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Effect of Irrigation levels, Mulching and Kaolin on Yield and Fruit Quality of Washington Navel Orange Trees Grown in Clay Soil

Ennab*, H.A.; A.M. Khadr and Mikhael, G.B.
Horticulture Research Institute, Agriculture Research Center, Giza, Egypt
Corresponding author: Hassan.ennab@yahoo.com

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Abstract

A field experiment was carried out during 2019 and 2020 seasons at El-Riad, Kafr El-Sheikh governorate, to study the effect of irrigation levels, mulching and antitranspiration on yield and fruit quality of Washington navel orange trees. Eighteen combination treatments consist of three irrigation levels of 100, 75 and 50% ETc, two mulching types viz, black polyethylene and rice straw beside bare soil as control; and spraying with two kaolin concentrations 0.0 and 3% were arranged in a randomized complete block design with three replicates. Results indicated that irrigation levels at 100 and 75% ETc significantly enhanced and increased fruit set %, yield kg/tree or ton/feddan, fruit quality, yield efficiency kg/m^3 of canopy volume, water use efficiency kg/m^3 water and reduce fruit drop %. In addition, soil mulching with black polyethylene or rice straw was significantly increased all studied parameters compared to bare soil. Moreover, foliar application of kaolin at 3% was more effective in most cases compared to spraying with tap water. Overall, the combination of irrigation at 75% ETc with black polyethylene or rice straw mulch combined with spraying kaolin at 3% showed the best results of fruit set, less fruit drop, total yield, and fruit quality and increased water use efficiency. Furthermore, this combination saved about 25% of the total used water without negative effect on tree yield and fruit quality.

Keywords: Citrus, covering, Rice, kaolin, irrigation

Introduction

In Egypt, water is one of the most critical factors in citrus production because rainfall is rare or low and almost agricultural production is mainly dependent upon irrigation, on the other hand, water resources are limited and concentrated upon the Nile River. Under these conditions saving water and conservation is a vital and essential demand to face the water gap problem, this can be achieved by using not only alternative water application method such as drip irrigation system and controlling amount of irrigation water but also using some agricultural processes that makes to reduce evapotranspiration such as mulching and spraying with antitranspiration in order to reduce water losses with maintaining maximum citrus trees growth, yield and fruit quality **(Faghih *et al.*, 2019 and Abd El-Raouf *et al.*, 2020)**.

Deficit irrigation is a strategy for water saving and sustainable crop production in water scarce regions. Reducing water supply during certain crop growth stages or throughout the whole growing season enhances the yield and fruit quality of citrus trees **(Ennab and Alam-Eldein 2020).** In this respect, **Garcia Tejero *et al.*, (2019)** reported that, Salustiana and Navalina oranges irrigated with deficit irrigation treatment produced fruit yield similar to that irrigated with fully water requirements and saving water up to 1000 m^3 ha^{-1}. Similar results are reported by **Shirgure *et al.*, (2016)** who revealed that, deficit irrigation scheduled with 40 and 60% reduction in irrigation water quantity at initial fruit enlargement stage of ‘Nagpur’ mandarin did not affect the yield and fruit quality.

Mulching has a beneficial effect on suppression of extreme fluctuation of soil temperature and reduction of water loss through evaporation, resulting is more stored soil moisture, maintenance of soil fertility **(Bhardwaj, 2013).** Also, mulching play an important role in reducing soil erosion, improving soil structure, organic matter, soil microbial, soil aeration, regulating soil temperature, conserving moisture in-situ, controlling weeds and reducing nutrient removal by leaching and weeds **(El-Taweel and Farag 2015).** In this regard, **Lalruatsangi and Hazarika (2018)** showed that using black polyethylene for mulching soil in acid lime trees orchard was the most effective with respect to plant growth, yield and fruit quality while paddy straw proves to be the best ideal treatment for improving soil in terms of soil moisture content, organic carbon, available nitrogen, phosphorus, potassium content and microbial population.

Antitranspirants are chemicals which decrease the water loss from plant leaves, this operation is very important because 95% of the water absorbed by the plant is lost in transpiration. Therefore, Kaolin treatments have been successfully applied for decrease leaf temperature and reduce transpiration rate. In this line, spraying with kaolin was found to enhance water use efficiency and reducing the adverse effects of water deficit on pistachio and pomegranate trees **(Azizi *et al.*, 2013 & El-Khawaga and Mansour 2014).** Also, **Ennab *et al.*, (2017)** concluded that, kaolin foliar spraying at 3 and 4% decreased leaf heat and fruit surface temperature and was more effective to control sunburned fruits of Balady mandarin trees. Also, kaolin appears to be an important and helpful tool to reduce insect attack, medfly fruit damage, and could be a valid alternative to intensive applications of insecticides **(Braham *et al.*, 2007).**

Therefore, this research was carried out to rationalizing the use of irrigation water through use deficit irrigation, mulching and spraying with kaolin, and their effect on yield and fruit quality of Washington navel orange trees under drip irrigation system in clay soil.

Materials and Methods

The present study was carried out during 2019 and 2020 seasons on 7 years old Washington navel orange trees (*Citrus sinensis*, Osbeck) budded on sour orange (*Citrus aurantium* L.) rootstock, and planted at 5×5 m apart in a private orchard at El-Demerdash village, El-Riad distract, Kafr El-Sheikh governorate, Egypt. Some physical and chemical analysis of the experimental soil were done as shown in Table (1). Treatments involved three irrigation levels, three mulching and two kaolin concentrations. Irrigation levels are 100, 75 and 50% ET_C applied through 16 dippers (I_1) as control, 12 dippers (I_2), or 8 dippers (I_3). Each dipper produces 4-liter water per hour. The irrigation water requirement for orange was calculated according to the meteorological data of the Sakha Weather Station, Kafr El-Sheikh governorate, depending on Penman-Monteith equation **(Allen *et al.*, 1998)**. Daily irrigation water was calculated by following equation for two seasons 2019 and 2020 under drip irrigation system: $IRg = [(ET_O \times Kc \times Kr)/Ei] - R + LR$. Where: IRg: gross irrigation requirements, mm/day, ET_O: reference evapotranspiration, mm/day, Kc: crop factor (FAO-56), Kr: ground cover reduction factor, Ei: irrigation efficiency %, R: water received by plant from other sources than irrigation, mm, LR: amount of water (mm) required for the leaching of salts. Water quantities applied per month and season/feddan are shown in Table (2).

Table 1. Some physical and chemical properties of the experimental soil

Parameter	0 – 60 cm depth
Clay %	60.61
Silt %	25.12
Sand %	14.27
Texture class	**Clay**
pH (1:2.5)	8.25
EC, dS/m^{-1} (1: 5)	1.48
Organic matter (%)	1.03
Bulk density (g/cm^3)	1.31
Na^+ meq/l	0.71
K^+ meq/l	0.57
Ca^{++} meq/l	0.80
Mg^{++} meq/l	0.83
Cl^- meq/l	0.63
CO_3^{--} meq/l	0.00
HCO_3^- meq/l	0.67
SO_4^{--} meq/l	1.61
Field capacity%	45.82
Wilting point%	23.47
Available water%	72.35

Table 2. Amount of water as m^{3}month and season/feddan for each irrigation treatment during 2019 and 2020 seasons

Months	Water amount (m^3 / month and season/feddan)					
	I_1 = 16 dippers/tree		I_2 = 12 dippers/tree		I_3 = 8 dippers/tree	
	2019	2020	2019	2020	2019	2020
December	125.0	114.5	93.7	86.0	62.4	57.4
January	156.2	156.2	117.2	117.2	78.1	78.1
February	188.2	190.0	141.4	142.6	94.0	94.9
Winter	**469.4**	**460.7**	**352.3**	**345.8**	**234.5**	**230.4**
March	260.4	249.9	195.2	187.4	130.2	124.9
April	302.4	287.2	226.8	215.3	151.2	143.6
May	390.6	374.9	292.8	281.2	195.2	187.4
Spring	**953.4**	**912.0**	**714.8**	**683.9**	**476.6**	**455.9**
June	398.2	388.0	298.5	290.9	199.0	194.0
July	463.5	442.6	347.5	331.9	231.8	221.2
August	364.5	359.3	273.3	269.4	182.2	179.5
Summer	**1226.2**	**1189.9**	**919.3**	**892.2**	**613.0**	**594.7**
September	352.8	342.7	264.6	257.0	176.4	171.3
October	312.5	286.4	234.3	214.8	156.2	143.3
November	166.3	166.3	124.8	124.6	83.1	83.1
Autumn	**831.6**	**795.4**	**623.7**	**596.4**	**415.7**	**397.7**
Total m^3 /fed.	3480.6	3358.0	2610.1	2518.3	1739.8	1678.7

Mulches materials used were black polyethylene with 60-micron thickness, rice straw in 10 cm and bare soil as control. The mulching was applied on both sides of the tree line on the first week of March until the end of September. Kaolin was sprayed at 0.0 and 3% once monthly from March to September with 10 liters/tree of the solution at early morning. Treatments were arranged in a randomized complete block design as split-split plot experiment, replicated three times with two trees per replicate. The irrigation levels were randomized in the main plots, mulches in sub-plots and kaolin spray in sub-sub plots.

Table 3. Mean of some meteorological data for north the delta area during the two growing seasons of 2019 and 2020.

Month	Air temperature (°C)		RH (%)	Wind velocity (Km/24h)	Pan Evap. (mm)	Rain (mm day)	Air temperature (°C)		RH (%)	Wind velocity (Km/24h)	Pan Evap. (mm)	Rain (mm day)
	Max.	Min.					Max.	Min.				
	2019						2020					
Jan.	18.9	12.3	67.8	33.1	113.8	2.98	18.4	11.8	74.7	30.0	208.8	8.11
Feb.	19.7	14.3	72.5	28.6	177.6	3.17	20.4	12.7	70.5	51.0	182.9	3.57
Mar.	21.7	17.6	72.2	45.7	285.8	3.65	22.6	15.6	67.5	80.1	511.9	9.22
Apr.	25.1	21.3	64.8	44.8	369.5	2.36	26.0	18.9	62.5	98.8	607.5	--
May	31.9	25.4	57.1	68.4	682.9	--	31.9	23.8	52.1	14.4	770.3	--
June	33.0	28.0	65.7	103.0	845.7	--	31.1	25.2	60.3	111.8	844.1	--
July	33.5	28.4	69.8	83.8	807.7	--	33.7	27.3	67.6	101.7	879.0	--
Aug.	34.2	28.9	70.6	68.7	682.4	--	34.6	28.2	67.4	92.4	803.0	--
Sept.	32.4	27.9	68.1	76.9	589.6	--	34.6	27.1	67.2	93.3	624.2	--
Oct.	30.3	26.7	70.8	56.6	383.7	6.61	31.5	24.6	65.9	72.7	412.3	--
Nov.	27.4	25.1	65.5	36.6	230.8	--	25.0	17.5	71.7	46.9	228.3	2.47
Dec.	21.4	13.4	72.9	38.5	265.6	8.48	24.0	17.2	71.8	40.5	230.1	7.33

* According to daily weather observations of Sakha Agriculture Research Weather Station.

The following data was recorded:

1. Fruit set and fruit drop %:

Number of flowers, fruitlets at initial set (15 days after full bloom) and fruit at harvest time were counted on selected main branches in four directions on each tree for calculated final fruit set and fruit drop percentages by using the following equations:

Fruit set% = (No. of harvested fruits ÷ No. of flowers) × 100

Fruit drop % = [(No. of fruitlets at initial set – No. of harvested fruits) ÷ No. of fruitlets at initial set] ×100

2. Yield:

Fruits were harvested in November 27th and December 12th during the first and the second seasons, respectively. Yield of each replicate was determined as kg/tree, and ton/feddan. Also, yield efficiency as kg/m^3 of canopy volume and water use efficiency as kg/m^3 water were calculated.

3. Fruit quality:

Ten fruits were collected randomly from the yield of each tree to determine fruit weight (g), fruit size (ml), fruit firmness (newton), and juice volume (ml). total soluble solid were recorded using a hand refractometer model RA-130, total acidity was estimated as citric acid, and ascorbic acid as mg per100 ml juice using 2, 6 dichlorophenol indophenol according to (A.O.A.C 1990), and then TSS/acid ratio was calculated.

Statistical analysis:

Statistical analysis was done using MSTAT version 5.5 (software informer, 2012) for analysis of variance, and the differences among means were compared using Duncan multiple range test (DMRT) at $p \leq 5\%$ **(Duncan, 1955)**.

Results and Discussion

1. Fruit set and fruit drop:

Data in Table 4 show the effect of irrigation levels and mulching soil combined with antitranspiration spraying on fruit set and fruit drop percentages of Washington navel orange trees in both seasons. As for the effect of irrigation levels, it is clear that high irrigation level (100% ET_C) led to significantly increase fruit set and reduces fruit drop followed by irrigation at 75% ET_C compared to irrigation at 50% ET_C which gave the lowest values of fruit set and higher values of fruit drop in both seasons. These results are in harmony with those obtained by **Ennab and Alam-Elden (2020)** they concluded that increasing irrigation levels led to an increase in fruit set and decreased fruit drop in Valencia orange trees. Also, **El-Zawily (2016)** revealed that high and moderate irrigation levels (24.06 and 18.05 m^3/tree/year) led to increase fruit set and reduces fruit drop as compared with low irrigation level (12.03 m^3/tree/year) in Washington navel orange trees.

Concerning the effect of covering soil, data in Table 4 indicated that, black polyethylene and rice straw mulching were significantly enhancing fruit set and reduced fruit drop compared to bare soil in both seasons. These findings are confirmed by the results obtained by **Lalruatsangi and Hazarika (2018)** on Acid lime. In this respect, **El-Taweel and Farag (2015)** concluded that mulching with black polyethylene and rice be at par about their effect on fruit set of pomegranate trees which produced higher values compared to other mulching materials like palm fronds, gravel and bare soil.

As regarding the effect of antitranspiration on fruit set and fruit drop percentages, the data showed trees sprayed with kaolin at 3% had significantly higher fruit set and lower fruit drop than that sprayed with tap water. Similar result was found by **El-Khawaga and Mansour (2014) and Ali and El Zayat (2019),** they revealed that kaolin foliar application enhances fruit set and fruit retention percentages of pomegranate and Washington navel orange trees.

Moreover, the interactions were significant in both seasons and the highest values of fruit set% was obtained by irrigation at 100% + mulching with black polyethylene + spraying with Tap water, followed by irrigation at 100% ET_C + mulching with black polyethylene + kaolin spray at 3% and irrigation at 75% ET_C + mulching with rice straw + kaolin spray at 3%, respectively. On the other hand, the highest values of fruit drop% was observed by irrigation at 50% ET_C and mulching with bare soil, rice straw and black polyethylene without kaolin spraying in both seasons, respectively. Similar results were obtained by **Ahmed and Aly (2017)** and **Fayed *et al.*, (2018),** they found that combination among different irrigation regimes and mulching or foliar sprays of antitranspiration enhancing fruit set and reduced fruit drop on different fruit crops. So, it could be concluded that using black polyethylene and rice straw mulches with spraying kaolin at 3% under high and moderate irrigation levels gave the best fruit set and also reduced fruit drop, these results could be explained as a reflection of the beneficial effects of mulching which add macro and micro nutrients to soil, increase microbial population and their activity which are produced natural hormones, vitamins and antioxidants which are available for tree. Thus, the improved tree growth and development caused by nutritional balance increases fruit set % and reduces fruit drop.

Table 4. Effect of drip irrigation, soil mulching and spraying with antitranspiration on fruit set, fruit drop and yield of 'Washington' navel orange trees during 2019 and 2020 seasons.

Treatments			**Fruit set %**		**Fruit drop %**		**Yield**			
							Kg/tree		ton/feddan	
			2019	2020	2019	2020	2019	2020	2019	2020
Irrigation levels										
I_1:100%			3.49^{A}	4.03^{A}	6.84^{C}	6.11^{C}	69.16^{A}	70.24^{A}	11.61^{A}	11.79^{A}
I_2:75%			3.06^{B}	3.48^{B}	7.68^{B}	6.87^{B}	64.45^{B}	64.53^{B}	10.82^{B}	10.83^{B}
I_3:50%			2.51^{C}	3.02^{C}	9.54^{A}	8.52^{A}	53.77^{C}	57.25^{C}	09.02^{C}	09.61^{C}
Mulching										
M_0: Bare soil			2.75^{b}	3.09^{c}	8.48^{a}	7.58^{a}	58.45^{c}	60.75^{c}	09.81^{c}	10.20^{c}
M_1: Rice straw			2.99^{b}	3.56^{b}	8.05^{b}	7.19^{b}	62.99^{b}	63.83^{b}	10.57^{b}	10.72^{b}
M_2: Black polyethylene			3.31^{a}	3.88^{a}	7.53^{c}	6.74^{c}	65.93^{a}	67.43^{a}	11.07^{a}	11.32^{a}
Antitranspiration										
A_0: Control (water spray)			2.86^{B}	3.33^{B}	9.42^{A}	8.41^{A}	59.39^{B}	60.86^{B}	09.97^{B}	10.22^{B}
A_1: Kaolin spray at 3%			3.17^{A}	3.69^{A}	6.62^{B}	5.92^{B}	65.52^{A}	67.15^{A}	11.00^{A}	11.27^{A}
I_1: 100%	Bare soil	Control	3.25 d	3.72 d	8.00 g	7.14 g	64.95 d	66.56 d	10.90 d	11.17 de
		Kaolin	3.41 c	3.95 c	5.97 l	5.34 m	67.81 c	69.25 cd	11.38 c	11.63 cd
	Rice straw	Control	3.44 c	3.95 c	7.91 g	7.07 g	68.11 c	67.60 cd	11.44 c	11.35 cd
		Kaolin	3.51 bc	4.09 b	5.97 l	5.34 m	70.59 b	72.52 ab	11.85 b	12.18 ab
	Black polyethylene	Control	3.68 a	4.25 a	7.66 h	6.84 h	69.18 bc	70.44 bc	11.61 bc	11.83 bc
		Kaolin	3.65 ab	4.23 a	5.55 m	4.96 n	74.32 a	75.07 a	12.48 a	12.61 a
I_2: 75%	Bare soil	Control	2.57 fg	2.79 g	9.93 d	8.87 d	59.37 g	58.48 ij	9.96 g	9.82 hi
		Kaolin	3.21 d	3.70 d	6.77 i	6.05 j	62.49 ef	64.26 ef	10.49 ef	10.79 ef
	Rice straw	Control	2.71 f	3.15 f	8.46 e	7.56 e	61.41fg	62.17 fg	10.31 fg	10.44 fg
		Kaolin	3.52abc	3.72 d	6.56 j	5.86 k	68.10 c	68.77 cd	11.43 c	11.54 cd
	Black polyethylene	Control	2.89 e	3.38 e	8.21 f	7.33 f	64.68 de	63.61 ef	10.86 de	10.68 ef
		Kaolin	3.49 bc	4.18 ab	6.18 k	5.59 l	70.69 b	69.91 bc	11.87 b	11.74 bc
I_3: 50%	Bare soil	Control	1.97 i	2.17 h	12.59 a	11.25 a	44.87 j	49.36 j	7.53 j	8.29 j
		Kaolin	2.09 i	2.24 h	7.66 h	6.84 h	51.26 hi	56.60 i	8.60 hi	9.50 i
	Rice straw	Control	2.27 h	3.16 f	11.92 b	10.64 b	49.65 i	51.55 j	8.33 i	8.65 j
		Kaolin	2.54 g	3.34 e	7.49 h	6.69 i	60.09 g	60.41 gh	10.09 g	10.14 gh
	Black polyethylene	Control	3.01 e	3.42 e	10.10 c	9.03 c	52.37 h	58.03 hi	8.79 h	9.74 hi
		Kaolin	3.19 d	3.82 cd	7.49 h	6.69 i	64.39 de	67.57 cd	10.81 de	11.34 cd

Means followed by the same letter within a column are not significantly different using DMRT at $P \leq 0.05$

2. Yield:

Data presented in Tables 4 and 5 indicated that total yield as kg/tree or ton/feddan has significantly increased with increasing irrigation level, the highest yield was found in trees irrigated with 100% ET_C water, but the lowest yield was observed in the trees irrigated with 50% water. In addition, yield efficiency kg/m^3 of canopy volume was gradually increased with increasing irrigation water, while water use efficiency kg/m^3 water was decreased with increasing irrigation water. These results agree with those obtained by **Ennab and El-Sayed (2014)** indicated that yield as kg or number fruit/tree was significantly higher in Balady mandarin trees irrigated with 25 and 15 m^3 than those irrigated with 10 m^3, moreover trees irrigated with15 m^3 recorded the highest water use efficiency and yield efficiency was decreased under deficit irrigation treatments. Also, **El-Zawily, (2016)** revealed that high and moderate irrigation levels (24.06 and 18.05 m^3) increased fruit yield and yield efficiency, while water use efficiency was increased under low irrigation level (12.03 m^3) in Washington navel orange trees.

Results in Tables 4 and 5 showed that, yield as kg/tree or ton/feddan and yield efficiency kg/m^3 of canopy volume as well as water use efficiency kg/m^3 water significantly increased by using black polyethylene or rice straw mulching compared to bare soil in both seasons. These results herein are in line with those obtained by **Kumar *et al.*, (2015), Manoj *et al.*, (2015)** and **Lalruatsangi and Hazarika (2018)** they found that, total yield as number of fruits or weight (kg) per tree as well as ton/hectare was the best by using black polyethylene or dry grasses mulches compared to bare soil in citrus orchards. In this respect, **El-Henawy *et al.*, (2009)** concluded that using rice straw mulching in orange trees orchard recorded higher values of water use efficiency than that on bare soil.

Table 5. Effect of drip irrigation, soil mulching and spraying with antitranspiration on yield efficiency and water use efficiency of ‘Washington’ navel orange trees during 2019 and 2020 seasons.

Treatments			Yield efficiency (kg/m^3 of tree canopy) 2019	Yield efficiency (kg/m^3 of tree canopy) 2020	water use efficiency (kg/m^3 water/year) 2019	water use efficiency (kg/m^3 water/year) 2020
Irrigation levels						
I_1:100%			2.82^{A}	2.79^{A}	3.33^{C}	3.50^{C}
I_2:75%			2.58^{B}	2.52^{B}	4.14^{B}	4.30^{B}
I_3: 50%			2.32^{C}	2.35^{C}	5.18^{A}	5.72^{A}
Mulching						
M_0: Bare soil			2.54^{b}	2.54^{a}	3.91^{c}	4.25^{c}
M_1: Rice straw			2.52^{b}	2.50^{a}	4.26^{b}	4.48^{b}
M_2: Black polyethylene			2.66^{a}	2.61^{a}	4.48^{a}	4.78^{a}
Antitranspiration						
A_0: Control (water spray)			2.53^{B}	2.48^{B}	3.98^{B}	4.26^{B}
A_1: Kaolin spray at 3%			2.61^{A}	2.62^{A}	4.46^{A}	4.75^{A}
I_1: 100%	Bare soil	Control	2.86 a	2.78 abc	3.13 l	3.32 j
		Kaolin	2.85 a	2.87 a	3.27 kl	3.46 ij
	Rice straw	Control	2.91 a	2.71 bcd	3.28 kl	3.37 ij
		Kaolin	2.64 bcd	2.76 abc	3.40 k	3.62 hi
	Black polyethylene	Control	2.80 ab	2.79 abc	3.34 k	3.52 hij
		Kaolin	2.85 a	2.83 ab	3.58 j	3.75 gh
I_2: 75%	Bare soil	Control	2.55 def	2.44 ghi	3.81 i	3.89 g
		Kaolin	2.59 cde	2.60 def	4.02 gh	4.28 f
	Rice straw	Control	2.44 ef	2.47 fgh	3.95 hi	4.14 f
		Kaolin	2.60 cde	2.51 efg	4.38 f	4.58 e
	Black polyethylene	Control	2.55 def	2.43 ghi	4.16 g	4.24 f
		Kaolin	2.76 abc	2.66 cd	4.54 e	4.66 e
I_3: 50%	Bare soil	Control	2.14 h	2.24 jk	4.33 f	4.93 d
		Kaolin	2.24 gh	2.34 ij	4.94 c	5.66 c
	Rice straw	Control	2.14 h	2.14 k	4.76 d	5.15 d
		Kaolin	2.39 fg	2.39 ghi	5.80 b	6.04 b
	Black polyethylene	Control	240 fg	2.37 hi	5.06 c	5.80 c
		Kaolin	2.61 cde	2.62 de	6.21 a	6.75 a

Means followed by the same letter within a column are not significantly different using DMRT at $P \leq 0.05$

Concerning the effect of foliar application of antitranspiration, data also revealed that, Washington navel orange trees sprayed with kaolin at 3% had significantly higher yield, yield efficiency kg/m^3 of canopy volume and water use efficiency kg/m^3 water than that sprayed with tap water. Similar result was found by **Ali and El Zayat (2019)** and **Abd El-Naby *et al.*, (2020)** they concluded that kaolin foliar application enhances fruit yield and crop efficiency of Valencia and Washington navel orange trees. In this line**, Azizi *et al.*, (2013)** and **El-Khawaga and Mansour (2014)** showed that, kaolin foliar application used for enhancing water use efficiency and reducing the adverse effects of water deficit on pistachio and pomegranate trees. In general, the obtained increase in yield as a result of kaolin foliar spraying maybe due to protect trees from climatic changes especially heat stress, increase water potential in tree, improves water use efficiency by decreasing leaf transpiration rate and reduce water loss, which reflected on overall positive effect on growth and productivity of trees.

With regard to the effect of interaction, the data exhibited that the highest values of fruit yield and yield efficiency kg/m^3 of canopy volume were obtained by irrigation at 100% ET_C + mulching with black polyethylene + kaolin spray at 3%, followed by irrigation at 75% ET_C + mulching with black polyethylene + kaolin spray at 3% and irrigation at 100% ET_C + mulching with rice straw + kaolin spray at 3%, respectively. On the other hand, the lowest values of fruit yield were observed by irrigation at 50% ET_C under bare soil without kaolin spraying in both seasons. On the other hand, water use efficiency kg/m^3 water was greater on deficit irrigation under mulch with block polyethylene or rice straw combined with kaolin spraying at 3% in both seasons. Similar results were obtained by **Ahmed and Aly (2017)** and **Fayed *et al.*, (2018),** they found that combination among irrigation levels and mulching or foliar sprays of antitranspiration enhancing fruit yield on different fruit crops.

Generally, it is obvious from above results that, using black polyethylene and rice straw mulches with spraying kaolin at 3% under high and moderate irrigation levels recorded an increase in yield as kg/tree or ton/feddan and also improved yield efficiency and water use efficiency, this leads to high effectiveness of irrigation and mulching treatments for best utilization and saving water supplies.

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3. Fruit quality:

3.1. Fruit physical characteristics:

The effects of irrigation levels, mulching, antitranspiration and their interaction on physical fruit quality of Washington navel orange trees as fruit weight (g), fruit volume (ml), fruit firmness (kg/cm^2) and fruit juice(ml) are presented in Table 6. The results indicated that fruit weight, fruit volume, fruit firmness and fruit juice were significantly increased with increasing amount of irrigation water. The highest values of fruit weight, fruit volume, fruit firmness and fruit juice were achieved by irrigation at 100% ET_C followed by irrigation at 75% ET_C, as compared with the lowest values exhibited in low volume irrigation at 50% ET_C in both seasons, respectively. Similar results were obtained by **Shirgure *et al.*, (2016)** on Nagpur mandarin. In this respect, **El-Zawily, (2016)** concluded that increasing irrigation levels from 12.03 to 24.06 m^3 water/tree/year was accompanied with improving fruit weight of Washington navel orange trees. Similar results were reported by **Ennab and El-Sayed (2014)** they observed that the effect of irrigation on Balady mandarin fruit quality such weight, diameter and juice volume was improved.

Also, it is clear from data in Table 6 that, soil mulching with black polyethylene and rice straw led to improvement fruit weight, fruit size, fruit firmness and fruit juice of Washington navel orange trees compared to bare soil with significant differences among them in both seasons. The highest physical fruit quality was recorded with black polyethylene, rice straw come the second for their effect on fruit quality, but superior to no mulching. These results agree with the findings of **Shirgure, (2012)** reported that fruit weight and juice content of Acid lime significantly increased using black polyethylene and grass mulches, respectively. Also, **Manoj *et al.*, (2015)** showed that, fruit length, breadth and weight of Kinnow mandarin were maximum in black polyethylene mulch as compare to paddy straw, sugarcane trash and pearl millet straw. In this line, **Lalruatsangi and Hazarika (2018)** found that maximum fruit length, grith, volume, weight, rind thickness and juice volume content in Acid lime with black polyethylene mulch.

In addition, the data also revealed that, spraying kaolin at 3% significantly increased all determined physical fruit characteristics of Washington navel orange trees in both seasons as compared with control treatment (Tap water spray). These results agree with the findings of **Ali and El Zayat (2019)** on Washington navel orange and **Abd El-Naby *et al.*, (2020)** on Valencia orange. They found that spraying kaolin at 3% or 10 g/l increased fruit weight, fruit size, fruit length and diameter and percentage of fruit juice.

With regard to the effect of the interaction the same data in Table (6) show clearly that, fruit weight, fruit volume, fruit firmness and fruit juice were significantly improved as a result of irrigating trees with100% ET_C + mulching with black polyethylene + kaolin spray at 3%, followed by irrigation at 100% ET_C + mulching with rice straw + kaolin spray at 3% and irrigation at 100% + mulching with black polyethylene + Tap water spray, respectively. On the other hand, the lowest values of physical fruit quality were observed by irrigation at 50% ET_C under bare soil without kaolin spraying in both seasons. Similar results were obtained by **Shirgure, (2012)** reported that, fruit weight and juice volume of Acid lime were significantly higher in drip irrigation at 60% with plastic mulch compared to control. Also, **Ahmed and Aly (2017)** obtained significantly higher fruit weight, length, and diameter of olive with drip irrigation at 70% and rice straw mulch as compared to drip irrigation without mulch. Similarly, El-Khawaga and Mansour (2014) found that spraying kaolin at 3% improved fruit weight and juice% of pomegranate under different irrigation regimes, especially at 6 m^3/tree/year.

3.2. Fruit chemical characteristics:

Data in Table 7 reveal that, increasing irrigation levels caused a significant decreasing on percentages of TSS and acidity in both seasons. On the other hand, vitamin C were significantly increased with irrigation at 100% ETc as compared to 75 and 50% ETc which be at par without significant differences between them in both seasons. Whereas, TSS/acid ratio don't any constant trend anyhow moderate irrigation at 75% ETc gave higher values of TSS/acid ratio than the other levels of irrigation and the differences were significant in the second season only. These results are in line with those obtained by **Shirgure et al., (2016)** on Nagpur mandarin and **El-**

Zawily, (2016) on Washington navel orange, they found that, moderate irrigation produced the highest TSS, TSS/acid ratio and vitamin C. In this respect, **Ennab and El Sayed (2014)** concluded that there was an increase in TSS and acidity as the amount of water applied decreased.

It is obvious from data in Table 7 that, TSS, acidity, TSS/acid ratio and ascorbic acid were significantly influenced by various mulches. In this respect, fruit harvested from trees mulched with polyethylene recorded maximum TSS, TSS/acid ratio, vitamin C and lower acidity. Also, mulching with rice straw come the first in their effect on acidity and the second for all remaining characters of fruit quality. These results agree with the findings of **Shirgure, (2012)** and **Manoj *et al.*, (2015).**

As for the effect of spraying antitranspiration, it is clear from Table 7 that spraying kaolin at 3% caused significant increase in TSS, TSS/acid ratio and vitamin C compared to control treatment in both seasons. In contrast, spraying kaolin at 3% led to significantly decreased fruit acidity as compared with control in both seasons. The present results are confirmed by **Ali and El Zayat (2019).**

Concerning the interaction effect on chemical fruit quality, it is clear that, the maximum TSS was observed with irrigation at 50% ET_C + mulching with black polyethylene + kaolin spray at 3%, and minimum was recorded in irrigation at 100% ET_C + bare soil + Tap water spray. Minimum acidity was observed with irrigation at 100% ET_C + mulching with black polyethylene + kaolin spray at 3% and maximum was in irrigation at 50 or 75% ET_C + bare soil + Tap water spray. The maximum of vitamin C was recorded in irrigation at 100% ET_C + mulching with black polyethylene + without or with kaolin spray at 3% and minimum was recorded in irrigation at 75% ET_C + bare soil + Tap water spray. The maximum TSS/acid ratio was recorded irrigation at 100% ET_C + mulching with black polyethylene + kaolin spray at 3% in the first season but in the second season it was irrigation at 75% ET_C + mulching with black polyethylene + kaolin spray at 3% and minimum was recorded in irrigation at 100% ET_C + bare soil + Tap water spray. The results are in agreement with those of **Shirgure, (2012), Ahmed and Aly (2017)** and **El-Khawaga and Mansour (2014).**

Generally, it is obvious from Table 7 that, irrigation with moderate level at 75% ETc and using polyethylene mulch combined with spraying kaolin at 3% they able to improve and increase fruit quality in terms of fruit weight, volume, juice volume, firmness, TSS, acidity, TSS/acid ratio and vitamin C of Washington navel orange trees compared to other treatments.

Table 6. Effect of drip irrigation, soil mulching and spraying with antitranspiration on fruit physical quality of 'Washington' navel orange trees during 2019 and 2020 seasons.

Treatments			Fruit weight (g)		Fruit volume (ml)		Fruit firmness (kg/cm^2)		Fruit juice (ml)	
			2019	2020	2019	2020	2019	2020	2019	2020
Irrigation levels										
I_1:100%			257.6^A	258.7^A	266.5^A	268.8^A	13.23^A	13.05^A	111.2^A	99.6^A
I_2:75%			233.1^B	234.0^B	241.1^B	243.1^B	11.80^B	11.56^B	099.1^B	89.1^B
I_3: 50%			218.3^C	219.4^C	224.0^C	227.5^C	10.82^C	10.62^C	091.1^C	81.9^C
Mulching										
M_0: Bare soil			221.8^c	222.9^c	229.5^c	231.4^c	11.24^c	11.02^c	094.5^c	85.0^c
M_1: Rice straw			233.5^b	234.4^b	241.5^b	243.5^b	11.82^b	11.62^b	099.3^b	89.3^b
M_2: Black polyethylene			253.6^a	254.7^a	260.6^a	264.5^a	12.79^a	12.59^a	107.5^a	96.3^a
Antitranspiration										
A_0: Control (water spray)			229.3^B	230.4^B	236.7^B	239.2^B	11.61^B	11.41^B	97.5^B	87.7^B
A_1: Kaolin spray at 3%			243.3^A	244.3^A	251.1^A	253.7^A	12.29^A	12.08^A	103.3^A	91.7^A
I_1: 100%	Bare soil	Control	240.3 g	241.3 g	248.7 f	250.8 g	12.39 ef	12.14 e	104.1 ef	93.6 ef
		Kaolin	248.8 de	249.9 de	257.5de	259.7de	12.81 d	12.55 d	107.6 d	96.7 cd
	Rice straw	Control	244.5 efg	245.5 efg	253.0 ef	255.2 f	12.60de	12.60 d	105.9de	95.2 de
		Kaolin	272.8 b	273.9 b	282.2 b	284.6 b	13.97 b	13.69 b	117.4 b	105.5 a
	Black polyethylene	Control	259.7 c	260.8 c	268.8 c	271.1 c	13.34 c	13.07 c	112.1 c	100.8 b
		Kaolin	279.6 a	280.8 a	289.3 a	291.8 a	14.30 a	14.30 a	120.2 a	106.1 a
I_2: 75%	Bare soil	Control	205.3 j	206.1 j	212.4 i	214.2 j	10.45 i	10.24 h	87.8 j	78.9 j
		Kaolin	215.2 i	216.0 i	222.6 h	224.4 i	10.93 h	10.71 fg	91.8 hi	82.6 hi
	Rice straw	Control	222.4 h	223.3 h	230.1 g	232.0 h	11.28 g	11.05 f	94.8 g	85.2 g
		Kaolin	243.2 fg	244.2 fg	251.5 f	253.6fg	12.29 f	12.04 e	103.2 f	92.9 ef
	Black polyethylene	Control	252.7 d	253.7 d	261.3 d	263.5 d	12.75 d	12.49 d	107.2 d	96.3 d
		Kaolin	259.9 c	261.0 c	268.8 c	271.1 c	13.10 c	12.84 cd	110.1 c	99.0 bc
I_3: 50%	Bare soil	Control	198.9 k	200.7 k	205.6 j	207.3 k	9.10 j	9.70 i	83.2 k	74.8 k
		Kaolin	222.7 h	223.6 h	230.2 g	232.1 h	11.01gh	10.83 fg	92.9 gh	83.5 ghi
	Rice straw	Control	216.6 i	217.7 i	224.1 h	225.9 i	10.77 h	10.55 gh	90.5 i	81.3 i
		Kaolin	201.5 jk	202.3 jk	208.3 ij	210.0 k	10.02 j	9.82 i	84.2 k	75.7 k
	Black polyethylene	Control	223.8 h	224.7 h	226.3gh	233.2 h	11.05gh	10.88 fg	93.3 gh	83.9 gh
		Kaolin	246.4 ef	247.4 ef	249.6 f	256.7 ef	12.20 f	11.96 e	105.5 f	92.2 f

Means followed by the same letter within a column are not significantly different using DMRT at $P \leq 0.05$

Table 7. Effect of drip irrigation, soil mulching and spraying with antitranspiration on fruit chemical quality of 'Washington' navel orange trees during 2019 and 2020 seasons.

Treatments			TSS %		Acidity %		TSS/acid ratio		Vitamin C mg/100 ml/juice	
			2019	2020	2019	2020	2019	2020	2019	2020
Irrigation levels										
I_1:100%			11.52^{B}	11.78^{C}	1.05^{B}	1.10^{B}	10.92^{A}	10.69^{C}	56.96^{A}	63.53^{A}
I_2:75%			11.79^{B}	12.78^{B}	1.08^{A}	1.11^{B}	10.88^{A}	11.50^{A}	51.01^{B}	56.85^{B}
I_3: 50%			12.10^{A}	13.05^{A}	1.11^{A}	1.17^{A}	10.92^{A}	11.11^{B}	51.09^{B}	56.88^{B}
Mulching										
M_0: Bare soil			11.62^{b}	12.32^{c}	1.10^{a}	1.14^{a}	10.57^{b}	10.75^{c}	45.98^{c}	51.21^{c}
M_1: Rice straw			11.75^{b}	12.54^{b}	1.10^{a}	1.13^{a}	10.60^{b}	11.08^{b}	51.77^{b}	57.73^{b}
M_2: Black polyethylene			12.04^{a}	12.75^{a}	1.04^{b}	1.11^{b}	11.55^{a}	11.47^{a}	61.31^{a}	68.32^{a}
Antitranspiration										
A_0: Control (water spray)			11.72^{B}	12.45^{B}	1.10^{A}	1.13^{A}	10.65^{B}	10.95^{B}	50.19^{B}	55.95^{B}
A_1: Kaolin spray at 3%			11.88^{A}	12.63^{A}	1.06^{B}	1.12^{B}	11.16^{A}	11.25^{A}	55.85^{A}	62.22^{A}
I_1: 100%	Bare soil	Control	1132 j	11.53 j	1.11 de	1.13 cd	10.19 g	10.29 i	47.03 k	52.41 k
		Kaolin	11.35 ij	11.71 i	1.02 j	1.09 ef	11.12 cde	10.74fgh	47.94 j	53.43 j
	Rice straw	Control	11.40 hi	11.86 h	1.10 ef	1.12 d	10.36 g	10.58 gh	50.41 h	56.51 h
		Kaolin	11.43 h	11.73 i	1.08 gh	1.12 d	10.58 fg	10.47 hi	59.92 d	66.78 d
	Black polyethylene	Control	11.50 g	11.76 i	1.02 j	1.08 fg	11.27 bcd	10.88 f	66.40 b	73.99 b
		Kaolin	12.12 b	12.09 g	1.01 j	1.08 fg	12.00 a	11.19 e	70.08 a	78.09 a
I_2: 75%	Bare soil	Control	11.63 f	12.66 e	1.14 ab	1.20 a	10.20 g	10.54ghi	41.50 m	46.24m
		Kaolin	11.60 f	12.70 de	1.07 h	1.09 ef	10.83 ef	11.64 bc	48.85 i	54.45 i
	Rice straw	Control	11.81 e	12.73 de	1.13 bc	1.14 c	10.45 fg	11.16 e	47.03 k	52.41 k
		Kaolin	11.80 e	12.74 de	1.09 fg	1.10 e	10.82 ef	11.58bcd	55.33 e	61.66 e
	Black polyethylene	Control	11.92 d	12.77 d	1.04 i	1.08 fg	11.46 bc	11.83 b	53.48 f	59.59 f
		Kaolin	12.00 c	13.12 b	1.04 i	1.07 g	11.53 b	12.26 a	59.92 d	66.78 d
I_3: 50%	Bare soil	Control	11.83 e	12.48 f	1.50 a	1.19 ab	10.28 g	10.47 hi	45.18 l	50.35 l
		Kaolin	12.00 c	12.87 c	1.11 de	1.19 ab	10.80 ef	10.81 fg	45.38 l	50.40 l
	Rice straw	Control	11.98 c	12.89 c	1.13 bc	1.12 d	10.59 fg	11.50 cd	45.41 l	50.45 l
		Kaolin	12.10 b	13.33 a	1.12 cd	1.19 ab	10.80 ef	11.20 e	52.56 g	58.58 g
	Black polyethylene	Control	12.15 b	13.38 a	1.10 ef	1.18 b	11.04 de	11.33 de	55.33 e	61.66 e
		Kaolin	12.59 a	13.40 a	1.05 i	1.18 b	11.99 a	11.35 de	62.69 c	69.86 c

Means followed by the same letter within a column are not significantly different using DMRT at $P \leq 0.05$

Conclusion

'Washington' navel orange trees grown in clay soil under drip irrigation system showed better yield and fruit quality under moderate irrigation at 75% ET_C and mulched with black polyethylene or rice straw combined with kaolin foliar spraying at 3%. Furthermore, this combination treatment improved yield efficiency, water use efficiency and saving about 25% with no negative effect on tree yield and fruit quality.

References

A.O.A.C. (1990). Association of official analytical chemists. Official Methods of Analysis. 15th Ed. Washington D.C., USA.

Abd El-Naby, S.K.; A. Abd El-Khalek; M.H. Baiea and O.A. Amin (2020). Impact of spraying some chemical substances on protecting Valencia orange trees from heat stress injuries. Plant Archives 20(2):2265 – 2270.

Abd El-Raouf, R.E.; M.A. El-Shawadfy; F.A. Hashem and B.M.M. Bakr (2020). Effect of deficit irrigation strategy and organic mulching on yield, water productivity and fruit quality of navel orange under arid regions conditions. Plant Archives 20(1): 3505 – 3518.

Ahmed, M.S.M. and A.A. Aly (2017). Effect of deficit irrigation regimes and rice straw mulching on growth and yield of olive trees (*Olea europaea* L.) in sandy soil. J. Plant Production, Mansoura Univ., 8(2):283 – 296.

Ali, M.S.M. and H.E. El Zayat (2019). Effect of some biological stimulants and kaolin particles sprays on fruit retention, productivity and fruit quality of Washington navel orange trees HortScience Journal of Suez Canal University, 8 (1): 69 – 78.

Allen, R.G.; L.S. Pereira; D. Raes and M. Smith (1998). Crop evapotranspiration. guidelines for computing crop water requirements. FAO Irrigation and Drainage, paper 56. Rome, Italy.

Azizi, A.; H. Hokmabadi; S. Piri and V. Rabie (2013). Effect of kaolin application on water stress in pistachio cv. Ohadi. Journal of Nuts 4(4): 9 – 14.

Bhardwaj, R.L. (2013). Effect of mulching on crop production under rainfed condition - a review. Agriculture. Reviews, 34 (3):188 – 197.

Braham, M.; E. Pasqualini and N. Ncira (2007). Efficacy of kaolin, spinosad and malathion against *Ceratitis capitata* in Citrus orchards. Bulletin of Insectology 60 (1):39 – 47.

Duncan, D.B. (1955). Multiple ranges and multiple F. test. Biometries.11 (1): 1- 42.

El-Henawy, A.S.; M.R. Khalifa; S.A. Mashali; S.M. Youssef and A. Rabie (2009). Effect of drip irrigation and soil mulching on growth, yield and yield quality of navel orange at north delta. The scientific conference on water, Faculty of Agriculture, Al-Gabal University, Libya, 16 – 17 December, 2009, Pp:1 – 14.

El-Khawaga, A.S. and Mansour, A.E. (2014). Enhancing the efficiency of irrigation water use by using some antitranspirants in wonderful pomegranate orchards. Middle East J. Agric. Res., 3(3):694 – 700.

El-Taweel, A.A. and A.A. Farag (2015). Mulching implication on productivity and fruit quality of pomegranate grown in a sandy soil. Egypt. J. Hort., 42(1):367 – 391.

El-Zawily, H.M.A. (2016). Evaluation the effect of different kinds of fertilizers on soil properties, vegetative growth, yield and fruit quality of Washington navel orange trees under different irrigation levels in sandy soil. Ph.D. Thesis, Horticulture department, Faculty of Agriculture, Kafr El-Sheikh University, Egypt.

Ennab, H.A. and S.A. El-Sayed (2014). Response of Balady mandarin trees to deficit irrigation. J. Agric. Res. Kafr El Sheikh Univ., 40(3): 616-629.

Ennab, H.A. and S.M. Alam-Eldein (2020). Foliar application of biostimulants to improve growth, yield and fruit quality of Valencia orange trees under deficit irrigation conditions. Journal of the American Pomological Society 74(3):118 – 134.

Ennab, H.A.; S.A. El-Sayed and M.M. Abo El-Enin (2017). Effect of kaolin applications on fruit sunburn, yield and fruit quality of Balady mandarin (*Citrus reticulata*, Blanco). Menoufia J. Plant Prod., 2:129 – 138.

Faghih, S.; Z. Zamani; R. Fatahi and A. Liaghat (2019). Effects of deficit irrigation and kaolin application on vegetative growth and fruit traits of two early ripening apple cultivars. Biological Research 52(43):1 – 12. https://doi.org/10.1186/s40659-019-0252-5

Fayed, T.A.; M.A. Abd El-Mohsen; M.M. Ali and M.S. Abd El-Karim (2018). Enhancing water use efficiency of "Le Conte" pear trees under deficit irrigation conditions. Bioscience Research 15(4):4452 – 4464.

Garcia-Tejero, I.F.; V.H. Duran-Zuazo and A.E. Rubio-Casa (2019). Deficit-irrigation strategies to enhance the water productivity in orange trees in semi-arid environments. Journal of Agriculture Food and Development, 5:43 – 51.

Kumar, V.; A.K. Bhat; V. Sharma; N. Gupta; P. Sohan and V.B. Singh (2015). Effect of different mulches on soil moisture, growth and yield of Eureka lemon (*Citrus limon* Burm) under rainfed condition. Indian J. Dryland Agric. Res. & Dev., 30(1):83 – 88.

Lalruatsangi, E. and B.N. Hazarika (2018). Effect of various mulching materials on crop production and soil health in acid lime (*Citrus aurantifolia* Swingle). International Journal of Agriculture, Environment and Biotechnology 11(2):311 – 317.

Manoj, B.; S.S. Sindhu and P. Prince (2015). Effect of various mulches on growth, yield and quality of Kinnow. The Bioscan, 10(3):1379 – 1382.

Shirgure, P.S. (2012). Sustainable Acid lime fruit production and soil moisture conservation with different mulches. Agricultural Engineering Today 36(3):21 – 26.

Shirgure, P.S.; A.K. Srivastava and A.D. Huchche (2016). Effect of drip irrigation scheduling on yield and quality of Nagpur mandarin (*Citrus reticulata* Blanco) fruits. Indian J. Hort. 73(1): 30 – 35.

تأثير مستويات الرى و تغطية التربة ورش الكاولين على المحصول و جودة الثمار فى أشجار البرتقال أبو سرة النامية بتربة طينية.

حسن أبو الفتوح عناب و عبد الفتاح منتصر خضر و جهاد بشرى ميخائيل

معهد بحوث البساتين – مركز البحوث الزراعية – الجيزة – مصر.

أجريت تجربة حقلية خلال موسمي 2019 و 2020 بمركز الرياض بمحافظة كفر الشيخ لدراسة تأثير مستويات الري والتغطية ومضادات النتح على المحصول و جودة الثمار فى أشجار البرتقال أبو سرة. ثمانية عشر معاملة مكونة من ثلاث مستويات ري 100 و 75 و 50 ٪ من البخر نتح، ومعاملتين لتغطية التربة هي التغطية بالبلاستك الاسود وقش الأرز والتربة المكشوفة (كونترول) والرش بتركيزين من الكاولين صفر و 3 ٪ تم ترتيبها في تصميم قطاعات كاملة العشوائية بثلاث مكررات.

أشارت النتائج: إلى أن مستويات الري 100 و 75٪ من البخر نتح أدت إلى زيادة نسبة الثمار العاقدة و المحصول كجم/شجرة أو طن/فدان وجودة الثمار و كفاءة المحصول كجم / م 3 من حجم الشجرة وكفاءة إستخدام المياه كجم / م 3 ماء و وتقليل نسبة سقوط الثمار. بالإضافة إلى ذلك ، أدت تغطية التربة بالبلاستك الأسود أو قش الأرز إلى زيادة معنوية في جميع الصفات المدروسة مقارنة بالتربة بدون تغطية. كان الرش الورقي للكاولين بنسبة 3٪ أكثر فعالية في معظم الحالات مقارنة بالرش بماء الصنبور.

وبشكل عام ، أظهرت معاملة الجمع بين الري بنسبة 75 ٪ من البخر نتح و تغطية التربة بالبلاستك الأسود أو قش الأرز جنبًا إلى جنب مع رش الكاولين بنسبة 3 ٪ أفضل النتائج من حيث عقد الثمار ، وقلة تساقط الثمار ، والمحصول وكذلك تحسين الصفات الطبيعية والكيميائية للثمار. علاوة على ذلك ، وفرت هذه المعاملة حوالي 25٪ من إجمالي المياه المستخدمة دون أي تاثير ضار على المحصول و جودة الثمار.