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Effect of Irrigation Intervals and Potassium Humate on Sugar Beet Productivity

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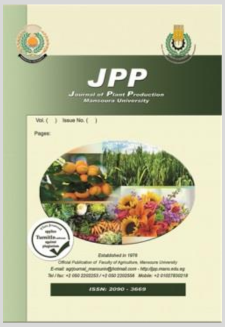

ABSTRACT

Present study was conducted under sprinkler irrigation system at private farm in Al-Salehya Al-gadida city, Al-Sharkia Governorate, Egypt. Two field experiments were conducted during two successive growing seasons 2016/2017 and 2017/2018 to study the effect of irrigation intervals (3, 5 and 7 days) and soil application of humic acid at rates of [0 kg (Control), 2.5 Kg and 5 Kg/Fed] in form of potassium humate on yield and quality of sugar beet (*Beta vulgaris* L.) variety Nancy (multigerm). A split plot design with three replications was used. Irrigation intervals allocated in the main plots, while the potassium humate levels were arranged in sub plots. Obtained results showed that decreasing irrigation intervals from 7 to 3 days significantly increased diameter and root fresh weight/plant, TSS % and root, top and sugar yields/fed in both seasons. Increasing humic acid rates from zero up to 5 kg/fed increased significantly root length, root diameter, root fresh weight/plant as well as root, top and sugar yields/fed and slightly juice quality in the two growing seasons. Moreover, the highest values of TSS % and sucrose % were recorded with humic acid treatments at 2.5 kg or 5 kg/fed in both seasons. Effect of interaction between irrigation intervals and humic acid applications didn't reach the 0.5% level of significance concerning root length, root yield/fed and sugar yield/fed in the two seasons, while the effect of interaction on TSS %, sucrose %, purity % and top yield/fed didn't reach the level of significance in the first season only.

Keywords: Sugar beet, Irrigation intervals, Humic acid, Root, top and sugar yields, Juice quality.

INTRODUCTION

Water is the most limiting natural resources for agricultural production in arid and semi-arid regions. According to Abdin and Gaafar (2009) Egypt is climatically an arid country with scarce water resources. Nile River, alone, provides the country with more than 95% of its various water requirements. Egypt is facing increasing water needs, demanded by rapidly growing population, increased urbanization, higher standards of living and by an agricultural policy which emphasizes expanding crop production. In turn, it is wise, for crop irrigation, to use water saving methods. Irrigation management of sugar beet, especially in the new reclaimed soils can maximize sugar beet yields as well as minimizing disease, water costs, fertilizer leaching, and soil erosion. Young sugar beet plants should not be stressed for moisture to encourage rapid foliage production and plant establishment. Later in the season, irrigations can be spaced apart to ensure the top 1 foot of soil never gets drier than 50% available soil moisture (Reddy *et al*., 2007). Sugar beet can grow in a wide range of water stress conditions and irrigation treatments (Davidoff and Hanks 1989).

Humic acids and its derived compounds is one of the most widespread organic soil conditioners. They can help improving soil structure due to increasing the amount of pore space and enhancing the air exchange, water movement, water holding capacity and root growth which result in better drought resistance and reduction in water usage (Al marshadi and Ismail, 2014). Khaled and Fawy (2011) concluded that humic acids can significantly reduce water evaporation and increase its use by plants and increase the water holding capacity of soils in arid and sandy soils. So, the main target of the present study was to evaluate the effect of water stress and potassium humate on sugar beet productivity.

MATERIALS AND METHODS

Two field experiments were conducted under sprinkler irrigation system in 2016/2017 and 2017/2018 at a private farm in Al-Salyhya Al-gadida, Al-Sharkia Governorate, Egypt. Aimed to investigate the yield and quality of sugar beet variety Nancy (multigerm) in relation to three different irrigation intervals (3, 5 and 7 days) and three levels of Humic acid [0 kg (Control), 2.5 kg and 5 kg/fed]. Humic acid applied in form of potassium humate (produced by Spanish-Egyptian Company) which contains 75% Humic acid, 10% K_2O, 4% Volvic and 2% Fe. A split plot design with three replications was used in each season. The treatments of irrigation intervals allocated in the main plots which separated from each other by ten meters, to avoid runoff water and the combined distribution of water from the overlap of individual sprinklers. While the three humic acid levels (0, 2.5 and 5 kg as potassium humate/fed) were randomly assigned to the sub plots. Potassium humate was applied as one dose after full emergence (fifty days of planting) and mixed thoroughly with moisten sand and drilled beside seedlings.

The sub plot area for each experimental site consisted of seven rows 5 m in length and 60 cm in width (21 m^2) with 20 cm hill spacing. Irrigation of sprinkler was

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conducted for 2 hours at every irrigation interval. The amounts of water which consumed throughout the growth season were calculated and attained for first irrigation interval (every 3 days) 5100 m^3/fed, for second irrigation interval (every 5 days) 3060 m^3/fed and for third irrigation interval (every 7 days) 2185.7 m^3 water/fed. Phosphorus fertilizer was applied in the form of calcium super phosphate (15.5 P_2O_5) at the rate of 31 P_2O_5 kg/fed at seed bed preparation. Nitrogen fertilizer was applied as ammonium nitrate (33.5%) at rate of 80 kg N/fed in two equal doses after thinning and one month later. Potassium fertilizer was applied in the form of potassium sulphate (48% K_2O) at the rate of 50 kg K_2O/fed, which was added with the second dose of nitrogen. Other cultural practices were performed as recommended in the region. Sowing of sugar beet seeds (*Beta vulgaris*, L.) variety Nancy took place during the 15th and 17th of October in the first and second season, respectively. Harvest was done 210 days after planting in both seasons. Because of sugar beet is sensitive to water stress (Doorenbos and Kassam, 1979), irrigation intervals (3, 5 and 7 days) started after four weeks of germination. Physical and chemical analyses of the soil (the upper 30 cm) of the experimental sites are given in Table (1) and some of meteorological data for the experimental sites during the two growing seasons are given in table (2).

Table 1. Physical and chemical properties of the experimental soil sites in the two seasons:

Seasons	Mechanical				Cations and Anions (meq^{-1})							Available nutrients(mg/l)			E.C. 25C°	pH Soil paste
	Sand %	Silt %	Clay %	Soil texture	Ca^{++}	Mg^{++}	Na^+	K^+	Cl^-	SO_4^{--}	HCO_3^-	N	P	K		
2016/2017	87.60	9.40	3.00	sandy	0.30	0.20	0.90	0.99	0.71	0.22	0.50	12.32	15.06	77.22	2.60	7.09
2017/2018	86.18	11.70	2.12	sandy	0.50	0.22	0.77	0.78	0.75	0.23	0.38	13.01	14.33	100.03	2.70	7.55

Table 2. Monthly average of some meteorological data for the experimental sites during the two growing seasons

	Average low temperature	Average high temperature	Average humidity	Average rainfall
October	16.6°C	30°C	55%	2mm
November	12.7°C	25.4°C	58%	6mm
December	8.9°C	20.9°C	60%	5mm
January	7.6°C	19.2°C	57%	7mm
February	8.3°C	20.9°C	54%	6mm
March	10.3°C	23.3°C	49%	7mm
April	14.1°C	28.6°C	43%	2mm
May	16.4°C	31.8°C	42%	2mm

The recorded data:

At harvest (210 days after planting), plants of two inner rows in each sub plot were harvested by hand and cleaned, then roots and tops were separated and weighted to determine:

1- Root length.
2- Root diameter (cm).
3- Root fresh weight/plant (kg).
4- Sucrose percentage was determined polarimetrically on a lead acetate extract of fresh macerated roots according to the method of Le Docte (1927).
5-TSS% was determined by using hand refractometer model PR-1, ATAGO, Japan.
6- Purity % = Sucrose % / TSS % × 100.
7- Impurities of juice, i.e. Na and K (meq. /100 g beet) were determined in the lead acetate extract of fresh macerated root tissue using "Atomic Absorption Spectrophotometer" method described by Brown and Lilliand (1964) while α-amino N was determined using Hydrogenation method according to the method of Carruthers *et al.* (1962). "Chromatography Amino Acid Analyzer"
8- Root yield (ton/fed): root weight per plot before taking samples was obtained and used to calculate root yield per fed.
9- Top yield (ton /fed).
10- Sugar yield (ton/fed) = root yield (ton) x sucrose content %.

Statistical analysis:

The data obtained from each trail was subjected to the analysis of variance of split plot design as described by Snedecor and Cochran (1967). Treatments means were compared using the least significant difference (LSD) test developed by Waller and Duncan (1969) at 0.5 % level.

RESULTS AND DISCUSSIONS

1-Effect of irrigation intervals:

Data in table (3) show that root diameter and root fresh weight/plant were gradually and significantly increased by decreasing irrigation intervals from every 7 days to 3 days, while root length significantly was decreased and that was true in the both seasons. Water stress (irrigation every 7 days) produced the longest roots 16.11cm and 18.17 cm), thinly roots (8.69 cm and 8.88 cm) and lightly root fresh weight/plant (1.19 kg and 1.16 kg), while the shortest roots (14.84 cm and 15.58 cm), largest root diameter (12.53 cm and 13.77 cm)and heaviest root fresh weight/plant (1.79 kg and 1.85 kg) were produced by normal irrigation interval (every 3 days) in the two seasons, respectively. Water stress (irrigation every 7 days) had deep effect on roots of sugar beet either as up taking system (taller roots) or as storage organ (thinly and lightly weight ones). The shortage of the available water in the root zoon pushing sugar beet plants to decrease the rate of photosynthesis as well as depress translocation of sucrose from leaves to roots. These results are in general agreement with those obtained by Ibrahim *et al*., (2002) who found that root grow longer under moisture stress. Also, Emara (1990) mentioned that the highest root length was obtained by irrigation every 28 days, while the lowest root length was every 14 days. Water stress inhibits cell enlargement more than cell division. Shortage of available water reduces plant growth by affecting various physiological and biochemical processes such as photosynthesis, respiration, translocation, ion uptake, carbohydrates, nutrient metabolism and growth promoters (Jaleel *et al*., 2008 a&e; Farooq *et al*., 2008 and Farooq *et al*., 2009).

Data in Table (4) show that percentage of total soluble solids (TSS %) in juice of sugar beet significantly decreased by increasing irrigation intervals from 3 to7 days but the adverse reaction was noticed concerning sucrose % and purity % which were increased by increasing irrigation intervals.

The concentration of impurities in juice of sugar beet (potassium, sodium, and alpha amino nitrogen meq. /100 g root) were illustrated in Table (5). It is evident that potassium % and alpha amino nitrogen juice were significantly increased by increasing irrigation intervals from 3 to 7 days, while sodium % was decreased and that was true in both seasons.

Table 3. Effect of irrigation intervals (days), potassium humate rates (kg/fed) and their interaction on root characters of sugar beet in the two seasons.

Treatments	Root length (cm)		Root diameter (cm)		Root fresh weight (kg/plant)	
	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
Irrigation intervals						
Every 3 days	14.84	15.58	12.53	13.77	1.79	1.85
Every 5 days	15.06	17.52	9.42	13.56	1.47	1.52
Every 7 days	16.11	18.17	8.69	8.88	1.19	1.16
LSD at 5%	0.80	0.24	0.39	0.73	0.05	0.11
Potassium humate rates (kg/fed)						
0 kg/fed	14.60	16.91	9.91	11.61	1.32	1.29
2.5 kg /fed	15.36	17.12	10.17	12.04	1.43	1.50
5 kg /fed	16.01	17.24	10.57	12.54	1.70	1.73
LSD at 5%	0.42	0.26	0.15	0.59	0.06	0.07
Interaction:	ns	ns	**	*	**	**

Table 4 .Effect of irrigation intervals (days), potassium humate rates (kg/fed) and their interaction on juice quality of sugar beet in the two growing seasons.

Treatments	TSS %		Sucrose %		Purity %	
	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
Irrigation intervals						
Every 3 days	20.97	21.70	17.00	17.33	81.10	79.92
Every 5 days	20.51	21.37	17.20	18.33	83.88	85.81
Every 7 days	19.38	20.67	17.51	20.07	90.38	97.10
LSD at 5%	0.34	0.19	0.36	0.04	2.77	0.68
Potassium humate rates (kg/fed)						
0 kg/fed	19.99	20.74	17.08	18.20	85.54	87.86
2.5 kg /fed	20.27	21.46	17.43	18.68	86.17	87.31
5 kg /fed	20.60	21.53	17.20	18.86	83.65	87.66
LSD at 5%	0.25	0.22	0.35	0.21	1.93	1.53
Interaction:	ns	**	ns	**	ns	*

Table 5. Impurities (potassium, sodium, and alpha amino nitrogen meq /100 g beet) contents of sugar beet as affected by irrigation intervals and potassium humate in 2016/2017 and 2017/2018 seasons.

Treatments	α-amino nitrogen %		Potassium %		Sodium %	
	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
Irrigation intervals						
Every 3 days	2.10	2.12	3.39	3.43	0.86	0.88
Every 5 days	2.26	2.29	3.49	3.61	0.81	0.84
Every 7 days	2.35	2.39	3.63	3.73	0.72	0.76
LSD at 5%	0.04	0.06	0.07	0.14	0.03	0.03
Potassium humate rates (kg/fed)						
0 kg/fed	2.35	2.39	3.39	3.48	0.82	0.85
2.5 kg /fed	2.25	2.27	3. 53	3.59	0.80	0.82
5 kg /fed	2.12	2.14	3.60	3.71	0.78	0.79
LSD at 5%	0.05	0.06	0.03	0.09	0.02	0.02
Interaction:	ns	ns	**	ns	*	ns

Concerning root yield per fed, data illustrated in Table (6) showed that irrigation intervals affected significantly on root, top and sugar yields/fed. Root yield/fed was decreased significantly with increasing irrigation intervals from 3 to 7days. The highest values of root yields (25.95 and 26.40 ton/fed) were obtained under irrigation every 3 days, while the lowest ones (19.00 and 20.68 ton/fed) were obtained under irrigation every 7 days and that was true in both seasons, respectively. Increasing irrigation intervals from 3 days to 5 days decreased roots yield by 15.21% and 15.37%, while increasing irrigation intervals from 3 days to 7 days decreased roots yield by 36.57% and 27.66% in the first and second seasons, respectively.

The same trend was noticed concerning top yield/fed as affected by irrigation intervals. Top yield recorded high values in the two seasons when sugar beet plants irrigated every 3 days. Top yields/fed were decreased by 9.56% and 6.12% with increasing irrigation intervals from 3 to 5 days, while decreased by 28.83% and 23.44% with increasing irrigation interval from 3 to 7 days in the two growing seasons, respectively (Table 6).

Also, productivity of sugar yield per fed significantly affected by irrigation intervals. Increasing irrigation intervals from 3 to 5 days produced a decrease in sugar yield by 8.68% and 10.88%, while increasing irrigation intervals from 3 to 7 days produced a decrease in sugar yield by 19.37% and 15.11% in the two seasons, respectively (Table 6). Practically, the decrease in sugar yield is related to the decreases in both root yield/fed and sucrose content (%). The above-mentioned results are in harmony with those obtained by Doorenbos and Kassam (1979); Davidoff and Hanks (1989); Emara (1990); Ibrahim *et al.* (2002) and Reddy *et al.* (2007).

Table 6. Effect of irrigation intervals (days), potassium humate rates (kg/fed) and their interaction on yield of sugar beet per fed (root, top and sugar) in 2016/2017 and 2017/2018 seasons.

Treatments	Root yield (ton/fed)		Top yield (ton/fed)		Sugar yield (ton/fed)	
	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
Irrigation intervals						
Every 3 days	25.95	26.40	8.29	8.49	4.49	4.50
Every 5 days	21.89	23.86	7.49	7.97	4.10	4.01
Every 7 days	19.00	20.68	5.90	6.50	3.62	3.82
LSD at 5%	0.43	0.14	0.32	0.25	0.09	0.10
Potassium humate rates (kg/fed)						
0 kg/fed	21.03	22.96	6.21	6.88	3.92	3.80
2.5 kg /fed	22.50	23.62	7.56	7.93	4.12	4.17
5 kg /fed	23.31	24.36	7.91	8.14	4.18	4.36
LSD at 5%	0.67	0.49	0.25	0.19	0.13	0.12
Interaction:	ns	ns	ns	*	ns	ns

2- Effect of humic acid:

Concerning to the effect of humic acid on some yield attributes of sugar beet during 2016/2017 and 2017/2018 seasons, the results in Table (3) show that the application of humic acid had positive and significant effect on root length, root diameter and root fresh weight per plant comparing with control treatment (0 kg potassium humate/fed) and that was true in the two growing seasons. Potassium humate (PH) at rate of 5 kg/fed gave the highest values of root length (16.01cm and 17.24 cm), root diameter (10.57 cm and 12.54 cm) and root fresh weight/plant (1.70 kg and 1.73 kg) in both seasons respectively. This may be due to Potassium humate act (organic matter) as a storehouse of humic and potassium, which leads to improve solubilize minerals, stabilize nitrogen and improve nitrogen efficiency, as well as improve nutrient availability and have impact on chemical and biological properties of soils. These results are in accordance with those reported by Mollasadeghi (2010); Mauromicale *et al.* (2011) and Enan *et al.* (2016).

Moreover, application of potassium humate (2.5 kg or 5 kg/fed) significantly increased TSS % compared with control treatment (0 kg PH), while slightly increase was noticed concerning sucrose % and purity % (Table 4).

Also, increasing level of potassium humate from 2.5 kg to 5 kg/fed significantly increased potassium in juice of sugar beet, while sodium and alpha amino nitrogen percentages were decreased in juice and that was true in the two growing seasons (Table 5).

Data in Table (6) illustrated that soil application of 5 kg potassium humate/fed gave the highest roots (23.31 ton and 24.36 ton/fed.), top (7.91 ton and 8.14 ton/fed.) and sugar (4.18 ton and 4.36 ton) yields/fed in the two growing seasons, respectively. These results are in harmony with those obtained by Shoae *et al.* (2013), Motaghi and Nejad (2014), Shaban *et al*. (2014), Rassam *et al*. (2015) and EL-Hassanin *et al*. (2016) who revealed that increasing humic acid make up an increase in yield and its components of sugar beet.

Effect of interaction:

Generally, the effect of interaction between irrigation intervals and humic acid applications did not reach the 0.5% level of significance concerning root length, α-amino nitrogen %, root yield/fed, and sugar yield/fed in both seasons. Moreover, root diameter and root fresh weight were affected significantly in both seasons. Also, TSS %, sucrose %, purity % and top yield/fed were affected significantly in the second season only (tables 3-6). These results mean that either irrigation intervals or humic acid were affected lonely on some studied characters, but they reacted together on the other characters. Data in Table (7) show that root fresh weight was affected significantly by the interaction between irrigation intervals and application of humic acid rates. The normal irrigation interval (every 3 days) and application of potassium humate at rate 5 kg/fed gave the highest root fresh weight/plant in the two seasons (2.05 kg and 2.15 kg/fed), respectively.

Table 7. Effect of interaction between irrigation intervals and potassium humate rates on root fresh weight in the two seasons.

Irrigation intervals	2016/2017				2017/2018			
	Potassium humate rates			Mean	Potassium humate rates			Mean
	0 kg	2.5 kg	5 kg		0 kg	2.5 kg	5 kg	
Every 3 days	1.56	1.77	2.05	1.79	1.56	1.85	2.15	1.85
Every 5 days	1.28	1.32	1.80	1.47	1.26	1.52	1.71	1.49
Every 7 days	1.11	1.20	1.25	1.19	1.07	1.15	1.27	1.16
LSD at 5%		0.09				0.11		
Mean	1.32	1.43	1.70		1.29	1.51	1.71	

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تأثير فترات الري وهيومات البوتاسيوم على إنتاجية بنجر السكر

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أقيمت هذه الدراسة فى مزرعة خاصة بالصالحية الجديدة بمحافظة الشرقية . أجريت تجربتان حقليتان في موسمين (2016/ 2017 – 2018/2017) وذلك لدراسة تأثير ثلاث فترات ري (كل 3 ، 5 ،7 أيام) وإضافة مستويين من هيومات البوتاسيوم إلى جانب معاملة الكونترول (صفر – 2.5 كجم – 5 كجم/فدان) على بعض مكونات المحصول ، محصول العرش والجذور والسكر/فدان وكذلك على جودة العصير للجذور. كان الصنف المنزرع نانسي (متعدد الأجنة) ، وتم تنفيذ كل تجربة بنظام القطع المنشقة في ثلاث مكررات ، حيث وزعت فترات الري في القطع الرئيسية ومستويات هيومات البوتاسيوم في القطع الفرعية. أوضحت النتائج أن تقصير فترات الري من 7 إلى 3 أيام أدى إلى زيادة في قطر ووزن الجذر/نبات ، النسبة المئوية للمواد الصلبة الذائبة الكلية في العصير ونسبة الصوديوم في العصير ومحصول العرش والجذور والسكر/فدان ،وادت أيضا إلى نقص في نسبة السكروز ونقاوة العصير ونسبة البوتاسيوم والفا أمينو نيتروجين في العصير .زيادة معدل إضافة هيومات البوتاسيوم من 2.5 كجم إلى 5 كجم /فدان أدت إلى زيادة معنوية في صفات الجذر/ نبات (طول - قطر – وزن غض) ، محصول الجذور والعرش والسكر للفدان . وكذلك إلى تحسن صفات العصير (نسبة المادة الصلبة الذائبة الكلية- السكروز – النقاوة) كما أدى إلى زيادة نسبة البوتاسيوم ونقص في نسبة الصوديوم والفا أمينو نيتروجين في العصير. عوامل التجربة أثرت منفردة على بعض الصفات تحت الدراسة وكان لها تأثير تفاعلي مشترك على بعض الصفات الأخرى.