Plant Archives Vol. 20, Supplement 1, 2020 pp.3112-3118 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

IRRIGATION WATER MANAGEMENT FOR SUGAR BEET UNDER WATER SCARCITY CONDITIONS IN EGYPT

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Abstract

Two experiments were conducted during the years from 2017 and 2016 successive growing seasons, Shibin El Kom, Mounfia Governorate, Egypt, for five varieties of sugar beet (*Beta vulgaris L.*) to study the effects of irrigation water management (irrigation interval period, and pulse irrigation) on the vegetative growth parameters, yield and some of yield parameters, as well as water productivity (WP) of sugar beet varieties to suggest the suitable irrigation program to farmers in Nile Delta (clay soil), Egypt, using the drip irrigation system. Results indicated that Oscar poly variety irrigated every 7 days and using P_2 pulse irrigation treatment (5 min on, and 15 min off) is the good condition for cultivating sugar beet plants with good water management. Moisture distribution in the soil profile was studied for the P_1 pulse irrigation treatment and P_2 pulse irrigation treatment for 7 days irrigation interval, the other experimental treatment were be neglected, because they gave low or bad results of all the vegetative growth and yield data for different sugar beet varieties. The moisture distribution in the soil profile (in the horizontal direction around the dripper) was not regular in different soil depths for P_1 (5 min on, and 10 min off) and 7 days irrigation interval, but the identical moisture distribution in the soil profile was using P_2 pulse irrigation treatment (5 min on, and 15 min off) and the same irrigation interval, which gave a good distribution of plant roots, which reflected good conditions for growing healthy plants.

Keywords: Pulse irrigation, Irrigation interval, Sugar beet, Varieties, Drip irrigation system.

Introduction

A limited water resource is the main obstacle for agriculture area expansion in Egypt. Recent years, the complex dimensions of fresh water in Egypt have received considerable attention as a primary priority issue politically, technically and scientifically (Abu-Zeid and Hamdy, 2003). Agricultural consumes more than 84 % of water resources in Egypt, especially for surface irrigation (basin, borders and furrow irrigation methods) in the Nile Delta and the Old Valley which represent clay soil, therefore there is a concern from the Egyptian Government to save water in this area (El-Beltagy and Abo-Hadeed, 2008). The results of over irrigation are high water losses and low irrigation efficiency, and thus creating drainage and salinity problems. The highest productivity of using the unit of the applied water depends upon the effective use of water by preventing water losses. This can partly be prevented by using new irrigation techniques and by reduction of evapotranspiration. Using drip irrigation system is one of the most important techniques for saving irrigation water.

Sugar beet season is long, so it is one of the highest water consuming plants, root growth is much less than shoot growth (Marschner, 1995). Sugar beet (*Beta vulgaris L.*) is the second source of sugar worldwide, after sugar cane, providing annually million tons of sugar for consumption and beet pulp for animal feed. Sugar beet can be grown in a wide range of climatic conditions, but water requirement can be a major cause of yield loss, depending on weather conditions, irrigation management, growth period, plant density, and genotype (Marshall *et al.*, 2009; and Iqbal and Saleem, 2015). Weeden (2000) noted that irrigation water was applied between the levels of 500 and 1000 mm to produce sugar beet in areas like the USA, Egypt and Pakistan. Sharmasarkar *et al.* (2001) revealed that sugar beet yield using drip irrigation was higher than furrow irrigation when the water depletion did not exceed 20%.

The potential benefits of deficit irrigation derived from two factors: increased irrigation efficiency, and reduced irrigation costs (English *et al.*, 1996). Abayomi (1992) indicated that drip irrigated of sugar beet at 75% level (deficit irrigation 25%) had significant benefits in terms of saved irrigation water and large WUP, reported a decisive advantage of deficit irrigation under limited water supply conditions. Kiymaz *et al.* (2015) studied treatments consisted of one irrigation interval (7 days); with two sugar beet varieties (C1: Esperanza and C2: Calixta) and three different irrigation levels (I1, I2, and I3) adjusted according to the class A pan evaporation (Epan) using three different plant-pan coefficients (Kcp1: 0.5; Kcp2: 0.75; and Kcp3: 1.00). They exposed that the lowest and the highest root yields were observed in the I3C1 (85.38 t ha^{-1}) and I2C2 (75.10 t ha^{-1}) treatments. On the other hand, in the C1 treatment of irrigation treatments had a significant effect, sugar yield, and other parameters. If the economic yield and quality are desired, the I1C1 treatment can be suggested for sugar beet production under the similar experimental conditions.

Masri *et al.* (2015) revealed that drip irrigated sugar beet plants with 75% of irrigation water requirements (IWR) recorded the highest significant leaf area index, the significant increase in root yield were detected by increasing irrigation water requirement from 50% up to 100% of the IWR. Mevhibe *et al.* (2010) found that drip irrigation in sugar beet production allows saving irrigation water more than using sprinkler and furrow irrigation which increased productivity and net profit. The spread of especially drip irrigation in sugar beet production has increased the economic use of water and profitability, through savings in input and reduction of costs. Similarly, Topak *et al.* (2011) found that root yield of sugar beet significantly decreased by the increment of water deficit in the semi-arid region. Ghamarnia *et al.* (2012) indicated that the water deficit caused significantly less root and sugar yield for sugar beet using water deficit. Therefore, the aim of this work was to investigate the effects of irrigation water management (irrigation interval period, and pulse irrigation) on the vegetative growth parameters, and yield and some of yield parameters, as well as water use productivity (WUP) of sugar beet varieties to suggest the suitable irrigation program to farmers in Nile Delta (clay soil) using the drip irrigation system.

The leaf area per plant was determined by drawing the leaf shape on a piece of paper and measuring the area of that shape by digital planimeter (Kenan and Cafer, 2004).

All data analyses in this study were done using split-split plot design with three replicates as an average of the two growing seasons. The least significant difference (LSD) test was used to assess the significant difference between the mean values with probability levels lower than 0.05 as described by Gomez and Gomez (1984).

Table 1 : The chemical and physical properties of the soil

Soil depth, cm	Chemical properties					Physical properties			
	Salinity (ds m^{-1})	pH^{**}	$CaCO_3$ (%)	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	F.C., %	W.P., %	Bulk density (g cm^{-3})	Texture
0 - 30	1.015	8.03	1.50	41	648	33.57	22.66	1.426	C.L
30 - 60	1.015	7.90	12.1	26	475	36.28	26.23	1.568	C.L

*Pw: % water by volume, ** pH: in paste.

Table 2 : Effect of irrigation intervals on vegetative growth parameters, and root yield and some related yield characteristics of sugar beet varieties under drip irrigation system.

Irrigation interval	No. of leaves	Leaf area, cm^2	Fresh weight, g	Dry weight, g	Root length, cm	Root diameter, cm	Root yield, ton/ha	WP, kg/m^3	Suger %
7 days	19.64	317.64	27.22	8.04	24.97	13.68	46.96	15.82	17.30
14 days	17.85	318.88	25.25	7.30	27.57	12.65	38.25	12.94	15.68
L.S.D at 5% level	**0.60**	**2.20**	**1.12**	**0.25**	**0.74**	**0.35**	**1.22**	**0.94**	**1.06**

Materials and Methods

Two experiments were conducted during the years from 2017 and 2016 successive growing seasons, Shibin El Kom, Mounfia Governorate, Egypt, for five varieties of sugar beet (*Beta vulgaris L.*), were sown at April of each year, at a row spacing of 0.50 m and in-row spacing of 0.15 m. Field plots were fertilized with 140 kg N ha^{-1}, 100 kg P ha^{-1}, and 80 kg K ha-1, which was distributed prior to seedbed preparation. Weeding was carried out by hand four times during the growing season. The drip laterals were 20 mm external diameter polyethylene pipes with inline drippers (GR 4 l/hr). Soil chemical and physical properties are shown in Table (1).

The experimental field was with an area of 30m x 30m, and was divided into main plots for irrigation interval (15m x 30m for each treatment) were applied by using a line-source Drip system, the irrigation interval treatments were irrigating plants every 7 days and every 14 days, the sub-main plots were divided into three plots for three pulse irrigation treatments (P1, P2 and P3 or irrigating plants for 5 minutes on and 10 minutes, 15 minutes and 20 minutes off, respectively), the area for each plot was 3m x 10m, these treatments were applied using three solenoid valves with a timer, all experimental treatments were be replicated three times.

Water use productivity (WUP) was determined in order the equation as follows:

$$WUP= Ey/Et$$

Where Ey is the economical root yield (kg ha^{-1}), Et is the applied irrigation water (m^3 ha^{-1}).

Results and Discussion

Irrigation Intervals Treatments:

Table (2) shows the effect of irrigation intervals on vegetative growth parameters, and root yield and some related yield characteristics of sugar beet varieties under drip irrigation system. Where the highest values of vegetative growth parameters were given by using 7 days irrigation intervals with significance differences comparing with that obtained using 14 days irrigation interval, except for leaf area (cm^2/plant). Moreover the same trend was observed for the yield characteristics (root diameter, and root yield, as well as water use productivity).

Root length increased with watering plants every 14 days by 9.9%, and decreased the root diameter by 6.22%, the root yield by 18.2%, and WUP by 18.5%comparing withwatering plants every 7 days. It is clear that using 14 days irrigation interval put the sugar beet plants under water stress. The increment of WUP for 7 days irrigation interval was related to the increment. These data are in the same concern with Simona *et al.* (2015), Weeden (2000), and Iqbal and Sleem (2015).

Pulse irrigation Treatments:

Data illustrated in Table (3) determine the response of sugar beet plants to pulse irrigation treatments P1, P2, and P3 where P1 was 5 min on and 10 min off, P2 was 5 min on and 15 min off, and P3 was 5 min on and 20 min off. All differences were significant for growth parameters (number of leaves per plant, leaf area per plant, fresh weight, and dry weight), root yield and its characteristics (root length and root diameter), as well as the water use productivity.

Generally the treatment P2 of the pulse irrigation (5 min on and 15 min off) gave the highest values of all mentioned measurements, followed by P3 treatment (5 min on and 20 min off) and the highest WUP, while there were no significant differences between the two treatments.

Using pulse irrigation from P1 to P2 treatments increased all the measurements of sugar beet plants, vegetative and yield parameters; therefore it is useful for sugar beet growers to use pulse irrigation for saving costs also to rise the productivity of the water unit. Moreover root yield increased clearly using P2 comparing to P1 treatment; on the other hand it decreased significantly using P3treatment because the plants were put under stress.

Response of sugar beet varieties:

Table (4) shows the response of five varieties of sugar beet (Helme, Oscar poly, Tenor, Mammut and Mira dor) under the experimental conditions. It was clear that there were significant differences between all illustrated data in Table (3) for the studied sugar beet variety, therefore Oscar Poly variety had high resistance to the water stress conditions, by giving the highest values of growth parameters, and yield and its parameters, as well as the water use productivity. This response was reordered descendingly for Helme, Tenor, Mammut and Mira Dor varieties. Root yield increased by 2.37 %, 11.98 %, 16.89 % and 22.73 % by comparing Oscar poly variety with Helme, Tenor, Mammut, and mirodor, respectively.

The interaction between irrigation intervals and pulse irrigation on vegetative growth parameters and root yield and some related yield characteristics of sugar beet varieties:

The highest values of No. of leaves and leaf area per plant were be increased using 7 days irrigation interval and P3 pulse irrigation treatment, followed by P2 pulse irrigation treatment with the same irrigation interval without significant differences (Table, 5). Fresh and dry weight (g/plant), root diameter, and root yield as well as sugar % were the highest under 7 days irrigation interval and P2 pulse irrigation treatment. But the highest value of water productivity was calculated using P3 pulse irrigation treatment and 7 days irrigation interval (Table, 5).

The interaction between irrigation intervals and sugar beet varieties on vegetative growth parameters and root yield and some related yield characteristics:

Table (6) show the interaction between irrigation interval and studied sugar beet varieties, this interaction effect gave significant differences of the vegetative growth parameters and root yield and some related yield characteristics such as root diameter, root yield, water productivity and sugar %. Generally the highest values of all measured characteristics were obtained by Oscar poly variety even by using 7 days or 14 days irrigation interval, except for sugar % which was using Tenor variety (16.88 %). Moreover the significant highest values were using 7 days interval with Oscar poly variety.

The interaction between pulse irrigation treatments and sugar beet varieties on vegetative growth parameters and root yield and some related yield characteristics:

Illustrated data in Table (7) show the effect of the pulse irrigation on the different sugar beet varieties, where Oscar poly gave the highest values of different measured parameters No. of leaves, leaf area, root length, root diameter, and root yield using the three studied pulse irrigation treatments (P1, P2 and P3). On the other hand the highest significant value of water productivity (19.99 kg/m^3) was calculated for Oscar poly and P3 pulse irrigation treatment only. Moreover Mira dor variety plants contained the highest percentage of sugar under different studied pulse irrigation treatments. Generally Oscar poly variety and P2 pulse treatment gave the highest values of the studied parameters, and there was no significant difference for sugar percentage comparing with that tested for Tenor variety for the same pulse irrigation treatment.

The interaction of the experimental treatments on the vegetative characteristics of sugar beet varieties:

The values of No. of leaves differ from experimental treatment to another for the five studied sugar beet varieties, for that No. of leaves of plants decreased for Helme, Tenor, Mammut, Mira dor under different irrigation treatments comparing with these obtained from Oscar poly and Helme varieties (Table, 8). The 2nd irrigation interval treatment (14 days) gave the lowest values of vegetative growth parameters, leaf area per plant, fresh weight and dry weight per plant. The 7 days irrigation interval and the second pulse irrigation treatment (P2, 5 min off and 15 min off) on Oscar poly sugar beet variety is the proper conditions for having the good growth of sugar beet plants, and leaf area (394 cm^2/plant). On the other hand, the highest values of fresh weight (39.4 g/plant) and dry weight (10.09 g/plant) were gained using P2 pulse irrigation treatment but for Tenor variety without significant difference compared with Oscar poly variety.

The interaction of the experimental treatments on the root yield and some related yield characteristics of sugar beet varieties:

Table (8) shows the significant differences of root yield and its characteristics of the evaluated sugar beet varieties under different water management conditions. The highest root lengths of Oscar poly sugar beet plants were the highest measured root lengths under the P2 irrigation pulse treatment and for all irrigation interval treatments, except using P3 irrigation pulse treatment and 7 days irrigation interval, but without significant difference comparing with P2 treatment. The same trend was detected for root diameter.

Root yield responded clearly to the experimental treatments, the highest root yield (ton ha^{-1}) was recorded for Oscar poly variety irrigated every 7 days and using P2 pulse irrigation treatment (5 min on, and 15 min off), this treatment with the same sugar beet variety had the superiority of water use productivity as well, except for Helme variety and irrigation every 7 days using P3 pulse irrigation treatment, without significant difference between the obtained data for Oscar poly variety. The highest value of sugar % was gained using 7 days irrigation interval and P2 pulse irrigation treatment but for Tenor variety without significant difference comparing with that for Oscar poly variety plants under the same studied irrigation treatment.

Generally, Oscar poly variety irrigated every 7 days and using P2 pulse irrigation treatment (5 min on, and 15 min off) is the good conditions for cultivating sugar beet plants with good water management conditions.

Table 3 : Effect of pulse irrigation on vegetative growth parameters, and root yield and some related yield characteristics of sugar beet varieties under drip irrigation system.

Pulse Irrigation	No. of leaves	Leaf area, cm^2	Fresh weight, g	Dry weight, g	Root length, cm	Root diameter, cm	Root yield, ton/ha	WP, kg/m^3	Suger %
P_1	18.62	304.38	27.67	7.61	26.65	12.36	42.91	9.30	16.20
P_2	18.95	318.67	28.27	7.91	29.76	12.91	44.55	15.37	16.51
P_3	18.67	318.59	26.68	7.41	28.50	13.95	40.34	18.46	16.06
L.S.D at 5% level	**0.8**	**4.75**	**0.53**	**0.17**	**1.04**	**0.53**	**0.59**	**3.03**	**0.46**

P_1: 5 min on, and 10 min off, P_2: 5 min on, and 15 min off, and P_3: 5 min on, and 20 min off

Table 4 : The response of some sugar beet varieties on vegetative growth parameters, and root yield and some related yield characteristics

varieties	No. of	Leaf	Fresh	Dry	Root	Root	Root	WP,	Suger
Helme	19.20	328.86	29.27	8.22	30.34	13.32	45.84	15.49	15.88
Oscar poly	20.42	377.49	30.61	8.36	32.50	16.82	46.91	15.77	15.78
Tenor	19.58	324.38	27.39	8.06	28.34	12.04	41.91	14.15	**16.77**
Mammut	17.82	273.05	26.79	7.18	26.50	11.48	40.13	13.53	15.97
Mira dor	16.14	265.54	23.41	6.41	23.24	11.37	38.25	12.97	16.92
L.S.D at 5% level	**1.43**	**37.32**	**2.40**	**0.65**	**3.09**	**1.82**	**1.22**	**0.93**	**1.02**

Table 5 : Effect of interaction between irrigation intervals and pulse irrigation on vegetative growth parameters and root yield and some related yield characteristics of sugar beet varieties.

Treatments		No. of leaves	Leaf area. cm^2	Fresh weight, g	Dry weight, g	Root length, cm	Root diamete, cm	Root yield, ton/ha	WP, kg/m^3	Suger %
Irrigation interval	**Pulse Irrigation**									
7 days	P_1	19.37	298.10	29.30	7.94	26.21	12.60	47.58	10.32	16.40
	P_2	19.54	310.47	30.26	8.43	27.80	13.52	49.41	17.04	17.48
	P_3	20.03	323.91	28.08	7.75	26.00	14.34	43.89	20.09	16.70
14 days	P_1	17.87	310.66	26.04	7.30	27.20	12.12	38.25	8.29	16.00
	P_2	18.26	326.78	26.22	7.38	24.60	12.27	39.75	13.71	15.62
	P_3	17.31	313.27	25.28	7.06	31.00	13.56	36.77	16.83	15.42
L.S.D at 5% level		**1.33**	**31.78**	**2.38**	**0.59**	**2.56**	**2.17**	**8.79**	**2.81**	**0.95**

Table 6 : Effect of interaction between irrigation intervals and sugar beet varieties on vegetative growth parameters and root yield and some related yield characteristics.

Treatments		No. of leaves	Leaf area. cm^2	Fresh weight, g	Dry weight, g	Root length, cm	Root diameter, cm	Root yield, ton/ha	WP, kg/m^3	Suger %
Irrigation interval	**varieties**									
7 days	**Helme**	20.09	317.48	28.19	8.82	30.67	13.03	51.84	17.45	16.50
	Oscar poly	21.02	392.37	31.78	8.67	29.33	17.00	52.69	17.74	16.40
	Tenor	20.83	317.03	32.75	8.80	27.00	12.49	46.22	11.76	17.33
	Mammut	19.64	342.57	25.42	7.38	24.33	12.10	43.03	14.50	16.43
	Mira dor	16.65	363.06	24.60	6.54	22.00	12.23	41.01	13.89	17.50
14 days	**Helme**	19.03	340.24	27.01	7.61	30.00	13.60	39.84	13.50	15.27
	Oscar poly	19.87	362.42	29.40	8.04	35.67	16.63	4115	13.81	15.10
	Tenor	18.33	331.74	26.03	7.32	28.67	11.67	37.85	12.79	16.20
	Mammut	16.20	283.03	24.56	6.97	28.67	10.85	37.20	12.56	15.80
	Mira dor	15.84	267.08	22.27	6.28	24.70	10.50	35.49	12.05	16.33
L.S.D at 5% level		**1.46**	**34.17**	**2.72**	**0.76**	**2.63**	**1.82**	**1.64**	**3.25**	**0.81**

Table 7 : Effect of interaction between pulse irrigation and sugar beet varieties on vegetative growth parameters and root yield and some related yield characteristics.

Treatments		No. of leaves	Leaf area. cm^2	Fresh weight, g	Dry weight, g	Root length, cm	Root diameter, cm	Root yield, ton/ha	WP, kg/m^3	Suger %
Irrigation interval	**Pulse Irrigation**									
P_1	**Helme**	18.43	308.92	28.67	8.82	29.00	11.65	45.39	9.84	15.80
	Oscar poly	20.15	367.46	28.18	8.14	32.00	16.20	48.02	10.41	15.65
	Tenor	21.02	332.73	28.03	7.95	26.50	12.20	41.81	9.07	16.75
	Mammut	18.11	260.53	24.78	7.25	24.00	11.80	40.94	8.88	16.25
	Mira dor	15.60	243.25	23.72	6.17	22.00	9.95	38.49	8.34	16.90
P_2	**Helme**	19.53	321.67	27.35	8.14	30.00	12.25	49.38	17.04	16.10
	Oscar poly	20.11	385.47	33.14	8.58	32.50	16.70	49.07	16.43	16.00
	Tenor	19.45	324.44	32.30	8.73	31.00	16.15	44.51	15.35	17.05
	Mammut	18.00	283.44	23.84	7.10	26.00	10.88	41.39	14.28	16.30
	Mira dor	16.81	278.12	24.80	6.99	24.40	12.50	38.56	13.30	17.10
P_3	**Helme**	19.89	355.99	27.00	7.69	32.00	16.05	42.72	19.55	15.75
	Oscar poly	20.15	370.55	30.47	8.35	33.00	17.55	43.67	19.49	15.60
	Tenor	19.25	311.08	27.85	7.50	22.50	12.75	34.39	18.03	16.50
	Mammut	17.84	275.17	26.35	7.45	22.50	11.75	38.08	17.43	15.35
	Mira dor	15.95	275.25	31.73	6.05	26.50	11.65	37.75	17.28	16.10
L.S.D at 5% level		**3.66**	**57.03**	**6.09**	**1.50**	**6.33**	**3.60**	**2.99**	**4.82**	**0.74**

Table 8 : Effect of irrigation intervals, and pulse irrigation on vegetative growth parameters as well as root yield and some related yield characteristics of sugar beet varieties under drip irrigation.

Treatments			No. of leaves	Leaf area. cm^2	Fresh weight, g	Dry weight, g	Root length, cm	Root diameter, cm	Root yield, ton/ha	WP, kg/m^3	Sugar %
Irrigation interval	**Surge Irrigation**	**Varity**									
7 days	**P_1**	**Helme**	19.50	279.00	27.20	10.40	30.0	13.50	52.69	11.42	15.87
		Oscar poly	20.33	390.50	28.54	7.63	32.0	15.90	52.96	11.48	15.70
		Tenor	22.00	326.33	29.85	8.40	25.0	13.50	47.08	10.21	16.85
		Mammut	19.30	231.16	24.60	7.00	23.0	12.30	44.03	9.55	16.35
		Mira dor	15.70	263.00	26.30	6.28	21.0	12.40	41.17	8.93	17.02
	P_2	**Helme**	20.09	301.68	28.07	7.85	30.0	14.80	54.24	18.71	16.19
		Oscar poly	21.02	394.60	35.20	9.89	30.0	18.90	56.55	19.51	16.80
		Tenor	19.98	307.23	39.40	10.09	30.0	13.50	49.69	17.14	17.15
		Mammut	19.00	283.85	23.25	7.23	26.0	12.00	44.70	15.42	16.39
		Mira dor	17.60	265.00	25.40	7.10	23.0	12.50	41.89	14.45	17.20
	P_3	**Helme**	20.67	371.75	29.30	8.20	32.0	10.80	48.55	22.22	15.86
		Oscar poly	21.70	392.60	31.60	8.50	26.0	16.20	48.55	22.22	15.73
		Tenor	20.50	317.03	29.00	7.90	26.0	12.20	41.89	19.17	16.65
		Mammut	20.61	274.17	28.40	7.91	24.0	12.00	40.46	18.52	15.51
		Mira dor	16.65	264.00	22.10	6.24	22.0	11.80	39.89	18.30	16.19
14 days	**P_1**	**Helme**	19.00	338.83	36.13	7.24	28.0	11.00	38.08	8.26	15.89
		Oscar poly	21.33	362.42	27.81	8.65	32.0	17.50	43.08	9.34	15.69
		Tenor	18.00	338.63	26.20	7.50	28.0	10.80	36.53	7.92	16.85
		Mammut	14.00	289.90	24.95	7.05	25.0	9.45	37.84	8.20	16.35
		Mira dor	17.00	223.50	21.13	6.05	23.0	12.60	35.70	7.74	16.99
	P_2	**Helme**	19.40	341.65	26.20	8.42	30.0	17.30	44.52	15.36	16.21
		Oscar poly	19.83	376.65	31.07	7.26	35.0	16.20	41.58	14.34	16.13
		Tenor	19.00	341.65	25.20	7.36	32.0	12.00	39.32	13.56	17.16
		Mammut	17.90	283.03	24.43	6.76	26.0	11.50	38.08	13.14	16.43
		Mira dor	15.67	291.23	24.20	6.89	25.8	10.80	35.22	12.15	17.21
	P_3	**Helme**	18.70	340.24	24.70	7.18	32.0	12.50	36.89	16.88	15.86
		Oscar poly	18.33	348.50	29.33	8.21	40.0	16.20	38.79	17.75	15.72
		Tenor	18.00	314.93	26.70	7.10	29.0	12.20	36.89	16.88	16.63
		Mammut	16.70	276.17	24.30	6.91	29.0	11.60	35.70	16.34	15.47
		Mira dor	14.84	286.50	21.35	5.91	25.0	8.10	35.52	16.26	16.22
L.S.D at 5% level			**2.66**	**57.03**	**6.09**	**1.50**	**6.33**	**3.60**	**2.99**	**4.82**	**0.80**

P_1: 5 min on, and 10 min off, P_2: 5 min on, and 15 min off, and P_3: 5 min on, and 20 min off

Water Distribution pattern in the soil profile under pulse irrigation treatments:

To study the moisture distribution under the pulse irrigation treatment and irrigation intervals, soil samples were be taken to measure the moisture content in the soil profile around the dripper in the drip line ± 25 cm (horizontal direction), and 30 cm depth in the soil (vertical direction). All soil samples were be taken after 24 hours from the irrigation process. The water moisture contents were be drawn as shown in Figures (1) and (2), for the P1 pulse irrigation treatment and P2 days irrigation interval for 7 days irrigation interval, respectively, as well as the other experimental treatment were be neglected, because they gave low or bad results of all the vegetative growth and yield data for different sugar beet varieties.

The results drawn in Figure (1-a) revealed that the moisture distribution in the soil profile (in the horizontal direction around the dripper) was not regular in different soil depths (5 cm, 15 cm, 25 cm and 30 cm depth). Figure (1-b) shows that the moister content (%) ranged from 25% to 40%. In the same manner, data in Figure (2-a) expresses the moisture content in the horizontal direction of the water source (dripper), at all soil depths, the moisture content was identical in the both sides around the dripper, where the minimum water content was at ±25 cm around the dripper, and the maximum water content was in the middle. The moisture content ranged from 20% to 33% as shown in Figure (2-b), with regular distribution of moisture in the soil profile, which gave a good distribution of plant roots, which reflected good conditions for growing healthy plants. These data was in the same concern with Mady *et al.* (2012), Mehanna *et al.* (2013) and Mehanna *et al.* (2017).

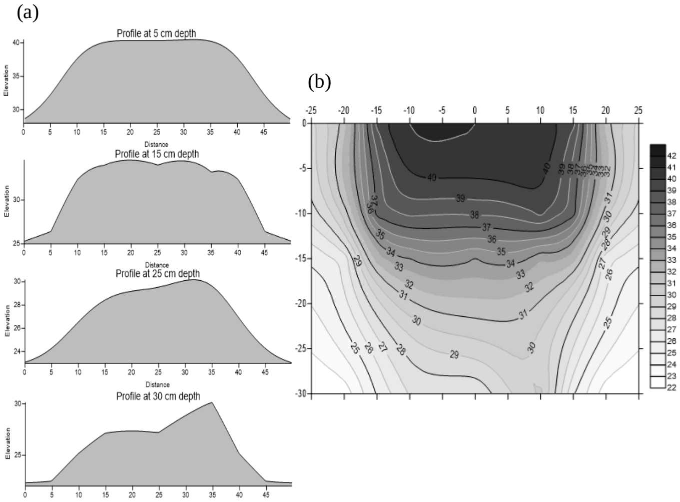

Fig. 1 : Water distribution pattern in the soil profile under the dripper for pulse irrigation treatment P_1 (5 min off and 10 min off): a. horizontal distribution (50 cm), b. vertical distribution (30 cm depth).

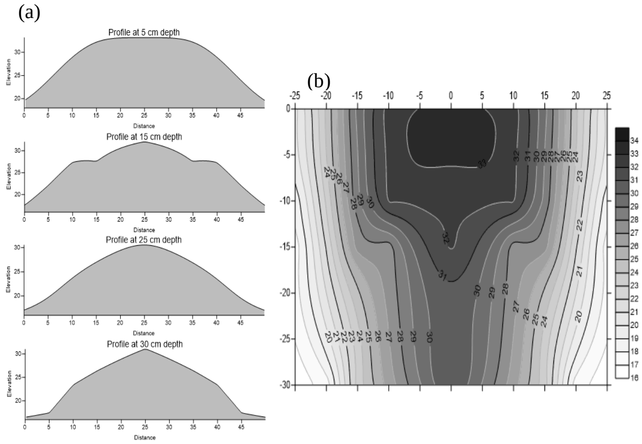

Fig. 2 : Water distribution pattern in the soil profile under the dripper for pulse irrigation treatment P_2 (5 min off and 15 min off): a. horizontal distribution (50 cm), b. vertical distribution (30 cm depth).

Conclusion

Oscar poly variety is a suitable variety to be cultivated in the clay soil in Egypt. Irrigation every 7 days and using P2 pulse irrigation treatment (5 min on, and 15 min off) is the good water management conditions for cultivating sugar beet plants. The identical moisture distribution in the soil profile was obtained using P2 pulse irrigation treatment (5 min on, and 15 min off) and 7 days irrigation interval, which gave a good distribution of plant roots, which reflected good conditions for growing healthy plants.

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