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Moisture Distribution Impact of Mini-Sprinkler on Mineral Fertilizers Use Efficiency, Growth, Fruit Yield and Quality of Apple Trees in Sandy Soil

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Abstract: *This study was set up to investigate the effect of irrigation using mini-sprinkler on mineral fertilizers use efficiency, vegetative growth, fruit yield and fruit quality of apple trees in sandy soil. This target was achieved by using drip irrigation compared to irrigate with one, two and three mini sprinklers. The study also examined the nutrient content of apple leaves and fruits, especially nitrogen and potassium which are considered one of the most mobile nutrients in soil (especially sand soil) and hence exposure to the loss by leaching. So four alternative combinations of both nutrients (Nitrogen and potassium) were used, i.e. 75/100/75, 100/100/75, 75/100/100 and 100/100/100% of N/P/K recommended dose (RD) i.e. 650/150/600 g/tree. The experiment was arranged in a split plot design with three replicates where the irrigation was the main plot and the mineral fertilization was the subplot. The obtained results indicate that irrigation with mini sprinkler improved all of the studied vegetative growth parameters (shoot No., shoot length (cm), shoot diameter (cm), total leaf area, total chlorophyll), leaves and fruits nutrient contents and yield parameters as well physical and chemical properties compared to drip irrigation and in the same time, using three mini sprinklers surpassed all the other used irrigation systems. On the other hand, the highest values of all the studied parameters were noticed at 100/100/100% of N/P/K RD. Concerning the interaction effect between the irrigation type and mineral fertilization, data indicated that the highest values of all the studied parameters were obtained in the treatment of 3 sprinkler+100/100/100% of N/P/K RD. Fertilizer use efficiency (FUE) were more on application of 75% RD of Nitrogen and potassium than at 100% RD of both nutrients with any type of irrigation.*

Keywords: *Apple, mini-sprinkler, fertilization, sand, water.*

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I. Introduction

Apple is considered as one of the major and the most important deciduous fruit crop in the world. The total acreage of apple in Egypt reached about 35078 ha during 2016/2017 and producing about 695769 MT with an average of 19.835 MT/ha **(Ministry of Agriculture in 2015)**. Many authors stated that yield and quality of "Anna"apple fruits relay on several factors. One of the most important factors which affect and play an important role in this concern is using of some fertilizers which enhance fruit growth, fruit quality and consequently increase productivity. Moreover, irrigation systems are very important factors which in turn reflect their impact on increasing and improving fruit yield and fruit characteristics.

Global climate change is predicted to have negative effects on both agricultural production and water resources. "Anna"apple tree grown successfully under Egypt conditions still needs a lot of studies towards adjusting the suitable horticultural practices that required for improving yield and fruit quality especially N, P and K fertilization. Several factors governed the N, P and K nutrition, namely soil texture, climatic conditions, soil pH, water table depth, soil salinity, soil $CaCO_3$, irrigation system, variety, tree age, plant density, supporting and pruning systems, and climatic conditions. Fertilization with N, P and K is considered as a backbone of plant nutrition. Building of all organic foods greatly depends on supplying the trees with their requirements from N, P and K at balanced rate **(Marschiner, 1995). Previous studies show that supplying Apple and other deciduous fruit crops with their needs from N, P and K at balanced rate was very necessary for improving yield and fruit quality (Firakand Deolankar, 2000, Kabeel*et al.*, 2005; El-Sehrawy, 2008; Dhillon*et al.*, 2009; Von- Bennewtz*et al.*, 2011; El-khawaga, 2011; Karimi *et al.*, 2012; Mansour *et al.*, 2007; Milosevic *et al.*, 2013; El-Sayed, 2013; and Kumar and Ahmed, 2014.**

Fertilizers should be applied in a form that becomes available to coincide with crop demand for maximum utilization of nutrients from fertilizers. Fertigation enables adequate supplies of water and nutrients with precise timing and uniform distribution to meet the crop nutrient demand. Further, fertigation ensures substantial saving in fertilizer usage and reduces leaching losses **(Kumar *et al*., 2007).** Similar to frequent application of water, optimally split applications of fertilizer improves quality and quantity of crop yield than the conventional practices **(Sharma *et al*. 2011)**. Compared with the NPK soil application, NPK fertigation significantly increased all The nitrogen, phosphorus and potassium (NPK) fertilizers which were applied through fertigation as well as soil application to test various attributes of 3-years-old guava CV. Shweta under meadow (ultra high density) orcharding. The investigation indicated that 100% irrigation of irrigation water/cumulative pan evaporation (I3) through drip resulted in maximum plant height (1.97 m), canopy volume (0.98 m3), girth of primary branches (2.41 cm), leaf area (62.94 cm2) and fruit weight (163.71 g). However, 75% irrigation of irrigation water/cumulative pan evaporation resulted in maximum plant spread east, west-north south (1.91 to 1.79 m), fruit yield/plant (5.87 kg) with a benefit: cost ratio of 2.62. Use of 60, 30 and 30 g NPK/plant/year produced maximum leaf area (63.39 cm2), fruit weight (162.43 g) and fruit yield/plant (6.01 kg).

Interaction effect of irrigation and fertigation levels showed that 100% irrigation of irrigation water/cumulative pan evaporation + 100% water soluble fertilizers gave maximum plant height (2.07 m), canopy volume (1.24 m3), girth of primary branches (2.48 cm), leaf area (66.08 cm2), fruit diameter 6.69 cm(polar) and 5.97 cm (equatorial), fruit weight (182.17 g), yield/plant (6.59 kg) (**Ramniwas,et al,2012).**Modern methods of orchard cultivation require more effective ways of irrigationand fertilization. An advantage of fertigation is the possibility of regulating the doses and frequency of water and nutrient applications according to plant requirements influenced by plant age, growth cycle and weather conditions**. Anna,(2011)** and **Waldemar, (2006).** Micro-sprinkler is a low volume sprinkler are operated at low pressure, requires less energy than conventional sprinklers and is less susceptible to clogging than a drip emitter. System performance was evaluated by estimating flow variability in lateral lines and field emission uniformity. The discharge pressure relation equation was developed based on actual field observations, **Jaspal Singh et al. (1990).**Three irrigation systems (drip, micro-sprinkler and flooding) are investigated and found that yields were higher in sprinkler irrigated trees and the fruits were smaller in flood irrigation, **Rumayor and Bravo (1991).**

The greatest yields are obtained under spray-jet trickle irrigation. Yield increases were not linear with the volume of root-zone irrigated, but ranged from 39% under the drip irrigation treatments which irrigated 5- 10% of the area beneath the tree canopies to 64% for two spray jet per tree, which irrigated as much as 50.7% of the areas beneath the tree canopies. **Smajstrla et al. (1984).** Drip, micro-sprinkler and overhead sprinkler irrigation are studied at two water application rate and found that fruit size and tree canopy area were 9 to 20% greater in the overhead sprinkler treatments. **Zekri and Parsons (1989).** The highest yields (190 kg/tree) are coupled with the largest increase in average fruit size with irrigation at a crop factor of 0.9 on a 3 day cycle. With this consumption micro-jet irrigation gave better results than drip irrigation, **Plessis (1985).**

The full ground cover, mid row mini-sprinkler system, and a micro-irrigation system using 100 liter/hr micro-sprinkler are wetted about 2/3 of the soil area under the canopy in the tree line, in a mature Valencia orange orchard at Wateron, NSW. The two systems were operated at 14 and 17 day intervals, respectively, during Nov. -Dec. Under-tree micro-sprinkler increased the yield by 12% and reduced water application by 9.8% compared to the conventional full ground cover system, resulting in increased in water use efficiency by 22%, **Grieve (1988).** The aim of the present investigation was to study the effect of moisture distribution by irrigation using mini-sprinkler compared to drip irrigation on mineral fertilizers use efficiency, vegetative growth, fruit yield and quality of apple trees grown in sandy soil.

II. Material And Method

This study was carried out during two successive seasons 2016 and 2017 at 10 years old Apple trees planted at 4x3 meters apart (about 833tree/ha) in sandy soil under drip irrigation system in a private farm located at Wadi El Natrown -Beheira Governorate, Egypt (located at about 106 km North-West of Cairo in (N 30° 24¯ and E 30° 30¯)). The phytochemical analysis of experimental soil and irrigation water was indicated in Table 1 and it was carried out according to **(Cottenie *et al*, 1982).** Forty eight uniform trees were selected for this study and all of them were subjected to the same cultural practices in the two seasons. The experiment was arranged in a split plot design with three replicates and each replicate included two trees.

Irrigation system:

The irrigation system consisted of the following components:

a- Control head:

Control head consisted of centrifugal pump 5 /5 inch (40m lift and 75 m^3/h discharge), driven by diesel engine (50 HP), pressure gauges, control valves, inflow gauges, water source is from an aquifer, main line then lateral lines and dripper lines. For traditional drip irrigation (control), Gr dripper was used by 4 l/h flow, two dripper in one meter, and two hoses for one tree row, where the treatments of mini-sprinklers are T_1 = 30.33 % of the total irrigation applied water using one mini-sprinkler around the apple tree, T_2 = 60.66 % of total irrigation applied water using two mini-sprinkler around the apple tree and finally T_2 = 100 % of total irrigation applied water using three mini-sprinkler around the apple tree using one hose for one tree raw.

Table 1: Some physical and chemical analysis of the experiments soil and irrigation water.

Soil depth (Cm)	**Soil particle distribution (%)**			**Soil texture**	**FC%**	**WP%**	**Aw%**	**Bd** (gcm^{-3})
	Sand	**Silt**	**Clay**					
0-30	82.1	10.3	7.6	Sand	14.0	5.2	8.8	1.40
30-60	86.9	8.3	4.8	Sand	13.3	4.7	8.6	1.52
60-90	89.9	6.1	4.1	Sand	12.1	3.9	8.2	1.56

Soluble cations and anions melcL-1) in soil past extraction

Soil Depth (cm)	**EC** dSm^{-1}	CO_3^{-2}	HCO_3	Cl^-	SO_4^{-2}	Ca^{+2}	Mg^{+2}	Na^+	K^+	**SAR**
0-30	1.25		0.93	1.98	9.61	6.33	2.24	3.44	0.51	1.66
30-60	1.36		1.33	2.11	10.16	6.75	2.29	3.91	0.65	1.84
60-90	2.15		1.8	2.58	17.12	12.71	3.67	4.4	0.72	1.54

EC, pH and Soluble cations and anions in water for irrigation ($mmol_c\ L^{-1}$)

EC dSm^{-1}	CO_3^{-2}	HCO^{-3}	Cl^-	SO_4^{-2}	Ca^{+2}	Mg^{+2}	Na^+	K^+	**SAR**
1.1		4.48	2	4.51	2.98	1.87	5.65	0.5	3.63

Irrigation requirements:

Irrigation water requirements for apple trees were calculated according to the local weather station data at Al-Beharia Governorate, belonged to the Central Laboratory for Agricultural Climate **(C.L.A.C.),** Ministry of Agriculture and Land Reclamation.

Irrigation process was done by calculating crop consumptive use (mm/day) according to **Doorenbos and Pruitt (1977) .**

$$IR = \left[\frac{K_c \times Et_o \times A \times C_F}{10^7 \times Ea} \right] + LR$$

Where:

- **IR** = Irrigation water requirements, m^3/ha/day.
- **E t_o** = Potential evapo-transpiration, mm day^{-1}
- **Kc** = Crop factor of apple,
- **Ea** = Application efficiency, %,where 90% drip irrigation.
- **A** = Area irrigated, (m^2)
- **LR** = Leaching requirements.
- **C_F** = Covering factor, of apple trees 45%.

The crop factor of apple was used to calculate Et_{crop} values, according to **FAO (1984).**

The effect of the previous treatments was studied by evaluating their influence on the following parameters:-

1- Vegetative parameters: At the end of growing seasons, the selected shoots were counted and measured from the average of no. of shoot, shoot length cm, shoot diameter cm, leaf area (cm^2) according to **Ahmad and Morsy (1999)** and total chlorophyll was measured using a chlorophyll meter SPAD 502.

2- Fruit Set% and yield kg/tree: One main branches from all directions of each tree were chosen and labble dat the beginning of each season, the number of flowers was recorded and those set fruits on the selected branches were counted for calculating the percentage of fruit set according to **Westwood, (1988)** equation:

$$\text{Fruit set \%} = \frac{\text{A number of set fruit-lets}}{\text{Number of open flowers}} \times 100$$

At the harvest time in both seasons, yield/tree (kg) was estimated.

3- Fruit Quality

Twenty fruits were randomly taken at harvest time from each replicate for the determination of both physical and chemical characteristics.

A. Fruit Physical Characteristics: Fruit weight (g), fruit length (cm), fruit diameter (cm), and fruit volume (cm^3).

B. Fruit Chemical Characteristics: Total soluble solids were determined using a hand refracto-meter, percentage of titra table acidity in fruit juice and ascorbic acid (mg/100 ml juice) was determined according to A.O.A.C. **(2005),** total sugars percentage was determined according to **Miller, (1959).**

4- Leaves and fruit nutrient content:

Samples of leaves from the middle part of the shoot according to **Chuntanaparb (1981)** and fruits at harvest were randomly selected from each replicate to determine their content from N%, P % and K %. Leaf and fruit samples were washed with tap water, then with distilled water and dried at 70ºC to a constant weight, finally, ground and acid digested using H_2SO_4 and H_2O_2 until a clear solution was obtained according to **Wilde *et al*. (1985).** The digested solution was used for the determination of each of nitrogen (N) using the micro Kjeldhal method, phosphorus (P) by vanadomolybdo method and potassium (K) was determined by flame photometer according to the method described by **Chapman (1961).**

Fertilizer use efficiency (FUE):

Fertilizer use efficiency was determined using the following equation:

FUE = Average yield (kg/fed)/ Amount of applied fertilizer (kg/fed) (kg yield/kg fertilizer) (**El-Gindy *et al*., 2009**)

- Statistical Analysis: The obtained data were subjected to the proper analysis of variance (ANOVA) according to **Snedecor and Cochran (1989).** Least significant difference (LSD) at the 0.05 % level of significance was used to compare the treatment means.

III. Results and discussions

This study was set up to investigate the effect of irrigation by using mini-sprinkler on mineral fertilizers use efficiency, growth, fruit yield and quality of Apple trees in sandy soil. This target was achieved by using drip irrigation compared to irrigate with one, two or three mini sprinklers. The study also examined the nutrient content of apple leaves and fruits, especially nitrogen and potassium which is considered one of the most mobile nutrients in soil, especially sand soil, and hence exposure to the loss by leaching. So four alternative combinations of both nutrients (Nitrogen and potassium) were used, i.e. 75/100/75, 100/100/75, 75/100/100 and 100/100/100% of N/P/K recommended dose i.e. 650/150/600 g $tree^{-1}$. All the obtained results are discussed as follows:

I. Soil moisture distribution:

a. Soil moisture distribution under mini-sprinkler irrigation systems:

Experiments plot texture is sand, so the water, soil repellent is so high and need a good management of irrigation systems. mini-sprinkler has many advantages such as the wet radius of water applied which fix the sand poor hold capacity of water, in addition to water distribution horizontally encourage the horizontal water movement according the water drop by pressure during the mini-sprinkler hole, the horizontal uniformity of the soil water distribution reduces the deep-percolation and seepage, by the same token, the nutrients and other soil addition losses reduce, on the other side the soil evaporation increases according to the wetted area increment and water drop. But mini-sprinkler still more suitable for orchards, according to the uniformity of the surface wetted area and a supporting the elements availability to plant adsorption, according to **Hanson *et al.*2007.** (Fig.1).

b. Soil moisture distribution under drip irrigation systems

Drip irrigation system is the most common micro irrigation systems in Egypt, since 1975 according to many characterizes, but still have many challenges, especially in sandy soil texture according to the high infiltration rate of sandy soil, which cause a lot of soil additions losses by seepage. In addition to the limit soil moisture patterns under the dripper which limited the nutrients availability and root growth as a result of the partial wetted area of soil section, in the long term it causes salt appearance which causes root damage. So to solve this problem, it's need many of drippers around the tree. As shown the water distribution is horizontally limited under the dripper especially in sandy soil, according to **Hanson *et al.* 2007.** (Fig.2).

c. Irrigation system requirements:

The results show the highest values of yield is under three sprinklers according to the amount of water and overlap of three mini-sprinklers which encourage the nutrient availability but under the good irrigation management and not exceeds. Beside the excellent water distribution all-round the tree, especially in sandy soil, which does not support the spread horizontally of water, but the pressure makes the water drops away from the water source center, According to **Zekri and Parsons (1989), Plessis (1985) and Grieve (1988).**

The roots of sprinkler irrigated tree may be uniformly distributed between the trees because sprinkling wets most of or the entire soil surface. On the other side under drip irrigation, the soil moisture can vary with distance and depth of the drip line, generally, where the drip lined are installed near the plant rows, most of the roots will be near the drip lines, particularly, for row crops. If the drip lines are not near the plant rows, according to **Hanson et al..2007.** The basic feature of mini-sprinkler irrigation is the distribution of water according to the coverage area of sprinkler water diameter as a result of the irrigation operating pressure which work on emit the water droplet for 0.5 meters, with this technique, the sprinkler irrigation can fix deal with the

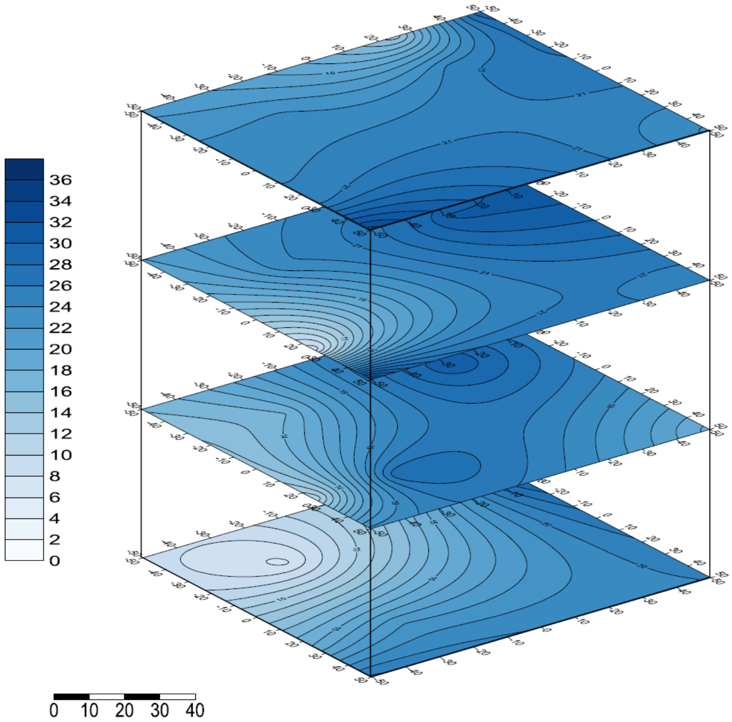


Fig.1: Soil moisture patterns under mini-sprinkler

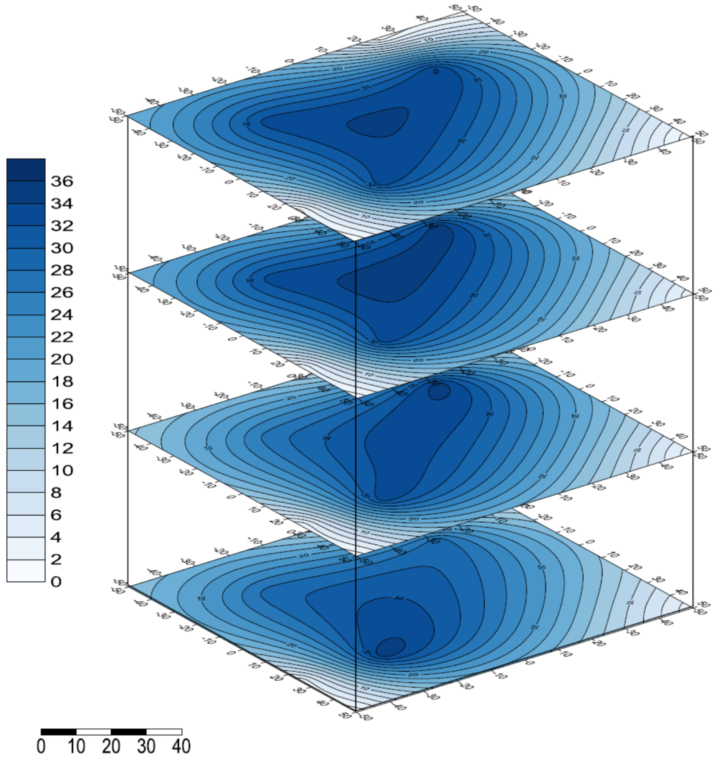


Fig.2: Soil moisture patterns under drip

Sand soil physics, which has a poor water hold capacity caused the narrow wet horizontal profile of soil moisture contents. By the same token, the deep percolation is higher under drip irrigation than sprinkler irrigation specially in sandy soil. Fig (3).

The values of apple yield, vegetative growth parameters and fruit quality characterizes under mini-sprinkler and 75% of recommended doses of nutrients are higher values than drip irrigation systems as a result of what was previously interpreted. According to the reduction of nutrients losing by leaching in deep-percolation in drip irrigation, on the other side, deep-percolation is limited under sprinkler and reduce whatever the number of sprinkler is increase all-round the tree which, causes the less applied water amount per area, less water head results less deep-percolation (less losses of nutrients), the less of applied water amounts in three sprinklers is compensated by the sprinklers number increasing all-round the tree. So generally, sprinkler irrigation saves about 25% of the recommended requirement of nutrients, by the same token three sprinklers saved nutrients more than two sprinklers and one sprinkler.

The values of apple yield, vegetative growth parameters and fruit quality characterizes under mini-sprinkler is higher values than drip irrigation systems as a result of what was previously interpreted. By the same token under various sprinklers treatments, the last production parameters are the highest under water amount 100% of applied water under three sprinklers, according to the non- water stress and very high excellent distribution of water under three mini-sprinklers all-round the tree, which support the water horizontal convey around the tree stem for 1 meter diameter, which support the root zoon to spreads for more distance and grows better, then obtains more availability of nutrients elements better than two sprinkler or one sprinklers.

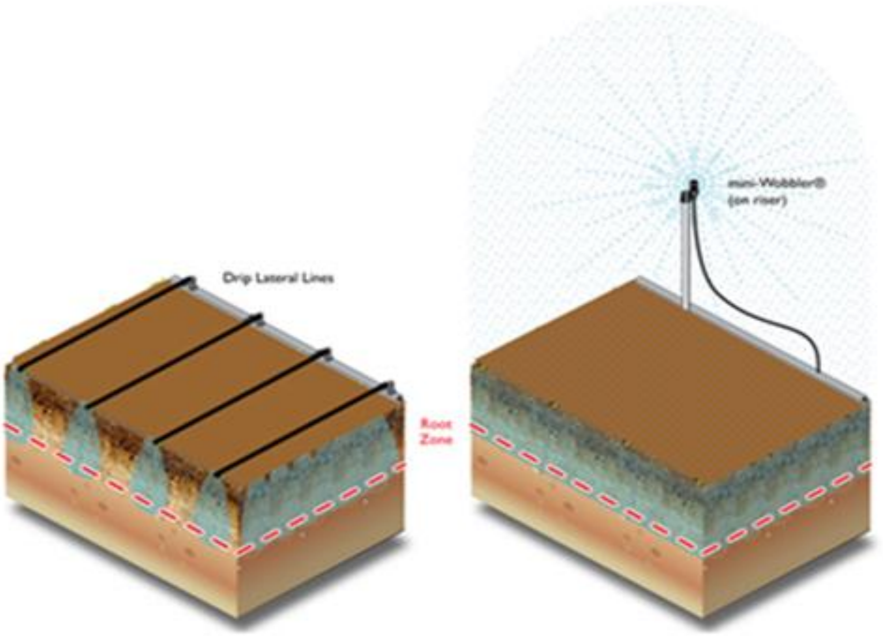


Fig.3: The performance of mini-sprinkler and drip on soil moisture distributions**.**

II. Vegetative growth and yield parameters as affected by irrigation and fertilization and their interaction:

a. Irrigation type effect on vegetative growth and yield parameters:

The results in Table (2) show that a significant differences were found between all irrigation treatments concerning their effects on vegetative growth and yield parameters such

Table2: Effect of irrigation type (Irrig.) and fertilization (Fert.) on vegetative growth and yield parameters of apple trees grown in sandy soil during two seasons.

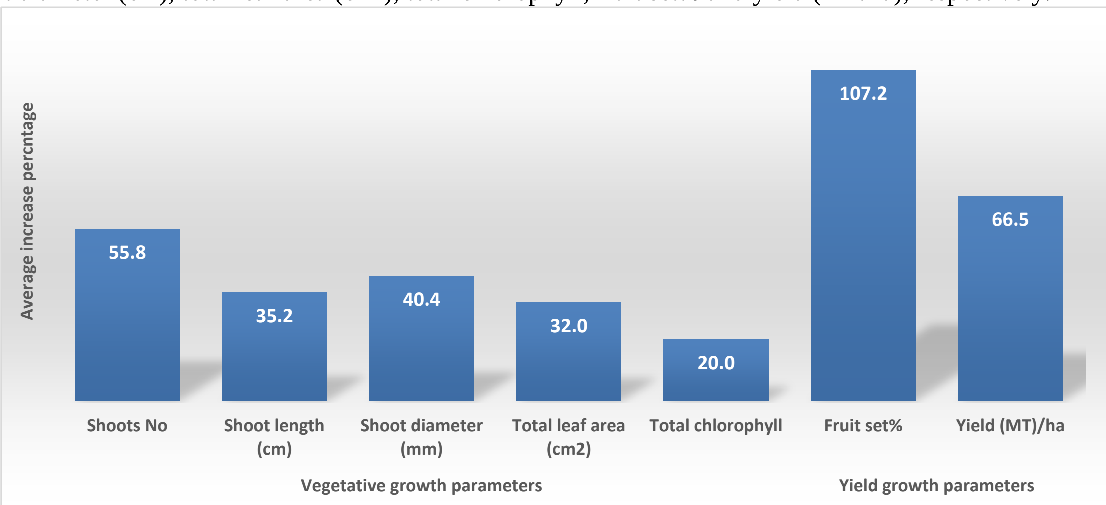
	2016					2017				
Irrigation (Irrig.)	**Drip**	**Sprinkler No**			**Mean**	**Drip**	**Sprinkler No**			**Mean**
		1	**2**	**3**			**1**	**2**	**3**	
Fertilization (Fert.)	**Shoots No**									
N1PK1	8.3	10.0	12.7	13.3	11.1	10.7	13.3	11.7	14.7	12.6
N2PK!	9.0	10.0	10.7	15.0	11.2	11.0	13.0	12.7	14.7	12.8
N1PK2	8.7	11.7	13.3	15.3	12.3	10.7	12.7	14.0	17.3	13.7
N2PK2	9.3	12.3	12.7	15.0	12.3	12.3	14.3	16.0	18.3	15.3
Mean	8.8	11.0	12.3	14.7		11.2	13.3	13.6	16.3	
LSD0.05	Irrig= 1.0606 Fert= 1.0606 Irrig*Firt= 2.1211					Irrig= 0.7412 Fert= 0.7412 Irrig*Firt=1.4824				
	Shoot length (cm)									
N1PK1	31.76	37.78	42.45	45.80	39.45	33.16	38.35	42.93	45.76	40.05
N2PK!	34.13	37.55	41.81	46.99	40.12	35.24	39.38	42.91	47.14	41.17
N1PK2	35.33	39.51	44.46	47.55	41.72	36.40	39.43	43.53	47.81	41.79
N2PK2	36.77	41.53	44.35	48.60	42.81	36.95	41.51	45.41	48.51	43.10
Mean	34.50	39.09	43.27	47.24		35.44	39.67	43.70	47.31	
LSD0.05	Irrig= 0.854 Fert= 0.854 Irrig*Firt= 1.7081					Irrig= 1.0249 Fert= 1.0249 Irrig*Firt=2.0499				

					Shoot diameter (cm)					
N1PK1	0.83	0.96	1.06	1.27	1.03	0.737	1.073	1.120	1.147	1.019
N2PK!	0.85	0.98	1.16	1.29	1.07	0.940	1.123	1.137	1.160	1.090
N1PK2	0.86	0.99	1.17	1.32	1.08	0.967	1.130	1.233	1.160	1.123
N2PK2	0.91	1.02	1.25	1.32	1.13	1.017	1.140	1.260	1.297	1.178
Mean	0.86	0.99	1.16	1.30		0.915	1.117	1.188	1.191	
LSD0.05	Irrig= 0.029 Fert= 0.029 Irrig*Firt= 0.058					Irrig= 0.1437 Fert= 0.1437 Irrig*Firt= 0.2874				
					leaf area (cm^2)					
N1PK1	24.52	26.22	28.29	31.17	27.55	25.45	27.02	29.64	34.02	29.03
N2PK!	24.89	27.08	29.59	32.25	28.45	25.74	27.17	30.40	35.30	29.65
N1PK2	24.99	28.00	30.62	33.10	29.18	26.34	28.10	32.78	35.42	30.66
N2PK2	25.68	28.56	30.93	33.17	29.59	27.17	28.49	33.33	35.98	31.24
Mean	25.02	27.47	29.86	32.42		26.17	27.70	31.54	35.18	
LSD0.05	Irrig= 0.6012 Fert= 0.6012 Irrig*Firt=1.2025					Irrig= 0.6093 Fert= 0.6093 Irrig*Firt=1.2185				
					Total chlorophyll					
N1PK1	39.09	39.78	42.56	44.52	41.49	37.73	39.91	42.78	46.31	41.69
N2PK!	39.09	40.43	42.13	45.32	41.74	38.31	40.33	44.03	47.03	42.43
N1PK2	39.65	41.08	43.50	45.73	42.49	37.73	41.72	45.82	47.65	43.23
N2PK2	40.00	41.74	43.90	46.30	42.99	37.89	42.34	45.97	48.09	43.57
Mean	39.46	40.76	43.02	45.47		37.91	41.08	44.65	47.27	
LSD0.05	Irrig= 0.6477 Fert= 0.6477 Irrig*Firt=1.2953					Irrig= 0.8314 Fert= 0.8314 Irrig*Firt=1.6628				
					Fruit set%					
N1PK1	16.12	20.78	28.46	33.25	24.65	16.60	22.47	29.07	34.31	25.61
N2PK!	16.22	21.82	31.40	34.65	26.02	16.68	23.33	30.32	34.47	26.20
N1PK2	16.10	24.52	31.72	34.62	26.74	16.96	25.88	31.84	34.41	27.27
N2PK2	16.56	27.21	33.77	35.42	28.24	18.45	27.99	33.78	35.68	28.97
Mean	16.25	23.58	31.34	34.49		17.17	24.92	31.25	34.72	
LSD0.05	Irrig=1.0963 Fert= 1.0963 Irrig*Firt= 2.1926					Irrig= 1.3835 Fert=1.3835 Irrig*Firt= 2.7669				
					Yield (MT/ha)					
N1PK1	20.55	22.11	30.82	34.04	26.88	21.28	21.99	26.91	36.16	26.59
N2PK!	22.11	27.36	32.99	33.92	29.09	20.83	22.07	29.11	37.03	27.26
N1PK2	22.63	30.00	33.04	36.47	30.54	21.05	23.35	30.55	37.13	28.02
N2PK2	24.26	31.57	34.10	36.74	31.67	21.31	24.37	34.83	37.75	29.57
Mean	22.39	27.76	32.74	35.29		21.12	22.94	30.35	37.02	
LSD0.05	Irrig= 2.2212 Fert= 2.2212 Irrig*Firt= 4.4425					Irrig= 0.947 Fert= 0.947 Irrig*Firt= 1.8939				

N1PK1= 75/100/75% of recommended Dose (RD) i.e. 488/150/450gtree^{-1} , N2PK1= 100/100/75%RD i.e. 650/150/450gtree^{-1}N1PK2= 75/100/100Rd i.e. 488/150/600 gtree^{-1} N2PK2= 100/100/100 i.e. 650/150/600 gtree^{-1}

As shoot No., shoot length (cm), shoot diameter (cm), total leaf area, total chlorophyll, fruit set% and fruit yield (MT/ha). Generally, irrigation with mini sprinkler improved all the studied vegetative growth and yield parameters compared to drip irrigation and using three mini sprinklers surpassed all the other used irrigation systems (Table2). A similar trend was observed in the second season.

The average increases percentage induced by irrigation with three sprinklers which showed the highest values compared to drip irrigation, which showed the lowest values in both studied seasons (Fig, 4). These increase percentages were as follows: 55.8, 35.2, 40.4, 32.0, 20.0, 107.2 and 66.5% for shoot No., shoot length (cm), shoot diameter (cm), total leaf area (cm^2), total chlorophyll, fruit set% and yield (MT/ha), respectively.

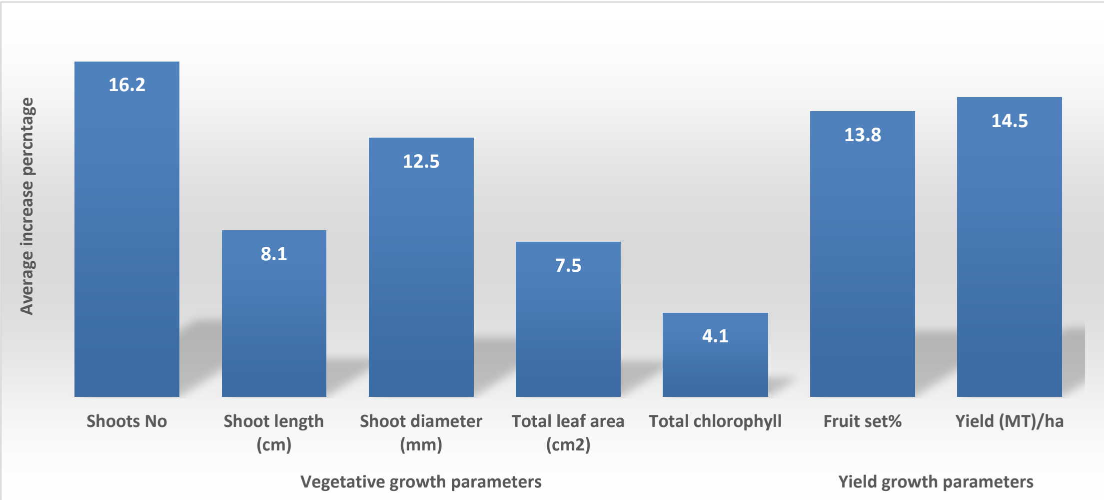


Fig, 4: Average increases percentage induced by using three sprinklers which showed the highest values compared to drip irrigation, which showed the lowest values in both studied seasons.

b. Fertilization effect on vegetative growth and yield parameters:

Data presented in the Table2 show that a significant difference was found between all the alternative combinations of mineral fertilization regarding their effects on vegetative growth and yield parameters such as shoot No., shoot length (cm), shoot diameter (cm), leaf area, total chlorophyll, fruit set% and fruit yield (MT/ha). Generally, the highest values of all the studied vegetative growth and yield parameters were obtained at 100/100/100% of N/P/K recommended dose (RD) i.e. 650/150/600 g tree^{-1} whereas the lowest values were obtained at 75/100/75%RD (Table2). The second season showed a similar trend.

Average increases percentage induced by applying 100/100/100% of N/P/K recommended dose (RD) which gave the highest values of vegetative growth and yield parameters compared to 75/100/75%RD which gave the lowest values of vegetative growth and yield parameters in both studied season are illustrated in Fig,5. Where these increase percentages were as follows: 16.7,8.1,12.5, 7.5, 4.1, 13.8 and 14.5% for shoot No., shoot length (cm), shoot diameter (cm), total leaf area (cm^2), total chlorophyll, fruit set% and yield (MT/ha), respectively.

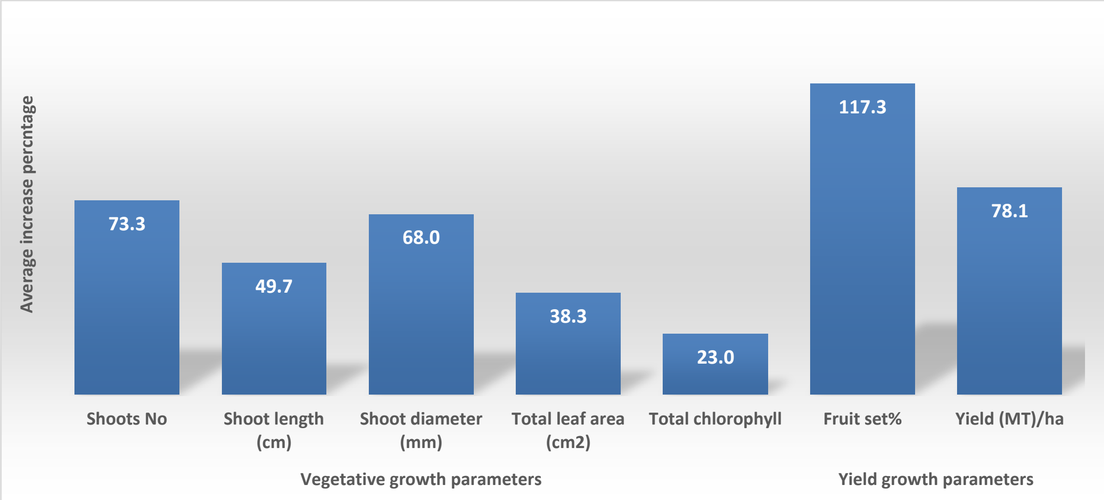


Fig, 5: Average increase percentage in vegetative and yield parameters induced by applying 100/100/100% of N/P/K recommended dose (RD) which gave the highest values compared to 75/100/75%RD which gave the lowest values in both studied seasons.

c. Interaction effect of irrigation and fertilization on vegetative growth and yield parameters:

Results in Table2 indicate that a significant differences were found between all the interaction treatments of irrigation and mineral fertilization regarding their effects on vegetative growth and yield parameters such as shoot No., shoot length (cm), shoot diameter (cm), total leaf area, total chlorophyll, fruit set% and fruit yield (MT/ha). Generally, the highest values all the studied vegetative growth and yield parameters were obtained in the treatment of 3 sprinkler+100/100/100% of N/P/K recommended dose (RD) i.e. 650/150/600 gtree^{-1} whereas the lowest values were at the treatment of drip irrigation+75/100/75%RD which gave (Table2). The same trend was noticed in the second season. These results are in agreement with those obtained by **Shirgure (2012)** who recorded that micro-irrigation and fertigation had been good responses on growth, yield and fruit quality in citrus. **Walid *et al.* (2015)** found that chemical fertilization of 'Anna' apple trees was improved significantly yield, fruit set, shoot diameter, shoot length, leaf area and decreased the percentages of fruit drop.The above results are in line with those of **(Singh *et al.* 2006; Waldemar, 2006;**; **Anna, 2011**; **Sharma *et al.* 2011**; **Ramniwas, *et al.*, 2012**; **Zhang, *et al.* 2013** on Apple tree and **Berkant *et al.*, 2014**)

Average increases percentage induced the interaction treatment 3sprinkler+100/100/100% of N/P/K recommended dose (RD) which gave the highest values compared to the interaction treatment drip irrigation+75/100/75% RD which gave the lowest values in both studied season are illustrated in Fig.6, Where these increase percentages were as follows: 73.3, 49.7,68.0, 38.3, 23.0, 117.3 and 78.1% for shoot No., shoot length (cm), shoot diameter (cm), total leaf area (cm^2), total chlorophyll, fruit set% and yield (MT/ha), respectively.



Fig, 6: Average increase percentage in vegetative and yield parameters induced by the interaction between using three sprinklers with applying 100/100/100% of N/P/K recommended dose (RD) which gave the highest values compared to using drip irrigation withapplying75/100/75%RD which gave the lowest values in both studied seasons.

From the above mentioned results it can be concluded that the effect of irrigation and fertilization and their interaction on different studied vegetative growth and yield parameters can be sorted in descending order as follows:

Interaction effect > Irrigation effect > fertilization effect.

On the other hand the response of different studied vegetative growth and yield parameters can be sorted in descending order as follows:

Fruit set% > Yield (MT/ha) > Shoot No. > Shoot diameter (cm) > Shoot length (cm) > Leaf area > Total chlorophyll

III. Apple fruit quality, i.e. fruit physical and chemical properties as affected by irrigation and fertilization and their interaction:

a. Irrigation type effect on fruit physical and chemical properties:

The results in Tables3 & 4 show that a significant differences were found between all irrigation treatments concerning their effects on fruit physical and chemical properties such as fruit length (cm), fruit width (cm), fruit weight (g), fruit volume (cm^3), TSS%, total sugar%, acidity% and ascorbic acid (mg/100 ml juice). Generally, irrigation with mini sprinkler improved all the studied fruit physical and chemical properties compared to drip irrigation and using three mini sprinklers surpassed all the other used irrigation systems (Tables3 & 4). A similar trend was observed in the second season.

Table3: Effect of irrigation type (Irrig.) and fertilization (Fert.) on fruit physical properties of apple grown in sandy soil during two seasons.

	2016					2017				
Irrigation (Irrig.)	**Drip**	**Sprinkler No**			**Mean**	**Drip**	**Sprinkler No**			**Mean**
		1	**2**	**3**			**1**	**2**	**3**	
Fertilization (Fert.)	**Fruit length (cm)**									
N1PK1	7.43	7.72	7.96	7.93	7.76	7.06	7.49	7.87	7.97	7.60
N2PK!	7.71	7.77	7.96	8.02	7.87	7.26	7.58	7.88	7.93	7.66
N1PK2	7.76	8.00	7.95	8.29	8.00	7.30	7.79	7.90	8.26	7.81
N2PK2	7.88	8.09	8.15	8.39	8.13	7.50	8.32	8.42	8.65	8.22
Mean	7.69	7.90	8.01	8.16		7.28	7.79	8.02	8.20	
LSD0.05	Irrig= 0.1287 Fert= 0.1287 Irrig*Firt= 0.2574					Irrig= 0.1436 Fert= 0.1436 Irrig*Firt= 0.2873				
	Fruit width (cm)									
N1PK1	7.09	7.24	7.55	7.62	7.38	7.15	7.34	7.51	7.71	7.43
N2PK!	7.18	7.27	7.56	7.63	7.41	7.22	7.44	7.58	7.64	7.47
N1PK2	7.21	7.31	7.52	7.69	7.43	7.36	7.37	7.48	7.72	7.48
N2PK2	7.44	7.47	7.60	7.70	7.55	7.56	7.58	7.71	7.75	7.65
Mean	7.23	7.32	7.56	7.66		7.32	7.43	7.57	7.70	
LSD0.05	Irrig= 0.0956 Fert= 0.0956 Irrig*Firt= 0.1912					Irrig= 0.1235 Fert= 0.1235 Irrig*Firt= 0.247				
	Fruit weight (g)									
N1PK1	164.5	167.5	174.2	181.2	171.9	164.9	167.8	172.1	190.4	173.8
N2PK!	167.4	177.0	182.9	187.8	178.8	165.8	168.3	179.8	193.3	176.8

N1PK2	168.4	177.9	185.4	193.1	181.2	167.0	172.4	180.4	191.5	177.8
N2PK2	168.9	183.9	188.4	192.3	183.4	168.1	172.0	190.4	193.7	181.0
Mean	167.3	176.6	182.7	188.6		166.5	170.1	180.7	192.2	
LSD0.05	Irrig= 2.4063 Fert= 2.4063 Irrig*Firt= 4.8125					Irrig= 2.9085 Fert= 2.9085 Irrig*Firt= 5.817				
	Fruit volume (cm3)									
N1PK1	139.1	143.4	156.2	164.0	150.7	138.1	144.1	154.0	164.9	150.3
N2PK!	138.8	145.6	156.3	162.8	150.9	138.1	148.1	157.5	160.6	151.1
N1PK2	139.5	151.6	159.8	165.7	154.2	138.9	152.0	160.1	166.3	154.3
N2PK2	144.1	152.4	160.4	166.8	155.9	142.2	152.0	163.7	166.8	156.2
Mean	140.4	148.3	158.2	164.8		139.3	149.0	158.8	164.6	
LSD0.05	Irrig= 3.2823 Fert= 3.2823 Irrig*Firt= 6.5646					Irrig= 2.7286 Fert= 2.7286 Irrig*Firt= 5.4572				

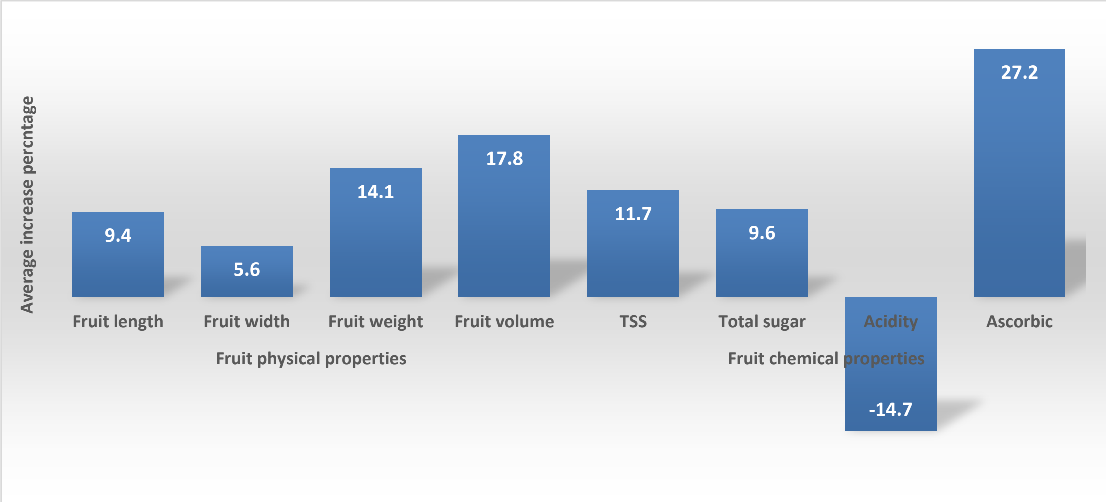
N1PK1= 75/100/75% of recommended Dose (RD) i.e. 488/150/450gtree^{-1} , N2PK1= 100/100/75%RD i.e. 650/150/450gtree^{-1} N1PK2= 75/100/100Rd i.e. 488/150/600 gtree^{-1} N2PK2= 100/100/100 i.e. 650/150/600 gtree^{-1}

Table4: Effect of irrigation type (Irrig.) and fertilization (Fert.) on fruit chemical properties of apple grown in sandy soil during two seasons.

	2016					**2017**				
Irrigation (Irrig.)	**Drip**	**Sprinkler N**			**Mean**	**Drip**	**Sprinkler No**			**Mean**
		1	**2**	**3**			**1**	**2**	**3**	
Fertilization (Fert.)	**TSS%**									
N1PK1	12.77	13.71	13.79	14.18	13.61	12.77	12.54	13.71	13.88	13.23
N2PK1	12.74	13.71	13.81	14.45	13.68	12.39	12.82	13.72	13.88	13.20
N1PK2	12.86	13.82	13.97	14.54	13.80	12.45	12.89	13.79	13.91	13.26
N2PK2	13.16	13.89	14.12	14.77	13.99	12.48	13.55	13.79	13.95	13.44
Mean	12.89	13.78	13.92	14.49		12.52	12.95	13.75	13.91	
LSD0.05	Irrig= 0.1602 Fert= 0.1602 Irrig*Firt=0.3204					Irrig= 0.1276 Fert= 0.1276 Irrig*Firt= 0.2552				
	Total Sugar%									
N1PK1	10.03	10.19	10.50	10.73	10.36	10.13	10.46	10.77	11.24	10.65
N2PK1	10.03	10.46	10.51	10.85	10.47	10.34	10.64	10.81	11.28	10.77
N1PK2	10.10	10.45	10.51	11.10	10.54	10.30	10.71	10.67	11.38	10.77
N2PK2	10.19	10.42	10.72	11.24	10.64	10.27	10.71	10.97	11.41	10.84
Mean	10.09	10.38	10.56	10.98		10.26	10.63	10.80	11.33	
LSD0.05	Irrig=0.113Fert=0.113 Irrig*Firt=0.226					Irrig= 0.133 Fert= 0.133 Irrig*Firt= 0.265				
	Acidity%									
N1PK1	0.647	0.630	0.650	0.563	0.623	0.647	0.633	0.567	0.547	0.598
N2PK1	0.627	0.563	0.600	0.573	0.591	0.657	0.627	0.557	0.520	0.590
N1PK2	0.623	0.617	0.577	0.573	0.598	0.653	0.617	0.557	0.517	0.586
N2PK2	0.637	0.643	0.573	0.577	0.608	0.660	0.597	0.553	0.520	0.583
Mean	0.633	0.613	0.600	0.572		0.654	0.618	0.558	0.526	
LSD0.05	Irrig= 0.028 Fert= 0.028 Irrig*Firt= 0.055					Irrig= 0.016 Fert= 0.016 Irrig*Firt= 0.031				
	Ascorbic acid (mg/100 ml juice)									
N1PK1	37.36	39.90	42.70	46.69	41.66	36.83	38.59	41.62	46.48	40.88
N2PK1	37.92	41.07	44.21	48.09	42.82	36.63	39.32	43.63	47.85	41.86
N1PK2	38.04	42.09	45.04	48.41	43.40	37.65	40.05	43.87	48.43	42.50
N2PK2	38.71	41.96	46.52	48.52	43.93	38.18	41.05	45.49	48.84	43.39
Mean	38.00	41.26	44.62	47.93		37.32	39.75	43.65	47.90	
LSD0.05	Irrig= 0.831 Fert= 0.831 Irrig*Firt= 1.662					Irrig= 0.595 Fert= 0.595 Irrig*Firt= 1.190				

N1PK1= 75/100/75% of recommended Dose (RD) i.e. 488/150/450gtree^{-1} , N2PK1= 100/100/75%RD i.e. 650/150/450gtree^{-1} N1PK2= 75/100/100Rd i.e. 488/150/600 gtree^{-1} N2PK2= 100/100/100 i.e. 650/150/600 gtree^{-1}

Average increases percentage induced by irrigation with three sprinklers which showed the highest values compared to drip irrigation, which showed the lowest values in both studied season are illustrated in Fig,7. Where these increase percentages were as follows: 9.4,5.6, 14.1, 17.8, 11.7, 9.6, -14.7 and 27.2% of fruit length (cm), fruit width (cm), fruit weight (g), fruit volume (cm^3), TSS%, total sugar%, acidity% (negative increase) and ascorbic acid (mg/100 ml juice), respectively.

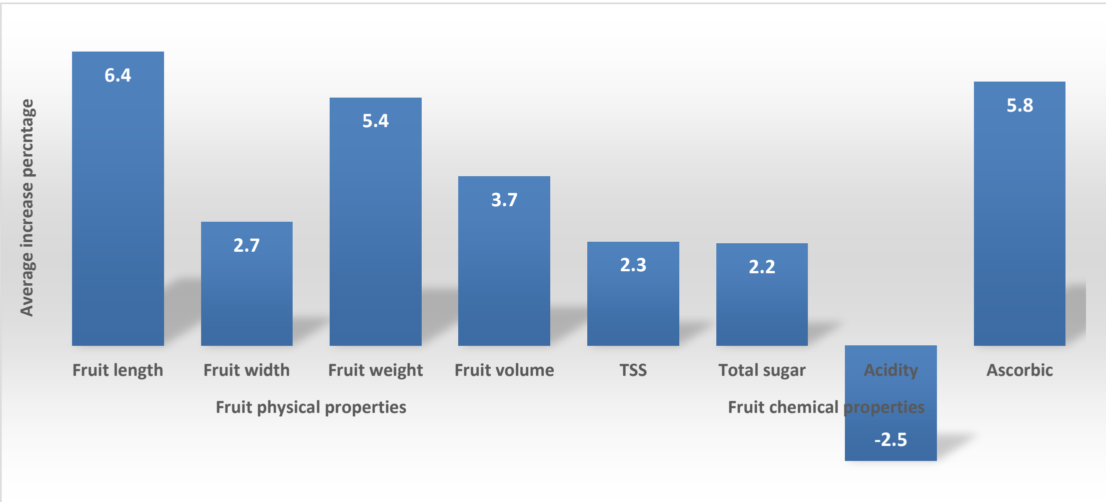


Fig, 7: Average increases percentage of physical and chemical properties induced by using three sprinklers which showed the highest values compared to drip irrigation which showed the lowest values in both studied seasons.

b. Fertilization effect on fruit physical and chemical properties:

Data presented in Tables3 & 4 show that a significant difference was found between all the alternative combinations of mineral fertilization regarding their effects on fruit length (cm), fruit width (cm), fruit weight (g), fruit volume (cm^3), TSS%, total sugar%, acidity% and ascorbic acid (mg/100 ml juice). Generally, the highest values of all the studied fruit physical and chemical properties were obtained at 100/100/100% of N/P/K recommended dose (RD) i.e. 650/150/600 g $tree^{-1}$ whereas the lowest values were obtained at 75/100/75%RD (Tables3 & 4). The second season showed a similar trend.

Average increases percentage induced by applying 100/100/100% of N/P/K recommended dose (RD) which gave the highest values compared to 75/100/75%RD which gave the lowest values in both studied season are illustrated in Fig,8. Where these increase percentages were as follows: 8.4,2.7,5.4, 3.7, 2.3, 2.2, -2.5 and 5.8% of fruit length (cm), fruit width (cm), fruit weight (g), fruit volume (cm^3), TSS%, total sugar%, acidity% (negative increase) and ascorbic acid (mg/100 ml juice), respectively.



Fig, 8: Average increase percentage of physical and chemical properties induced by applying 100/100/100% of N/P/K recommended dose (RD) which gave the highest values compared to 75/100/75%RD which gave the lowest values in both studied seasons.

c. Interaction effect of irrigation and fertilization on fruit physical and chemical properties:

Results in Tables3 & 4 indicate that a significant differences were found between all the interaction treatments of irrigation and mineral fertilization regarding their effects on fruit physical and chemical properties such as fruit length (cm), fruit width (cm), fruit weight (g), fruit volume (cm^3), TSS%, total sugar%, acidity% and ascorbic acid (mg/100 ml juice). Generally, the highest values of all the studied fruit physical and chemical properties were obtained in the treatment of 3 sprinkler+100/100/100% of N/P/K recommended dose (RD) i.e.

650/150/600 gtree^{-1} whereas the lowest values were at the treatment of drip irrigation+75/100/75%RD which gave (Tables3 & 4). The same trend was noticed in the second season.These results are in agreement with those obtained by **Walid *et al*. (2015)** who found that chemical fertilization of 'Anna' apple trees was had the highest positive effect to improve the percentages by reducing sugar and total soluble solids as compared to the control. The above results are in line with those of (**Neilsen, 2004** on Apple tree, **Esmaeil, 2010** on Apples, **Ramniwas, *et al*., 2012**; on Apple tree; **Shirgure, 2012** on Citrus; **Zhang, *et al.* 2013** on Apple tree and **Berkant, *et al*., 2014** on Apples)

Average increases percentage induced the interaction treatment 3sprinkler+100/100/100% of N/P/K recommended dose (RD) which gave the highest values compared to the interaction treatment drip irrigation+75/100/75%RD which gave the lowest values in both studied season are illustrated in Fig.9. Where these increase percentages were as follows: 17.7, 8.5, 16.8, 20.3, 12.4, 12.3, -15.2 and 31.2% of fruit length (cm), fruit width (cm), fruit weight (g), fruit volume (cm^3), TSS%, total sugar%, acidity% (negative increase) and ascorbic acid (mg/100 ml juice), respectively.

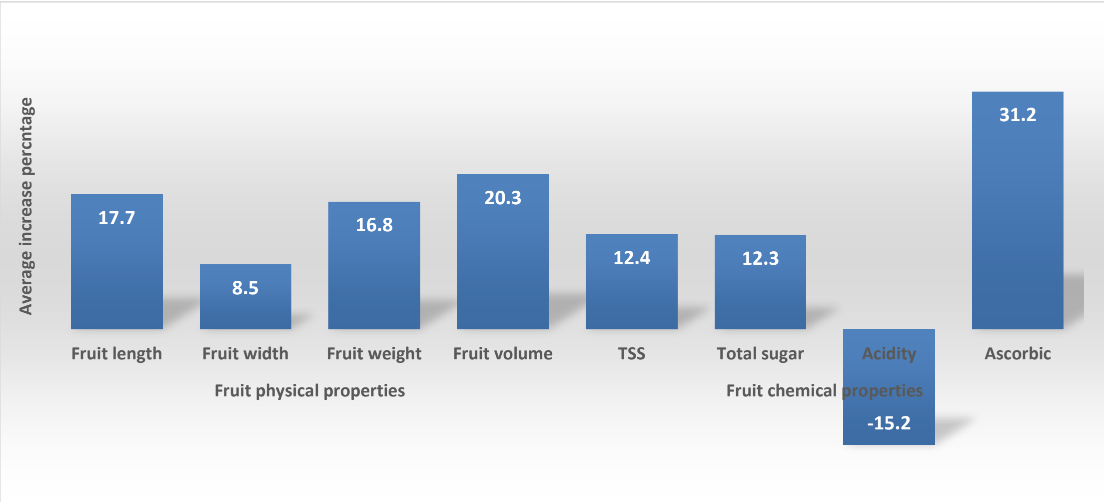


Fig.9: Average increase percentage of physical and chemical properties induced by the interaction between using three sprinklers with applying 100/100/100% of N/P/K recommended dose (RD) which gave the highest values compared to using drip irrigation with applying75/100/75%RD which gave the lowest values in both studied seasons.

From the aforementioned results it can be concluded that the effect of irrigation and fertilization and their interaction on different studied physical and chemical properties can be sorted in descending order as follows: Interaction effect > Irrigation effect > fertilization effect.

On the other hand the response of different studied fruit physical and chemical properties can be sorted in descending order as follows:

Ascorbic acid (mg/100 ml juice)> fruit volume (cm^3) > fruit length (cm) > fruit weight (g) > acidity% (negative increase) > TSS% >total sugar%> fruit width (cm)

IV. Apple leaves and fruit nutrients content as affected by irrigation and fertilization and their interaction:

a. Irrigation type effect on apple leaves and fruit nutrient content:

The results in Tables5, 6 & 7 show that a significant differences were found between all irrigation treatments concerning their effects on nutrient content such as N%, P%, K%, N uptake, P uptake and K uptake in both leaves and fruits. Generally, irrigation with mini sprinkler improved all the studied nutrient content, either in the leaves or in fruits compared to drip irrigation and using three mini sprinklers surpassed all the other used irrigation systems (Table5). A similar trend was observed in the second season.

Table5: Effect of irrigation type (Irrig.) and fertilization (Fert.) on the nitrogen content of leaves and fruits, chemical properties of apple grown in sandy soil during two seasons.

	2016					2017				
Irrigation (Irrig.)	Drip	Sprinkler No 1	Sprinkler No 2	Sprinkler No 3	Mean	Drip	Sprinkler No 1	Sprinkler No 2	Sprinkler No 3	Mean
Fertilization (Fert.)	N% in leaves									
N1PK1	1.423	1.720	1.817	1.980	1.735	1.547	1.710	1.777	1.860	1.723

N2PK1	1.453	1.800	1.860	1.960	1.768	1.640	1.717	1.817	1.870	1.761
N1PK2	1.777	1.867	1.940	2.097	1.920	1.663	1.757	1.820	1.877	1.779
N2PK2	1.813	1.887	1.943	2.187	1.958	1.680	1.780	1.843	1.893	1.799
Mean	1.617	1.818	1.890	2.056		1.633	1.741	1.814	1.875	
LSD0.05	Irrig= 0.1148 Fert= 0.1148 Irrig*Firt= 0.2297					Irrig= 0.018 Fert= 0.018 Irrig*Firt= 0.0359				
					N%in fruits					
N1PK1	1.46	1.57	1.69	1.78	1.63	1.43	1.55	1.68	1.75	1.60
N2PK1	1.48	1.61	1.71	1.79	1.65	1.45	1.55	1.69	1.74	1.61
N1PK2	1.48	1.64	1.74	1.80	1.67	1.49	1.56	1.73	1.78	1.64
N2PK2	1.54	1.68	1.74	1.81	1.69	1.52	1.65	1.73	1.79	1.67
Mean	1.49	1.63	1.72	1.80		1.47	1.58	1.71	1.77	
LSD0.05	Irrig= 0.019 Fert= 0.019 Irrig*Firt= 0.037					Irrig= 0.040 Fert= 0.040 Irrig*Firt= 0.080				
					N uptake (mg/leaf)					
N1PK1	3.493	4.491	5.134	6.172	4.822	3.94	4.62	5.27	6.33	5.04
N2PK1	3.630	4.867	5.504	6.318	5.080	4.22	4.66	5.52	6.60	5.25
N1PK2	4.445	5.237	5.941	6.931	5.639	4.38	4.94	5.96	6.65	5.48
N2PK2	4.639	5.385	6.012	7.257	5.823	4.56	5.07	6.14	6.81	5.65
Mean	4.052	4.995	5.648	6.669		4.28	4.82	5.72	6.60	
LSD0.05	Irrig= 0.316 Fert= 0.316 Irrig*Firt= 0.632					Irrig= 0.105 Fert= 0.105 Irrig*Firt= 0.211				
					N uptake (mg/fruit)					
N1PK1	430.3	441.1	460.5	452.1	446.0	431.6	471.1	470.9	585.6	489.8
N2PK1	430.4	462.0	518.5	487.1	474.5	440.1	469.1	491.0	600.0	500.0
N1PK2	417.0	469.0	533.5	505.8	481.3	445.9	497.2	533.5	620.2	524.2
N2PK2	411.2	654.4	568.6	546.0	545.0	459.3	518.7	607.9	612.8	549.7
Mean	422.2	506.6	520.3	497.7		444.2	489.0	525.8	604.7	
LSD0.05	Irrig= 19.32 Fert= 19.32 Irrig*Firt= 38.65					Irrig= 28.93 Fert= 28.93 Irrig*Firt=57.86				

N1PK1= 75/100/75% of recommended Dose (RD) i.e. 488/150/450gtree^{-1} , N2PK1= 100/100/75%RD i.e. 650/150/450gtree^{-1} N1PK2= 75/100/100Rd i.e. 488/150/600 gtree^{-1} N2PK2= 100/100/100 i.e. 650/150/600 gtree^{-1}

Table6: Effect of irrigation type (Irrig.) and fertilization (Fert.) on the phosphorus content of leaves and fruits, chemical properties of apple grown in sandy soil during two seasons.

	2016					**2017**				
Irrigation (Irrig.)	**Drip**	**Sprinkler No**			**Mean**	**Drip**	**Sprinkler No**			**Mean**
		1	**2**	**3**			**1**	**2**	**3**	
Fertilization (Fert.)					**P% in leaves**					
N1PK1	0.209	0.211	0.253	0.316	0.247	0.210	0.249	0.260	0.278	0.249
N2PK1	0.211	0.215	0.283	0.305	0.253	0.218	0.247	0.264	0.282	0.253
N1PK2	0.209	0.220	0.287	0.325	0.260	0.225	0.262	0.270	0.298	0.264
N2PK2	0.215	0.242	0.288	0.327	0.268	0.235	0.264	0.273	0.304	0.269
Mean	0.211	0.222	0.278	0.318		0.222	0.256	0.267	0.290	
LSD0.05	Irrig= 0.0197 Fert= 0.0197Irrig*Firt= 0.0394					Irrig= 0.0104 Fert= 0.0104 Irrig*Firt= 0.0208				
					P% in fruits					
N1PK1	0.192	0.203	0.217	0.227	0.210	0.187	0.209	0.198	0.231	0.206
N2PK1	0.202	0.208	0.220	0.227	0.214	0.189	0.218	0.227	0.236	0.218
N1PK2	0.199	0.214	0.220	0.230	0.216	0.201	0.217	0.220	0.230	0.217
N2PK2	0.200	0.217	0.225	0.233	0.219	0.210	0.218	0.222	0.237	0.222
Mean	0.198	0.211	0.221	0.229		0.197	0.216	0.217	0.234	
LSD0.05	Irrig= 0.0044 Fert= 0.0044 Irrig*Firt= 0.0087					Irrig= 0.0088 Fert= 0.0088 Irrig*Firt= 0.0177				
					P uptake (mg/leaf)					
N1PK1	0.513	0.553	0.715	0.984	0.691	0.534	0.673	0.772	0.946	0.731
N2PK1	0.524	0.582	0.837	0.984	0.732	0.562	0.671	0.801	0.995	0.757
N1PK2	0.523	0.617	0.876	1.077	0.773	0.594	0.737	0.885	1.054	0.818
N2PK2	0.553	0.690	0.892	1.086	0.805	0.637	0.751	0.909	1.093	0.847
Mean	0.528	0.610	0.830	1.033		0.582	0.708	0.842	1.022	
LSD0.05	Irrig= 0.0662 Fert= 0.0662Irrig*Firt= 0.1323					Irrig= 0.035 Fert= 0.035 Irrig*Firt= 0.0701				
					P uptake (mg/fruit)					
N1PK1	57.80	54.72	58.39	79.78	62.67	57.97	71.99	76.28	90.21	74.11
N2PK1	56.59	61.47	50.81	74.98	60.96	64.26	74.75	82.27	89.90	77.79
N1PK2	60.85	50.95	79.52	76.60	66.98	69.18	75.20	82.64	91.35	79.59
N2PK2	67.22	44.26	67.64	66.19	61.33	69.44	74.36	87.25	90.05	80.28
Mean	60.62	52.85	64.09	74.39		65.21	74.08	82.11	90.38	
LSD0.05	Irrig= 3.6838 Fert= 3.6838 Irrig*Firt= 7.3675					Irrig= 3.0875 Fert= 3.0875 Irrig*Firt= 6.1751				

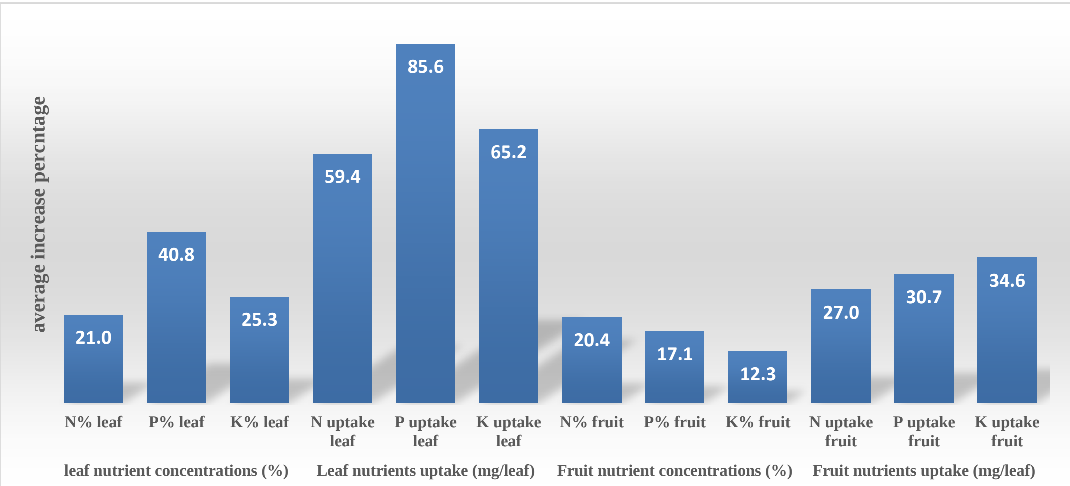
N1PK1= 75/100/75% of recommended Dose (RD) i.e. 488/150/450gtree^{-1} , N2PK1= 100/100/75%RD i.e. 650/150/450gtree^{-1} N1PK2= 75/100/100Rd i.e. 488/150/600 gtree^{-1} N2PK2= 100/100/100 i.e. 650/150/600 gtree^{-1}

Table7: Effect of irrigation type (Irrig.) and fertilization (Fert.) on the potassium content of leaves and fruits, chemical properties of apple grown in sandy soil during two seasons.

Irrigation (Irrig.)	2016 Drip	2016 Sprinkler No 1	2016 Sprinkler No 2	2016 Sprinkler No 3	2016 Mean	2017 Drip	2017 Sprinkler No 1	2017 Sprinkler No 2	2017 Sprinkler No 3	2017 Mean
Fertilization (Fert.)					K% in leaves					
N1PK1	0.88	1.07	1.15	1.19	1.07	0.88	0.98	1.12	1.13	1.03
N2PK1	0.89	1.13	1.17	1.20	1.10	0.91	1.00	1.13	1.14	1.04
N1PK2	1.03	1.12	1.18	1.20	1.14	0.92	1.06	1.13	1.15	1.06
N2PK2	1.04	1.15	1.19	1.21	1.15	0.95	1.11	1.13	1.16	1.09
Mean	0.96	1.12	1.17	1.20		0.92	1.04	1.13	1.15	
LSD0.05	Irrig= 0.0227 Fert= 0.0227 Irrig*Firt= 0.0454					Irrig= 0.0158 Fert= 0.0158 Irrig*Firt= 0.0316				
					K5 in fruits					
N1PK1	1.49	1.58	1.69	1.74	1.63	1.46	1.55	1.60	1.64	1.56
N2PK1	1.51	1.64	1.70	1.76	1.65	1.49	1.55	1.59	1.64	1.57
N1PK2	1.52	1.66	1.72	1.76	1.66	1.55	1.56	1.61	1.65	1.59
N2PK2	1.58	1.64	1.74	1.76	1.68	1.52	1.58	1.62	1.67	1.60
Mean	1.53	1.63	1.71	1.75		1.51	1.56	1.61	1.65	
LSD0.05	Irrig= 0.0187 Fert= 0.0187 Irrig*Firt= 0.0373					Irrig= 0.0273 Fert= 0.0273 Irrig*Firt= 0.0546				
					K uptake (mg/leaf)					
N1PK1	2.149	2.804	3.244	3.709	2.977	2.25	2.64	3.31	3.86	3.01
N2PK1	2.206	3.060	3.472	3.881	3.155	2.34	2.71	3.43	4.04	3.13
N1PK2	2.586	3.149	3.613	3.983	3.333	2.42	2.98	3.70	4.06	3.29
N2PK2	2.677	3.278	3.671	4.026	3.413	2.57	3.16	3.78	4.17	3.42
Mean	2.405	3.073	3.500	3.900		2.40	2.87	3.55	4.03	
LSD0.05	Irrig= 0.1024 Fert= 0.1024 Irrig*Firt= 0.2049					Irrig= 0.0709 Fert= 0.0709 Irrig*Firt= 0.1418				
					K uptake (mg/fruit)					
N1PK1	343.2	408.4	456.5	580.4	447.1	343.6	451.2	514.0	565.6	468.6
N2PK1	480.3	463.1	393.7	555.9	473.2	411.0	460.8	506.8	588.4	491.7
N1PK2	502.0	605.0	704.2	630.3	610.4	424.5	476.5	523.4	604.8	507.3
N2PK2	475.9	546.0	792.2	434.7	562.2	440.8	496.4	557.4	622.9	529.4
Mean	450.4	505.6	586.6	550.3		405.0	471.2	525.4	595.4	
LSD0.05	Irrig= 24.289 Fert= 24.289 Irrig*Firt= 48.578					Irrig= 28.197 Fert= 28.197 Irrig*Firt= 56.394				

N1PK1= 75/100/75% of recommended Dose (RD) i.e. 488/150/450gtree^{-1} , N2PK1= 100/100/75%RD i.e. 650/150/450gtree^{-1} N1PK2= 75/100/100Rd i.e. 488/150/600 gtree^{-1} N2PK2= 100/100/100 i.e. 650/150/600 gtree^{-1}

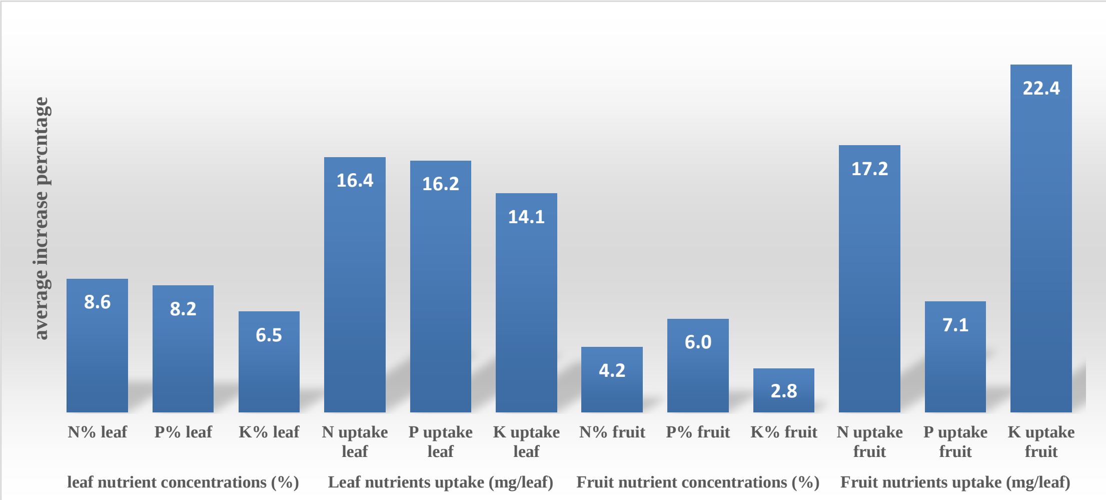
Average increases percentage induced by irrigation with three sprinklers which showed the highest values compared to drip irrigation, which showed the lowest values in both studied season are illustrated in Fig.10. Where these increase percentages were as follows: 21.0, 40.8, 25.3, 59.4, 83.6, 65.2% of N%, P%, K%, N uptake, P uptake and K uptake in leaves, respectively, and 20.4, 17.1, 12.3, 27.0, 30.7 and 34.6% of N%, P%, K%, N uptake, P uptake and K uptake in fruits, respectively.



Fig, 10: Average increases percentage in apple leaves and fruit nutrient content induced by using three sprinklers which showed the highest values compared to drip irrigation which showed the lowest values in both studied seasons.

b. Fertilization effect on apple leaves and fruit nutrient content:
Data presented in Tables5, 6 & 7 show that a significant differences were found between all the alternative combinations of mineral fertilization regarding their effects on nutrient content such as N%, P%, K%, N uptake, P uptake and K uptake in both leaves and fruits. Generally, the highest values of all the studied nutrient content, either in the leaves or fruits were obtained at 100/100/100% of N/P/K recommended dose (RD) i.e. 650/150/600 $gtree^{-1}$ whereas the lowest values were obtained at 75/100/75%RD (Tables5, 6 & 7). The second season showed a similar trend..

Average increases percentage induced by applying 100/100/100% of N/P/K recommended dose (RD) which gave the highest values compared to 75/100/75%RD which gave the lowest values in both studied season are illustrated in Fig,11. Where these increase percentages were as follows: 8.6, 4.2, 16.4, 17.2, 8.2, 6.0% of N%, P%, K%, N uptake, P uptake and K uptake in leaves, respectively, and 16.2, 7.1, 6.5, 2.8, 14.1 and 22.4% of N%, P%, K%, N uptake, P uptake and K uptake in fruits, respectively.



Fig, 11: Average increase percentage in apple leaves and fruit nutrient content induced by applying 100/100/100% of N/P/K recommended dose (RD) which gave the highest values compared to 75/100/75%RD which gave the lowest values in both studied seasons.

c. Interaction effect of irrigation and fertilization on apple leaves and fruit nutrient content:
Results in Tables5, 6 & 7 indicate that a significant differences were found between all the interaction treatments of irrigation and mineral fertilization regarding their effects on nutrient content such as N%, P%, K%, N uptake, P uptake and K uptake in both leaves and fruits. Generally, the highest values of all the studied nutrient content, either in the leaves or fruits were obtained in the treatment of 3 sprinkler+100/100/100% of N/P/K recommended dose (RD) i.e. 650/150/600 $gtree^{-1}$ whereas the lowest values were at the treatment of drip irrigation+75/100/75%RD which gave (Table5, 6 & 7). The same trend was noticed in the second season.These results are in agreement with those obtained by **Walid et al, (2015)** who found that chemical fertilization of 'Anna' apple trees was had the highest positive effect on increasing Ca, P, K, N, B, Zn, Mn and Fe in the leaves in the two studied seasons, as compared to the control. The same results were found by **Neilsen, (2004)** on Apple tree and **Shirgure, 2012** on Citrus**.**

Average increases percentage induced the interaction treatment 3sprinkler+100/100/100% of N/P/K recommended dose (RD) which gave the highest values compared to the interaction treatment drip irrigation+75/100/75% RD which gave the lowest values in both studied season are illustrated in Fig, 12. Where these increase percentages were as follows: 17.7, 8.5, 16.8, 20.3, 12.4, 12.3, -15.2 and 31.2% of fruit length (cm), fruit width (cm), fruit weight (g), fruit volume (cm^3), TSS%, total sugar%, acidity% (negative increase) and ascorbic acid (ppm), respectively.

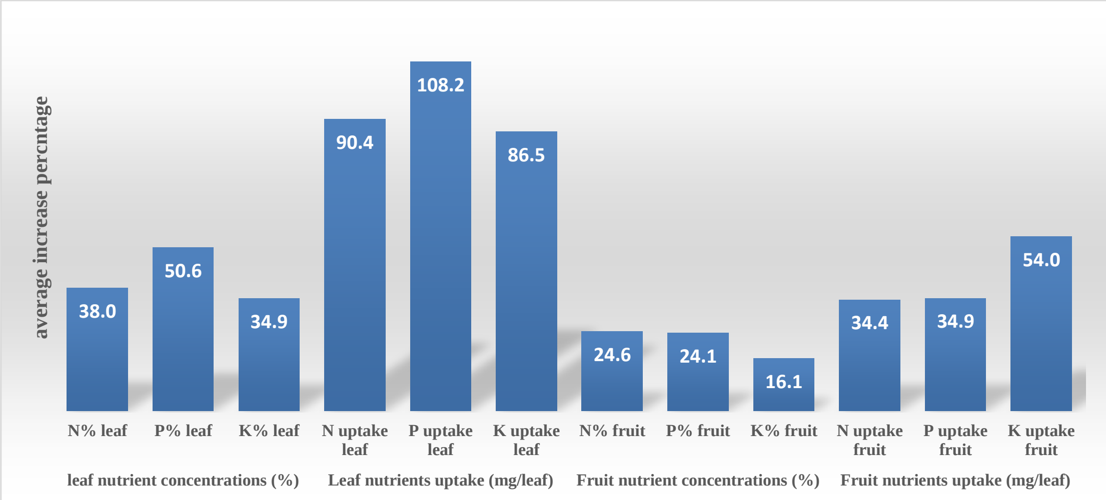


Fig.12: Average increase percentage in apple leaves and fruit nutrient content induced by the interaction between using three sprinklers with applying 100/100/100% of N/P/K recommended dose (RD) which gave the highest values compared to using drip irrigation with applying75/100/75%RD which gave the lowest values in both studied seasons.

V. Fertilizer use efficiency (FUE):

Significant differences were observed for values of fertilizer use efficiency (FUE) at the different treatments of irrigation types (with the same rate of irrigation water, 90Lh^{-1}) and rates of fertilizer application (Table8 and Fig.13). Generally, the highest values of FUE were observed in the application of 75% RD of Nitrogen and potassium compared with 100% RD of both nutrients with any type of irrigation. It is noteworthy to mention that the potassium use efficiency was slighter than nitrogen use efficiency. The highest values of FUE were noticed when three sprinklers were used in irrigation by 75% RD where it was 90.86 and 94.60 kg yield/kg nitrogen and potassium, respectively. On the other hand, the lowest significant FUE values were obtained at drip irrigation with 100% RD where it was 42.19 and 45.57 kg yield/kg nitrogen and potassium, respectively.

Table8: Fertilizer use efficiency (FUE) of Nitrogen and Potassium under different types of irrigation with the same rate of irrigation water (90Lh^{-1})

Irrigation types	Doses percent age	Fruits yield	Applied fertilization		FUE (kg yield/kg N fertilizer)	
		kg ha^{-1}	kg Nha^{-1}	kg Kha^{-1}	N use efficiency	K use efficiency
Drip	75%	21840	405	375	53.93f	57.25f
	100%	22785	540	500	42.19h	45.57h
1sprinkler	75%	26675	405	375	65.86d	65.91e
	100%	27970	540	500	51.80g	55.94g
2sprinkler	75%	31795	405	375	78.51b	82.80b
	100%	34465	540	500	63.82e	68.93d
3sprinkler	75%	36800	405	375	90.86a	94.60a
	100%	37245	540	500	68.97c	74.49c
		LSD$_{0.05}$			0.270	0.276

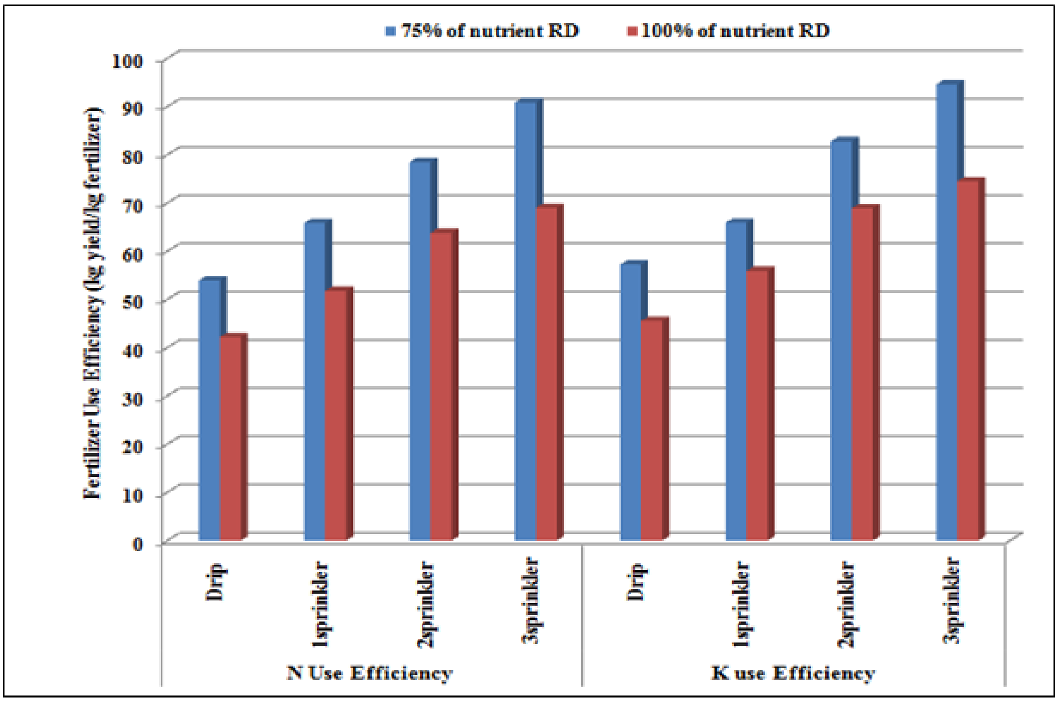


Fig.13: Fertilizer use efficiency (FUE) of Nitrogen and Potassium under different types of irrigation with the same rate of irrigation water ($90Lh^{-1}$)

IV. Conclusions

Under condidtions environemental of trial site, apple yield, vegetative growth parameters and fruit quality characterizes under mini-sprinkler are better than drip irrigation, in addition to the production parameters under three sprinklers systems (100% of applied water)is better than two mini-sprinklers (66.6% of applied water) and then one sprinkler (33.3 % of applied water).investigates results recommend to convert irrigation for apple tress to mini-sprinkler, where the best number of sprinklers all-round tree is three then two reaching to one mini-sprinkler.

Beside, The highest values of FUE were noticed when three sprinklers were used in irrigation by 75% RD. On the other hand, the lowest significant FUE values were obtained at drip irrigation. So the nutrient can be saved by 25% of recommended dosed under three sprinkler irrigation systems.

References

[1]. **Ahmad, F.F.** and **M.H. Morsy, 1999.** A new method for measuring leaf area in differentspecies.Menia J. of Agric. Res. And Develop.19: 97-105, Egypt.

[2]. **Anna J.,(2011)** quality of fruit Cherry,Peach and plum cultivated under different water and fertilization regimes. J. Elemental., 16 (1): 51–58

[3]. **Association of Official Agricultural Chemists, 2005.** Official Methods of Analysis (A.O.A.C), 26th Ed. Benjamin Franklin Station, Washington, D.C. U.S.A. pp. 490 - 510.

[4]. **Berkant, O., Senem,T. And D. Buyuktas. 2014.** The effects of irrigation and fertilizer applications on yield, pathological characteristics and fruit cracking in Nova mandarin. Agricultural Water Management Volume 135, 31 March, Pages 54-60.

[5]. **Chapman, H.D, F.Parker, 1961.** Determination of NPK method of analysis for soil, plant and water. Division of Agricultural Sciences,University of California, USA. 150- 179.

[6]. **Chuntanaparb, N.** and **C. Cummings,**1981. Seasonal trends in concentration of nitrogen, phosphorus, potassium, calcium, and magnesium in leaf portions of apple, blueberry, grape, and peach. Journal of the American Society for Horticultural Science. 105:933-935.

[7]. **Cottenie A, M.Verloo, L.Kickens, G.Velgle,A.Camerlynuck, 1982 .** Chemical analysis of plant and soil. Laboratory of Analytical and Agrochemistry, State University of Belgium. Gent.;43-51.

[8]. **Dhillon, W.S.,P.P.S.Gill and N.P. Singh, 2009.** Effect of nitrogen, phosphorus and potassium, fertilization on growth, yield and quality of pomegranate Kandhari. ISHS Acta Hort. 890 II Inter. Symp.Onpomegranate and Minor including Mediterranean Fruits.

[9]. **El- Sayed, A.A.M.S. 2013.** Response of Manfaloutypomegranate transplants and trees to different sourcesof fertilization.Ph. D. Thesis Fac. of Agric. Assiut.Univ. Egypt.

[10]. **El- Sehrawy, O.A.M.M, 2008.** Influence of bio and organic fertilizations on growth of Anna apple in thereclaimed land. Ph. D. Thesis Fac. of Agric. Minufiya Univ. Egypt.

[11]. **El-Gindy, A. M., E. El-Banna, M. A. El-Adl and M. F. Metwally, 2009.**Effect of fertilization and irrigation water levels on summer Squash yield under drip irrigation. Misr J. Ag. Eng., 26(1): 94- 106.

[12]. **El-Khawaga, AS.A., 2011.** Partial replacement of mineral N fertilizers using humic acid and *spirulinaplanteneis*alga. In Florida prince peach orchards.MiddleEast. J. of Applied Sciences 1 (1): 5-10.

[13]. **Fallahi, E.,B. Fallahi, G.H. Neilsen, D. Neilsen and F.J. Peryea., 2010**. Efficient Irrigation for Optimum Fruit Quality and Yield in Apples. HORTSCIENCE VOL. 45(11).
[14]. **Firak, N.N and K.P. Deolankar, 2000.** Response of pomegranate to soluble fertilizer through drip. J. of Maharshtra. Agric. Univ. 25(2): 196-197.
[15]. **Grieve, A.M., 1988.** Water use efficiency of micro-irrigated Citrus. Proc. 4th Intern. micro-irrigation congress, Oct 23-28, 1988. Albury- Nodonga, Australia Vol.2.
[16]. **Hanson B., S. Orloff and B. Sanden.2007.** Monitoring Soil Moisture for Irrigation Water Management. Guide lines for assessing irrigation. (2007), University of California, Agriculture and Natural Resources, 2007 –PP. 38-40.
[17]. **Jaspal Singh, Singh, A.K., Jain S., Garg, R., Mathur, I.N., 1990.** Microsprinklers performance evaluation and constraint for its adoption. Proc. 11th Int. Cong.Use of Plastics in Agril., New Delhi, 26th Feb. - 2nd March, 1990
[18]. **Kabeel, H.,G.S. Abdel-Latif and A.A. Khalil,2005.** Effect of soil application of different mineral and biofertilizer parameters, fruit properties and leaf nutrient content of Canino apricot trees. J. of Agric. Sci.Mansour Univ. 30 (3): 1583-1594.
[19]. **Karimi, H.R.; Sevandi – Nash, S. and H.R.Roosta, 2012.** The effect of salicylic acid and potassium onsome characteristics nuts and physiological parametersof pistachio trees cv. Owhadi J. of Nuts 3(3): 21-26.
[20]. **Kumar, A., R.K.Singh, A.K.Sinha., H.K.Singh.,**and **A.PMishra,2007.** Effect of fertigation on banana through drip irrigation in North Bihar. J. Res. Birsa Agric. niv.19:81-86.
[21]. **Kumar, D. and N.Ahmed, 2014.** Response of nitrogen and potassium fertigation to Warisalmond (*Prumusdulcis*) under northeastern Himalaya region India. The Scientific World J., Vol. 2014, 6 pages.
[22]. **Mansour, A.E.M.; Ahmed, F.F.; Abdelaal, A.M.K. and G.P. Cimpoies, 2007.** Use of mineral, organic, slow release and biofertilizers for Anna apple trees in a sandy soil. African Crop. Sci. Conf. Proc. Vol. 8 pp.265-271.
[23]. **Marschner, H.,** 1995.*Mineral nutrition of higher plants*, 2nd ed., London: Academic Press.
[24]. **Miller, G.L,1959.** Use of dinitrosalicylic acid reagent for determination of reducing sugar.*Analytical Chemistry*.;31(3):426–428.
[25]. **Milosevic, T.; Milosevic, N. and I.Glisic, 2013.** Tree growth, yield and fruit quality attributes and leafnutrient content of Roxana apricot as influenced by naturalzeelite, organic and inorganic fertilizers.Scientia Hort. 156: 131- 139.
[26]. **Narda, N. K., and J. K. Chawla, 2002.** A simple nitrate submodel for trickle irrigated potatoes. *Irrigation and Drainage*,51(4): 361-371.
[27]. **Neilsen,G.H;D. Neilsen,L.C.Herbert and E.J. Houge.2004.** Response of apple fertigation on N and K conditions susceptible to the development of K deficincy. J. Amer. Soc. Hort. Sci. 129 (1):26-31.
[28]. **Plessis, S.F.Du. 1985.** Irrigation of citrus. Citrus and Sub tropical Fruit J. 614 ,12.
[29]. **Ramniwas, R. A.,D. KKaushik,S. P. Sarolia, and V. Singh,2012.** Effect of irrigation and fertigation scheduling on growth and yield of guava (*Psidium guajava* L.) under meadow orcharding. African Journal of Agricultural Research Vol. 7(47), pp. 6350-6356.
[30]. **Rumayor-Rodriguez, A., Bravo-Lonzano, A., 1991.** Effects of three systems and levels of irrigating apple trees. Scientia Hort. 47, 67-75.
[31]. **Sharma S, S.K.Patra andR. Ray, 2011.** Effect of drip fertigation on growth and yield of guava cv. Khaja. Environ. Eco. 29:34-38.
[32]. **Shirgure, P.S.,2012.** Micro-irrigation systems, automation and fertigation in citrus. Scientific Journal of Review 1(5) 156-169
[33]. **Shirgure,P.S,2012.** Micro-irrigation systems, automation and fertigation in citrus. Scientific Journal of Review 1(5) 156-169.
[34]. **Singh, B. K., K. N. Tiwari, S. Chourasia and S. Mandal,2007.** Crop water requirement of guava (*Psidium guajava L.*)Cv. Kg/kaji under drip irrigation and plastic mulch *ActaHorticulturae,* 735: 399-405.
[35]. **Smajstrla, A.G., Koo, R.C.J., Weldon, J.H., 1984.** Effects of volume of the rootzone irrigated on water use and yield of citrus. J. Am. Soc. of Agri. Eng., 84, 2107
[36]. **Snedecor, G.W**and **W.G.Cochran, 1989.** Statisticalmethods, 7th edition, Ames, Iowa: IowaState University Press.85-86.
[37]. **Von- Bennewitz, E. Cooper, T. Benavoides, C. Lasak,I. and J.Hlusek, 2011.** Response of Jongaoldappletrees to Ca, K and Mg fertilization in an andisolinsouthernchile J. Soil Sci. plant Nutr. 11: 71-81.
[38]. **Waldemar, T., 2006.** Influence of fertigation with nitrogen and a complete fertilizer on growth and yielding of "Gala Apple trees". Journal of Fruit and Ornamental Plant Research Vol. 14, 143-154.
[39]. **Walid F. A. M,A.A,Nagwa andS.P.Lidia, 2015.** The Effect of the Foliar Application of Potassium,Calcium, Boron and Humic Acid on VegetativeGrowth, Fruit Set, Leaf Mineral, Yield and Fruit Quality of 'Anna' Apple Trees.American Journal of Experimental Agriculture 8(4): 224-234.
[40]. **Westwood, N.M, 1988.** Temperate - Zone Pomology. Timber Press. 9999 SWWilshirePortland, Oregon 97225.181.
[41]. **Wilde, S.A, R.B.Corey, J.G.Lyer, G.K.Voigt, 1985**. Soils and plant analysis for tree culture. 3rd Ed. Oxford, IBH, New Delhi. 1-218.
[42]. **Zekri,M., Parsons, L.R., 1989.** Grapefruit leaf and fruit growth in response to drip, micro-sprinkler and overhead sprinkler irrigation. J.Am. Soc. Hort. Sci. 114, 25-29
[43]. **ZHANG, L., J. ZHOU., Y. GUI ZHAO., Y. ZHAI ., K. WANG.,A. K. ALVAand S. PARAMASIVAM,.2013.** Optimal combination of chemical combound fertilizer and humic acid to improve soil and leaf properties,yield and quality of Apple (Malusdomestica) in the loess plateau of china. *Pak. J. Bot*., 45(4): 1315-1320.

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