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EFFECT OF DRIP IRRIGATION AND NITROGEN FERTILIZATION ON:

I- THE VEGETATIVE GROWTH AND ACTIVE ROOTING DEPTH OF "ANNA" APPLE TREES GROWN IN NEW RECLAIMED SOILS

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ABSTRACT

The present study was carried out in 1997 , 1998 , 1999 seasons on 5-years old "Anna" apple trees budded on MM. 106 rootstock and grown in a loamy sand soil at Desert Development Center (DDC) of the American University in Cairo (AUC) Sadat Research Station (SRS), El-Menofeya Governorate. The goal of this work was to study the effect of four irrigation treatments and three nitrogen levels on the vegetative growth, and active rooting depth (ARD). The amount of irrigation water applied to each tested tree based on soil-matrix-potential in the three irrigation treatments (I_1 , I_2 and I_3) , and the control treatment.

The main results can be summarized in the following points:

1- The trunk cross-sectional area (TCA), branch diameter, average shoot length and number of shoot per tree, average leaf area increased proportionally with increasing irrigation rate and N level applied.

2- Dry matter percentage in the leaves significantly increased with increasing the irrigation rate, while the effect of the three N levels on this value was not big enough to be significant.

3- Active rooting depth (ARD) increased as irrigation rate increased.

INTRODUCTION

Apple is considered as one of the important fruit crops in Egypt. The total planted area increased rapidly through the last two decades from less than one thousand feddans in 1979 to more than 70 thousand feddans in 1997 producing 403 thousand tons of fruits (according to statistics of the Ministry of Agriculture and Land Reclaimation in 1979 and 1997). On the basis of total planted area of fruits in ARE, apples occupied the fifth fruit crop in 1997. This rapid increase in the apple acreage is due to the introduction of "Anna" apple variety (a hybrid between "Red Hadassiya" and "Golden Delicious" apple varieties).

The increase of the new established apple orchards mostly was in Nubaria region (new cultivated area), where the total area of apple orchards was reached 50400 feddans. This area represents 71.5% of the total apple acreage in Egypt. In these new cultivated regions, the drip irrigation is the main system used to irrigate apple orchards, since saving water is considered one of the main aims in these regions.

The present investigation was conducted on "Anna" apple trees budded on MM. 106 rootstock in order to study the effect of applying the trees with four irrigation treatments and three nitrogen levels on the vegetative growth and active rooting depth.

MATERIALS AND METHODS

The present investigation was carried out during 1997, 1998 and 1999 growing seasons, on 5-year-old "Anna" apple trees (*Malus domestica,* Brokh*)* budded on MM. 106 rootstock, in order to study the effect of four drip irrigation treatments combined with three nitrogen fertilization levels on the vegetative growth, and active rooting depth of the trees.

The experimental trees spaced at 3.5 × 3.5 meters apart and grown in the Desert Development Center (DDC), American University in Cairo (AUC), at Sadat Research Station (SRS), El-Menofeya Governorate. "Dorsette Golden" apple variety was planted as a pollinator. The physical and chemical analysis of the experimental orchard soil were conducted before starting these experiments in 1996. Four soil layers, reached to 150 cm depth, were distinguished and the percentages of sand, clay and silt were ranged from 84-86.2%, 8 .9-10.3% and 4.8 – 5.3%, respectively. In addition, chemical analysis of soil samples showed that its pH was 7.05 – 7.29, EC = 1.81 – 2.47 ds/m and $CaCo_3$ = 5.8 – 13.8%. Thus, the soil texture was classified as loamy sand with pH=7.2. The chemical analysis of irrigation water [according to Chapman and Pratt, 1961] cleared that pH was 7.4 , sodium absorption ratio (SAR) = 2.6 and EC = 0.94 ds/m. The organic manure samples were taken yearly in November, dried and chemically analyzed. The average N, P, K, Ca and Mg content of manure was 1.65 – 1.72 , 0.71 – 0.73, 0.77 – 0.81, 2.88 – 2.94 and 1.28 – 1.32%, respectively, on the dry weight basis. The corresponding concentrations of Fe, Mn , Zn and Cu were ranged from 540 – 553, 29-34, 122-130 and 48 – 55 ppm, respectively. There was one line of drip irrigation for every row of the trees, with 2 emitters per tree (12 L/h for each) installed in a location opposite to tree trunk at distance of 35 cm of tree trunk. The trees received the same cultural practiecs as usually done in this orchard.

Seventy two trees, as uniform as possible, were selected at random for this study. The trees were planted in eight rows each of nine trees. Within the row, the trees were devided into three groups, and each group received one of the three fertilization treatments. Such selected trees were under three irrigation treatments plus control one. The treatments were arranged in a randomized complete block design with six replicates for each treatment, using one tree as a single replicate (twelve treatment × six replicates = seventy two trees). The main factor was the irrigation treatments, and the submain factor was the fertilization treatments. The treatments were laid out as split in complete randomized design. The statistical analysis was done according to SAS (1989). The trial was repeated for three consecutive seasons on the same trees in 1997, 1998 and 1999.

Irrigation treatments

In order to calculate water requirements of trees, a retention curve of the soil was made by determining the soil moisture in samples taken at every 15 cm from the soil surface to 120 cm depth at bars from 0.0 to 0.8 bars according to Black (1965).

For every irrigation treatment (except the control) a mercury manometer was used to monitor the irrigation treatments. The manometer was located beside one of the two emitters and on 45 cm soil depth. When the mercury reached the detected soil matrix potential, the irrigation started and the manometer was readjusted after every irrigation . The irrigation treatments for the three years were as follows:

I_1 (Normal irrigation treatment): Each tree received 30, 40 and 60 litres of water in 1997, 1998 and 1999, respectively, when the soil matrix potential reached to 0.1 – 0.3 bars.

I_2 (Medium irrigation treatment): Each tree received 25, 34 and 53 litres of water in 1997, 1998 and 1999, respectively, when soil matrix potential reached to 0.3 – 0.5 bars.

I_3 (Deficit irrigation treatment): Each tree received 22, 29 and 46 litres of water in 1997, 1998 and 1999, respectively, when soil matrix potential reached to 0.5 – 0.7 bars.

I_4 (Control treatment): Each tree received 72, 72 and 84 litres of irrigation water in 1997, 1998 and 1999, respectively.

In addition, each tree was supplied with leaching requirements (6%) to the applied quantity of water/tree to every fourth irrigation (except for the control treatment).

Fertilization treatments

Each fertilizer was added to each tree during irrigation. There were three different nitrogen treatments for "Anna" apple trees in addition to supplying the trees with a constant dose of potassium sulphate (352 , 484 and 761 gm) and orthophosphoric acid (80 , 110 and 172.8 cm^3) in 1997, 1998 and 1999 seasons, respectively. Thus, the added doses differed in the three years of experiment according to the size of tree and the quantity of irrigation water supplied to it. In addition, tree growing season was divided into three periods each as follows: from mid February to end of March, from first April to end of June and from first July to end of September. In each period, the fertilizer was dissolved in one litre of water and applied in a circle (70 cm in diameter) around the tree trunk. The doses of ammonium nitrate supplied was 325, 405.6 and 487.6 gm/tree in 1997, 442.0 , 552.5 and 663 gm/tree in 1998 and 702.0 , 877.5 and 1053 gm/tree in 1999 for the first, second and third nitrogen treatment, respectively. The total amount of manure, which added (in December) to each experimental tree was 10 kgs/tree in either 1997 or 1998 and increased to 15 kgs/tree in 1999. In addition, from the beginning of April, the trees were sprayed with a solution of chelated Fe, Mn and Zn at 0.75 , 0.33 and 0.17 gm per litre, respectively. The spray was repeated every month till the end of September.

A. Vegetative growth measurements

Four main branches as uniform as possible were chosen at the four cardinal points of each tree (east, west , north and south) and tagged. Their diameters were measured at 10 cm from the base of the branch and the trunk circumference was measured at 10 cm above the scion-stock union on January 25th , 1997, 1998 and 1999. The number of the current shoots on each selected branch was counted on October 16th. The diameter and length of 15 new shoots on each chosen branch were measured. The trunk cross-sectional area (TCA) was calculated in each year. In order to determine the leaf area, samples of 10 mature leaves each were collected at random from each tree on August 7th, washed with tap water and dried with a piece of cotton tissue. The leaf area was determined by using leaf area meter (Model CI-203, CID, Inc, U.S.A.).

To determine the percentage of leaf dry matter, twenty five leaves from each combined treatment, were collected from the middle part of the current outer growing non-bearing shoots on August 7th in each year. The leaves of each sample were cleaned by pieces of cotton, weighed, washed several times with tap water, rinsed three times in distilled water, and then dried at 70-80 °C in an electric air drying oven to a constant weight. The dried leaf samples were then weighed again to estimate the percentage of leaf dry matter.

B. Determination of active rooting depth (ARD)

Active rooting depth (ARD) is defined as the maximum soil depth which supplies plant with 80 percent of water and considered an indirect method to show the distribution of root system in the soil profile. It was determined for apple trees according to Levin *et al.*, (1973).

RESULTS AND DISCUSSION

A. Vegetative growth

1. Branch diameter

Concerning the effect of irrigation treatments on the average increase in branch diameter, irrespective the effect of N levels, the data in Table (1) indicated that the increase was significantly higher in the control treatment, as compared with that in all irrigation treatments in 1997 and 1998 and the I_2 and 1_3 treatments in 1999. In addition, the increase in branch diameter in I_1 was significantly higher than that of I_2 and I_3 in the three seasons. These results agreed with those obtained by Kipp (1988), who found that trickle irrigation promoted shoot growth of apple trees.

Regarding the effect of N levels on the increase in branch diameter, irrespective the effect of irrigation treatments, the data of the three seasons indicated that the trees had the highest increase in branch diameter at N_3 level (Table 1) followed by N_2 level, whereas N_1 level gave the lowest value. The statistical analysis showed significant differences in the increase in branch diameter among all N levels except between N_1 and N_2 levels in 1997 and 1998 only. These results agreed with the findings of Klein *et al.*, (1989),

who reported that the vegetative growth of "Starking Delicious" apple trees was correlated positively with the amount of N applied .

Table (1) : Effect of irrigation and nitrogen fertilization treatments on the average increase of branch diameter (cm) of "Anna" apple trees in 1997,1998 and 1999 seasons.

Fertilization Levels	Irrigation treatments				Average
	I_1	I_2	I_3	Control	
	1997				
N_1	0.30 ^{de}	0.24 ^{g}	0.11 ^{h}	0.35 ^{c}	0.25 ^{b}
N_2	0.33 ^{cd}	0.25 ^{fg}	0.10 ^{h}	0.39 ^{b}	0.27 ^{b}
N_3	0.47 ^{a}	0.28 ^{ef}	0.07 ^{h}	0.47 ^{a}	0.32 ^{a}
Average	0.37 ^{b}	0.25 ^{c}	0.10 ^{d}	0.40 ^{a}	
L.S.D. (0.05)	Irrigation 0.0224	Fertilization 0.0185		Interaction 0.0369	
	1998				
N_1	0.41 ^{c}	0.24 ^{e}	0.11 ^{f}	0.41 ^{c}	0.29 ^{b}
N_2	0.44 ^{c}	0.25 ^{e}	0.07 ^{f}	0.49 ^{b}	0.31 ^{b}
N_3	0.50 ^{b}	0.33 ^{d}	0.07 ^{f}	0.58 ^{a}	0.37 ^{a}
Average	0.45 ^{a}	0.27 ^{b}	0.08 ^{c}	0.49 ^{a}	
L.S.D (0.05)	Irrigation 0.0502	Fertilization 0.0261		Interaction 0.0522	
	1999				
N_1	0.34 ^{cd}	0.22 ^{f}	0.14 ^{g}	0.33 ^{d}	0.26 ^{c}
N_2	0.39 ^{b}	0.25 ^{ef}	0.12 ^{gh}	0.37 ^{bc}	0.28 ^{b}
N_3	0.58 ^{a}	0.28 ^{e}	0.10 ^{h}	0.54 ^{a}	0.38 ^{a}
Average	0.43 ^{a}	0.25 ^{b}	0.12 ^{c}	0.41 ^{a}	
L.S.D (0.05)	Irrigation 0.0225	Fertilization 0.0185		Interaction 0.0369	

The values followed by the same letter do not differ at 5% level of significance.

2. Shoot number

In view of the effect of irrigation treatments on the average number of shoots produced on each selected branch, irrespective the effect of N levels, the data in Table (2) showed that it was significantly higher in the control irrigation treatment, as compared with all other treatments in 1997 and 1998 seasons, whereas in 1999 season the highest values were obtained in both control and I_1 treatments. The above mentioned results were in accordance with those obtained by Goode and Hyrycz (1964), who reported that the main effect of water was an increase in the number of shoots produced by "Laxton's Superb" apple trees. Hipps (1997) noted that the irrigation consistently inereased new shoot growth of the apple cultivar "Queen Cox" on M.9 rootstock as compared with no irrigation.

Table (2) : Effect of irrigation and nitrogen fertilization treatments on the average shoot number of each selected branch of "Anna" apple trees in 1997,1998 and 1999 seasons.

Fertilization levels	Irrigation treatments				Average
	I_1	I_2	I_3	Control	
	1997				
N_1	16.40 ^{cd}	12.30 ^{f}	12.00 ^{f}	17.00 ^{c}	14.43 ^{c}
N_2	18.20 ^{b}	14.80 ^{e}	11.40 ^{f}	19.10 ^{b}	15.88 ^{b}
N_3	21.30 ^{a}	16.00 ^{d}	10.00 ^{g}	22.20 ^{a}	17.38 ^{a}
Average	18.63 ^{b}	14.37 ^{c}	11.13 ^{d}	19.43 ^{a}	
L.S.D. (0.05)	Irrigation 0.545	Fertilization 0.465		Interaction 0.931	
	1998				
N_1	16.60 ^{de}	12.40 ^{g}	11.60 ^{g}	17.20 ^{d}	14.45 ^{c}
N_2	18.30 ^{c}	14.90 ^{f}	10.30 ^{h}	19.40 ^{b}	15.73 ^{b}
N_3	21.50 ^{a}	16.10 ^{e}	8.70 ^{I}	22.40 ^{a}	17.18 ^{a}
Average	18.80 ^{b}	14.47 ^{c}	10.20 ^{d}	19.67 ^{a}	
L.S.D. (0.05)	Irrigation 0.556	Fertilization 0.463		Interaction 0.925	
	1999				
N_1	17.60 ^{c}	14.00 ^{f}	12.60 ^{g}	17.30 ^{cd}	15.38 ^{c}
N_2	20.00 ^{b}	15.20 ^{e}	11.40 ^{h}	19.60 ^{b}	16.55 ^{b}
N_3	22.60 ^{a}	16.20 ^{de}	10.30 ^{h}	22.50 ^{a}	17.90 ^{a}
Average	20.07 ^{a}	15.13 ^{b}	11.43 ^{c}	19.80 ^{a}	
L.S.D. (0.05)	Irrigation 0.688	Fertilization 0.569		Interaction 1.140	

The values followed by the same letter do not differ at 5 % level of significance.

As for the effect of the nitrogen levels on the average shoot number of the selected branch, irrespective the effect of irrigation treatments, the results showed that the increase in nitrogen level applied to each tree proportionally increased the average number of shoot per each selected branch and the differences among the different N levels were statistically significant in the three seasons (Table 2). These results agreed with those obtained by Vasilenko (1991), who found that the highest N rate gave the largest number of shoots per apple tree of the cultivars "Renet Simirenko" and "King David".

3. Shoot length

Redarding the effect of the different irrigation treatments on the average shoot length, irrespective the influence of different N levels, the data in Table (3) indicated that the highest significant average shoot length was found in control and I_1 treatments followed by I_2 treatment, while I_3 treatment showed the lowest value during the three seasons and the differences among them were significant. These findings were in line with those reported by Gergely and Farago (1985), who mentioned that trickle irrigation increase shoot length of "Jonathan" apple trees. Moreover, Mills *et al.*, (1996) reported

that the shoot length of "Braeburn" apple trees on MM.106 rootstock was reduced when subjected to deficit irrigation.

Concerning the effect of the different N levels on the shoot length, irrespective the effect of irrigation treatments, the data of the three seasons in Table (3) indicated that the average shoot length was significantly higher at the highest N level treatment, as compared with that of the other nitrogen treatments while the lowest significant average shoot length was observed in the lowest N level treatment. These results agreed with those obtained by Vasilenko (1991), who found that the highest N rate gave the largest shoot length of "Renet Simirenko" and "King David" apple varieties. Hipps (1997) mentioned that the N fertilizer increased shoot growth of apple trees cultivar "Queen Cox" /M.9 rootstock as compared with the control.

Table (3) : Effect of irrigation and nitrogen fertilization treatments on the average shoot length (cm) of "Anna" apple trees in 1997,1998 and 1999 seasons.

Fertilization levels	Irrigation treatments				Average
	I_1	I_2	I_3	Control	
	1997				
N_1	18.10 ^{d}	15.90 ^{f}	13.10 ^{g}	17.80 ^{d}	16.23 ^{c}
N_2	19.50 ^{c}	16.80 ^{ef}	12.80 ^{g}	19.80 ^{bc}	17.23 ^{b}
N_3	20.60 $^{a\,b}$	17.20 ^{de}	12.20 ^{g}	21.00 ^{a}	17.75 ^{a}
Average	19.40 ^{a}	16.63 ^{b}	12.70 ^{c}	19.53 ^{a}	
L.S.D (0.05)	Irrigation 0.510	Fertilization 0.499		Interaction 0.998	
	1998				
N_1	19.20 ^{c}	16.70 ^{e}	12.60 ^{f}	19.40 ^{c}	16.98 ^{c}
N_2	20.80 ^{b}	18.20 ^{d}	12.10 ^{fg}	21.00 ^{b}	18.03 ^{b}
N_3	21.70 ^{a}	19.90 ^{c}	11.70 ^{g}	21.90 ^{a}	18.55 ^{a}
Average	20.57 ^{a}	17.93 ^{b}	12.13 ^{c}	20.77 ^{a}	
L.S.D (0.05)	Irrigation 0.308	Fertilization 0.309		Interaction 0.617	
	1999				
N_1	20.00 ^{d}	17.10 ^{f}	13.40 ^{g}	19.80 ^{d}	17.58 ^{c}
N_2	22.30 ^{bc}	18.20 ^{e}	12.90 ^{gh}	21.90 ^{c}	18.83 ^{b}
N_3	23.10 ^{a}	18.60 ^{e}	12.50 ^{h}	22.80 $^{a\,b}$	19.25 ^{a}
Average	21.80 ^{a}	17.97 ^{b}	12.93 ^{c}	21.50 ^{a}	
L.S.D (0.05)	Irrigation 0.390	Fertilization 0.299		Interaction 0.599	

The values followed by the same letter do not differ at 5% level of significance.

4. Shoot diameter

Concerning the effect of irrigation treatments on the average shoot diameter, irrespective the influence of N levels, the data in Table (4) showed that the average shoot diameter was significantly higher in both control and I_1

than that in the other irrigation treatments, in1997 and 1998. In 1999, the average shoot diameter was significantly higher in I_1 than that in the other irrigation treatments. This finding seemed to be agreed with those obtained by Hussein (1998), who mentioned that the irrigation at the optimum rate positively increased shoot diameter of "Anna" apple trees.

As for the effect of the nitrogen levels on the average shoot diameter, irrespective the effect of irrigation water, the data of the three seasons in Table (4) indicated that the highest average shoot diameter was found in the highest level (N_3) followed by the intermediate level (N_2) while the lowest values were found in the lowest level (N_1), and the differences among all nitrogen levels were statistically significant except between N_2 and N_1 in 1997 only. These results in generally agreed with previous investigators such as Tromp and Bolding (1988), who found that the fertilization with N, enhanced shoot growth of several apple cultivars.

Table (4): Effect of irrigation and nitrogen fertilization treatments on the average shoot diameter (cm) of "Anna" apple trees in 1997,1998 and 1999 seasons.

Fertilization levels	Irrigation treatments				Average
	I_1	I_2	I_3	Control	
	1997				
N_1	0.68 ^{c}	0.50 ^{ef}	0.45 ^{fg}	0.70 ^{c}	0.58 ^{b}
N_2	0.76 ^{b}	0.54 ^{de}	0.43 ^{g}	0.80 ^{ab}	0.60 ^{b}
N_3	0.81 ^{ab}	0.58 ^{d}	0.40 ^{g}	0.85 ^{a}	0.63 ^{a}
Average	0.75 ^{a}	0.54 ^{b}	0.43 ^{c}	0.78 ^{a}	
L.S.D (0.05)	Irrigation 0.032	Fertilization 0.027		Interaction 0.052	
	1998				
N_1	0.70 ^{c}	0.52 ^{e}	0.48 ^{ef}	0.72 ^{c}	0.61 ^{c}
N_2	0.80 ^{b}	0.59 ^{d}	0.45 ^{fg}	0.81 ^{ab}	0.66 ^{b}
N_3	0.84 ^{ab}	0.62 ^{d}	0.42 ^{g}	0.86 ^{a}	0.69 ^{a}
Average	0.78 ^{a}	0.58 ^{b}	0.45 ^{c}	0.81 ^{a}	
L.S.D (0.05)	Irrigation 0.032	Fertilization 0.026		Interaction 0.052	
	1999				
N_1	0.79 ^{d}	0.53 ^{h}	0.50 ^{i}	0.76 ^{e}	0.65 ^{c}
N_2	0.90 ^{b}	0.60 ^{g}	0.48 ^{ij}	0.86 ^{c}	0.71 ^{b}
N_3	0.97 ^{a}	0.65 ^{f}	0.46 ^{j}	0.91 ^{b}	0.75 ^{a}
Average	0.89 ^{a}	0.59 ^{c}	0.48 ^{d}	0.84 ^{b}	
L.S.D (0.05)	Irrigation 0.022	Fertilization 0.002		Interaction 0.025	

The values followed by the same letter do not differ at 5 % level of significance.

5. Trunk cross - sectional area (TCA) increase

Concerning the TCA increase, the data are shown in Table (5). As an average of irrigation treatments, irrespective the influence of the different

nitrogen levels, the results indicated that the control treatment gave the highest TCA increase, while the third irrigation treatment (deficit irrigation) showed significantly the lowest value in the 1st and 2nd seasons of study. Meanwhile, the differences among all irrigation treatments were significant. In 1999, TCA increase in I_1 was significantly higher than that of the other irrigation treatments and the differences among them were significant. These results agreed with those obtained by previous investigators such as Goode and Hyrycz (1964), Goode and Ingram (1971), Assaf *et al.*, (1975) and Lotter *et al.*, (1985). They mentioned that annual trunk growth of apple trees increased as a result of receiving supplemental water. In addition, Neilsen *et al.*, (1995) reported that the average trunk cross-sectional area of " Gala" apple trees /M.26 was at high irrigation frequency significantly higher than those at intermediate and low frequency.

Table (5) : Effect of irrigation and nitrogen fertilization treatments on the trunk cross - sectional area(TCA) increase in cm^2 of "Anna" apple trees in 1997,1998 and 1999 seasons.

Fertilization levels	Irrigation treatments				Average
	I_1	I_2	I_3	Control	
	1997				
N_1	8.80 ^{bc}	7.15 ^{d}	4.48 ^{e}	10.05 ^{b}	7.62 ^{c}
N_2	9.01 ^{bc}	8.25 ^{cd}	3.81 ^{e}	12.65 ^{a}	8.43 ^{b}
N_3	13.09 ^{a}	9.61 ^{bc}	3.24 ^{e}	13.35 ^{a}	9.82 ^{a}
Average	10.31 ^{b}	8.33 ^{c}	3.84 ^{d}	12.02 ^{a}	
L.S.D. (0.05)	Irrigation 1.250	Fertilization 0.810		Interaction 1.620	
	1998				
N_1	10.41 ^{de}	7.59 ^{g}	4.97 ^{h}	12.08 ^{d}	8.76 ^{c}
N_2	14.11 ^{c}	8.46 ^{fg}	3.94 ^{hi}	14.75 ^{c}	10.29 ^{b}
N_3	16.86 ^{b}	9.67 ^{ef}	2.32 ^{i}	20.42 ^{a}	12.32 ^{a}
Average	13.75 ^{b}	8.57 ^{c}	3.74 ^{d}	15.75 ^{a}	
L.S.D. (0.05)	Irrigation 1.170	Fertilization 0.899		Interaction 1.799	
	1999				
N_1	14.93 ^{bc}	8.51 ^{de}	6.78 ^{ef}	13.35 ^{c}	10.89 ^{b}
N_2	15.74 ^{b}	8.99 ^{d}	6.17 ^{f}	15.58 ^{b}	11.62 ^{b}
N_3	20.33 ^{a}	10.24 ^{d}	3.16 ^{g}	18.62 ^{a}	13.09 ^{a}
Average	17.00 ^{a}	9.24 ^{c}	5.37 ^{d}	15.85 ^{b}	
L.S.D. (0.05)	Irrigation 1.044	Fertilization 0.956		Interaction 1.911	

The values followed by the same letter do not differ at 5% level of significance.

As for the effect of the N levels fertilization on the TCA increase, irrespective the irrigation treatments, the data of the three seasons inTable (5) revealed that TCA increase differed significantly among all N treatments in the three seasons except that between N_1 and N_2 levels in 1999, where the difference was not significant. These findings agreed with those of Fallahi *et al.*, (1997), who reported that cv. "BC-2 Red Fuji" apple trees which received a total of 197g urea as a soil application over 3 growing seasons had a

greater trunk cross – sectional area than those which received one three rates of foliar application.

6. Leaf area

As for the effect of irrigation treatments, irrespective the effect of N levels, on the average leaf area, the data in Table (6) indicated that the highest significant leaf area was found in the control and I_1 treatments, as compared with that in I_2 and I_3 through the three seasons. These results in generally agreed with previous investigators such as Chapman (1973), who noticed that, leaf area of apple trees was positively affected by the increase of available water. Mills *et al.*, (1996) reported that leaf area of "Braeburn" apple trees was reduced in DI (deficit – irrigation) as compared with control (fully watered) treatments.

Table (6): Effect of irrigation and nitrogen fertilization treatments on the average leaf (cm^2) of "Anna" apple trees in 1997,1998 and 1999 seasons.

Fertilization levels	Irrigation treatments				Average
	I_1	I_2	I_3	Control	
	1997				
N_1	31.25^{cd}	25.36^{e}	21.11^{f}	33.91^{bc}	27.91^{b}
N_2	34.24^{bc}	29.34^{d}	20.65^{f}	36.31^{ab}	30.14^{a}
N_3	35.63^{ab}	30.07^{d}	19.18^{f}	39.03^{a}	30.97^{a}
Average	33.71^{a}	28.25^{b}	20.31^{c}	36.41^{a}	
L.S.D. (0.05)	Irrigation 3.449	Fertilization 1.724		Interaction 3.448	
	1998				
N_1	32.81^{cd}	26.44^{f}	19.40^{g}	34.57^{c}	28.30^{c}
N_2	34.73^{c}	28.59^{e}	16.81^{h}	37.60^{b}	29.43^{b}
N_3	37.57^{b}	31.07^{d}	13.57^{i}	40.03^{a}	30.81^{a}
Average	35.03^{b}	28.70^{c}	16.59^{d}	37.73^{a}	
L.S.D. (0.05)	Irrigation 1.556	Fertilization 1.062		Interaction 2.125	
	1999				
N_1	36.92^{a}	26.66^{de}	25.25^{e}	35.82^{ab}	31.16^{a}
N_2	38.69^{a}	30.80^{cd}	22.36^{ef}	36.48^{a}	32.08^{a}
N_3	40.44^{a}	31.34^{bc}	19.26^{e}	38.73^{a}	32.44^{a}
Average	38.68^{a}	29.61^{b}	22.29^{c}	37.01^{a}	
L.S.D. (0.05)	Irrigation 4.333	Fertilization 2.326		Interaction 4.653	

The values followed by the same letter do not differ at 5% level of significance.

As for the effect of the nitrogen levels on the average leaf area, irrespective the effect of irrigation treatments, the data of 1997 season in Table (6) indicated that the leaf area of the trees grown under N_3 and N_2 levels was equal and significantly higher than the values obtained from trees grown under N_1 level. The data of the second season in Table (6) indicated that the average leaf area was higher in N_3 level followed by N_2 level and the lowest value was found in N_1 level and the differences in leaf area among the three N levels were statistically significant.These results are in accordance

with those obtained by Millard and Neilsen (1989), who found that increasing N supply increased leaf growth of M.26 apple rootstock.

7. Leaf dry matter content

Concerning the effect of the irrigation water treatments on the leaf dry matter content, irrespective the effect of different nitrogen levels, the data in Table (7) showed that it was significantly higher in the control and I_1 treatments, as compared with that in I_2 and the latter was significantly higher than that in I_3 treatment in 1997, 1998 and 1999 seasons. These results generally agreed with those of previous investigators such as Chapman (1973), who found that leaf dry weight of nursery apples was positively affected by increasing of available water. Moreover, Hussein (1998) found that, leaf dry weight of "Anna" apple trees decreased as the irrigation rate was decreased.

Table (7) : Effect of irrigation and nitrogen fertilization treatments on the percentage of leaf dry matter of "Anna" apple trees in 1997,1998 and 1999 seasons.

Fertilization levels	Irrigation treatments				Average
	I_1	I_2	I_3	Control	
	1997				
N_1	47.91 [a]	46.08 [bc]	44.15 [cd]	48.23 [a]	46.59 [a]
N_2	49.04 [a]	46.11 [bc]	42.89 [d]	49.33 [a]	46.84 [a]
N_3	49.97 [a]	46.92 [b]	41.42 [de]	50.35 [a]	47.16 [a]
Average	48.97 [a]	46.37 [b]	42.82 [c]	49.30 [a]	
L.S.D. (0.05)	Irrigation 1.945	Fertilization 0.817		Interaction 2.506	
	1998				
N_1	48.95 [ab]	47.13 [b]	46.20 [b]	49.23 [ab]	47.88 [a]
N_2	50.08 [a]	46.83 [b]	44.89 [c]	50.32 [a]	48.03 [a]
N_3	51.08 [a]	47.81 [b]	43.35 [c]	51.33 [a]	48.39 [a]
Average	50.04 [a]	47.26 [b]	44.81 [c]	50.31 [a]	
L.S.D. (0.05)	Irrigation 1.952	Fertilization 0.756		Interaction 2.472	
	1999				
N_1	49.25 [ab]	47.16 [b]	46.23 [bc]	48.97 [ab]	47.90 [a]
N_2	50.35 [a]	47.25 [b]	44.97 [cd]	50.10 [a]	48.17 [a]
N_3	51.35 [a]	47.90 [b]	43.48 [d]	51.11 [a]	48.46 [a]
Average	50.32 [a]	47.44 [b]	44.89 [c]	50.06 [a]	
L.S.D. (0.05)	Irrigation 2.053	Fertilization 0.941		Interaction 2.697	

The values followed by the same letter do not differ at 5% level of significance.

As for the effect of N levels on the leaf dry matter content, irrespective the effect of irrigation treatments, the data shown in Table (7), indicated that the differences among the different N levels was not so big enough to be statistically significant, in 1997, 1998 and 1999 seasons. These results are in agreement with those of Naiema (1998), who found insignificant differences in the leaf dry matter content of "Anna" apple trees between the

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control treatment (high fertilizer) and Kristalon fertilizer theatment (low fertilizer).

B. Active (Effective) rooting depth (ARD)

Regarding the effect of the four irrigation treatments on the active rooting depth (ARD) in both May, 1998 and October, 1999 seasons, the obtained data cleared the following results:

a) The best ARD was found under the higher (control) and normal (I_1) irrigation treatments in 1998 and 1999 seasons . The lack of applied quantity of irrigation water to " Anna" apple trees reduced the ARD which was 95.8cm, 95.5cm,90.3cm and 76.2cm in 1998 and 99.8 cm, 97.6 cm, 81.3 cm and 76.7 cm in 1999 under the control , I_1 , I_2 and I_3 , respectively.

b) The ARD in the control treatment increased from 95.8 cm in 1998 to 99.8 cm in 1999 season, and in normal irrigation (I_1) from 95.5 cm in 1998 to 97.6 cm in 1999 season. On the contrary, ARD was decreased from 90.3 cm in 1998 season to 81.3 cm in 1999 for I_2 treatment whereas under deficit irrigation (I_3) it was almostly constant (about 76.6 cm in 1999).

These results revealed a positive relationship between the applied quantity of irrigation water to "Anna" apple trees and their active rooting depth. This was observed with previous investigators such as Proebsting *et al.*, (1977) and Levin *et al.*, (1979 and 1980). Assaf *et al.*, (1989) mentioned that applied drip irrigation at a lower soil-matrix-potential (SMP) threshold to apple cultivars "Golden Delicions" and "Jonathan" uses less water and limits the volume of wetted soil, restricting root spread and giving

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تأثير الرى بالتنقيط والتسميد النيتروجينى على:
١- النمو الخضرى وعمق الجذور النشط لأشجار التفاح صنف "آنا" النامية فى الأراضى حديثة الاستصلاح

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أجريت هذه الدراسة فى أعوام ١٩٩٧ و ١٩٩٨ و ١٩٩٩ على أشجار التفاح صنف "آنا" عمرها خمسة سنوات مطعومة على أصول مولنج مورتن ١٠٦ ونامية فى أرض ذات قوام "طميى رملى" بمحطة بحوث السادات التابعة لمركز تنمية الصحراء التابع للجامعة الأمريكية بالقاهرة والكائنة بمحافظة المنوفية . والهدف من هذا البحث هو دراسة تأثير أربع معاملات رى وثلاثة مستويات نيتروجين على النمو الخضرى وعمق الجذور النشط لأشجار التفاح صنف " آنا ".

كمية المياه المضافة إلى كل شجرة تفاح مبنية على أساس جهد الشد الرطوبى فى ثلاث معاملات رى (رى١ ، رى٢ ، رى٣) بالإضافة إلى معاملة الكنترول.

ويمكن تلخيص النتائج الرئيسية فى النقاط التالية:

١- كانت مساحة مقطع الجذع وقطر الأفرع ومتوسط طول النموات الحديثة وعددها لكل شجرة ومتوسط مساحة الورقة فى زيادة متناسبة مع زيادة معدل الرى ومستوى النيتروجين.

٢- النسبة المئوية للمادة الجافة فى الأوراق زادت معنويا مع زيادة معدل الرى بينما تأثير الثلاثة مستويات من النيتروجين على هذه القيمة لم يكن كبيرا بدرجة المعنوية.

٣- عمق الجذور النشطة زاد بزيادة معدل الرى.