm in both seasons in this respect. Mepiquat chloride foliar application on 300 ppm produced the highest TSS (8.58 and 9.68%) and the highest TSS/acid ratio (20.83 and 17.2%) in the first and second season respectively. However, no significant difference between mepiquat chloride foliar application at 150 ppm and without mepiquat chloride foliar application (control) on TSS in both studied seasons in this respect.

TSS and TSS/acid ratio significantly affected by the interaction between the two studied factors where, the highest values of TSS and TSS/acid ratio (10.30 and 11.40 % in TSS and 30.62 and 23.46 in TSS/acid ratio) obtained from trees irrigated with 100% of calculated ETc with mepiquat chloride foliar application at 150 ppm in the first and second seasons, respectively.

Regarding to the effect of mepiquat chloride foliar application on TSS and TSS/acid ratio of peach fruits we found significant differences between the three using concentrations in both seasons in this respect. Mepiquat chloride foliar application at 300 ppm produced the highest TSS (8.58 and 9.68%) and the highest TSS/acid ratio (20.83 and 17.2%) in the first and second season respectively. However, no significant difference between mepiquat chloride foliar application at 150 ppm and without mepiquat chloride foliar application (control) on TSS in both studied seasons in this respect.

Table 10. Effect of irrigation levels, foliar application of mepiquat chloride and their interaction on TSS and TSS/acid ratio of peach fruits during 2018 and 2019 seasons

| Irrigation treatments | Mepiquat chloride treatments | TSS | TSS/acid ratio |
|-----------------------|-----------------------------|-----|---------------|
|                       |                             | 2018 | 2019          |
|                       |                             | Control | 150 ppm | 300 ppm | Mean | Control | 150 ppm | 300 ppm | Mean |
| 100 ETC               |                             | 7.17cd | 10.30a  | 8.73b  | 8.73A | 15.87cd | 30.68a  | 22.97b  | 23.17A |
| 80 ETC               |                             | 7.47cd | 7.05d   | 9.13b  | 7.88AB| 16.14cd | 17.6cd  | 21.22b  | 18.33B |
| 60 ETC               |                             | 7.67cd | 7.11d   | 7.87c  | 7.54B | 15.65d | 17.2cd  | 18.31c  | 17.05B |
| Mean                 |                             | 7.43B  | 8.15AB  | 8.58A  | 8.53B | 15.89B | 21.83A  | 20.83A  |       |

Means with the same letter(s) in each column or row are not significantly different at 5% level.

Data in Table (11) revealed that acidity and total sugars percentage significantly affected by the three irrigation levels applied but no significant difference between irrigation by 80 or 60% from calculated ETc in both seasons. Besides, the lowest acidity (0.39 and 0.54%) and the highest total sugars (7.18 and 6.68%) obtained from trees irrigated by 100% of calculated ETc in 2018 and 2019 seasons respectively.

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The acidity and total sugars of peach fruits significantly affected by mepiquat chloride foliar application by the three using concentrations in both seasons in this respect. Mepiquat chloride foliar application at 300 ppm produced the lowest values of acidity (0.41 and 0.56 %) but the highest values of total sugars (7.52 and 7.03 %) has obtained from trees treated by mepiquat chloride foliar application at 150 ppm in the first and second season respectively. But no significant difference between mepiquat chloride foliar application at 300 ppm and control on total sugars in both studied seasons in this respect.

Table 11. Effect of irrigation levels, foliar application of mepiquat chloride and their interaction on acidity and Total sugars of peach fruits during 2018 and 2019 seasons

| Irrigation treatments | Mepiquat chloride treatments | 2018 Acidity | Total sugars |
|-----------------------|-----------------------------|--------------|--------------|
|                       | Control 150 ppm 300 ppm Mean | Control 150 ppm 300 ppm Mean |
| 100 ETC               | 0.45bc 0.34g 0.38f 0.39B 6.80de 7.73a 7.00cd 7.18A |
| 80 ETC                | 0.46ab 0.40ef 0.43cd 0.43A 6.76de 7.60ab 6.85de 7.07AB |
| 60 ETC                | 0.49a 0.42de 0.43cd 0.45A 6.62e 7.25bc 6.78de 6.88B |
| Mean                  | 0.47A 0.38B 0.41C 6.73B 7.53A 6.88B |
| 2019                  |                                         |
| 100 ETC               | 0.60bc 0.53f 0.53f 0.54B 6.30de 7.23a 6.50cd 6.68A |
| 80 ETC                | 0.61ab 0.55de 0.58cd 0.58A 6.26de 7.10ab 6.35de 6.6AB |
| 60 ETC                | 0.64a 0.57de 0.58cd 0.60A 6.12e 6.75bc 6.28de 6.38B |
| Mean                  | 0.62A 0.53B 0.56C 6.23B 7.03A 6.37B |

Means with the same letter(s) in each column or row are not significantly different at 5% level.

Finally, total acidity and total sugars significantly affected by the interaction between the two studied factors where, the lowest values of total acidity (0.34 and 0.53%) obtained from trees irrigated with 100% of calculated ETC with mepiquat chloride foliar application at 150 ppm but this treatment produced peach fruits with the highest total sugars (7.73 and 7.23%) in the first and second season respectively.

These results were agree with the obtained by Pliakoni and Nanos (2010) studied the effect of deficit irrigation with 50% of Etc on “Royal Glory” peach and “Caldesi 2000” nectarine trees and the results showed an increase in total soluble solid (TSS) with higher acidity than fruit from control trees. Rufat et al., (2010) whose study irrigation restriction of 28% Etc during stage III of peach trees which led to a clear yield reduction in comparison with T1 (100%Etc). They were revealed that this result gave an increase in total soluble solids and soluble sugar with 30% Etc. Omina and El-Hagarey (2014) indicated that TSS and total acidity % where the highest significant values were obtained with irrigation by 80% of calculated ETC under Gr surface drip 4 l/h. irrigation systems. Sheren et al., (2017) were found that the best soluble solids content (SSC) and sugar contents in berries Juice obtained from irrigation vineyard trees at 100% of calculated ETC by sub surface drip irrigation system. On the other side, 80% water amount under by sub surface drip irrigation system gave the lowest total acidity in both seasons.

Hanaa and Samia, 2014 studied mepiquat chloride at 150 and 250 ppm on five years old 'Le Conte' pear trees. Results indicated that mepiquat chloride in both concentrations increased chlorophyll content improved fruit quality.

Leaf Anatomy

Microscopical counts and measurements of certain histological characters in transverse section through the blade of peach trees leaf sprayed with mepiquat chloride at 150 ppm and 300 ppm in Table (12) and fig. (1). It is obvious, the foliar application with mepiquat chloride at 150 ppm and 300 ppm on peach trees a prominent increase in thickness of lamina of leaf blade more than those of unsprayed ones (control). It is clear that the increase in lamina thickness increments in thickness of upper epidermis, lower epidermis, palisade tissue and spongy tissue compared with unsprayed ones. Bundle length, Midvein thick., Midvein width, midvein bundle length and xylem vessels/ midvein row number decreased in response to spraying mepiquat chloride at 150 ppm and 300 ppm this decrease was accompanied by increasing in leaf thickness and numbers of xylem row and vessels, yet all the recorded values were still higher than the control treatment.
Table 12. Effect of spraying with mepiquat chloride at 150 ppm and 300 ppm on leaf anatomical traits of peach trees in successive growing season of 2018

| Characters of leaf anatomy                  | Control     | Mepiquat chloride concentrations |
|--------------------------------------------|-------------|---------------------------------|
|                                            | 300 ppm     | 150 ppm                         |
| Midvein thick. (µ)                         | 990         | 623.4                           |
| Midvein width (µ)                          | 970.2       | 643.5                           |
| Midvein bundle length (µ)                  | 623.7       | 485.1                           |
| Midvein bundle width (µ)                   | 297         | 247.5                           |
| Palisade mesophyll (µ)                     | 69.3        | 89.1                            |
| Spongy mesophyll (µ)                       | 39.6        | 59.4                            |
| Lamina thick. (µ)                          | 138.6       | 178.2                           |
| Xylem vessels/midvein row number           | 31          | 25                              |

All enhanced leaf anatomical parameters (palisade cell length, spongy tissue thickness, blade thickness, midrib vascular bundle width, midrib vascular bundle length and midvein thickness) due to spraying with mepiquat chloride at 150 ppm and 300 ppm on peach trees reflected on a good translocation of the observed water and nutrients into cell to be used in different metabolic process which positively affected fresh weight of leaves and shoot on photosynthesis process activity and accumulation of photo-assimilates, Therefore, helping in better retention of flowers and fruits and this in turn increased yield.

Fig. 1. Transverse sections through the blade of leaf developed on shoots of peach trees. Effect of sprayed with mepiquat chloride on leaf anatomy at 15 days after spray at the season of 2018. (×100)

A- Palisade tissue thick.; B- Spongy tissue thick.; C- Blade thick.; D- Midvein thick.; E- Midvein width; F- Midrib V.B. Width.; G- Midrib V.B. length.

Water saving: It is clear from data in Table (13) that irrigated peach trees by 60% of calculated ETc led to the highest water saving (4.48 and 4.42 m³/tree/season) and (1254.787 and 1238.721 m³/feddan/season) but irrigated peach trees by 80% of calculated ETc only save (2.24 and 2.21 m³/tree/season) and (627.39 and 619.36 m³/feddan/season) compared with used water when peach trees irrigated by 100% of calculated ETc in 2018 and 2019 seasons, respectively.

Table 13. Effect of irrigation levels applied to peach trees on water saving (m³/tree/season and m³/feddan/season) during 2018 and 2019 seasons

| Irrigation treatments  | Water saving m³/tree/season | Water saving m³/feddan/season |
|------------------------|-----------------------------|-------------------------------|
|                        | 2018                        | 2019                         |
| 100 ETc                | 0                           | 0                            |
| 80 ETc                 | 2.240691                    | 2.212002                     |
| 60 ETc                 | 4.481381                    | 4.424004                     |

Productivity of irrigation water: Additionally data in Table (14) showed that irrigated peach trees by 60% of calculated ETc gave the highest productivity of irrigation water where every used m³ water gave (4.83 and 5.33 kg peach fruits) followed by (4.15 and 4.53 kg peach fruits) obtained from each m³ water when peach trees irrigated by 80% of calculated ETc compared with (4.04 and 4.35 kg peach fruits) obtained from each m³ water when peach trees irrigated by 100% of calculated ETc in 2018 and 2019 seasons, respectively.
Table 14. Effect of irrigation levels applied to peach trees on productivity of irrigation water (kg fruits/m² of water) during 2018 and 2019 seasons

| Irrigation treatments | 2018  | 2019  |
|-----------------------|-------|-------|
| 100 ETC               | 4.04  | 4.35  |
| 80 ETC                | 4.15  | 4.53  |
| 60 ETC                | 4.83  | 5.33  |

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