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Effect of some soil amendments on yield and quality traits of sugar beet (*Beta vulgaris* L.) under water stress in sandy soil

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TO STUDY the ability of soil amendments treatments for improving sugar beet quality and yield with reduce quantities of mineral nitrogen fertilizer under water stress. Two field experiments were carried out at Wadi El-Natrun, El-Beheira Governorate, Egypt, during 2014/2015 and 2015/2016 growing seasons. Compost and bentonite as soil amendments solely or mixed and two nitrogen rates (216 and 288 kg N/ha) under water stresses (100, 75 and 50% of irrigation water requirements, IWR) using a drip irrigation system were applied. The obtained results showed that increasing water stress up to 50% of water requirement significantly decreased sugar lost in molasses, root and sugar yields. While, it increased sucrose % and sugar extractable. Decrease nitrogen fertilizer from 100% to 75% of recommended rate (288 kg N/ha) significantly decreased root and sugar yields, however, increased sucrose % and sugar extractable. Application of 12 ton/ha compost or bentonite as well as mixed 6 ton/ha of each of them led to a significant increase in all studied traits. Compost followed by bentonite was the best treatments. The maximum values of root and sugar yields were produced from the interaction between irrigation without water stress and fertilization by 216 or 288 kg N/ha and application of 12 ton/ha compost in the second season.

Keywords: Bentonite, Compost, Nitrogen, Sugar beet, Sandy soil, Water stress.

Introduction

Sandy soils are described by low fertility and holding water capacity (Goa et al., 1998). Sandy soil as Wadi El-Natrun area could be considered as one of the encouraging areas for agricultural expansion but a lot of hydrological problems face many reclamation projects in Wadi El-Natrun area. Therefore, great efforts and many investigations have been carried out taking into consideration, avoiding the different side effects of development. Sugar-beet (*Beta vulgaris* L.) is a drought resistant crop that could produce a valuable yield even with declines irrigation (Winter, 1980). Sugar beet can be grown in a wide range of environment conditions and is noted for its tolerance to salinity and adapted to water stress (Monreala et al., 2007). The global climate change next to the limited water components are the most important factors at all in the field of crop production. Due to increasing use water cost and decreased available water in these regions, water stress has been the center of much attention (Winter, 1980). Drip irrigation one of the modern irrigation methods which have a significant role in increasing water use efficiency. Sharmasarkar et al. (2001) reported that sugar beet yield and sucrose content were better under drip irrigation system. Mahmoodi et al. (2008) showed that 70% of field capacity was the best soil-water content which provided the highest values of yields. Also, Masri et al. (2015) revealed that the maximum values of quality traits were recorded in drip irrigated sugar beet with 75% of IWR.

Nitrogen is the most important elements in sugar beet productivity and the production extensively reduced to half due to decline of nitrogen fertilizer in soil (Cooke & Scott, 1993). Mahmoud & Masri (2009) reported that the dose

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of nitrogen (160 kg N/fad) significantly increased root weight (8.34 ton/fad) in both seasons. Masri et al. (2015) reported that increasing nitrogen fertilizer levels from 60 up to 120 kg N/fad significantly increased the root yield in both seasons and white sugar yield (ton/fad) only in the first season. El-Hassanin et al. (2016) found that decreasing nitrogen fertilization level from 90 kg to 36 kg/fad significantly decreased sucrose %, sugar lost in molasses, extractability percentage and yields ton/fad in both seasons of sugar beet. Also, Abdel-Motagally (2016) concluded that the nitrogen dose at three folds of plant growth stages lead to raise the yield and quality of sugar beet.

Compost as an organic soil amendment is a main source of humans, which found as resulted of organic material decomposition. Compost is improves the soil physical and chemical properties and increasing water holding capacity. Wallace & Carter (2007) showed that the using of compost increases soil fertility which led to increasing sugar beet root yield by 7%. Mahmoud et al. (2014) found that adding of compost (2 ton/fad) gave the maximum values of root yield, as well as improved juice quality traits of sugar-beet. Also, application 12 ton/ha of compost with drip irrigation system improved root yield of sugar-beet (Masri et al., 2015).

Bentonite as an inorganic soil amendment is a rock containing clay minerals (Tawfiq, 2009) and has been documented in several countries as good amendments to increase the properties of such infertile sandy soil (Satje & Nelson, 2009). Bentonite can significant increases cation exchange capacity (CEC) in soil as a source of negative charge as well as the availability of nutrients, enhancing agricultural productivity and improving fertilizer use efficiency (Noble & Suzuki, 2005). Anas et al. (2009) found that the application of composts and bentonite led to the best use efficiency of available water and nutrients for maximizing growth and yield of peanut. Reguieg et al. (2011) and Hassan & Mahmoud (2013) showed that the application of bentonite increased the growth and yield of faba bean and corn. Shaheen et al. (2013) showed that adding of bentonite in sandy soil had a significant effect on yield and quality of potato. Eldardiry & Abd El-Hady (2015) found that the increasing bentonite rates from 0 to 8% revealed increasing of barley grains and straw. Therefore, under the current circumstances and future, it has become the mandatory application of the appropriate methods to conserve water and reduce chemical inputs in the field of crop production. The aim of this work is to study the effect of organic and inorganic soil amendments on yield, and quality traits of sugar beet in sandy soil under water stress.

Materials and Methods

Two field experiments were conducted at Wadi El-Natrun (30º 23′ 19.89″ N latitude, 30 º 21′ 41.06″ E longitude and the latitude is 17.98 m above the sea), El-Beheira Governorate, Egypt during 2014/2015 and 2015/2016 growing seasons to study the effect of some soil amendments on quality and yield of sugar beet plant under water stress using a drip irrigation system.

Materials

Soil samples

The experimental soil samples were collected from two successive depths (0-30 cm) and (30-60 cm) from soil surface before cultivation to determine some physical and chemical properties of soil according to Chapman & Pratt (1961) and the description was given in Table 1. However, data in Table 1 illustrate some physical and chemical characteristics of the experimental soil. As shown in this table, soil texture is considered a sandy, where the mean of the two seasons were over 90% sand, 2.0% silt and 5.24% clay. The soil pH was alkaline (8.00). The analysis also illustrate that soil is non saline where electrical conductivity (EC) was 1.45 dSm^{-1} less than 4 dSm^{-1}. Soil organic matter content was poor (0.13).

Irrigation water samples

Chemical characteristic irrigation water is shown in Table 2. As shown in this table, the soil pH was (7.10) and electrical conductivity (EC) was recorded (2.10 dSm^{-1}). It shows that this soil has permissible saline.

Sugar beet seeds

Multi-germ variety Beta Poly Tery imported from Hungary was sown on October, 30^{th} in the first season and November, 1^{st} in the second season.

Treatments

the experiment included 24 treatments, represented a combination between three water levels 100, 75 and 50% of irrigation water requirement (IWR), four soil amendment treatments (without, 12 ton/ha compost, 12 ton/ha bentonite and 6 ton/ha compost + 6 ton/ha bentonite) and two nitrogen fertilizer levels 100 and 75% of recommending rate (288 kg N/ha).

TABLE 1. Soil physical and chemical properties of the experimental soil site.

Soil analysis	2014	2015
Particular size distribution (%)		
Coarse sand	53.40	56.30
Fine sand	39.36	32.46
Silt	2.00	2.00
Clay	5.24	9.24
Texture class	Sandy	Sandy
EC (ds/m)	2.1	1.95
pH (soil paste)	7.90	8.10
Organic matter (%)	0.23	0.34
Soluble anions (mg/L)		
CO_3	-	-
HCO_3	1.00	1.20
Cl	10.30	11.50
SO_4	8.70	9.47
Soluble cations (mg/L)		
Ca	6.40	7.20
Mg	7.20	6.80
Na	11.1	5.70
K	0. 70	0.37
Macronutrients (ppm)		
N	30.00	25.00
P	20.00	22.00
K	220.00	128.00
Fe	2.14	3.40
Cu	0.24	0.54
Zn	1.9	2.5
Mn	4.4	4.0

TABLE 2. Chemical characteristic of irrigation water.

EC	pH	Soluble anions (mg/L)				Soluble cations (mg/L)			
(ds/m)		CO_3	HCO_3	Cl	SO_4	Ca	Mg	Na	K
1.85	7.10	-	3.6	3.75	9.84	4.22	4.47	6.40	2.10

Application of chemical fertilizations and soil amendments

compost and bentonite were added before sowing. Thinning process was done to one plant/hill at 4 leaf stage (after 2 weeks from sowing). Nitrogen fertilizer was added in the form of ammonium nitrate (33.5% N) in three equal doses; the first was applied after thinning and the second and third were added at one and two months later. Phosphorus was added in the form of super-phosphate (15.5% P_2O_5) at rate 72 kg/ha before sowing and during land preparation. Potassium was added in the form of potassium sulfate (48% K_2O) at the rate 115.2 kg/ha with the first dose of nitrogen. The chemical analysis of applied bentonite and compost are presented in Tables 2 and 3.

Application of irrigation water

Drip irrigation system was done through narrow tubes that deliver water directly to the base of the plant and irrigation water used in the experiment was pumped from a well. The amounts of applied water for the three water stress (average of two growing seasons) were 6012, 4664.4 and 3172.8 m^3ha^{-1} for 100, 75 and 50% of (IWR), respectively. Amount of irrigation water requirements was determined using Blany & Criddle (1962) method and its chemical analysis is given in Table 4.

TABLE 3. Chemical analysis of Compost (%).

Compost analysis	Unit	Concentration
Weight of m³	kg	680
Moisture content	%	16.60
pH		7.86
EC	ds/m	4.46
Ammonium nitrogen	ppm	141
Nitrate nitrogen	ppm	19.60
Total nitrogen	%	1.03
Organic matter	%	31
Organic carbon	%	17.50
Ashes	%	69
C/N ratio		1:17
Total phosphoric	%	1.25
Total potassium	%	1.34
Weed seeds		Not found
Nematode	larva/200 gm	Not found
Fecal coliform	cell/gm	Not found
Salmonella bacterium	cell/gm	Not found

TABLE 4. Chemical analysis of bentonite (%).

O.M	$CaCO_3$ (g/kg)	$CaSO_4$ (g/kg)	EC (ds/m)	pH	Soluble anions (mg/L)			Soluble cations (mg/L)			
					CO_3^{--} + HCO_3^-	Cl^-	SO_4^{--}	Ca++	Mg++	Na+	K+
nil	149.1	3.6	3.9	7.10	0.24	0.59	1.34	0.79	0.27	1.95	0.02

Quality traits and yield measurements

At harvest (180 days from sowing), the three guarded central rows of each plot were harvested and cleaned to determine the following traits in both seasons.

Juice quality

1-Sucrose percentage was determined by using Saccharometer according to Carruthers & Oldfield (1960).

2-Sugar lost in molasses (SM%)

Sugar lost in molasses=0.14 (V1+V2) + 0.25 (V3) + 0.50 (Devillers, 1988).

3-Sugar extractable (%)

Sugar extractable =V4-SM-0.6 (Dexter et al., 1967)

where: V_1=Sodium. V_2= Potassium. V_3= α-amino N. V_4 = Pol%

Yields

1- Top yield (ton/ha).
2- Root yield (ton/ha).
3- Sugar yield (ton/ha)

Sugar yield = Root yield (ton/ha) x Sugar extraction %.

Experimental design and statistical analysis

A split–split plot design with three replications was done. The experiment included 24 treatments, represented the combination among three water stress occupied the main plots, four soil amendments allocated in the sub plots and two nitrogen levels were randomly distributed in the sub-sub plots. Each sub-sub plot area was 10.5 m², 5 ridges, 3.5 m long and 60 cm apart and spacing between hills were 20 cm. All data were exposed to statistical analysis. The least significant differences (LSD) values at 5% level of probability according to Snedecor & Cochran (1989).

Results and Discussion

Juice quality

Effect of water stress

According to Tables 5 and 6, irrigated sugar beet with 100% of IWR gave significantly the minimum sucrose percentage (17.56 and 17.73%) in both seasons. After which irrigation with 75% of IWR with the average sucrose (17.93% and 18.05%) were the second rank and increasing water stress to 50% of IWR with (18.56 and 18.50%) had the maximum sucrose the third one. There was a significant difference between the levels 100% and 75% of IWR and also between these two levels and water stress at 50 % of IWR. These results are in harmony with obtained by Abyaneh et al. (2017) who reported that the increasing of nitrogen and irrigation water applications reasons a decrease in the sugar content.

Sugar lost in molasses and sugar extractable percentages had the same trend where the highest values recorded 1.90 and 16.06% in the first season and 2.17 and 15.73% in the second season, respectively were detected from irrigated by 50% of IWR. The results are similar to Esmaeili (2011) and Masri et al. (2015). Furthermore, Kaur et al. (2007) reported that, under water shortage, the higher sucrose content accompanied by higher sugar phosphate synthetase and lower acid invertase activities in roots.

Effect of nitrogen rates

Decreasing nitrogen fertilizer rate from 100% to 75% of recommended rate tended to significantly increase the sucrose % from 17.85 to 18.18% and 17.97 to 18.22% in the two seasons, respectively and sugar extractable from 15.40 to 15.83% and 15.26 to 15.58%. On the other hand, decreasing nitrogen from 100 to 75% of recommended rate significantly decreased sugar lost in molasses from 1.84 to 1.76% and 2.11 to 2.04% in two seasons, respectively (Tables 5 and 6).

The decrease in sucrose % owing to increasing nitrogen fertilizer level can be attributed to its role in increasing impurities such as α-amino acid and hence increasing sugar lost in molasses thus decreasing sucrose content in roots. The results are similar to Esmaeili (2011). Previously, Milford & Watson (1971) showed that nitrogen fertilizer increased the fraction of the assimilate entering the root that was used in plant growth at the expense of that stored as sugar. Also, Weeden (2000) explained that with an increase of nitrogen in soil, amino acid in root increases that it causes sugar crystallization and so decreasing of extractable sugar.

Effect of some soil amendments

Soil amendments under study significantly increased sucrose %, sugar lost in molasses % and sugar extractable % in the two seasons as compared to control (without soil amendments) (Tables 5 and 6). Application of 12 ton/ha compost or bentonite gave the maximum values of sucrose 18.92 and 18.36% in the first season and 18.58 and 18.75% in the second season. Data on hand revealed that no significant differences between the application of compost or bentonite were observed in both seasons. Data also found that there was no significant difference between compost and bentonite or compost + bentonite for sugar lost in molasses % in both seasons. Regarding sugar extractable %, the addition of 12 ton/ha compost gave the highest value 16.45% in the first season. While in the second season the highest value was 16.06% produced from the addition of 12 ton/ha bentonite to the soil. This finding agreed with obtaining by of Kabil et al. (2015). However, compost led to increasing of photosynthetic process and leaf area which revealed in increase sugar production (Molnou et al., 2008). Moreover, bentonite plays a significant role in providing plants with needs of sufficient water and nutrients that should recover to form good quality (Eldardiry & Abd El-Hady, 2015).

Effect of interactions

The first order interaction: Water deficient and nitrogen rates interaction significantly effected sucrose and sugar lost in molasses but sugar extractable didn't significantly affect in the two seasons. The highest values of sucrose % were produced from beet irrigated by 50% of water requirement and addition of nitrogen at 75% of the recommended rate. Data also, found that the best interaction gave the lowest sugar lost in molasses was resulted from 100% of IWR and fertilization of nitrogen at 75% of the recommended rate in the two seasons.

TABLE 5. Effect of some soil amendments, water stress and nitrogen rates on sucrose %, sugar lost in molasses and sugar extractable of sugar beet in sandy soil in 2014/2015 season.

Treatments		Sucrose %				Sugar lost in molasses				Sugar extractable			
		Water stress (W)											
Soil amendments (A)	Nitrogen rates (N)	100%	75%	50%	Mean	100%	75%	50%	Mean	100%	75%	50%	Mean
Control	100%	16.60	16.66	17.21	16.86	1.57	1.70	1.81	1.69	14.43	14.47	14.80	14.57
	75%	16.24	16.57	16.90	16.57	1.55	1.63	1.73	1.64	14.09	14.34	14.57	14.33
Mean		16.42	16.67	17.06	16.72	1.56	1.66	1.77	1.66	14.26	14.41	14.68	14.45
Compost	100%	17.37	18.00	18.87	18.08	1.83	1.90	2.00	1.91	14.94	15.50	16.27	15.57
	75%	19.07	19.83	20.35	19.75	1.72	1.81	1.93	1.82	16.75	17.42	17.82	17.33
Mean		18.22	18.92	19.61	18.92	1.78	1.86	1.97	1.87	15.84	16.46	17.04	16.45
Bentonite	100%	17.69	17.91	18.78	18.13	1.76	1.88	2.02	1.89	15.33	15.43	16.16	15.64
	75%	18.25	18.40	19.15	18.60	1.70	1.79	1.88	1.79	15.95	16.01	16.67	16.21
Mean		17.97	18.16	18.97	18.36	1.73	1.83	1.95	1.84	15.64	15.72	16.41	15.92
Compost + Bentonite	100%	17.82	18.15	19.00	18.32	1.79	1.87	1.98	1.88	15.43	15.68	16.42	15.84
	75%	17.42	17.80	18.19	17.80	1.72	1.77	1.84	1.78	15.10	15.43	15.75	15.43
Mean		17.62	17.98	18.60	18.06	1.75	1.82	1.91	1.83	15.27	15.55	16.09	15.63
Mean of N%	100%	17.37	17.71	18.47	17.85	1.74	1.84	1.95	1.84	15.03	15.27	15.91	15.40
	75%	17.75	18.15	18.65	18.18	1.67	1.75	1.85	1.76	15.47	15.80	16.20	15.83
Mean		17.56	17.93	18.56	18.01	1.71	1.79	1.90	1.80	15.25	15.54	16.06	15.61
Water stress (W)			0.35				1.98					0.29	
Nitrogen rates (N)			0.14				0.07					0.07	
Soil amendments (A)			0.58				0.19					0.13	
W*N			0.23				0.15					N.S	
W*A			0.60				N.S					N.S	
N*A			0.49				N.S					N.S	
W*N*A			0.85				N.S					N.S	

TABLE 6. Effect of some soil amendments, water stress and nitrogen rates on sucrose %, sugar lost in molasses and sugar extractable of sugar beet in sandy soil in 2015/2016 season.

Treatments		Sucrose %				Sugar lost in molasses				Sugar extractable			
		Water stress (W)											
Soil amendments (A)	Nitrogen rates (N)	100%	75%	50%	Mean	100%	75%	50%	Mean	100%	75%	50%	Mean
Control	100%	16.80	17.12	17.40	17.11	1.88	1.99	2.09	1.99	14.32	14.53	14.71	14.52
	75%	15.98	16.61	17.01	16.53	1.85	1.97	2.03	1.68	13.53	14.04	14.38	13.99
Mean		16.39	16.87	17.21	16.82	1.86	1.98	2.06	1.83	13.93	14.29	14.55	14.25
Compost	100%	17.65	17.93	18.34	17.97	2.09	2.16	2.24	2.16	14.96	15.17	15.50	15.21
	75%	18.88	19.11	19.54	19.18	1.99	2.08	2.17	1.81	16.29	16.43	16.77	16.50
Mean		18.27	18.52	18.94	18.58	2.04	2.12	2.21	1.99	15.63	15.80	16.13	15.85
Bentonite	100%	18.08	18.43	18.82	18.44	2.00	2.11	2.26	2.13	15.48	15.72	15.96	15.72
	75%	18.52	18.93	19.72	19.06	1.97	2.05	2.16	1.79	15.95	16.28	16.96	16.40
Mean		18.30	18.68	19.72	18.75	1.99	2.08	2.21	1.96	15.71	16.00	16.46	16.06
Compost + Bentonite	100%	18.08	18.32	18.61	18.34	2.04	2.15	2.24	2.14	15.44	15.57	15.77	15.59
	75%	17.81	17.96	18.53	18.10	1.97	2.06	2.16	1.80	15.24	15.30	15.77	15.43
Mean		17.81	18.14	18.57	18.22	2.01	2.10	2.20	1.97	15.34	15.44	15.77	15.51
Mean of N%	100%	17.65	17.95	18.29	17.97	2.00	2.10	2.21	2.11	15.05	15.25	15.48	15.26
	75%	17.80	18.15	18.70	18.22	1.94	2.04	2.13	2.04	15.25	15.51	15.97	15.58
Mean		17.73	18.05	18.50	18.09	1.97	2.07	2.17	2.07	15.15	15.38	15.73	15.42
Water stress (W)			0.24				0.10				0.25		
Nitrogen rates (N)			0.25				0.08				0.21		
Soil amendments (A)			0.36				0.16				0.17		
W*N			0.25				0.14				N.S		
W*A			0.55				N.S				N.S		
N*A			0.47				N.S				N.S		
W*N*A			0.93				N.S				N.S		

The interaction between water deficient and soil amendment was significantly only on the sucrose % in both seasons. The best interaction gave the highest values of sucrose % was produced from irrigation by 50% of IWR and application of 12 ton/ha compost in the first season. While in the second season was from 50% IWR and 12 ton/ha bentonite.

Data also in Tables 5 and 6 found that sucrose% had a significant effect on the interaction between nitrogen rates and soil amendments in the two seasons. The highest values of sucrose % were recorded from application of 12 ton/ha of compost and addition of nitrogen at 75% of recommended rate followed by the same rate of nitrogen fertilizer and bentonite at 12 ton/ha (with significance level difference among).

The second order interaction: Sugar lost in molasses and sugar extractable % didn't have a significant effect on the interaction between water deficient, nitrogen rates and soil amendments in the two seasons. While sucrose % had significantly affect where the highest values of sucrose % recording from 50% of IWR and nitrogen at 75% of recommended rate and application of 12 ton/ha compost in the first season. While, the same interaction, but added bentonite instead of compost gave the highest sucrose % in the second season.

Yield characteristics

Top and root yield (ton/ha)

Effect of water stress: Top and root yield significantly decreased by increasing water deficient from 100 to 50% of IWR in both seasons (Tables 7 and 8). The optimum irrigation was 100% of IWR where, it produced the highest values of top and root yield recorded 23.02 and 61.08 ton/ha, respectively, in the first season as well as 21.94 and 63.36 ton/ha in the second seasons. On the contrast, the lowest means of the top and root yields were achieved when irrigated by 50% of IWR. It is important to mention that there were three significant differences between levels of irrigation water requirement under study in both seasons.

The decreases of top and root yield have been detected as water deficiency is related to decreasing pressure potential stomata conductivity and relative water content of leaf that cause lower growth which, led to decrease yield. The results are similar to Esmaeilli (2011) and Masri et al. (2015).

Effect of nitrogen rates: The data in Tables 7 and 8 showed that decreasing nitrogen rates from 100 to 75% of recommended rate significantly decreased top yield from 23.35 to 19.42 and from 23.21 to 19.34 ton/ha in the two seasons, respectively. Regarding root yield, the significant decrease was from 57.14 to 52.54 and 58.51 to 54.65 ton/ha. These results may be due to that nitrogen has a vital role in building up metabolites, activating enzymes and carbohydrates accumulation which transferred from leaves to developing root which in turn enhanced root length, diameter, and fresh weight finally roots yield per unit area. Similar findings were reported by Ramadan et al. (2003) and El-Hassanin et al. (2016).

Effect of some soil amendments: Compost and bentonite as an individual or together significantly increased top and root yields as compared with control (without soil amendments) in both seasons (Tables 7 and 8). Application of 12 ton/ha compost recorded the highest values of top and root yields ton/ha since results were 25.32 and 60.72 ton/ha, respectively, in the first season and 24.53 and 62.4 ton/ha in the second seasons. The second rank was the application of 12 ton/ha bentonite where it recorded 21.98 and 56.59 ton/ha for the top and root yields, respectively, as well as 21.41 and 57.55 ton/ha in both seasons, respectively (with the significance level difference between them). Such positive effect may be due to that compost increases the capacity of soil water retention. It also increases cation exchange capacity of the soil, therefore, increases its ability to retain nutrients which promote the development of root systems. Bentonite also could raise the storage capacities of soil for water and fertilizer, which led to the maximum growth and yield (Iskander et al., 2011). The same trend was found by Reguieg et al. (2011) and Youssef (2013).

Effect of interactions

The first order interaction: Referring the effect of the interaction between water deficient and nitrogen rates on top and root yields, it was significant in two seasons. The highest averages of root yield were observed when the sugar beet irrigated by 100% of IWR and addition of nitrogen at 100% of the recommended rate in both seasons. Meanwhile, sugar beet irrigated by 100% of IWR and fertilized by nitrogen at 75% of recommended rate occupied the second rank.

TABLE 7. Effect of some soil amendments, water stress and nitrogen rates on top, root and sugar yields of sugar beet in sandy soil in 2014/2015 season.

Treatments		**Top yield (ton/ha)**				**Root yield (ton/ha)** **Water stress (W)**				**Sugar yield (ton/ha)**			
Soil amendments (A)	**Nitrogen rates (N)**	**100%**	**75%**	**50%**	**Mean**	**100%**	**75%**	**50%**	**Mean**	**100%**	**75%**	**50%**	**Mean**
Control	100%	21.98	19.75	16.46	19.40	56.74	52.32	45.17	51.41	8.18	7.58	6.70	7.49
	75%	18.98	15.41	13.44	15.94	62.22	46.13	40.94	49.76	7.37	6.62	5.98	6.66
Mean		20.48	17.58	14.95	17.67	59.48	49.23	43.06	50.59	7.78	7.10	6.34	7.07
Compost	100%	28.82	28.08	26.06	27.65	69.50	63.74	55.25	62.83	10.39	9.89	9.00	9.76
	75%	24.74	23.18	21.00	22.97	63.98	57.22	54.58	58.59	10.73	9.96	9.72	10.14
Mean		26.78	25.63	23.53	25.31	66.74	60.48	54.92	60.71	10.56	9.93	9.36	9.95
Bentonite	100%	24.46	23.76	22.90	23.71	65.95	58.27	51.07	58.43	10.10	9.00	8.26	9.12
	75%	21.72	22.01	17.11	20.28	60.77	55.25	48.19	54.74	9.70	8.86	8.04	8.87
Mean		23.09	22.87	20.01	21.99	63.36	56.76	49.63	56.58	9.90	8.93	8.15	8.99
Compost + Bentonite	100%	24.00	20.86	18.36	21.07	62.59	55.20	49.92	55.90	9.65	8.66	8.21	8.84
	75%	19.58	20.38	15.60	18.52	56.83	49.92	44.35	50.37	8.59	7.70	6.98	7.76
Mean		21.79	20.62	16.98	19.80	59.71	52.56	47.14	53.14	9.12	8.18	7.60	8.30
Mean of N%	100%	24.82	23.11	20.95	22.96	63.70	57.38	50.35	57.14	9.58	8.68	8.04	8.77
	75%	21.26	20.25	16.79	19.43	60.95	52.13	47.02	53.37	9.10	8.29	7.68	8.36
Mean		23.04	21.68	18.87	21.20	62.33	54.76	48.69	55.26	9.34	8.49	7.86	8.56
Water stress (W)			1.20				1.01				0.77		
Nitrogen rates (N)			0.34				1.10				0.46		
Soil amendments (A)			1.32				1.58				0.84		
W*N			0.58				1.03				N.S		
W*A			N.S				1.80				0.74		
N*A			N.S				N.S				N.S		
W*N*A			N.S				N.S				N.S		

TABLE 8. Effect of some soil amendments, water stress and nitrogen rates on top, root and sugar yields of sugar beet in sandy soil in 2015/2016 season.

Treatments		Top yield (ton/ha)				Root yield (ton/ha) Water stress (W)				Sugar yield (ton/ha)			
Soil amendments (A)	**Nitrogen rates (N)**	**100%**	**75%**	**50%**	**Mean**	**100%**	**75%**	**50%**	**Mean**	**100%**	**75%**	**50%**	**Mean**
Control	100%	21.02	21.60	20.28	20.98	59.52	51.17	47.62	55.18	8.69	7.58	7.13	7.80
	75%	17.26	17.50	16.18	16.97	57.41	48.19	44.02	49.87	7.92	6.89	6.46	7.08
Mean		19.13	19.56	18.22	18.96	58.46	49.68	46.82	51.31	8.30	7.22	6.79	7.44
Compost	100%	28.51	26.28	25.56	26.78	72.00	63.41	57.12	64.18	10.97	9.79	9.00	9.91
	75%	24.02	21.17	21.58	22.25	68.26	59.52	54.10	60.62	11.30	9.94	9.22	10.15
Mean		26.26	23.74	23.57	24.53	70.13	61.46	55.61	62.40	11.14	9.86	9.12	10.03
Bentonite	100%	23.47	24.60	20.52	22.87	66.24	57.60	53.52	59.11	10.42	9.22	8.67	9.43
	75%	19.56	18.70	19.20	19.94	60.55	57.12	50.26	55.97	9.82	9.46	8.65	9.31
Mean		21.50	21.65	21.07	21.41	63.41	57.36	51.89	57.55	10.13	9.34	8.66	9.38
Compost + Bentonite	100%	23.14	21.96	21.53	22.22	63.36	57.60	53.06	58.01	9.96	9.12	8.52	9.19
	75%	18.43	18.34	17.69	18.14	59.57	50.54	46.22	52.10	9.24	7.87	7.42	8.16
Mean		20.81	20.14	19.61	20.18	61.46	54.07	49.66	55.06	9.60	8.50	7.97	8.69
Mean of N%	100%	24.05	23.62	21.96	23.21	65.28	57.46	52.82	58.51	10.01	8.93	8.33	9.10
	75%	19.80	18.94	19.27	19.34	61.44	53.86	48.65	54.65	9.58	8.54	7.94	8.69
Mean		21.94	21.29	20.62	21.26	63.36	55.66	50.74	56.59	9.79	8.74	8.14	8.88
Water stress (W)			0.89				0.84				0.96		
Nitrogen rates (N)			0.62				1.06				0.19		
Soil amendments (A)			0.82				0.84				0.74		
W*N			N.S				0.55				N.S		
W*A			1.39				1.44				0.82		
N*A			N.S				N.S				0.38		
W*N*A			N.S				2.04				0.67		

The response of root yield to the interaction between water deficient and soil amendment was significant in two seasons. It can be considered that the highest values of root yield were obtained due to irrigation by 100 % of IWR and application of 12 t/ha of compost followed by the same IWR and treated by 12 t/ha bentonite in both seasons. The interaction between nitrogen rates and soil amendment did not significantly effect on top or root yields in both seasons.

The second order interaction: Water deficient, nitrogen rates and soil amendments interaction had a significant effect on root yield in the second season only. The maximum value of root yield was produced from irrigation by no water stress and application of 12 t/ha compost with added nitrogen at 100 % of the recommended rate.

Sugar yield (ton/ha)

Effect of water stress

Results in Tables 7 and 8 showed that irrigated sugar beet by 100% of IWR with sugar yield 9.34 and 9.79 ton/ha had the maximum yield in the two seasons, respectively. After which irrigation with 75%, then 50% of IWR with average sugar yield of 8.52 and 7.85 ton/ha in the first season as well as 8.74 and 8.14 ton/ha in the second season. It is important to note that there wasn't a significant difference between the levels at 100% and 75% of IWR, but there was significant between irrigation by 100 and 50% of IWR in both seasons. The decrease sugar yield by increasing water stress may be attributed to highly decrease in root yield although; increase sugar extractable. The results are similar to Masri et al. (2015). On other hand, Mahmoud et al. (2018) reported that 30–50% from field capacity as water stress may be suitable for high yield of sugar beet

Effect of nitrogen fertilizer

Decreasing nitrogen fertilizer rate from 100 to 75% of recommended rate tended to significant decrease sugar yield from 8.78 to 8.35 ton/ha and 9.53 to 8.69 ton/ha in both seasons, respectively (Tables 7 and 8). The increase in sugar yield per unit area due to the application of nitrogen can be explained by the fact that nitrogen has a vital role in improving all growth attributes and root weight, consequently increasing sugar yield per unit area. These results are agree with those stated by Ramadan et al. (2003) and El-Hassanin et al. (2016). On other hand, Marajan et al. (2017) found that compost and nitrogen treatments alone showed significant differences in sugar beet root fresh and dry weights.

Effect of soil amendments

All soil amendments under study significantly increased sugar yield as compared to control (without soil amendment) in both seasons (Tables 7 and 8). Application of 12 ton/ha compost or bentonite had the maximum sugar yield were, there was no significant difference between them. The highest amounts of sugar yield were 9.94 and 8.98 ton/ha in the first season and 10.03 and 9.38 ton/ha in the second season, for compost and bentonite, respectively. The increase of sugar yield by application of compost or bentonite may be due to that it's role in increase each of root yield and sugar extractable as mentioned before. This finding agreed with obtained by of Kabil et al. (2015).

Effect of interactions

The first order interaction: There were no significant differences between water deficient and two nitrogen rates interactions on sugar yield ton/ha in the two growing seasons. This may be due to the individual effect of each factor.

Sugar yield ton/ha was affected significantly by the interaction between water deficient and soil amendments in both seasons. The highest values were obtained from the application of compost or bentonite with irrigation by 100% of IWR in both seasons. On the other hand, the lowest values resulted from control (without soil amendment) and 50% of IWR.

The response of beet sugar yield to the interaction between two nitrogen rates and soil amendments was significant in the second season only. The highest values of sugar yield were recorded from the application of 12 ton/ha compost and dressing of nitrogen at 75% or 100% of the recommended rate.

The second order interaction: The effect of the interaction among all factors under study on sugar yield was significant in the second season. The highest values of sugar yield were produced from the interaction between without water stress and the addition of nitrogen at 75% of recommended rate and treated soil by 12 ton/ha compost. On the other hand, the lowest value was produced as a result of irrigation by 50% of IWR and fertilization by nitrogen at 75% of recommended rate and without soil amendments.

Conclusion

The highest values of sugar yield were produced from interaction between nitrogen addition at

75 % of recommended rate and treated soil by 12 ton/ha compost and without water stress. On the other hand, the lowest value was produced as result of irrigation by 50% of irrigation water requirements and fertilization by nitrogen at 75% of recommended rate and without soil

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تأثير بعض محسنات التربة على إنتاجية وجودة بنجر السكر تحت الإجهاد المائي في الأراضي الرملية

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لدراسة تاثير المعاملة بمحسنات التربة لتحسين جودة وإنتاجية بنجر السكر وتقليل الأسمدة النتروجينية تحت ظروف الإجهاد المائي في الأراضي الرملية تم اجراء تجربتين حقليتين خلال موسمي النمو 2015/2014 و 2016/2015 بوادي النطرون، محافظة البحيرة، مصر. تم إضافة كلا من الكمبوست (عضوي) والبنتونيت (غير عضوي) كلا على حده أو مخلوط من الكمبوست والبنتونيت على حد سواء ومعدلات إضافة من النيتروجين (216 و 288 كجم نيتروجين/هكتار) تحت الإجهاد المائي (100 و 75 و 50%) من الإحتياجات المائية المحسوبة للنبات باستخدام نظام الري بالتنقيط. وقد أوضحت النتائج إلى أن زيادة الإجهاد المائي إلى 50% من الإحتياجات المائية للمحصول ادت إلى حدوث إنخفاض معنوي في السكر المفقود في المولاس ومحصول السكر ومحصول الجذور ولكن ادت إلى زيادة النسبة المئوية للسكروز والسكر المستخلص. وأدى انخفاض التسميد النتروجيني من 100 إلى 75% من المعدل الموصي به (288 كجم ن/هكتار) إلى انخفاض معنوي لكل من محصول السكر ومحصول الجذور ولكن ادى إلى زيادة النسبة المئوية للسكروز والسكر المستخلص. إضافة 12 طن/هكتار كمبوست أو بنتونيت أو خليط من كل منهم أدى إلى زيادة معنوية في كل الصفات السابقة الذكر مقارنة بالكنترول (بدون محسنات أرضية). كانت المعاملة بالكمبوست هي الأفضل يليها المعاملة بالبنتونيت. والتداخل بين الري بدون إجهاد مائي والتسميد بـ 288 او 216 كجم/هكتارنيتروجين وإضافة 12 طن/هكتار كمبوست أعطى معنوياً أعلى قيم لكل من محصول الجذور ومحصول السكر.