J. Plant Production, Mansoura Univ., Vol. 7 (2): 203 - 216, 2016

EFFECT OF REPLACING MINERAL NITROGEN BY ORGANIC MANURES UNDER DIFFERENT IRRIGATION REGIMES ON: A. VEGETATIVE GROWTH AND NUTRITIONAL STATUS OF "ANNA" APPLE TREES

Mikhael, G.B.Y.* and Manal A. Aziz**

*** Deciduous Fruit Trees Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt.**

**** Soil, Water and Environ. Res. Inst., ARC, Giza, Egypt.**

ABSTRACT

This investigation was carried out during three consecutive seasons of 2011, 2012 and 2013 to study the effect of irrigation regime, organic fertilization treatments and their interaction on some soil chemical and physical properties, vegetative growth and nutritional status of "Anna" apple trees budded on Malus root stock grown on clay soil at Tanta district, El-Gharbia Governorate. Results were only taken in 2012 and 2013 seasons. In this respect, three irrigation regimes at 70, 50 and 30% of available soil water (I_1, I_2 and I_3) were used and cattle or chicken organic manures was applied at 0, 50, 75 and 100% combined with mineral N at 100%, 50%, 25% and 0% of the recommended dose of 400 g/tree/year in seven fertilization treatments (F_1-F_7).

The obtained results indicated that, soil physical and chemical properties except for pH and EC were significantly influenced by the tested organic fertilization and irrigation treatments in both seasons. The best results in increasing the percentage of organic matter and organic carbon, total porosity, aggregation parameters and reducing soil bulk density were obtained by increasing the application rate of organic manures up to 100% and using moderate irrigation rate at 50% AW (I_2) compared to high (I_1) or deficit (I_3) irrigation one.

Data of both seasons cleared that, shoot and leaf growth parameters, trunk cross section area-increase as well as average number and fresh weight of fibrous roots were significantly increased with increasing irrigation rate up to 50, 70% AW. However, fertilization of 50% cattle or chicken manure + 50% mineral fertilizer (F_2 or F_5) resulted in the highest significant values of these vegetative growth parameters. The application of (I_1 x F_2), (I_1 x F_5), (I_2 x F_2) and/or (I_2 x F_5) considered to be the best combination treatments for enhancing vegetative growth of "Anna" apple trees.

Obtained data revealed that application of cattle or chicken organic manure alone (F_4 & F_7) significantly increased leaf macro and micro nutrients as well as total chlorophyll contents, but significantly reduced free proline content. Moreover, fertilizing with chicken manure alone surpass of cattle manure alone in enhancing leaf mineral content. On the other hand, reducing irrigation rate up to 30% AW led to a significant reduction in leaf macro and micro-nutrients and total chlorophyll content, while, leaf free proline content was significantly increased in both seasons of study.

The maximum values of N, P, K, Ca, Mg, Fe, Mn, Zn and total chlorophyll content were produced by (I_1 x F_7), (I_1 x F_4) and/or (I_2 x F_7) combination treatments without significant difference among them, while the minimum values recorded with (I_3 x F_1) treatment in both seasons.

Thus, this study recommended "Anna" apple growers to apply 50% cattle or chicken manure + 50% mineral N fertilizer under moderate irrigation regime in (I_2 x F_2) or (I_2 x F_5) which considered to be the best combination treatments for improving the most of soil physical and chemical properties, saving irrigation water with 11.73% and keeping soil moisture content which enhanced top and root system growth and leaf mineral and chlorophyll contents under clay soil conditions. By this treatment organic manures can reduce the need for about 50% of N mineral fertilizers, minimizing both production cost and environmental pollution which could be occurred by excess of chemical fertilizer.

INTRODUCTION

"Anna" apple (*Malus domestica,* Borkh) is an early cultivar has a high productivity and regular bearing, it considered as a hybrid between "Red Hadassya" and "Golden Delicious" (Raid and Olma, 1972). The area cultivated with "Anna" apple trees is progressively increased especially in the last few years in Egypt due to its low chilling requirements (300-350 effective chilling units) and high income return per feddan, it reached about 53443 feddans which produced 546164 tons of fruits/year (FAO, 2013).

The importance of water resources management is due to the increase of population and water demand especially in the Middle East and North Africa, which classified as arid and semi-arid regions. These are threatened by water crisis in the future. Egypt is classified among these regions. Agriculture in Egypt relies heavily on irrigation. The agriculture sector consumes more than 84% of available water resources (El-Beltagy and Abo-Hadeed, 2008). So, effective management of irrigation sector specially at on-farm level become a must one of the main procedures.

The effect of irrigation regimes on vegetative growth and nutritional status of fruit trees were investigated by many authors. Hegazi *et al*. (2002) reported that values of growth parameters of pomegranate transplants were greater when grown under low water stress (100%) of available water level, then decreased with increasing water stress to reached minimum values when the available water level lower to (25%). Mikhael (2007) found that shoot length, leaf area, trunk cross sectional area-increase as well as number and fresh weight of fibrous roots of "Anna" apple trees were proportionally increased with increasing irrigation rate. Ibrahim and Abd El-Samad (2009) indicated that shoot length and leaf area of "Manfaloty" pomegranate trees were affected by irrigation regimes and highest shoot length and biggest leaf area were obtained by trees irrigated at 70% available water, while the lowest values were found by trees subjected to severe water stress (30% AW). Furthermore, Abd El-Nasser and El-Shazly (2000) on "Anna" apple, El-Seginy (2006) on "Canino" apricot and Khattab *et al*. (2011) on "Manfalouty" pomegranate reported that depletion of soil moisture caused a reduction in leaf mineral and chlorophyll contents.

To enhance the vegetative growth and productivity of fruit trees without polluting the environment, a number of alternative technologies are needed to apply. Organic fertilization is a very important technique in this respect. Significant attentions have been paid to both grower and agricultural authorities to replace manufactured mineral fertilizers by another naturally organic fertilizer which appear to be safety for environment and correct the soil fertility (David, 2002).

The application of organic materials to soils improved their physical, chemical and biological properties. Beside, reduced the lose of soil moisture and enhanced the water retention and drought resistance of plants (El-Sedfy, 1998).

Haynes and Swift (1990) reported that, the most important of organic materials applications on different soils are that contributed in improving the soil physical properties i.e. density, porosity, structure, aggregation and water retention.

Organic manure improved vegetative growth and leaf mineral content of "Washington Navel" orange (Abd El-Naby *et al*., 2004). Moreover, Ibrahim and Abd El-Samed (2009) on "Manfaloty" pomegranate and Moharam and Zaen El-Deen (2011) on "Early Grand" Peach, reported that organic fertilizers (cattle and chicken manures and olive solid wastes) significantly increase growth characters and leaf mineral contents

Therefore, the present work was carried out to study the effect of different irrigation regimes and replacing nitrogen mineral fertilizer by organic manures on some soil properties, vegetative growth and leaf mineral contents of "Anna" apple trees grown in clay soil.

MATERIALS AND METHODS

This investigation was carried out during three successive seasons of 2011, 2012 and 2013 on eight years old "Anna" apple trees budded on Malus rootstock spaced at 4 x 4 meters (260 tree/fed.) grown at a private orchard located at Khilwat Rishah village, north Tanta district, El-Gharbia Governorate, Egypt. Results were taken in 2012 and 2013 seasons. The trees were subjected to cultural practices usually done in this area. The orchard soil is classified as clay with slight alkaline (pH = 7.9) and the depth of water table was about 140-160 cm. Some physical and chemical properties of the experimental soil are presented in Table (1). Soil moisture constant for the experimental site is illustrated in Table (2).

The experiment was arranged in split plot design in complete randomized blocks. Three irrigation regimes, I_1, I_2 and I_3 (irrigated at 70, 50 and 30% of available water) were allocated in the main plots, while seven organic fertilization treatments (replacing mineral nitrogen by organic manures) were assigned in sub plots in twenty one combination treatments (3 irrigation regimes x 7 organic fertilization treatments) including the control (I_1 x F_1) each treatment replicated three times with two trees in each replicate (3 replicate x 2 trees). Thus, 126 trees were selected in a good healthy condition and uniform in both vegetative growth and fruit load are used in this study.

Table (1): Some initial chemical and physical properties of the studied soil samples

Soil variable	Soil depth (cm)	
	0-30	**30-60**
pH	7.9	7.8
EC (dS/m)	1.94	2.32
SAR	7.91	8.15
Organic matter (%)	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

Table (2): 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

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

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

Irrigation treatments	No. of irrigations	Amount of each irrigation water Depth (cm)	m^3/fed.	Water applied (Wa) m^3/fed./season
70% AW	17	4.524	190.0	3230
50% AW	9	7.543	316.8	2851
30% AW	6	10.421	438.7	2652

Submerged orifice with fixed dimension was used to convey and measure the amount of water applied as the following equation (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, causing discharge through the orifice, cm

Two organic manures (cattle, 1.8% N and chicken, 2.3%N) were taken from the same farm in three studied seasons, broadcasted and incorporated into the root zone of tree in winter service (mid-Dec.) and their properties are given in Table (4). The mineral nitrogen fertilizer was applied in the form of ammonium nitrate (33.5% N) at three unequal batches 40% at growing start (1st week of March), 30% just after fruit setting (April) and 30% at one month later (May). The application of these fertilizers were as follows:

F_1= 100% mineral N fertilizer (1200 g/tree ammonium nitrate 33.5% N) = 400 g N/tree as the recommended dose (MALR, 2003).
F_2= 50% cattle manure (11.11 kg/tree) + 50% mineral N fertilizer (600 g/tree ammonium nitrate 33.5%N).
F_3= 75% cattle manure (16.67 kg/tree) + 25% mineral N fertilizer (300 g/tree ammonium nitrate 33.5%N).
F_4= 100% cattle manure (22.22 kg/tree) + zero mineral N fertilizer.
F_5= 50% chicken manure (8.70 kg/tree) + 50% mineral N fertilizer (600 g/tree ammonium nitrate 33.5%N).
F_6= 75% chicken manure (13.05 kg/tree) + 25% mineral N fertilizer (300 g/tree ammonium nitrate 33.5%N).
F_7= 100% chicken manure (17.40 kg/tree) + zero mineral N fertilizer.

Phosphorus and potassium fertilizers were applied for all treatments at the rate of 0.750 kg calcium super phosphate (15.5% P_2O_5) and 0.45 kg potassium sulphate (48% K_2O) per tree.

Table (4): 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
Organic matter %	39.62	42.58
Organic carbon%	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

The initial soil physical and chemical properties and moisture constant of the experimental site and chemical analysis of organic manures were determined according to standard methods described by Black (1983) and Klute (1986)

Measurements and determinations:

1. Soil chemical and physical properties:

The effect of tested treatments was studied on some soil physical and chemical properties. Soil samples were taken at end of two growing seasons from surface layer (0-30 cm), air dried and passed through 2 mm sieve to be ready for chemical and physical analysis. Chemical properties i.e. soil reaction (pH) values were determined in 1:2.5 soil water suspension, total soluble salts were measured by electrical conductivity (EC) apparatus in the saturated soil paste extracted and organic matter was determined, then organic carbon was calculated (Black, 1983) . While other studied physical properties such as bulk density, total porosity, water stable aggregation (WSA) and aggregation index (AI) were done according to Klute (1986).

2. Vegetative growth parameters:

Four main branches in different direction on each tree were labeled. All current shoots developed on these branches in spring were used for measuring vegetative growth parameters i.e. shoot length (cm), shoot diameter (cm) and leaf area (cm^2) by Li-Core 3100 area meter. Leaves were dried at 70^oC and weighed to get leaf dry weight (g) and then leaf specific weight (LSW) was calculated as (g/cm^2) according to Hunt (1989). Also, seasonal increment in trunk cross section area (TCSA) cm^2 was calculated.

3. Root growth and distribution:

Fibrous roots density was determined in soil samples taken in November of both seasons at (0-30), (30-60) and (60-90) cm depth by soil auger at 130-150 cm from tree trunk horizontal in four directions. Fibrous roots less than 2 mm in diameter from each sample were cleaned, counted and their fresh weight was determined as g/hole (1570 cm^2) according to methods described by Cahoon *et al*. (1959) and Ford (1962).

4. Chemical determinations:

Thirty mature mid-shoot leaves in mid August of both seasons were sampled to determine leaf mineral content. Nitrogen was estimated by micro-kjeldahl gunning method (AOAC, 1990). Phosphorus was determined with a colourimetric method as described by Foster and Cornelia (1967). Potassium was determined by flame photometer model E.E.L. (Jackson, 1967). Calcium, magnesium, iron, zinc, and manganese were determined by Perking-Elmer Atomic Absorption spectrophotometer model 2380 AL, according to Jackson and Ulish (1959) and Yoshida *et al*. (1972).

Leaf total chlorophyll content (SPAD unit) value was determined by using portable Minolta Chlorophyll Meter (Model SPAd-501). Leaf sample collected in mid-June and the reading was taken at the middle of leaf blade according to Murquard and Timpton (1987).

Fully expanded leaves were sampled in first of August in 2012 and 2013 seasons. Approximately 0.5 g of fresh leaf samples was homogenized in 10 mL of 3% sulphosalicylic acid and the homogenate filtered through Whatman No. 2 filter paper, then the proline was extracted in the filtrate using acid non-hydrine and galical acetic acid. The absorbency of the supernatant was recorded using spectrophotometer at 520 nm wave length and the concentration was estimated from standard curve as µmole/g fresh weight according to Bates *et al*. (1973).

The obtained data were subjected to statistical analysis according to Snedecor and Cochran (1990) and LSD test at 0.5 level was used for comparing between averages.

RESULTS AND DISCUSSION

Effect of irrigation regime (I), organic fertilization treatment (F) and their interaction (I x F) on:

1. Soil chemical and physical properties:

a. Soil chemical properties:

Data obtained in Table (5) showed that, organic matter (OM) and organic carbon (OC)% in soil were significantly affected by irrigation regimes, organic manures and their interaction in both seasons. Application of organic manures significantly increased the percentage of organic matter and organic carbon compared to mineral fertilization treatment F_1 (100% mineral N). These values were gradually increased by increasing the rate of cattle or chicken manure and the highest values of OM and OC were obtained with 100% cattle or chicken manure. These results are in harmony with those reported by Nassr (2014) who indicated that organic carbon and organic matter in soil were increased progressively with increasing the application rate of composted materials. The data also cleared that, soil organic matter and organic carbon were significantly higher under moderate irrigation regime (I_2) compared to high (I_1) or deficit (I_3) irrigation one in the first season. Data of the second season showed the same trend. These results exhibit positive correlation between soil moisture level and its content of organic matter.

Table (5): Effect of irrigation and organic fertilization treatments and their interaction on some soil chemical properties in 2012 and 2013 seasons.

Treatments		pH		EC (dS/m)		Organic matter %		Total organic carbon %	
Irrigation regime (I)	Fertilization (F)	2012	2013	2012	2013	2012	2013	2012	2013
	F_1	7.86	7.83	1.90	1.89	1.46	1.54	0.85	0.90
	F_2	7.78	7.75	1.85	1.86	1.61	1.64	0.95	0.95
	F_3	7.75	7.75	1.92	1.89	1.64	1.69	0.96	0.98
I_1	F_4	7.76	7.69	1.93	1.94	1.77	1.79	1.03	1.04
	F_5	7.78	7.69	1.85	1.87	1.57	1.60	0.91	0.93
	F_6	7.72	7.64	1.92	1.96	1.61	1.67	0.94	0.97
	F_7	7.60	7.60	1.94	1.96	1.72	1.75	1.00	1.02
Average		7.75	7.71	1.90	1.91	1.63	1.67	0.95	0.97
	F_1	7.92	7.92	1.93	1.92	1.70	1.71	0.99	0.99
	F_2	7.81	7.81	1.86	1.88	1.84	1.87	1.07	1.09
	F_3	7.70	7.72	1.94	1.95	1.90	1.95	1.10	1.13
I_2	F_4	7.78	7.73	1.95	1.98	1.96	1.99	1.14	1.16
	F_5	7.81	7.72	1.89	1.90	1.81	1.85	1.05	1.08
	F_6	7.75	7.72	1.95	1.95	1.85	1.92	1.08	1.12
	F_7	7.66	7.64	1.97	1.97	1.92	1.96	1.12	1.14
Average		7.78	7.75	1.93	1.94	1.85	1.89	1.08	1.10
	F_1	7.98	7.92	1.93	2.01	1.52	1.58	0.88	0.92
	F_2	7.90	7.87	1.96	1.96	1.68	1.74	0.98	1.01
	F_3	7.95	7.78	1.99	2.06	1.73	1.76	1.00	1.02
I_3	F_4	7.81	7.76	2.00	2.01	1.82	1.86	1.06	1.08
	F_5	7.90	7.92	1.96	1.99	1.63	1.71	0.95	0.99
	F_6	7.87	7.72	2.01	1.97	1.70	1.72	0.99	1.00
	F_7	7.81	7.75	2.00	2.01	1.79	1.87	1.04	1.09
Average		7.89	7.82	1.98	2.00	1.70	1.75	0.99	1.02
	F_1	7.92	7.89	1.92	1.94	1.56	1.61	0.91	0.94
	F_2	7.83	7.81	1.89	1.90	1.71	1.75	1.00	1.02
	F_3	7.80	7.75	1.95	1.97	1.76	1.80	1.02	1.04
Average	F_4	7.78	7.73	1.96	1.98	1.85	1.88	1.08	1.09
	F_5	7.83	7.78	1.90	1.92	1.67	1.72	0.97	1.00
	F_6	7.78	7.69	1.96	1.96	1.72	1.77	1.00	1.03
	F_7	7.69	7.66	1.97	1.98	1.81	1.86	1.05	1.08
	I	NS	NS	NS	NS	0.119	0.111	0.084	0.059
LSD 0.05	F	NS	NS	NS	NS	0.080	0.074	0.068	0.043
	I x F	NS	NS	NS	NS	0.139	0.128	0.117	0.074

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) + 50% mineral N
F_3 = 75% organic N (cattle manure) + 25% mineral N
F_4 = 100% organic N (cattle manure)
F_5 = 50% organic N (chicken manure) + 50% mineral N
F_6 = 75% organic N (chicken manure) + 25% mineral N
F_7 = 100% organic N (chicken manure)

These results are in line with those achieved by El-Zaher *et al*. (2004) and Nassr (2014). However, the most important data were disclosed by the interaction (I x F) which was significant in both seasons. The highest percentages of soil organic matter and organic carbon were obtained under moderate irrigation regime (50% of available water) by using N as 75 or 100% from cattle or chicken manure in (I_2 x F_3), (I_1 x F_4), (I_2 x F6) and (I_2 x F_7) interaction without significant differences among them in both seasons, while the least values belonged to the control (I_1 x F_1), deficit irrigation rate at 30% AW x 100% mineral nitrogen.

Data tabulated in Table (5) also revealed that soil pH and total soluble salts as represented by values of electrical conductivity (EC) were not significantly affected by all irrigation and organic fertilization treatments as well as their interaction in first and second seasons, even though the highest soil pH was obtained by mineral fertilization treatment (100% mineral N), while, replacing mineral nitrogen by 50 to 100% cattle or chicken manure slightly reduced soil pH under each irrigation regime. Similar findings were also obtained by Abu-Zahra and Tahboub (2008) who indicated that soil pH did not show any significant differences between the control and organic manure treatments due to high buffering capacity of the soil of the experimental site which can fix any change in its pH during organic matter decomposition.

b. Soil physical properties:

Data in Table (6) clarify that, reducing irrigation rate from 70% to 50% of available soil water significantly reduced the values of soil bulk density in the surface layer (0-30 cm depth). Moreover, moderate irrigation rate (50% AW) recorded the lowest values of bulk density while, high irrigation rate (70% AW) produced the highest significant values in both seasons. The increment of soil bulk density under high irrigation level may be due to applied irrigation at short irrigation intervals which led to rearrangement of soil particles and reorientation of soil pores. Such results were obtained by Haynes and Swift (1990) and Ibrahim and Abd El-Samad (2009). With respect to the effect of fertilization treatment, the data exhibited that the application of organic manure alone or in combination with mineral fertilizer revealed significant decreases in the soil bulk density values in comparison to used mineral-N fertilizer alone. Furthermore, the lowest significant values of bulk density were recorded when fertilizing with 100% chicken or cattle manure, respectively. While, applying a mixture of organic manure (cattle or chicken) + mineral –N fertilizer at rates (50 + 50) or (75 + 25)%, respectively gave intermediate values. The decrease of the density can be described to an increase in volume of micro pore spaces as well as decreasing particle density in soil amended with organic materials. Similar conclusion was also achieved by Ibrahim and Abd El-Samad (2009) and Nassr (2014). However, the interaction was significant and the lowest bulk density was obtained when applied 100% chicken manure under 50% AW (I_2 + F_7). Meanwhile, the highest values were recorded with the control of 100% mineral-N under 70 AW (I_1 x F_1) in both seasons.

Data presented in Table (6) show the effects of irrigation and fertilization treatments and their interaction on total soil porosity and aggregation parameters i.e. water stable aggregates (WSA) and aggregates index (AI) which were significant except for the effect of irrigation on total soil porosity in both seasons. These values were high under moderate irrigation rate 50% AW (I_2) descendingly followed by deficit rate 30% AW (I_3), while the lowest values belonged to high irrigation one 70% AW (I_1). As for the effect of organic fertilization, it is clear that, total soil porosity and aggregation parameters were significantly increased by increasing the level of organic-N in form of either chicken or cattle manure up to 100%. Therefore, 100% cattle and 100% chicken manure (F_4 & F_7) produced the highest values while, 100% mineral-N fertilizer (F_1) recorded the lowest values. Furthermore, fertilizing by mixture of organic manure (chicken or cattle) and mineral-N fertilizer gave the intermediate values. This hold was true in both seasons.

Table (6): Effect of irrigation and organic fertilization treatments and their interaction on some soil physical properties in 2012 and 2013 seasons.

Treatments		Bulk density (g/cm^3)		Total porosity (%)		Aggregation WSA%*		AI**	
Irrigation regime (I)	Fertilization (F)	2012	2013	2012	2013	2012	2013	2012	2013
I_1	F_1	1.232	1.223	46.65	46.92	9.94	10.12	0.216	0.221
	F_2	1.224	1.213	47.67	47.97	11.22	11.39	0.237	0.243
	F_3	1.205	1.194	49.16	49.98	11.97	12.23	0.242	0.256
	F_4	1.193	1.185	51.28	52.71	12.38	12.81	0.262	0.263
	F_5	1.211	1.199	48.98	49.86	11.06	11.24	0.226	0.232
	F_6	1.199	1.186	50.45	51.73	12.06	12.18	0.246	0.241
	F_7	1.195	1.178	52.50	53.82	12.31	12.56	0.257	0.266
Average		1.208	1.197	49.38	50.43	11.56	11.79	0.241	0.246
I_2	F_1	1.212	1.204	46.75	47.29	11.14	11.34	0.243	0.249
	F_2	1.194	1.182	48.08	48.62	12.42	12.62	0.272	0.277
	F_3	1.183	1.172	49.38	50.92	13.23	13.53	0.280	0.287
	F_4	1.166	1.157	51.49	53.36	13.69	14.12	0.302	0.321
	F_5	1.190	1.177	49.22	50.46	12.36	12.55	0.263	0.279
	F_6	1.179	1.166	50.72	52.61	13.21	13.36	0.276	0.291
	F_7	1.162	1.151	52.81	54.49	13.58	13.88	0.291	0.306
Average		1.184	1.173	49.78	51.11	12.08	13.06	0.275	0.287
I_3	F_1	1.228	1.221	46.64	47.18	10.33	10.49	0.225	0.231
	F_2	1.221	1.208	47.92	48.43	11.58	11.78	0.259	0.264
	F_3	1.203	1.192	49.24	50.84	12.39	12.58	0.267	0.273
	F_4	1.190	1.181	51.34	52.90	12.78	13.21	0.291	0.295
	F_5	1.208	1.194	49.05	50.13	10.44	11.64	0.254	0.248
	F_6	1.195	1.183	50.57	52.29	12.23	12.41	0.255	0.263
	F_7	1.171	1.157	52.61	54.05	12.69	12.89	0.271	0.275
Average		1.202	1.191	49.62	50.83	11.78	12.14	0.260	0.264
Average	F_1	1.224	1.216	46.68	47.13	10.47	10.65	0.228	0.234
	F_2	1.213	1.201	47.89	48.34	11.74	11.93	0.256	0.261
	F_3	1.197	1.186	49.26	50.58	12.53	12.78	0.263	0.272
	F_4	1.183	1.174	51.37	52.99	12.95	13.38	0.285	0.293
	F_5	1.203	1.190	49.08	50.15	11.29	11.81	0.248	0.253
	F_6	1.191	1.178	50.58	52.21	12.50	12.65	0.259	0.265
	F_7	1.176	1.162	52.64	54.12	12.86	13.11	0.273	0.282
LSD 0.05	I	0.0133	0.0173	NS	NS	0.456	0.704	0.0178	0.0183
	F	0.0956	0.0135	0.655	0.615	0.432	0.384	0.0135	0.0139
	I x F	0.0166	0.0234	1.135	1.065	0.748	0.664	0.0234	0.0240

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) + 50% mineral N
F_3 = 75% organic N (cattle manure) + 25% mineral N
F_4 = 100% organic N (cattle manure)
F_5 = 50% organic N (chicken manure) + 50% mineral N
F_6 = 75% organic N (chicken manure) + 25% mineral N
F_7 = 100% organic N (chicken manure)
*** WSA = Water stable aggregation, ** AI = Aggregation Index**

Buckman and Bardy (1969) pointed out that organic matter play an important role for desirable soil structure by developing micro-aggregation which increase soil porosity. Also, Boyle *et al*. (1989) indicated that organic amendments increased soil particles together into aggregates were larger or wide pore size distribution favors the downward flow of water in soil. These findings were supported by those obtained by Ibrahim and Abd El-Samad (2009) and Nassr (2014). However, the interaction (I x F) was significant and the highest values of total porosity and aggregation parameters were obtained by (I_2 x F_4) and (I_2 x F_7) treatments without significant differences between them, while the control treatment produced the lowest values in both seasons.

2. Vegetative growth parameters:

a. Shoot and leaf growth parameters:

The obtained data in Table (7) indicated that shoot and leaf growth parameters of "Anna" apple trees were significantly affected by irrigation regime, organic manure and their interaction in 2012 and 2013 seasons. The highest values of shoot length and diameter (cm), leaf area (cm^2) and individual leaf dry weight (g) as well as leaf specific weight (mg/cm^2) were obtained from trees irrigated at 70% available soil water (I_1), while the lowest values in this respect were found by trees subjected to deficit irrigation rate 30% AW (I_3). This reduction in tree growth under water stress conditions could be attributed to lower photosynthetic rate and somato conductance (Mpelasoka *et al*., 2001). In this respect, Atkinson *et al*. (2000) reported that drought stress induced an increase in root abscisic acid (ABA) production and transportation to the shoot. The increase in ABA could be expected to reduce shoot growth and leaf expansion. These results are in agreement with those obtained by Fathi (1999a) on "LeConte" pear trees, Mikhael *et al*. (2010) on "Dessert Red" peach trees and Kakehzadeh *et al*. (2014) on "Golden Delicious" apple trees. They indicated that shoot and leaf growth were significantly reduced under low irrigation rates.

Table (7): Effect of irrigation and organic fertilization treatments and their interaction on vegetative growth of "Anna" apple trees in 2012 and 2013 seasons.

Treatments		Shoot length (cm)		Shoot diameter (cm)		Leaf area (cm^2)		Leaf dry weight (g)		Leaf specific weight (mg/cm^2)	
Irrigation regime (I)	Fertilization (F)	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
I_1	F_1	40.18	42.20	0.89	0.90	40.51	40.81	0.448	0.457	11.05	11.19
	F_2	42.41	44.47	0.93	0.94	44.07	45.22	0.501	0.519	11.37	11.48
	F_3	39.97	40.50	0.86	0.89	39.15	41.64	0.428	0.460	10.93	11.04
	F_4	35.10	36.54	0.84	0.86	38.27	39.29	0.403	0.411	10.52	10.45
	F_5	43.03	45.12	0.94	0.95	44.17	44.71	0.504	0.515	11.41	11.52
	F_6	39.94	40.89	0.88	0.90	40.63	41.59	0.447	0.461	11.00	11.09
	F_7	34.45	37.68	0.85	0.88	39.81	38.70	0.416	0.408	10.44	10.54
Average		39.30	41.06	0.88	0.90	40.94	41.71	0.450	0.462	10.96	11.04
I_2	F_1	38.87	40.71	0.84	0.87	38.96	38.62	0.426	0.424	10.92	10.99
	F_2	41.95	44.02	0.91	0.92	43.18	43.87	0.484	0.498	11.21	11.35
	F_3	35.14	36.69	0.81	0.85	35.76	37.27	0.388	0.405	10.84	10.87
	F_4	31.23	32.84	0.78	0.80	335.16	35.48	0.350	0.357	9.95	10.07
	F_5	42.51	44.87	0.92	0.93	43.71	43.98	0.494	0.500	11.30	11.38
	F_6	36.79	39.91	0.82	0.86	36.78	38.81	0.399	0.425	10.86	10.96
	F_7	33.92	33.18	0.77	0.81	36.95	37.32	0.370	0.378	10.02	10.14
Average		37.20	38.75	0.84	0.86	38.64	39.34	0.416	0.427	10.73	10.82
I_3	F_1	33.81	35.06	0.73	0.75	34.72	36.16	0.359	0.375	10.34	10.37
	F_2	33.92	35.68	0.74	0.76	35.21	36.25	0.365	0.382	10.36	10.53
	F_3	28.26	30.23	0.67	0.69	30.42	31.28	0.300	0.316	9.86	10.10
	F_4	24.13	25.78	0.61	0.62	29.32	29.21	0.272	0.275	9.27	9.42
	F_5	35.09	36.07	0.76	0.79	36.65	37.17	0.379	0.393	10.35	10.58
	F_6	29.56	31.59	0.69	0.71	31.21	32.73	0.309	0.333	9.91	10.17
	F_7	25.29	26.91	0.63	0.65	30.08	31.43	0.282	0.300	9.39	9.53
Average		30.01	31.62	0.69	0.71	32.52	33.46	0.324	0.339	9.93	10.10
Average	F_1	37.62	39.32	0.82	0.84	38.06	38.53	0.411	0.419	10.77	10.85
	F_2	39.43	41.39	0.86	0.87	40.82	41.78	0.450	0.466	10.98	11.12
	F_3	34.12	35.81	0.78	0.81	35.11	36.73	0.372	0.394	10.54	10.67
	F_4	30.15	31.72	0.74	0.76	34.25	34.66	0.342	0.348	9.91	9.98
	F_5	40.21	42.02	0.87	0.89	41.51	41.95	0.459	0.469	11.02	11.16
	F_6	35.43	37.13	0.80	0.82	36.21	37.83	0.385	0.406	10.59	10.74
	F_7	31.22	32.59	0.75	0.78	35.61	35.82	0.356	0.362	9.95	10.07
LSD 0.05	I	2.306	1.860	0.013	0.042	5.425	4.561	0.0420	0.0415	0.126	0.197
	F	1.693	1.973	0.030	0.010	2.339	1.626	0.0096	0.0091	0.052	0.145
	I x F	2.932	3.417	0.052	0.017	4.050	2.816	0.0166	0.0161	0.091	0.251

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) + 50% mineral N
F_3 = 75% organic N (cattle manure) + 25% mineral N
F_4 = 100% organic N (cattle manure)
F_5 = 50% organic N (chicken manure) + 50% mineral N
F_6 = 75% organic N (chicken manure) + 25% mineral N
F_7 = 100% organic N (chicken manure)

With respect to the effect of organic manures, the data revealed that application of 50% organic manure (cattle or chicken) + 50% mineral fertilizer (F_2 & F_5) gave the highest significant values of shoot and leaf growth parameters followed by 100% mineral fertilizer Meanwhile, these parameters significantly decreased by increasing the application rate of organic manures till reach minimum values when 100% cattle or chicken manure was applied. The positive action of organic manures on stimulating growth characters might be due to their essential role in enhancing soil fertility, secreting nature hormones and antibiotics, increasing nutrient supply and improving the physical conditions of the soil (Dahama, 1999). Also, data of soil physical properties in Table (6) supported this conclusion. These results confirmed those reported by Ahmed *et al*. (2012) on “Ruby seedless” grapevines and Wassel *et al*. (2015) on “Kodatta” fig trees. However, the interactions was significant in both seasons and the highest values of shoot and leaf growth parameters were obtained by fertilizing 50% of recommended nitrogen in organic form (cattle or chicken manure) + 50% mineral fertilizer under high (70% AW) or moderate (50% AW) irrigation rate in (I_1 x F_2), (I_1 x F_5), (I_2 x F_2) or (I_2 x F_5) interaction without significant differences among them. So, (I_2 x F_2) or (I_2 x F_5) considered the suitable combination treatments due to saving irrigation water by using moderate irrigation rate (I_2).

b. Trunk cross section (TCSA) increase (cm^2):

Data illustrated in Fig. (1) showed that TCSA-increase (cm^2) of “Anna” apple trees take the same trend of leaf and shoot growth parameters as affected with irrigation regimes, organic manures and their interaction.

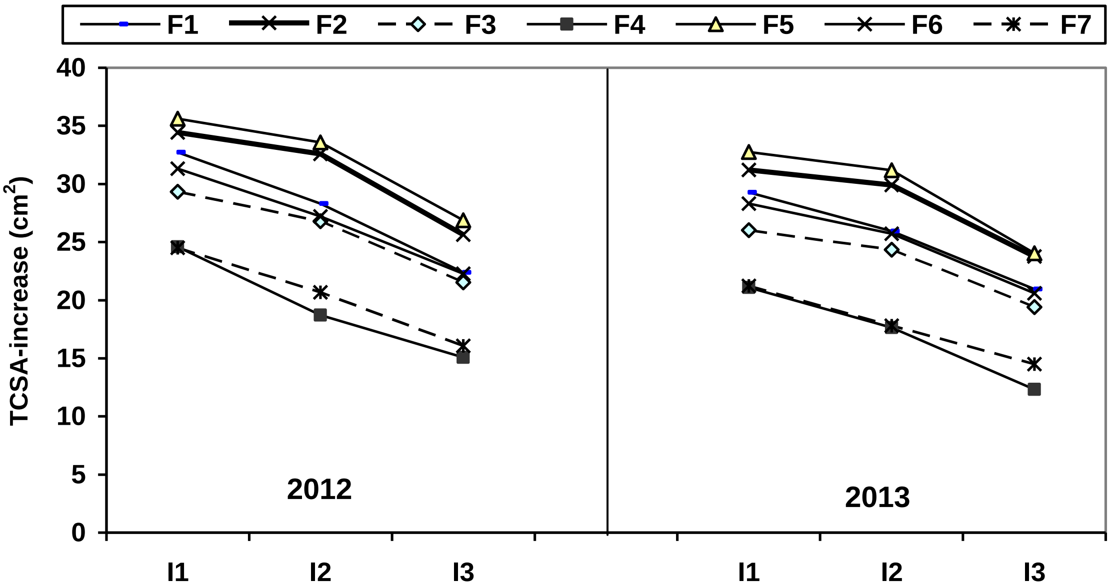

Fig. (1): Effect of irrigation regime and organic fertilization on trunk cross section area (TCSA) increase of “Anna” apple trees in 2012 and 2013 season.

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) + 50% mineral N
F_3 = 75% organic N (cattle manure) + 25% mineral N
F_4 = 100% organic N (cattle manure)
F_5 = 50% organic N (chicken manure) + 50% mineral N
F_6 = 75% organic N (chicken manure) + 25% mineral N
F_7 = 100% organic N (chicken manure)

It was markedly decreased by reducing irrigation rate from 70% to 30% of available soil water. Similar response were reported by Mikhael *et al*. (2010) and Kakehzaded *et al*. (2014) who reported that, higher rate of irrigation induced significantly higher TCSA-increase due to the improvement in shoot growth and leaf expansion. Meanwhile, fertilizing with 50% cattle manure + 50% mineral fertilizer (F_2) or 50% chicken manure + 50% mineral fertilizer (F_5) markedly increase TCSA-increase (cm^2) compared to mineral or organic manures alone. Similar results were obtained by Milosevic and Milosevic (2013). Moreover, the most effective combination treatments were (I_1 x F_2), (I_1 x F_5), (I_2 x F_2) and (I_2 x F_5) which recorded the largest TCSA-increase (cm^2). On the other hand, the lowest increase produced by (I_3 x F_4) and (I_3 x F_7) interaction. This hold was true in both 2012 and 2013 seasons.

c. Root growth parameters:

Data of both seasons in Table (8) shows the average number and fresh weight (g/hole) of the fibrous roots of “Anna” apple trees at (0-30), (30-60) and (60-90) cm, soil depth as influenced by irrigation regime (I), organic fertilizing treatment (F) and their interaction (I x F) during 2012 and 2013 seasons. The data revealed that, average number and fresh weight (g/hold) of fibrous roots were decreased by increasing depth from soil surface up to (60-90 cm) depth. Additionally, more fibrous roots with heavy fresh weights were produced at the surface soil layer (0-30 cm), depth compared to deeper soil one (60-90 cm), depth in 2012 and 2013 seasons.

Data of both seasons also exhibited that, average number of fresh weight of fibrous roots at all soil depths were significantly decreased with reducing irrigation levels. The highest values obtained by I_1 (70% AW), while the least values were recorded with I_3 (30% AW). This reduction in root density and fresh weight under soil drought condition might be due to reducing the uptake of water and mineral nutrients via the roots. Also, the shortage of water supply caused death of more roots. These findings are in harmony with those obtained by Fathi (1999b) on pear, El-Sanhoury (2003) on apricot and Mikhael (2007) on apple.

Table (8): Effect of irrigation and organic fertilization treatments and their interaction on number and fresh weight of fibrous roots of "Anna" apple trees in 2012 and 2013 seasons.

Treatments		Av. number of roots*						Av. roots fresh weight (g/hole)					
Irrigation regime (I)	Fert. (F)	0-30 cm depth		30-60 cm depth		60-90 cm depth		0-30 cm depth		30-60 cm depth		60-90 cm depth	
		2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
	F_1	51.3	51.5	24.3	26.6	5.7	6.4	1.923	2.031	1.024	1.096	0.272	0.314
	F_2	63.9	64.7	32.2	33.8	7.3	8.0	2.485	2.523	1.326	1.457	0.364	0.384
	F_3	58.6	59.8	29.5	30.8	6.8	7.0	2.294	2.335	1.215	1.324	0.345	0.336
I_1	F_4	47.5	48.2	24.0	25.7	5.5	5.7	1.849	1.786	1.018	1.057	0.258	0.268
	F_5	64.5	65.7	32.5	34.6	7.3	8.1	2.521	2.563	1.395	1.495	0.372	0.405
	F_6	58.9	59.6	29.9	30.4	6.8	7.3	2.366	2.412	1.237	1.226	0.356	0.358
	F_7	49.8	50.4	24.5	25.5	5.7	6.1	1.892	1.947	0.982	1.068	0.279	0.287
Average		56.3	57.1	28.1	29.6	6.4	6.9	2.190	2.228	1.176	1.246	0.321	0.336
	F_1	47.2	49.1	22.8	23.9	5.2	5.6	1.789	1.868	0.935	0.983	0.250	0.258
	F_2	59.6	60.9	30.1	31.5	6.9	7.5	2.337	2.386	1.268	1.357	0.332	0.368
	F_3	55.9	56.9	28.1	29.4	6.4	6.9	2.181	2.251	1.155	1.235	0.307	0.331
I_2	F_4	43.1	44.5	21.7	22.7	4.9	5.4	1.595	1.643	0.892	0.934	0.230	0.259
	F_5	61.4	62.8	30.9	32.3	7.0	7.6	2.392	2.475	1.316	1.393	0.343	0.350
	F_6	55.3	56.9	27.8	29.1	6.5	7.0	2.167	2.213	1.193	1.252	0.312	0.336
	F_7	43.0	44.6	21.6	22.6	4.9	5.3	1.681	1.736	0.891	0.956	0.225	0.249
Average		52.2	53.7	26.1	27.4	6.0	6.5	2.020	2.082	1.093	1.159	0.286	0.307
	F_1	41.3	42.8	20.7	20.6	4.7	4.8	1.489	1.569	0.872	0.895	0.230	0.232
	F_2	51.7	53.1	25.9	27.1	5.9	6.3	1.916	1.972	1.114	1.156	0.283	0.302
	F_3	49.7	50.6	24.9	26.2	5.8	6.2	1.793	1.823	1.085	1.147	0.278	0.298
I_3	F_4	37.5	38.4	18.8	19.1	4.3	4.5	1.432	1.497	0.776	0.792	0.202	0.212
	F_5	52.9	53.7	26.6	27.3	6.1	6.5	2.015	2.135	1.144	1.197	0.299	0.325
	F_6	50.8	51.8	25.5	27.2	5.9	6.4	1.966	2.054	1.095	1.172	0.283	0.312
	F_7	38.3	39.7	19.3	20.3	4.4	4.7	1.384	1.441	0.818	0.857	0.211	0.221
Average		46.0	47.2	23.1	24.0	5.3	5.6	1.714	1.784	0.986	1.031	0.255	0.272
	F_1	46.6	47.8	22.6	23.7	5.2	5.6	1.734	1.823	0.944	0.991	0.251	0.268
	F_2	58.4	59.6	29.4	30.8	6.7	7.3	2.246	2.294	1.236	1.323	0.326	0.351
	F_3	54.7	55.1	27.5	28.8	6.3	6.7	2.089	2.136	1.152	1.235	0.310	0.322
Average	F_4	42.7	43.7	21.5	22.5	4.9	5.2	1.625	1.642	0.895	0.928	0.230	0.246
	F_5	59.6	60.7	30.0	31.4	6.8	7.4	2.309	2.391	1.285	1.362	0.338	0.360
	F_6	55.0	56.1	27.7	28.9	6.4	6.9	2.166	2.226	1.175	1.267	0.317	0.335
	F_7	43.7	44.9	21.8	22.8	5.0	5.4	1.652	1.708	0.897	0.960	0.238	0.252
	I	4.77	3.59	1.75	3.93	0.88	0.58	0.0594	0.0133	0.0420	0.0130	0.0138	0.0419
LSD 0.05	F	2.78	2.26	2.14	1.98	0.67	0.59	0.0605	0.0302	0.0304	0.0300	0.0096	0.0302
	I x F	4.82	3.91	3.71	3.43	1.17	1.02	0.1047	0.0524	0.0526	0.0520	0.0166	0.0523

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) + 50% mineral N
F_3 = 75% organic N (cattle manure) + 25% mineral N
F_4 = 100% organic N (cattle manure)
F_5 = 50% organic N (chicken manure) + 50% mineral N
F_6 = 75% organic N (chicken manure) + 25% mineral N
F_7 = 100% organic N (chicken manure)
*** The average number of fibrous roots in hale (1570 cm^3)**

Concerning the effect of organic manures, data of both seasons indicated that, fertilizing with 50% chicken or cattle manure + 50% mineral fertilizer (F_2 or F_5) treatment produced the highest number and heaviest weight of fibrous roots followed by 75% chicken or cattle manure + 25% mineral fertilizer (F_3 or F_6) treatment, then by 100% mineral (F_1). Nevertheless, application of 100% organic manure (F_4 or F_7) gave the least number and lightest weight of fibrous root. Moreover, chicken manure treatments enhanced root growth more than use of cattle manure. These results might be attributed to the great benefits of organic manures on increasing availability of nutrients and water as well as continuous and balanced release of N and enhancing physical characters of the soil could be resulted in stimulating growth of roots (Miller *et al*., 1990).Regarding the interaction between irrigation regimes and organic fertilization treatment (I x F) was significant in both seasons and the highest number and heaviest fresh weight of fibrous roots at different soil depth in 2012 and 2013 seasons were produced with (I_1 x F_2), (I_1 x F_5), (I_2 x F_2) and (I_2 x F_5) interaction, while the minimum values were belonged to (I_3 x F_4) and (I_3 x F_7) interaction.However, other combination treatments gave intermediate values. Thus using (I_2 x F_3) or (I_2 x F_5) is considered the best combination treatment in improving root growth of "Anna" apple trees under the condition of this study.

3. Nutritional status:

a. Leaf mineral content:

As shown in Tables (9 and 10), it is clear that reducing irrigation rate from 70 to 30% of available water decreased leaf N, P, K, Ca, Mg, Fe, Mn and Zn contents and the differences between I_1 and I_3 irrigation rates were only significant in 2012 and 2013 seasons.

Table (9): Effect of irrigation and organic fertilization treatments and their interaction on leaf macronutrients of "Anna" apple trees in 2012 and 2013 seasons.

Treatments		Macro nutrients % on dry weight basis									
		N		P		K		Ca		Mg	
Irrigation regime (I)	Fertilization (F)	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
I_1	F_1	1.97	2.03	0.21	0.20	1.47	1.49	1.24	1.28	0.29	0.31
	F_2	2.13	2.33	0.27	0.25	1.62	1.65	1.39	1.41	0.42	0.42
	F_3	2.30	2.37	0.31	0.30	1.70	1.73	1.41	1.44	0.44	0.46
	F_4	2.47	2.47	0.34	0.35	1.79	1.84	1.44	1.48	0.49	0.50
	F_5	2.27	2.37	0.28	0.26	1.67	1.71	1.42	1.43	0.43	0.47
	F_6	2.37	2.50	0.34	0.33	1.76	1.80	1.43	1.45	0.47	0.49
	F_7	2.53	2.57	0.37	0.36	1.85	1.89	1.47	1.50	0.52	0.54
Average		2.29	2.38	0.30	0.29	1.69	1.73	1.40	1.43	0.44	0.46
I_2	F_1	1.90	1.93	0.19	0.17	1.35	1.40	1.22	1.25	0.26	0.29
	F_2	2.10	2.20	0.24	0.22	1.50	1.53	1.35	1.37	0.40	0.41
	F_3	2.27	2.30	0.27	0.26	1.58	1.62	1.36	1.39	0.41	0.43
	F_4	2.37	2.43	0.32	0.28	1.68	1.73	1.40	1.43	0.44	0.45
	F_5	2.17	2.23	0.26	0.25	1.55	1.59	1.37	1.38	0.39	0.42
	F_6	2.33	2.40	0.31	0.29	1.64	1.69	1.38	1.40	0.43	0.44
	F_7	2.43	2.47	0.32	0.31	1.75	1.81	1.44	1.47	0.47	0.48
Average		2.22	2.28	0.27	0.25	1.58	1.62	1.36	1.38	0.40	0.42
I_3	F_1	1.80	1.83	0.16	0.15	1.15	1.22	1.12	1.16	0.20	0.22
	F_2	2.07	2.00	0.19	0.17	1.32	1.34	1.15	1.18	0.21	0.23
	F_3	2.17	2.20	0.23	0.21	1.40	1.45	1.22	1.22	0.25	0.28
	F_4	2.27	2.37	0.27	0.24	1.49	1.56	1.33	1.32	0.29	0.32
	F_5	2.10	2.17	0.21	0.19	1.37	1.41	1.23	1.27	0.27	0.31
	F_6	2.23	2.30	0.25	0.22	1.43	1.50	1.31	1.29	0.31	0.33
	F_7	2.37	2.40	0.29	0.27	1.55	1.67	1.34	1.39	0.33	0.35
Average		2.14	2.18	0.23	0.21	1.39	1.45	1.24	1.26	0.27	0.29
Average	F_1	1.89	1.93	0.19	0.17	1.32	1.37	1.19	1.23	0.25	0.27
	F_2	2.10	2.18	0.23	0.21	1.48	1.51	1.30	1.32	0.34	0.35
	F_3	2.25	2.29	0.27	0.26	1.56	1.60	1.33	1.35	0.37	0.39
	F_4	2.37	2.42	0.31	0.29	1.65	1.71	1.39	1.41	0.41	0.42
	F_5	2.18	2.26	0.25	0.23	1.53	1.57	1.34	1.36	0.36	0.40
	F_6	2.31	2.40	0.27	0.28	1.61	1.66	1.37	1.38	0.40	0.42
	F_7	2.44	2.48	0.33	0.31	1.72	1.79	1.42	1.45	0.44	0.46
LSD 0.05	I	0.119	0.103	0.013	0.013	0.111	0.073	0.102	0.042	0.013	0.014
	F	0.096	0.080	0.010	0.030	0.079	0.086	0.043	0.040	0.009	0.032
	I x F	0.166	0.139	0.017	0.052	0.138	0.148	0.074	0.072	0.016	0.054

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) + 50% mineral N
F_3 = 75% organic N (cattle manure) + 25% mineral N
F_4 = 100% organic N (cattle manure)
F_5 = 50% organic N (chicken manure) + 50% mineral N
F_6 = 75% organic N (chicken manure) + 25% mineral N
F_7 = 100% organic N (chicken manure)

These results may lead to the conclusion that nutrient uptake was retarded under water stress condition where a substantial decrease in transpiration rates and impaired active transport and membrane permeability and resulting in a reduced root absorbing power of plant. Thus, depletion of soil moisture level caused a reduction in leaf mineral content. The above mentioned results are in accordance with those obtained by Abd El-Nasser and El-Shazly (2000) and Mikhael (2007) on "Anna" apple trees and Ibrahim and Abd El-Samad (2009) and Khattab *et al*. (2011) on "Manfalouty" pomegranate trees. They reported that leaf mineral content significantly declined under drought conditions.

It is clear from the data presented in Tables (9 and 10) that application of N completely via organic source (cattle or chicken manure) then using combination between organic and mineral sources were significantly effective in enhancing leaf N, P, K, Ca, Mg, Fe, Mn and Zn-contents compared to the application of N in the mineral source only. There were a gradual promotion in these nutrients with increasing the percent of organic manure from 50, 70, to 100%. On the contrary, the least values of these nutrients were obtained in leaves of trees received 100% of N via mineral fertilizer. Moreover, chicken manure treatments enhanced leaf macro and micronutrients more than other cattle manure treatments. This hold was true in both seasons. The positive action of organic manures on increasing soil acidity and organic matter which reflected in enhancing the availability of most nutrients and this effect could explain the present results.

These results are confirmed with those reported by Mansour *et al*. (2007) on apple, Moharam and Zaen El-Deen (2011) on peach, Masoud (2012) and Shaheen *et al*. (2013) on grapevine and Wassel *et al*. (2015) on fig they found that organic fertilizers increased leaf content of macro and micro nutrients. The interaction (I x F) was significant meaning the importance of irrigation regime and organic fertilization in influencing leaf mineral content. The highest values of leaf N, P, K, Ca, Mg, Fe, Mn and Zn-contents recorded with (I_1 x F_7), (I_1 x F_4), (I_2 x F_7) and (I_2 x F_4) interaction. Meanwhile, deficit irrigation rate (30% AW) + application of 100% mineral N fertilizer in (I_3 x F_1) combination treatment produced the least values.

Table (10): Effect of irrigation and organic fertilization treatments and their interaction on leaf micronutrients, total chlorophyll and free proline contents of "Anna" apple trees in 2012 and 2013 seasons.

Treatments		Micronutrients (ppm) Fe		Mn		Zn		Total leaf chlorophyll (SPAD unit)		Free proline µmoles/g fresh weight	
Irrigation regime (I)	Fertilization (F)	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
I_1	F_1	148.2	152.3	46.5	49.5	17.1	18.3	45.9	46.4	0.45	0.44
	F_2	170.3	181.2	53.3	57.1	21.3	22.1	51.3	52.2	0.39	0.37
	F_3	182.9	196.1	59.2	61.8	23.2	24.4	53.1	53.3	0.33	0.32
	F_4	176.4	199.5	66.6	70.4	26.7	27.6	55.6	57.7	0.29	0.27
	F_5	181.3	185.6	56.4	61.5	20.4	21.5	53.5	53.9	0.35	0.34
	F_6	187.6	201.9	63.5	66.7	22.4	23.3	55.2	55.7	0.33	0.30
	F_7	204.7	212.2	69.9	73.1	24.1	25.6	56.9	57.1	0.27	0.25
Average		178.8	189.8	59.3	62.9	22.2	23.3	53.1	53.9	0.34	0.33
I_2	F_1	141.4	145.5	42.6	46.2	15.7	17.1	43.7	44.7	0.51	0.47
	F_2	161.7	173.1	51.8	53.5	19.9	21.4	50.7	50.1	0.44	0.42
	F_3	173.9	187.3	56.9	58.2	22.0	23.0	50.8	51.8	0.43	0.41
	F_4	169.3	189.2	63.2	67.3	25.2	26.2	53.8	55.3	0.35	0.34
	F_5	172.5	178.1	55.9	58.0	19.0	20.2	51.2	52.0	0.46	0.42
	F_6	180.8	193.6	60.9	63.1	21.2	21.9	52.5	53.9	0.39	0.38
	F_7	195.3	205.4	66.2	69.7	22.8	23.8	54.7	55.8	0.33	0.31
Average		170.7	181.7	56.8	59.4	20.8	21.9	50.0	51.9	0.42	0.39
I_3	F_1	124.6	130.4	41.5	41.7	12.8	14.5	40.9	41.2	0.59	0.55
	F_2	160.9	153.3	47.0	51.0	19.4	18.3	43.9	45.9	0.55	0.53
	F_3	175.7	167.4	54.6	57.6	20.2	19.5	46.7	48.2	0.50	0.47
	F_4	169.4	187.0	62.8	62.5	22.7	23.8	49.1	51.2	0.47	0.44
	F_5	153.8	165.8	51.8	51.8	15.8	17.7	47.1	48.6	051	0.50
	F_6	181.7	172.1	56.2	57.4	18.5	19.3	49.5	50.6	0.49	0.43
	F_7	178.8	177.3	61.6	62.1	22.4	22.9	49.8	52.4	0.42	0.39
Average		163.6	164.8	53.6	54.9	18.8	19.4	46.7	48.3	0.50	0.47
Average	F_1	138.1	142.7	43.5	45.8	15.2	16.6	43.5	44.1	0.52	0.49
	F_2	164.3	169.2	50.7	53.9	20.2	20.6	48.6	49.4	0.46	0.44
	F_3	177.5	183.6	56.9	59.2	21.8	22.3	50.2	51.1	0.42	0.40
	F_4	171.7	191.9	64.2	66.7	24.9	25.9	52.8	54.7	0.37	0.35
	F_5	169.2	176.5	54.7	57.1	18.4	19.8	50.6	51.5	0.44	0.42
	F_6	183.4	189.2	60.2	62.4	20.7	21.5	52.4	53.4	0.40	0.37
	F_7	192.9	198.3	65.9	68.3	23.1	24.1	53.8	55.1	0.34	0.32
LSD 0.05	I	5.03	3.24	5.63	3.54	2.26	1.35	4.65	2.44	0.013	0.013
	F	8.96	7.57	4.86	3.78	1.23	1.06	3.28	2.21	0.030	0.032
	I x F	15.52	13.10	8.41	6.55	2.13	1.83	5.68	3.82	0.018	0.053

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) + 50% mineral N
F_3 = 75% organic N (cattle manure) + 25% mineral N
F_4 = 100% organic N (cattle manure)
F_5 = 50% organic N (chicken manure) + 50% mineral N
F_6 = 75% organic N (chicken manure) + 25% mineral N
F_7 = 100% organic N (chicken manure)

b. Leaf chlorophyll content:

Tabulated data in Table (10) clarify that, total chlorophyll in leaves of "Anna" apple trees was significantly higher under high irrigation rate 70% AW (I_1) descendingly followed by 50% AW (I_2) and 30%, respectively. Differences were only significant between I_1 and I_3 irrigation treatments in both 2012 and 2013 seasons. The data also exhibited significant increase in leaf total chlorophyll content with increasing the application rate of organic manure (cattle or chicken) up to 100% in both seasons. These findings revealed positive correlation between leaf chlorophyll content and soil moisture and organic matter contents. This increment in total leaf chlorophyll content might be due to increasing of macronutrients uptake, especially N and Mg as consequence of improved soil moisture and its organic matter contents, whereas N and Mg nutrient are necessary for chlorophyll synthesis. Data of macronutrients expressed in Table (9) supported these findings. The interaction was significant in both seasons and the highest values were produced with fertilized "Anna" apple trees with 50% chicken or cattle manure + 50% mineral fertilizer under high or moderate irrigation rate in (I_1 x F_7), (I_1 x F_4), (I_2 x F_7) and (I_2 x F_4) interaction without significant differences among them in both seasons. Meanwhile, the least values were recorded with application of 100% mineral fertilizer under deficit irrigation regime (I_3 x F_1). Similar conclusion was also achieved by El-Seginy (2006) on “Canino” apricot, Mikhael (2007) on “Anna” apple, Mikhael *et al*. (2010) on “Dessert Red” peach and Khattab *et al*. (2011) on “Manfaloty” pomegranate. They found that leaf chlorophyll content was significantly higher in trees grown under high irrigation rate. Moreover, Fathi (1999a) on pear mentioned that, leaf chlorophyll content was significantly reduced under drought stress. In addition, Wassel *et al*. (2015) indicated that increasing percentages of organic manures (farmyard manure, compost or chicken manure) from 0.0 to 62.5% significantly enhanced chlorophyll pigments (chlorophyll a & b and total chlorophylls) in leaves of “Kadotta” fig trees.

c. Leaf free proline content:

The obtained data in Table (10) indicated that, reducing irrigation level significantly increased leaf free proline content of “Anna” apple trees and the highest values were obtained under deficit irrigation level (I_3) followed by (I_2) and (I_1), respectively in 2012 and 2013 seasons. These findings exhibited negative correlation between soil moisture level and leaf free proline content. These results could be attributed to increase hydrolysis of proteins and stimulate the biosynthesis and accumulation of free amino acid proline in leaves as a result to water stress under deficit irrigation conditions. Furthermore, proline accumulation may be an indicator of drought resistance besides, it plays an important role in osmotic adjustment in plants (Watanabe *et al*., 2000). These results are in agreement with those obtained by El-Sanhoury (2003) and El-Seginy (2006) on apricot, Mikhael *et al*. (2010) on peach and Khattab *et al*. (2011) pomegranate. They concluded that, water stress under deficit irrigation rate causes an increase in leaf free proline content. Concerning the influence of organic fertilization treatments, data of Table (10) showed that, free proline content was significantly higher in leaves of trees fertilized by mineral fertilizer alone. This value gradually reduced by increasing the application rate of organic manure and reached minimum values when trees fertilized by chicken or cattle manure alone. These results mean that, application of organic materials improved soil water retention and reduced lose of soil moisture, so, reduced water stress and decreased accumulation of proline. The interaction (I x F) was significant in both seasons and the highest values of free proline content produced in leaves of trees received 100% mineral nitrogen fertilizer under deficit irrigation regime (I_3 x F_1) interaction.

Therefore, this study recommends “Anna” apple growers on clay soil to irrigate it at 50% available soil water (2851 m^3/fed/season) and replacing 50% mineral N fertilizer by cattle or chicken manure by adding 11.11 kg cattle manure + 600 g ammonium nitrate/tree/season (I_2 x F_2) or 8.70 kg chicken manure + 600 g ammonium nitrate/tree/season (I_2 x F_5) which considered the best combination treatment. These two treatments not only saved water use by about 379 m^3/fed./season (11.73%) and improved soil chemical and physical properties but also enhanced vegetative growth and nutritional status of trees under the experimental conditions.

REFERENCES

Abd El-Naby, S.K.M.; E.A.A. Abd El-Moneim and A.S.E. Abd-Allah (2004). Effect of source and date of organic manure application on growth, yield, fruit quality and mineral content of Washington Navel orange grown in sandy soil. Minufiya J. Agric. Res. 29(2): 515-540.

Abd El-Nasser, G. and S.M. El-Shazly (2000). Irrigation management of Anna apple trees in relation to growth, yield, fruit quality, leaf constituents and water relation. Alex. J. Agric. Res., 45: 225-247.

Abo-Zahra, T.R. and A.B. Tahboub (2008). Effect of organic matter sources on chemical properties of the soil and yield of strawberry under organic farming conditions. World Applied Sciences Journal 5(3): 383-388.

Ahmed, F.F.; A.M.K. Abd El-Aal and A.A.B. Masoud (2012). Attempts for reducing nitrite pollution in “Ruby Seedless” grapes by using some organic manures enriched with EM. Minufiya J. Agric. Res. 37(3): 611-619.

AOAC (Association of Official Agriculture Chemists) (1990). Official methods of analysis.. 15^{th} Ed. Washington D.C., USA.

Atkinson, C.J.; A.D. Webster; S.P. Vaughan; L. Taylor and G. Kingswell (2000). Interaction between root restriction, irrigation, rootstock treatments on “Queen Cox” apple trees: Effect of soil and plant water relation. J. Hort. & Biotech., 75(4): 376-382.

Bates, L.S.; R.P. Waldrenn and L.D. Teare (1973). Rapid determination of tree proline for water stress studies. Plant and Soil, 39: 205-207.

Black, C.A. (1983). Methods of soil analysis. Part I and II. Amer Agron. Inc. Publ., Madison, Wisconsin, USA.

Boyle, M.; W.Jr. Frnkenberger and L.H. Stolzy (1989). The influence of organic matter on soil aggregation and water infiltration. J. Production Agric. 24: 290-299.

Buckman, H.O. and N.C. Bardy (1969). The nature and properties of soil. The Macmillan Company. Collicr Macamillan Limited, London.

Cahoon, G.A.; E.S. Morton; W.W. Jone and M.L. Garber (1959). Effect of various type of nitrogen fertilization on root density and distribution as related to water infiltration and fruit yield of “Washington Navel” orange in a long term fertilizer experiment. Proc. Amer. Soc. Hort. Sci., 74: 289-299.

Dahama, A.K. (1999). Organic farming for sustainable agriculture. Agro. Botanic Daryagun, New Delhi, pp. 258.

David, G. (2002). Tree fruit production with organic farming methods. Center for sustaining agriculture and natural resources. Washington State University, Wenatchee, USA.

El-Beltagy, A.t. and A.F. Abo-Hadeed (2008). The main pillar of the national program for maximizing the water use efficiency in the old land. 30 p. The Research and Development Concil. Ministry of Agriculture and Land Reclamation (MALR), Giza, Egypt (in Arabic).

El-Sanhoury, A.M. (2003). Studies on drought tolerance of three apricot varieties. M.Sc. Thesis, Fac. Agric. Kafr El-Sheikh, Tanta Univ.

El-Sedfy, F.G. (1998). Technology of irrigation for sandy soil: A comparative study between different irrigation systems in sandy soils in Egypt. Ph.D. Thesis, Fac. Agric., Cairo Univ., Egypt.

El-Seginy, A.M. (2006). Response of Canino apricot trees to different irrigation and potassium treatments. Alex. Sci. Exchange. J., 27: 64-75.

El-Zaher, H.; A.F. Saad; A.M. Osman and R.G. Kerlous (2004). Effect of organic amendments and water stress on some crops grown in calcareous soils. I. Hydrophsical and chemical properties. Water consumptive use and water use evidence. Alex. J. Agric. Res. 49(1): 119-130.

FAO (2013). Food and Agriculture Organization. http://faostat-fao.org.

Fathi, M.A. (1999a). Drip irrigation efficiency for pear trees. A. Yield, fruit properties and vegetative growth. J. Agric. Sci. Mansoura Univ., 24(6): 3021-3034.

Fathi, M.A. (1999b). Drip irrigation efficiency for pear trees. B. Root system growth and distribution. J. Agric. Sci. Mansoura Univ., 234(6); 3035-3049.

Ford, H.W. (1962). Thickness and subsoil organic layer in relation to tree size and root distribution of citrus. J. Amer. Soc. Hort. Sci., 82: 177-179.

Foster, D.S. and T.S. Cornelia (1967). Colormetric methods of analysis. D. Vann Nostrand Company Inc., pp. 551-552.

Haynes, R.J. and R.S. Swift (1990). Stability of aggregates in relation to organic constituents and soil water content. J. Soil Sci., 41: 73-83.

Hegazi, E.S.; T.A. Yehia; S.A. Abo-Talep and M. Abou El-Wafa (2002). Effect of different available water levels on some transplants of pomegranate cultivars. 2nd Conf. Recent Technologies in Agriculture, Bull. Fac. Agric. Cairo Univ., 11: 447-462.

Hunt, R. (1989). Plant growth curves. Textbook, Printed (in Arabic), Baghdad, Iraq, pp. 25-76.

Ibrahim, A.M. and G.A. Abd El-Samad (2009). Effect of different irrigation regimes and partial substitution of N-mineral by organic manures on water use, growth and productivity of pomegranate trees. European Journal of Scientific Research, 38(2): 199-218.

Jackson, N.L. (1967). Soil chemical analysis. Prentice Hall Inc. Englewood Cliffs, N.S.

Jackson, N.L. and A. Ulich (1959). Analytical method for use in plant analysis. Coll. of Agric. Exp. State. Bull. 766, p. 25.

Kakehzadeh, S.; S. Sharafzadeh and B. Amiri (2014). Vegetative growth of apple trees as affected by irrigation frequency and chicken manure rate. International Journal of Biosciences, 4(2): 120-124.

Khattab, M.M.; A.E. Shaban; A.H. El-Shrief and A.S. Mohamed (2011). Growth and productivity of pomegranate trees under different irrigation levels. III: Leaf pigments, proline and mineral content. J. Hort. Sci. & Ornament. Plants 3(3): 265-269.

Klute, A. (1986). Methods of Soil Analysis Part 1-2nd ed. ASA and SSSA, Madison.

MALR (2003). Ministry of Agriculture and Land Reclamation. Planting and Productivity of apple in Egypt. Horticultural Institute, ARC, Bulletin, No. 14, (In Arabic).

Mansour, A.E.M.; F.F. Ahmed; A.M.K. Abdel-Aal and G.P. Cimpoles (2007). Use of mineral, organic, slow release and biofertiliers for Anna apple trees in a sandy soil. African Crop Science Conference Proceedings. 8: 265-271. Printed in El-Minia, Egypt.

Masoud, A.A.R. (2012). Effect of organic and bio-nitrogen fertilization on growth, nutrient status and fruiting of Flame seedless and Roby seedless grapevines. Res. J. Agric. and Bio. Sci., 8(2): 83-91.

Michael, A.M. (1978). Irrigation theory and practice. Vikus Publishing House, PVTLTD, New Delhi, India.

Mikhael, G.B. (2007). Effect of some drip irrigation and mulching treatments on: 1-Vegetative growth and nutritional status of “Anna” apple trees grown in new reclaimed soil. Minufiya J. Agric. Res. 32(4): 1155-1174.

Mikhael, G.B.Y.; M.A. Aziz and W.M. Abd El-Messeih (2010). Effect of some flood irrigation and potassium fertilization treatments on vegetative growth, yield and fruit quality of “Dissert Red” peach trees grown in clay soil. J. of Plant Production, Mansoura Univ. 1(4): 599-620.

Miller, R.W.; R.L. Donahue and J.V. Miller (1990). Soil. An introduction to soil and plant growth. 6th Ed. Prentice Hall Inter., London, pp. 50-60.

Milosevic, T. and N. Milosevic (2013). Response of young apricot trees to natural zeolite organic and inorganic fertilizers. Plant Soil Environ., 59(1): 44-49.

Moharam, F.A. and E.M.A. Zaen El-Deen (2011). Effect of partial substitution of mineral fertilizers with organic fertilizers on peach production under supplemental irrigation in North Sinai. Res. J. Agric. & Biological Sci. 7(6): 434-442.

Mpelasoka, B.S.; M.H. Behboudian and Mills (2001). Water relations, photosynthesis, growth, yield and fruit size of “Braeburn” apple response to deficit irrigation and crop load. J. of Hort. Sci. & Biotechnology, 76(2): 150-156.

Murquard, R.D. and J.L. Timpton (1987). Relation between extractable chlorophyll and an in situ method to estimate leaf green. Hort. Sci., 22(6): 1327.

Nassr, M.M.I. (2014). Saving irrigation water and reducing mineral fertilization for wheat using rice straw compost. J. Soil Sci. and Agric. Eng., Mansoura Univ., 5(4): 583-599.

Raid, M.B. and H.P. Olma (1972). Register of new fruits and nut. 2nd ed. pp. 708 (7-120) Davis, California, USA.

Shaheen, M.A.; S.M. Abd El-Wahab; F.M. El-Morsy and A.S.S. Ahmed (2013). Effect of organic and bio-fertilizers as a partial substitute for NPK mineral fertilization on vegetative growth, leaf mineral content, yield and fruit quality of Superior grapevine. J. Horticultural Science & Ornamental Plants. 5(3): 151-159.

Snedecor, G.W. and W.G. Cochran (1990). Statistical Methods. 7th Ed. The Iowa State Univ. Press, Ames. Iowa, USA, p. 393.

Wassel, A.M.; A.M.K. Abdelaal; A.M. Gowda and M.H. Abdel Aziz (2015). Response of Kadotta fig using some organic manures enriched with EM as a partial substitution of mineral N fertilizer. World Rural Observation, 7(2): 22-29.

Watanabe, S.; K. Kojima; Y. Lde and S. Sasaki (2000). Effect of saline and osmotic stress on proline and sugar accumulation in *Populus euphratica in vitro*. Plant Cell Tissue and Organic Culture, 63: 199-206.

Yoshida, S.; D.A. Fornno; J.H. Cock and K.A. Gomez (1972). Laboratory manual for physiological studies of rice. The International Rice research institute Los Banos, Philippines.

تأثير إحلال الأسمدة العضوية محل النيتروجين المعدنى تحت معدلات مختلفة من الرى على:
أ- النمو الخضرى والحالة الغذائية لأشجار التفاح صنف "آنا"

جهاد بشرى يوسف ميخائيل* و منال عادل عزيز**

*** قسم بحوث الفاكهة المتساقطة الاوراق - معهد بحوث البساتين - مركز البحوث الزراعية - الجيزة - مصر**

**** معهد بحوث الأراضى والمياه والبيئة - مركز البحوث الزراعية - الجيزة - مصر**

أجرى هذا البحث لدراسة تأثير مستويات الرى ومعاملات التسميد العضوى والتفاعل بينهما على بعض صفات التربة الكيماوية والطبيعية والنمو الخضرى والحالة الغذائية لأشجار 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. تم استخدام ثلاث مستويات من الرى عند ٧٠ ، ٥٠ ، ٣٠% من الماء الميسر فى التربة (رى١ ، رى٢ ، رى٣) مع إضافة سماد الماشية أو الدواجن العضوى بمعدل صفر ، ٥٠ ، ٧٥ ، ١٠٠% مع إضافة الباقى (١٠٠% ، ٥٠% ، ٢٥% ، صفر%) من الجرعة الموصى بها على صورة نيتروجين معدنى (٤٠٠ جم/شجرة /سنة) وذلك فى سبعة معاملات سمادية (تسميد١ - تسميد٧).

- أوضحت النتائج تأثير الصفات الطبيعية والكيماوية للتربة معنويا فيما عدا pH ، EC بكلا من معاملات التسميد العضوى والرى فى كلا الموسمين وكانت أفضل النتائج من حيث زيادة نسبة المادة العضوية والكربون العضوى والمسامية الكلية ومقاييس التحبب مع خفض الكثافة الظاهرية للتربة التى تم الحصول عليها بزيادة إضافة السماد العضوى حتى ١٠٠% وأيضا باستخدام الرى المتوسط عند ٥٠% من الماء الميسر (رى٢) مقارنة بمستوى الرى العالى أو المنخفض.
- كما أظهرت نتائج كلا الموسمين أن زيادة معدل الرى إلى ٥٠ أو ٧٠% من الماء الميسر قد أدى إلى زيادة معنوية فى مقاييس النمو والورقة والزيادة فى مساحة مقطع الجزع علاوة على متوسط عدد جذور الامتصاص ووزنها الطازج كما بينت النتائج أن التسميد بإضافة ٥٠% من سماد الماشية أو الدواجن + ٥٠% من السماد المعدنى (تسميد٢ أو تسميد٥) قد أدت إلى زيادة معنوية فى قيم مقاييس النمو هذه كما تعتبر المعاملات المركبة (رى١ × تسميد٢) ، (رى١ × تسميد٥) ، (رى٢ × تسميد٢) ، (رى٢ × تسميد٥) أفضل معاملات لتشجيع النمو الخضرى لأشجار التفاح صنف آنا.
- عكست النتائج المتحصل عليها إن إضافة سماد الماشية أو الدواجن العضوى منفردا (تسميد٤ ، تسميد٧) أدى إلى زيادة معنوية فى محتوى الأوراق من العناصر الكبرى والصغرى والكلوروفيل الكلى وخفض محتواها من البرولين الحر معنويا علاوة على ذلك فإن التسميد بسماد الدواجن منفردا قد تفوق على سماد الماشية منفردا فى تحسين المحتوى المعدنى للأوراق ومن جهة أخرى أدى خفض معدل الرى حتى ٣٠% من الماء الميسر إلى نقص معنوى فى محتوى الاوراق من العناصرالكبرى والصغرى والكلوروفيل الكلى بينما زاد محتوى الاوراق من البرولين الحر معنويا فى كلا من سنتى الدراسة.
- كما بينت النتائج أن استخدام المعاملات المركبة (رى١ × تسميد٧) ، (رى١ × تسميد٤) ، (رى٢ × تسميد٧) أو (رى٢ × تسميد٤) قد أعطى أعلى قيم فى محتوى الأوراق من النيتروجين والفوسفور والبوتاسيوم والكالسيوم والماغنسيوم والحديد والمنجنيز والزنك والكلوروفيل الكلى بدون فروق معنوية بينهم بينما أقل القيم تتبع (رى٣ × تسميد١) فى كلا الموسمين.
- لذلك توصى هذه الدراسة مزارعى التفاح صنف "آنا" بتسميد أشجارهم بإضافة ٥٠% من سماد الماشية أو سماد الدواجن + ٥٠% من السماد النيتروجينى المعدنى تحت المعدل المتوسط من الرى فى المعاملة المركبة (رى٢ × تسميد٢) أو (رى٢ × تسميد٥) والتى تعتبر أفضل معامل لتحسين معظم صفات التربة الطبيعية والكيماوية وتوفير مياه الرى بحوالى ١١.٧٣% والحفاظ على رطوبة التربة مما يشجع من نمو المجموع الخضرى والجذرى ومحتوى الاوراق من العناصر المعدنية والكلوروفيل تحت ظروف الاراضى الطينية حيث انه باستخدام هذه المعاملة يمكن خفض الحاجة إلى التسميد المعدنى بمعدل ٥٠% بالاضافة لتقليل تكاليف الانتاج والتلوث البيئى الذى يحدث نتيجة الاسراف فى استخدام الاسمدة المعدنية.