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Impact of Irrigation Scheduling and Application Rate of Organic Fertilizers under Rotational Distribution System in Sandy Soils to Mitigate Water Stress on Apple Trees

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This study investigated the optimum irrigation scheduling and the best application rate of compost under rotational distribution system in sandy soils conditions to mitigate water stress on apple trees for improving yield, water productivity and quality traits. The obtained results indicated that applying optimum irrigation scheduling (adding Water Irrigation Requirements (WIR)) for apple in three and four days as irrigation interval) and increasing the application rate of compost up to 25 ton per fed, increase water and fertilizers uptake rate with good growing conditions. Meanwhile, the fruit yield, quality trait, and water productivity of apple were increased. In apple cultivation and other crops which follow the bilateral irrigation rotation, the irrigation requirements should be splitted in three days per week along with increasing the application rate of compost up to 25 ton fed-1 with drip irrigation system to mitigate the negative effect of water stress on apple trees.

Keywords: Compost, Rotational Distribution System, Soil organic matter, Water productivity

INTRODUCTION

The canal systems distributing the water have different design capacities, command areas and lengths requiring different duration of operation. Irrigation scheduling under these conditions especially for rotational water distribution becomes a complex process. Rotational water distribution has been introduced in some of the systems to manage the shortage of water. Improving crop production is one of the most important issues in the world in term of sustainable agriculture. Some of other off-site elements such as chemical fertilizers, deep tillage, and unsustainable agricultural practices have increased the plant productions in expense of soil in which it could negatively affect soil quality. Under these circumstances, agricultural practices lead to reduced soil organic matter (SOM) content, soil biodiversity, degradation of soil physical properties and the wider environment (e.g., increased soil erosion, transfer of sediments, pollution of surface and ground-waters) (Kibblewhite et al., 2008; Lal, 2008). As alternative way to sustain the environment, numerous studies have suggested the use of organic soil amendment approach that is considered to be the best way for sustaining economically viable crop production with minimal environmental pollution. In order to guaranty a high yield of apple trees, it is important for the soil to stay fertile through supplying adequate elements, and the importance of addition organic substances to augment the biological activities and optimize acidity of the soil, to untie the soil deeply for the enhancement of water-air regime, etc (Gasparatos et al., 2011; Vliegen- Verschure, 2013). Promotion of microorganisms with apple trees by applying biofertilization is currently considered as healthy option to chemical fertilization. The preparation of microbial organisms including living cells of varies microorganisms which are able to convert plant nutrients in the soil from unavailable to available form are called biofertilizers. Thus, they increase the crop yield by around 30% with cost effective along with providing good soil biological activities conditions (Mosa et al., 2015). Adequate SOM level by continuous additional of organic matter sources such as manure is important, which is easily oxidized within the Mediterranean conditions (Gasparatos et al., 2011). Decomposing plant residues are reported to release substantial levels of nutrients and organic matter into the soil (Yih-Chi et al 2009). The use of drip irrigation in combination with plant residues and chicken manure can increase the okra yield and water use efficiency significantly at I2 irrigation level. The additional irrigation water caused an increase in the uptake of N P K and if compared to the lowest level of irrigation water it increased the growth parameters in expense of okra yield (Abd El-Kader, et al., 2010). Studying the effect of applying organic and chemical fertilizers on cucumber yield and fruit characteristics had been done by Aly (2002). He found that organic treatment (10 m^3 compost/540 m^2) gave significantly greater early, exportable and total yield than inorganic (chemical) treatment. Abdelraouf, (2014) mention that, there was positive impact for adding compost with volumetric distribution to improving yield and water productivity of maize under sandy soils conditions, as well as adding organic matter to the soil increase from water holding capacity (Vengadaramana and Jashothan, 2012). Furthermore, the average fruit weight, length, diameter, length / width ratio, fruit firmness, T.S.S., total sugars, chlorophyll and ascorbic acid content were significantly increased by using compost of organic materials over the inorganic treatment. According to Lal , (1997), one of the key conditions to increase soil productivity in the sub-Saharan zone is to ensure effective water infiltration and storage in the soil. The soil's water-holding capacity is intimately linked to its texture, structure and organic matter content (Hillel, 1980, Ouattara, 1994). Thus the depletion of SOM is the major cause of ecosystem degradation and loss the ecosystem resilience (Bronick and Lal, 2005; Lal, 2005; Feller et al., 2012). The aim of this study was to determine the best irrigation scheduling and application rate of compost under rotational irrigation system and sandy soils conditions to mitigate water stress volume on apple trees for improving yield, water productivity and quality traits of apple.

MATERIALS AND METHODS

Location of experimental study:

Field experiments were conducted during 2015 and 2016 on sand soil located in northern Cairo–Egypt at private farm in EL-Emam Malek village, El-NUBARIA, (latitude 30º 26' 28''N, longitude 30º 18' 0'' E, and mean altitude above sea level 21 m), Al Buhayra governorate, Egypt. The selected area is characterized with an arid climate, cool winters and hot dry summer, and an average annual temperature of 21.4 ^{0}C and annual precipitation of 30 mm.

Physical and chemical properties of soil, irrigation water and compost:

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} electrical conductivity (EC). The main physical and chemical properties of the soil illustrated in table 1 were determined in the laboratory at the beginning of the experiment. The main physical and chemical properties of irrigation water and compost are reported in table 2

.

Experimental Design:

Experimental design and treatments were split plot with three replicates. Three irrigation scheduling under rotational irrigation system (IS1: WIR in one day, IS2: WIR in two days and IS3: WIR in three days) in main plots. Meanwhile, five rates of compost were distributed in sub-main plots as following; [R1: control without compost, R2: 10 ton. fed^{-1}., R3: 15 ton. fed^{-1}., R4: 20 ton. fed^{-1}. and R5: 25 ton. fed^{-1}. The total numbers of plots were 45 and the area of each plot was 140 m^2. The soil moisture profile probe access tubes were placed in each plot to measure the soil moisture (figure 1) as shown in table 3.

Irrigation requirements for Anna apple:

Drip irrigation system has been used as an irrigation method while the daily irrigation water requirement was calculated using Penman Monteith equation and the crop coefficient, according to Allen et al., (1989).

Table 1; Physical and chemical characteristics of the soil of the experimental area

Soil Characteristics	Soil depth (cm)				
	0–20	20-40	40-60	60-80	80-120
Physical parameters					
Texture	Sandy	Sandy	Sandy	Sandy	Sandy
Course sand (%)	45.97	53.39	39.32	37.69	38.45
Fine sand (%)	51.20	42.64	57.11	58.33	58.04
Silt + clay (%)	2.83	3.97	3.57	3.98	3.51
Bulk density (t m^{-3})	1.60	1.59	1.57	1.61	1.59
Chemical parameters					
EC (dS m^{-1})	0.35	0.32	0.44	0.45	0.53
pH (1:2.5)	8.8	8.9	8.7	9.1	8.9
Total $CaCO_3$ (%)	7.02	2.34	4.68	5.01	5.2
Organic matter (%)	0.65	0.40	0.25	0.24	0.21

Table2; Main characteristics of irrigation water and compost of the experimental area

Parameter	Irrigation canal water, IW	Compost
Electric Conductivity, dS m^{-1}	0.41	0.70
pH	7.44	5.92
Chemical characteristics, concentrations		
Ca^{2+}	1.00	
Mg^{2+}	0.50	1
Na^{2+}	2.40	2.4
K^+	0.20	2.2
CO_3^{2-}	< 0.01	
HCO_3^-	0.10	
Cl^-	2.70	3.5
SO_4^{2-}	1.30	
NH_4^++NO_3^-	< 0.01	
PO_4^{3-}	0.20	2.9
Cu^{++}	0.02	
Ni^{++}	0.01	
Zinc, Zn^{++}	1.00	
Calcium, Ca^{2+}	1.00	2.0
Organic Matter, (%)		97.2
Moisture Content, (%)		18
Nitrogen, (%)		0.91
Phosphorus, (%)		0.85
Potassium, (%)		0.90

Table 3 Irrigation Scheduling and application rate of compost under rotational irrigation system

Irrigation Scheduling (IS)	Days of week							Application Rate of Compost (R)	T
IS1: WIR in one day	On	Irrigation intervals, 6 days							
	On	Off	Off	Off	Off	Off	Off	Control	IS1R1 (C)
	On	Off	Off	Off	Off	Off	Off	10 ton/ fed.	IS1R2
	On	Off	Off	Off	Off	Off	Off	15 ton/ fed.	IS1R3
	On	Off	Off	Off	Off	Off	Off	20 ton/ fed.	IS1R4
	On	Off	Off	Off	Off	Off	Off	25 ton/ fed.	IS1R5
IS2: WIR in two days	On	On	Irrigation intervals, 5 days						
	On	On	Off	Off	Off	Off	Off	Control	IS2R1
	On	On	Off	Off	Off	Off	Off	10 ton/ fed.	IS2R2
	On	On	Off	Off	Off	Off	Off	15 ton/ fed.	IS2R3
	On	On	Off	Off	Off	Off	Off	20 ton/ fed.	IS1R4
	On	On	Off	Off	Off	Off	Off	25 ton/ fed.	IS2R5
IS3: WIR in three days	On	On	On	Irrigation intervals, 4 days					
	On	On	On	Off	Off	Off	Off	Control	. IS3R1
	On	On	On	Off	Off	Off	Off	10 ton/ fed.	IS3R2
	On	On	On	Off	Off	Off	Off	15 ton/ fed.	IS3R3
	On	On	On	Off	Off	Off	Off	20 ton/ fed.	IS3R4
	On	On	On	Off	Off	Off	Off	25 ton/ fed.	IS3R5

T: Treatments; C: Control Treatment; On: Irrigation on; Off: Irrigation off

Table 4 Monthly and seasonal irrigation water applied during season 2015 and 2016

Months	Season 2015 (m^3)	Season 2016 (m^3)
January	62	74.4
February	291.2	280
Mars	372	434
April	552	588
May	644.8	657.2
June	636	660
July	669.6	744
August	744	719.2
September	506.4	516
October	229.4	260.4
November	114	132
December	38.44	49.6
Total	4860	5115

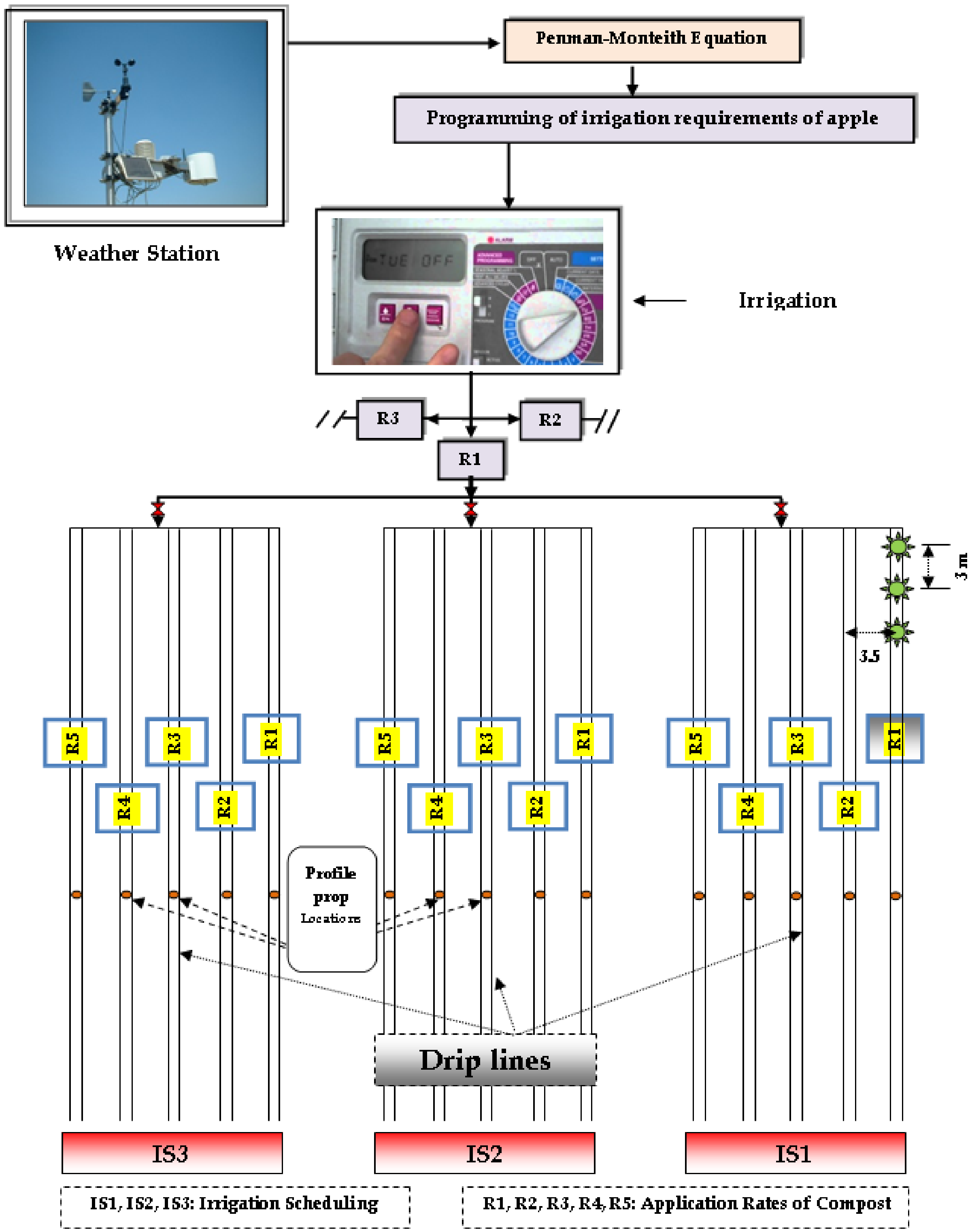
Weather Station
Penman-Monteith Equation
Programming of irrigation requirements of apple
Irrigation
R3
R2
R1
3 m
3.5
R5
R3
R1
R4
R2
Profile prop Locations
Drip lines
IS3
IS2
IS1
IS1, IS2, IS3: Irrigation Scheduling
R1, R2, R3, R4, R5: Application Rates of Compost

Table 5 Estimation method of application efficiency

Soil depth, cm	θ_1 %	θ_2 %	d, cm	ρ	$D_s = (\theta_1 - \theta_2) * d * \rho$ cm³	D_a, cm³	AE = D_s / D_a AE = $(d_{s1} + d_{s2} + d_{s3} + d_{s4}) / D_a$
0 -25					d_{s1}		
25 -50					d_{s2}		
50 -75					d_{s3}		
75 – 100					d_{s4}		

AE = Application efficiency, D_s =Depth of stored water in root zone, D_a =Depth of applied water, d =Soil layer depth, θ_1 =Soil moisture content after irrigation, θ_2 = Soil moisture content before irrigation, ρ = Relative bulk density of soil (dimensionless). d_{s1}= depth of stored water in root zone from 0 – 25 cm , d_{s2}= depth of stored water in root zone from 25 – 50 cm, d_{s3}= depth of stored water in root zone from 50 –75cm, d_{s4}= depth of stored water in root zone from 75 –100 cm

The seasonal irrigation water applied was 4860 and 5115 m^3 fed^{-1} $season^{-1}$ for 2015 and 2016, respectively as shown in table 4.

Evaluation parameters:

Application Efficiency:

Application efficiency relates to the actual storage of water in the root zone to meet the crop water needs in relation to the water applied to the field. According to El-Meseery, (2003) application efficiency "AE" was calculated using the following relation: AE = Ds/ Da

Where: AE = Application efficiency, (%), Ds = Depth of stored water in root zone (cm) where: Ds = (θ1 – θ2) * d * ρ

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), (table 5) show estimation method of application efficiency in the field.

Water stress:

Referring to measuring soil moisture content in effective root zone before and after irrigation, where the field capacity and wilting point are considering 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 in effective root zone.

Apple yield:

At harvest, a random fruit samples were taken from each plot to determine fruit yield and then converted to yield (ton/fed.).

Water productivity of apple, "WP_{apple}":

WP_{apple} was calculated according to James, (1988) as follows:

$WP_{apple} = Ey/Ir$

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

Quality traits:

Fruit physical characteristics, average values of fruit weight (gm), fruit size (cm^3), fruit length (cm.), fruit diameter (cm), fruit shape index (fruit length /fruit diameter ratio) and fruit firmness ($Ib/inch^2$) which was determined by using pentrometer (pressure tester) were estimated. Fruit chemical characteristics: The following four fruit juice chemical properties of mature fruits were determined according to the A.O.A.C (1985) as follows: (1) Total soluble solids percentage (TSS %): fruit juice was determined using a Carl Zeiss hand refractometer. (2) Total titratable acidity percentage: Total acidity of fruit juice was estimated as a percentage of anhydrous malic acid.

Statistical analysis:

The standard analysis of variance procedure of split plot design with three replications as described by Snedecor and Cochran (1982) was used. All data were calculated from combined analysis for both growing seasons (2015, 2016). The treatments were compared according to L.S.D. test at 5% level of significance.

RESULTS AND DISCUSSION

Application Efficiency:

Effect of irrigation scheduling on application efficiency "AE":

The obtained indicated that, there was significant effect of irrigation scheduling on AE under rotational irrigation system where, AE was increased as a result of increasing the number of irrigation days per week. In both seasons the AE was improved where it was 79.03% and 76.67 %

with WIR in one day, but it recorded 96.26 % and 93.37% as a highest value with WIR in three, respectively. The increasing of AE may be due to increasing number of days for irrigation, reducing from total water volume escaping out of root zone by deep percolation.

Effect of application rate of compost on application efficiency

The results presented in showed that, there was a positive effect of compost application on AE under rotational irrigation system. Under the control treatment, no compost added, the AE recorded 86.53 % while it recorded 90.18 % as a highest value under the treatment of added 25 ton fed^{-1} in the first season (2015), the same trend has been observed in second season (2016). The enhancing of AE attributed to the increase compost rate which improves the water holding capacity within the root zone. Indeed, SOM improves the soil structure and thus affects the stocking of the soil water reserves (Ouédraogo et al., 2001). Hence, maintaining SOM is a key component of sustainable land use management (Feller and Beare, 1997, Bationo, 1998).

Effect of the interaction between irrigation scheduling and application rate of compost on application efficiency

As it graphically illustrated in figure 2 the obtained data signified that, there was a constructive impact of irrigation scheduling and compost application rate on AE under rotational irrigation system. However, the AE in both seasons were increased as a result of increasing the number of irrigation days per week and increasing the application rate of compost. The WIR and compost application rates increased as the AE increased whereas, through seasons 2015 and 2016 it was recorded 77.53 % with WIR in one day and without adding compost, but it recorded 98.93% and 95.93% as a highest value with adding 25 ton fed^{-1} for seasons 2015 and 2016, respectively. The improving of AE might be attributed to the interaction of two factors; the saving and reducing the volume of water went/escaping out of the root zone (deep percolation) by increasing the numbers of days for irrigation and enhancing the water holding capacity within the root zone by increasing the application rate of compost. Those results were in agreement with Abdelraouf, (2014), Vengadaramana and Jashothan, (2012), Ouattara, (1994), Ouédraogo et al., (2001) Volk and Ullery, (1993).

Water Stress:

The obtained results of soil moisture content before and after irrigation during one week only (maximum WIR) as illustrated in figure 3 indicated that, there was positive impact for irrigation scheduling and application rate of compost on water stress "WS". Under rotational irrigation system where, the maximum WS has been observed under the WIR in one day and without adding compost in comparing with the other treatments as well as the minimum WS has been observed under the WIR in three days. Additional of 25 ton fed^{-1} of compost was done in both seasons. The acceptable reduction of WS occurred within the WIR in three days and along with adding 25 ton fed^{-1} (Dotted Curve) and that might be due to; 1) encouraging the vertical water movement instead of deep percolation by reducing the interval days of irrigation in which kept the wetted root zone within the optimum water volume, and 2) the role of compost in improving the soil water holding capacity in root zone. Water holding capacity of soils is controlled primarily by: (i) the number of pores and pore-size distribution of soils; and (ii) the specific surface area soils. This is one of the most important physical facts for agriculture. Application of wastes, either for plant nutrient supply or for disposal purposes, increases the C content of the soil. An increase in C content of the soil increases aggregation, decreases bulk density, increases water holding capacity, and hydraulic conductivity (Volk and Ullery, 1993).

Apple Yield:

Effect of irrigation scheduling on apple yield "AY"

The effect of irrigation scheduling on apple yield indicated that, AY under rotational irrigation system to some extent increased as a result of increasing the irrigation day's number per week. In this respect, the application of weekly water requirements in three days induced variable values of AY in both seasons (2015 and 2016), where it recorded 3.826 ton.fed^{-1} with weekly water requirements in one day, whereas it recorded 6.526 ton.fed^{-1} as a highest value with weekly water requirements in three days for season 2015. The increasing of AY might be due to enhancing the AE which resulted from increasing the irrigation days number which means reducing the total water volume that went out of root zone by deep percolation, thus, reducing the water stress within the root zone in addition to improving the fertigation efficiency.

Effect of application rate of compost on apple yield

The AY under rotational irrigation was significantly varied according to compost rate. In the first season (2015), the best AY (6.511 ton fed^{-1}) was recorded under the treatment of add 25 ton fed^{-1}; while it recorded 4.3 ton fed^{-1} under the treatment of no add of compost. The increasing of AY might be due to the interaction of three constant; 1) increasing the application rate of compost which boosted the water holding capacity inside root zone and then enhancing the AE; 2) mitigation the water stress within the root zone in addition to increasing from fertigation efficiency; and 3) enriching the growing media with the available nutrients as a result of compost degradation.

Effect the interaction between irrigation scheduling and application rate of compost on apple yield

The interaction effect of irrigation schedule and compost application rate is graphically illustrated in figure 4 under rotational irrigation system with increasing the weekly irrigation and application rate of compost had a positive impact on AY. The AY improved through seasons 2015 and 2016 where it was 3.1 ton fed^{-1} with WIR in one day and without adding compost while it recorded 8.233 ton fed^{-1} as a highest value with adding 25 ton fed^{-1} for season 2015. The main causes of enhancing the AY might be attributed to; 1) increasing number of days for irrigation in which reducing the total water volume went/escaping out of root zone by deep percolation and then, alleviating the water stress within the root zone in addition to improving the fertigation efficiency; 2) increasing of application rate of compost enhanced the water holding capacity inside root zone which resulted in enhancing the AE; 3) reducing of water stress volume within root zone resulted in maximizing the fertigation efficiency; 4) the compost degradation resulted in increasing the availability of nutrients. These results were agreed with Kibblewhite et al., (2008), Lal, (2008) and Papathanasiou et al., (2012).

Water Productivity of Apple:

Effect of irrigation scheduling on water productivity of apple "WP_{apple}"

The collected data indicated that, similar trend of the above-mentioned parameters have been observed as effected by irrigation scheduling on WP_{apple} under rotational irrigation system where, WP_{apple} increased as a result of increasing the number of irrigation days per week. WP_{apple} improved through seasons 2015 and 2016 where it was 0.788 kg $_{yield}$ $.m^{-3}{}_{water}$ with add WIR in one day, whereas it recorded 1.343 kg $_{yield}$ $.m^{-3}{}_{water}$ as a highest value with add WIR in three days for season 2015.

Effect of application rate of compost on water productivity of apple

The results were obtained after the statistical analysis has indicated that, there was a positive effect of compost application rate on WP_{apple} under rotational irrigation system further, WP_{apple} increased as a result of increasing the application rate of compost. In both seasons WP_{apple} have been improved where it recorded 0.883 kg $_{yield}$ $.m^{-3}{}_{water}$ with no add of compost and it recorded 1.289 kg $_{yield}$ $.m^{-3}{}_{water}$ as a highest value with adding 25 ton fed^{-1} for season 2015, similar trend has been detected in 2016 season.

Effect the interaction between irrigation scheduling and application rate of compost on water productivity of apple

As shown in figure 5, the positive effect of the interaction between the irrigation schedule and compost application rate on WP_{apple} under rotational irrigation system confirmed the importance of increasing the application rate of compost along with increasing the number of days of irrigation per week. The WP_{apple} improved through seasons 2015 and 2016 as it was recorded 0.640 kg $_{yield}$ $.m^{-3}{}_{water}$ with add WIR in one day and without adding compost but it recorded 1.696 kg $_{yield}$ $.m^{-3}{}_{water}$ as a highest value with adding 25 ton fed^{-1} for season 2015, similar tendency also recorded in second season.

Quality Traits of Apple:

Effect of irrigation scheduling on physical and chemical quality properties of apple "PCQPA"

The data of the PCQPA resulted as the effect of irrigation schedule showed that PCQPA increased as a result of increasing of number of irrigation days per week. The mean value of PCQPA as T.S.S. and acidity recorded through seasons 2015 and 2016 13.8 and 0.613, respectively, with adding WIR in one day and it recorded 16.5 and 0.913 as highest values with adding WIR in three days for 2015 season.

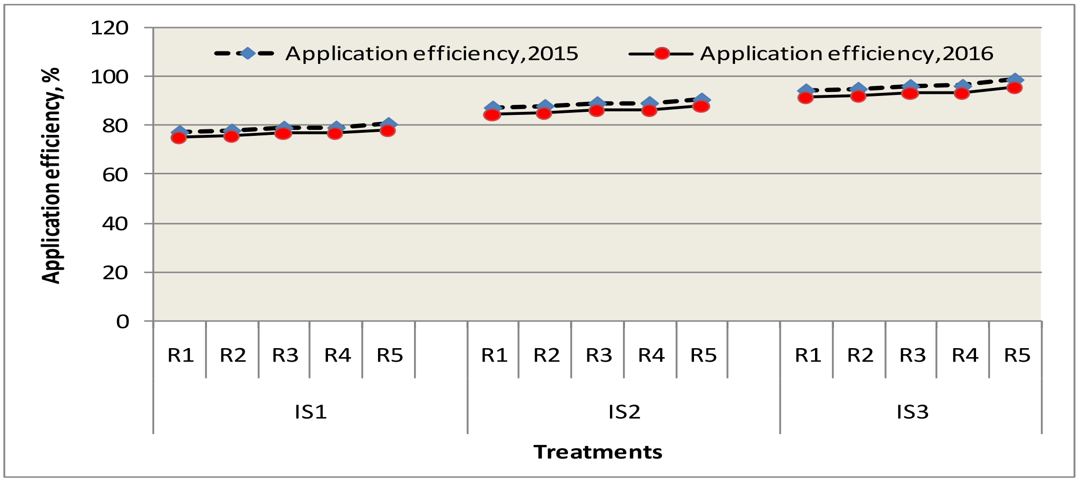

Figure 2 Effect of irrigation scheduling under rotational irrigation system and application rates of compost to sandy soils on application efficiency during seasons 2015

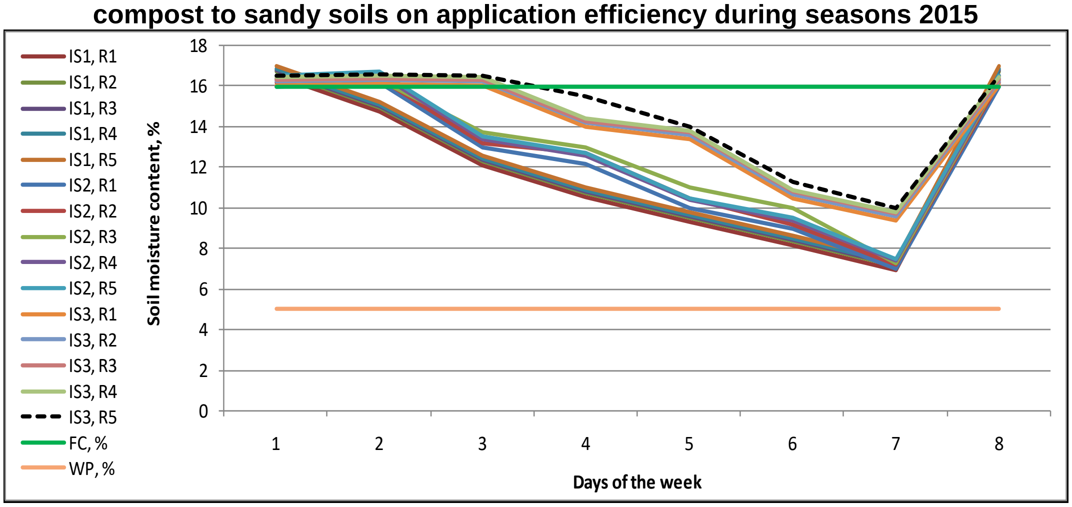

Figure 3 Effect of irrigation scheduling under rotational irrigation system and application rates of compost to sandy soils on water stress during seasons 2015 and 2016

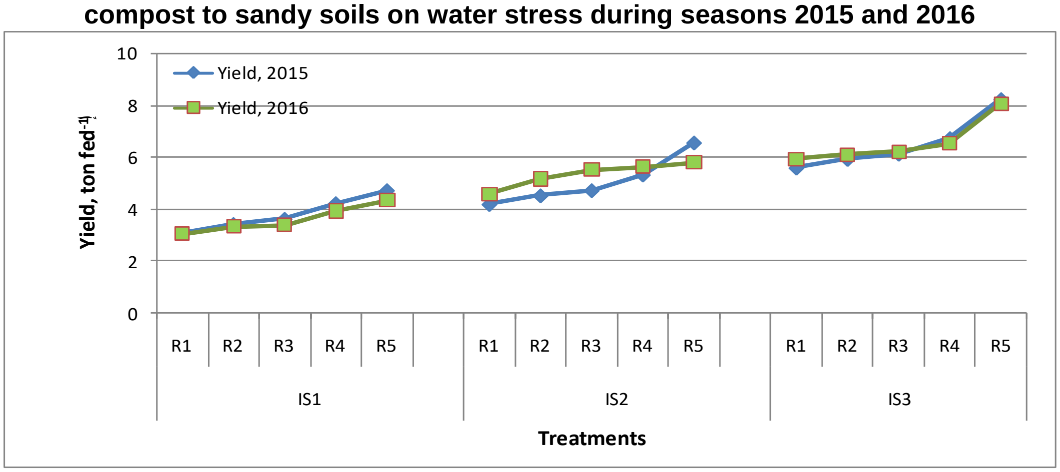

Figure 4 Effect of irrigation scheduling under rotational irrigation system and application rates of compost to sandy soils on apple yield during seasons 2015 and 2016

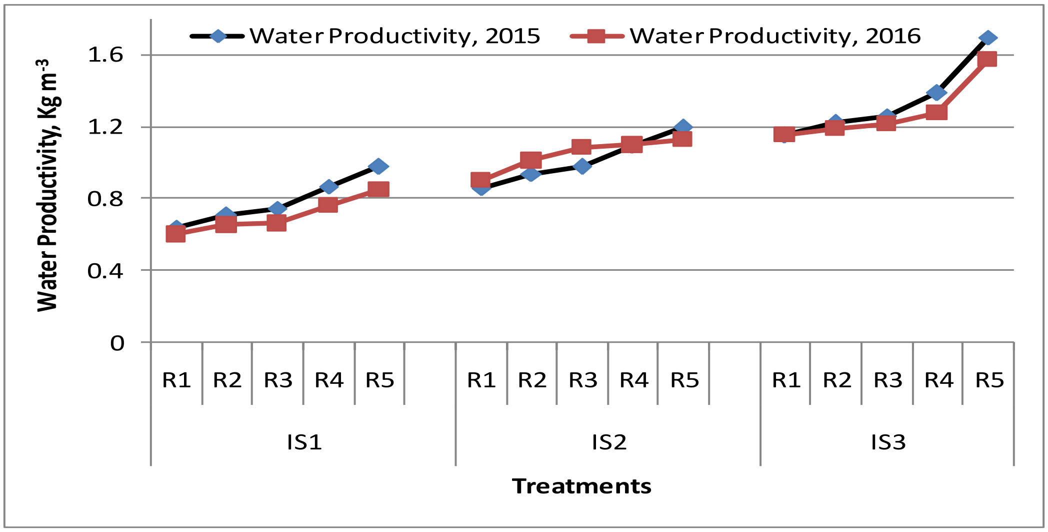

Figure 5 Effect of irrigation scheduling under rotational irrigation system and application rates of compost to sandy soils on water productivity of apple during seasons 2015 and 2016

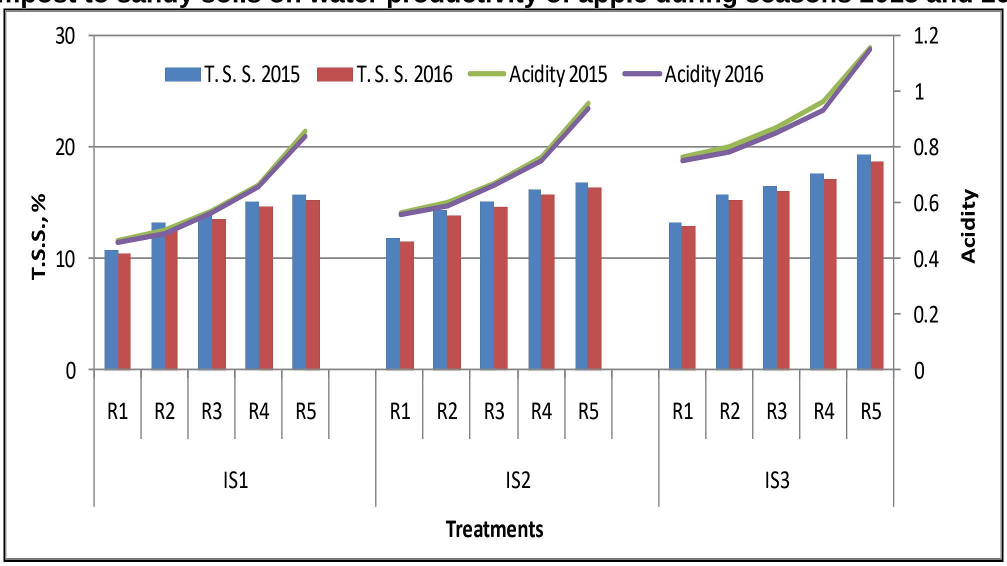

Figure 6 Effect of irrigation scheduling under rotational irrigation system and application rates of compost to sandy soils on T.S.S. and acidity of apple juice during seasons 2015 and 2016

The increasing of PCQPA might have attributed to increasing of AE by increasing number of days for irrigation hence, increasing the water uptake rate.

Effect of application rate of compost on physical and chemical quality properties of apple

The results were obtained after the statistical analysis indicated that, there was effect of compost application rate on PCQPA under rotational irrigation system where, increasing of application rate of compost resulted in increasing PCQPA. Furthermore, in both seasons the PCQPA improved, where T.S.S. and acidity recorded a value of 12 and 0.599 with no adding for compost but it recorded 17.299 and 0.993 as a highest value with adding 25 ton fed^{-1} for season 2015, respectively. The increasing of PCQPA might be due to enhancing the water and nutrients as result of increasing the compost application rate and reducing the water stress within the root zone.

Effect the interaction between irrigation scheduling and application rate of compost physical and chemical quality properties of apple:

Figure 6 illustrated the overall means of

PCQPA resulted from the interaction between the irrigation scheduling and compost application rate indicated that, to somewhat extent, there was a significant difference between increasing the day numbers of irrigation per week along with increasing the compost application rate and irrigation schedule in one day along with no adding of compost. While, the PCQPA have been improved in both seasons (2015-2016), where the T.S.S. and acidity as shown in Figure 5 recorded a value of 10.8 and 0.466, respectively, with adding WIR in one day and without adding compost and recorded a value of 19.266 and 1.16, respectively, as highest values with adding WIR in three days and adding 25 ton fed^{-1} for season 2015. Increasing of PCQPA might be due to increasing water and fertilizers uptake rate with healthy growing conditions as a result of the previous mentioned applications.

CONCLUSION

This study investigated the optimum irrigation scheduling and the best application rate of compost under rotational irrigation system on sandy soils conditions to mitigate water stress volume on apple trees for improving yield and water productivity and quality traits of apple.

The obtained results indicated that by applying optimum irrigation scheduling (WIR in three days and 4 days as irrigation interval) and increasing the compost application rate up to 25 $ton.fed^{-1}$, leads to increasing water and fertilizers uptake rate with healthy growing conditions as a result of; 1) reducing the water losses by deep percolation and improving the fertigation efficiency as result of increasing the number of irrigation days; 2) enhancing the water holding capacity as a result of increasing the compost application rates; and 3) the availability of nutrients within the root zone due to the compost decay.

In the same time, the fruit yield, quality trait and water productivity of apple were increased by applying optimum irrigation scheduling (adding WIR for apple in three days and 4 days as irrigation interval) and increasing the application rate of compost up to 25 $ton.fed^{-1}$. It is worthy mentioning that the *IS3R5* treatment recorded the highest values of fruit yield, quality traits and water productivity of apple, whereas *IS1R1* treatment recorded the lowest values of all the above mentioned variables. In general perspective, in El-Nubaria region, the recommended rate of compost is 25 $ton.fed^{-1}$ and irrigation frequencies must be three times per week (IS3) under drip irrigation system to mitigate the negative effect of water stress volume on apple trees.

CONFLICT OF INTEREST

The authors declare no conflict of interest regarding this study

AUTHOR CONTRIBUTIONS

All authors contributed in collecting and analyzing data. All authors participated in writing every part of this study. All authors read and approved the final version.

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