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EFFECT OF PULSE DRIP IRRIGATION AND ORGANIC MULCHING BY RICE STRAW ON YIELD, WATER PRODUCTIVITY AND QUALITY OF ORANGE UNDER SANDY SOILS CONDITIONS

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Abstract

There are many benefits for applying pulse irrigation and using rice straw as organic mulching for saving irrigation water under drought conditions. This study investigated the effect of pulse drip irrigation and rice straw organic mulching on yield, water productivity and quality of orange crop under sandy soils conditions during 2016 and 2017 seasons in the research farm station of National Research Centre at Al-Nubariya Region, Al-Buhayrah Governorate, Egypt. The greatest values of productivity, water productivity and some quality characteristics of the orange crop occurred when the daily irrigation water was added eight times daily with the organic mulch of the rice straw at 9 tons per ha^{-1} where, yield of orange were 33.15 ton. ha^{-1} and 32.27 ton.ha^{-1} for 2016 and 2017 respectively compared with the lowest values were 10 ton. ha^{-1} and 9.8 ton. ha^{-1} for 2016 and 2017 respectively when the irrigation water was added one time per day and without organic mulching. The effect of adding water on eight times a day rather than adding it once, increased the size of the wet soil within the root zone, thus increasing the application efficiency of the irrigation water and decreasing the water stress on the roots of the orange trees and also the positive effect of increasing the rates of organic cover with rice straw at a rate 9 tons per hectare, could be due to a low evaporation rate and salts accumulation in the root zone compared with non-mulching. The positive effect of the study factors led to increasing the crop yield, water productivity and some quality characteristics of the orange crop during 2016 and 2017 when applying the daily water needs at a rate of eight times instead of one time, in addition to the organic mulching by rice straw at the rate of 9 tons per ha^{-1}.

***Key word*: Pulse irrigation, Irrigation scheduling, citrus crops, rotational irrigation system, sandy soils

Introduction

In arid countries with large population growth and reduction of fresh water, there is considerable pressure on the agricultural sector to reduce water consumption and access to fresh water for industrial and urban sectors (Abdelraouf and Abuarab 2012). The agricultural sector faces a serious challenge of producing more food with as little water as possible, which can be achieved by increasing crop water productivity (Abdelraouf *et al.,* 2013c). Increasing crop production is an important national objective to meet the high demand for large population growth (Bakry *et al.,* 2012). In Egypt, water productivity is of great interest where irrigation water resources are limited and precipitation is a limiting factor (Hozayn *et al.,* 2013). Water scarcity is one of the serious and major problems facing crop production in Egypt, which is necessary to reduce irrigation water consumption through the development of new technologies that can fully help to make use of these valuable inputs and use them effectively (Abdelraouf *et al.,* 2013b). The application of modern irrigation methods is an important concept to be followed in arid zones such as Egypt to provide part

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of irrigation water due to the limited water resources (El-Habbasha *et al.,* 2014). Several methods and methods of conserving agricultural water have been explored (Okasha *et al.,* 2013).

Pulsed drip irrigation technology is applied worldwide because it has positive effects on yield increase, improved quality, water saving, minimization of blockage triggers, etc. Pulsing irrigation refers to short-term irrigation and then a short period of time, repeating this cycle until the entire irrigation water is applied (Eric *et al.,* 2004). If drip irrigation is drained after each irrigation, cut it to the longest possible pulses to reduce drainage losses. Re-design the irrigation system if the wet area is too small (limited) and the pulse is not an option (Helen, 2007). Based on reports from other countries (where soils differ), it is often thought that the size of wetlands can be increased if irrigation is beating (Eric *et al.,* 2004). The pulsing irrigation system and the amount of irrigation and timing are the objectives of reducing runoff and reduce the filtration of water below the root area and reduce the evaporation of water after irrigation (El-Gindy and Abdel Aziz 2001). The application of irrigation water in stages or pulses instead of all at the same time can provide water by giving the media time to moisten from the first pulse of water, allowing it to absorb subsequent irrigation more easily and reduce the total amount of water required (Scott, 2000). The frequency of high irrigation may provide desirable conditions for soil water movement and root absorption (Segal *et al.,* 2000).

The mulch is a protective layer of organic or inorganic substances that spread in the upper soil in order to: 1) reduce the moisture loss of the soil by preventing evaporation from sunlight and wind drying, 2) prevent weed growth, 3) Provide home to earthworms and natural enemies found in soil, 5) reduce soil compressibility of heavy rain effect. Mulch helps regulate the temperature of the soil by shading it in summer, making it cooler and helps to isolate it in the winter from cold winds. This systematic effect of temperature helps to promote plant root growth, preventing soil erosion (USDA, *et al.,*). Tropics in the tropics promote plant and animal health. Improves bleaching of nutrients and water retention in the soil, promotes microbial activity of soil and worms, and stops weed growth. The benefit objectives of mulching in the agriculture are moisture conservation, prevention of the surface compaction, temperature control; erosion and reduction of runoff, improvement in the soil structure in addition, weed control. Soil improvement means improving soil structure, increasing water retention capacity, maintaining moisture, and improving soil drainage. It also restricts evaporation of moisture from the field. Soil moisture prevents direct solar radiation and airflow through the soil surface, resulting in reduced soil moisture loss. Evaporation of moisture from soil surface is very efficient use of crop water. Evaporation from the soil surface accounted for 25 to 50 percent of total evaporation in crop land (Liu *et al.,* 2002; Hu *et al.,* 1995). Many researchers report that mulch with agricultural waste has increased water retention and prevented soil evaporation (Kar and Singh 2004). The mulch layer reflects the maximum amount of sunlight or other sunlight in the soil. Maintains optimum soil temperature. The evaporation rate has been restricted from the soil surface by avoiding direct access to solar radiation. Therefore, the application is useful in hot and dry climates. The mulch layer also restricts grass growth because if the soil is covered with a cover, light is not accessible on the soil surface. It also protects the soil surface from erosion of wind speed and runoff. Organic mulch has also been improved soil properties. It improves soil physical, chemical and biological properties. These mulch degrade slowly, and they increase the organic content in the soil which helps to keep the soil loose. These organic contents become food for beneficial earthworms and other microorganisms available in the soil. Organic stains also improve organic carbon in the soil. The more organic carbon, the more fragile the soil. It facilitates root penetration, root development and extraction of nutrients from a deeper layer of soil. It improves the growth of root crops, increases water leakage, and the ability to retain water in the soil. Organic plants attract most of the small soil beneficial to plants, which in turn removes waste and auxiliary substances in plant nutrient degradation (Ranjan *et al.,* 2017).

Citrus fruit is one of the highest fruit crops in terms of international trade. Citrus fruits are produced all over the world, where 70% of the total citrus production is grown in the Northern Hemisphere. Citrus is one of the most important fruit crops in Egypt. The cultivated area is about 204095 hectares, representing about 29% of the total area of fruit (700854 ha) according to the Ministry of Agriculture (2016). The total seasonal quantity of irrigation water needed by the entire orchard depends on the optimal yield on a daily flow of evaporation, rain distribution and citrus diversity. In a Mediterranean climate, precipitation is concentrated in the winter months with little rain in the summer (Yoseph, 1998).

The aim of this study was investigating the effect of pulse drip irrigation and organic mulch by rice straw on yield, water productivity and quality of orange under sandy soils conditions.

Materials and Methods

Location and climate of experimental site: The field experiments were conducted during 2016 and 2017 seasons at the research farm station of National Research Centre (NRC) (latitude 30°30' 1.4" N, longitude 30°19' 10.9" E, and 21 m + MSL (mean sea level) at Al-Nubariya Region, Al-Buhayrah Governorate, Egypt. The experimental area has an arid climate with cool winters and hot dry summer. The data of average temperature, relative humidity and wind speed were obtained from the local weather station at El-Nubaryia farm, as shown in Fig. 1.

Physical and chemical properties of soil and irrigation water: Irrigation water source was an irrigation channel passing through the experimental area, with an average pH of 7.35 and 0.41 dS m^{-1} as electrical conductivity (EC). The main physical and chemical properties of the soil are shown in Table 1.

Irrigation system components: Irrigation system components consisted of control head, pumping and filtration unit. It consists of submersible pump with 45m^3/h discharge and it was driven by electrical engine and screen filter and back flow prevention device, pressure regulator, pressure gauges, flow-meter, control valves. Main line was of PVC pipes with 110 mm in diameter (OD) to convey the water from the source to the main control points in the field. Sub-main lines were of PVC pipes with 75 mm diameter (OD) was connected to the main line. Manifold lines: PE pipes was of 63 mm in diameter (OD) were connected to the sub main line through control valve 2" and discharge gauge. Emitters, built in laterals tubes of PE with 16 mm diameter (OD) and 40 m in long (emitter discharge was 4 lph at 1.0 bar operating pressure).

Experimental design: Experimental design and treatments was split plot with three replications. pulse drip irrigation (adding of daily water requirements on 4 times and on 8 times compared with adding of daily water requirements on 1 time) in main plots and organic mulching by rice straw [0 (without covering "WC"), 1 layer of rice straw "1LRS" = 5 tons ha^{-1}, 2 layers of rice straw "2LRS" = 7 tons ha^{-1}, 3 layers of rice straw "3LRS" = 9 tons ha^{-1})] were used in sub main plots as shown in Fig. 2.

Estimation the seasonal irrigation water for orange: Seasonal irrigation water was estimated according to the meteorological data of the Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center, Dokki, Egypt depending on Penman-Monteith equation. Seasonal irrigation water requirement for orange crop were 7200 m^3 ha^{-1} for 2016 and 7500 m^3 ha^{-1} for 2017. Daily irrigation water was calculated by following equation (1) for two seasons 2016 and 2017 under drip irrigation system:

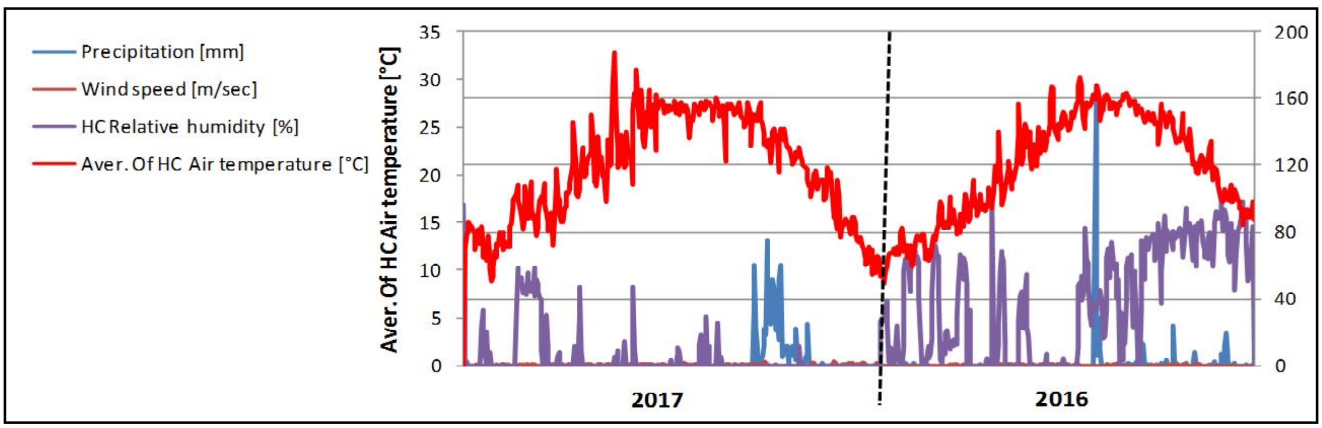


Fig. 1: The data of average temperature, relative humidity and wind speed were obtained from the local weather station at El-Nubaryia farm

Table 1: Physical and chemical properties of the soil of the experimental area

Physical properties				
Soil layer depth (cm)	0–25	25-50	50-75	75-100
Texture	Sandy	Sandy	Sandy	Sandy
Course sand (%)	48.66	55.71	37.76	37.57
Fine sand (%)	48.83	40.58	58.43	57.32
Silt+ clay (%)	2.51	3.71	3.81	5.11
Bulk density (t m^{-3})	1.69	1.68	1.67	1.69
Chemical properties				
$EC_{1:5}$ (dS m^{-1})	0.45	0.53	1.00	1.56
pH (1:2.5)	8.60	8.70	9.32	9.03
Total $CaCO_3$ (%)	7.00	2.34	4.66	5.02

$$IRg = [(ET_O \times Kc \times Kr)/Ei]-R + LR \quad \text{............ (1)}$$

Where:

IRg = Gross irrigation requirements, mm/day, ET_O= Reference evapotranspiration, mm/day, Kc = Crop factor

(FAO-56), Kr = Ground cover reduction factor and the values of Kr measured by Keller equation (2):

$$Kr = GC\% + 0.15\ (1 - GC\%) \quad (2)$$

Where GC%: ground cover = (shaded area per plant/ area per plant)

Ei = Irrigation efficiency, %, R = Water received by plant from sources other than irrigation, mm (for example rainfall), LR = Amount of water required for the leaching of salts, mm

Evaluation parameters:

Water stress inside root zone: Measuring soil moisture content in effective root zone before and after irrigation and taking field capacity and wilting point as evaluation lines is considered as an evaluation parameter for exposure range of the plants to water stress "WS" (Abdelraouf, 2014). Soil moisture content was measured by profile probe device.

Application efficiency of irrigation water "AE_{IW}" at maximum actual water requirements **:** Soil moisture content "SMC" was determined were taken at maximum actual water requirements by profile probe before and 2 hours after irrigation and from different locations inside effective root zone (75 cm depth) on the X-Y directions, SMC were collected from different depths from soil surface. According to El-Meseery, (2003) application efficiency "AE_{IW}" was calculated using the following relation (3):

$$AE_{IW} = Ds\ /\ Da \quad (3)$$

Where: AE_{IW} = Application efficiency of irrigation water, (%), Ds = Depth of stored water in root zone (cm) calculated by equation (4) where:

$$Ds = (\theta 1 - \theta 2) * d * \rho \quad (4)$$

Da = Depth of applied water (cm), d = Soil layer depth (cm), θ1 = Soil moisture content after irrigation (%), θ2 = Soil moisture content before irrigation (%), ρ = Relative bulk density of soil (dimensionless).

Salt accumulation in side root zone: measuring the total salts in the root zone at maximum actual water requirements in growing season.

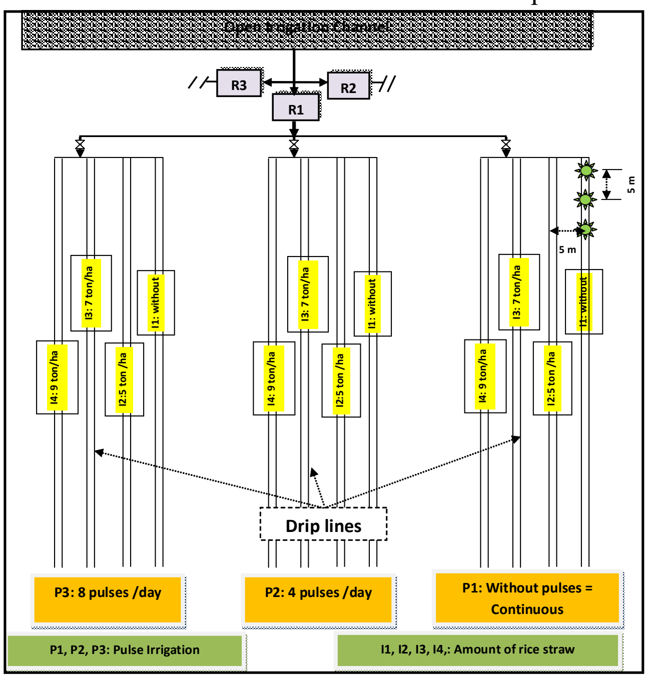
Yield of orange: At harvest time of each four citrus species, yield as number of fruits and Kg per tree and ton per hectare were calculated.

Water productivity of Sour orange: "$WP_{Sour\ orange}$" was calculated according to James (1988) by equation (5) as follows:

$$WP_{Sour\ orange} = Ey/Ir \quad (5)$$

Where: $WP_{Sour\ orange}$ is water productivity of citrus (kg $_{Sour\ orange}$/ m^3 $_{irrigation\ water}$), Ey is the economical yield (kg $_{Sour\ orange}$/fed./season); Ir is the applied amount of irrigation water (m^3 $_{irrigation\ water}$ /fed./season).

Quality traits of orange juice: Juice volume, total sugars % and TSS were investigated for fruit properties of Sour orange. Chemical properties of mature fruits were determined according to the A.O.A.C. (1985) as follows: (1) Juice volume, (2) total sugars % and (3) Total soluble solids percentage (TSS %) fruit juice was determined using a Carl Zeiss hand refractometer.



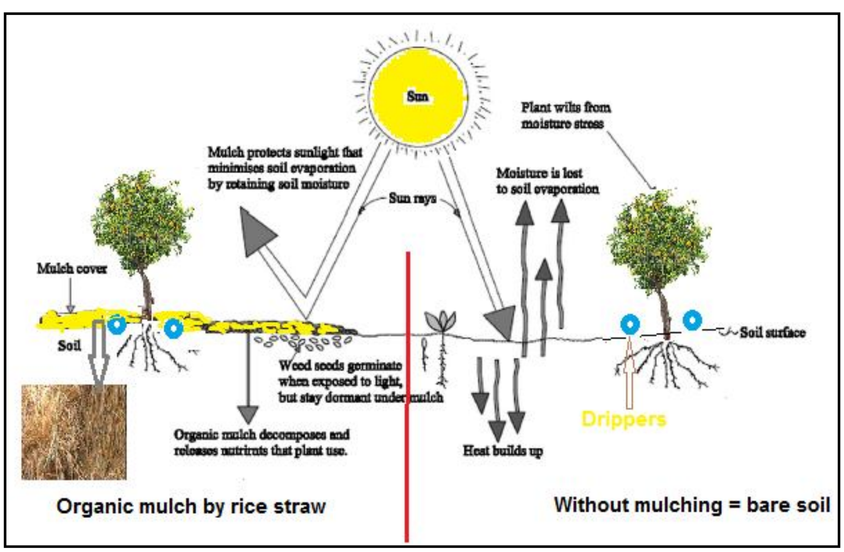


Fig. 2: Layout of the experimental design.

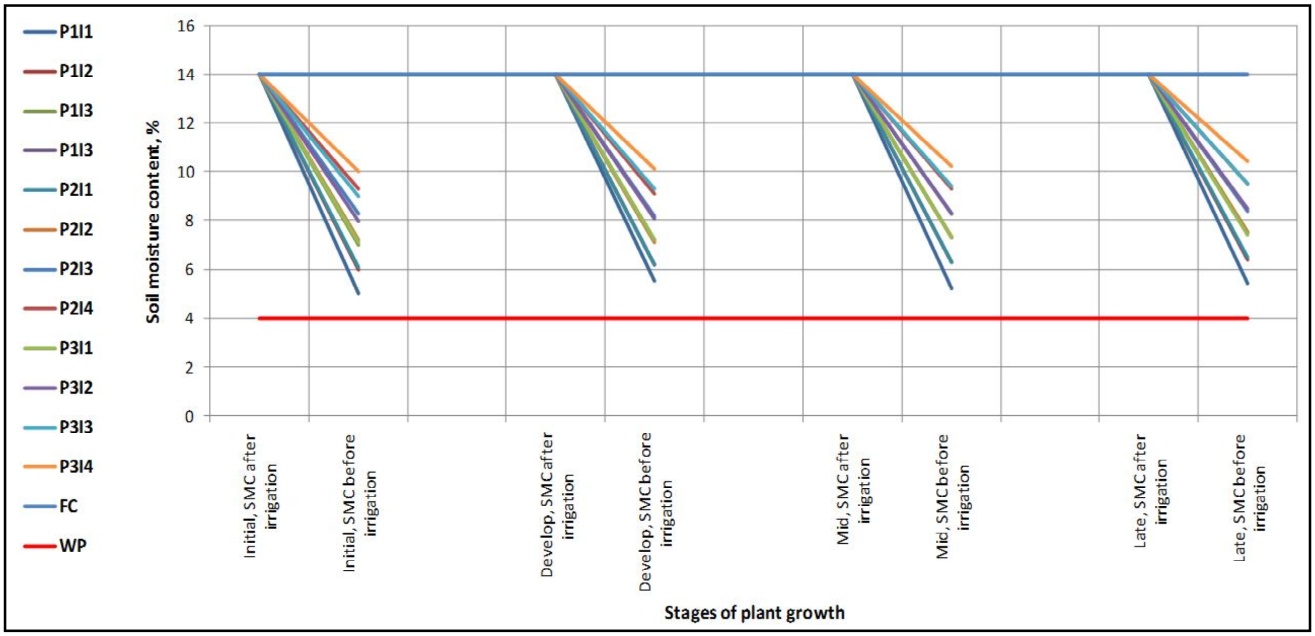


Fig. 3: Effect of pulse drip irrigation (P1: without pulses, P2: adding irrigation water on 4 times per day, P3: adding irrigation water on 8 times per day) and organic mulch by rice straw (I1: without mulch, I2: 5 ton. ha^{-1}, I3: 7 ton. ha^{-1} and I4: 9 ton. ha^{-1}) on the water stress for orange trees during all growth stages 2016.

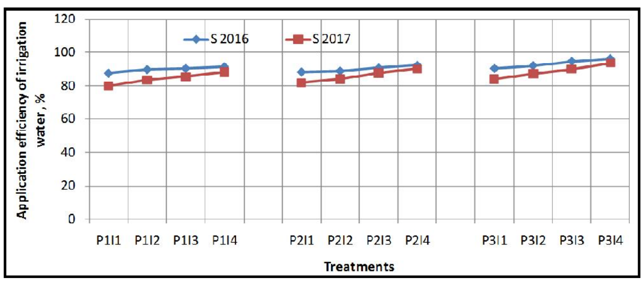


Fig. 4: Effect of pulse drip irrigation (P1: without pulses, P2: adding irrigation water on 4 times per day, P3: adding irrigation water on 8 times per day) and organic mulch by rice straw (I1: without mulch, I2: 5 ton. ha^{-1}, I3: 7 ton. ha^{-1} and I4: 9 ton. ha^{-1}) on application efficiency of irrigation water for seasons 2016 and 2017

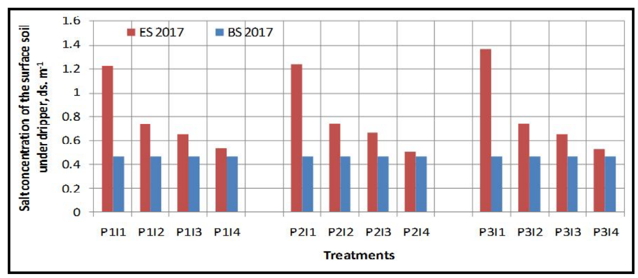


Fig. 6: Effect of pulse drip irrigation (P1: without pulses, P2: adding irrigation water on 4 times per day, P3: adding irrigation water on 8 times per day) and organic mulch by rice straw (I1: without mulch, I2: 5 ton. ha^{-1}, I3: 7 ton. ha^{-1} and I4: 9 ton. ha^{-1}) on salt concentration of the surface soil under dripper for season 2017.

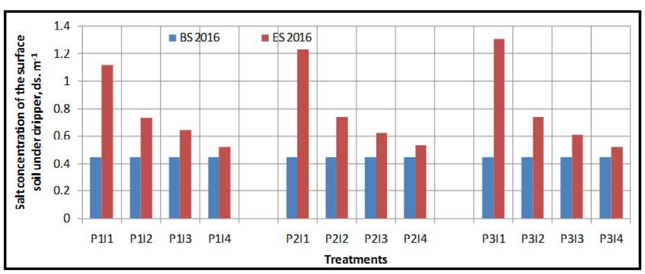


Fig. 5: Effect of pulse drip irrigation (P1: without pulses, P2: adding irrigation water on 4 times per day, P3: adding irrigation water on 8 times per day) and organic mulch by rice straw (I1: without mulch, I2: 5 ton. ha^{-1}, I3: 7 ton. ha^{-1} and I4: 9 ton. ha^{-1}) on salt concentration of the surface soil under dripper for season 2016.

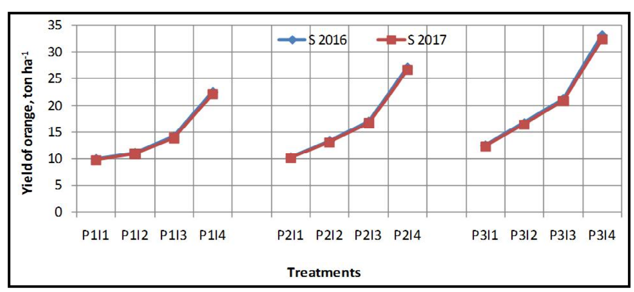


Fig. 7: Effect of pulse drip irrigation (P1: without pulses, P2: adding irrigation water on 4 times per day, P3: adding irrigation water on 8 times per day) and organic mulch by rice straw (I1: without mulch, I2: 5 ton. ha^{-1}, I3: 7 ton. ha^{-1} and I4: 9 ton. ha^{-1}) on yield of orange for seasons 2016 and 2017.

Statistical Analysis: All the obtained data in the two combined seasons of the study were statistically analyzed using the analysis of variance method according to Snedecor and Cochran (1980). while, the values of least

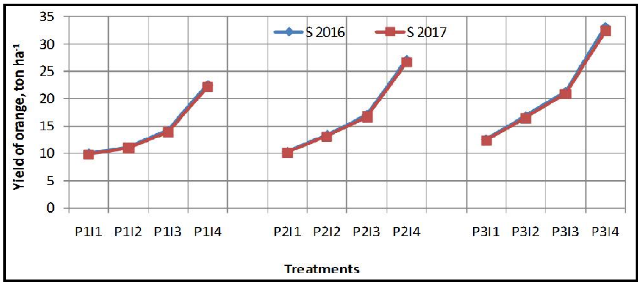


Fig. 8: Effect of pulse drip irrigation (P1: without pulses, P2: adding irrigation water on 4 times per day, P3: adding irrigation water on 8 times per day) and organic mulch by rice straw (I1: without mulch, I2: 5 ton. ha^{-1}, I3: 7 ton. ha^{-1} and I4: 9 ton. ha^{-1}) on water productivity of orange for seasons 2016 and 2017.

significant differences (L.S.D. at 5% level) were calculated to compare the means of different treatments.

Results

Water stress inside root zone

Fig. 3 shows the effect of pulse drip irrigation and organic mulching by rice straw on water stress within the root zone of the orange crop. The increase in the number of drip irrigation pulses led to a decrease in water stress within the root zone area. Water stress was also reduced due to increased rice straw mulch. The lowest water stress value was when the daily irrigation water was added eight times daily with the organic mulching of the rice straw at 9 tons per hectare and the greatest value of water stress was when the irrigation water was added to the daily one time without organic mulching.

Application efficiency of irrigation water, AE_{IW}

Fig. 4 and Table 2 shows the effect of pulse drip irrigation and organic mulching by rice straw on AE_{IW}. The increase in the number of drip irrigation pulses led to an increase in AE_{IW}. AE_{IW} was also increased due to increased rice straw mulch. The greatest values of AE_{IW} were 96.2% and 93.7% for 2016 and 2017 respectively when the daily irrigation water was added eight times daily with the organic mulch of the rice straw at 9 tons per hectare and the lowest values of AE_{IW} were 87.6% and 79.9% for 2016 and 2017 respectively when the irrigation water was added at one time per day without organic mulching.

Salt concentration of the surface soil under dripper, SCSS

The Fig. 5 and 6 and Table 2 show the effect of pulse drip irrigation and organic mulching by rice straw on **SCSS**. The increase in the number of drip irrigation pulses led to an increase in **SCSS** with only none mulched treatments but **SCSS** was decreased by increasing the amount of rice straw for mulching for seasons 2016 and 2017.

Yield of orange, YO

Fig. 7 and Table 3 shows the effect of pulse drip irrigation and organic mulching by rice straw on YO. The increase in the number of drip irrigation pulses led to an increase in YO. YO was also increased due to the increased amount of rice straw mulching. The greatest values of YO were 33.15 ton. ha^{-1} and 32.27 ton. ha^{-1} respectively when the daily irrigation water was added eight times a day with the organic mulching of the rice straw at a rate of 9 tons per hectare and the lowest values of YO were 10 ton. ha^{-1} and 9.8 ton. ha^{-1} for 2016 and 2017 respectively when the irrigation water was added at one time a day and without organic mulching.

Water productivity "WP_{orange}"

Fig. 8 and Table 3 shows the effect of pulse drip irrigation and organic mulching by rice straw on

Table 2: Effect of pulse drip irrigation and organic mulch by rice straw on application efficiency of irrigation water and salt concentration of the surface soil under dripper for seasons 2016 and 2017.

Number of drip irrigation pulses per day	Organic mulching by rice straw ton ha^{-1}	Application efficiency of irrigation water at PIWR, %		Salt concentration of the surface soil under dripper, ds. m^{-1}			
				2016		2017	
		2016	2017	BS	ES	BS	ES
1 time/ day (control)	0	87.6	79.9	0.45	1.12	0.47	1.22
	5	89.7	83.4		0.73		0.74
	7	90.4	85.6		0.64		0.66
	9	91.5	88.4		0.52		0.54
4 time/ day	0	88.3	81.9	0.45	1.23	0.47	1.24
	5	88.9	84.2		0.75		0.78
	7	90.7	87.8		0.68		0.70
	9	92.3	90.3		0.58		0.59
8 time/ day	0	90.4	84.3	0.45	1.31	0.47	1.36
	5	92.1	87.4		0.84		1.00
	7	94.7	90.1		0.69		0.79
	9	96.2	93.7		0.59		0.61

BS: in the begging of season, ES: in the end of season, PIWR: Peak of Irrigation Water Requirement during growing season of sour orange, P1: without pulses, P2: adding irrigation water on 4 times per day, P3: adding irrigation water on 8 times per day), I1: without mulch, I2: 5 ton. ha^{-1}, I3: 7 ton. ha^{-1} and I4: 9 ton. ha^{-1}

Table 3: Effect of pulse drip irrigation and organic mulch by rice straw on Yield of orange and Water productivity of orange for seasons 2016 and 2017.

Number of drip irrigation pulses per day	Organic mulching by rice straw, ton ha^{-1}	Yield of orange, ton ha^{-1}		Water productivity "WP orange, kg m^{-3}	
		2016	2017	2016	2017
Effect of pulse drip irrigation on the yield and water productivity of orange					
1 time/day (control)		14.29c	14.20c	2.01	1.89
4 times/day		16.98b	16.64b	2.36	2.22
8 times/day		20.95	20.47	2.91	2.73
LSD at 5%		0.5194	0.46		
Effect of organic mulching rate on the yield and water productivity of orange					
	0	10.97d	10.75d	1.52	1.43
	5	13.78c	13.50c	1.91	1.80
	7	17.53b	17.18b	2.43	2.29
	9	27.62a	26.99a	3.84	3.60
	LSD at 5%	0.97	0.94		
Effect the interaction of pulse drip irrigation and organic mulching rate on the yield and water productivity of orange					
1 time/day (control)	0	10.00g	9.80g	1.39	1.31
	5	11.17fg	10.95fg	1.55	1.46
	7	14.22e	13.93e	1.98	1.86
	9	22.59c	22.14c	3.14	2.95
4 times /day	0	10.34g	10.13g	1.44	1.35
	5	13.40e	13.13e	1.86	1.75
	7	17.06d	16.72d	2.37	2.23
	9	27.11b	26.57b	3.77	3.54
8 times /day	0	12.57ef	12.32ef	1.75	1.64
	5	16.76d	16.42d	2.23	2.19
	7	21.32c	20.90c	2.96	2.79
	9	33.15a	32.27a	4.60	4.30
	LSD at 5%	1.69	1.63		

P1: without pulses, P2: adding irrigation water on 4 times per day, P3: adding irrigation water on 8 times per day), I1: without mulch, I2: 5 ton. ha^{-1}, I3: 7 ton. ha^{-1} and I4: 9 ton. ha^{-1}

WP_{orange}. The increase in the number of drip irrigation pulses led to an increase in WP_{orange}. WP_{orange} was also increased due to the increased amount of rice straw mulching. The greatest values of WP_{orange} were 4.6 kg. m^{-3} and 4.3 kg. m^{-3} respectively when the daily irrigation water was added eight times daily with the organic mulch of the rice straw at a rate of 9 tons per hectare and the lowest values of WP_{orange} were 1.39 kg. m^{-3} and 1.31 kg. m^{-3} for 2016 and 2017 respectively when the irrigation water was added at one time a day and without organic mulching.

Some of quality traits of orange juice

Table 4 shows the effect of pulse drip irrigation and organic mulch by rice straw on juice volume, total sugars and TSS of orange juice. The increase in the number of drip irrigation pulses led to an increase in all the previous traits of orange juice. The quality traits of orange juice "QTOJ" were also increased due to increased in amount of rice straw for mulching during two seasons 2016 and 2017. The greatest values of QTOJ when the daily irrigation water was added eight times daily with the organic mulch of the rice straw at 9 tons per hectare and the lowest values of QTOJ were when the irrigation water was added to the daily one time and with no organic mulch.

Discussion

It is clear from the previous results of the effect of pulse drip irrigation and the rates of organic mulching by rice straw, the positive effect of both on yield and water productivity and some quality properties studied.

The effect of pulse drip irrigation (the increase in the number of irrigation times per day) increased the application efficiency of irrigation water in the root zone of orange trees. This means increasing the wet soil size in the root propagation area, which indicated the increase of the horizontal movement of irrigation water inside the soil root zone due to frequency of irrigation. All this reduces the water stress on the roots of orange trees. These results were agreement with many researchers such as (Eric *et al.,* 2004), (Helen, 2007), (El-Gindy and Abdel Aziz 2001), (Scott, 2000) and (Segal *et al.,* 2000) they reported that, when using drip irrigation, you may need to irrigate more than once daily to meet maximum water requirements. If the drip irrigation system drains after each irrigation, cut the irrigation to the longest possible pulses to reduce drain loss and the area of the wet zone could be increased if irrigation was pulsing, the benefits of pulsed irrigation, such as reducing soil water evaporation, reducing fertilizer filtration, yield improvement, etc., were documented by two different researchers.

The effect of increasing the organic mulching by rice straw to reduce evaporation from the soil surface also led to two benefits. First of all, reduction of evaporation from the surface of the soil, which helped to maintain the soil moisture for as long as possible in the area of root spread and this region is not exposed to rapid drought due to non-coverage. The second benefit is the low accumulation of salts on the surface of the soil, also due to the low rate of evaporation from the soil surface due to the organic mulching by rice straw. These results were

Table 4: Effect of pulse drip irrigation and organic mulch by rice straw on some of quality traits of orange juice (juice volume, total sugars and TSS) for seasons 2016 and 2017.

Number of drip irrigation pulses per day	Organic mulching by rice straw, ton ha^{-1}	Juice Volume		Total sugar, %		TSS	
		2016	2017	2016	2017	2016	2017
Effect of pulse drip irrigation on juice volume, Total sugars and TSS of orange							
1 time/day (control)	0	82.33	78.22	8.25	7.53	8.35	7.52
4 times/day	0	88.92	84.47	9.08	8.28	10.44	9.40
8 times/day	0	106.7	101.4	10.44	9.64	11.60	10.44
Effect of organic mulching rate on juice volume, Total sugars and TSS of orange							
0	0	79.90	75.90	6.36	6.00	8.73	7.86
0	5	88.15	83.74	8.23	7.76	9.08	8.18
0	7	96.78	91.94	10.47	9.33	10.48	9.43
0	9	105.8	100.5	11.97	10.91	12.23	11.00
Effect the interaction of pulse drip irrigation and organic mulching rate on Juice volume, Total sugars and TSS of orange							
1 time/day (control)	0	71.00	67.45	5.67	5.11	7.20	6.48
	5	78.33	74.42	7.33	6.82	7.49	6.74
	7	86.00	81.70	9.33	8.24	8.64	7.78
	9	94.00	89.30	10.67	9.34	10.08	9.07
4 times /day	0	76.68	72.85	6.23	5.51	9.00	8.10
	5	84.60	80.37	8.07	7.66	9.36	8.43
	7	92.88	88.24	10.27	9.54	10.80	9.72
	9	101.52	96.44	11.73	10.88	12.60	11.34
8 times /day	0	92.02	87.42	7.17	6.66	10.00	9.00
	5	101.52	96.44	9.28	8.76	10.40	9.36
	7	111.46	105.89	11.81	10.94	12.00	10.80
	9	121.82	115.73	13.50	12.77	14.00	12.60

P1: without pulses, P2: adding irrigation water on 4 times per day, P3: adding irrigation water on 8 times per day), I1: without mulch, I2: 5 ton. ha^{-1}, I3: 7 ton. ha^{-1} and I4: 9 ton. ha^{-1}

consistent with many researchers such as Liu *et al.,* 2002, Hu *et al.,* 1995, Kar and Singh 2004, including Ranjan *et al.,* 2017 where they recommended using that mulching with organic materials increases soil nutrients, maintains optimal soil temperature, restricts the evaporation rate from soil surface, restricts the growth of weeds and prevents soil erosion. It also helps improve soil health. Organic mulch is a cheap material. Therefore, the cost of mulch is also economical.

The positive effect of the previous study factors led to increased productivity, water productivity and some quality characteristics of the orange crop during 2016 and 2017 when adding the daily water needs to eight times instead of one time, in addition to the organic mulching by rice straw at the rate of 9 tons per ha^{-1}.

Conclusion

The effect of adding water on eight times a day rather than adding it once, increased the size of the wet soil within the root zone, thus increasing the application efficiency of the irrigation water and decreasing the water stress on the roots of the orange trees and also the positive effect of increasing the rates of organic cover with rice straw 9 tons per hectare, indicates a low evaporation rate and salts accumulation in the root zone compared to non-coverage. The positive effect of the previous study factors led to increased productivity, water productivity and some quality characteristics of the orange crop during 2016 and 2017 when adding the daily water needs to eight times instead of one time, in addition to the organic mulching by rice straw at the rate of 9 tons per ha^{-1}.

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