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EFFECT OF DRIP IRRIGATION AND NITROGEN FERTILIZATION ON:

III- THE YIELD, FRUIT QUALITY AND SAVING WATER OF "ANNA" APPLE TREES GROWN IN NEW RECLAIMED SOILS

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ABSTRACT

The present research 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 objective of this work was to study the effect of four irrigation treatments and three nitrogen levels on the yield, fruit quality and saving irrigation water. 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- Fruit yield per tree was significantly lower in trees grown under low irrigation rate. The yield increased positively with increasing N level and irrigation rate.

2- Increasing irrigation rate as well as N level proportionally increased fruit weight, length and diameter.

3- The concentration of anthocyanin in fruit skin, fruit firmness, TSS% in fruit juice and the percentage of starch in fruits increased gradually with decreasing irrigation rate.

4- Increasing N level caused a significant decrease in fruit firmness and TSS% in fruit juice. On the other hand, the all used levels of nitrogen fertilization had no effect on anthocyanin concentration in the fruit skin and the percentages of total sugars, reducing sugars and starch in "Anna" apple fruits.

5- The percentage of juice acidity proportionally decreased with decreasing irrigation rate and N level.

6- The highest fruit yield was obtained from the trees grown under normal irrigation rate (I_1) at the end of present study (1999) although, in 1999 season, the latter irrigation treatment used less quantity of irrigation water (1934. 01 m^3/feddan) than the control (2559.53 m^3/feddan) through the entire season.

INTRODUCTION

Apple is ranking superior over many fruit crops that grown in Egypt. The area subjected to apple plantation 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).

Most of the increase of the new established apple orchards concentrated in Nubaria region (new cultivated area), where the total area of apple orchards reached to 50400 feddan which considered 71.5% of the total apple acreage in ARE. 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 rates and three nitrogen levels on yield, fruit quality and save irrigation water.

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 different drip irrigation treatments combined with three nitrogen fertilization levels on the yield, fruit quality and saving irrigation water.

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.

1. Yield

The average fruit yield per tree was estimated by using the average number of fruits per tagged branches of each tree and multiplying them by the total number of branches per tree x average fruit weight (gm) at harvested time (on June 27th in each year).

2. Fruit quality

A sample of ten fruits was harvested on June 27th from each experimental tree to determine the different characteristics of fruit quality. Fruit weight, length and diameter were measured in each sample. In addition, four fruits of each experimental tree were used to determine the fruit firmness by Magness and Taylor (1925) pressure tester using a 5/16 plunger. Two readings were taken at two different positions on the flesh of each fruit after peeling; i.e. 8 readings / each sample. The anthocyanin pigment content of the apple peel tissues was determined according to Geissman (1962). The optical densities of the extracts were measured by a Carle Zeiss photoelectric colorimeter at 530 n m. Anthocyanin was expressed as O.D/g of fresh weight. The percentage of total soluble solids (TSS%) in the fruit juice was determined by a hand refractometer . Fruit juice acidity was determined according to the A.O.A.C. (1980),by titration with 0.1 N sodium hydroxide . Acidity was expressed as percent of malic acid in fruit juice.

To determine the charbohydrates in the fruit pulp tissues , four fruits from each replicate were washed separately with distilled water , cut into small pieces by a clean knife , mixed well and then dried at 70°C in an air drying oven. A 0.5 gm of ground dried material was used to extract the reducing and total sugars of each replicate by distilled water. The reducing and total sugars were determined by Nelson-arsenate molybdate colorimetric method (Malik and Singh, 1980) before and after hydrolysis with concentrated HCL. Starch content was determined in the residue remaining after sugar extraction. A 0.1g of the residue was hydrolyzed with concentrated HCL for three hours under reflex condenser according to A.O.A.C.,(1980) , and the reducing potential of the hydrosate was determined by the arsenate-molybdate method. A factor of 0.9 was used to calculate starch (Woodman,1941). The different carbohydrate fractions were expressed as percent on dry weight basis.

RESULTS AND DISCUSSION

1. Yield:

As for the effect of the different irrigation treatments on the average fruit yield, irrespective the effect of different N levels, the data in Table (1) revealed that the highest significant average fruit yield was obtained from the trees grown at control followed by those grown at I_1 in 1997 and 1998. The same trend appeared in 1999 but the average weight of yield per tree significantly increased in I_1 treatment, as compared with that in the control. These results agreed with those of Higgs and Jones (1991), who found that the drought decreased fruit yield of apple trees. Meanwhile, Velickovic and Jovanovic (1993) reported that the irrigation significantly increased the yield of apple trees. Similar findings were mentioned by Hipps (1997), who noticed that the fruit yield of apple trees was increased by irrigation. Moreover, Treder and Czynczyk (1997) found that, the total yield of irrigated apple trees was higher than unirrigated trees.

Table (1): Effect of irrigation and nitrogen fertilization treatments on the average fruit yield per tree (Kgs) 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	12.53 ^{e}	8.20 ^{g}	5.85 ^{h}	15.12 ^{d}	10.43 ^{c}
N_2	15.53 ^{cd}	10.38 ^{f}	5.57 ^{h}	17.10 ^{c}	12.15 ^{b}
N_3	20.22 ^{b}	12.23 ^{e}	5.10 ^{h}	24.17 ^{a}	15.43 ^{a}
Average	16.09 ^{b}	10.27 ^{c}	5.51 ^{d}	18.79 ^{a}	12.15 ^{b}
L.S.D. (0.05)	Irrigation 1.215	Fertilization 0.911		Interaction 1.821	15.43 ^{a}
	1998				
N_1	19.78 ^{d}	11.55 ^{f}	6.25 ^{g}	22.45 ^{bc}	15.01 ^{c}
N_2	21.90 ^{c}	12.77 ^{f}	5.48 ^{g}	23.92 ^{b}	16.02 ^{b}
N_3	25.92 ^{a}	17.08 ^{e}	4.50 ^{g}	26.72 ^{a}	18.55 ^{a}
Average	22.53 ^{b}	13.80 ^{c}	5.41 ^{d}	24.36 ^{a}	
L.S.D. (0.05)	Irrigation 1.093	Fertilization 0.876		Interaction 1.752	
	1999				
N_1	27.94 ^{cd}	14.38 ^{f}	8.46 ^{g}	27.23 ^{d}	19.63 ^{b}
N_2	30.65 ^{bc}	16.01 ^{f}	7.45 ^{g}	28.54 ^{cd}	20.66 ^{b}
N_3	35.18 ^{a}	19.76 ^{e}	6.36 ^{g}	32.25 ^{b}	23.39 ^{a}
Average	31.25 ^{a}	16.89 ^{c}	7.42 ^{d}	29.34 ^{b}	
L.S.D. (0.05)	Irrigation 1.339	Fertilization 1.357		Interaction 2.714	

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

Concerning the effect of the different N levels on the yield, irrespective the effect of irrigation treatments, the data in the same table indicated that the highest significant fruit yield was obtained from the trees grown at the high nitrogen level (N_3) during 1997 and 1998. In 1999, the same trend was found but the difference between N_1 and N_2 levels was not big enough to be significant. These findings were in line with those obtained

by Yoshioka *et al.*, (1989), who found that the yield of apple trees increased with increasing nitrate concentration in nutrient solutions. Dencker (1992) reported that apple trees received N fertilization showed a significant increase in yield as the level of N was raised. Likewise, Maula *et al.*, (1996) found that the fruit yield of "Red Delicious" apple trees was the highest at the highest N rate and it was the lowest in the unfertilized control.

2. Fruit quality

2.1. Physical properties

2.1.1 Fruit weight

Concerning the effect of the different irrigation treatments on the average fruit weight, irrespective the effect of the different N levels, the data in Table (2) indicated that the highest significant fruit weight was found in the control and I_1 treatments in the three seasons. These findings agreed with those of Pacholak (1986), who mentioned that the irrigation increased fruit weight of "James Grieve" apple. Similarly, Rakicevic (1989) reported that the irrigation increased fruit weight of "Golden Delicious" apple.

Table (2) : Effect of irrigation and nitrogen fertilization treatments on the average fruit weight (gm) 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	86.58 ^{bcd}	75.92 ^{e}	57.08 f	89.00 ^{bc}	77.15 ^{b}
N_2	87.67 ^{bc}	78.80 ^{de}	56.75 ^{f}	93.17 ^{b}	79.10 ^{ab}
N_3	92.33 ^{b}	81.67 ^{cde}	49.42 f	102.17 ^{a}	81.41 ^{a}
Average	88.86 ^{b}	78.79 ^{c}	54.42 ^{d}	94.78 ^{a}	
L.S.D. (0.05)	Irrigation 4.700	Fertilization 3.909		Interaction 7.819	
	1998				
N_1	96.83 ^{cd}	85.50 ^{e}	58.67 ^{f}	100.00 ^{bc}	85.25 ^{c}
N_2	103.00 ^{bc}	90.00 ^{e}	58.33 ^{f}	104.00 ^{b}	88.83 ^{b}
N_3	114.00 ^{a}	92.00 ^{de}	54.17 ^{f}	117.33 ^{a}	49.38 ^{a}
Average	104.61 ^{a}	89.17 ^{b}	57.06 ^{c}	107.11 ^{a}	
L.S.D. (0.05)	Irrigation 4.758	Fertilization 3.350		Interaction 6.701	
	1999				
N_1	129.17 ^{bc}	100.00 ^{c}	80.00 ^{e}	125.00 ^{c}	108.54 ^{c}
N_2	134.38 ^{b}	104.18 ^{dc}	72.92 ^{ef}	131.17 ^{bc}	110.66 ^{bc}
N_3	145.83 ^{a}	110.42 ^{d}	66.67 ^{f}	140.08 ^{a}	115.75 ^{a}
Average	136.46 ^{a}	104.87 ^{b}	73.19 ^{c}	132.08 ^{a}	
L.S.D. (0.05)	Irrigation 6.130	Fertilization 4.316		Interaction 8.633	

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

Regarding the effect of the three nitrogen levels on the average fruit weight, irrespective the effect of irrigation treatments, the data in Table (2) indicated that the highest significant fruit weight was produced from trees under the high nitrogen level (N_3) in the three seasons. These results were in

line with those obtained by Yoshioka *et al.*, (1989), who found that fruit weight of apple trees increased with increasing nitrate concentration in the nutrient solutions.

2.1.2 Fruit length

As for the effect of irrigation treatments on the average fruit length, irrespective the effect of different N levels, the data in Table (3) indicated that the lowest significant value was found in I_3. These results agreed with those obtained by Hussein (1998), who mentioned that fruit length of "Anna" apples on MM. 106 rootstock significantly decreased with water reduction.

Table (3): Effect of irrigation and nitrogen fertilization treatments on the average fruit 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	5.92 ^{de}	5.61 ^{f}	5.02 ^{g}	5.96 ^{cde}	5.62 ^{b}
N_2	6.16 ^{bcd}	5.78 ^{ef}	4.93 ^{g}	6.23 ^{bc}	5.77 ^{a}
N_3	6.38 ^{ab}	5.80 ^{ef}	4.86 ^{g}	6.56 ^{a}	5.90 ^{a}
Average	6.15 ^{a}	5.73 ^{b}	4.94 ^{c}	6.25 ^{a}	
L.S.D. (0.05)	Irrigation 0.152	Fertilization 0.139		Interaction 0.279	
	1998				
N_1	6.25 ^{d}	5.47 ^{g}	5.38 ^{g}	6.41 ^{c}	5.88 ^{c}
N_2	6.30 ^{cd}	5.66 ^{f}	5.26 ^{h}	6.73 ^{b}	5.99 ^{b}
N_3	6.79 ^{b}	5.89 ^{e}	5.06 ^{i}	7.34 ^{a}	6.27 ^{a}
Average	6.45 ^{b}	5.67 ^{c}	5.23 ^{d}	6.82 ^{a}	
L.S.D. (0.05)	Irrigation 0.081	Fertilization 0.049		Interaction 0.098	
	1999				
N_1	6.87 ^{cd}	6.20 ^{ef}	6.03 f	6.85 ^{cd}	6.49 ^{a}
N_2	7.05 ^{bc}	6.27 ^{ef}	5.58 ^{g}	7.00 ^{bc}	6.48 ^{a}
N_3	7.53 ^{a}	6.52 ^{de}	5.02 ^{h}	7.30 ^{ab}	6.59 ^{a}
Average	7.15 ^{a}	6.33 ^{b}	5.54 ^{c}	7.05 ^{a}	
L.S.D. (0.05)	Irrigation 0.224	Fertilization 0.199		Interaction 0.399	

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

As for the effect of the different N levels on the average fruit length, irrespective the effect of irrigation treatments, the obtained data in Table (3) indicated that trees grown at high nitrogen level (N_3) had the higher average fruit length, as compared with the moderate and low N levels. These findings agreed with those obtained by Hipps (1997), who reported that the N fertilizer increased the mean fruit size of the apple trees.

2.1.3. Fruit diameter

Concerning the effect of the different irrigation treatments on the average fruit diameter, irrespective the effect of the different N levels, it was significantly higher in the control and I_1 treatments, through the three seasons (Table 4). Gergely and Farago (1985) reported that water deficit reduced fruit diameter of "Jonathan" apple trees. In addition, Naor *et al.*, (1997) found that irrigation treatments increased the fruit diameter in "Golden Delicious" apple trees.

Table (4) : Effect of irrigation and nitrogen fertilization treatments on the fruit 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	5.37 ^{c}	5.09 ^{d}	4.68 ^{e}	5.45 ^{c}	5.15 ^{b}
N_2	5.41 ^{c}	5.26 ^{cd}	4.61 ^{e}	5.73 ^{b}	5.25 ^{b}
N_3	5.71 ^{b}	5.35 ^{c}	4.51 ^{e}	6.32 ^{a}	5.47 ^{a}
Average	5.49 ^{b}	5.23 ^{c}	4.61 ^{d}	5.83 ^{a}	
L.S.D. (0.05)	Irrigation 0.123	Fertilization 0.115		Interaction 0.230	
	1998				
N_1	5.41 ^{cd}	5.08 f	4.53 ^{g}	5.49 ^{bc}	5.13 ^{c}
N_2	5.56 ^{bc}	5.22 ^{ef}	4.51 ^{g}	5.65 ^{b}	5.23 ^{b}
N_3	5.95 ^{a}	5.27 ^{de}	4.15 ^{h}	5.96 ^{a}	5.33 ^{a}
Average	5.64 ^{a}	5.19 ^{b}	4.41 ^{c}	5.71 ^{a}	
L.S.D. (0.05)	Irrigation 0.112	Fertilization 0.087		Interaction 0.173	
	1999				
N_1	6.37 ^{bcd}	5.63 ^{fgh}	5.40 ^{gh}	6.15 ^{cde}	5.89 ^{b}
N_2	6.47 ^{abc}	5.77 ^{efg}	5.32 ^{h}	6.33 ^{bcd}	5.97 ^{ab}
N_3	6.83 ^{a}	6.02 ^{def}	4.90 ^{i}	6.63 ^{ab}	6.11 ^{a}
Average	6.56 ^{a}	5.81 ^{c}	5.21 ^{d}	6.37 ^{b}	
L.S.D. (0.05)	Irrigation 0.171	Fertilization 0.195		Interaction 0.391	

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

Concerning the effect of the three nitrogen levels on the average fruit diameter, irrespective the effect of irrigation treatments, the data in Table (4) indicated that the fruit diameter was significantly higher for the trees grown at the high nitrogen level (N_3) and the values gradually were decreased with decreasing nitrogen level in the three seasons. Raese and Drake (1997) reported that fruit size of apples cv. "Fuji" increased with increasing N rate.

2.1.4 Fruit firmness

Regarding the effect of the different irrigation treatments on the fruit firmness, irrespective the effect of different N levels , the data in Table (5) cleared that the highest fruit firmness was found in trees grown under I_3 followed by I_2 , I_1 and control in the three seasons.

As for the effect of the three nitrogen levels on the fruit firmness, irrespective the effect of irrigation treatments, the data of both 1997 and 1999 indicated that there was no effect for N levels on fruit firmness, however, the fruit firmness in N_3 level was significantly higher than that in N_1 or N_2, in 1998 season (Table 5).

Table (5) : Effect of irrigation and nitrogen fertilization treatments on the fruit firmness (lb/inch^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	9.82 ^{de}	10.33 ^{d}	11.73 ^{c}	9.45 ^{ef}	10.33 ^{a}
N_2	9.28 ^{f}	10.18 ^{d}	12.48 ^{b}	9.03 ^{fg}	10.25 ^{a}
N_3	9.03 ^{fg}	10.03 ^{d}	14.28 ^{a}	8.53 ^{g}	10.47 ^{a}
Average	9.38 ^{c}	10.18 ^{b}	12.83 ^{a}	9.01 ^{d}	
L.S.D. (0.05)	Irrigation 0.364	Fertilization 0.259		Interaction 0.518	
	1998				
N_1	9.40 ^{e}	10.28 ^{d}	13.78 ^{c}	9.22 ^{ef}	10.67 ^{b}
N_2	9.32 ^{e}	10.10 ^{d}	14.43 ^{b}	9.13 ^{ef}	10.75 ^{b}
N_3	8.78 ^{fg}	9.93 ^{d}	17.13 ^{a}	8.28 ^{g}	11.03 ^{a}
Average	9.17 ^{c}	10.11 ^{b}	15.12 ^{a}	8.88 ^{d}	
L.S.D. (0.05)	Irrigation 0.411	Fertilization 0.266		Interaction 0.532	
	1999				
N_1	11.42 ^{cde}	12.50 ^{abc}	13.08 ^{ab}	11.50 ^{cde}	12.13 ^{a}
N_2	11.17 ^{de}	12.25 ^{bcd}	13.17 ^{ab}	11.25 ^{de}	11.96 ^{a}
N_3	10.83 ^{e}	12.17 ^{bcd}	13.58 ^{a}	10.92 ^{e}	11.88 ^{a}
Average	11.14 ^{b}	12.31 ^{ab}	13.28 ^{a}	11.22 ^{b}	
L.S.D. (0.05)	Irrigation 1.173	Fertilization 0.598		Interaction 1.196	

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

2.2 Biochemical constituents

2.2.1 Fruit skin anthocyanin

As for the effect of irrigation treatments on the fruit skin anthocyanin content, irrespective the effect of the different N levels, the results indicated that trees grown at I_3 had significantly the highest concentration of anthocyanin in the fruit skin, as compared with that in the other irrigation treatments (Table 6).

Regarding the effect of the three tested nitrogen levels on the fruit skin anthocyanin content, irrespective the effect of irrigation treatments, the obtained data showed that the values of anthocyanin content of fruits resulted from the trees grown at the three nitrogen levels almostly the same with no significant differences through the three seasons of study (Table 6).

Table (6) : Effect of irrigation and nitrogen fertilization treatments on the concentration of anthocyanin in the fruit skin (O.D/g) 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	0.52 ^{b}	0.58 ^{ab}	0.66 ^{ab}	0.32 ^{c}	0.52 ^{a}
N_2	0.50 ^{b}	0.58 ^{ab}	0.69 ^{a}	0.30 ^{c}	0.52 ^{a}
N_3	0.50 ^{b}	0.58 ^{ab}	0.72 ^{a}	0.31 ^{c}	0.52 ^{a}
Average	0.51 ^{b}	0.58 ^{b}	0.69 ^{a}	0.31 ^{c}	
L.S.D. (0.05)	Irrigation 0.075	Fertilization 0.082		Interaction 0.165	
	1998				
N_1	0.46 ^{b}	0.51 ^{b}	0.57 ^{a}	0.34 ^{c}	0.47 ^{a}
N_2	0.46 ^{b}	0.49 ^{b}	0.59 ^{a}	0.32 ^{c}	0.46 ^{a}
N_3	0.45 ^{b}	0.49 ^{b}	0.61 ^{a}	0.30 ^{c}	0.46 ^{a}
Average	0.45 ^{b}	0.49 ^{b}	0.59 ^{a}	0.32 ^{c}	
L.S.D. (0.05)	Irrigation 0.050	Fertilization 0.032		Interaction 0.064	
	1999				
N_1	0.52 ^{cd}	0.57 ^{bcd}	0.63 ^{abc}	0.52 ^{cd}	0.56 ^{a}
N_2	0.50 ^{d}	0.54 ^{cd}	0.68 ^{ab}	0.50 ^{d}	0.56 ^{a}
N_3	0.50 ^{d}	0.53 ^{cd}	0.70 ^{a}	0.51 ^{d}	0.56 ^{a}
Average	0.51 ^{b}	0.54 ^{b}	0.67 ^{a}	0.50 ^{b}	
L.S.D. (0.05)	Irrigation 0.064	Fertilization 0.064		Interaction 0.128	

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

2.2.2 Fruit total soluble solids (TSS %)

In view of the effect of irrigation treatments on the TSS %, irrespective the effect of different N levels, the data in Table (7) indicated that there was a gradual decrease in fruit TSS % parallel to the increase of irrigation rate. The statistical analysis confirmed that the differences among the different irrigation treatments were significant between the control and I_1 in all seasons of study. The negative relationship between irrigation rate and juice TSS % of apple fruits in the present study are supported with those obtained by Pacholak (1986), who mentioned that the irrigation reducd fruit soluble solids content of "James Grieve" apple cultivar. Mills *et al.*, (1996) found that deficit irrigation increased TSS% in fruit juice of "Braeburn" apple trees on MM. 106 rootstock.

Table (7) : Effect of irrigation and nitrogen fertilization treatments on the percentage of fruit total soluble solids (TSS%) 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	12.42 ^{c}	13.12 ^{b}	15.50 ^{a}	12.05 ^{c}	13.27 ^{a}
N_2	12.45 ^{c}	13.17 ^{b}	15.60 ^{a}	12.25 ^{c}	13.37 ^{a}
N_3	12.48 ^{c}	13.28 ^{b}	16.05 ^{a}	12.33 ^{c}	13.54 ^{a}
Average	12.45 ^{c}	13.19 ^{b}	15.72 ^{a}	12.21 ^{c}	
L.S.D. (0.05)	Irrigation 0.271	Fertilization 0.310		Interaction 0.620	
	1998				
N_1	11.87 ^{de}	12.13 ^{cd}	14.35 ^{b}	11.55 ^{e}	12.48 ^{b}
N_2	12.05 ^{cd}	12.23 ^{cd}	14.70 ^{b}	11.55 ^{e}	12.63 ^{b}
N_3	12.10 ^{cd}	12.47 ^{c}	15.32 ^{a}	11.88 ^{de}	12.94 ^{a}
Average	12.01 ^{bc}	12.28 ^{b}	14.79 ^{a}	11.66 ^{c}	
L.S.D. (0.05)	Irrigation 0.458	Fertilization 0.218		Interaction 0.437	
	1999				
N_1	12.00 ^{e}	12.97 ^{bc}	13.10 ^{bc}	12.10 ^{de}	12.54 ^{b}
N_2	12.37 ^{cde}	13.03 ^{bc}	14.03 ^{a}	12.47 ^{bcde}	12.98 ^{a}
N_3	12.77 ^{bcd}	13.13 ^{b}	14.53 ^{a}	12.83 ^{bcd}	13.32 ^{a}
Average	12.38 ^{c}	13.04 ^{b}	13.89 ^{a}	12.47 ^{c}	
L.S.D. (0.05)	Irrigation 0.465	Fertilization 0.381		Interaction 0.763	

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

Concerning the effect of the three nitrogen levels on the TSS% of fruit, irrespective the effect of irrigation treatments, the data indicated that the TSS% was increased as N level increasing, in the three seasons (Table 7). These findings were supported by those obtained by Kumar and Singh (1995), who found that TSS% of fruits of "Red Delicious" apple trees increased with increasing N rate. On the contrary, Raese and Drake (1997) found that the fruits of "Fuji" apple cultivar had higher TSS% at lower rates of N, as compared with fruits from the high N treatments.

2.2.3 Fruit acidity

Regarding the effect of irrigation treatments on fruit acidity, irrespective the effect of different N levels, the data in Table (8) showed that the highest significant juice acidity was noticed in the friuts that produced from the trees grown at control and I_1, through the three seasons. These findings are in line with those stated by Kato *et al.*, (1985), who found that the fruit content of malic acid was low in non irrigated apple trees. On the contrary, these results disagreed with those of Mills *et al.*, (1996), who found that the fruit acidity of "Braeburn" apple trees was higher in deficit irrigation than control (fully watered).

Concerning the effect of the three experimental nitrogen levels on the fruit acidity, irrespective the effect of the irrigation treatments, the data in Table (8) showed that the trees grown at the high nitrogen level recorded fruit acidity % significantly higher than those of the trees grown at N_1 in the three seasons. These findings were in line with those obtained by Szafranek (1976), who found that total acidity of apple fruits was increased as a result of fertilization with urea. Otherwise, Klein and Spieler (1987) found that the N fertilizer had no consistent effect on fruit acidity of "Anna" apples. Byun *et al.*, (1989) reported that fruit total acidity of "Fuji" apple trees were not affected by N application.

Table (8): Effect of irrigation and nitrogen fertilization treatments on the percentage of fruit acidity 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	0.41 [a]	0.33 [b]	0.28 [c]	0.43 [a]	0.36 [b]
N_2	0.42 [a]	0.35 [b]	0.29 [c]	0.43 [a]	0.37 [ab]
N_3	0.42 [a]	0.37 [b]	0.29 [c]	0.44 [a]	0.38 [a]
Average	0.42 [a]	0.35 [b]	0.29 [c]	0.43 [a]	
L.S.D. (0.05)	Irrigation 0.045	Fertilization 0.018		Interaction 0.037	
	1998				
N_1	0.54 [a]	0.43 [b]	0.29 [c]	0.55 [a]	0.45 [b]
N_2	0.55 [a]	0.43 [b]	0.31 [c]	0.56 [a]	0.46 [b]
N_3	0.58 [a]	0.52 [a]	0.34 [c]	0.60 [a]	0.51 [a]
Average	0.56 [a]	0.46 [b]	0.31 [c]	0.57 [a]	
L.S.D. (0.05)	Irrigation 0.045	Fertilization 0.041		Interaction 0.082	
	1999				
N_1	0.55 [ab]	0.39 [c]	0.38 [c]	0.54 [b]	0.46 [b]
N_2	0.56 [ab]	0.41 [c]	0.40 [c]	0.55 [ab]	0.48 [ab]
N_3	0.58 [a]	0.41 [c]	0.40 [c]	0.57 [ab]	0.49 [a]
Average	0.56 [a]	0.41 [b]	0.39 [b]	0.55 [a]	
L.S.D. (0.05)	Irrigation 0.022	Fertilization 0.019		Interaction 0.037	

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

2.2.4 Fruit content of total sugars

As for the effect of the different irrigation treatments on the total sugars content, irrespective the effect of the different N levels, the data in Table (9) cleared that the value was proportionally decreased as the irrigation rate decreased. The statistical analysis indicated that, the fruit total sugars content in the trees grown at deficit irrigation (I_3) was significantly lower than in the other irrigation treatments, in the three seasons.

Regarding the effect of the different N levels on the fruit content of the total sugars, irrespective the effect of the irrigation treatments, the data in

Table (9) cleared, that the applied N levels had no significant effects on the fruit content of the total sugars, through the three seasons. These findings agreed with those of El-Morshedy (1997), who found that increasing N rate applied to "Anna" apple trees had no effect on total sugars of the fruits. On the other hand, the present results disagreed with those obtained by Yoshioka *et al.*, (1989), who found that fruit sugar content of apple trees increaed with increasing nitrate concentration. Also, kumar and Singh (1995) mentioned that fruit total sugars content of "Red Delicious" apple trees increased with increasing N rate.

Table (9): Effect of irrigation and nitrogen fertilization treatments on the percentage of fruit total sugars content (on dry weight basis) 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	47.24 ^{ab}	42.52 ^{bc}	37.86 ^{cd}	47.45 ^{ab}	43.77 ^{a}
N_2	48.74 ^{ab}	44.24 ^{abc}	33.10 ^{d}	50.88 ^{a}	44.24 ^{a}
N_3	49.17 ^{ab}	45.42 ^{abc}	31.28 ^{d}	51.20 ^{a}	44.26 ^{a}
Average	48.38 ^{a}	44.06 ^{a}	34.08 ^{b}	49.84 ^{a}	
L.S.D. (0.05)	Irrigation 7.280	Fertilization 3.922		Interaction 7.850	
	1998				
N_1	48.43 ^{abcd}	43.09 ^{de}	38.05 ^{ef}	49.05 ^{abcd}	44.66 ^{a}
N_2	49.51 ^{abcd}	44.93 ^{cd}	34.39 ^{f}	50.43 ^{abc}	44.81 ^{a}
N_3	51.80 ^{ab}	46.30 ^{bcd}	33.01 ^{f}	53.18 ^{a}	46.07 ^{a}
Average	49.91 ^{a}	44.78 ^{a}	35.15 ^{b}	50.89 ^{a}	
L.S.D. (0.05)	Irrigation 7.504	Fertilization 3.405		Interaction 6.814	
	1999				
N_1	57.30 ^{abc}	52.72 ^{de}	49.97 ^{ef}	55.93 ^{bcd}	53.98 ^{a}
N_2	58.22 ^{ab}	54.09 ^{cd}	48.59 ^{f}	56.85 ^{abc}	54.44 ^{a}
N_3	60.06 ^{a}	55.01 ^{bcd}	47.22 ^{f}	57.30 ^{abc}	54.91 ^{a}
Average	58.53 ^{a}	53.94 ^{b}	48.59 ^{c}	56.69 ^{a}	
L.S.D. (0.05)	Irrigation 2.324	Fertilization 1.714		Interaction 3.430	

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

2.2.5 Fruit content of reducing sugars

Concerning the effect of the different irrigation treatments on the fruit content of reducing sugars, irrespective the effect of N levels, the data in Table (10) indicated that the higher significant values of the reducing sugars content were found in fruits that produced from the trees grown at high (control) and normal irrigation rate (I_1) in the three seasons.

As for the effect of the different N levels on the reducing sugars of fruits, irrespective the effect of irrigation treatments, the data revealed that with increasing the nitrogen level the reducing sugars content in the fruits proportionally increased (Table 10). These findings agreed with those

obtained by Helm and Ludders (1982), who found that increasing nitrogen nutrition, generally, increased fruit glucose and fructose of "Cox's Orange Pippin" apples. On the other side, El-Morshedy (1997) found that increasing N rate applied to "Anna" apple trees had no effect on fruit reducing sugars. On the contrary, Raese and Drake (1997) reported that fruits of "Fuji" apples exhibited higher fructose content at lower rates of N, as compared with fruits from the high N treatments.

Table (10) : Effect of irrigation and nitrogen fertilization treatments on the percentage of fruit reducing sugars content (on dry weight basis) 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	7.33 ^{b}	7.13 ^{b}	7.04 ^{b}	7.38 ^{b}	7.22 ^{a}
N_2	7.53 ^{b}	7.18 ^{b}	7.03 ^{b}	8.48 ^{a}	7.56 ^{a}
N_3	7.63 ^{b}	7.23 ^{b}	6.94 ^{b}	8.62 ^{a}	7.60 ^{a}
Average	7.50 ^{b}	7.18 ^{bc}	7.00 ^{c}	8.16 ^{a}	
L.S.D. (0.05)	Irrigation 0.404	Fertilization 0.401		Interaction 0.803	
	1998				
N_1	13.06 ^{cd}	11.35 ^{fg}	10.81 ^{gh}	13.60 ^{bc}	12.21 ^{b}
N_2	13.33 ^{c}	11.80 ^{ef}	10.36 ^{hi}	13.69 ^{bc}	12.30 ^{b}
N_3	14.23 ^{ab}	12.43 ^{de}	9.82 ^{i}	14.77 ^{a}	12.81 ^{a}
Average	13.54 ^{a}	11.86 ^{b}	10.33 ^{c}	14.02 ^{a}	
L.S.D. (0.05)	Irrigation 0.805	Fertilization 0.341		Interaction 0.682	
	1999				
N_1	13.60 ^{a}	10.18 ^{bc}	10.18 ^{bc}	13.61 ^{a}	11.89 ^{b}
N_2	14.86 ^{a}	10.90 ^{bc}	9.64 ^{c}	14.32 ^{a}	12.43 ^{ab}
N_3	15.04 ^{a}	11.62 ^{b}	9.55 ^{c}	14.45 ^{a}	12.67 ^{a}
Average	14.50 ^{a}	10.90 ^{b}	9.79 ^{b}	14.12 ^{a}	
L.S.D. (0.05)	Irrigation 1.486	Fertilization 0.780		Interaction 1.561	

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

2.2.6 Fruit starch content

Regarding the effect of the different irrigation rates on the percentage of starch in fruits, irrespective the effect of N levels, the data in Table (11) indicated that the fruit of the trees grown under the lowest irrigation rate (I_3) had a significant higher starch content than that in the other irrigation treatments, during the three seasons. Kato *et al.*, (1985) mentioned that fruit starch content of "Starking Delicious" apple trees was not affected by irrigation or non-irrigation treatments.

Table (11): Effect of irrigation and nitrogen fertilization treatments on the percentage of fruit starch content (on dry weight basis) 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	25.49 ^{de}	29.14 ^{bcd}	33.59 ^{abc}	23.78 ^{de}	28.00 ^{a}
N_2	23.57 ^{de}	28.49 ^{cd}	34.92 ^{ab}	20.35 ^{e}	26.62 ^{a}
N_3	23.14 ^{de}	26.78 ^{de}	35.56 ^{a}	20.14 ^{e}	26.03 ^{a}
Average	24.07 ^{bc}	27.64 ^{b}	34.69 ^{a}	21.14 ^{c}	
L.S.D. (0.05)	Irrigation 5.888	Fertilization 3.181		Interaction 6.364	
	1998				
N_1	22.06 ^{c}	26.35 ^{bc}	28.92 ^{abc}	23.78 ^{c}	25.28 ^{a}
N_2	21.64 ^{c}	24.85 ^{c}	33.63 ^{ab}	22.50 ^{c}	25.65 ^{a}
N_3	21.21 ^{c}	24.44 ^{c}	35.35 ^{a}	22.06 ^{c}	25.47 ^{a}
Average	21.64 ^{b}	24.82 ^{b}	32.63 ^{a}	22.78 ^{b}	
L.S.D. (0.05)	Irrigation 7.452	Fertilization 3.867		Interaction 7.737	
	1999				
N_1	14.78 ^{d}	17.57 ^{abc}	18.43 ^{ab}	16.28 ^{bcd}	16.76 ^{a}
N_2	14.78 ^{d}	16.71 ^{bcd}	19.51 ^{a}	15.42 ^{cd}	16.60 ^{a}
N_3	14.57 ^{d}	16.28 ^{bcd}	19.71 ^{a}	14.78 ^{d}	16.33 ^{a}
Average	14.71 ^{c}	16.85 ^{b}	19.21 ^{a}	15.49 ^{bc}	
L.S.D. (0.05)	Irrigation 2.110	Fertilization 1.204		Interaction 2.409	

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

As for the effect of the three N levels on the percentage of starch in fruits, irrespective the effect of the different irrigation treatments, the data of the three seasons indicated that nitrogen level had no effect on the fruit starch content (Table 11).

3. Saving water

The highest quantity of irrgation water applied to each tree or feddan was found in the control treatment followed at descending order by I_1 , I_2 and I_3 (Table 12).

Table (12): The total quantity of irrigation water applied to each "Anna" apple tree and per feddan in the different irrigation treatments during 1997, 1998 and 1999 seasons.

Year	Irrigation treatments	Total amount of irrigation water per tree/season (liters)	Total irrigation water per feddan/season (m^3)
1997	I_1	3428	1172.376
	I_2	1283	438.786
	I_3	734	251.028
	control	6416	2194.272
1998	I_1	4008	1370.736
	I_2	1606	549.252
	I_3	820	280.440
	control	6416	2194.272
1999	I_1	5655	1934.01
	I_2	2589	885.438
	I_3	1270	434.340
	control	7484	2559.528

From the mentioned data in Table (12) it was cleared that saving water as compared with the control treatment reached to 46.5 , 80.0 and 88.6 % in 1997, 37.53 , 74.97 and 87.22% in 1998 and 24.44 , 65.41 and 83.03% in 1999 for I_1 , I_2 and I_3 treatments, respectively. This saving water occurred as a result of the well distribution of the irrigation frequencies during the ten months started from February till November in the three experimental seasons (Table 13).

Table (13) : The quantity of irrigation water applied to each "Anna" apple tree (in liters) in the different irrigation treatments during the months from February till November in 1997 , 1998 and 1999 seasons.

Year	Irrigation treatments	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Total
1997	I_1	91	241	331	511	451	511	481	361	270	180	3428
	I_2	51	76	126	151	176	176	151	126	150	100	1283
	I_3	45	45	133	89	89	89	67	45	66	66	734
	Control	649	649	649	649	649	649	649	649	648	576	6411
1998	I_1	121	321	441	521	481	521	521	481	360	240	4008
	I_2	69	103	137	171	239	205	171	205	170	136	1606
	I_3	59	59	88	117	88	117	88	88	58	58	820
	Control	577	649	721	505	649	649	721	577	720	648	6416
1999	I_1	187	403	790	852	790	666	790	527	387	263	5655
	I_2	107	120	279	332	345	279	345	279	278	225	2589
	I_3	93	104	139	150	150	150	139	104	149	92	1270
	Control	673	757	673	757	757	757	841	757	756	756	7484

These findings are agreed with the results of Levin *et al.*, (1972), who mentioned that increasing water uptake by apple trees from layers below 120 cm by watering them was not effective. Likewise, Levin *et al.*, (1979) reported

that the soil moisture-saturated level in soil profile of apple orchard (in their irrigation treatments), in the area under the trickler, caused water loss by drainage during the irrigation process, and the loss was estimated to be 17% of the water applied. In the same line, Blasse *et al.*, (1986) stated that in 3-year experiments on apples with synchronized impluse sprinkling, 30% of water was saved by applying 2-3 mm/day to keep the soil moist down to 40 cm. Assaf *et al.*,(1989) suggested that irrigation "Golden Delicious" and "Jonathan" apple trees at a lower SMP (soil – matrix-potential) uses less water and limits the volume of soil wetted.

In conclusion, the data of the present study cleared that drip irrigation had a benefit effect on the production of "Anna" apple trees, as well as the N fertilizers. Increasing irrigation rate up to 72 liter twice a week during 1997 and 1998 seasons gave the higher yield per tree, fruit weight, length and diameter, juice acidity % and total sugars, whereas, fruit firmness, TSS%, starch, skin anthocyanin were decreased. Normal irrigation treatment (I_1) based on soil-matrix-potential at threshold 0.1-0.3 bars is nearly equal to the above mentioned one in its effects on the trees in 1997 and 1998, whereas in 1999, it gave the better effects, although the quantity of irrigation water applied to each "Anna" apple tree in the normal irrigation treatment was less than the used yearly by 24.4 to 46.5 %, therefore , it was more beneficial because of saving water and energy resource as well as resulting high yield of good fruit quality. The moderate (I_2) and deficit irrigation (I_3) irrigation treatments caused moderate and drastic effects on the yield of "Anna" apple trees.

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تأثير الرى بالتنقيط والتسميد النيتروجينى على:
٣- المحصول وصفات جودة الثمار وتوفير المياه لأشجار التفاح صنف "آنا" النامية فى الأراضى حديثة الاستصلاح

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أجرى هذا البحث 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 المحصول وصفات جودة الثمار وتوفير مياه الرى 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- محصول الثمار لكل شجرة كان الأقل معنويا فى الأشجار النامية تحت معدل الرى المنخفض. وقد زاد المحصول إيجابيا بزيادة كل من مستوى النيتروجين ومعدل الرى.

٢- زيادة معدل الرى يماثل تماما زيادة مستوى النيتروجين فكان متناسبا مع زيادة متوسط وزن الثمرة وطولها وقطرها.

٣- تركيز صبغة الأنثوسيانين فى جلد الثمرة وصلابة الثمار والمواد الصلبة الذائبة الكلية فى عصير الثمار والنسبة المئوية للنشا فى الثمار انخفضت تدريجيا مع زيادة معدل الرى .

٤- زيادة مستوى النيتروجين أدت إلى تخفيض معنوى فى صلابة الثمار ومحتوى الثمار من المواد الصلبة الذائبة الكلية فى عصيرها. على الجانب الآخر كل مستويات التسميد النيتروجينى المستخدمة لم يكن لها تأثير على تركيز صبغة الأنثوسيانين فى جلد الثمرة والنسبة المئوية للسكريات المختزلة والنشا فى ثمار التفاح صنف "آنا".

٥- النسبة المئوية للحموضة فى عصير الثمار انخفضت تناسبيا مع انخفاض معدل الرى ومستوى التسميد النيتروجينى.

٦- أعلى محصول ثمار تم الحصول عليه من الأشجار النامية تحت الرى العادى (رى١) فى نهاية هذه الدراسة (١٩٩٩) بالرغم من أنه فى موسم ١٩٩٩ فإن معاملة الرى (رى١) استخدمت كمية مياه رى (١٩٣٤,٠١ م٣/فدان) اقل من المستخدمة فى معاملة رى الكنترول (٢٥٥٩,٥٣ م٣/فدان) خلال الموسم الكامل.