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Effect of Mid to Late Season Drought and Potassium Fertilization on The Mineral Content of Sugar Beet and Some Soil Chemical Properties at North Nile Delta

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FIELD experiments were carried out during 1994/95 and 1995/96 growing seasons at the Farm of Sakha Aricultural Research Station, Kafr El-Sheikh Governorate to study the N,P,K and Na content of sugar beet plant and soil salinity, pH, ESP and available K as affected by different drought periods and potassium fertilization. Soils of the studied area were non saline non sodic (ECe= 1.21 dS/m & ESP=9.91) in the 1^{st} season and saline sodic (ECe=6.72 dS/m & ESP=16.67) in the 2^{nd} season. The drought periods were imposed by omitting one or more irrigation during the growing season. The experimental design was split plot with 4 replicates. The drought periods (as main plots) were 3 weeks (treat. A), 6 weeks (treat. B), 9 weeks (treat. C), 12 weeks (treat. D), 15 weeks; 9 weeks before harvesting and 6 weeks at mid season (treat. E) and 15 weeks before harvesting (treat. F.). The potassium fertilization treatments were O (K), 48 (K_2), 72 (K_3) and 96 kg K_2O/fed. (K_4) (as sub-plots).

The obtained results could be summarized as follows:

Electrical conductivity (ECe) of soil paste extract was increased with increasing the period of drougt before harvesting during the two growing seasons. The highest average values of ECe and significant ESP increase were found under the longest drought period (treat. F) in the two growing seasons. Increasing the rate of K fertilization resulted in a significant increase in ESP in the surface soil layer during the two growing seasons. The lowest values of ESP (4.18) and (9.38) were obtained under drought treatments (B) and (A) without K fertilization in the 1^{st} and 2^{nd} season, respectively.

Soil avaliable K was significantly increased by increasing the drought periods and / or K fertilization rate during the two growing seasons. Where application of 96 kg K_2O/ Fed under F treatment resulted in the highest available K.

Increasing the period of drought before harvesting resulted in a significant decrease in N, P, K and Na uptake by leaves and roots of sugar beet plants, while increasing the K fertilizer rate significantly increased N, P and K uptake by leaves and K by roots during the two growing seasons. Na conc. and uptaeke by leaves and roots were significantly decreased by increasing K rats. The highest N and P content of leaves were obtained by the interaction between K_4 and A treatments in the 1^{st} and 2^{nd} seasons, while the lowest N content of roots were obtained by the combination of (F) treatment K_4 and F treatments.

The interaction between K_4 and B resulted in a highest K content in leaves and roots.

But the lowest Na and K concentrations and uptake were resulted from K_4 xF combination. The Na uptake by sugar beet was higher under the higher levles of soil salinity and sodicity in the two studied seasons.

Keywords: Drought, potassium, mineral content, sugar beet.

Limited work has been done to establish the relationship between soil moisture levels and nutrient absorption by sugar beet at North Delta. Nutrient absorption is affected directly by levels of soil moisture as well as indirectly by the effect of water on the metabolism activity of the plant, soil aeration and the salt concentration of the soil solution. Samwel *et al.* (1990) stated that the major portion of the phosphorus and potassium moves to roots by diffusion through the water films around the soil particles. Under moisture stress the water films are thin and path length of ion movement increases. Hence movement of phosphorus and potassium in the soil and thus in the soil solution increases delivery to the roots. Henderson *et al.* (1968) indicated that irriggation of sugar beet at late season caused a very rapid increase in nitrogen and phosphorus uptake .

Carter *et al.* (1980) revealed that withholding irrigation of sugar beet at late season resulted in reducing N uptake by the plant, which created a partial N deficiency in the sugar beet.

Carter (1986) pointed out that increasing K uptake by sugar beet decreased the uptake of both Na and N. The antagonism between K and Na in sugar beet roots and leaves was observed by Rathert *et al.* (1981a). They showed that the K^+ content of root and leaves of sugar beet for extreme Na^+ treatment was reduced below the value of control. The K^+ and Na^+ antagonism in leaves of sugar beet does not affect metabolic reactions because K^+ can partly be replaced by Na^+ in its physiological function in the case of K deficiency (El-Sheikh and Ulriech, 1970; Rowell and Erel, 1971; Marschner and Possingham, 1975) .

James *et al.* (1968) found that K fertilization of sugar beet increased K content in the plant and decreased Na in roots and leaves and N in roots.

The current work was carried out to study the effect of drought periods before harvesting and potassium fertilization rates on the NPK and Na concentrations and its uptake by sugar beet and some soil chemical properties at North Delta.

Material and Methods

The present investigation was carried out at Sakha Agricultural Research Station Farm, Kafr El-Sheikh during 1994/95 and 1995/96 growing seasons. The soil type is Typicustorthent and was non-saline non-sodic in the 1^{st} season and saline sodic in the 2^{nd} season (Table 1). The experimental area characterized by a cold rainy winter with mean air temperature about 6.4° in winter and exceeds 32° in summer with mean relative humidity 73.5%. Total rainfall was 114.3 and 76.6 mm during the first and second growing seasons, respectively. The EC of irrigation water is 0.4 dS/m and SAR is 1.50 so, it is suitable for irrigating different crops. Kwaemera sugar beet variety was the crop of the experiment. The effects of drought periods at mid to late season and/or potassium fertilizeration on the mineral composition and some soil chemical properties were studied. The experiment design was split plot with four replications. The plot area was 21 m^2 (3x7), each plot had five furrows 60 cm apart and 7 m in length. The main plots were designated for ix drought treatments. Drought treatments were A (3 weeks),B (6weeks), C(9weeks), D(12 weeks), E(15 weeks; 9 weeks at mid-season and 6 weeks before harvesting) and F(15 weeks) before harvesting. Sugar beet roots and leaves were collected at harvest, dried, ground and digested by sulfuric and perchloric acids to determine the dry matter content and the NPK and Na concentrations and uptake as described by Page (1982). Soil samples were collected at harvest from the surface layer (0-30 cm) to determine the salinity, exchangeable sodium percentage and available potassium according to page (1982).

TABLE 1. Soil physical and chemical characteristics of the studied surface layer (0-30 cm) before planting during the two successive seasons.

	First season (1994/95)	Second season (1995/96)
Particle size distribution		
Sand, %	16.67	23.15
Silt, %	30.06	27.80
Clay, %	53.27	49.05
Textural class	Clayey	Clayey
Soil moisture characteristics:		
F.C., %	42.14	43.86
W.P, %	22.90	23.84
Av. W	19.24	20.02
Bulk density	1.21	1.20
Soil chemical characteristics:		
pH (1: 2.5)	8.11	7.76
ECe, dS/m	1.21	6.72
Soluble ions, me/L		
Ca^{2+}	1.81	19.72
Mg^{2+}	2.09	21.04
Na^{+}	8.80	26.05
K^{+}	0.112	0.98
CO^{2-}_3	0.00	0.00
HCO^{-}_3	3.43	7.72
Cl^{-}	4.32	31.72
SO^{2-}_4	5.06	28.35
CEC, me/100 g soil	26.00	24.74
ESP	9.914	16.67
Available K, ppm	195.0	565.5

Furrow irrigation of sugar beet every 3 weeks was controlled by syphons methods (FAO, 1974) to reach the soil profile (60 cm) at field capacity.

The sub-plots were subjected to potassium fertilization treatments, 0 (K_1), 48 (K_2), 72 (K_3) and 96 kg K_2O/fed.(K_4) in the form of K-sulfate (48% K_2O) added by dressing in one dose after thinning and before the 1st irrigation. Nitrogen was added at the recommended rate (90 kg N/fed.) as urea (46.5% N) in two equal doses after thinning and before the second irrigation. Phosphorus was broadcasted before planting as superphosphate (15.5% P_2O_5) at the recommended rate (15 kg P_2O_5/fed.).

Dates of sowing were November 15th and November 23rd and harvesting were June 5 th and June 23 rd in the 1st and the 2nd seasons, respectively.

Results and Discussion

Soil salinity

Data in Table 2 indicated that the electrical conductivity of soil paste extract increased with increasing the period of drought before harvesting sugar beet crop. The lowest values of ECe (1.63 and 4.09 dS/m) were found under full-irrigated treatment (A) while the highest values (2.28 and 7.38 dS/m) were obtained under the driest treatment (F) in the 1^{st} and 2^{nd} seasons, respectively. Regarding the effect of K fertilization of soil ECe, the obtained results indicated that there were no regular trend during the two growing seasons.

It was interesting to note that the applied irrigations had a major effect in decreasing the concentrations of soluble cations and anions particularly Na^+, Cl^- and SO^{2-}_4. Data also showed that SO^{2-}_4 was the dominant anion comparing with other anions . This may be resulted from the applied K-fertilizer (K_2SO_4) which increase soil solution by SO^{2-}_4 after its dissolution by the applied irrigation water (Khalifa and Ibrahim, 1995).

Soil pH

Results in Table 2 revealed that increasing the period of drought more than 6 and 9 weeks in the 1^{st} and 2^{nd} seasons, respectively increased soil pH. Concerning the effect of K-fertilization on soil pH, the obtained results showed that it had no regular trend to be detected.

Illustrated data in Table 3 showed that extending the period of drought before harvesting resulted in a significant increase in the ESP during the two growing seasons. The rate of increase was more pronounced in the 2^{nd} season compared to the 1^{st} one . Increasing the rate of K fertilizer caused a significant increase in ESP during the two growing seasons. This could be attributed to the antagonism between uptake of K and Na by roots of sugar beet. However, Rathert *et al.* (1981a) noticed the preferential uptake of K compared to Na. The lowest ESP values (4.18 and 4.14) were obtained with drought period 6 weeks without K fertilization in the first and second seasons, respectively.

Soil available potassium

The obtained results (Table 4) demonstrated that increasing the period of drought before harvesting resulted in a significant increase in soil available potassium during the two growing seasons. This increase could be attributed to two reasons: the first was that the severe soil water stress resulted in a secondary salinization and accumulation of soluble salts in stressed zone, and the second

TABLE 2. Electrical conductivity (ECe), soil reaction (pH) and soluble cations and anions in surface soil layer (0-30) after the two growing seasons of sugar beet.

Drought treatments	K treat.	ECe dS/m	pH	Soluble cations (meq/l)					Soluble anions (meq/l)		
				Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}
1994/95 season											
A	K_0	1.29	7.68	2.55	5.76	4.80	0.004	0.96	3.12	4.70	4.34
	K_{48}	1.56	7.86	4.08	3.36	8.45	0.006	0.48	3.24	5.53	6.65
	K_{72}	1.90	8.05	7.14	3.84	8.50	0.008	0.72	3.48	7.75	7.54
	K_{96}	1.75	7.65	3.06	6.24	8.35	0.006	0.72	2.88	6.36	7.70
B	K_0	1.44	7.55	4.59	4.60	5.50	0.01	0.72	2.16	4.13	7.69
	K_{48}	2.24	7.75	5.10	8.16	9.50	0.01	0.96	2.64	9.39	8.79
	K_{72}	2.01	7.55	6.08	5.41	8.78	0.05	0.48	1.92	9.47	8.45
	K_{96}	1.92	7.63	6.12	5.68	6.80	0.012	0.96	3.01	4.80	9.84
C	K_0	2.13	7.66	7.14	6.24	8.25	0.01	0.48	3.36	5.53	12.27
	K_{48}	1.82	7.80	5.44	4.00	9.20	0.006	0.96	3.00	7.97	6.72
	K_{72}	2.00	7.72	5.10	6.72	8.40	0.007	0.72	3.36	7.19	8.96
	K_{96}	2.07	7.72	3.57	7.68	9.75	0.006	0.48	2.52	6.64	11.37
D	K_0	1.94	7.64	4.59	8.00	7.27	0.05	0.48	2.40	8.10	8.94
	K_{48}	2.33	7.68	6.12	6.24	11.20	0.01	0.48	3.72	7.74	11.63
	K_{72}	1.96	7.73	5.10	5.28	9.57	0.01	0.72	2.99	6.18	10.07
	K_{96}	2.08	7.88	4.59	5.76	10.70	0.01	1.44	2.52	8.02	9.08
E	K_0	2.07	7.76	4.59	6.72	9.60	0.007	0.72	2.64	7.19	10.37
	K_{48}	2.04	7.86	3.57	6.17	10.91	0.015	0.48	1.44	5.22	13.52
	K_{72}	2.41	7.55	3.14	6.48	14.90	0.038	0.48	2.88	7.52	13.68
	K_{96}	2.20	7.80	4.34	6.93	10.91	0.01	0.96	2.52	6.90	11.80
F	K_0	2.01	7.88	5.10	4.80	10.60	0.022	0.48	2.28	9.96	7.81
	K_{48}	2.48	7.98	5.10	5.76	14.20	0.079	0.96	3.60	8.59	11.99
	K_{72}	2.03	7.87	4.08	5.28	11.40	0.023	1.20	2.64	6.64	10.31
	K_{96}	2.61	7.78	5.61	9.12	11.65	0.010	0.96	2.64	7.47	15.33
1995/96 seasons											
A	K_0	3.10	7.76	6.15	5.19	19.50	0.39	0.72	4.44	14.76	11.31
	K_{48}	4.21	7.62	15.81	9.67	16.68	0.37	0.00	5.62	14.96	21.95
	K_{72}	4.29	7.66	13.36	10.56	18.25	0.56	0.64	4.92	14.83	22.34
	K_{96}	4.77	7.82	16.32	13.20	17.75	0.84	0.64	2.76	11.62	33.08
B	K_0	5.28	7.70	18.87	9.12	24.50	0.84	0.00	4.70	25.71	22.89
	K_{48}	5.22	7.75	16.33	11.52	22.30	0.89	0.96	3.36	21.16	25.52
	K_{72}	5.81	7.70	21.41	15.56	20.75	0.87	0.96	6.48	24.06	27.09
	K_{96}	6.02	7.75	20.38	13.57	25.81	0.90	0.48	3.24	25.44	31.49
C	K_0	6.12	7.65	19.89	17.76	23.25	0.68	1.20	5.09	16.60	38.70
	K_{48}	5.39	7.67	19.13	15.36	19.25	0.72	0.72	4.84	18.80	30.10
	K_{72}	5.73	7.70	20.40	16.32	20.15	0.81	0.48	5.90	17.47	33.83
	K_{96}	5.61	7.73	24.47	11.52	19.10	0.92	0.48	5.04	17.70	32.88
D	K_0	6.82	7.80	22.44	20.16	25.44	0.77	0.48	7.20	42.59	18.54
	K_{48}	6.91	7.69	19.89	22.92	26.13	0.76	1.68	6.96	39.35	21.61
	K_{72}	5.83	7.65	16.83	10.56	30.45	0.71	0.72	5.10	22.83	29.9
	K_{96}	6.58	7.73	19.04	18.01	28.13	0.96	0.00	5.78	29.80	30.56
E	K_0	4.45	7.73	14.79	10.08	19.75	0.39	0.00	3.84	18.81	22.36
	K_{48}	5.14	7.65	19.59	8.06	23.40	0.74	0.48	4.56	22.34	24.42
	K_{72}	5.42	7.83	17.14	10.37	26.21	0.81	0.72	5.19	17.25	31.37
	K_{96}	5.64	7.80	18.97	11.43	25.55	0.79	0.72	3.96	18.59	33.47
F	K_0	7.19	7.80	21.68	20.88	28.94	1.02	0.00	5.16	33.60	33.76
	K_{48}	8.60	7.75	22.75	24.96	37.69	0.99	0.00	6.72	40.62	39.05
	K_{72}	8.75	7.73	24.73	22.47	39.49	1.15	1.44	5.88	41.35	39.18
	K_{96}	7.90	7.73	21.42	24.96	31.75	1.24	0.00	3.60	33.19	42.58

Exchangeable sodium percentage (ESP):

TABLE 3. Exchangeable sodium percentage (ECP) and soil available potassium (PPm) in the surface soil layer (0.30 cm) as influenced by drought periods and potassium fertilization after harvesting in the two growing seasons.

Drought treatments	Potassium treatments (kg K_2O/fed.)									
	K_0	K_{48}	K_{72}	K_{96}	Drought means	K_0	K_{48}	K_{72}	K_{96}	Drought means
	First season (1994-1995)					Second season (1995-1996)				
	ESP									
A	5.22	6.78	4.79	4.82	5.40	5.54	7.89	5.91	4.27	5.90
B	4.18	5.68	7.13	6.29	5.57	4.14	7.66	6.68	7.17	6.41
C	4.82	5.86	5.40	6.46	5.64	7.75	7.38	7.29	8.10	7.63
D	7.07	5.75	6.76	7.76	6.84	10.59	9.84	12.33	11.95	11.18
E	8.88	7.10	7.69	7.57	7.81	13.63	12.75	12.33	16.32	14.53
F	12.55	12.68	12.90	13.11	10.81	13.49	14.30	15.40	17.15	15.09
K. means	7.12	7.31	7.45	7.70		9.39	9.97	9.98	10.82	
L.S.D. at 0.05		*D 0.76	K 0.49		D x K 1.19	D 1.34		K 0.51		D x K 1.25
	Soil available potassium (ppm)									
A	109.3	175.8	205.3	222.3	178.2	249.1	337.1	380.6	502.1	367.2
B	156.0	178.0	185.0	196.0	178.8c	374.5	413.8	440.3	507.1	433.9
C	161.3	191.10	210.9	235.1	199.6	413.3	487.8	503.5	529.9	482.7
D	253.6	292.6	324.3	331.8	300.6	452.6	470.4	510.8	523.2	489.3
E	243.7	331.9	337.1	341.8	313.6	457.1	480.3	547.6	572.1	514.5
F	409.6	462.6	487.3	514.8	468.5	459.5	497.6	534.8	585.8	514.4
K. means	222.3	272.0	291.7	306.9		401.0	447.8	486.3	536.0	
L.S.D. at 0.05		D 39.11		K 19.51	D x K 47.80	D 50.1		K 35.81		D x K 87.73

*D (drought), K (K-fertilization)

was that with the prolonged periods of drought, the growth of sugar beet plant hindered and consequently there was a redduction in K uptake from the soil. Application of K fertilizer caused a significant increase in available K compared to the control treatment in the two growing seasons. The highest values of available K (514.8 and 585.8 ppm) in surface soil layer were obtained with application 96 kg K_2O/fed. (K_4) under the longer period at drought treatment F) in the 1st and 2nd seasons, respectively. Data also showed that soil available K was higher under saline sodic conditions in the second season than that under non-saline non-sodic conditions in the first season. The obtained results were in general agreement with those of Mengel and Kirkby (1980), Kovar and Barber (1990) and Khalifa and Ibrahim (1995).

Nitrogen

Illustrated data in Table 6 showed that drought treatment had a significant effect on N concentration and its uptake by leaves and roots of sugar beet during the two growing seasons. It was obvious from the obtained data that the

TABLE 4. Nitrogen concentration (%) in the dry matter and uptake (kg N/fed). by sugar beet as affected by drought periods and potassium fertilization.

Drought treatments	Potassium treatments (kg K_2O/fed.)									
	K_0	K_{48}	K_{72}	K_{96}	Drought means	K_0	K_{48}	K_{72}	K_{96}	Drought means
	First season (1994-1995)					Second season (1995-1996)				
N% of dry matter										
Leaves										
A	2.34	2.43	2.40	3.12	2.57	2.55	3.20	3.31	3.37	3.11
B	1.78	1.66	2.17	2.39	2.00	3..09	3.21	3.13	3.33	3.19
C	1.72	2.08	2.13	2.10	2.01	2.51	2.44	2.84	3.24	2.76
D	1.72	2.08	2.13	2.08	2.00	2.05	2.12	2.12	2.81	2.28
E	1.61	1.58	1.61	2.31	1.78	1.62	1.67	1.64	1.78	1.68
F	1.68	1.66	2.03	2.08	1.86	1.52	1.65	2.13	2.91	2.05
K. means	1.81	1.92	2.08	2.35		2.22	2.38	2.53	2.91	
L.S.D. at 0.05	D 0.43		K 0.28		D x K 0.68	D 0.36		K 0.29		D x K 0.71
Roots										
A	0.78	0.75	0.67	0.57	0.69	1.65	1.21	1.16	0.99	1.25
B	0.75	0.61	0.71	0.67	0.69	1.47	1.26	1.14	0.82	1.17
C	0.71	0.43	0.43	0.42	0.50	1.40	1.25	1.18	0.91	1.19
D	0.57	0.40	0.38	0.38	0.43	1.28	1.16	1.14	0.89	1.12
E	0.57	0.45	0.36	0.32	0.43	1.28	1.16	1.04	0.95	1.11
F	0.57	0.43	0.40	0.25	0.41	1.31	1.05	1.03	0.80	1.04
K. means	0.66	0.51	0.49	0.44	1.40	1.40	1.18	1.12	0.90	
L.S.D. at 0.05	D 0.063		K 0.052		D x K 0.127	D 0.16		K 0.15		D x K 0.37
Uptake (kg N/fed.)										
Leaves										
A	25.51	34.75	34.56	46.18	35.25	36.27	36.48	37.40	38.76	37.22
B	20.65	21.58	30.16	38.48	27.72	33.68	36.92	33.80	38.63	35.76
C	21.50	28.91	27.48	31.08	27.24	25.1	25.38	29.54	30.46	27.62
D	16.34	20.38	20.66	24.75	20.53	20.30	19.50	21.62	32.03	23.36
E	11.11	18.01	19.66	28.18	19.12	16.04	17.20	18.20	19.40	17.71
F	13.10	14.94	17.26	22.26	16.89	13.53	13.70	17.89	29.39	18.63
K. means	18.04	23.10	24.88	31.87		24.15	24.86	26.41	31.45	
L.S.D. at 0.05	D 6.694		K 3.443		D x K 8.44	D 4.76		K 3.751		D x K 9.188
Roots										
A	51.63	56.03	51.39	46.17	51.31	101.48	77.92	78.65	67.91	81.49
B	54.3	44.84	58.36	62.91	55.10	97.17	87.07	80.37	59.37	81.00
C	52.26	33.47	34.49	36.04	38.82	83.44	74.5	78.12	69.34	68.11
D	33.92	24.44	35.56	27.47	27.35	71.55	69.48	68.29	63.10	63.65
E	33.46	26.87	21.67	24.83	26.71	61.31	66.35	62.92	64.04	48.49
F	25.94	20.04	23.28	14.55	20.95	49.91	49.62	52.12	42.24	
K. means	41.92	34.28	37.46	35.33		77.48	70.82	70.08	61.00	
L.S.D. at 0.05	D 1.653		K 3.068		D x K 7.715	D 9.782		K 8.47		D x K 20.75

length of drought period caused the lowest N concentration and its uptake by leaves and roots of sugar beet. The highest mean values of N concentration in leaves (2.27 and 3.11%) and in roots (0.69 and 1.25 %) at harvest during the first and second seasons, respectively were found under full-irrigated treatment (A). However, Henderson *et al.* (1968) reported that the ability of dry soil to supply nutrients was the dominant factor. Data in the same table showed also that the highest mean values of N uptake by leaves (35.25 and 37.22 kg N/fed.) were resulted under (A) treatment A in the first and second season respectively. While the lowest N uptake by roots were obtained under (F) treatment. The obtained results also showed that potassium fertilization significantly affect the concentration and the uptake of N by leaves and roots of sugar beet. Increasing the rate of K fertilization increased the concentration and the uptake of N by leaves but decreased in roots K_4 treatment resulted in the highest mean values of N concentration and uptake by leaves in the two seasons.

The interaction (A x K_4) resulted in the highest values of N concentrations and uptake by leaves of sugar beet in the two seasons. The lowest N concentrations and driest uptake by roots were found under the driest trewatment F with K_4 treatment. The reduction of root N concentration due at K fertilization was also obtained by Kochl (1978). It was interesting to mention that at harvest time it was much more desirable to have the higher levels of N and K in leaves rather than in root of sugar beet. These finding are in coincide with those reported by Powers and Payne (1964).

Phosphorus

Data of P concentration in leaves and roots of sugar beet (Table 5) revealed that increasing the period of drought before harvest caused a significant decrease in P concentration in leaves and roots during the two growing seasons. Potassium fertilization resulted in a significant increase in P concentration in leaves and a significant decrease in roots during the two growing seasons. The interaction between periods of drought and K fertilization had a significant effect on P concentrations (0.25 and 0.27%) were resulted from (K_4 x A) treatment. While the highest values of P concentration in roots were found under (K_1 x A) treatment (A).

Regarding to the data of P uptake by sugar beet in Table 5 showed that drought periods and K fertilization had a significant effect. The prolonged periods of drought before harvest caused a significant decrease in P uptake by leaves and roots of sugar beet during the two growing seasons. Results indicated that increaseing the rate of K fertilization up to 96 kg K_2O/fed resulted in a

TABLE 5. Phosphorus concentration (%) in the dry matter and uptake (kg P/fed). by sugar beet as affected by drought periods and potassium fertilization.

Drought treatments	Potassium treatments (kg K_2O/fed.)									
	K_0	K_{48}	K_{72}	K_{96}	Drought means	K_0	K_{48}	K_{72}	K_{96}	Drought means
	First season (1994-1995)					Second season (1995-1996)				
P% of dry matter										
Leaves										
A	0.14	0.15	0.18	0.25	0.18	0.19	0.22	0.23	0.27	0.23
B	0.13	0.16	0.19	0.22	0.18	0.18	0.20	0.21	0.24	0.21
C	0.16	0.17	0.17	0.21	0.18	0.17	0.21	0.21	0.26	0.21
D	0.13	0.15	0.17	0.20	0.16	0.16	0.16	0.20	0.22	0.19
E	0.16	0.16	0.17	0.20	0.17	0.21	0.21	0.2	0.25	0.22
F	0.14	0.14	0.16	0.18	0.16	0.17	0.17	0.19	0.19	0.18
K. means	0.14	0.15	0.18	0.21		0.18	0.20	0.21	0.24	
L.S.D. at 0.05		D 0.02		K 0.02	D x K 0.05	D 0.02		K 0.02		D x K 0.05
Roots										
A	0.14	0.14	0.12	0.06	0.12	0.26	0.22	0.21	0.21	0.23
B	0.12	0.12	0.10	0.09	0.11	0.23	0.21	0.20	0.14	0.20
C	0.13	0.10	0.10	0.09	0.11	0.26	0.20	0.17	0.17	0.20
D	0.12	0.09	0.07	0.07	0.09	0.24	0.22	0.17	0.16	0.20
E	0.13	0.10	0.07	0.06	0.09	0.22	0.19	0.19	0.17	10.19
F	0.12	0.11	0.11	0.09	0.11	0.23	0.21	0.16	0.16	0.19
K. means	0.13	0.11	0.10	0.08		0.24	0.21	0.18	0.17	
L.S.D. at 0.05		D 0.024		K 0.012	D x K 0.045	D 0.030		K 0.030		D x K 0.060
P uptake (kg P/fed.)										
Leaves										
A	1.53	2.15	2.59	3.70	2.49	1.96	2.51	2.60	3.11	2.55
B	1.51	2.08	2.64	3.54	2.44	1.96	2.30	2.27	2.78	2.33
C	2.00	2.36	2.19	3.11	2.42	1.70	2.18	2.18	2.44	2.13
D	1.24	1.47	1.65	2.38	1.69	1.58	1.47	2.04	2.51	1.90
E	1.11	1.82	2.02	2.44	1.85	2.05	2.16	2.44	2.73	2.35
F	1.09	1.26	1.36	1.93	1.41	1.51	1.41	1.60	1.92	1.61
K. means	1.41	1.86	2.08			1.80	2.01	2.19	2.58	
L.S.D. at 0.05	D 0.471		K 0.357		D x K 0.874	D 0.356		K 0.306		D x K 0.750
Roots										
A	9.27	10.46	9.20	4.86	8.45	15.99	14.17	14.24	14.41	14.70
B	5.69	8.82	8.22	8.45	8.25	15.20	14.51	14.10	10.14	13.49
C	9.57	7.55	8.02	7.72	8.22	15.50	11.92	11.25	12.95	12.41
D	7.14	5.50	4.34	5.06	5.51	13.42	13.18	10.18	11.34	12.03
E	7.63	5.97	3.61	4.66	5.47	10.54	10.87	11.50	11.46	11.09
F	5.46	5.13	5.15	5.24	5.25	8.76	9.93	8.10	8.45	8.81
K. means	7.96	7.24	6.42	6.00		13.24	12.43	1.56	11.46	
L.S.D. at 0.05	D 1.85		K 1.307		D x K 3.202	D 0.749		K 0.659		D x K 1.616

significant increase in P uptake by leaves and a significant decrease in P uptake by roots of sugar beet.These findings are in full-agreement with those of Sayed (1988)Maani Abu Amou *et al.* (1996) and El-Rommady (1997).

The interaction A x K_4 resulted in the highest P uptake by leaves. The shortest perdiod of drought treatment (A) resulted in the highest P uptake by roots (10.46 kgP/fed.) with 48 kg K_2O/fed in the first season and (15.99 kg P/fed without K fertilization in the second season.

Potassium

Registered data in Table 6 showed that increasing the period of drought led to a significant increase in K concentration in leaves and roots of sugar beet during the two growing seasons. Recorded data also revealed that increasing the

TABLE 6. Potassium concentration (%) in the dry matter and uptake (kg K/fed) by sugar beet as affected by drought period and potassium fertilization.

Drought treatments	Potassium fertilization treatments									
	K_0	K_{48}	K_{72}	K_{96}	Drought means	K_0	K_{48}	K_{72}	K_{96}	Drought means
	First season (1994/95)					Second season (1995/96)				
K % of dry matter										
Leaves										
A	4.47	4.64	5.04	5.14	4.83	3.69	5.27	5.53	5.66	5.04
B	4.54	4.74	4.80	5.24	5.02	4.17	4.94	5.21	6.06	5.10
C	4.83	4.94	5.01	5.01	4.95	4.44	5.39	5.40	5.63	5.22
D	4.80	4.94	5.20	5.24	5.05	5.09	5.27	5.41	5.74	5.38
E	4.49	4.63	4.64	4.77	4.63	4.18	5.54	4.51	4.87	4.53
F	5.31	5.19	5.33	5.98	5.45	4.79	5.41	5.64	5.92	5.44
K. means	4.74	4.85	5.14	5.23		4.39	5.14	5.28	5.62	
L.S.D. at 0.05	D 0.32		K 0.25		D x K 0.60	D 0.68		K 0.51		D x K 1.26
Roots										
A	0.44	0.51	0.77	0.84	0.64	1.39	1.48	1.51	1.70	1.52
B	0.48	0.65	0.69	0.81	0.66	1.55	156	1.57	1.78	1.62
C	0.64	0.66	0.75	0.76	0.70	1.50	1.55	1.66	1.68	1.60
D	0.67	0.70	0.75	0.80	0.73	1.65	1.68	1.71	1.80	1.71
E	0.66	0.70	0.77	0.79	0.73	1.62	1.89	1.91	1.96	1.85
F	0.63	0.67	0.79	0.90	0.75	1.72	1.73	1.80	1.99	1.81
K. means	0.59	0.64	0.75	0.82		1.57	1.65	1.69	1.82	
L.S.D. at 0.05	D 0.10		K 0.04		D x K 0.11	D 0.27		K 0.18		D x K 0.41
K uptake (kg K/fed.)										
Leaves										
A	48.69	66.10	73.15	76.37	66.08	38.50	60.22	62.27	66.21	56.80
B	52.29	59.72	67.31	86.88	66.55	45.61	56.60	56.13	70.10	57.11
C	59.37	68.38	69.96	74.14	67.96	45.20	50.70	54.27	68.4	54.64
D	45.58	48.77	50.35	63.16	51.97	49.06	51.04	54.79	63.54	54.61
E	42.59	51.57	55.48	57.86	51.88	41.51	46.96	49.91	53.48	47.97
F	41.45	47.24	52.50	63.31	51.13	42.65	49.51	55.84	59.05	51.76
K. means	48.33	56.96	61.43	70.29		51.96	52.51	55.52	63.46	
L.S.D. at 0.05	D 10.52		K 8.06		D x K 19.75	D 9.87		K 6.04		D x K 14.80
Roots										
A	28.57	37.73	58.95	67.97	48.31	85.30	94.78	102.49	117.23	99.95
B	23.81	40.77	56.88	76.34	49.45	103.66	107.02	109.92	129.17	112.44
C	47.02	49.62	61.12	64.65	55.60	88.62	93.53	108.67	128.10	104.73
D	40.00	45.19	51.41	60.15	49.19	91.71	99.54	102.27	128.08	105.40
E	40.69	41.32	47.24	54.43	47.59	77.61	108.69	114.76	131.26	108.08
F	28.36	31.39	40.45	50.49	39.67	65.93	83.61	90.48	104.62	86.19
K. means	34.74	41.00	52.68	62.34		85.47	97.86	104.77	123.08	
L.S.D. at 0.05	D 7.56		K 4.18		D x K 10.22	D 15.09		K 10.70		D x K 26.22

rate of K fertilizer significantly increased the K concentration and its uptake by leaves and roots of sugar beet during the two growing seasons . Although K concentration was increased with drought. The uptake took the reverse direction because the reduction of the dry matter production under drought conditions. Application of 96 kg K_2O/fed under the direst treatment (F) gave the highest K concentration in leaves (5.98 and 5.92) and 1.99%) in roots during the 1^{st} and 2^{nd} season, respectively. The highest K uptake by leaves (86.88 and 70.10 kg K/fed.) were obtained with the application of 96 kg K_2O/fed. in the first and second growing seasons, respectively. However, Mengel and Kirkby (1980) concluded that when low soil moisture conditions were limiting K availability, the application of K may result in a yield response and K uptake.

Sodium

Illustrated data in Table 7 showed that increasing the period of drought before harvest resulted in a significant increase of Na concentration in leaves and root of sugar beet during the two growing seasons. While the drought at late season (treatment E) gave the highest Na uptake leaves. The obtained data (Table 7) also revealed that increasing the rate of K fertilizer caused a significant reduction in Na concentration and uptake by leaves and roots of sugar beet. These results were in good agreement with those of Kochl (1978) and Rathert *et al.* (1981) who found that increasing the K fertilizer rate reduced Na concentration of sugar beet. Also, Hamid and Talibudeen (1976) observed the antagonism of Na and K in sugar beet throught the growth periods. The lowest Na concentrations in leaves and in roots were obtained under (K_4 x A) treatment.

While the lowest Na uptake by leaves and roots resulted from (K_4 x F) treatment. It obvious from data that Na concentration and uptake by sugar beet were higher under soil salinity and sodicity conditions during the second season comparing with the non-saline non-sodic conditions during the first season. These results are in good agreement with khalifa *et al.* (1995) and El-Rammady (1997).

Conclusion

It could be concluded that the drought stress at mid to late season of sugar beet resulted in decreasing the N,P,K and Na uptake by leaves and roots. Soil salinity also increased by increasing the period of drought before harvesting . Increasing the rate of K-fertilization increased the N,P and K uptake by leaves but decreased the Na uptake by leaves and roots. The concentration and uptake of N,P,K, and Na were higher under the saline sodic soil than under non saline non sodic one.

TABLE 7. Sodium concentration (%) in the dry matter and uptake (kg Na/fed.) by sugar beet as affected by drought periods and potassium fertilization.

Drought treatments	Potassium treatments (kg K_2O/fed.)									
	K_0	K_{48}	K_{72}	K_{96}	Drought means	K_0	K_{48}	K_{72}	K_{96}	Drought means
	First season (1994-1995)					Second season (1995-1996)				
Na % of dry matter										
Leaves										
A	4.00	3.60	3.54	3.15	3.57	5.48	5.29	4.95	4.13	4.96
B	4.03	3.88	3.79	3.17	3.72	5.58	5.08	4.88	4.55	5.02
C	4.66	4.27	4.15	4.08	4.29	5.79	5.71	4.91	4.25	5.15
D	4.82	4.47	4.39	4.36	4.51	6.07	5.38	5.10	4.74	5.32
E	5.87	5.42	5.26	4.93	4.37	6.12	6.03	5.62	5.52	5.82
F	4.74	4.61	4.24	4.09	4.42	5.28	5.31	4.83	4.53	4.99
K. means	4.62	4.38	4.23	3.96		5.72	5.46	5.05	4.72	
L.S.D. at 0.05		D		K	D x K	D		K		D x K
		0.57		0.30	0.73	0.82		0.49		1.26
Roots										
A	0.16	0.14	0.14	0.12	0.14	0.37	0.32	0.28	0.27	0.31
B	0.17	0.16	0.16	0.12	0.15	0.44	0.41	0.38	0.33	0.39
C	0.17	0.16	0.15	0.14	0.16	0.45	0.39	0.36	0.35	0.39
D	0.19	0.18	0.14	0.14	0.16	0.52	0.40	0.35	0.31	0.40
E	0.20	0.19	0.18	0.16	0.18	0.48	0.46	0.44	0.41	0.45
F	0.29	0.19	0.16	0.16	0.20	0.50	0.49	0.41	0.38	0.45
K. means	0.20	0.17	0.16			0.46	0.41	0.37	0.34	
L.S.D. at 0.05		D		K	D x K	D		K		D x K
		0.041		0.026	0.060	0.067		0.025		0.063
Na uptake (kg Na/fed.)										
Leaves										
A	58.15	51.28	49.98	41.85	50.30	56.32	55.60	53.24	52.08	54.31
B	51.36	52.68	53.41	51.27	52.18	57.80	58.36	52.97	52.72	55.46
C	58.28	55.32	56.16	51.92	55.42	57.37	50.08	46.58	45.57	49.90
D	46.46	45.53	48.20	44.29	45.37	61.31	52.59	52.07	45.26	52.81
E	58.35	63.21	62.10	57.91	60.39	61.44	61.72	61.35	60.46	61.24
F	39.26	36.58	36.26	34.73	36.71	51.94	49.14	47.77	44.41	48.32
K. means	52.00a	50.76	50.52	46.99		57.70	54.58	52.33	50.08	
L.S.D. at 0.05		D		K	D x K	D		K		D x K
		7.81		4.92	12.06	11.51		6.48		15.87
Roots										
A	10.31	10.88	10.03	8.30	9.88	22.61	20.61	18.96	16.03	19.55
B	12.11	12.03	10.38	11.78	11.58	28.91	28.06	26.88	24.22	27.02
C	12.58	12.03	11.85	11.87	12.08	27.28	23.27	23.85	24.94	24.99
D	11.48	11.19	10.63	9.97	10.52	29.08	23.95	21.14	21.89	24.02
E	11.41	11.33	10.99	10.93	11.17	25.32	25.91	24.85	22.18	24.56
F	13.05	9.95	9.17	8.50	10.16	23.02	23.44	21.41	20.06	21.98
K. means	11.82	11.24	10.51	10.22		26.04	24.21	22.85	21.55	
L.S.D. at 0.05		D		K	D x K	D		K		D x K
		1.35		0.76	1.85	1.73		2.60		6.36

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تأثير الجفاف في المراحل المتوسطة والمتأخرة من موسم النمو والتسميد البوتاسي على المحتوى المعدني لبنجر السكر وبعض خواص التربة الكيميائية في شمال دلتا النيل

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أجريت تجارب حقلية بمزرعة محطة البحوث الزراعية بسخا بمحافظة كفر الشيخ في موسمين زراعيين متتاليين ٩٤، ١٩٩٥، ١٩٩٦/٩٥ بغرض دراسة تأثر بعض صفات التربة الكيميائية وتركيزات عناصر النيتروجين ،الفوسفور ، البوتاسيوم والصوديوم وإمتصاصها بتأثير فترات الجفاف عند مراحل النمو المتوسطة والمتأخرة لبنجر السكر والتسميد البوتاسي باستخدام قطع منشقة في ٤ مكررات. تمثل القطع الرئيسية فترات الجفاف بواسطة الحرمان من ريه أو أكثر أثناء موسم النمو حيث كانت فترات الجفاف قبل الحصاد وهي المعاملة (A)٣ أسابيع ، المعاملة (B)٦ أسابيع ، المعاملة (C)٩ أسابيع ، المعاملة (E)٦ أسابيع قبل الحصاد مع ٩ أسابيع في المرحلة الوسطى من موسم النمو ثم المعاملة (F)١٥ أسبوع .أما القطع التحت رئيسية فتمثل التسميد البوتاسي بمعدلات صفر ،٤٨، ٧٢ ، ٩٦ كجم/بو ٢أ/ فدان كانت التربة في الموسم الأول غير ملحية غير صودية (ECe=1.21 and Esp =9.91) أما في الموسم الثاني فكانت ملحية صودية (ECe=6.72 and Esp=16.67) ويمكن تلخيص أهم النتائج فيما يلي :

- ازداد التوصيل الكهربي لمستخلص عينة التربة المسبعة بزيادة فترة الجفاف قبل حصاد بنجر السكر خلال موسمي النمو وقد وجدت أعلى قيم للتوصيل الكهربي في الطبقة السطحية للتربة (٢٨ , ٢ ، ٣٦ , ٧ ديسيمتر / متر) تحت أطول فترة جفاف المعاملة (F) خلال موسمي النمو الأول والثاني على الترتيب .
- أوضحت النتائج أنه بزيادة فترة الجفاف قبل الحصاد أدى إلى زيادة معنوية في قيم النسبة المئوية للصوديوم المتبادل خلال موسمي النمو.
- وجدت أقل القيم لـ ESP(١٨ , ٤)تحت فترة جفاف ٦ أسابيع قبل الحاصد المعاملة (A) بدون تسميد بوتاسي خلال موسم النمو الأول بينما أقل قيمة لـ ESP في الموسم الثاني (٤٨ , ٩) قد تحصل عليها تحت معاملة الري الكامل (A) بدون تسميد بوتاسي .

- أوضحت النتائج أن البوتاسيوم الميسر بالتربة قد زاد زيادة معنوية بزيادة فترة الجفاف قبل الحصاد خلال موسمي النمو . قد أدى زيادة معدل إضافة السماد البوتاسي إلى زيادة معنوية فى Kالميسر فى طبقة التربة السطحية خلال موسمي النمو كما أدى إضافة ٩٦ كجم بو ٢أ/ فدان تحت أطول فترة جفاف المعاملة (F)إلى الحصول على أعلى القيم للبوتاسيوم الميسر (٨ . ٥١٤ ، ٨ . ٥٨٥ جزء فى المليون) خلال موسمي النمو الأول والثانى على الترتيب.

- أدت زيادة فترة الجفاف قبل الحصاد إلى زيادة معنوية فى تركيز الصوديوم والبوتاسيوم ونقص معنوى فى تركيز النيتروجين والفوسفور فى أوراق وجذور بنجر السكر خلال موسم النمو . كما أدى زيادة فترة الجفاف قبل الحصاد إلى نقص معنوى فى إمتصاص النيتروجين ، الفوسفور ، البوتاسيوم ، الصوديوم بواسطة أوراق وجذور بنجر السكر خلال موسمي النمو .

- زيادة معدل التسميد البوتاسي أدى الى زيادة معنوية فى تركيز وإمتصاص النيتروجين ، الفوسفور ، والبوتاسيوم بواسطة أوراق بنجر السكر إلا أن تركيز وإمتصاص الصوديوم بواسطة الجذور قد انخفض معنويا خلال موسمي النمو.

- تحصل علي زعلى القيم لتركيز النيتروجين والفوسفور فى أوراق بنجر السكر بواسطة التفاعل بين ٩٦ كجم بو ٢أ/فدان ومعا ملة المدى الكامل (A)خلال موسمي النمو ، بينما أقل قيم لتركيز النيتروجين فى الجزور قد نتجت من التفاعل بين إضافة ٩٦ كجم بو٢أ/فدان وأطول فترة جفاف المعاملة (F)خلال موسمي النمو .

- أدى التفاعل بين ٩٦ كجم بو ٢أ/فدان ومعاملة الجفاف (B)إلى الحصول على أعلى القيم لإمتصاص البوتاسيوم بواسطة الأوراق وجذور بنجر السكر خلال موسمي النمو .

- أدى التفاعل بين إضافة ٩٦ كجم بو ٢ أ/فدان وأطول فترة جفاف المعاملة (F) إلى الحصول على أقل قيم لإمتصاص الصوديوم بواسطة بنجر السكر. خلال موسمي النمو .

- أدى التفاعل بين إضافة ٩٦ كجم بو ٢أ/فدان وأطول فترة جفاف المعاملة (F)إلى الحصول على اقل قيم لإمتصاص الصوديوم بواسطة بنجر السكر.

- كما أوضحت النتائج ان تركيز وأمتصاص الصوديوم والبوتاسيوم بواسطة بنجر السكر كان أعلى تحت ظروف الأرض الملحية الصودية خلال موسمي النمو.