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EFFECT OF REPLACING MINERAL NITROGEN BY ORGANIC MANURES UNDER DIFFERENT IRRIGATION REGIMES ON: B.PRODUCTIVITY AND WATER USE EFFICIENCY OF "ANNA" APPLE TREES

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ABSTRACT

This study was conducted through three successive seasons of 2011, 2012 and 2013 to investigate the effect of three irrigation regimes at 70%, 50% and 30% of available soil water and seven fertilization treatments include replacing 50%, 75% and 100% of mineral nitrogen by cattle or chicken organic manure comparing to 100% mineral fertilizer and their interaction on productivity, fruit quality and some water relations of "Anna" apple trees budded on *Malus* rootstock grown on clay soil at Tanta district, El-Gharbia Governorate. Results were only taken in 2012 and 2013 season.

The obtained results could be summarized as follows:

- Yield of "Anna" apple tree as fruits number and their weight (kg) as well as total yield (ton/fed) were gradually increased by increasing irrigation rate from 30% to 70% of available soil water due to the increase of fruit set% and reduced preharvest fruit drop % in both seasons.
- Application of 50% chicken or cattle manure + 50% mineral fertilizer (F_2 & F_5) produced maximum tree yield as fruits number and weight (kg) also total yield ton/fed. followed by 100% mineral. While, minimum yield correlated to that fertilized with 100% cattle or chicken manures in the two seasons of study .
- Highest yield kg/tree and ton/fed. were produced when "Anna" apple trees grown under high or moderate irrigation regimes (70 or 50% AW) and received 50% cattle or chicken manure + 50% mineral N fertilizer in (I_1 x F_2), (I_1 x F_5), (I_2 x F_2) and/or (I_2 x F_5) combination treatment without any significant differences among them while, trees subjected to severe water stress (30% AW) and fertilized by 100% cattle or chicken manure in (I_3 x F_4) or (I_3 x F_7) treatment gave the least significant values in both seasons.
- Increasing irrigation level resulted in a significant increase of fruit weight, volume, dimensions but reduce fruit firmness and TSS and anthocyanin contents. Meanwhile, nitrate and nitrite contents insignificantly affected with irrigation regime.
- The heaviest and largest fruits were recorded by adding nitrogen as 50% cattle or chicken manure + 50% mineral fertilizer followed by applying mineral fertilizer alone while, the lightest and smallest fruits were produced by using organic manure alone. Moreover, increasing the rate of organic manure in fertilization program significantly improved the chemical properties of apple fruit in term of increased total soluble solids (TSS) and anthocyanin contents but reduced nitrate and nitrite contents.
- Data of both seasons revealed that, the interaction (I x F) was significant and maximum fruit weight, volume and dimensions belonged to (I_1 x F_2), (I_1 x F_5), (I_2 x F_2) or (I_2 x F_5) combination treatments without significant difference among them. While, the least values obtained by (I_3 x F_4) or (I_3 x F_7) treatment. In addition, red color% and anthocyanin content of apple fruit skin were significantly highest under (I_2 x F_2) or (I_2 x F_5) treatment. Meanwhile, the control treatment (I_1 x F_1) obtained the least values.
- Minimum values of seasonal water consecutive use, m^3 (CU) recorded with deficit irrigation rate. On the contrary, the maximum values belonged to high irrigation level. Furthermore, the highest significant values of water use efficiency (WUE) and productivity of irrigation water (PIW) kg/m^3 obtained when tree irrigated at moderate irrigation regime (50% AW).
- Trees fertilized with 100% cattle or chicken manure consumed the least values of water. Meanwhile, tree irrigated at 50% AW gave the highest significant values of water use efficiency and productivity of irrigation water. However, the interaction (I x F) was significant in both seasons and the highest values of WUE and Piw were recorded by (I_2 x F_2) or (I_2 x F_5).

Thus, this study recommended "Anna" apple growers to irrigate their trees at 50% available water and apply 50% cattle or chicken manure plus 50% mineral N fertilizer in (I_2 x F_2) or (I_2 x F_5) combination treatment which consider the best one for producing maximum yield with good quality, beside, reducing water consumptive use and increasing water use efficiency and productivity of irrigation water.

INTRODUCTION

"Anna" apple (*Malus domestica*, Barkh) is considered one of the leading apple cultivars in Egypt, being of low chilling requirements. It needs chilling about 300-350 hrs below 7.2°C to break their bud dormancy (Zayan and Morsy, 1989). The cultivated area of "Anna" apple cultivar is being increased rapidly especially during the last three decades to reach 53443 feddan in 2013 which produced 546164 ton according to FAO (2013).

In Egypt, although the quantity of irrigation water is available, the ideal use of this water is essential. This minimizing water use not only reduced production cost but also help to meet the environmental regulation due to reduce the leaching of nutrients into ground water (Hanks, 1983). Soil moisture content is one of the main factors that most likely affect fruit production and fruit quality (Abd El-Samad *et al*., 2006; Fallahi *et al*., 2010; Mohuram and Zeen El-Deen, 2011 and Wang *et al*., 2014).

Increasing moisture stress reduced the actual consumptive use and productivity of "Anna" apple trees (El-Gendy and Abd El-Messeih, 2002 and Mikhael and Mady, 2007). Moreover, increasing irrigation rate (IR) from 11.76 to 17.64 m^3 water/tree/year significantly increased yield and improved fruit quality and water use efficiency of pear trees (Fathi, 1999).

Fertilization, especially nitrogen is one of an important management tools for increasing crop yield. The efficiency of nitrogen fertilizer under field and surface irrigation conditions, rarely exceeds 50% and is usually ranging between 30 and 40% (Sahrawat, 1979). Such low efficiency may be due to losses of nitrogen from soils as nitrate and nitrite by leaching or as N gas through nitrate reduction by volatilization (Goring, 1962), which causing many problems such as nitrate and nitrite pollution of ground water and environment. Moreover, they alter the composition of vegetables, fruits and root crops and decrease their content of vitamins, minerals and other useful compounds, beside harmful residues that remain in food pose threats to health (Bogatyre, 2000). Thus organic fertilization is used as partially or completely substitute for mineral N fertilization for fruit crops to avoid pollution of the environment and produce a safe food.

Application of organic manures as N source has been considered as a best management because organic N is more gradually released than water soluble in organic N fertilizers. In addition, organic manures has numerous merits such as reducing soil pH and increasing the availability of all nutrients, reducing soil salinity as well as enhancing soil fertility, water retention, soil organic matter, soil cation exchange, biological activity, formation of natural hormones and antibiotics (Nijjar, 1985).

Previous studies emphasized all different benefits of using the suitable N through inorganic and organic sources rather than using mineral N fertilization alone in enhancing yield and fruit quality of various fruit crops (Barakat *et al*., 2007; El-Sehrawy, 2008; Gad El-Kareem, 2009; Ahmed *et al*., 2012; Salama *et al*., 2012 and Zuoping *et al*., 2014).

The present investigation was planned to study the possible effects of three irrigation regimes and replacing mineral N fertilizer by using two organic N fertilizers namely cattle and chicken manures on yield, fruit quality and water use efficiency of "Anna" apple trees grown on clay soil.

MATERIALS AND METHODS

The present study was planned during three progressive seasons of 2011, 2012 and 2013 on 8 years old "Anna" apple trees budded on Malus rootstock to determine the effect of irrigation regimes and replacing mineral nitrogen fertilizer by cattle or chicken manures as an organic fertilization on productivity, fruit quality and water use efficiency of "Anna" apple trees. Results were taken in both 2012 and 2013 seasons. The trees were grown on clay soil at a commercial orchard in Khalwat Rishah village, North Tanta District, belonging to El-Gharbia Governorate, Egypt. The experimental site represents the circumstance and conditions of North Middle Nile Delta region. Agrometerological data of Sakha Weather Station, RRTC, ARC during the two seasons of 2012 and 2013 are presented in Table (1).

Table (1): Mean of some meteorological data for North Middle Delta area during the two growing seasons of 2012 and 2013.

Month	2012 season							2013 season						
	Air temperature °C		RH%		Wind speed (km/day)	Pan evap., mm/day	Rain, mm/ month	Air temperature °C		RH%		Wind speed (km/day)	Pan evap., mm/day	Rain, mm/ month
	Max.	Min	Max.	Min				Max.	Min	Max.	Min			
Jan.	18.2	8.4	77.5	60.3	63.2	2.13	64.0	19.2	7.6	91.0	65.4	46.3	1.98	78.8
Feb.	17.5	9.6	75.6	62.1	71.5	3.00	32.7	20.8	9.0	90.2	63.9	61.1	2.90	-
Mar.	20.5	12.3	77.1	59.8	94.3	4.50	42.8	24.4	12.4	79.6	50.9	89.3	4.45	-
Apr.	27.1	17.1	73.5	53.5	89.7	5.15	-	26.0	15.9	74.2	43.9	96.3	5.05	8.5
May	30.8	20.8	75.7	50.1	100.1	5.72	-	31.4	21.8	75.0	45.8	102.7	6.13	-
Jun.	33.6	23.5	79.6	50.8	104.0	6.49	-	32.4	24.0	74.6	51.3	115.4	6.61	-
Jul.	33.2	25.3	84.1	53.0	91.7	6.05	-	32.3	24.3	79.6	54.7	111.0	6.11	-
Aug.	34.7	25.0	84.9	52.1	90.9	5.79	-	33.8	24.8	83.6	60.5	90.2	5.13	-
Sep.	32.3	22.7	82.9	52.3	86.3	6.60	-	32.5	22.9	81.0	56.6	87.6	3.82	-
Oct.	29.9	20.6	85.2	55.3	74.2	4.30	6.6	27.8	19.4	76.2	57.4	109.0	2.87	-
Nov.	25.3	15.5	89.2	61.8	57.0	1.87	29.3	25.4	15.1	87.0	64.4	68.7	2.28	-
Dec.	21.4	10.6	84.8	60.8	63.0	2.27	23.0	19.6	8.5	92.1	67.6	52.7	0.42	77.3

Source: Meteorological station at Sakha 31°-07`N latitude, 30°-57`E longitude, elevation 6 m.

The trees planted in square system of four meters (260 trees/feddan), irrigated via surface irrigation and subjected to common horticultural practices at this region. The initial soil physical and chemical characters and moisture constant of the experimental site and chemical analysis of organic manures were determined according to the standard methods described by (Black, 1983 and Kulte, 1986). The data of tested soil and organic manures are shown in Table (2a-c).

The experiment was arranged as split plot in randomized complete block design, each treatment was replicated three times with two trees per each. The main plots were assigned to three irrigation regimes i.e. irrigated at 70% (I_1), 50% (I_2) and 30% (I_3) of available soil water (AW), while the subplots were assigned to seven fertilization treatments representing partial or total replacing mineral nitrogen fertilizer by organic (cattle or chicken) manures.

Table (2a):Some initial chemical and physical characters of the studied soil sample

Soil variable	Soil depth (cm) 0-30	Soil depth (cm) 30-60
pH value	7.9	7.8
EC (dS/m)	1.94	2.32
SAR	7.91	8.15
OM (%)	1.56	1.23
$CaCO_3$	3.61	3.82
Porosity %	46.70	42.21
Soluble cations (meq/L)		
Na^+	12.62	14.20
K^+	0.46	0.55
Ca^{++}	4.04	4.76
Mg^{++}	2.22	4.92
Soluble anions (meq/L)		
Cl^-	8.82	11.15
HCO_3^-	3.54	5.12
CO_3^{--}	0.00	0.00
SO_4^{--}	6.98	8.16
Particle size distribution		
Sand	22.84	23.41
Silt	28.17	26.36
Clay	48.99	50.23
Textural grade	Clay	Clay

OM= Organic matter

Table (2b):Soil moisture constant for the experimental site.

Soil depth (cm)	Field capacity (%)	Permanent wilting point %	Available water %	Bulk density (g/cm^3)
0-15	45.19	23.64	21.55	1.16
15-30	41.36	21.66	19.70	1.29
30-45	38.48	19.85	18.63	1.34
45-60	36.41	18.92	17.49	1.40
Average	40.36	21.02	19.34	1.30

Table (2c):Some chemical analysis of the used organic manures.

Variable	Cattle manure	Chicken manure
pH	7.52	7.22
EC (dS/m)	4.62	3.45
OM %	39.62	42.58
OC%	23.03	24.76
C/N ratio	12.87	10.76
$CaCO_3$%	1.22	2.41
N%	1.80	2.30
P%	0.32	0.78
K%	1.25	1.51
Fe (ppm)	372.38	445.63
Mn (ppm)	291.18	216.81
Zn (ppm)	143.52	262.34

OM = Organic matter OC = Organic carbon

Amount of irrigation water applied for each treatment was determined according to soil moisture content in the soil sample taken from consecutive depth of 15 cm down to depth of 60 cm even before irrigation at (70%, 50% and 30% of available soil water) to reach its field capacity with 3230, 2851 and 2652 m^3/fed/season, distributed on 17, 9 and 6 irrigations, respectively as presented in Table (3).

Submerged orifice with fixed dimensions was used to measure the amount of applied water as the following equation of Michael (1978).

$$Q = CA\sqrt{2gh}$$

Where:
Q=Discharge through orifice (L/sec.)
C=Coefficient of discharge (0.61).
A=Cross section area of the orifice (cm^2).
g=Acceleration due to gravity, cm/sec.^{2} (981 cm/sec^2).
h=Pressure head, over the orifice center (cm).

Table (3): The quantity of irrigation water applied (m^3/feddan) in the different irrigation treatments during each growing season.

Irrigation treatments	Irrigation number	Amount of each irriga. Water		Water applied m^3/fed./season
		Depth, cm	m^3/fed.	
70% available soil water	17	4.524	190.0	3230
50% available soil water	9	7.543	316.8	2851
30% available soil water	6	10.421	438.7	2652

The fertilization treatments representing various levels of nitrogen fertilization (inorganic and organic). Each fertilization treatment had under the same recommended nitrogen level of 400 g N/tree/season according to MALR (2003).

The mineral nitrogen fertilizer (inorganic N source) was added in the form of ammonium nitrate, NH_4NO_3 (33.5% N) at three unequal doses 40% at growing start (1st week of March, 30% after fruit setting in April, and 30% at one month later in May of each season. Meanwhile, organic-N was applied as cattle (1.8N%) or chicken (2.3% N) manures taken from the same farm added superficially and mixed into the root zone under shedding of the tree canopy once in mid-December of each season. The application of these fertilizers were arranged as follows:

F_1: 100% mineral N fertilizer (1200 g per tree ammonium nitrate 33.5% N) = 400 g N per tree as the recommended dose (MALR, 2003).

F_2: 50% cattle manure (11.11 kg per tree) + 50% mineral N fertilizer (600 g per tree ammonium nitrate 33.5%N).

F_3: 75% cattle manure (16.67 kg per tree) + 25% mineral N fertilizer (300 g per tree ammonium nitrate 33.5%N).

F_4: 100% cattle manure (22.22 kg per tree) + zero mineral N fertilizer.

F_5: 50% chicken manure (8.70 kg per tree) + 50% mineral N fertilizer (600 g per tree ammonium nitrate 33.5%N).

F_6: 75% chicken manure (13.05 kg per tree) + 25% mineral N fertilizer (300 g per tree ammonium nitrate 33.5%N).

F_7: 100% chicken manure (17.40 kg per tree) + zero mineral N fertilizer.

P and K fertilizers were applied at constant rates for all experimental trees i.e. 0.750 kg calcium super phosphate (15.5% P_2O_5) + 0.45 kg potassium sulfate (48% K_2O)/tree/season.

Measurements and determinations:

1.Estimating fruit set and preharvest fruit drop percentages:

On April 8th fruit set% was estimated by counting the total number of flowers and fruits which was developed on the selected main branches (four-year old). The number of preharvest dropped fruits was recorded at June drop, then the percentage of preharvest fruit drop (as an average) was calculated in ratio to the total number of fruits harvested per tree.

2.Yield and fruit quality:

At harvest time (June, 23rd and June 25th) in 2012 and 2013 seasons, respectively yield as number of fruits and weight (kg) per tree were recorded, then total yield (ton/fed) was calculated. Ten mature fruits were calculated at random to determine fruit weight (g), volume (cm^3), dimensions (cm), fruit firmness (Lb/in^2) and skin colour % visually. Juice samples were prepared to determine total soluble solids (TSS) by using galliles hand refractometer and total titratable acidity % as malic acid (A.O.A.C., 1990). Nitrate (NO_3^-) and nitrite (NO_2^-) contents as ppm in the juice were determined according to method that outlined by Sen and Donaldson (1978). Anthocynanin pigments content in fruit skin µg/cm^2 were determined colourimetrically according to Ranganna (1979).

3. Some water relations:

a. Water consumptive use (CU):

Soil moisture content was determined (on weight basis) before and after each irrigation to calculate water consumptive use (CU) or actual evapotranspiration (ETa) basis on soil moisture depletion by using the following equation according to Hansen *et al.* (1979).

$$CU = \sum_{i=1}^{i-4} Di \text{ x } D_{bi} \text{ x } \frac{Pw_2 - Pw_1}{100}$$

Where:

CU =Water consumptive use (cm) in the effective depth (60 cm).

Di =Soil layer depth (15 cm each)

Dbi =Soil bulk density (g/cm^2) for this depth.

P_{w1} =Soil moisture percentage before irrigation

P_{w2} =Soil moisture percentage, 48 hours after irrigation

i =Number of soil layer (each 15 cm depth)

b. Water use efficiency (WUE):

Water use efficiency (WUE) or water productivity (PW) was computed according to the following equation described by Ali *et al.* (2007):

$$WUE = \frac{Y}{CU}$$

Where:

WUE =Water use efficiency (kg/m^3)

Y =Yield (kg/fed.)

CU =Water consumptive use (m^3/fed.)

c. Productivity of irrigation water (PIW):

Productivity of irrigation water (PIW) was estimated according to Ali *et al.* (2007) as follow:

$$PIW = \frac{Y}{IWa}$$

Where:

PIW =Productivity of irrigation water (kg/m^3)

Y =Yield (kg/fed.)

IWa =Irrigation water applied (m^3/fed.)

Data were statistically analyzed according to Snedecor and Cochran (1990) and LSD test at a level of 0.05 was used for comparing among averages.

RESULTS AND DISCUSSION

1.Fruit setting and preharvest fruit dropping:

Data listed in Table (4) clearly show that percentages of fruit set and preharvest fruit drop were significantly influenced by irrigation and organic fertilization treatments and their interaction in the two seasons. Increasing irrigation rate from 30% to 50% or 70% of (AW) markedly increased fruit set percentage. The difference between 50% AW (I_2) and 70% AW (I_1) was insignificant. On the contrary, preharvest fruit drop percentage was decreased as the level of irrigation was increased. So, under deficit irrigation regime 30% AW (I_3), lowest fruit set % and highest preharvest fruit drop % were recorded. These results could be attributed to lower photosynthetic rate under drought conditions (Mpelasoka *et al*., 2001). These findings are in harmony with those obtained by George and Nissem (2002), Mikhael and Mady (2007) and Fallahi *et al*. (2010) on apple and El-Abd *et al*. (2012) on orange who concluded that, as the severity of drought increased fruit set was reduced but preharvest fruit drop was increased. With respect to the effect of organic fertilization treatments, the obtained data indicated that highest fruit set percentages were recorded with tree received mixed organic and mineral nitrogen fertilizers 50% cattle or chicken manure plus 50% mineral fertilizer (F_2 & F_5) followed by 75% cattle or chicken manure plus 25% mineral fertilizer (F_3 & F_6) treatments compared to other trees received 100% mineral fertilizer (F_1), or 100% cattle or chicken manures (F_4 & F_7) which recorded the least percentages. However, the least significant preharvest fruit drop percentages were obtained by trees fertilized with F_2 (50% cattle manure plus 50% mineral N fertilizer) and F_5 (50% chicken manure plus 50% mineral N fertilizer) were as the highest percentages belonged to trees treated with mineral fertilizer alone. Other treatments show the intermediate values in the two seasons. The positive effect of organic manure on increasing fruit set and reducing fruit drop might be due to enhancing root growth and increasing the absorption of nutrients especially Ca^{++} via roots. These results are in complete agreement with those of Abd El-Salam *et al*. (2009) who mentioned that the combination of mineral nitrogen with organic fertilizer increased fruit set% but decreased preharvest fruit drop% of Washington Navel orange. Moreover, Mansour *et al*. (2007) pointed out that, application of mineral, organic and bioforms of N together was significantly accompanied with reducing preharvest fruit dropping% of "Anna" apple trees compared to using N as 100% mineral source. However, the interaction (I x F) was significant in the two seasons and the best interactions were (I_1 x F_2), (I_1 x F_5), (I_2 x F_2) and (I_2 x F_5) which gave the highest fruit set and least preharvest fruit drop percentage as shown in Table (4).

2.Yield:

a.Number of fruits per tree:

Data obtained in Table (4) revealed that number of fruits per "Anna" apple tree was gradually increased by irrigation rate increase and the highest number of fruits was produced by (I_1) while the least number was obtained under deficit irrigation regime. Such results could be attributed to the role of irrigation in increasing fruit set and reducing preharvest fruit drop. Similar results were obtained by Mikhael and Mady (2007) on apple and Moursi and Abo El-Enien (2015) on Navel orange. The data also exhibited no significant reduction in number of fruits per tree when half of recommended N dose was applied in organic source (F_2 & F_5) 50% cattle or chicken manure + 50% mineral fertilizer as compared to the use of mineral fertilizer alone. Meanwhile, added organic manures (cattle or chicken) alone greatly decreased number of fruits per tree in both seasons. Such findings are in harmony with those of Abd El-Salam *et al*. (2009) on "Navel" orange trees. The interaction was significant and the highest number of fruits per tree obtained by (I_1 x F_1), (I_1 x F_2), (I_1 x F_5), (I_2 x F_1), (I_2 x F_2) and (I_2 and F_5) without any significant differences among them while the least number of fruits recorded with (I_3 x F_3) and (I_3 x F_7) interactions.

b.Yield (kg/tree) and total yield (ton/fed.):

As shown in Table (4), yield (kg/tree) and total yield (ton/fed.) of "Anna" apple trees were gradually decreased by reducing irrigation level from 70 to 30% of AW. The maximum significant yield were fruited by trees received the high rate of irrigation 70% AW descendingly followed by treated with 50% AW, while the minimum values were produced under deficit irrigation one 30% AW in both seasons. These findings might be due to the role of irrigation in increasing number of fruits per tree and improving average fruit weight. Such results are in line with those obtained by Naor *et al*. (1997) on apple, Abd El-Samad *et al*. (2006) on pear, Ibrahim and Abd El-Samad (2009) on pomegranate and Mikhael *et al*. (2010) on peach who concluded that great reduction in fruit yield was noticed in deficit irrigation regime compared with the wet treatment. Moreover, yield as (kg/tree) and total yield (ton/fed.) was significantly affected by fertilization levels. The highest values were obtained when applied 50% chicken or cattle manure plus 50% mineral fertilizer (F_5 and F_2) followed by adding 100% mineral fertilizer F_1 while the least values belonged to fertilized with 100% cattle or chicken manures (F_5 and F_7) in both seasons. The positive action of different N sources on growth and nutritional status could result in enhancing the yield. The effect of them in increasing fruit set and reducing preharvest fruit drop could give another explanation. Similar conclusion was also achieved by Mansour *et al*. (2007) and Mikhael and Mady (2007) on apple, Garhwal *et al*. (2014) on mandarin, El-Wasfy and Abd El-Rahman (2014) on date palm and Wassal *et al*. (2015) on fig. Meanwhile, the interaction was significant in the two seasons and the highest yield (kg/tree) and (ton/fed.) were produced when "Anna" apple trees were grown under 70 or 50% of available soil water and received 50% cattle or chicken manure with half the recommended dose of mineral nitrogen fertilizer (I_1 x F_2), (I_1 x F_5), (I_2 x F_2) and/or (I_2 x F_5) combination treatments without significant differences among them. While, trees subjected under severe water stress (30% AW) and fertilized by 100% cattle or chicken manure in (I_3 x F_4) or (I_3 x F_7) interaction gave the least significant values of yield.

Table (4): Fruit set, preharvest fruit drop and yield of "Anna" apple trees as influenced by irrigation and organic fertilization treatments and their interaction during 2012 and 2013 seasons.

Treatments Irrigation regime (I)	Fert. (F)	Fruit set %*		Preharvest fruit drop (%)		Yield: No. of fruits/tree		kg/tree		ton/fed	
		2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
	F_1	20.84	21.19	10.46	9.91	201	206	32.48	34.49	8.44	8.97
	F_2	26.65	26.85	7.33	6.69	200	207	33.96	36.49	8.83	9.49
	F_3	25.18	25.60	7.92	7.32	196	202	30.14	31.57	7.84	8.21
I_1	F_4	21.59	21.96	9.74	9.15	192	199	27.14	29.29	7.06	7.61
	F_5	26.32	26.69	7.65	7.14	198	205	34.76	36.60	9.04	9.52
	F_6	24.83	25.23	8.52	8.15	198	203	30.94	32.77	8.04	8.52
	F_7	21.05	21.51	9.81	9.24	194	200	28.13	30.49	7.32	7.93
Average		23.78	24.15	8.78	8.23	197	203	31.08	33.10	8.08	8.61
	F_1	17.79	18.17	12.58	11.94	197	203	30.17	32.23	7.84	8.38
	F_2	23.45	23.75	9.34	8.81	204	207	33.10	35.05	8.61	9.11
	F_3	22.05	22.45	10.07	9.46	183	188	26.64	27.90	6.93	7.25
I_2	F_4	18.41	18.84	11.90	11.39	176	183	23.53	25.64	6.12	6.67
	F_5	23.18	23.64	9.79	9.28	198	207	33.32	35.57	8.66	9.25
	F_6	21.70	22.03	10.63	10.27	184	191	27.33	29.24	7.11	7.60
	F_7	17.92	18.31	11.94	11.46	177	185	24.37	26.66	6.34	6.93
Average		20.64	21.03	10.89	10.37	188	195	28.35	30.33	7.37	7.88
	F_1	15.31	15.90	14.33	13.79	183	189	26.34	27.74	6.85	7.21
	F_2	21.03	21.97	10.08	9.41	173	180	25.98	28.15	6.75	7.32
	F_3	19.65	20.38	12.19	11.24	165	171	21.72	23.47	5.65	7.10
I_3	F_4	15.97	16.85	13.67	13.18	154	162	18.56	20.93	4.83	5.44
	F_5	20.73	21.42	11.57	11.15	175	183	27.60	29.37	7.18	7.64
	F_6	19.34	20.36	12.41	11.94	168	176	22.51	24.70	5.85	6.42
	F_7	15.36	16.12	13.81	13.23	159	167	20.27	22.04	5.27	5.73
Average		18.20	19.00	12.58	11.99	168	175	23.28	25.20	6.05	6.69
	F_1	17.98	18.42	12.46	11.88	194	199	29.66	31.49	7.71	8.19
	F_2	23.71	24.19	8.92	8.30	192	198	31.01	33.23	8.06	8.64
	F_3	22.29	22.81	10.06	9.34	181	187	26.17	27.65	6.81	7.52
Average	F_4	18.66	19.22	11.77	11.24	174	183	23.08	25.29	6.00	6.57
	F_5	23.41	23.92	9.67	9.19	190	198	31.89	33.85	8.29	8.80
	F_6	21.96	22.54	10.52	10.12	183	190	26.93	28.90	7.00	7.51
	F_7	18.11	18.65	11.85	11.31	177	184	24.26	26.40	6.31	6.86
	I	3.831	3.228	0.650	0.183	8.6	6.3	0.686	0.899	0.163	0.739
LSD 0.05	F	1.798	2.848	0.614	0.364	7.0	5.1	1.237	1.580	0.347	0.411
	I x F	3.113	4.932	1.064	0.631	12.2	8.9	2.142	2.737	0.602	0.712

I_1, I_2 and I_3 : Irrigation at 70, 50 and 30% of available water (AW), respectively.
F_1 : 100% mineral N
F_2 : 50% organic N (cattle manure) plus 50% mineral N
F_3 : 75% organic N (cattle manure) plus 25% mineral N
F_4 : 100% organic N (cattle manure)
F_5 : 50% organic N (chicken manure) plus 50% mineral N
F_6 : 75% organic N (chicken manure) plus 25% mineral N
F_7 : 100% organic N (chicken manure)
*** Fruit set % in April 8th**

Conclusively (I_2 x F_2) and (I_2 x F_5) were considered the best combination treatments for improving productivity of "Anna" apple trees (33.10 & 35.05 kg/tree) and (33.32 & 35.57 kg/tree) in 2012 and 2013 seasons, respectively.

3.Physical and chemical fruit properties:

a.Fruit weight, volume and dimensions:

It is obvious from the data in Table (5) that fruit weight (g), volume (cm^3), length and diameter (cm) were significantly increased by raising irrigation level and the largest fruits were produced under wet irrigation regime I_1 (70% AW). While, the smallest fruit were obtained under deficit irrigation rate I_3 (30% AW). The reduction in fruit weight and size under deficit soil moisture content could be due to decreasing fruit cell enlargement through reducing fruit trigor early in the season beside, decreased cell water content (Li *et al*., 1989). Moreover, Behbudian *et al*. (1994) mentioned that the reduction in fruit size under drought conditions could be due to assimilate availability through decreased photosynthesis rate (Pn). These findings were supported by those of George and Nissen (2002), Mikhael and Mady (2007) and Fallahi *et al*. (2010) on apple and Moharam and Zaen El-Deen (2011) on peach who concluded that fruit weight and size were markedly increased by irrigation.

Concerning the effect of organic manures, data presented in Table (5) revealed significant influence in fruit weight, volume and dimensions of "Anna" apple due to fertilization of organic manures. The heaviest and largest fruits were obtained by applying nitrogen requirements as 50% cattle or chicken manure + 50% mineral fertilizer followed by application of mineral fertilizer alone (100%). Otherwise, increasing the ratio of organic manure more than 50% reduced fruit weight and size. The highest and smallest fruits were produced by trees fertilized with organic manure alone (F_3 & F_7) in both seasons. These results are in accordance with those reported by Ibrahim and Abd El-Samad (2009) on pomegranate, El-Khawaga (2011) on peach and Garhwal *et al*. (2014) on mandarin who indicated that application of organic manure significantly improved fruit weight and size. However, the interaction (I x F) was significant in both seasons and the maximum fruit weight, volume and dimensions came from (I_1 x F_2), (I_1 x F_5), (I_2 x F_2) and (I_2 x F_5) without significant differences among them, whereas the minimum values produced by (I_3 x F_4) and (I_3 x F_7) interactions.

Table (5)Some physical properties* of "Anna" apple fruits as influenced by irrigation and organic fertilization treatments and their interaction during 2012 and 2013 seasons.

Treatments Irrigation regime (I)	Fert. (F)	Av. fruit weight (g)		Av. fruit volume (cm^3)		Fruit length (cm)		Fruit diameter (cm)		Fruit firmness (lb/in^2)	
		2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
	F_1	161.56	167.42	164.6	169.8	7.91	7.95	7.39	7.42	8.04	7.86
	F_2	169.85	176.30	172.7	178.9	7.97	8.07	7.44	7.54	8.93	8.82
	F_3	153.77	155.93	156.1	158.1	7.44	7.47	6.99	7.04	9.22	9.15
I_1	F_4	141.32	147.19	143.7	149.5	7.02	7.09	6.69	6.73	9.76	9.65
	F_5	175.51	178.52	177.8	181.5	8.12	8.17	7.60	7.64	9.12	8.95
	F_6	156.29	161.44	159.1	164.0	7.49	7.59	7.07	7.23	9.41	9.32
	F_7	145.13	152.45	147.6	154.6	7.11	7.19	6.77	6.69	10.02	9.87
Average		157.63	162.75	160.2	165.2	7.58	7.65	7.14	7.18	9.21	9.09
	F_1	153.16	158.71	155.2	160.6	7.59	7.67	7.09	7.17	9.37	9.28
	F_2	162.26	169.28	164.5	171.7	7.85	7.91	7.34	7.39	10.38	10.32
	F_3	145.18	148.39	147.4	150.6	7.12	7.18	6.72	6.75	10.73	10.64
I_2	F_4	133.79	140.15	136.1	142.5	6.71	6.82	6.27	6.44	11.21	11.12
	F_5	168.32	171.82	171.0	174.4	7.94	8.01	7.42	7.49	10.53	10.41
	F_6	148.46	153.25	150.7	155.7	7.22	7.37	6.75	6.89	10.91	10.81
	F_7	137.61	144.11	140.1	146.8	6.79	6.87	6.47	6.54	11.42	11.29
Average		149.83	155.10	152.1	157.5	7.32	7.40	6.87	6.95	10.71	10.55
	F_1	143.87	146.71	145.7	148.5	7.07	7.34	6.65	6.87	10.43	10.44
	F_2	150.02	156.38	151.2	158.6	7.61	7.65	7.19	7.22	11.64	11.49
	F_3	131.75	137.21	133.9	139.3	6.59	6.77	6.20	6.28	12.01	11.88
I_3	F_4	120.44	129.39	122.2	131.5	6.22	6.24	5.67	5.89	12.45	12.29
	F_5	157.80	160.41	160.3	162.3	7.53	7.58	7.05	7.08	11.77	11.72
	F_6	133.84	140.40	135.9	142.6	6.83	6.96	6.44	6.57	12.05	11.97
	F_7	127.51	132.05	129.8	134.3	6.38	6.41	5.96	5.99	12.56	12.50
Average		137.89	143.22	139.9	145.3	6.89	6.99	6.45	6.56	11.84	11.76
	F_1	152.86	157.61	155.2	159.6	7.52	7.65	7.04	7.15	9.28	9.19
	F_2	160.71	167.32	162.8	169.7	7.72	7.88	7.32	7.38	10.32	10.21
	F_3	143.57	147.18	145.8	149.3	7.05	7.14	6.64	6.69	10.65	10.56
Average	F_4	131.85	138.91	134.0	141.2	6.65	6.72	6.21	6.35	11.14	11.02
	F_5	167.21	170.25	169.7	172.7	7.86	7.92	7.39	7.40	10.47	10.36
	F_6	146.20	151.70	148.6	154.1	7.18	7.31	6.75	6.90	10.79	10.70
	F_7	136.75	142.87	139.2	145.2	6.76	6.82	6.40	6.41	11.33	11.22
	I	5.290	3.289	4.815	8.106	0.311	0.238	0.146	0.762	0.259	0.163
LSD 0.05	F	4.420	6.094	4.639	7.966	0.321	0.803	0.113	0.324	0.279	0.096
	I x F	7.656	10.550	8.035	13.800	0.557	1.390	0.196	0.562	0.483	0.166

I_1, I_2 and I_3 : Irrigation at 70, 50 and 30% of available water (AW), respectively.
F_1 : 100% mineral N
F_2 : 50% organic N (cattle manure) plus 50% mineral N **F_5 : 50% organic N (chicken manure) plus 50% mineral N**
F_3 : 75% organic N (cattle manure) plus 25% mineral N **F_6 : 75% organic N (chicken manure) plus 25% mineral N**
F_4 : 100% organic N (cattle manure) **F_7 : 100% organic N (chicken manure)**
*** At harvest time (June 23rd and June 25th) in 2012 ad 2013 seasons.**

b. Fruit firmness:

As shown in Table (5), it is clear that, reducing irrigation level and increasing rate of organic manures led to an increase in fruit firmness. The differences were significant in both seasons. However, the interaction (I x F) was significant in 2012 and 2013 seasons and the firm fruits were achieved by (I_3 x F_3), (I_3 x F_4), (I_3 x F_6) and (I_3 x F_7) while the control (I_1 x F_1) gave less fruit firmness. The reduction in fruit firmness might be due to increasing fruit volume and reducing calcium concentration as influenced by irrigation and fertilizers application. These results coincided with those obtained by Mikhael *et al*. (2010) who reported that deficit irrigation regime induced significantly higher fruit firmness. Furthermore, Salama *et al*. (2012) concluded that the values of fruit firmness of Sewy date fruit were increased when 100% of nitrogen was applied completely via organic form compared to added 100% mineral nitrogen fertilizer.

c.Total soluble solids and total acidity percentage:

Data in Table (6) revealed that fertilization of "Anna" apple trees with recommended rate of N via 50 to 100% organic manure (cattle or chicken) gradually increased total soluble content % compared to using N completely via inorganic source. Maximum values were recorded with application of cattle or chicken manure alone with (13.31 & 13.46) or (13.51 & 13.69), in 2012 and 2013 seasons, respectively. Meanwhile, the lowest significant values were recorded with 100% mineral fertilizer (11.89 & 12.0) in 2012 and 2013 seasons. The advancing effect on ripening of organic manures could explain the present results. Similar observations were also achieved by Selem and Telep (2008) and Shahean *et al*. (2013) on grapevine, Mansour *et al*. (2007) on apple and Wassel *et al*. (2015) on fig who mentioned that promotion of fruit quality in terms of increasing TSS was associated with decreasing the percentage of mineral nitrogen fertilizer and in the meantime increasing the percentage of organic N form in the fertilization program. The data also indicated that, there was a progressively increase in fruit TSS content with increasing the rate of irrigation from 30% to 70% AW in 1st and 2nd seasons. These findings might be due to advance fruit maturity under drought condition. These results are in accordance with those of Mikhael *et al*. (2010) who found that the values of soluble solids content (SSC) in fruits of "Dessert Red" peach trees increase by decreasing the level of irrigation regime from 80% to 60% field capacity (FC). Other wise, Kaya *et al*. (2010) noticed that there were no significant differences for the tested irrigation regimes in total soluble content of apricot fruit. However, the interaction (I x F) was significant in the two seasons and the highest values recorded with (I_3 x F_7) and (I_3 x F_4) in both seasons.

Data of Table (6) exhibited that, total acidity was not significantly influenced by all the tested irrigation and fertilization treatments and their interaction in both seasons. Similar results were also obtained by Mikhael and Mady (2007) and Kaya *et al*. (2010) on irrigation apple and apricot trees and Abd El-Migeed *et al*.(2007) on organic fertilization of Navel orange trees.

d.Nitrate and nitrite content:

From the data presented in Table (6), it could be concluded that nitrate and nitrite contents in "Anna" apple fruit juice were significantly decreased by different cattle or chicken manure treatments in the two seasons of study comparing with 100% mineral N fertilizer. This means that replacing partially or completely through using 50, 75 and 100% N as cattle or chicken manure instead of 100% mineral N had a beneficial effect on reducing nitrate and nitrite in fruit juice. This result could be described that using organic materials are often considered as a desirable nitrogen source because the nitrogen is in the mineralization immobilization cycle longer and thus is more slow available (Hallberg and Keeriey, 1993). Furthermore, the addition of organic manure as slow release for N resulted in a further reduction in NO_3 accumulation in the plant in comparison with mineral nitrogen as fast release for N (El-Sisy, 2000). Such results are in harmony with those obtained by Abd El-Migeed *et al*. (2007) on Navel orange, Salama *et al*. (2012) on date palm and Abd El-Monem *et al*. (2008) and Shaheen *et al*. (2013) on grapevine. They concluded that nitrate and nitrite content of fruits were significantly reduced by decreased the amount of N mineral fertilizer.

Data also revealed that, nitrate and nitrite content were not significantly affected by all tested irrigation treatments used in this study in both seasons. The interaction (I x F) was significant in 2012 and 2013 seasons and the highest values of NO_3 and NO_2 (ppm) in fruit juice were detected when 100% mineral fertilizer was applied to soil irrigated at 30% AW (I_3 x F_1). Meanwhile, these values were decreased with partial or complete substitution of mineral fertilizer by organic manure under high irrigation regime (70% AW) and the minimum values came from (I_1 x F_4) or (I_1 x F_7) interaction in both seasons.

e.Fruit color:

With respect to the impact of irrigation regimes and fertilization treatments and their interaction on red color % and skin anthocyanin content of "Anna" apple fruit, the data of 2102 and 2013 seasons tabulated in Table (6) and illustrated in Fig. (1) revealed that, the percent of red color and the values of anthocyanin content in apple fruit skin were increased by reducing irrigation regime and increasing application rate of organic manures. The interaction was significant during the two seasons and the highest values recorded with (I_2 x F_2) and (I_2 x F_5) without significant difference between them in both seasons. While, the control (I_1 x F_1) obtained the least values. These results might be attributed to the positive action of organic application and moderate irrigation regime in the improving of biosynthesis of carbohydrate and accelerating fruit ripening (Mansour *et al*., 2007). These findings confirmed with those achieved by Shahien *et al*. (2002) on "Anna" apple and Mikhael *et al*. (2010) on "Dessert Red" peach indicated that, trees under deficit irrigation regime had significantly highest concentration of anthocyanin in fruit skin and higher percent of fruit color. Moreover, Masoud (2012) mentioned that fertilizing "Flame seedless" and "Ruby seedless" grapevines by organic fertilizer (compost) either alone or in combination with mineral N fertilizer significantly increased anthocyanin content in berry juice.

Generally, replacing mineral nitrogen by organic manures significantly improved the chemical properties of apple fruit in terms of increased TSS, slightly reduced the total acidity, reduced nitrate and nitrite content and increased anthocyanin content in fruit skin.

Table (6):Some chemical properties* of “Anna” apple fruits as influenced by irrigation and organic fertilization treatments and their interaction during in 2012 and 2013 seasons.

Treatments Irrigation regime (I)	Fert. (F)	TSS (%) 2012	TSS (%) 2013	Acidity (%) 2012	Acidity (%) 2013	Nitrate (ppm) 2012	Nitrate (ppm) 2013	Nitrite (ppm) 2012	Nitrite (ppm) 2013	Skin anthocyanine content (μg/cm^2) 2012	Skin anthocyanine content (μg/cm^2) 2013
I1	F_1	11.40	11.33	0.58	0.56	39.2	35.6	2.04	1.92	12.76	13.74
	F_2	12.07	12.40	0.54	0.53	27.8	23.9	1.06	0.98	12.81	14.38
	F_3	12.27	12.67	0.52	0.49	22.7	18.5	0.85	0.69	14.95	15.38
	F_4	12.80	12.93	0.50	0.48	17.9	15.7	0.62	0.52	15.42	16.74
	F_5	12.20	12.13	0.53	0.50	30.5	24.2	1.32	1.22	13.76	14.47
	F_6	12.47	12.87	0.49	0.47	26.2	22.4	0.94	0.78	15.83	15.71
	F_7	12.93	13.07	0.47	0.44	19.2	14.8	0.72	0.56	16.39	17.13
Average		12.31	12.49	0.52	0.50	26.2	22.2	1.08	0.95	14.56	15.36
I_2	F_1	11.93	12.13	0.55	0.51	43.6	35.9	1.98	1.89	13.92	14.76
	F_2	12.73	12.67	0.51	0.50	29.1	24.6	1.02	0.96	17.25	17.46
	F_3	13.07	13.20	0.48	0.46	23.9	21.2	0.79	0.70	16.69	16.98
	F_4	13.40	13.53	0.46	0.42	18.4	16.3	0.62	0.51	16.95	17.21
	F_5	12.87	13.07	0.49	0.47	28.6	24.9	1.26	1.15	17.36	17.51
	F_6	13.33	13.40	0.46	0.46	25.1	20.1	0.91	0.76	16.96	17.06
	F_7	13.67	13.80	0.45	0.42	19.8	16.7	0.70	0.54	16.85	17.29
Average		13.00	13.11	0.49	0.46	26.9	22.8	1.04	0.93	16.57	16.90
I_3	F_1	12.33	12.53	0.49	0.47	44.2	37.4	1.95	1.84	14.90	15.54
	F_2	13.27	13.13	0.46	0.44	27.5	24.1	0.97	0.94	17.19	17.21
	F_3	13.47	13.40	0.44	0.43	24.5	22.4	0.78	0.65	17.05	17.26
	F_4	13.73	13.93	0.45	0.41	18.3	15.4	0.59	0.48	17.12	17.38
	F_5	13.33	13.47	0.45	0.45	29.7	26.2	1.22	1.12	16.61	17.25
	F_6	13.67	13.73	0.43	0.42	24.9	22.9	0.86	0.72	17.10	17.29
	F_7	13.93	14.20	0.42	0.41	22.5	17.1	0.67	0.50	17.16	17.39
Average		13.39	13.48	0.45	0.43	27.4	23.6	1.01	0.89	16.73	17.05
Average	F_1	11.89	12.00	0.54	0.51	42.3	36.3	1.99	1.88	13.86	14.68
	F_2	12.69	12.73	0.50	0.49	28.1	24.2	1.02	0.96	15.75	16.35
	F_3	12.94	13.09	0.48	0.46	23.7	20.7	0.81	0.68	16.23	16.54
	F_4	13.31	13.46	0.47	0.44	18.2	15.8	0.61	0.50	16.50	17.11
	F_5	12.80	12.89	0.49	0.47	29.6	25.1	1.27	1.16	15.91	16.41
	F_6	13.16	13.33	0.46	0.45	25.4	21.8	0.90	0.75	16.63	16.69
	F_7	13.51	13.69	0.44	0.42	20.5	16.2	0.70	0.53	16.80	17.27
LSD 0.05	I	0.073	0.188	NS	NS	NS	NS	NS	NS	0.288	0.291
	F	0.166	0.142	NS	NS	2.93	1.99	0.093	0.072	0.184	0.258
	I x F	0.286	0.246	NS	NS	5.07	3.46	0.161	0.125	0.319	0.447

I_1, I_2 and I_3 : Irrigation at 70, 50 and 30% of available water (AW), respectively.
F_1 :100% mineral N
F_2 : 50% organic N (cattle manure) plus 50% mineral N
F_3 : 75% organic N (cattle manure) plus 25% mineral N
F_4 : 100% organic N (cattle manure)
F_5 : 50% organic N (chicken manure) plus 50% mineral N
F_6 : 75% organic N (chicken manure) plus 25% mineral N
F_7 :100% organic N (chicken manure)
*** At harvest time (June 23rd and June 25th) in 2012 ad 2013 seasons.**

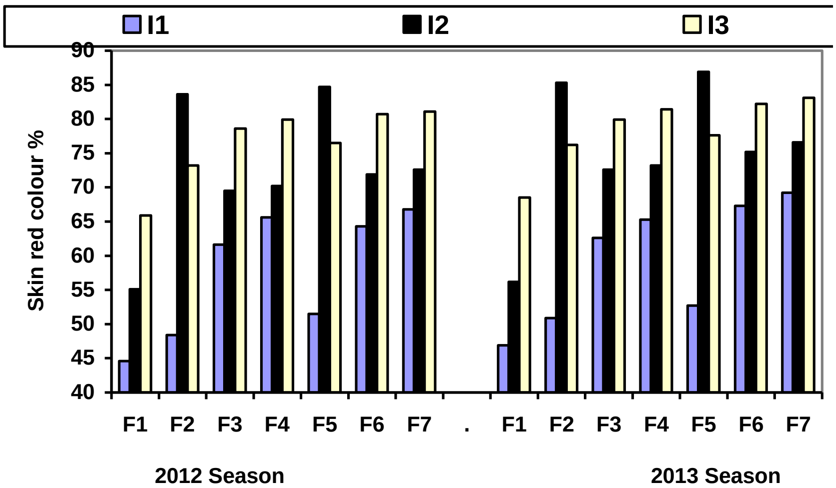

Fig. (1): Skin red colour % of “Anna” apple fruits as influenced by irrigation regime and organic fertilization during 2012 and 2013 seasons.

I_1, I_2 and I_3 : Irrigation at 70, 50 and 30% of available water (AW), respectively.
F_1 : 100% mineral N
F_2 : 50% organic N (cattle manure) plus 50% mineral N
F_3 : 75% organic N (cattle manure) plus 25% mineral N
F_4 : 100% organic N (cattle manure)
F_5 : 50% organic N (chicken manure) plus 50% mineral N
F_6 : 75% organic N (chicken manure) plus 25% mineral N
F_7 : 100% organic N (chicken manure)

Conclusively, irrigated "Anna" apple trees with moderate irrigation rate under soil application with 50% cattle or chicken manure plus 50% mineral nitrogen in (I_2 x F_2) and/or (I_2 x F_5) combination treatments was considered the suitable one. This treatment no only increased productivity of "Anna" apple trees but also improved fruit quality, especially fruit weight, volume and color as well as increasing TSS and reducing nitrate and nitrite content beside saving irrigation water.

4.Some water relations:

a.Water consumptive use (CU):

Data obtained in Table (7) indicated that water consumptive use (CU) of apple trees (m^3/fed) was significantly influenced by irrigation regime, organic manure and their interaction in both seasons. It decreased by decreasing irrigation rate. The maximum values of seasonal consumptive use (UC) was obtained with high irrigation level I_1 with (2293.8 & 2296.6 m^3/fed/year), while minimum values belonged to deficit irrigation rate with (1650.3 & 1670.8 m^3/fed/year) in 2012 and 2013 seasons, respectively. These results are in harmony with those of Abd El-Samad *et al*. (2006) who found that pear trees which received more frequent irrigation had greater CU than trees received less frequent irrigation under the same conditions of climatic. Similar results were also obtained by Mikhael and Mady (2007) on apple, El-Abd *et al*. (2012) and Moursi and Abo El-Enien (2015) on citrus.

Table (7):Water consumptive use (CU), water use efficiency (WUE) and productivity of irrigation water (PIW) for "Anna" apple trees as influenced by irrigation and organic fertilization treatments and their interaction during 2012 and 2013 seasons.

Treatments Irrigation regime (I)	Fert. (F)	CU (m^3/fed.) 2012	CU (m^3/fed.) 2013	WUE (kg/m^3) 2012	WUE (kg/m^3) 2013	PIW (kg/m^3) 2012	PIW (kg/m^3) 2013
I_1	F_1	2525.9	2535.6	3.34	3.53	2.62	2.78
	F_2	2322.4	2299.8	3.80	4.13	2.73	2.94
	F_3	2254.5	2235.2	3.47	3.67	2.43	2.54
	F_4	2193.2	2257.8	3.22	3.37	2.19	2.36
	F_5	2306.2	2303.0	3.92	4.13	2.80	2.95
	F_6	2245.4	2251.3	3.58	3.78	2.49	2.64
	F_7	2209.3	2193.2	3.31	3.61	2.27	2.45
Average		2293.8	2296.6	3.52	3.75	2.50	2.67
I_2	F_1	2044.2	2106.9	3.84	3.98	2.75	2.94
	F_2	1841.7	1887.4	4.67	4.83	3.02	3.19
	F_3	1821.8	1847.4	3.81	3.93	2.43	2.54
	F_4	1750.5	1787.6	3.50	3.73	2.15	2.34
	F_5	1861.7	1910.2	4.67	4.84	3.04	3.24
	F_6	1844.6	1858.9	3.86	4.09	2.49	2.67
	F_7	1784.7	1807.5	3.56	3.84	2.22	2.43
Average		1849.9	1886.6	3.99	4.18	2.59	2.76
I_3	F_1	1816.6	1869.7	3.77	3.85	2.58	2.72
	F_2	1623.0	1662.8	4.16	4.40	2.55	2.76
	F_3	1601.8	1633.6	3.52	3.68	2.13	2.30
	F_4	1575.3	1567.3	3.06	3.48	1.82	2.05
	F_5	1689.3	1686.7	4.25	4.53	2.71	2.88
	F_6	1652.2	1665.5	3.54	3.86	2.21	2.35
	F_7	1593.8	1609.8	3.30	3.56	1.99	2.16
Average		1650.3	1670.8	3.66	3.91	2.28	2.45
Average	F_1	2128.9	2170.7	3.65	3.79	2.65	2.81
	F_2	1929.0	1950.0	4.21	4.45	2.78	2.96
	F_3	1892.7	1905.4	3.52	3.76	2.33	2.46
	F_4	1839.7	1870.9	3.26	3.53	2.05	2.25
	F_5	1952.4	1966.6	4.28	4.50	2.85	3.02
	F_6	1917.1	1925.2	3.66	3.91	2.40	2.55
	F_7	1862.6	1870.2	3.39	3.67	2.16	2.35
LSD 0.05	I	88.34	66.02	0.117	0.119	0.042	0.151
	F	32.28	57.52	0.211	0.218	0.109	0.210
	I x F	55.92	99.62	0.347	0.378	0.189	0.363

I_1, I_2 and I_3 : Irrigation at 70, 50 and 30% of available water (AW), respectively.

F_1 : 100% mineral N

F_2 : 50% organic N (cattle manure) plus 50% mineral N

F_3 : 75% organic N (cattle manure) plus 25% mineral N

F_4 : 100% organic N (cattle manure)

F_5 : 50% organic N (chicken manure) plus 50% mineral N

F_6 : 75% organic N (chicken manure) plus 25% mineral N

F_7 : 100% organic N (chicken manure)

*** At harvest time (June 23rd and June 25th) in 2012 ad 2013 seasons.**

With regard to the impact of organic manures, the data exhibited significant decrease by raising the application rate of organic manure. In this respect, trees fertilized with all recommended nitrogen via mineral source (F_1) consumed the highest values of water consumptive use (2128.9 & 2170.7 m^3/fed/year) in 1^{st} and 2^{nd} seasons, respectively, while, trees received 100% cattle or chicken manure consumed the least values. These findings are in complete agreement with those obtained by Ibrahium and Abd El-Samad (2009) on pomegranate trees. However, the interaction was significant in the two seasons. Trees irrigated at 70% AW and fertilized by 100% mineral fertilizer (I_1 x F_1) (control) recorded the highest CU values (2525.9 & 2535.6 m^3/fed/year) in first and second seasons, respectively. Meanwhile the least values came from (I_3 x F_4) and/or (I_3 x F_7) interaction (1575.3 & 1567.3 m^3/fed/year) and (1593.8 & 1609.8 m^3/fed/year) in first and second seasons, respectively. Other combination treatments came in-between.

b. Water use efficiency (water productivity) and productivity of irrigation water:

WUE (PI) and PIW values are used to evaluate the effectiveness of irrigation and organic fertilization practices for maximum utilization of water supplies (Table 7).

Water use efficiency (WUE) or water productivity (PI) is a tool for maximizing crop production per unit of consumed water (CU) while, productivity of irrigation water (PIW) is a tool for maximizing crop production per unit of applied water (WA). Tabulated data in Table (7) showed that WUE and PIW of “Anna” apple trees were significantly influenced by irrigation level (I), organic fertilization (F) and their interaction (I x F) in both seasons. The highest significant values were obtained when trees irrigated at 50% AW (moderate irrigation) regime followed by those irrigated at 30% and 70% AW, respectively in both seasons. Similar findings were achieved by Mikhael and Mady (2007) on apple and El-Abd *et al*. (2012) and Moursi and Abo El-Enien (2015) on citrus who indicated a gradual decrease in WUE (PI) and PIW value due to increase the amount of applied water.

As for the effect of fertilization treatments, the present data cleared that, application of 50% cattle or chicken manure (F_2 & F_5) for “Anna” apple trees gave the highest significant values of WUE and PIW without significant differences between them compared to using organic (cattle or chicken) manure or mineral fertilizer alone. These results are supported by the conclusion of Ibrahim and Abd El-Samad (2009) who obtained relative increment in water use efficiency by using organic manures to pomegranate trees due to the positive influence of organic manure on saving water use and improving efficiency of water uptake.

As for the interaction, the data revealed that the interaction was significant in the both seasons of study and the highest values of WUE and PIW [(4.67 & 4.83) and (4.67 & 4.84) kg/m^2] and [(3.02 & 3.19) and (3.04 & 3.24) kg/m^3)] were obtained by (I_2 x F_2) and (I_2 x F_5) in first and second seasons, respectively. Without significant difference between them which considered the best combination treatments for reducing consumptive use (CU) and increasing water use efficiency (WUE) and productivity of irrigation water (PIW).

CONCLUSION

From the above mentioned results, it could be concluded that irrigation “Anna” apple trees grown on clay soil at 50% available soil water (2851 m^3/fed/season) and replacing 50% of mineral nitrogen fertilizer by cattle or chicken manure through adding 11.11 kg cattle manure + 600 g ammonium nitrate/tree/season (I_2 x F_2) or adding 8.70 kg chicken manure + 600 g ammonium nitrate/tree/season (I_2 x F_5) which considered the superior combination treatment under the condition of this study for increasing fruit yield and improving fruit quality, especially fruit weight, volume, color, TSS and reducing nitrate and nitrite content. Beside, decreasing water consumptive use and increasing water use efficiency and productivity of irrigation water.

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تأثير إحلال الأسمدة العضوية محل النيتروجين المعدنى تحت معدلات مختلفة من الرى على:
ب- إنتاجية وكفاءة الاستخدام المائى لأشجار التفاح صنف ""آنا""

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أجرى هذا البحث لدراسة تأثير ثلاث مستويات من الرى عند ٧٠% ، ٥٠% ، ٣٠% من الماء الميسر فى التربة مع سبعة معاملات سمادية تشمل إحلال ٥٠% ، ٧٥% ، ١٠٠% من السماد النيتروجينى المعدنى بسماد الماشيه أو سماد الدواجن العضوى مقارنة بـ ١٠٠% من السماد المعدنى والتفاعل بينهما على إنتاجية وجودة ثمار أشجار التفاح صنف "آنا" المطعومة على أصل المالس والنامية فى التربة الطينية بمركز طنطا بمحافظة الغربية خلال ثلاث مواسم متتالية ٢٠١١ ، ٢٠١٢ ، ٢٠١٣ وتم أخذ النتائج فى موسمى ٢٠١٢ ، ٢٠١٣ فقط.

ويمكن تلخيص النتائج المتحصل عليها كما يلى:

- أوضحت النتائج زيادة محصول أشجار التفاح صنف "آنا" كعدد وكوزن كجم لكل شجرة والمحصول الكلى (طن/فدان) تدريجيا بزيادة معدل الرى من ٣٠% إلى ٧٠% من الماء الميسر فى التربة نتيجة لزيادة النسبة المئوية العقد وانخفاض النسبة المئوية لتساقط الثمار قبل الجمع فى كلا الموسمين.
- أوضحت النتائج أن المعاملة بإضافة ٥٠% من سماد الماشية أو سماد الدواجن +٥٠% من السماد المعدنى (تسميد ٢ أو تسميد ٥) قد أنتجت أعلى محصول كعدد ثمار وكوزن كجم/شجرة والمحصول الكلى طن/فدان يليها المعاملة بإضافة ١٠٠% من السماد المعدنى بينما أقل محصول يتبع التسميد بإضافة ١٠٠% من سماد الماشية أو سماد الدواجن فى كلا من سنتى الدراسة.
- كما أظهرت النتائج أن أشجار التفاح صنف "آنا" النامية تحت معدلات الرى العالية مع إضافة ٥٠% من سماد الماشية أو سماد الدواجن + ٥٠% من السماد المعدنى فى المعاملات المركبة (رى١ × تسميد٢) ، (رى١ × تسميد٥) ، (رى٢ × تسميد٢) ، (رى٢ × تسميد٥) قد أعطت أعلى محصول (كجم/شجرة) و (طن/فدان) مع عدم وجود فروق معنوية بينهم ، بينما الأشجار التى تعرضت للإجهاد المائى بريها عند ٣٠% من الماء الميسر مع إضافة ١٠٠% من سماد الماشية أوسماد الدواجن فى المعاملتين (رى٣ × تسميد ٤) أو (رى٣ × تسميد ٧) قد أعطت أقل قيم فى كلا الموسمين.
- عكست النتائج أن زيادة مستوى الرى قد أدى إلى زيادة معنوية فى وزن وحجم وأبعاد الثمرة ولكن انخفضت صلابة الثمار ومحتواها من المواد الصلبة الذائبة الكلية (TSS) والأنثوسيانين. بينما لم يتاثر محتوى الثمار من النترات والنيتريت بمعاملات الرى فى كلا من سنتى الدراسة.
- أدت المعاملة بإضافة ٥٠% من سماد الماشية أو سماد الدواجن +٥٠% من السماد المعدنى إلى الحصول على أثقل وأكبر ثمار تلتها المعاملة بإضافة السماد المعدنى منفردا بينما المعاملة باستخدام السماد العضوى منفردا أنتجت أخف وأصغر ثمار ، علاوة على ذلك أدى زيادة مستوى السماد العضوى فى البرنامج السمادى إلى تحسن معنوى فى الصفات الكيماوية لثمار التفاح متمثله فى زيادة محتوى الثمار من المواد الصلبة الذائبة الكلية (TSS) والأنثوسيانين وخفض محتواها من النترات والنيتريت.
- أوضحت نتائج كلا الموسمين أن التفاعل بين معاملات الرى والتسميد كان معنويا وأن أكبر الثمار وزنا وحجما وأبعادا تتبع أى من المعاملات المركبة الآتية (رى١ × تسميد٢) ، (رى١ × تسميد٥) ، (رى٢ × تسميد٢) ، (رى٢ × تسميد٥) دون فروق معنوية بينهم ، بينما أقل القيم أنتجتها أى من المعاملتين (رى٣ × تسميد٤) ، (رى٣ × تسميد٧) ، علاوة على ذلك فإن نسبة اللون الأحمر ومحتوى جلد ثمار التفاح من صبغة الأنثوسيانين كان عالى معنويا مع أى من المعاملتين (رى٢ × تسميد٢) ، (رى٢ × تسميد٥) بينما أعطت معاملة الكنترول (رى١ × تسميد١) أقل قيم.
- سجلت معاملة الرى المنخفضة اقل قيم للاستهلاك المائى الموسمى (CU) (م٣) وعلى العكس فإن أعلى القيم تتبع مستوى الرى العالى ، وعلاوة على ذلك فإن معاملة الرى المتوسط عند ٥٠% من الماء الميسر فى التربة قد أعطت أعلى قيم لكفاءة الاستخدام المائى (WUE) وإنتاجية وحدة الماء (PIW) (كجم/م٣).
- كما بينت النتائج أن الأشجار المسمدة بإضافة ١٠٠% سماد الماشية أو الدواجن العضوى قد استهلكت كمية أقل من الماء بينما أعطت الأشجار التى تم ريها عند ٥٠% من الماء الميسر فى التربة اعلى قيم لكفاءة استخدام الماء وإنتاجية وحدة الماء وكان التفاعل بين معاملات التسميد والرى معنويا فى كلا الموسمين وسجلت أى من المعاملتين (رى٢ × تسميد٢) ، (رى٢ × تسميد٥) أعلى قيم لكفاءة الاستخدام المائى وإنتاجية وحدة الماء.

لذلك توصى هذه الدراسة مزارعى التفاح صنف "آنا" برى أشجارهم عند ٥٠% من الماء الميسر فى التربة مع إضافة ٥٠% من سماد الماشية أو سماد الدواجن + ٥٠% من السماد المعدنى فى أى من المعاملتين المركبتين (رى٢ × تسميد٢) ، (رى٢ × تسميد٥) والتى تعتبر أفضل معاملة لإنتاج أعلى محصول مع أفضل صفات جودة بجانب خفض الاستهلاك المائى وزيادة كفاءة الاستخدام المائى وانتاجية وحدة الماء.