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Management of Irrigation Systems to Improve Productivity and Quality of Grapevine under Desert Conditions

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Abstract: *The trials were carried out during 2015 and 2016 seasons on Flame Seedless grapevines grown in sandy soil under drip irrigation systems at Al-Khatatiba district, in El-Monoufia Governorate, Egypt. The aim of this research was to save irrigation water without any reduction of growth, productivity and quality of Flame Seedless grapevines. In this experiment irrigation systems were applied as follow; subsurface drip, surface drip and suspended drip irrigation named as (SD, D, PD respectively). Beside three level of irrigation (60, 80 and 100% of calculated applied water) named as (W1, W2 and W3). The obtained results cleared that: The most high uniform distribution of soil moisture contents is under PD, the highest soil moisture contents values are under (SD,W3), SD irrigation system underW2 water amount resulted the best number of leaves per shoot, leaf area, total chlorophyll content, leaf mineral content (N,P and K), total yield, cluster weigh , cluster length and width, berry dimensions, weight and volume of 100 berries, soluble solids content (SSC), sugar contents in berries Juice. On the other side, W2 water amount under SD irrigation system gave the lowest total acidity in both seasons.*

Keywords*: grapevine, drip, suspended drip, subsurface drip, water, sand.*

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I. Introduction

Grapes are very popular fruit for their high nutritional and therapeutic value. In Egypt, grapes rank second among fruit crops while citrus being the first. A global increase in demand for high quality grape has prompted numerous researchers to find efficient and reliable ways to increase grape production and quality.

Irrigation is an effective way of regulating the availability of water for grapevines and consequently their yield. Stomatal closure seems to be the main cause of the decrease in the photosynthetic rate under mild drought conditions [1]. However, non-stomatal effects can occur, such as decreasing in the photo system efficiency under field grown conditions [2]. Hence, it seems adequate to study vine physiology under irrigation conditions [3]. Water is the basic component of plant cell tissue. Most of the water absorbed by the plant comes from the soil. Nutrients present in the soil are dissolved in water, taken up by the roots to supply all of the plant organs through translocation. Water is needed by the plant for transpiration. A number of factors should to be taken into consideration, if irrigation is to be applied in a vineyard; the most significant factor is the amount of water that should apply and the season of application. With respect to the amount of water, several studies have shown that grapes quality falls if too much of water were supplied [4 and 5].

Developed irrigation systems are very important for saving irrigation water which is the most limiting and most precious resources for agriculture today [6]. Drip irrigation systems are having an important priority in the new reclaimed area. Drip irrigation systems was found to result in 30 to 70% water savings in various orchards crops with 10 to 60% increases in yield as compared to conventional methods of irrigation. Surface and subsurface drip irrigation methods can play a significant role in overcoming the scarcity of water mostly in water shortage areas [7]. Drip irrigation systems and subsurface drip irrigation has been part of the modern agriculture. Current commercial and grower interest levels indicate that future use of subsurface drip irrigation systems will continue to increase. Subsurface drip irrigation applies water below the soil surface, using buried drip tapes [8]. Subsurface drip irrigation uses buried lateral pipelines and emitters to apply water directly to the plant root zone.

Subsurface drip irrigation requires the highest level of management of all micro irrigation systems. The performance of the drip irrigation should be tested under adverse conditions of shallow water table and heavy soils. In addition, irrigation management is a tool whereby timely application of water can improve irrigation efficiencies and ultimately yields [9]. Studies on the effects of furrow, micro-jet, surface drip, and sub-surface drip irrigation on vegetative growth and early production of `Crimson Lady' peach [*Prunus persica*

(L.)] trees indicated that sub surface drip irrigation improve vegetative growth [10]. While, fruit quality (i.e. cluster weight, cluster length, cluster width, weight of 100 berries, and volume of 100 berries) and yield decreased with increasing water stress levels, While acidity increased with increasing water stress levels in two table grapes cultivars (*vitis vinifera* L.), namely Thompson seedless and Flame seedless [11]. Subsurface drip irrigation was better than surface drip irrigation on Manfalouty pomegranate (cv.) shrubs. In addition, sub surface drip irrigation gave the high leaf area, leaf chlorophyll, number of leaves/shoot, fruit length, fruit diameter, fruit weight, grains weight, TSS and total sugar content in both seasons. On the other side, surface drip irrigation gave the highest total acidity [12].

The aim of this research was to save irrigation water without any reduction of growth, productivity and quality of Flame Seedless grapevines.

II. Material And Methods

The trials were conducted during the two successive seasons 2015 and 2016 in a vineyard at EL-Khatatba, EL-Menofia Governorate, Egypt. The experiment was designed as spilt plot design. Three replicates were used for each treatment and every replicate was represented by three trees in a factorial arrangement for treatments the following factors and levels are arranged as follow; the main factor were the three irrigation water amounts (60, 80, 100% of the calculated applied water named as (W1, W2 and W3, respectively.), and sub main factor is the three drip irrigation systems (subsurface, surface and suspended named as SD, D and PD respectively).The experiment included 81 vines. Trees under investigation were grown in a sandy soil (Table 1). Irrigation water was analysis shown in (Table 2). The selected vines were7-years old uniform in vigor, planted at 1.5x3 meters (vine * row). The vines trained according to the double cordon system. Pruning was carried out at the first week of January by leaving 45-55 buds per vine (20 fruiting spurs * 2-3 buds / spur).

Table1: Some physical and chemical properties of the experimental orchard soil.

Particle size distribution (%)			Texture Soil	Ec ds/m	pH	Soluble cation meq/L				Soluble Anions meq/L			
Sand	Silt	Clay				Ca^{++}	Mg^{++}	Na^{++}	K^{+}	CO_3	HCO_3	Cl^-	SO_4
91.72	6.15	2.13	sandy	1.99	7.87	6.65	3.40	9.18	0.57	--	3.85	8.30	7.85

Table2: Some chemical analysis of irrigation water.

characters	pH	EC ds/m	Soluble cation meq/L				Soluble Anions meq/L			
			Ca^{++}	Mg^{++}	Na^{++}	K^{+}	CO_3^-	HCO_3^-	CL^-	SO_4^-
value	7.46	1.33	3.00	3.70	6.30	0.32	0.50	2.42	6.40	4.00

Irrigation system:

The irrigation system consisted of the following components:

Control head:

Control head consisted of centrifugal pump 5 /5 inch (20m lift and 80 m3/h discharge), driven by diesel engine (50 Hp), pressure gauges, control valves, inflow gauges, water source in the form of an aquifer, main line then lateral lines and dripper lines. For traditional drip irrigation, Gr dripper was used by 8 l/h/m, discharge, and two hoses for one tree row, where there are three irrigation systems applied as follow (subsurface drip, surface drip and suspended drip irrigation) named as SD, D, PD respectively, Beside three water amount (60, 80 and 100% of calculated applied water) named as (W1, W2 and W3) respectively. Fig (1).

Figure 1 Suspended drip irrigation of Grapevines.

Irrigation requirements:
Irrigation water requirements for Grapevines were calculated according to the local weather station data at El-Monoufia 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 [13].

Water requirements for Grapevines were calculated according to the following equation as recommended by [14]. Table (3) and table (4).

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

Where:

IR	= Irrigation water requirements, m^3/ha/day,
E to	= Potential evapo-transpiration, mm day^{-1}
Kc	= Crop factor of Grapevine,
A	= Area irrigated, (m^2),
Ea.	= Application efficiency, %, where 90% drip irrigation,
LR	= Leaching requirements and
CF	= Covering factor, for Grapevines 35%.

The crop factor of Grapevine was used to calculate Et crop values, according to [15].

Table (3): Calculated consumptive use (mm/day) of Grapevines.

Growth stage	month	ET_o mm/day	K_c	Et_c mm/day	W_t (L/tree/ day)	W_d (m^3/ha/ day)
	January	1.34	-	-	-	-
Initial	February	1.76	-	-	-	-
	march	2.41	0.25	0.6025	2.71	6.02
Mid-season	April	3.54	0.45	1.593	7.17	15.93
	May	4.15	0.6	2.49	11.21	24.90
	June	4.37	0.7	3.059	13.77	30.59
	July	4.57	0.7	3.199	14.40	31.99
Season end	Augusts	4.3	0.65	2.795	12.58	27.95
	September	4.02	0.55	2.211	9.95	22.11
	October	2.9	0.45	1.305	5.87	13.05
	November	1.98	-	-	-	-
	December	1.56	-	-	-	-
Total (Ws)	7409.9 (m^3/ha/season).					
Total Ir	8233 (m^3/ha/season).					

Where:

W_t	=	Water requirements for tree per day (L/ha/day),
W_d	=	Water requirements for hectare per day (L/ha/day),
W_s	=	Water requirements for ha per season (m^3/ha/season) and
I_r	=	Irrigation requirements for ha per season (m^3/ha/season).

Table (4): Calculated water amounts versus irrigation systems for Grapevines.

Characters	Irrigation requirements per season for ha (m^3/ha/season)*
60% ETC = (W1)	4940
80% ETC = (W2)	6587
100% ETC = (W3)	8233

* The hectare = (10,000 m^2)

-Soil measurements:
Soil samples were taken by a screw auger at three spaces from beginning of the drip main line, the space between samples were20cm, and at three depths (20,40, 60, 80 and 100cm) at two direct X and Y where the

horizontal and vertical space of the sample was 20 cm. Samples were analyzed for determining soil moisture. The results were drawn by SURFER, ve. 11 under on a color scale for soil moisture 0-30, under windows program, and the "Kriging" regression method as the base model for analysis and contour map development.

The following parameters were measured for both seasons:-

1-Number of leaves per shoot: Leaves developed on the new shoots were counted at Veraison stage
2-Leaf Area (cm^2): Was determined by using the leaf area meter CL203.
3- Total chlorophyll content %: Total chlorophyll content (in fresh leaves) was measured in the third leaf from the base at the end of July in field using Minolta meter SPAD-502.
4-Leaf mineral content:-

Samples of 30 leaves for each replicate of every treatment were collected from the first full mature leaves (5th – 7th) of shoot tips in mid-July, prepared and analyzed according to [16]. Total NPK are calorimetrically determined as described by [17].

5-Total yield (kg/vine):- The average weight of cluster at harvest date (commercial maturity TSS $\geq 16^{o}$ brix) and the yield /vine was expressed as follows:
Vine yield (kg) =average weight of cluster (g) x number of cluster per vine.
6-Cluster weight (g):- Cluster weight was determined using 10 clusters per replicate and weighed
7-Number of cluster:-was recorded
8 -Cluster length and width(cm):- At harvesting, two clusters were taken at random from each vine to determine cluster traits such as cluster length and width
9-Berry dimensions (cm):- Berry length and diameter were measured (cm) in 10 berries by using vernal clipper; the average length and diameter of berries were calculated.
10-Weight and volume 100 berries:- Weight of 100 berries was determined using digital balance; the volume (cm^3) of the same berries was determined by the water displacement method.
11-Soluble solids content (SSC)%: was determined as percentage in juice by means of hand refractometer apparatus according to [18].
12-Sugar contents in berries Juice%:-The total sugars were determined according to [19].
13-Titratable acidity (%): berries Juice titratable acidity was determined according to [20].

Statistical analysis

The data were subjected to analysis of variance and Duncan's multiple range tests was used to differentiate means as described by [21]. The data were tabulated and statistically analyzed according to the spilt plot design [22]. The percentages were transformed to the arcsine to find the binomial percentages according to [23].

III. Results And Discussion

-Soil moisture distribution:

Suspended drip irrigation:

Data of (PD, W1), (PD, W2) and (PD, W3) cleared that the highest values of soil moisture contents are (16.39, 18.46 and 20%) respectively, while the lowest value are (5.97, 6.57 and 7.52%) respectively. there is a good distribution of Y, X and Z direction.

The water distribution under suspended drip irrigation is close to typical soil moisture patterns in sandy soil, according to the soil moisture patterns in sandy soil which has the highest infiltration rate which cause the speedy water movement in the vertical direction then support the deep-percolation and seepage through the soil layers to depth, but suspended drip technique encourage the uniformity of water distribution in both directions X and Y (Horizontal and vertical) according to the water splash erosion for water drop when go down from tube to the soil surface and is splits and divided to more little drops of water. So it's clear the good symmetry of water distribution of suspended drip irrigation, on the other hand, the evaporation water losses from tube emitters and soil surface increasing acceding to the sunny area. Increasing of water during irrigation operating and the soil wet surface area was according to the splash erosion. So suspended drip irrigation is so good for not hot or aired regions, besides it's typical for grapevine in humid regions. It's important to mention that the lifespan of drip tube is the longest according to the tube is suspended on vine and faraway of labor works or machines service or a rodent which means that the suspended drip irrigation is more economic more than other system for long term.

Subsurface drip irrigation:

Data of (SD, W1) , (SD, W2) and (SD, W3) cleared that the highest values of soil moisture contents are (21.79, 24.53 and 30.5%) reseptivly, while the lowest value are (9.63, 10.35 and 12%) reseptivly. It's clear that the highest soil moisture values are found under subsurface drip absolutely.

The subsurface irrigation system is the best for the Egyptian climate acoording to the high temperature and less humidity which encorage to the eavaporation losses from plants and soil surface. It means that so by buring the drip tube, the water move down and little up by cappillary which is so weak in sandy soil, so losses by evaporation decrease without any additions or more costs. The highest yield is occurred not only under subrface drip irrigation but also with the good management and scheduling of irrigation process. It's noticiable that the highest yield and quailty under (SD, W2) then (SD, W3) had significant difference due to the excessive water in W3 which cause the nutrient losses by deep percolation and seepage to the under ground layer which reduce the plante usage of nutrient. On the contrary W2 the exactly perfect water amount under these conditions and give plant more time and chance to have the binifites of nutrients. Wahtever, buried hoses need mor costs for buring tubes but it's still economic according to the high yield and quality income. Fig (2).

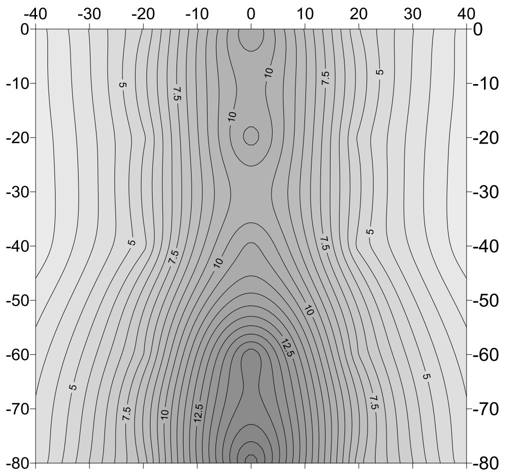
Surface drip irrigation:

Data of (D, W1), (D, W2) and (D, W3) cleared that the highest values of soil moisture contents are (18.03, 21.11 and 25.3%) reseptivly. while the lowest value are (7.84, 6.75 and 7.98%) reseptivly.

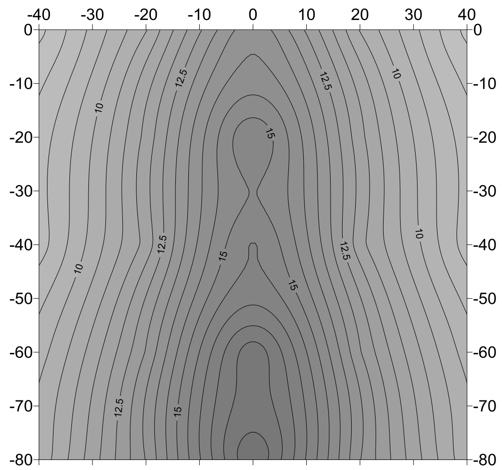
Surface drip irrigation is the common systems in Egypt according to the beginning of drip use and for ease and spread among farmers, it's can note that the excessive water under the emmiter verticaly especially when the water amount increasing, which lead to loss water and nutrients by percolaion in addtion to pollute the underground water by N and pesiticides

As to progressive soil layer, (0– 100 cm) water was moving descending with continuous augmentation in its esteems achieving the majority of moisture content 18.03% for 100 cm soil profundity. Such decrease in the water content in the upper layers 0– 20 cm and the continuous augmentation in its incentive inside the layers 20– 40 cm can be for the most part credit to the variety in the aggregate potential.

Previously, the soil moisture contents increases with the soil depth increament according to the water move direction under gravity and there is evaporation losses, for that the best systems is SD under good management and scheduling without excessive water, suspended irrigation system is good for cold or in good climate zone which not encourage the evaporation.



Suspended drip and 60% of ETa



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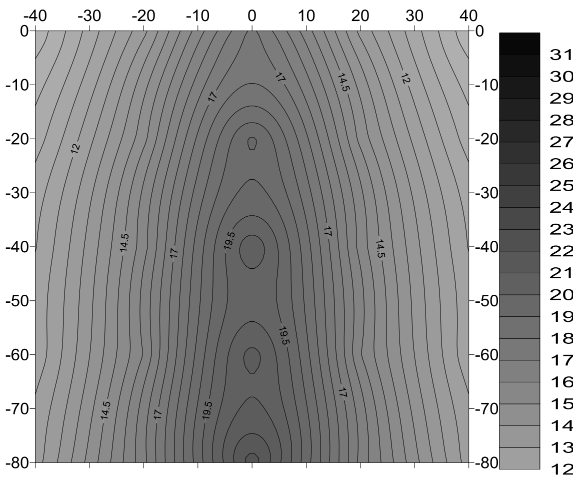

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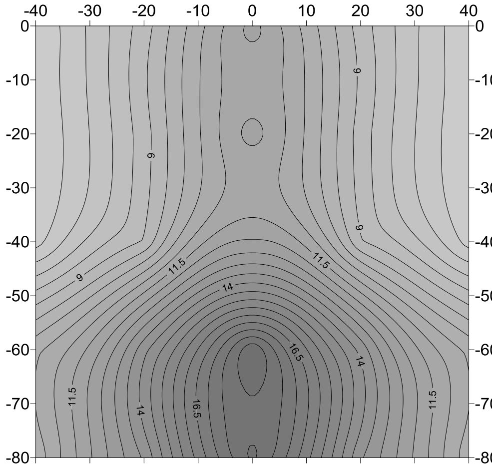

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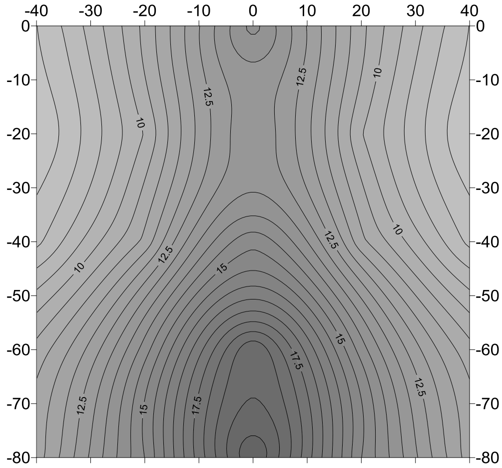
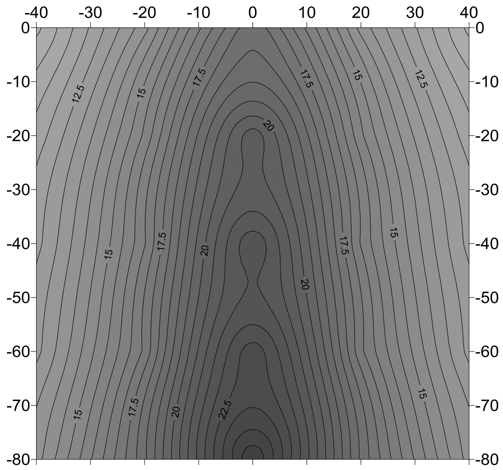


Suspended drip and 100% of ETa



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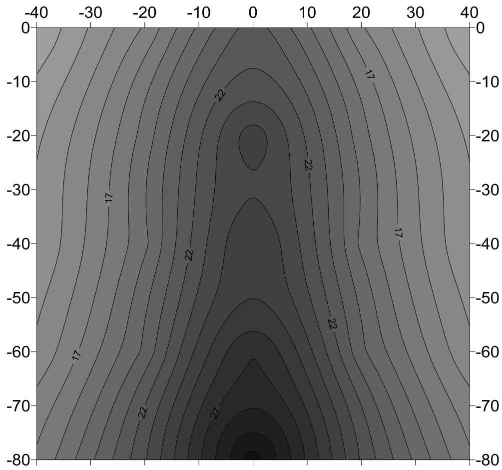

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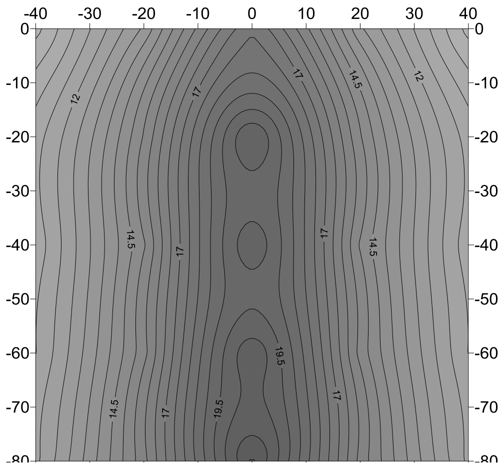
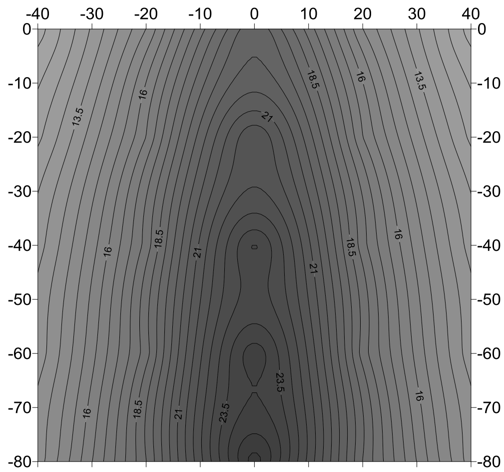


Surface drip and 80% of ETa



Surface drip and 100% of ETa

Figure 2: The soil moisture distribution under PD, SD and D irrigation systems and applied water amounts

Number of leaves per new shoot, Leaf area (cm^2) and Total chlorophyll content %:-

Table 5, cleared that number of leaves, leaf area and total chlorophyll content was significantly affected by the three water amounts applied in both seasons. However, (W2) water amounts gave the best number of leaves, leaf area and total chlorophyll in both seasons comparing with the others water amounts.

Regarding to irrigation systems effect, number of leaves, leaf area and total chlorophyll were affected significantly by different irrigation systems in both seasons. In addition, (SD) irrigation system produced the highest number of leaves, leaf area and total chlorophyll content comparing with others irrigation systems used. While, (PD) irrigation system was the lowest number of leaves, leaf area and total chlorophyll content in both seasons.

The obtained data from the interaction between water amounts and irrigation systems cleared that, (SD) irrigation under (W2) water amounts recorded the highest number of leaves (46.00 in the 1st and 46.99 in the 2nd season), leaf area (132.07in the 1st and 134.00 (cm^2) in the 2nd season) and total chlorophyll content (40.23 in the 1st and 43.00% in the 2nd season). In addition, D irrigation under (W1) water amounts recorded the lowest number of leaves, leaf area and total chlorophyll content

These results may be due to water deficit that limiting plant growth. If vines grown under drought stress, leaf photosynthetic production would decrease [24]. This decrease is due to that stomata is sensitive to water deficits and will close to prevent excessive loss of water through transpiration. Stomata closure during part of the day prevents carbon dioxide from entering the leaves and inhibits photosynthesis which affected vegetative growth [25]. Furthermore, subsurface drip irrigation allows uniform soil moisture minimizes the evaporative loss and delivery water directly to the plant root zone which increases yield [26].

The obtained results are in agreement with [27] who found that sub surface drip irrigation improve vegetative growth of newly planted Crimson Lady peach [*Prunus persica* (L.)] trees. Drip irrigation increase growth parameters in Sapota (Achraszapota) as compared with ring basin irrigation [29]. In addition, sub surface drip irrigation was better than surface drip irrigation system. Moreover, sub surface drip irrigation gave the high leaf area, leaf chlorophyll, number of leaves/shoot on Manfalouty pomegranate (cv.) shrubs [12].

Table 5: Effect of water amounts and different drip irrigation systems on some vine vegetative growth parameters of Flame Seedless grapevines at 2015 and 2016 seasons.

		leaves number /shoots		Leaf area(cm^2)		Total chlorophyll content (%)	
		2015	2016	2015	2016	2015	2016
Effect of water amounts*							
	W1*	35.66C	37.00C	124.84C	126.34C	33.24C	35.24 C
	W2	43.80A	45.11 A	130.95A	132.55 A	39.28A	41.68 A
	W3	39.77B	40.66 B	127.77B	129.17 B	36.12B	38.17 B
Effect irrigation systems*							
	SD*	41.33A	42.33 A	128.84A	130.38 A	37.16A	39.50 A
	D	39.55B	40.88 B	127.83B	129.33 B	36.27B	38.23 B
	PD	38.36C	39.55C	126.90C	128.35 C	35.22C	37.35 C
Effect of interaction between of water amounts and irrigation systems							
water amounts	**irrigation systems**	**leaves number /shoots**		**Leaf area(cm^2)**		**Total chlorophyll content (%)**	
		2015	**2016**	**2015**	**2016**	**2015**	**2016**
W1	**SD**	37.00G	38.33 G	125.74G	127.11G	34.08G	36.15 F
	D	35.66H	37.00H	124.86H	126.14H	33.27H	35.17 G
	PD	34.33I	35.66 I	123.92I	125.78 H	32.37I	34.41 G
W2	**SD**	46.00A	46.99A	132.07A	134.00A	40.23A	43.00 A
	D	43.33B	45.00 B	130.85B	132.65 B	39.45B	41.56B
	PD	42.08C	43.33 C	129.93C	131.00 C	38.18C	40.47 C
W3	**SD**	41.00D	41.66 D	128.69D	130.04 D	37.18D	39.37D
	D	39.66E	40.66E	127.78E	129.19 E	36.08E	37.96 E
	PD	38.66F	39.66F	126.85F	128.27F	35.12F	37.18E

Means having the same letter (s) in each column, row or interaction are not significantly different at 5% level.
*W1:60% Water amounts -W2:80% Water amounts -W3:100% Water amounts. While, SD: subsurface drip irrigation, D: surface drip irrigation and PD: suspended drip irrigation).

Leaf nitrogen, phosphorus and potassium content (%)

Data in Table (6) showed that, nitrogen, phosphorus and potassium content in leaves was significantly affected by the three water amounts in both seasons. However, (W2) water amount gave the best leaf nitrogen content (2.43 in the 1st and 2.52 % in the 2nd season), phosphorus (0.40 in the 1st and 0.42 % in the 2nd season) and potassium (1.25 in the 1st and 1.27 % in the 2nd season).

In addition, nitrogen, phosphorus and potassium content in leaves were affected significantly by different irrigation systems in both seasons. The (SD) irrigation system produced the highest number of nitrogen, phosphorus and potassium content in leaves comparing with other systems used. Moreover, (PD) irrigation system was the lowest nitrogen, phosphorus and potassium content in leaves in both seasons

The interaction between water amounts and irrigation systems cleared that, SD irrigation system under (W2) water amount recorded the highest nitrogen, phosphorus and potassium content in leaves in both seasons. However, (PD) irrigation system under (W1) water amount recorded the lowest in both seasons.

The positive influence of these results may be due to that, the most of leaching water with nutrients absorbed by the plant roots from the soil to supply all of plants organs during translocation. However, if this water was too much or deficit a lot of nutrients lost in the soil by leaching or not be sufficient causing limiting of plant growth and therefore decrease in grapes growth and quality. Subsurface irrigation is a highly efficient method of water application with minimum of water losses through evaporation and deep percolation, thus assisting water and nutrient conservation. Furthermore, subsurface drip irrigation allows uniform soil moisture, minimize the evaporative loss and delivery water directly to the plant root zone which increases use efficiency and yield [26].

Generally, these results are in agreement with, [27] who found that sub surface drip irrigation improve vegetative growth of newly planted `Crimson Lady' peach [*Prunus persica* (L.)] trees. In addition, the amount of applied water for (80%) gave the best effect on vegetative growth on Florida prince peach trees (*Purnus perseca* L.) [29].

Table 6: Effect of water amounts and different drip irrigation systems on leaf nitrogen, phosphorus and potassium content of Flame Seedless grapevines at 2015 and 2016 seasons.

		N%		P%		K%	
		2015	2016	2015	2016	2015	2016
Effect of water amounts							
W1		1.95 C	31.91C	0.26 C	0.28C	1.14C	1.15 C
W2		2.43 A	2.52 A	0.40 A	0.42A	1.25A	1.27 A
W3		2.18 B	2.23 B	0.32 B	0.35B	1.20 B	1.21 B
Effect irrigation systems							
SD		2.27 A	2.34 A	0.35 A	0.37A	1.21A	1.23 A
D		2.18 B	2.22 B	0.33B	0.35B	1.20B	1.21 B
PD		2.10 C	2.10 C	0.31 C	0.33C	1.18C	1.19 C
Effect of interaction between of water amounts and irrigation systems							
Water amounts	**irrigation systems**	**N% 2015**	**N% 2016**	**P% 2015**	**P% 2016**	**K% 2015**	**K% 2016**
W1	**SD**	2.06F	2.07 G	0.28G	0.30 G	1.16G	1.17 G
	D	1.95 G	1.91H	0.26 H	0.28 H	1.15G	1.15 H
	PD	1.85H	1.76 I	0.25I	0.26 I	1.12H	1.14 I
W2	**SD**	2.51A	2.62 A	0.42A	0.45 A	1.26A	1.28 A
	D	2.44B	2.51B	0.40B	0.42 B	1.25B	1.27 B
	PD	2.32 c	2.42 C	0.38C	0.40 C	1.23C	1.25 C
W3	**SD**	2.26D	2.34 D	0.35D	0.37D	1.22D	1.24 D
	D	2.15E	2.24 E	0.32E	0.36 E	1.20E	1.22 E
	PD	2.13E	2.13 F	0.30F	0.32 F	1.18F	1.19 F

Length and width of cluster

It could be noticed from tables (7) that all treatments were significantly affected in length and width of cluster in both seasons. However, (W2) water amount gave the best length and width of cluster in both seasons. On the other side, (W1) water amount gave the lowest length and width of cluster in both seasons

Length and width of cluster was affected significantly by different irrigation systems in both seasons. It was clearly noticed that, (SD) irrigation system produced the highest length and width of cluster in both seasons comparing with other systems used. Moreover, (PD) irrigation system was the lowest length and width of cluster in both seasons.

The interaction between water amounts and irrigation systems cleared that, (SD) irrigation system under (W2) water amount recorded the highest length of cluster (25.33 in the 1st and 26.32 cm in the 2nd season) and width of cluster (17.23 in the 1st and 17.95 cm in the 2nd season). While, (PD) irrigation system under (W1) water amount recorded the lowest level of length of cluster (18.96 in the 1st and 18.58 cm in the 2nd season) and width of cluster (10.83 in the 1st and 10.82 cm in the 2nd season).

Table 7: Effect of water amounts and different drip irrigation systems on length and width of cluster of Flame Seedless grapevines at 2015 and 2016 seasons.

		Length of cluster (cm)		width of cluster(cm)	
		2015	**2016**	**2015**	**2016**
Effect of water amounts					
W1		19.86 C	19.53 C	11.82 C	11.79 C
W2		24.53 A	25.22 A	16.57 A	16.89 A
W3		22.31 B	22.45 B	14.41 B	14.53 B
Effect irrigation systems					
SD		23.06 A	23.36 A	15.03 A	15.38 A
D		22.09 B	22.41 B	14.21 B	14.33 B
PD		21.55 C	21.45 C	13.57 C	13.50 C
Effect of interaction between of water amounts and irrigation systems					
Water amounts	**irrigation systems**	**Length of cluster(cm) 2015**	**2016**	**width of cluster(cm) 2015**	**2016**
W1	**SD**	20.83 E	20.29 G	12.79 E	12.81 G
	D	19.80 F	19.73 G	11.85 F	11.75 H
	PD	18.96 G	18.58 H	10.83 G	10.82 I
W2	**SD**	25.33 A	26.32 A	17.23 A	17.95 A
	D	24.27 B	25.11 B	16.44 B	16.73 B
	PD	24.01 BC	24.24 C	16.03 BC	16.00 C
W3	**SD**	23.04 C	23.47 D	15.07 C	15.36 D
	D	22.20 D	22.38 E	14.33 D	14.52 E
	PD	21.70 E	21.52 F	13.83 DE	13.70 F

Length and diameter of berry (cm)

Concerning the results in Table 8, length and diameter of berry was significantly affected by the three water amounts in both seasons. However, (W2) water amount gave the best length of berry (1.88 in the 1st and 1.87cm in the 2nd season) and diameter of berry (1.75 in the 1st and 1.77 cm in the 2nd season)

Furthermore, length and diameter of berry were affected significantly by different irrigation systems in both seasons. The (SD) irrigation system produced the highest length and diameter of berry comparing with other systems used. Moreover, (PD) irrigation system was the lowest in length and diameter of berry in both seasons

The interaction between water amounts and irrigation systems cleared that, (SD) irrigation system under (W2) water amount recorded the highest length and diameter of berry in both seasons. However, (PD) irrigation system under (W1) water amount recorded the lowest length of berry in first season. In addition, (D) and (PD) irrigation systems under (W1) water amount gave the lowest length of berry in second season. While, (PD) irrigation systems under (W3) water amount gave the lowest length and diameter of berry in both seasons.

The obtained results are in agreement with, [11] who showed that, cluster length, cluster width, decreased with increasing water stress levels in Thompson seedless and flame seedless grapes cultivars (*vitis vinifera* L.) under three water regimes. While, the amount of applied water for (80%) gave the best effect on fruit length and fruit diameter on Florida prince peach trees (*Purnus perseca*L.) [31]. sub surface drip irrigation was better than surface drip irrigation system. In addition, sub surface drip irrigation gave the high fruit length and fruit diameter, on Manfalouty pomegranate (cv.) shrubs [12]. Furthermore, the best quality of grapes was obtained under subsurface drip irrigation system on King Ruby seedless grapes [30].

Weight (g) and volume (cm^3) **of 100berries**

Table 9, cleared that, weight and volume of 100 berries was significantly affected by three water amounts in both seasons. However, (W2) water amount gave the best weight of 100 berries (291.01 in the 1st and 304.32 g in the 2nd season), volume of 100 berries (273.34 in the 1st and 288.65 (cm^3) in the 2nd season).

Furthermore, weight and volume of 100 berries were affected significantly by different irrigation systems in both seasons. The (SD) irrigation system produced the highest weight and volume of 100 berries comparing with other systems used. Moreover, (PD) irrigation system was the lowest weight and volume of 100 berries in both seasons

The interaction between water amounts and irrigation systems cleared that, (SD) irrigation system under (W2) water amount recorded the highest weight and volume of 100 berries in both seasons. However, (PD), (D) and (PD) irrigation systems under (W1) water amount recorded the lowest weight and volume of 100 berries in both seasons both seasons.

These results in table (7,8 and 9) may be due to that subsurface drip irrigation allows uniform soil moisture, minimize the evaporative loss and delivery water directly to the plant root zone which increases use efficiency and yield [26].

The obtained results are in agreement with [11] Showed that, weight and volume of 100 berries was decreased with increasing water stress levels in Thompson seedless and flame seedless grapes cultivars (*vitis vinifera* L.) under three water regimes. While, the amount of applied water for (80%) gave the best effect on fruit length and fruit diameter on Florida prince peach trees (*Purnus perseca* L.) [29]. sub surface drip irrigation was better than surface drip irrigation system. In addition, sub surface drip irrigation gave the high fruit length and fruit diameter, on Manfalouty pomegranate (cv.) shrubs [12]. The best quality of grapes was obtained under subsurface drip irrigation system on King Ruby seedless grapes [30].

Table 8: Effect of water amounts and different drip irrigation systems on length and diameter of berry of Flame Seedless grapevines at 2015 and 2016 seasons.

		Length of berry (cm)		diameter of berry(cm)	
		2015	**2016**	**2015**	**2016**
Effect of water amounts					
W1		1.37 C	1.36 C	1.26 C	1.28 C
W2		1.88 A	1.87 A	1.75 A	1.77 A
W3		1.64 B	1.64 B	1.56 B	1.52 B
Effect irrigation systems					
SD		1.72 A	1.70 A	1.59 A	1.59 A
D		1.61 B	1.61 B	1.51 B	1.52 B
PD		1.57 C	1.56 C	1.46 C	1.46 C
Effect of interaction between of water and irrigation systems					
water amounts	**irrigation systems**	**Length of berry(cm)**		**diameter of berry(cm)**	
		2015	**2016**	**2015**	**2016**
W1	SD	1.45 F	1.46 F	1.33 F	1.35 F
	D	1.35 G	1.33 G	1.25 G	1.26 G
	PD	1.31 H	1.30 G	1.22 G	1.24 G
W2	SD	1.96 A	1.93 A	1.81 A	1.84 A
	D	1.86 B	1.85 B	1.74 B	1.76 B
	PD	1.83 B	1.83 B	1.70 B	1.72 B
W3	SD	1.74 C	1.71 C	1.64 C	1.60 C
	D	1.62 D	1.65 D	1.56 D	1.53 D
	PD	1.58 E	1.57 E	1.47 E	1.43 E

Yield (Kg), weight (g) and number of cluster

Concerning the results in Table (10) yield, weight and number of cluster was significantly affected by the three water amounts in both seasons. However, (W2) water amount gave the best yield, and weight of cluster on both seasons. In addition, (W2) water amount gave the high number of cluster number in first season. While, there was non-significant effect between (W3) and (W2) water amounts in second season.

In addition, different irrigation systems were affected significantly of yield, weight and number of cluster in both seasons. Furthermore, (SD) irrigation system produced the highest yield and weight of cluster comparing with other systems used in both seasons. On the other side, there was insignificantly affected between (SD) and (D) irrigation systems in number of cluster in both seasons. Moreover, (PD) irrigation system gave the lowest yield, weight and number of cluster in both seasons.

The obtained data from the interaction between water amounts and irrigation systems cleared that, yield and weight of cluster were the highest with (SD) irrigation system under (W2) water amount in both season followed with (D) irrigation system under (W2) water amount. On the other hand, there was insignificantly affected with (SD), (D) and (PD) irrigation systems under (W2) water amount in number of cluster in first season, While, there was insignificantly affected between (SD), (D) and (PD) irrigation systems under (W2) water amount and (SD), (D) irrigation systems under (W3) water amount in second season. However, (PD) irrigation system under (W1) water amount recorded the lowest yield, weight and number of cluster in both seasons.

Table 9: Effect of water amounts and different drip irrigation systems on weight and volume of 100 berries of Flame Seedless grapevines at 2015 and 2016 seasons.

		Weight of 100 berries (g)		Volume of 100 berries (cm^3)	
		2015	2016	2015	2016
Effect of water amounts					
W1		240.07 C	243.29 C	222.07 C	224.95 C
W2		291.01 A	304.32 A	273.34 A	288.65 A
W3		257.69 B	263.61 B	239.03 B	249.44 B
Effect irrigation systems					
SD		272.91A	281.74 A	255.24 A	267.24 A
D		261.09B	269.56 B	242.75 B	249.90 B
PD		254.77C	259.90 C	236.44 C	245.90 C
Effect of interaction between of water and irrigation systems					
water amounts	**irrigation systems**	**Weight of 100 berries(g)**		**Volume of 100 berries**(cm^3)	
		2015	**2016**	**2015**	**2016**
W1	**SD**	243.19 G	247.87 F	225.19 G	233.87 F
	D	239.79GH	243.16 FG	221.79 GH	221.16 G
	PD	237.23H	238.83 G	219.23 H	219.83 G
W2	**SD**	310.24A	323.54 A	295.24 A	307.54 A
	D	286.54B	304.28 B	266.54 B	286.28 B
	PD	276.23C	285.13 C	258.23 C	272.13 C
W3	**SD**	265.30D	273.81 D	245.30 D	260.31 D
	D	256.93 E	261.26 E	239.93 E	245.75 E
	PD	250.86F	255.75 E	231.86 F	242.26 E

Table 10: Effect of water amounts and different drip irrigation systems on yield, weight and number of Flame Seedless grapevines at 2015 and 2016 seasons.

		Yield (Kg)		Weight of clutter (g)		No. of cluster	
		2015	2016	2015	2016	2015	2016
Effect of water amounts							
W1		12.10 C	13.426 C	389.61 C	396.12 C	31.03 C	33.87B
W2		19.43 A	20.52 A	524.16A	570.47 A	37.09 A	35.46 A
W3		15.47 B	16.93 B	458.31 B	476.97 B	33.74 B	35.96 A
Effect irrigation systems							
SD		16.67 A	18.02 A	481.35 A	504.17 A	34.46 A	35.66 A
D		15.80 B	17.04 B	452.76 B	477.77 B	34.65 A	35.51 A
PD		14.53 C	15.81 C	437.98 C	461.62 C	32.76 B	34.12 B
Effect of interaction between of water amounts and irrigation systems							
water amounts	**irrigation systems**	**Yield (Kg)**		**Weight of clutter(g)**		**No. of cluster**	
		2015	**2016**	**2015**	**2016**	**2015**	**2016**
W1	**SD**	13.19 G	14.20 G	400.20 G	410.50 G	32.95CD	34.60 BC
	D	12.53 H	13.41 H	388.05 H	396.56 H	32.30 D	33.83CD
	PD	10.60 I	12.65 I	380.57 I	381.31 I	27.85 E	33.18 D
W2	**SD**	20.23 A	21.68 A	555.44 A	600.32 A	36.42 B	36.12 A
	D	19.53 B	20.33 B	516.89 B	557.76 B	37.79 A	36.44 A
	PD	18.54 C	19.55 C	500.15 C	553.32 C	37.06AB	35.33 AB
W3	**SD**	16.61 D	18.18 D	488.39 D	501.70 D	34.02 C	36.25 A
	D	15.34 E	17.37 E	453.32 E	478.98 E	33.85 C	36.27 A
	PD	14.45 F	15.24 F	433.21 F	450.23 F	33.36CD	33.85 CD

Soluble solids content (SSC), Sugar contents and acidity in berries Juice (%)

It could be noticed from tables (11) that, soluble solids content (SSC), sugar contents and acidity in berries juice was significantly affected by three water amounts in both seasons. However, (W2) water amount gave the best soluble solids content (SSC) and sugar contents in berries juice in both seasons, while (W1) water amount gave the high acidity in berries juice in both seasons.

In addition, soluble solids content (SSC), sugar contents and acidity in berries juice were affected significantly by different irrigation systems in both seasons. (SD) irrigation system produced the highest soluble solids content (SSC), sugar contents and the lowest acidity in berries juice comparing with other systems used in both seasons. Moreover, (PD) irrigation system was the lowest soluble solids content (SSC), sugar contents and the highest acidity in berries juice in both seasons.

The obtained data from the interaction between water amounts and irrigation systems cleared that, (SD) irrigation system under (W2) water amount recorded the highest, soluble solids content (21.14 in the 1st and 21.71% in the 2nd season), sugar contents (19.64 in the 1st and 20.64% in the 2nd season) and the lowest acidity in berries juice (0.51 in the 1st and 0.50 % in the 2nd season). However, (D) irrigation system under (W1) water amount recorded the lowest soluble solids content, sugar contents and the highest acidity in berries juice in both seasons.

It's note that the significant difference between the highest yield and quality under (SD, W2) and (SD, W3) is due to the excessive water in W3 which cause the nutrient losses by deep percolation and seepage to the underground layer which reduce the plant usage of nutrient, On the contrary W2 is the exactly perfect water amount under these conditions and provide the plant with more time and chance to have the benefits of nutrients. Furthermore, subsurface drip irrigation allows uniform soil moisture; minimize the evaporative loss and delivery water directly to the plant root zone which increases use efficiency and yield [26].

The obtained results are in agreement with [11] who showed that, cluster weight, and yield decreased with increasing water stress levels. While, acidity increased with increasing water stress levels. The amount of applied water of (80%) gave the best effect on tree yield and fruit quality on Florida prince peach trees (*Purnus perseca* L.) [29]. Sub surface drip irrigation was better than surface drip on Manfalouty pomegranate (cv.) shrubs. In addition, sub surface drip irrigation gave the high fruit weight, TSS and total sugar content in both seasons. On the other side, surface drip irrigation gave the highest total acidity [12]. The highest yield and the best quality of grapes were obtained under subsurface drip irrigation system on King Ruby seedless grapes [29]. Yield was the highest under subsurface irrigation as compared with drip irrigation in citrus [31].

Table 11: Effect of water amounts and different drip irrigation systems on soluble solids content (SSC), sugar contents and titratable acidity of Flame Seedless grapevines at 2015 and 2016 seasons.

	Soluble solids content (SSC)%		Sugar contents%		Titratable acidity%	
	2015	2016	2015	2016	2015	2016
Effect of water amounts						
W1	14.19 C	15.42 C	12.14 C	13.22 C	0.60 A	0.61 A
W2	20.27 A	21.43 A	18.49 A	19.34 A	0.52 C	0.52C
W3	17.11 B	18.59 B	15.11 B	16.16 B	0.56 B	0.57 B
Effect irrigation systems						
SD	18.13 A	18.619 A	16.36 A	17.342 A	0.55 C	0.55 C
D	17.23 B	17.342 B	15.12 B	16.208 B	0.56 B	0.57 B
PD	16.21 C	16.489 C	14.27 C	15.183 C	0.57 A	0.58 A

Effect of interaction between of water and irrigation systems

water amounts	irrigation systems	Soluble solids content (SSC)%		Sugar contents%		Titratable acidity%	
		2015	2016	2015	2016	2015	2016
W1	**SD**	15.04 G	16.39 G	13.36 G	14.25 G	0.59 B	0.60 C
	D	14.32 H	15.42 H	12.07 H	13.22 H	0.60 A	0.61B
	PD	13.23I	14.46 I	11.00 I	12.19 I	0.61 A	0.62A
W2	**SD**	21.14A	21.71 A	19.64 A	20.64 A	0.51 H	0.50 I
	D	20.29 B	21.14 B	18.22 B	19.17 B	0.52 G	0.52 H
	PD	19.37C	20.44 C	17.62C	18.20 C	0.54 F	0.54 G
W3	**SD**	18.21D	19.75D	16.08 D	17.12 D	0.55 E	0.56 F
	D	17.08E	18.46 E	15.08E	16.22 E	0.57 D	0.57 E
	PD	16.04F	17.56 F	14.19F	15.14 F	0.58 C	0.58 D

IV.Conclusion

It could be concluded that highest uniform distribution of soil moisture contents occurred under (PD) and the highest soil moisture contents vales were under (SD, W3). The best irrigation system for Egypt desert condition is subsurface drip, while suspended drip is not suitable for desert climate in Egypt in spite of being economical to save tubes and extend its lifespan. Subsurface drip irrigation system under 80%water amount from applied water improved the number of leaves per shoot, leaf area , total chlorophyll content ,leaf mineral content (N, P and K),total yield, cluster weight ,cluster length and width, berry dimensions, weight and volume of 100 berries, soluble solids content (SSC), sugar contents in berries Juice. On the other side, (W2) water amount under (SD) irrigation system gave the lowest total acidity in both seasons.

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