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Water deficiency and mulching effects on valencia orange trees

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Abstract

This study was carried out during 2014/2015 and 2015/2016seasons to improve water use efficiency on ten years old Valencia orange trees (*Citrus sinenses*L.*)* budded on sour orange rootstock (*Citrus aurantium* L.) under conditions of sandy loam soil at Belbeis region – El Sharqia Governorate, Egypt. The study aimed to improve water use efficiency by using different levels of water supply (100, 85 and 70% of ETc. i.e. Evapotranspiration) and mulching soil surface under drip irrigation system by Nile river water to determine the most effective treatment.

The data reveal that, increasing water supply level combined with soil mulching enhanced total number of buds, number of leaf buds, percentage of leaf buds, number of flower buds, number of opened buds, opened buds percentage, leaf free water content, chlorophyll a, carotenoids, total number of inflorescences, number of leafy inflorescences, number of solitary flowers per twig as well as yield in both seasons.

The most effective economic treatment was soil mulching × 85% Etc which produced 5.18 and 5.33 kg fruit for each one cubic meter of irrigation water in the first and the second seasons , respectively.

Keywords: Water deficiency - mulching - leafy inflorescences

Introduction

The economic value put the citrus trees in the top with other important fruit crops. World citrus production and consumption have witnessed a period of strong growth since 1980**.**Citrus is one of the most important fruit crops in the world with an annual production exceeding 122.5 million tons in 2010 (**FAO, 2012**).Citrustrees are the most important fruit crop in Egypt. They has an outstanding economic importance among fruit crops in Egypt, particularly for exportation**(Ministry of Agric., 2014).** The total area under citrus trees is 541,723 feddan, out of them 439,024feddanare fruitful producing 4,098,590 tons (43.00% of the total production of fruit trees) with average of 9.34 tons per feddan. The total area under Valencia orange trees is 145,858 feddan out of them 106,862 feddan are fruitful producing 1,030,713 tons with average of 9.65 tons per feddan. The total exports of orange fruits are about 1,027,554 tons representing 25.07 % of the total citrus production. (**M.A.L.R., 2014)**.

Water scarcity is one of the major causes of low productivity and decline of citrus orchards. Water deficit in citrus diminishes vegetative growth and yield, and reduces fruit size, and sometimes quality, causing important economic losses in orchards (**Gonzalez-Altozano and Castel, 2000 and Romero *et al.,* 2006**). Deficit irrigation is a recently proposed water saving technique in irrigated agriculture. The impact deficit irrigation versus full irrigation has been evaluated in citrus orchards under a hot sub-humid climate **(Panigrahi and Srivastava, 2016).**

In semi-arid ecosystem, the most important factors for fruit trees production is moisture stress. Mulches not only conserve soil moisture but also impart manifold beneficial effect, like suppression of extreme fluctuation of soil temperature, reduce water loss through evaporation, maintenance of soil fertility **(Thakur *et al.,* 1997),** improvement in growth and yield (**Shukla *et al.,* 2000),** resulting more stored soil moisture (**Shirugure *et al.,* 2003**)**.**

Organic mulching reduces soil temperature in summer and increases it in winter season which is beneficial for proper growth during winter and fruit development during summer months (**Ping *et al.,* 1997**). Continuous use of organic mulches are helpful in improving the physico-chemical properties, microbial flora and soil aeration which ultimately resulted into better growth and yield of plant (**Rao and Pathak, 1998**). The requirement of water through mulch can further be reduced by using locally available organic materials as mulches which not only saves irrigation water but also conserves soil moisture. Various studies have indicated that in fruit crops like apple, sapota, and acid lime, mulching improves soil moisture status, growth, yield and quality of these fruits, beside reducing weed growth **(Reddy *et al.*,1998;kumar*et al.,* 1999** and **Shirugure *et al.,* 2005).** The conservation of soil moisture by application of mulches becomes essential in semi arid ecosystem **(Kumar *et al.,* 2014)**.

The main target of this study was to pilot water deficiency and mulching effects on Valencia orange trees and to determine the most effective treatment.

Material and Methods

The present investigation has been carried out during two successive seasons (2014/2015&2015/2016) to study the effect of different levels of water supply (100, 85 and 70% of ETc)and soil mulching on flowering, fruit set, water relation and yield of Valencia orange trees (*Citrus sinenses)* budded on sour orange (*Citrus aurantium*) rootstock. The experimental trees were ten years old and grown at 4×5 meters, in sandy loam soil under drip irrigation system by Nile river water in private orchard at Belbeis region – El Sharkia Governorate, Egypt.

All the trees under this study received the same applied agricultural practices except experimental treatments. The experiment was arranged in two factors contained mulching soil surface or no mulching soil surface (control) with three water irrigation levels (100, 85 and 70% of ETc) which equal six treatments. Each treatment had three replicates and two trees for each replicate, in a split plot design.

The first factor was mulching soil surface with rice straw, the mulching thickness was about 15 cm covering the soil surface around the plant basin. In the control no mulch was applied.

The second factor was irrigation levels, the tested irrigation levels are based on different rates of irrigation wateri. e. 4509.02, 3834.42 and 3157.07 m^3 /fed./year, which resulted from the **FAO – Penman - Moteith equation** using meteorological data of the region and characteristics of the experimental trees as in the following tables:

Table (I): Reference crop evapotranspiration rate (ETc) calculated with CROPWAT V.8.00computer program from meteorological data under Sharkia Governorate conditions using FAO – Penman - Moteith equation (Average of two years2012&2013

Meteorological factor	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Min Temp °C	6.60	7.10	9.20	12.00	15.50	18.60	20.20	20.40	18.60	16.60	13.00	8.60
Max Temp °C	19.70	21.00	23.60	27.60	31.40	34.00	34.40	34.20	32.50	30.20	25.70	21.20
Humidity %	71.00	66.00	62.00	55.00	50.00	52.00	59.00	64.00	65.00	65.00	69.00	73.00
Wind km/day	136.00	139.00	139.00	168.00	163.00	151.00	124.00	96.00	99.00	124.00	104.00	124.00
Sun hours	6.90	7.40	8.60	9.80	11.00	12.60	12.30	11.40	10.70	9.30	7.70	6.90
Rad MJ/m²/day	12.10	14.90	19.30	23.20	26.20	28.90	28.10	25.90	22.80	17.90	13.40	11.40
ETc mm/day	1.93	2.50	3.42	4.82	5.92	6.62	6.30	5.61	4.75	3.77	2.48	1.88
ETc (100%)	1.93	2.50	3.42	4.82	5.92	6.62	6.30	5.61	4.75	3.77	2.48	1.88
ETc (85%)	1.64	2.13	2.91	4.10	5.03	5.63	5.36	4.77	4.04	3.20	2.11	1.60
ETc (70%)	1.35	1.75	2.39	3.37	4.14	4.63	4.41	3.93	3.33	2.64	1.74	1.32

Water requirements = Kc × ETc
Kc = crop coefficient

Table (II): The first irrigation level of total water requirement (W. R.): m^3 / fed. / Year = 4509.02; this theoretical irrigation rate (m^3/ fed./ year) was calculated according to the monthly data as shown in the following table.

Water requirements (W.R)	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
ETc (100%)	1.93	2.5	3.42	4.82	5.92	6.62	6.3	5.61	4.75	3.77	2.48	1.88
crop coefficient	0.61	0.64	0.67	0.72	0.78	0.81	0.80	0.97	0.46	0.51	0.64	0.58
W.R (mm/tree/day)	1.18	1.60	2.29	3.47	4.62	5.36	5.04	5.44	2.19	1.92	1.59	1.09
W.R (m3/fed./day)	4.94	6.72	9.62	14.58	19.39	22.52	21.17	22.86	9.18	8.08	6.67	4.58
W.R (m3/ fed. Month)	148.34	201.60	288.72	437.27	581.82	675.64	635.04	685.65	275.31	242.26	199.99	137.39

Table (III): the second irrigation level of total water requirement (W. R.):m^3 / fed. / Year = 3834.52; this theoretical irrigation rate (m^3 / fed./ year) was calculated according to the monthly data as shown in the following table.

Water requirements (W.R)	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
ETc (85%)	1.64	2.13	2.91	4.1	5.03	5.63	5.36	4.77	4.04	3.2	2.11	1.6
crop coefficient	0.61	0.64	0.67	0.72	0.78	0.81	0.80	0.97	0.46	0.51	0.64	0.58
W.R (mm/tree/day)	1.00	1.36	1.95	2.95	3.92	4.56	4.29	4.63	1.86	1.63	1.35	0.93
W.R (m3/fed./day)	4.20	5.73	8.19	12.40	16.48	19.15	18.01	19.43	7.81	6.85	5.67	3.90
W.R (m3/ fed. Month)	126.05	171.76	245.66	371.95	494.35	574.60	540.29	582.99	234.16	205.63	170.15	116.93

Table (IV): The third irrigation level of total water requirement (W. R.):m^3 / fed. / Year = 3156.07; this theoretical irrigation rate (m^3 / fed. / Year) was calculated according to the monthly data as shown in the following table.

Water requirements (W.R)	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
ETc (70%)	1.35	1.75	2.39	3.37	4.14	4.63	4.41	3.93	3.33	2.64	1.74	1.32
crop coefficient	0.61	0.64	0.67	0.72	0.78	0.81	0.80	0.97	0.46	0.51	0.64	0.58
W.R (mm/tree/day)	0.82	1.12	1.60	2.43	3.23	3.75	3.53	3.81	1.53	1.35	1.11	0.77
W.R (m3/fed./day)	3.46	4.70	6.73	10.19	13.56	15.75	14.82	16.01	6.43	5.65	4.68	3.22
W.R (m3/ fed. Month)	103.76	141.12	201.76	305.73	406.88	472.54	444.53	480.32	193.01	169.65	140.31	96.47

The tested treatments were evaluated throw the following parameters:

1- Budbehavior

The numbers of: leaf buds, flower budsand dormant budsas well as the openedbuds and total number of buds per twig were counted and recorded. In addition, the percentage of each bud type was calculated.

2- Flowering and fruit set

The total number of inflorescences, leafy and leafless inflorescences and their percentages as well as solitary flowers per twig were counted and recorded. In addition, the numbers of flowers on each inflorescence type were recorded. The numbers of set fruitlets on leafy and leafless inflorescences as well as from solitary flowers per twig were counted and recorded. Finally, the fruit set percentage in each case was calculated.

3- Yield and water use efficiency

At harvesting, the numbers of harvested fruits per tree were counted, the total weight of all fruits per tree (the yield/tree, in kg) was determined and recorded and the hypothetic yield/ fed. [on basis of 210 trees/fed. (4x5m apart)] was calculated.

Water use efficiency (WUE) value was calculated according to the following equation **(Jensen, 1983).**

$$WUE = \frac{Yield\ (kg\ per\ feddan)}{Seasonal\ ET\ (m3\ per\ feddan)}$$

4- Fruit physical properties

Samples of 15 fruits per each replicate were randomly taken, the studied parameters involved: fruit weight (g), fruit volume (cm^3), fruit height (cm), fruit diameter (cm), fruit shape index, peel weight (g), fruit pulp weight (g), juice weight / fruit (g) and juice volume / fruit (cm^3).

5- Chemical constituents of the fruit juice

The following parameters were considered: total soluble solids percentage (TSS) was determined using a hand refractometer, total titratable acidity as g citric acid / 100 ml of juice was determined by titration against 0.1 N sodium hydroxide in presence of phenol phthalin as an indicator, values of the TSS /acid ratio were calculated, ascorbic acid content (mg / 100 ml of juice) was determined by titration against 2,6- dichlorophenol indophenol (mg/ 100 ml) following the method illustrated in the **A.O.A.C. (1985).**

6- Leaf photosynthetic pigments and proline and leaf dry matter percentage

The photosynthetic pigments contents (mg/ g of fresh weight) were determined in fresh samples of leaf blades collected in August according to **Von-Wetteste in (1957).** Moreover, the proline content of fresh leaves (μ moles/g fresh weight) was determined following the method adopted by **Bates *et al.*, (1973).** Where, The leaf osmotic pressure of the cell sap of leaf blades was determined following the method of **Gosov (1960)**. Lastly, the leaf dry matter percentage (%) was determined according the following equation= $\frac{\text{leaf dry weight}}{\text{leaf fresh weight}} \times 100.$

Statistical analysis:

The experiment was arranged in two factors contained mulching soil surface or no mulching soil surface (control) with three water irrigation levels (100, 85 and 70% of ETc) which equal six treatments. Each treatment had three replicates and two trees for each replicate, in a factorial experiment -split plot design.The data obtained were statistically analyzed using the analysis of variance method as reported by **Snedecor and Cochran, (1980)**. The differences between means were differentiated by using Duncan's range test.**(Duncan, 1955)**.

Results and Discussion

1. Bud behavior:

Data in table (1) show the effect of mulching, different levels of water supply and their interaction on bud behavior of Valencia orange trees.

1.1.Total number of buds

The differences between mulching and the control for total numbers of buds were significant in the two seasons.The highest values were 43.45 and 45.99 buds for mulching against 36.45 and 36.17 buds for control in the 1^{st} and 2^{nd} seasons, respectively.

It was clear that total number of buds were increased with 100% ETc being 44.89 and 47.88against33.27 and 31.53buds for 70% Etcin the 1^{st} and 2^{nd} seasons, respectively.

The interaction between mulching and water supply revealed highest values with mulching × 100% ETc being 50.52 and 53.70buds against control × 70 % ETc being 31.84 and 27.73 buds in the 1^{st} and 2^{nd} seasons, respectively.

1.2. Number and percentage of leaf buds

There are significant differences between soil mulching and control fornumbers and percentages of leaf buds in both seasons. The highest values for number of leaf buds were 3.64 and 3.97for mulching against 3.00 and 3.28 leaf buds for control in the 1^{st} and 2^{nd} seasons, respectively.

Regarding, numbers of leaf buds, they were increased with 100% ETc being 3.94 and 4.17against 2.53 and 2.89 leaf buds for 70% Etc in the 1^{st} and 2^{nd} seasons, respectively.

The interaction between mulching and water supply for number of leaf buds revealed highest values with mulching × 100% ETc being 4.33 and 4.47 against 2.24 and 2.49 for control × 70 % ETcin the 1^{st} and 2^{nd} seasons, respectively.

1.3. Number and percentages of flower buds

The differences between mulching and control for numbers and percentages of flower buds were significant in both seasons. The highest values for flowers buds percentages were 54.96 and 58.13 (%) for the control against 51.21 and 52.61 (%) for mulching in the 1^{st} and 2^{nd} seasons, respectively.

It was clear that the percentage of flower buds were increased with 70% ETc being 57.26 and 61.76 (%) against 50.31 and 51.29(%) for100 % ETc in the two seasons, respectively.

The interaction between mulching and water supply for flowers buds percentages revealed highest values with mulching × 70% ETc being 58.38 (%) in the first season while was 63.21 (%) with control × 70% ETc in the second season against mulching × 100 % ETc being 46.53 and 47.45(%) in the 1^{st} and 2^{nd} seasons, respectively.

1.4. Number and percentages of dormant buds

There are significant differences values between mulching and control for numbers and percentages of dormant buds in both seasons. The highest values for percentages of dormant buds were 40.43 and

38.69(%) for mulching against 36.88 and 32.81 (%) for control in the 1st and 2nd seasons, respectively.

It was clear that percentages of dormant buds was increased with 100% ETc being 40.90in the first season while was 39.96 with 100% ETcand 38.19 (%) for 85% ETc in the second season against 35.17 and 29.11 (%) for 70 % ETcin the 1st and 2nd seasons, respectively.

The interaction between mulching and water supply for percentages of dormant buds revealed highest values with mulching × 100% ETc being 44.89 and 44.23(%)in the two seasons, respectively against mulching × 70 % ETc being 33.50 (%) in the first season and 27.82 (%) with control × 70 % ETc in the second season.

1.5. Number and percentages of opened buds

There are statistically differences values between mulching and control for number and percentage of opened buds in both seasons. The highest values for percentage of opened buds were 63.12 and 67.19(%) for control against 59.57 and 61.31 (%) for mulching in the 1st and 2nd seasons, respectively.

With regarding, the percentage of opened buds was increased with 70% ETc being 64.83 and 70.90(%) in the two seasons, respectively against 59.10 (%) in the first season and 60.04 and 61.82 (%) with 100 % ETc and 85 % ETc in the second season.

The interaction between mulching and water supply for percentage of opened buds revealed highest values with mulching × 70% ETc being 66.50 (%) in the first season while was 72.18 (%) with control × 70% ETc in the second season against mulching × 100 % ETc being 55.11 and 55.77 (%) in the two seasons, respectively.

Koshita & Takahara (2004) and **Falivene *et al.*,(2016)** reported that soil drought and water-stress treatment affects flower-bud formation and induces flowering in citrus.

The increase in total number of buds, number of leaf buds, percentage of leaf buds, number of flower buds, number of dormant buds, percentage of dormant buds and numbers of opened buds were possibly due to the increase in soil moisture availability, moderate evaporation from soil surface, temperature, light, energy exchange,soil organic carbon,N, P, K valuesand less weed growth**(Tarara, 2000**; **Shiruguree*t al.*, 2003;Heißner*et al.*, 2005; Jiang *et al.*, 2014; Kumar *et al.*, 2014; Onyegbule*et al.*, 2014**and **Falivene *et al.*, 2016).**

Table 1. Effect of mulching and different levels of water supplyon bud behavior of Valencia orange trees (2014/2015-2015/2016 seasons).

Treatments	Total number of buds		Number of leaf buds		Percentage of leaf buds		Number of flower buds		Percentage of flower buds		Number of dormant buds		Percentage of dormant buds		Number of opened buds		Percentage of opened buds	
First season																		
Control	36.45	B	3.	B	8.2	B	20.	B	54.	A	13.	B	36.	B	23.	B	63.	A
Mulching	43.45	A	3.	A	8.3	A	21.	A	50.	B	17.	A	41.	A	25.	A	58.	B
100% ETc	44.89	A	3.	A	8.7	A	22.	A	49.	C	18.	A	41.	A	26.	A	58.	C
85% ETc	41.69	B	3.	B	8.4	B	21.	B	51.	B	16.	B	40.	B	24.	B	59.	B
70% ETc	33.27	C	2.	C	7.6	C	19.	C	57.	A	11.	C	35.	C	21.	C	64.	A
Control×100%	39.26	c	3.	c	9.0	a	21.	c	54.	d	14.	c	36.	c	24.	c	63.	b
Control×85%E	38.24	d	3.	d	8.4	c	20.	d	54.	c	14.	d	36.	c	24.	d	63.	b
Control×70%E	31.84	f	2.	f	7.0	f	17.	f	56.	b	11.	f	36.	c	20.	f	63.	b
Mulching×100	50.52	a	4.	a	8.5	b	23.	a	46.	f	22.	a	44.	a	27.	a	55.	d
Mulching×85	45.13	b	3.	b	8.3	d	21.	b	48.	e	19.	b	42.	b	25.	b	57.	c
Mulching×70	34.70	e	2.	e	8.1	e	20.	e	58.	a	11.	e	33.	d	23.	e	66.	a
Second season																		
Control	36.	B	3.	B	9.0	A	20.	B	57.	A	12.	B	33.	B	24.	B	66.	A
Mulching	45.	A	3.	A	8.6	B	23.	A	51.	B	18.	A	39.	A	27.	A	60.	B
100% ETc	47.	A	4.	A	8.7	B	24.	A	50.	C	19.	A	40.	A	28.	A	59.	B
85% ETc	43.	B	3.	B	8.7	B	23.	B	52.	B	16.	B	38.	A	26.	B	61.	B
70% ETc	31.	C	2.	C	9.1	A	19.	C	61.	A	9.2	C	29.	B	22.	C	70.	A
Control×100%	42.	c	3.	c	9.2	b	23.	c	55.	d	15.	c	35.	c	27.	c	64.	c
Control×85%E	38.	d	3.	d	9.0	c	21.	d	56.	c	13.	d	34.	d	25.	d	65.	d
Control×70%E	27.	f	2.	f	8.9	d	17.	f	63.	a	7.7	f	27.	f	20.	f	72.	a
Mulching×100	53.	a	4.	a	8.3	f	25.	a	47.	f	23.	a	44.	a	29.	a	55.	f
Mulching×85	48.	b	4.	b	8.4	e	24.	b	50.	e	20.	b	41.	b	28.	b	58.	e
Mulching×70	35.	e	3.	e	9.3	a	21.	e	60.	b	10.	e	30.	e	24.	e	69.	b

Mean followed by the same letter\s within each column are not significantly different from each other at 0.5% level.

2. Flowering and fruit set

2.1. Leafy inflorescence characteristics:

Data in table (2) show the effect of mulching, different levels of water supply and their interaction on leafy inflorescence characteristics of Valencia orange trees.

2.1.1. Total number of inflorescences

The differences between mulching and the control for total number of inflorescences per twig were significant in the two seasons. The highest values were 17.51 and 19.37 inflorescences for mulching against 15.85 and 16.66 inflorescences for control in the 1st and 2nd seasons, respectively.

It was clear that total number of in florescencesper twig was increased with 100% ETc being 17.82 & 19.78 inflorescences and with 85% ETc being 17.12 & 18.80 inflorescences against 15.11 and 15.46 inflorescences for 70 % ETc in the 1st& 2ndseasons, respectively.

The interaction between mulching and water supply revealed highest values with mulching × 100% ETc being 18.74 and 20.69 inflorescences against control × 70 % ETc being 13.98 and 13.63 inflorescences in the 1st& 2ndseasons, respectively.

2.1.2. Number and percentage of leafy inflorescences

The differences between mulching and the control for number and percentages of leafy inflorescences per twig were significant in the two seasons. The highest values for leafy inflorescences percentage were 58.14 and 56.01 (%) for mulching against 53.61 and 54.52 (%) for the control in the 1st and 2nd seasons, respectively.

It was clear that percentage of leafy inflorescences was increased with 100% ETc being 59.07 and 56.03 (%) against 51.58 and 54.58 (%) for 70 % ETc in the 1st and 2nd seasons, respectively.

The interaction between mulching and water supply for leafy inflorescences percentage revealed highest values with mulching × 100% ETc being 63.01 and 58.05 (%) in the 1st& 2ndseasons, respectively against control × 70 % ETc being 51.16 (%) in the first season while was 52.29 (%) with mulching × 70% ETc in the second season.

2.1.3. Number of flowers, number of fruitlets and fruit set percentage on leafy inflorescences

The differences between mulching and the control for number of flowers, number of fruitlets and fruit set percentage on leafy inflorescence were significant in the two seasons. The highest values for fruit set percentage of leafy inflorescence were 19.37 and 18.56 (%) for mulching against 17.33 and 16.45 (%) for control in the 1st& 2ndseasons, respectively.

It was clear that fruit set percentage of leafy inflorescences increased with 100% ETc being 20.49 and 20.30 (%) against 16.09 and 14.89 (%) for 70 % ETc in the 1st& 2ndseasons, respectively.

Table 2. Effect of mulching and different levels of water supply on leafy inflorescence characteristics of Valencia orange trees (2014/2015-2015/2016 seasons).

Treatments	Total number of inflorescences per twig		Number of leafy inflorescences per twig		Percentage of leafy inflorescences		Number of flowers on leafy inflorescence		Number of fruitlets on leafy inflorescence		Fruit set percentage on leafy inflorescence	
First season												
Control	15.85	B	8.52	B	53.61	B	5.28	B	0.92	B	17.33	B
Mulching	17.51	A	10.23	A	58.14	A	6.17	A	1.21	A	19.37	A
100% ETc	17.82	A	10.56	A	59.07	A	6.25	A	1.29	A	20.49	A
85% ETc	17.12	A	9.76	B	56.98	B	5.83	B	1.08	B	18.47	B
70% ETc	15.11	B	7.80	C	51.58	C	5.08	C	0.82	C	16.09	C
Control×100%ETc	16.90	c	9.32	c	55.13	c	5.67	c	1.05	c	18.47	d
Control×85%ETc	16.68	d	9.10	d	54.55	d	5.67	c	1.04	d	18.31	e
Control×70%ETc	13.98	f	7.15	f	51.16	f	4.50	d	0.68	f	15.21	f
Mulching×100%ETc	18.74	a	11.81	a	63.01	a	6.83	a	1.54	a	22.50	a
Mulching×85%ETc	17.55	b	10.43	b	59.41	b	6.00	b	1.12	b	18.63	b
Mulching×70%ETc	16.25	e	8.45	e	52.00	e	5.67	c	0.96	e	16.98	c
Second season												
Control	16.66	B	9.05	B	54.52	B	5.24	B	0.87	B	16.45	B
Mulching	19.37	A	10.89	A	56.01	A	6.10	A	1.15	A	18.56	A
100% ETc	19.78	A	11.10	A	56.03	A	6.16	A	1.26	A	20.30	A
85% ETc	18.80	A	10.41	B	55.17	B	5.84	B	1.01	B	17.33	B
70% ETc	15.46	B	8.40	C	54.58	C	5.01	C	0.75	C	14.89	C
Control×100%ETc	18.88	c	10.19	c	54.01	d	5.63	c	1.02	c	18.09	c
Control×85%ETc	17.47	d	9.20	d	52.66	e	5.60	d	0.92	d	16.44	d
Control×70%ETc	13.63	f	7.75	f	56.88	c	4.50	f	0.67	f	14.81	f
Mulching×100%ETc	20.69	a	12.01	a	58.05	a	6.69	a	1.51	a	22.50	a
Mulching×85%ETc	20.13	b	11.61	b	57.69	b	6.08	b	1.11	b	18.21	b
Mulching×70%ETc	17.29	e	9.04	e	52.29	f	5.51	e	0.82	e	14.96	e

Mean followed by the same letter\s within each column are not significantly different from each other at 0.5% level.

The interaction between mulching and water supply for fruit set percentage of leafy inflorescence revealed highest values with mulching × 100% ETc being 22.50 and 22.50 (%) against control × 70 % ETc being 15.21 and 14.81(%) in the 1st& 2ndseasons, respectively.

2.2. Leafless inflorescence characteristics:

Data in table (3) show the effect of mulching, different levels of water supply and their interaction on leafless inflorescence characteristics of Valencia orange trees.

2.2.1. Number and percentages of leafless inflorescences

In the two seasons of investigation, all the tested treatments and their interaction did not have any significant effect on the number of leafless inflorescences per twig.

On the other hand, the differences between mulching and the control for percentage of leafless inflorescences were significant in the two seasons. The highest values were 46.39 and 45.48 (%) for the control against 41.86 and 43.99 (%) for mulching in the 1st& 2ndseasons, respectively.

It was clear that percentage of leafless inflorescences was increased with 70% ETc being 48.42 and 45.42 (%) against 40.93 and 43.97 (%) for 100 % ETc in the 1st and 2nd seasons, respectively.

The interaction between mulching and water supply for percentage of leafless inflorescences revealed highest values with control × 70% ETc being 48.84 (%) in the first season while was 47.34 (%) for control × 85% Etc and 47.71 (%) for mulching× 70% ETc in the second season against mulching × 100 % ETc being 36.99 and 41.95 (%) in the 1st& 2ndseasons, respectively.

Table 3. Effect of mulching and different levels of water supplyon leafless inflorescence characteristics of Valencia orange trees(2014/2015-2015/2016 seasons).

Treatments	Number of leafless inflorescences per twig		Percentage of leafless inflorescences		Number of flowers on leafless inflorescence		Number of fruitlets on leafless inflorescence		Fruit set percentage on leafless inflorescence	
First season										
Control	7.33	A	46.39	A	4.78	B	0.10	B	2.10	B
Mulching	7.29	A	41.86	B	5.69	A	0.30	A	5.03	A
100% ETc	7.26	A	40.93	C	5.79	A	0.25	A	4.04	A
85% ETc	7.35	A	43.02	B	5.33	B	0.25	A	4.46	A
70% ETc	7.31	A	48.42	A	4.58	C	0.10	B	2.18	C
Control×100%ETc	7.58	a	44.87	d	5.00	c	0.10	b	2.00	b
Control×85%ETc	7.58	a	45.45	c	4.83	d	0.10	b	2.07	b
Control×70%ETc	6.83	a	48.84	a	4.50	f	0.10	b	2.22	b
Mulching×100%ETc	6.93	a	36.99	f	6.58	a	0.40	a	6.08	a
Mulching×85%ETc	7.12	a	40.59	e	5.83	b	0.40	a	6.86	a
Mulching×70%ETc	7.80	a	48.00	b	4.67	e	0.10	b	2.14	b
Second season										
Control	7.61	A	45.48	A	4.70	B	0.10	B	2.17	B
Mulching	8.48	A	43.99	B	5.68	A	0.29	A	4.88	A
100% ETc	8.68	A	43.97	C	5.75	A	0.29	A	4.72	A
85% ETc	8.39	A	44.83	B	5.35	B	0.21	B	3.79	B
70% ETc	7.06	A	45.42	A	4.49	C	0.09	C	2.08	C
Control×100%ETc	8.68	a	45.99	b	4.94	c	0.11	c	2.28	c
Control×85%ETc	8.27	a	47.34	a	4.75	d	0.10	d	2.21	c
Control×70%ETc	5.88	a	43.12	c	4.42	f	0.09	e	2.03	c
Mulching×100%ETc	8.68	a	41.95	e	6.55	a	0.47	a	7.15	a
Mulching×85%ETc	8.51	a	42.31	d	5.94	b	0.32	b	5.37	b
Mulching×70%ETc	8.25	a	47.71	a	4.56	e	0.10	d	2.13	c

Mean followed by the same letter\s within each column are not significantly different from each other at 0.5% level.

2.2.2. Number of flowers, number of fruitlets and fruit set percentage on leafless inflorescence

The differences between mulching and the control for number of flowers, number of fruitlets and fruit set percentage on leafless inflorescence were significant in the two seasons. The highest values for fruit set percentage on leafless inflorescences were 5.03 and 4.88 (%) for mulching against 2.10 and 2.17 (%) for control in the 1st and 2nd seasons, respectively.

It was clear that fruit set percentage on leaf lessinflorescences was increased with 85% ETc being 4.46 (%) and with 100% ETc being 4.04 (%) in the first season while was 4.72 (%) for 100% ETc in the second season against 2.18 and 2.08 (%) for 70 % ETcin the 1st and 2nd seasons, respectively.

The interaction between mulching and water supply for fruit set percentage on leafless inflorescences revealed highest values with mulching × 100% ETc being 6.08 (%) and mulching × 85% ETc being 6.86 (%) in the first season while was 7.15 (%) for mulching × 100% ETc in the second season. On the other hand, the lowest values came from the interaction control × 100 % ETc being 2.00 (%), control × 85 % ETc being 2.07 (%), control × 70 % ETc being 2.22 (%) and mulching × 70 % ETc being 2.14 (%) in the first season against control × 100 % ETc being 2.28 (%), control × 85 % ETc being 2.21 (%), control × 70 % ETc being 2.03 (%) and mulching × 70 % ETc being 2.13 (%) in the second season

2.3. Solitary flowers characteristics:

Data in table (4) show the effect of mulching, different levels of water supply and their interaction on total number of solitary flowers, number of fruitlets from solitary flowers, fruit set percentage from solitary flowers, total flowers per twig, total number of set fruitlets per twig and overall fruit set percentage per twig of Valencia orange trees.

The differences between mulching and the control for number of solitary flowers, number of fruitlets and fruit set percentage from solitary flowers per twig were significant in the two seasons. For fruit set percentage from solitary flowers, the highest values were 39.95 and 37.15 (%) for mulching against 31.5 and 29.35 (%) for control in the 1st and 2nd seasons, respectively.

It was clear that fruit set percentage for solitary flowers was increased with 100% ETc being 46.88 and 40.30 (%) against 20.90 and 23.27 (%) for 70 % ETc in the 1st and 2nd seasons, respectively.

The interaction between mulching and water supply for fruit set percentage on solitary flowers revealed highest values with mulching × 100% ETc being 54.17 and 44.61 (%) against control × 70 % ETc being 16.11 and 19.56 (%)in the 1st and 2nd seasons, respectively.

Table 4. Effect of mulching and different levels of water supply on solitary flowers, number of fruitlets from solitary flowers, fruit set percentage from solitary flowers, total flowers per twig, total number of set fruitlets per twig and overall fruit set percentage per twig of Valencia orange trees (2014/2015-2015/2016 seasons).

Treatments	Total number of solitary flowers per twig		Number of fruitlets from solitary flowers per twig		Fruit set percentage for solitary flowers		Total number of flowers per twig		Total number of set fruitlets per twig		Overall fruit set percentage per twig	
First season												
Control	4.15	B	1.33	B	31.57	B	84.76	B	10.09	B	11.66	B
Mulching	4.41	A	1.80	A	39.95	A	109.32	A	16.58	A	14.73	A
100% ETc	4.55	A	2.15	A	46.88	A	113.07	A	17.87	A	15.40	A
85% ETc	4.33	B	1.71	B	39.51	B	100.50	B	14.07	B	13.91	B
70% ETc	3.95	C	0.83	C	20.90	C	77.54	C	8.07	C	10.27	C
Control×100%ETc	4.33	c	1.72	c	39.58	c	95.04	c	12.23	c	12.86	c
Control×85%ETc	4.23	d	1.65	d	39.03	d	92.44	d	11.85	d	12.82	c
Control×70%ETc	3.90	f	0.63	f	16.11	f	66.79	f	6.20	f	9.29	e
Mulching×100%ETc	4.77	a	2.58	a	54.17	a	131.10	a	23.51	a	17.93	a
Mulching×85%ETc	4.44	b	1.78	b	40.00	b	108.55	b	16.28	b	15.00	b
Mulching×70%ETc	4.01	e	1.03	e	25.69	e	88.29	e	9.94	e	11.26	d
Second season												
Control	4.15	B	1.23	B	29.35	B	88.10	B	10.02	B	11.19	B
Mulching	4.39	A	1.65	A	37.15	A	119.71	A	16.99	A	13.70	A
100% ETc	4.55	A	1.84	A	40.30	A	123.32	A	18.60	A	14.72	A
85% ETc	4.30	B	1.56	B	36.17	B	110.32	B	14.01	B	12.53	B
70% ETc	3.96	C	0.92	C	23.27	C	78.09	C	7.90	C	10.09	C
Control×100%ETc	4.32	c	1.55	c	35.99	c	104.58	c	12.91	c	12.34	c
Control×85%ETc	4.23	d	1.37	d	32.50	d	95.01	d	10.71	d	11.27	d
Control×70%ETc	3.90	f	0.76	f	19.56	f	64.72	f	6.46	f	9.97	f
Mulching×100%ETc	4.78	a	2.13	a	44.61	a	142.06	a	24.30	a	17.10	a
Mulching×85%ETc	4.38	b	1.74	b	39.85	b	125.62	b	17.32	b	13.79	b
Mulching×70%ETc	4.02	e	1.08	e	26.99	e	91.46	e	9.34	e	10.21	e

Mean followed by the same letter\s within each column are not significantly different from each other at 0.5% level.

2.4. Total number of flowers, number of fruitlets and overall fruit set percentage per twig

The differences between mulching and the control for total number of flowers**,** number of fruitlets and overall fruit set percentage per twig were significant in the two seasons. For overall fruit set percentage per twig, the highest values were 14.73 and 13.70 (%) for mulching against 11.66 and 11.19 (%) for control in the 1st& 2ndseasons, respectively.

In addition, the overall fruit set percentage per twig increased with 100% ETc being 15.40 and 14.72 (%) against 10.27 and 10.09 (%) for 70 % ETc in the 1st& 2ndseasons, respectively.

The interaction between mulching and water supply for overall fruit set percentage per twig revealed highest values with mulching × 100% ETc being 17.93 and 17.10 (%) against control × 70 % ETc being 9.29 and 9.97 (%) in the 1st& 2ndseasons, respectively.

The results of the present investigation revealed that flowering, inflorescences and fruit set characteristics were affected significantly by mulching and water stress; this was in harmony with results found by **Patil*et al.*, (2003)** on Nagpur Mandarin;**Koshita and Takahara(2004)** on Satsuma mandarin trees;**Melgar*et al.*, (2010)** on Valencia oranges;**Mahmoud (2012)** on Washington navel orange trees;**Syvertsen*et al.*, (2012)** on citrus trees and **Falivene*et al.*,(2016)**on citrustrees.

In addition**, Koshita&Takahara (2004)**and **Falivene*et al.*,(2016)**reported that soil drought and water-stress treatments affect flower-bud formation and induce both flowering and fruit set in citrus. Mulching soil surface increased soil moisture availability for longer duration, moderate evaporation from soil surface and temperaturewhich led to improving flowering, inflorescences and fruit set characteristics (**Tarara, 2000**; **Shirugure*et al.*, 2003;Heißner*et al.*, 2005; Jiang *et al.*, 2014; Kumar *et al.*, 2014; Onyegbule*et al.*, 2014**and **Falivene*et al.*, 2016).**

3.Yield and water use efficiency (WUE)

Data in table (5) show the effect of mulching, different levels of water supply and their interaction on yield component and water use efficiency of Valencia orange trees.

3.1. Number of fruits per tree and tree yield and hypothetic yield per feddan

The differences between mulching and the control for number of fruits per tree and tree yield and hypothetic yield per feddan were significant in the two seasons. For hypothetic yield per feddan, the highest values were 18.45 and 18.17 (ton) for mulching against 14.24 and 13.96 (ton) for control in the 1st and 2nd seasons, respectively.

Also, the hypothetic yield per feddan increased with 100% ETc being 20.26 and 19.77 (ton) against 10.95 and 10.89 (ton) for 70 % ETc in the 1st and 2nd seasons, respectively.

The interaction between mulching and water supply revealed highest values with mulching × 100% ETc being 23.30 and 22.63 (ton) against control × 70 % ETc being 9.70 and 10.35 (ton) in the 1st and 2nd seasons, respectively.

Table 5. Effect of mulching and different levels of water supply on yield and water use efficiency of Valencia orange trees (2014/2015-2015/2016 seasons).

Treatments	Number of fruits per tree		Tree yield (kg)		Hypothetic yield per feddan (ton)		Water use efficiency (kg/m^3)	
First season								
Control	408.63	B	67.80	B	14.24	B	3.67	B
Mulching	510.46	A	87.88	A	18.45	A	4.74	A
100% ETc	554.98	A	96.46	A	20.26	A	4.50	B
85% ETc	500.29	B	84.94	B	17.84	B	4.65	A
70% ETc	323.36	C	52.13	C	10.95	C	3.47	C
Control×100%ETc	485.85	c	81.97	c	17.21	c	3.82	c
Control×85%ETc	454.91	d	75.25	d	15.80	d	4.12	b
Control×70%ETc	285.13	f	46.20	f	9.70	f	3.07	e
Mulching×100%ETc	624.11	a	110.96	a	23.30	a	5.17	a
Mulching×85%ETc	545.67	b	94.62	b	19.87	b	5.18	a
Mulching×70%ETc	361.59	e	58.05	e	12.19	e	3.86	d
Second season								
Control	403.66	B	66.49	B	13.96	B	3.62	B
Mulching	490.46	A	86.52	A	18.17	A	4.66	A
100% ETc	526.39	A	94.13	A	19.77	A	4.39	B
85% ETc	487.01	B	83.54	B	17.54	B	4.58	A
70% ETc	327.78	C	51.85	C	10.89	C	3.45	C
Control×100%ETc	472.11	c	80.49	c	16.90	c	3.75	d
Control×85%ETc	422.11	d	69.69	d	14.63	d	3.82	c
Control×70%ETc	316.76	f	49.29	f	10.35	f	3.28	f
Mulching×100%ETc	580.66	a	107.78	a	22.63	a	5.02	b
Mulching×85%ETc	551.92	b	97.39	b	20.45	b	5.33	a
Mulching×70%ETc	338.80	e	54.40	e	11.42	e	3.62	e

Mean followed by the same letter\s within each column are not significantly different from each other at 0.5% level.

3.2. Water use efficiency (WUE)

The differences between mulching and the control for water use efficiency were significant in the two seasons. The highest values were 4.74 and 4.66 kg fruit per m^3 water for mulching against 3.67 and 3.62 kg fruit per m^3 water for control in the 1st and 2nd seasons, respectively.

It was clear that water use efficiency increased with 85% ETc being 4.65 and 4.58 kg fruit per m^3 water against 3.47 and 3.45 kg fruit per m^3 water for 70 % ETcin the 1st and 2nd seasons, respectively.

The interaction between mulching and water supply revealed highest values with mulching × 100% ETc being 5.17 and mulching × 85% ETc being 5.18 in the first season while was mulching × 85% ETc being 5.33 kg fruit per m^3 water in the second season against control × 70 % ETc being 3.07 and 3.28 kg fruit per m^3 water in the 1st and 2nd seasons, respectively.

The results of the present investigation revealed that yield and water use efficiency were affected significantly by mulching and water stress; this was in harmony with results found by **Shirgure*et al.*, (2003)** on Nagpur mandarin;**De *et al.*, (2005)** on mandarine;**BangChu*et al.*, (2007)** on citrus trees;**Garcia-Tejero*et al.*, (2010)** on citrus trees;**Mahmoud (2012)** on Washington navel orange trees;**Melgar*et al.*, (2012)** on Valencia oranges;**Barua and Hazarika (2014)** on Assam lemon;**Dorji*et al.*, (2016)** on citrus treesand **Falivene*et al.*, 2016** on citrus trees.

Mulching soil surface increase soil moisture availability, soil moisture for longer duration, moderate evaporation from soil surface, temperature and soil organic carbon as well as N, P, K values according to (**Tarara, 2000**; **Shirugure*et al.*, 2003;Heißner*et al.*, 2005; Jiang *et al.*, 2014; Kumar *et al.*, 2014;Onyegbule *et al.*, 2014**and **Falivene*et al.*, 2016)** which led to increasing yield and enhancing water use efficiency.

4. Fruit weight, fruit volume, fruit height, fruit diameter, fruit shape index, peel weight and pulp weight:

Data in table (6) show the effect of mulching, different levels of water supply and their interaction on fruit weight, fruit volume, fruit height, fruit diameter, fruit shape index, peel weight and pulp weight of Valencia orange fruits.

In the two seasons of investigation, all the tested treatments and their interaction did not have any significant effect on fruit weight, fruit volume, fruit height, fruit diameter, fruit shape index, peel weight and pulp weight.

Table 6. Effect of mulching and different levels of water supply on fruit volume, fruit height, fruit diameter, fruit shape index, peel weight and pulp weight of Valencia orange fruits (2014/2015-2015/2016 seasons).

Treatments	Fruit weight(g)		Fruit volume (cm^3)		Fruit height (L) (cm)		Fruit diameter (D) (cm)		Fruit shape index(L/D)		Peel weight (g)		Pulp weight (g)	
First season														
Control	165.3	A	189.0	A	6.3	A	4.9	A	1.279	A	48.4	A	116.9	A
Mulching	170.5	A	194.9	A	6.4	A	5.0	A	1.277	A	47.0	A	123.5	A
100% ETc	173.2	A	197.9	A	6.4	A	5.0	A	1.275	A	46.7	A	126.5	A
85% ETc	169.4	A	193.6	A	6.3	A	5.0	A	1.278	A	47.3	A	122.0	A
70% ETc	161.2	A	184.3	A	6.2	A	4.8	A	1.279	A	49.2	A	112.0	A
Control×100%ETc	168.7	a	192.8	a	6.3	a	4.9	a	1.279	a	47.2	a	121.4	a
Control×85%ETc	165.4	a	189.0	a	6.3	a	4.9	a	1.279	a	47.9	a	117.4	a
Control×70%ETc	162.0	a	185.1	a	6.2	a	4.8	a	1.280	a	50.2	a	111.8	a
Mulching×100%ET	177.7	a	203.1	a	6.5	a	5.1	a	1.273	a	46.2	a	131.5	a
Mulching×85%ETc	173.4	a	198.1	a	6.4	a	5.0	a	1.277	a	46.8	a	126.5	a
Mulching×70%ETc	160.5	a	183.4	a	6.2	a	4.8	a	1.279	a	48.1	a	112.3	a
Second season														
Control	163.7	A	175.2	A	5.9	A	4.6	A	1.280	A	44.8	A	118.8	A
Mulching	174.2	A	187.3	A	6.1	A	4.8	A	1.277	A	45.0	A	129.1	A
100% ETc	178.0	A	202.4	A	6.5	A	5.1	A	1.274	A	47.6	A	130.3	A
85% ETc	170.7	A	184.0	A	6.1	A	4.8	A	1.278	A	45.1	A	125.6	A
70% ETc	158.0	A	157.4	A	5.6	A	4.3	A	1.284	A	42.0	A	116.0	A
Control×100%ETc	170.4	a	183.5	a	6.1	a	4.8	a	1.277	a	44.9	a	125.5	a
Control×85%ETc	165.1	a	188.6	a	6.3	a	4.9	a	1.277	a	47.8	a	117.2	a
Control×70%ETc	155.6	a	153.5	a	5.5	a	4.2	a	1.286	a	41.6	a	113.9	a
Mulching×100%ET	185.6	a	221.3	a	6.8	a	5.4	a	1.272	a	50.3	a	135.2	a
Mulching×85%ETc	176.4	a	179.4	a	5.9	a	4.6	a	1.278	a	42.3	a	134.0	a
Mulching×70%ETc	160.5	a	161.3	a	5.6	a	4.4	a	1.282	a	42.3	a	118.2	a

Mean followed by the same letter\s within each column are not significantly different from each other at 0.5% level.

Table 7. Effect of mulching and different levels of water supply on juice volume, weight, TSS, acidity, TSS / acid ratio and ascorbic acid content of Valencia orange fruits (2014/2015-2015/2016 seasons).

Treatments	Juice volume/ fruit (cm^3)		Juice weight/ fruit (g)		Juice TSS (%)		Juice acidity (%)		TSS/acid ratio		Ascorbic acid (mg/100 ml)	
First season												
Control	60.76	A	61.18	A	10.49	A	0.98	A	10.70	A	42.86	A
Mulching	64.15	A	64.05	A	10.28	A	0.95	A	10.82	A	41.79	A
100% ETc	64.15	A	64.47	A	10.15	A	0.94	A	10.80	A	41.44	A
85% ETc	63.16	A	63.40	A	10.25	A	0.97	A	10.57	A	42.46	A
70% ETc	60.05	A	59.98	A	10.75	A	0.98	A	10.97	A	43.09	A
Control×100%ETc	62.53	a	63.16	a	10.28	a	0.97	a	10.60	a	42.59	a
Control×85%ETc	61.62	a	62.24	a	10.30	a	0.98	a	10.51	a	42.65	a
Control×70%ETc	58.14	a	58.14	a	10.89	a	0.98	a	11.11	a	43.34	a
Mulching×100%ETc	65.78	a	65.78	a	10.02	a	0.91	a	11.01	a	40.28	a
Mulching×85%ETc	64.71	a	64.56	a	10.20	a	0.96	a	10.63	a	42.26	a
Mulching×70%ETc	61.95	a	61.81	a	10.62	a	0.98	a	10.84	a	42.84	a
Second season												
Control	56.42	A	56.83	A	10.38	A	1.00	A	10.38	A	42.90	A
Mulching	61.59	A	61.50	A	10.17	A	0.96	A	10.59	A	42.17	A
100% ETc	65.61	A	65.91	A	10.16	A	0.96	A	10.58	A	41.76	A
85% ETc	60.05	A	60.30	A	10.17	A	0.98	A	10.38	A	42.74	A
70% ETc	51.35	A	51.29	A	10.49	A	1.00	A	10.49	A	43.09	A
Control×100%ETc	59.54	a	60.14	a	10.24	a	0.99	a	10.34	a	42.52	a
Control×85%ETc	61.51	a	62.13	a	10.24	a	0.99	a	10.34	a	43.09	a
Control×70%ETc	48.21	a	48.21	a	10.65	a	1.01	a	10.54	a	43.09	a
Mulching×100%ETc	71.67	a	71.67	a	10.09	a	0.92	a	10.97	a	41.01	a
Mulching×85%ETc	58.60	a	58.47	a	10.10	a	0.97	a	10.41	a	42.40	a
Mulching×70%ETc	54.49	a	54.37	a	10.34	a	0.99	a	10.44	a	43.09	a

Mean followed by the same letter\s within each column are not significantly different from each other at 0.5% level.

5. Juice volume, juice weight, TSS, acidity, TSS / acid ratio and ascorbic acid contents:

Data in table (7) show the effect of mulching, different levels of water supply and their interaction on juice volume, weight, TSS, acidity, TSS / acid ratio and ascorbic acid contents of Valencia orange fruits.

In the two seasons of investigation, all the tested treatments and their interactions did not have any significant effect on juice volume, weight, TSS, acidity, TSS / acid ratio and ascorbic acid contents.

Regarding fruit physical characteristics, results revealed that physical characteristics were not affected by soil mulching or water stress; this was in harmony with results found by **Shi *et al.*,(2011)** onPonkan tangerine and **Melgar*et al.*, (2012)** on Valencia orange**.**

6. Leaf photosynthetic pigments and proline content, cell sap osmotic pressure and leaf dry matter percentage:

Data in table (8) show the effect of mulching, different levels of water supply and their interaction on photosynthetic pigments and proline contents, cell sap osmotic pressure and dry matter percentage of Valencia orange leaves.

6.1. Leaf photosynthetic pigments

The differences between mulching and the control for chlorophyll a, chlorophyll b and leaf carotenoids contents were significant in the two seasons. For leaf chlorophyll a content, the highest values were 138.81 and 138.18 (mg/ g of leaf F. W.) for mulching against 126.82 and 124.30 (mg/ g of leaf F. W.) for control in the 1st and 2nd seasons, respectively.

In addition, the leaf chlorophyll a content increased with 100% ETc being 144.82 & 144.41 (mg/ g of leaf F. W.) against 116.10 and 112.54 (mg/ g of leaf F. W.) for 70 % ETc in the 1st and 2nd seasons, respectively.

Moreover, the interaction between mulching and water supply revealed highest values with mulching × 100% ETc being 151.70 and 153.13 (mg/ g of leaf F. W.) against control × 70 % ETc being 111.62 and 109.57 (mg/ g of leaf F. W.) in the 1st and 2nd seasons, respectively.

6.2.Leaf proline content

The differences between mulching and the control for leaf proline content were significant in the two seasons. The highest values were 56.88 and 61.07 (µ g / g of leaf D. W.) for control against 45.32 and

50.35 (µ g / g of leaf D. W.) for mulching in the 1st and 2nd seasons, respectively.

The leaf proline content was increased with 70% ETc being 63.40 and 69.30 (µ g / g of leaf D. W.) against 42.33 and 46.55 (µ g / g of leaf D. W.) for 100 % ETcin the 1st and 2nd seasons, respectively.

The interaction between mulching and water supply revealed highest values with control × 70 % ETc being 65.50 and 71.80 (µ g / g of leaf D. W.)against mulching × 100% ETc being 34.55 and 39.70 (µ g / g of leaf D. W.) in the 1st and 2nd seasons, respectively.

6.3.Leaf cell sap osmotic pressure

The differences between mulching and the control for leaf cell sap osmotic pressure were significant in the two seasons. The highest values were 21.11 and 21.63(atm.) for control against 19.66 and 20.29 (atm.) for mulching in the 1st and 2nd seasons, respectively.

It was clear that leaf cell sap osmotic pressure was increased with 70% ETc being 21.93 and 22.66 (atm.) against 19.29 and 19.82 (atm.) for 100 % ETc in the 1st& 2ndseasons, respectively.

The interaction between mulching and water supply revealed highest values with control × 70 % Etcbeing 22.19 and 22.98 (atm.)against mulching × 100% ETc being 18.32 and 18.96 (atm.) in the 1st& 2ndseasons, respectively.

6.4. Leaf dry matter percentage

In the two seasons of investigation, all the tested treatments and their interactions did not have any significant effect on leaf dry matter percentage.

Table 8. Effect of mulching and different levels of water supply on leaf photosynthetic pigments and proline contents and cell sap osmotic pressure of Valencia orange leaves (2014/2015-2015/2016 seasons).

Treatments	Leaf chlorophyll a content (mg/ g of leaf F. W.)		Leaf chlorophyll b content (mg/ g of leaf F. W.)		Leaf carotenoids content (mg/ g of leaf F. W.)		Leaf proline content (µ g / moles of leaf D. W.)		Leaf cell sap osmotic pressure (atm.)		Leaf dry Matter percentage (%)	
First season												
Control	126.82	B	60.09	A	57.06	B	56.88	A	21.11	A	31.11	A
Mulching	138.81	A	52.73	B	62.77	A	45.32	B	19.66	B	30.00	A
100% ETc	144.82	A	50.63	C	65.63	A	42.33	C	19.29	B	29.87	A
85% ETc	137.53	B	54.63	B	62.16	B	47.58	B	19.95	B	30.32	A
70% ETc	116.10	C	63.96	A	51.95	C	63.40	A	21.93	A	31.48	A
Control×100%ETc	137.94	c	55.45	d	62.35	c	50.10	d	20.26	c	30.82	a
Control×85%ETc	130.91	d	58.97	c	59.00	d	55.05	c	20.88	c	31.01	a
Control×70%ETc	111.62	f	65.85	a	49.82	f	65.50	a	22.19	a	31.50	a
Mulching×100%ETc	151.70	a	45.81	f	68.90	a	34.55	f	18.32	f	28.91	a
Mulching×85%ETc	144.16	b	50.29	e	65.31	b	40.10	e	19.01	e	29.62	a
Mulching×70%ETc	120.58	e	62.08	b	54.08	e	61.30	b	21.66	b	31.46	a
Second season												
Control	124.30	B	59.41	A	56.52	B	61.07	A	21.63	A	31.15	A
Mulching	138.18	A	51.83	B	63.13	A	50.35	B	20.29	B	30.60	A
100% ETc	144.41	A	49.30	C	66.10	A	46.55	C	19.82	C	30.31	A
85% ETc	136.76	B	52.80	B	62.46	B	51.28	B	20.41	B	30.46	A
70% ETc	112.54	C	64.76	A	50.92	C	69.30	A	22.66	A	31.86	A
Control×100%ETc	135.70	c	53.81	d	61.95	c	53.40	d	20.68	d	30.68	a
Control×85%ETc	127.62	d	57.85	c	58.10	d	58.00	c	21.25	c	30.80	a
Control×70%ETc	109.57	f	66.57	a	49.51	f	71.80	a	22.98	a	31.96	a
Mulching×100%ETc	153.13	a	44.79	f	70.25	a	39.70	f	18.96	f	29.94	a
Mulching×85%ETc	145.89	b	47.75	e	66.81	b	44.55	e	19.57	e	30.11	a
Mulching×70%ETc	115.51	e	62.95	b	52.34	e	66.80	b	22.35	b	31.76	a

Mean followed by the same letter\s within each column are not significantly different from each other at 0.5% level.

The obtained results in this study revealed that some of the pervious characteristics were affected significantly by mulching and water stress; this was in harmony with results found by**ShenXi*et al.,* (2010) and Avila *et al.,* (2012)** on citrus trees**; Mahmoud (2012)** on Washington navel orange trees**; Panigrahi*et al.,* (2012)** on Nagpur mandarin;**ShenXi*et al.,* (2012)**on citrus trees**;XiaoLi*et al.,*(2013)**on citrus trees; **Malik *et al.,*(2014) on** Satsuma mandarin trees;**ShenXi*et al.,* (2016)** on citrus trees and**Zaher-Ara *et al.,* (2016)** on citrus trees**.**

Moreover, the promotion in those characteristics might be due to an increase in soil moisture availability, moderate evaporation from soil surface, as well as to changes in temperature, light, energy exchange and to soil N, P, K contents and to less weed growth **(Tarara, 2000**; **Shirugure*et al.,* 2003;Heißner *et al.,* 2005; Jiang *et al.,* 2014; Kumar *et al.,* 2014 and Onyegbule*et al.,* 2014).**

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تأثيرات نقص الماء و تغطية سطح التربة على أشجار البرتقال فالنشيا

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اجري هذا البحث خلال موسمي 2013 /2014، 2016/2015 لتحسين كفاءة استخدام الماء لأشجار البرتقال الفالنشيا (*Citrus sinenses*L.) عمر 10 سنوات المطعومة على أصل النارنج (*Citrus aurantium* L.)في تربة رملية طميية في منطقة بلبيس بمحافظة الشرقية بمصر. تهدف الدراسة إلى تحسين كفاءة استخدام الماء باستخداممستويات مختلفة من الإمداد المائي (100، 85 ، 75% من البخر نتح المرجعي) وتغطية سطح التربة تحت نظام الري بالتنقيط باستخدام ماء النيل لتحديد افصل المعاملات تأثيرا.

تشير النتائج أن زيادة مستويات الإمداد المائي مع تغطية سطح التربة أدىإلى تحسين صفات عدد البراعم الكلية، عدد البراعم الورقية، نسبة البراعم الورقية، عدد البراعم الزهرية ، عدد البراعم المتفتحة ، نسبة البراعم المتفتحة ، الماء الحر ، كلورفيل أ ، الكاروتينات، عدد النورات الكلية ، عدد النورات الورقية ، عدد الأزهار المفردة على الفرع كما زادت من المحصول في كلا الموسمين.

كانت أفضل معاملة تأثيرا هي تغطية سطح التربة مع مستوى إمداد مائي 85% من البخر نتح المرجعي و التي أنتجت5.18 ، 5.33 كجم ثمار لكل متر مكعب من ماء الري في الموسم الأول و الثاني على التوالي.