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PRODUCTIVITY OF SUGAR BEET AND FABA BEAN IN RELATION TO SOME SOIL AND WATER TABLE CHARACTERISICS

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ABSTRACT

Two field experiments were conducted at North Nile Delta (Kafr El-Shiek Governorate, Egypt), during the two successive seasons 2011 and 2012 to appraise the effect of distance from drain line on some soil properties and characteristics of sugar beet and faba bean crops, as will as determined the relation between the studied parameters. The main results could be summarized as follows:

1) The drop of water table level was faster above drain line than midway between drain lines. Where water table depth were 95.7, 71.3 and 57.9 cm under sugar beet and were 99.3, 70.3 and 55.9 cm under faba bean for above drain line, 1/4 and 1/2 distance from drain line, respectively.
2) A higher reduction of soil and water table salinity and soil moisture content was recorded above drain line more than that at 1/4 and 1/2 distances from drain line.
3) Gross sugar yield of sugar beet were higher by 360 and 530 Kg fed^{-1} and seed yield of faba bean were higher by 245 and 410 Kg fed^{-1} above drain line than at 1/4 and 1/2 distances from drain line, respectively.
4) A highly significant positive correlations were found between water table depth and characteristics of sugar beet (root length, root yield and gross sugar) and faba bean (root length, seeds yield and straw yield) crops. Also, a highly significant positive correlations were found among soil and water table salinity and soil moisture content.
5) A highly significant negative correlations were found between water table depth and water table salinity, soil salinity and/or soil moisture content. Also, similar correlations were detected among characteristics of sugar beet and faba bean plants and water table salinity, soil salinity and with moisture content.

Keywords: Drainage, Moisture, Clay Soil, Yield, Root Length, Sugar Beet, Faba Bean.

INTRODUCTION

Drainage plays a vital role in low permeable clay soils in order to prevent soil degradation. In Egypt, northern part of the Nile Delta represents large area of heavy clay soils with low permeability that might have a potential production. These soils are always threatened by a shallow saline groundwater, which is a permanent source of soil salinization that causes poor productivity (Abdel-Aal *et al*., 2006 and Moukhtar *et al*., 2010). Drainage objectives are met through two direct effects and large number of indirect effects (Osterbaan, 1994). The two direct effects are, 1) reduction in the average amount of water stored on/or in the soil, inducting drier soil conditions and reducing water logging. 2) Discharge of water through the system. The indirect effects of drainage system in soil resulted in lower water

table levels and drier soil. Lowering water table leads to better structure of top soil, higher infiltration and porosity. Also increasing soil aeration, drainable porosity, hydraulic conductivity, and reduce bulk density. Drainage in soil leads to disposing of the excess water and provides suitable salt balance and reduces soil salinity, soil sodicity and pH. In general, drainage system in soil resulted in improving soil properties as well as, improve the yield and quality of the crops (Antar, 2000 and Antar *et al*., 2012).

Crop growth and productivity are highly variable due to the spatial heterogeneity of soil properties (Zaman, 2002). Although sugar beet is considered a salt tolerant crop, it is important to evaluate its behavior under more favorable soil conditions. Sugar beet is an important crop for manufacturing sugar for complementary national provisions of sugar in Egyptian market. Sugar beet provides about 40% of the world's sugar production (Abd-el-Hadi *et al*., 2002). Sugar beet in Egypt has a considerably higher sugar content and short growth period compared with sugar cane. Sugar beet is widely grown in areas with salinity problems (Abdel-Aal *et al*., 2006 and Moukhtar *et al*., 2010). Faba bean (Vicia faba L.) is the most important legume crop in Egypt, due to its high nutritive value for human food and its role break crop in cereal rotation system. In northern parts of Egypt the planted faba bean area represent about 85% of the total planted faba bean area. (El-Galay, Ola *et al*., 2008).

Several researchers have investigated the relationship between soil water content and EC_e. Kachanoski *et al*. (1988) found significant correlation (r2 = 0.88 to 0.94) among variation of soil water content, soil solution electrical conductivity, and ECa measured with electromagnetic induction methods. Brevik *et al*. (2006) correlated the volumetric water content with EMI values and found a significant correlation (R2 = 0.70 or higher for four fields) for grasses temporally.

The current study aims to evaluate the effect of distance from drain line on some soil properties and the yields of sugar beet and faba bean plants, as will as determined the relation between studied parameters.

MATERIALS AND METHODS

Two field experiments were conducted at North Nile Delta (Islah-Perempal Region, Motobus District, Kafr El-Shiek Governorate, Egypt), during the two successive seasons 2011 and 2012 to evaluate the effect of distance from drain line on some soil properties and characteristics of sugar beet and faba bean plants, as will as determined the relation between the studied parameters. The field is provided by tile drains network spaced at 60 m with 1.4 m depth. The soil has a clayey texture; the average textural analysis for this soil is 13.3% sand, 32.3% silt and 54.4 % clay. The location is situated at 31°22′ 35″ N latitude and 30°31′ 15″ E longitude. The field was plowing two times with chisel plow to a depth of 20cm. and making traditional land leveling. The main source of irrigation water is mixed water. The salinity of irrigation water ranges between 1.01 - 1.08 dSm^{-1} with an average of 1.04 dSm^{-1}. The experiments were conducted in a completely randomized block design.

In the two winter seasons of 2011 and 2012 where sugar beet (*pleno variety*) and faba bean (*Vicia faba L.*) were planted. The different agricultural practices were done as recommended for two crops under study. To monitor water table fluctuation, observation wells were installed above and between drains at 1/2 and 1/4 distances from tile drain as recommended by Dieleman and Trafford (1976). Water table samples were collected from observation wells to measure the salinity of water table in all plots. Through the maturity stage of sugar beet and faba bean soil samples (0-15, 15-30, 30-60 and 60-90cm depth) were collected and determined for some soil parameters. Salinity was determined in the saturated soil paste extract according to Page *et al*. (1982). Soil moisture content (%) was determined by drying the soil samples at 105°C to constant weight and the moisture content was calculated according to Singh, (1980). Root lengths for both crops were measured before harvesting. Productivities for both crops with different treatments were determined and sucrose % in sugar beet root was determined. Gross sugar yield (ton fed^{-1}) was calculated by multiplying root yield (ton fed^{-1}) by sucrose %.

Statistical analyses for both crops were carried out by using computer programs according to Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Water table depths:

The results illustrated in Figures, 1 and 2 indicate that the water table depth increased rapidly with elapsing of the time after irrigation until it reached the highest values. The average values of water table depth after 14 days from irrigation were 119, 88 and 76 cm for above drain line, at 1/4 and at 1/2 distance between the drain line, respectively, under sugar beet plant. The corresponding values under faba bean plant were 117, 94 and 79 cm, respectively. The water table depth varies depending on the distance from drain line. Whereas, the drop of water table level was faster above the drain line than at midway between the drain line. The average values of water table depth were 95.7, 71.3 and 57.9 cm for above drain line, at 1/4 and at 1/2 distance from drain line, respectively, under sugar beet plant. The corresponding values under faba bean plant were 99.3, 70.3 and 55.9cm, respectively. This may be due to more effectiveness of drainage system near the drain line than that far from the drain line. Similar results were obtained by Gendy, *et al*, (2009) and Paulo Castanheira (2010).

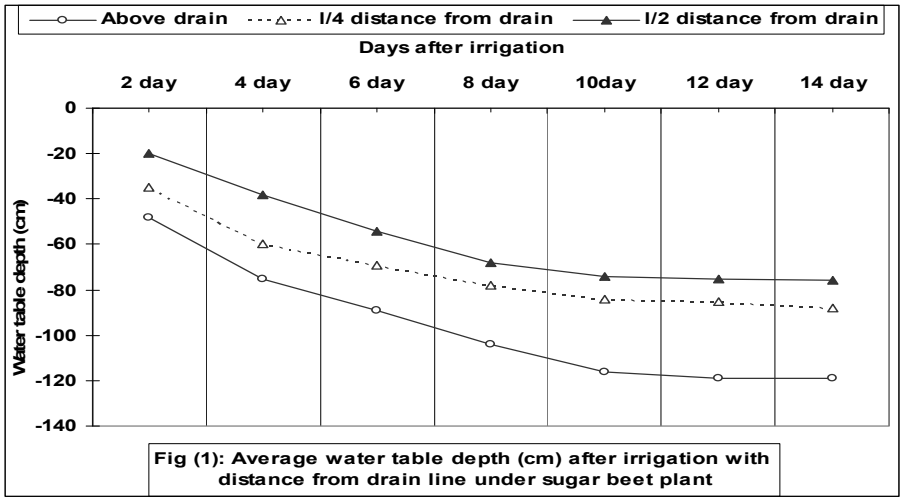


Fig (1): Average water table depth (cm) after irrigation with distance from drain line under sugar beet plant

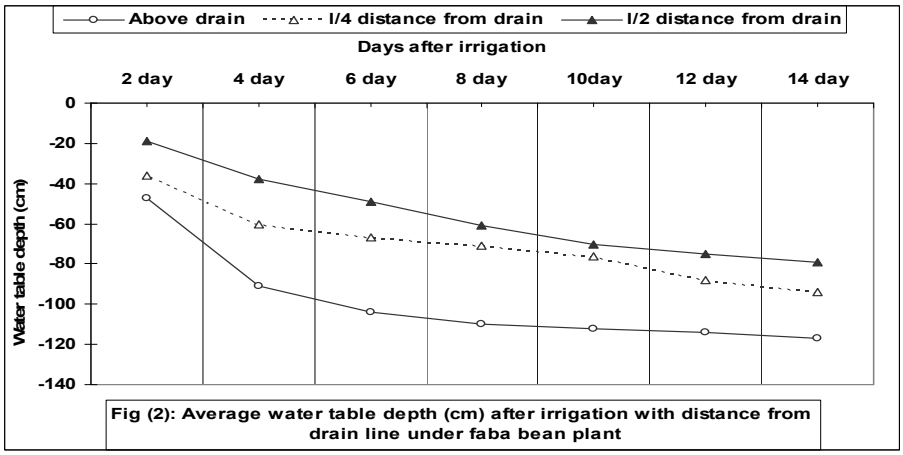


Fig (2): Average water table depth (cm) after irrigation with distance from drain line under faba bean plant

Soil and water table salinity:

Data in Table (1) show that soil salinity is increased markedly with the increasing of soil depth. Soil salinity in the topsoil up to 30cm, varies from 3.38 to 5.55 dSm^{-1} under both crops. The corresponding values in the deeper layers (30-90cm) are 4.45 to 7.75 dSm^{-1}. This trend may be due to an efficient leaching of salts in the surface layer, which is characterized with high porosity. The effect of distance from drain line on soil salinity is more pronounced with that above drain line as compared to those between drain lines. This may be due to the leaching of salts especially sodium salts in the area adjacent to the drain lines. The reduction of soil salinity (EC_e) above drain line are 0.89 and 1.60 dSm^{-1} under beet, and 0.74 and 1.84 dSm^{-1} under faba bean lower than that at 1/4 and 1/2 distance from drain line, respectively. These results are in agreement with those obtained by Ibrahim (1999) and Antar *et al* (2012).

Data in Table (1) clear that the salinity of water table is paralleled to soil salinity. Whereas, salinity values of water table above the drain line are lower

than that between drains. The values of water table salinity are 4.84, 6.42 and 7.37 dSm^{-1} under sugar beet and 4.49, 6.22 and 7.11 dSm^{-1} under faba bean for above drain line, at 1/4 and at 1/2 distance from drain line, respectively. This may be due to the drainage system near the drain line is more effectiveness than far from the drain line, which lead to lower water table depth and consequently leach more salts in the area adjacent to the drain lines. These results are in agreement with those obtained by Abo Waly, *et al*. (2012).

Table (1): Average of soil and water table salinity under sugar beet and faba bean crops as affected by the distance from drain line.

Distance from drain line	Soil depth (cm)	Sugar beet		Faba bean	
		Soil salinity (dSm^{-1})	Water table salinity (dSm^{-1})	Soil salinity (dSm^{-1})	Water table salinity (dSm^{-1})
Above drain	0-15	3.45	4.84	3.38	4.49
	15-30	3.75		3.78	
	30-60	4.78		4.67	
	60-90	4.78		4.45	
Mean		4.19		4.07	
l/4 distance from drain	0-15	3.79	6.42	3.97	6.22
	15-30	4.32		4.73	
	30-60	5.64		4.98	
	60-90	6.55		5.54	
Mean		5.08		4.805	
l/2 distance from drain	0-15	4.21	7.37	5.71	7.11
	15-30	4.85		5.55	
	30-60	6.33		6.14	
	60-90	7.75		6.22	
Mean		5.79		5.905	

Soil moisture contents

Soil moisture contents are considered as one of the parameters which indicate the status of soil structure and consequently, soil water, air and heat regimes. Soil moister redistributions as affected by distance from drain line is presented in Table 2 and Figures 3 and 4. Results show that soil moisture contents were higher after 2 days from irrigation and reduced in process of time until it reached the lowest values before the next irrigation. Soil moisture contents after 2 days from irrigation were varied from 37.08 to 53.31 % while, after 14 days from irrigation it varied from 21.23 to 39.81% due to evapotranspiration process and lowering of water table depth with elapsing of the time after irrigation (Figs. 1 and 2).

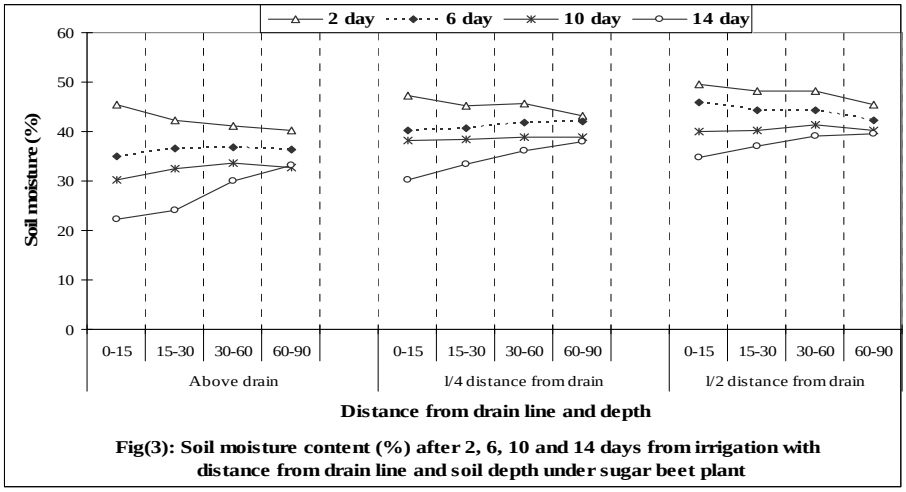
Data also show that, soil moisture contents 2 days after irrigation are higher in the topsoil layers and decrease with increasing soil depth. Values of soil moisture continents, after 2 days from irrigation range from 45.36 to 53.31 % in the upper layers and 37.08 to 45.83% in the deeper layers. This due to the addition of irrigation water. On the other hand, the reverse trend is found after 14 days from irrigation, some soil moisture contents are low in the topsoil layers and increase with increasing soil depth. Values of soil moisture

continent after 14 days from irrigation ranged from 21.23 to 34.68 % in the upper layers and 33.16 to 39.72 % in the deeper layers. This is due to the lowering of water table level before the next irrigation (Figs. 1 and 2) which leads to increase of soil aeration in the root zoon and consequently reduce of soil moisture content.

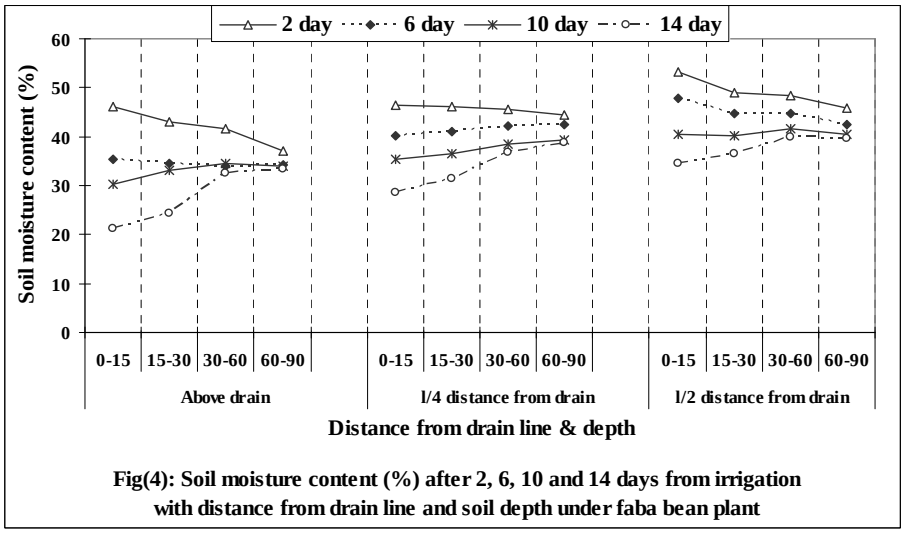
Data indicated that distance from drain line affect clearly soil moisture content. Results in Table 2 and Figures 3 and 4 shows that soil moisture contents above the drains line are lower than that between drain lines and are superior in surface soil layers. Also, the superior decreases of soil moisture content above drain lines compared to that between drains are found before the next irrigation. Under sugar beet, soil moisture contents are lower above drain by 7.26, 13.96, 19.73 and 25.62% than that at 1/4 distance from drains and about 13.10, 22.14, 25.40 and 37.13 % than that recorded at 1/2 distance from drain lines after 2, 6, 10 and 14 days from irrigation, respectively. Also, under faba bean, the mean values of soil moisture content above drain line are 41.99, 34.44, 32.93 and 27.89% after 2, 6, 10 and 14 days from irrigation, respectively. The corresponding values are 45.62, 41.47 37.45 and 33.92% at 1/4 distance from drain line and are 49.11, 44.95, 40.66 and 39.72% at 1/2 distance from drain line. This may be due to improve the drainage conditions in the area adjacent to the drain lines. Whereas, cycles of drying and wetting of soil decrease soil compaction and improves soil properties. Also, lowering water table by drainage gave the top soil layer a chance to dry and permitted shrinkage and formation of water passage ways which allowed a rather easier movement of water into drain pipes.

Table (2): Average of soil moisture content (%) with days after irrigation under sugar beet and faba bean crops with distance from drain line.

Distance from drain line	Soil depth (cm)	Days after irrigation of sugar beet				Days after irrigation of faba bean			
		2 day	6 day	10 day	14 day	2 day	6 day	10 day	14 day
Above drain	0-15	45.36	35.02	30.18	22.26	46.25	35.24	30.22	21.23
	15-30	42.35	36.54	32.44	24.14	43.08	34.43	33.21	24.44
	30-60	41.21	36.75	33.71	30.08	41.56	33.86	34.41	32.45
	60-90	40.25	36.40	32.62	33.16	37.08	34.22	33.86	33.45
Mean		42.29	36.18	32.24	27.41	41.99	34.44	32.93	27.89
l/4 distance from drain	0-15	47.24	40.25	38.24	30.27	46.28	40.33	35.43	28.64
	15-30	45.26	40.65	38.33	33.42	46.20	40.97	36.64	31.52
	30-60	45.65	41.88	38.95	36.14	45.65	42.12	38.42	36.87
	60-90	43.27	42.15	38.87	37.88	44.35	42.44	39.32	38.65
Mean		45.36	41.23	38.60	34.43	45.62	41.47	37.45	33.92
l/2 distance from drain	0-15	49.54	45.87	40.08	34.68	53.31	47.83	40.34	34.62
	15-30	48.15	44.32	40.13	37.05	48.86	44.76	40.13	36.42
	30-60	48.21	44.36	41.28	39.08	48.44	44.67	41.74	39.81
	60-90	45.42	42.22	40.21	39.55	45.83	42.52	40.44	39.72
Mean		47.83	44.19	40.43	37.59	49.11	44.95	40.66	37.64



Fig(3): Soil moisture content (%) after 2, 6, 10 and 14 days from irrigation with distance from drain line and soil depth under sugar beet plant



Fig(4): Soil moisture content (%) after 2, 6, 10 and 14 days from irrigation with distance from drain line and soil depth under faba bean plant

Yields:

Sugar beet crop:

The average of sugar beet roots length in relation to water table depth and soil moisture content under different distances from drain line is presented in Table (3). Results indicate that distance from drain line highly significantly affect sugar beet root lengths and consequently crop yield. Results showed also that there is an increment in root length of sugar beet with near the drain line; the root length are 35, 31 and 29 cm for above drain, at 1/4 and at 1/2 distance from drain line, respectively. These increments of sugar beet root length with decrement the distance from drain line may be due to deeper water table depth and consequently improving soil properties which affects water-air relationships in the root zone and root penetration. Similar results were obtained by Abdel-Aal *et al*., (2006).

Data in Table (3) indicate that distance from drain line affect significantly sugar beet production. Data show that there is an increment in sugar beet production with decrement the distance from drain line. The average root yield are 34.01, 32.02 and 31.24 ton fed^{-1} for above drain line, 1/4 and 1/2 distance from drain line, respectively (1 fed ≈ 4200m^2). This trend may be due to improving drainage conditions near the drain line which caused water-air balance in the root zone, and increasing the amount of available nutrients for the plant. Similar results were obtained by Abdel-Aal *et al*., (2006), Moukhtar *et al*. (2010) and Antar *et al*., (2012). Data show also that, there are no obvious differences between sugar percentages in all treatments. Gross sugar yield in all treatments are paralleled to the root yields values. Gross sugar yield above the drain line is higher by 0.36 and 0.53 ton fed^{-1} than that at 1/4 and 1/2 distance from drain line, respectively. These results were confirmed by the work of Antar *et al*.(2012).

Table (3): Root length, root yield and gross sugar of sugar beet crop as affected by the distance from drain line.

Distance from drain line	Root length (cm)	Root yield (ton $fed.^{-1}$)	Sugar (%)	Gross sugar (ton fed^{-1})
Above drain line	35a	34.01a	17.71	6.02
L/4 distance from drain	31ab	32.02ab	17.69	5.66
L/2 distance from drain	29b	31.24b	17.56	5.49

Faba bean crop:

Results in Table (4) show the faba bean root length and yields in relation to water table depth and soil salinity in the different distance from drain line. Results show that there is significant increment in faba bean production with decrement the distance from drain line. The average root lengths are 27, 22 and 19 cm for the plants grown above drain line, 1/4 and 1/2 distance from drain line, respectively. These increments of faba bean root lengths with decrement the distance from drain line treatments are the result of deeper water table depth, and consequently improves soil properties which affects water-air relationships in the root zone and root penetration. These results were agreed with those obtained by Moustafa *et al*., (1987).

Data also show that the faba bean seeds yield above the drain are higher by 1.63 ardab fed^{-1} than that at 1/4 distance from drain line and about 2.73 ardab fed^{-1} than that at 1/2 distance from drain line (1 ardab ≈ 150 Kg). Straw yield of faba bean above drain are higher than that at 1/4 and 1/2 distance from drain line by about 9.09 and 14.71 %, respectively. These results may be due to the effect of drainage on conditioning water-air relationship in the root zone and its effect on mobility of nutrients in root zoon which cause more vegetative growth and subsequently produce a higher yield. These results were confirmed by the work of Moustafa *et al*., (1987) and Antar, (2000).

Table (4): Root length, seeds yield and straw yield of faba bean crop as affected by the distance from drain line.

Distance from drain line	Root length (cm)	Seeds yield (ardabfed^{-1})	Straw yield (ton fed^{-1})
Above drain line	27a	10.33a	2.23
L/4 distance from drain	22ab	8.7ab	2.04
L/2 distance from drain	19b	7.6b	1.94

Relation between some parameters of soil and studied plants:

Tables (5 and 6) show the correlations between some soil properties and characteristics of sugar beet and faba bean plants. The values reveal that the sugar beet and faba bean characteristics are mainly dependent on soil properties, such as water table depth and salinity, soil salinity and soil moisture content. A high significant positive correlations are found between water table depth and characteristics of sugar beet and faba bean plants. Whereas, the increase of water table depth leads to increase of root length, root yield and gross sugar yield for sugar beet plant. Also, the increase of water table depth leads to increase of root length, seeds yield and straw yield of faba bean plant. On the other hand, a highly significant negative correlations are found between water table depth and water table salinity, soil salinity and soil moisture content. Whereas, the increase of water table depth leads to decrease of water table salinity, soil salinity and soil moisture content. Data also, show a high significant negative correlations among characteristics of sugar beet and faba bean plants and water table salinity, soil salinity and moisture content. This indicate that the high salinity of water table and soil and high moisture content reduce root length, root yield and gross sugar yield of sugar beet plant. Also, the high values of soil and water table salinity and moisture content reduce root length, seeds and straw yields of faba bean plant. Also a high significant positive correlations are found among soil and water table salinity and soil moisture content. Whereas, increasing rates of soil and water table salinity are equal to increasing rate of soil moisture content, as well as, increasing soil salinity leads to increase of water table salinity. A high significant positive correlations are found among root length and/or root yield and/or gross sugar beet yield. This trend indicates that the increase of root length increases the root yield, gross sugar yield and gross sugar yield. Also, a high significant positive correlations are found among root length and/or seeds yield and/or straw yield of faba bean. This indicates that the increase of root length increases of seeds and straw yields, and the increase of seeds yield is due to increase of straw yield.

Table (5): Correlations between sugar beet parameters and some soil properties.

Parameter	Water table depth (cm)	Water table salinity dS-m^{-1}	Soil salinity dS-m^{-1}	Soil moisture content (%)	Root length (cm)	Yield tonfed^{-1}	Gross sugar tonfed^{-1}
Water table depth (cm)	1.00						
Water table salinity, dSm^{-1}	-0.96	1.00					
Soil salinity, dSm^{-1}	-0.68	+0.68	1				
Soil moisture content (%)	-0.98	+0.97	+0.72	1			
Root length (cm)	+0.88	-0.89	-0.52	-0.89	1		
Yield, tonfed.$^{-1}$	+0.86	-0.82	-0.56	-0.82	+0.73	1.00	
Gross sugar, tonfed.$^{-1}$	+0.76	-0.79	-0.67	-0.77	+0.79	+0.75	1.00

Table (6): Correlations between faba bean parameters and some soil properties.

Parameter	Water table depth (cm)	Water table salinity dS-m^{-1}	Soil salinity dS-m^{-1}	Soil moisture content (%)	Root length (cm)	Yield tonfed^{-1}	Gross sugar tonfed^{-1}
Water table depth (cm)	1.00						
Water table salinity, dSm^{-1}	-0.97	1.00					
Soil salinity, dSm^{-1}	-0.85	+0.85	1.00				
Soil moisture content (%)	-0.97	+0.95	+0.89	1.00			
Root length (cm)	+0.92	-0.94	-0.80	-0.89	1.00		
Yield, tonfed.$^{-1}$	+0.97	-0.97	-0.90	-0.96	+0.92	1.00	
Gross sugar, tonfed.$^{-1}$	+0.53	-0.56	-0.58	-0.52	+0.51	+0.53	1.00

Conclusion: Sugar beet and faba bean characteristics is mainly dependent on soil properties, such as water table depth and salinity, soil salinity and moisture content. Whereas, decreasing the distance towards the drain line resulting in lowering of water table level, soil salinity and moisture content that led to improve soil properties and consequently improve sugar beet and faba bean yields.

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انتاجية بنجر السكر والفول البلدى وعلاقته ببعض خواص التربة و الماء الارضى

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أجريت تجربتان حقليتان بمنطقة شمال الدلتا (محافظة كفر الشيخ- مصر) خلال موسمي النمو ٢٠١١ و ٢٠١٢ وذلك لدراسة تأثير المسافة من خط المصرف على بعض خصائص التربة وصفات بنجر السكر والفول البلدي وكذلك تحديد العلاقة بين الصفات المدروسة. وقد ابرزت النتائج الاتى:

١) سرعة هبوط مستوى الماء الارضى فوق خط المصرف عنه عند منتصف المسافة بين خطوط المصارف. حيث سجل مستوى الماء الارضى ٩٥.٧ ، ٧١.٣ و ٥٧.٩ سم تحت محصول البنجر بينما سجل ٩٩.٣، ٧٠.٣ و ٥٥.٩ سم تحت محصول الفول البلدى لكل من المعاملات فوق خط المصرف ،عند ربع ومنتصف المسافة بين خطوط المصارف على الترتيب.

٢) انخفاض درجة ملوحة التربة والماء الارضى وكذلك محتوى التربة من الرطوبة فوق خط المصرف مقارنة بها عند عند ربع ومنتصف المسافة بين خطوط المصارف.

٣) ازداد انتاج السكر الخام لمحصول البنجر بحوالى ٣٦٠ و ٥٣٠ كجم/فدان كذلك ازداد محصول حبوب الفول البلدى بحوالى ٢٤٥ كجم و ٤١٠ كجم/ فدان فوق خط المصرف عنها عند ربع ومنتصف المسافة بين خطوط المصارف على التوالى.

٤) وجود ارتباط موجب عالى المعنوية بين مستوى الماء الارضى وصفات كل من محصولى بنجر السكر والفول البلدى.وكذلك بين كل من ملوحة التربة والماء الارضى ومحتوى التربة من الرطوبة.

٥) وجود ارتباط سالب عالى المعنوية بين مستوى الماء الارضى وملوحة الماء الارضى والتربة او محتوى التربة من الرطوبة. كذلك بين كل من صفات كل من محصولى بنجر السكر والفول البلدى.و ملوحة التربة والماء الارضى ومحتوى التربة من الرطوبة.

الاستنتاج: تعتمد صفات محصولى بنجر السكر والفول البلدى اعتمادا كبيرا على خواص التربة مثل مستوى الماء الارضى وملوحته وكذلك ملوحة التربة ومحتواها الرطوبى. حيث انه بتقليل المسافة فى اتجاه خط المصرف يعمل ذلك على انخفاض مستوى الماء الارضى وملوحة التربة وكذلك محتواها الرطوبى مما يؤدى الى تحسين خواص التربة وينتج عن ذلك تحسن فى محصولى بنجر السكر والفول البلدى.

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