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Yield and Quality of Sugar Beet Crop as Affected by Mid to Late Season Drought and Potassium Fertilization at North Nile Delta

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FIELD EXPERIMENTS were carried out during 1994/1995 and 1995/1996 growing seasons at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate to study yield and quality characteristics of sugar beet plant (Kawe mera sugar beet variety) as affected by the different periods of drought at mid and /or late season and K-fertilization. The drought periods were imposed by withholding one or more irrigation during the growing season. The experimental design was a 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 treatment were 0,48,72 and 96 kg K_2O/Fed. (as subplots).

The obtained results, under the condition of the studied area showed that, the maximum allowable soil drought that sugar beet crop will tolerate without reducing sugar beet yield not exceed 9 weeks before harvesting. Potassium fertilization replenished the reduction of sugar beet yield resulted from the drought for a long period before harvesting. The highest values of root yield (40.7 and 33.1 ton/fed) and white sugar yield (6.61 and 3.86 ton/fed) were obtained with addition of 96 kg K_2O/fed under treatment (B) and (C) in the 1st and 2nd season, respectively. The yield decrease in 2nd season compared to the 1st one, was attributed to the high soil salinity of the 2nd season.

The highest increment percentage of root yield (22% and 24%) and that of white sugar yield (25.4% and 37.7%) was obtained at

addition of 96 kg K_2O/fed, proving that K-fertilization increment improve sugar beet quality more that production quantity.

Roots, shoots, sugar yields and root diameter were all significantly decreased with increasing drought periods, while root length, sugar percentage and juice purity all significantly increased with increasing drought periods. The highest values of these characters were obtained under drought treatment (F) with addition of 96 kg K_2O/fed during the two growing seasons.

Keywords: Sugar beet crop, MID, potassium fertilization North Nile Delta.

The need for water by different plant species depend on how much moisture stress they are able to tolerate at any particular stage of growth. Economic irrigation requires application of water at the proper time and suitable amount to meet the needs of the growing crop, to prevent salt accumulation in the soil and to prevent excessive waste of water.

Sugar beet could be extensively grown under the Egyptian conditions because of its adaptation to a wide range of climate, tolerance to salinity, hardness and its productivity which makes it a good chash crop.

Sugar beet have been credit with a rather wide range of response to mid and late season drought stress. Carter et al. (1980) among of others, showed that use of mid to late season deficit water management could substantially reduce sugar beet production costs in irrigated areas and economically benefit the consumer, producer and manufacturer. However, sufficient soil water should be present at harvest to prevent loss of roots by breaking.

On the other hand, potassium is an essential element for plant growth not only in regard to its concentration in plant tissues but also with respect to its physiological and biochemical functions. Potassium is necessary for activating the starch synthetase enzyme (Nitoses and Evaus, 1969). Khalifa et al. (1995) reported that root yield and sugar yield of sugar beet significantly increased by increasing K-rates up to 48 kg K_2O/fed.

Therefore, the current work was carried out to find out the convenient rate of potassium fertlization under the drought conditions for optimum yield and quality of sugar beet.

Material and Methods

Field experiments were conducted at Sakha Agricultural Research Station Farm, Kafr El-Sheikh during 199411995 and 199511996 growing seasons. The soil was non-saline in first season (ECe = 1.21 dS/m, ESP = 9.91 and pH (1:2.5) = 8-11), whereas in the second season the soil was clay saline sodic (ECe = 6.72 dS/m, ESP = 16.67 and pH (1:2.5) = 7.76) for the depth of soil (0-30 cm). Kwaemera sugar beet variety was the crop of the experiment. Data of sowing was Nov. 15th in the 1st season and Nov. 23rd in the 2nd season. Date of harvest was June 5th in the 1st season and June 23rd in the 2nd season.

A split plot design with four replications in the 1st and 2nd growing season was used. The plot area was 21 m^2 (3x7), each plot had five rows 60 cm apart and 7m in length. The main plots were designated for six drought periods treaments . The drought treatments were A (3 weeks); B (6 weeks) ; C (9 weeks) ; D (12 weeks) ; E (15 weeks at mid-season and 6 weeks before harvesting) and F (15 weeks before harvesting).

The interval between each two irrigation was about 3 weeks. Irrigation water was applied by 2-inches in diameter plastic siphons.

The subplots were subjected to potassium fertilization treatments at rates of 0,48, 72, 96 kg K_2O/ fed in form of potassium sulfate (48% K_2O). Each rate was added in one dose before the first irrigation.

Nitrogen and phosphorus fertilization were added at the recommended rate of 90 kg N/Fed and 15 kg P_2O_5/Fed, respectively. N was added in form of area (46.5%N) in two equal doses. The first dose after thinning and the second one before the 2nd irrigation. P was broadcasted before planting as super phosphate (15.5% P_2O_5).

The following parameters of sugar beet yield and quality were determined from the central three ridgges of the plots: root and shoot yields (Ton/Fed), sucrose and juice purity % were determined in Delta sugar company limited at EL-Hammol, Kafr El-Sheikh Governorate, sugar yield (Ton/fed) = sucrose percentage x root yield (Ton/fed.) and root diameter and root length (cm).

Data collected for yield and quality of sugar beet were subjected to the statistical analysis, according to Gomes and Gomes (1984), and all means were compared by Duncan's Multiple Range Test.

Results

Root and shoot yields (Ton/Fed)

Data presented in Table 1 showed that drought periods, had a highly significant effect on root and shoot yields during the two growing seasons. The highest average value of root yield (34.95 and 30.20 Ton/Fed) and shoot yield (7.30 and 6.01 ton/fed) were obtained under drought treat. (B) in the first and second seasons, respectively.

It was clear from the obtained result that increasing the period of drought from mid season up to harvesting had pronounced effect in decreasing both root and shoot yields.

Potassium fertilization had a highly significant effect on both root and shoot yields during the growing season. The highest average root yield (33.21 and 29.57 ton/fed) and shoot yield (7.18 and 5.82 ton/fed) were obtained with addition of 96 kg k_2O/fed) in the first and second seasons, respectively.

The interaction between drought periods and potassium fertilization on root and shoot yields were highly significant during the two growing seasons. The highest values of root yield (40.76 aud 33.11 Ton/Fed) were obtained with addition of 96 Kg K_2O/fed. under drought treatments (B) and (C) in the first and second seasons, respectively (Table 1). Meanwhile, the highest shoot yield (8.59 and 6.28 ton/fed) were obtained under drought treatment (B) with potassium fertilization rate of 96 kg K_2O/fed in the 1^{st} and 2^{nd} season, respectively (Table 2). The reduction of root and shoot yields in the 2^{nd} season compared with the 1^{st} one was attributed to the higher soil salinity and ESP in the second season which hindered sugar beet growth and yield.

TABLE 1. Root and shoot yields of sugar beet (ton/fed.) as affected by drought periods and potassium fertilization during the two growing seasons,

Drought Treatments	Potassium treatments (Kg K_2O / Fed.)									
	First season (1994-1995)					Second season (1995-1996)				
	K_0	K_{48}	K_{72}	K_{96}	Drought means	K_0	K_{48}	K_{72}	K_{96}	Drought Means
Root yield										
A	28.75	32.45	33.33	35.20	32.43	26.70	27.98	29.44	29.81	28.48
B	31.44	31.91	35.69	40.76	34.95	28.72	30.00	30.64	31.42	30.20
C	31.99	32.78	34.85	37.30	34.23	25.88	25.88	28.76	33.11	28.41
D	25.88	26.56	26.94	31.39	27.69	24.26	25.99	26.03	30.86	26.78
E	25.52	25.94	26.55	29.37	26.84	20.8	24.86	26.29	29.29	25.31
F	19.76	20.14	24.84	25.27	22.50	16.58	20.55	21.98	22.91	20.50
K means	27.22	28.29	30.37	33.21		23.82	25.88	27.19	29.57	
L.S.D. at 0.05										
Drought (D)	2.76					3.17				
K-fertilization	1.84					2.25				
D xK	4.51					5.50				
Shoot yield										
A	5.81	7.64	771	7 92	727	5.50	6.10	6.02	6.25	5.97
H	6.20	6.96	7.46	8 59	7 30	5.83	6.13	5.78	6.28	6.01
C	666	7.45	6.86	7.91	722	5.34	5.55	5.52	5.00	5.35
D	5.09	5.26	5 18	6 37	5 47	5.29	5.20	5.45	6.18	5.53
E	5.03	6.11	h37	651	6.00	5.31	5.50	5.95	5.83	5.64
F	4.18	4.81	4.56	5 75	4 82	4.77	4.93	5.31	5.37	5.09
K means	5 50	6.37	6.30	7 18		5.34	5.57	5.67	5.82	
L.S.D. at 0.05										
Drought (D)	1 07					0.76				
K-fertilization	0 72					0.41				
D xK	1 76					1.00				

These results were in general agreement with those of Carter et *al.* (1980), Winter (1980), Zalat, (1986); Khalifa and Ibrahim (1995); El-Kammah and Ali (1996) and El-Rammady (1997).

Root length and root diameter (cm)

Data in Table 2 showed that increasing the drought period resulted in significantly increase root length and decrease root diameter in the first and the second seasons. The longest period of drought (treatment F) had the longest root of sugar beet (40.22 and 38.94 cm) and the smallest root diameter (10.5 and 14.48 cm) in the first and second growing seasons, respectively. The same finding were found by Winter (1980) and Eid (1994) who reported that roots grow longer under moisture stress. Potassium fertilization had a highly significant effect on root length of sugar beet during the two growing seasons. Application of 96 kg k_2O/Fed resulted in the highest average values (40.35 and 38.11 cm) of root length in the first and second growing season, respectively.

TABLE 2. Root length and diameter of sugar beet (cm) as affected by drought periods and potassium fertilization during the two growing seasons.

Drought Treatments	Potassium treatments (kg K_2O / Fed.)									
	First season (1994-1995)					Second season (1995-1996)				
	K_0	K_{48}	K_{72}	K_{96}	Drought means	K_0	K_{48}	K_{72}	K_{96}	Drought Means
Root length										
A	34.92	35.50	36.58	37.33	36.08	32.47	33.20	34.00	34.33	33.50
B	36.78	38.70	38.53	40.57	38.64	31.95	33.97	36.44	37.05	34.46
C	37.50	37.38	38.58	38.70	38.04	35.38	36.00	36.00	36.65	36.01
D	37.20	37.88	37.78	41.63	38.62	31.23	33.60	37.58	38.15	35.14
E	36.95	36.83	37.55	41.88	38.30	34.60	34.13	38.97	41.30	37.25
F	39.33	39.65	39.88	42.00	40.22	35.85	37.33	39.88	42.70	38.94
K means	37.11	37.65	38.15	40.35		33.58	34.70	37.14	38.11	
L.S.D. at 0.05										
Drought (D)	2.06					2.48				
K-fertilization	1.59					1.18				
D xK	3.90					2.89				
Root diameter										
A	11.93	12.32	12.48	12.80	12.38	14.98	15.15	15.48	15.88	15.37
B	11.93	12.52	12.40	12.90	12.44	15.27	15.50	15.75	15.98	15.63
C	11.60	12.43	12.50	13.75	12.57	15.45	16.88	16.98	17.48	16.69
D	10.03	10.73	11.43	11.63	10.95	15.20	15.38	15.32	15.71	15.40
E	11.02	11.27	11.52	12.38	11.55	15.25	15.25	15.48	15.98	15.49
F	10.32	10.35	10.38	11.33	10.50	13.98	14.48	14.50	14.95	14.48
K means	11.14	11.60	11.78	12.47		15.02	15.44	15.58	16.00	
L.S.D.at 0.05										
Drought (D)	0.62					0.16				
K-fertilization	0.34					0.07				
D xK	0.84					0.17				

Data also showed that the interaction between drought and potassium treatments had a highly significant effect on root length. The longest roots of sugar beet (42.0 and 42.7 cm) were obtained with K-fertilization rate of 96 kg K_2O/Fed under drought treatment (F) in the first and second growing seasons, respectively. It was noticed that root length was higher in the 1st season than in the 2nd one. This attributed to the higher salinity in 2nd season which hindered the growth and elongation of root in comparison with the condition of the lower soil salinity in the first season. The obtained results were in close agreement with those of Winter (1980). Emara (1990) and Eid (1994).

With respect to root diameter of sugar beet, data in Table 4 showed that the highest average values of root diameter (12.57 and 16.69 cm) were obtained under drought treatment (C) in the first and second seasons, respectively. Increasing the rate of potassium fertilization resulted in a significant increase in root diameter. The highest average values of root diameter resulted from addition of 96 kg K_2O/Fed (12.47 and 16.00 cm) in 1st and 2nd season, respectively. Data also, showed that the interaction between drought periods and K-fertilization on root diameter was highly significant. The biggest root diameter of sugar beet was obtained with application of 96 kg K_2O/Fed under drought periods treatment (C), (15.57 and 16.69) in the first and second season, respectively. The obtained results were in close agreement with those of Abd El-Wahab *et* al. (1996) Abo-Soliman et a1 (1996) and El-Rammady (1997).

***Sucrose and* juice *purity* percentages**

Values of sucrose and juice purity percentage as affected by drought periods and potassium fertilization were shown in Table 3. Data showed that sucrose percentage and juice purity were increased significantly with increasing the period of drought. The highest average sucrose percentage (20.41 and 16.8%) and juice purity percentage (85 and 73.49%) were obtained under the longest period of drought treatment (F), in the first and second seasons, respectively. While, the lowest percentage of sucrose (18.75 and 14.84%) and juice purity (81.94 and 68.09%) were found under full-irrigated treat (A) in the first and second growing seasons, respectively. These obtained results were in good agreement with those of Winter (1980),Carter et al. (1980) and Fuehring and Finkner (1973) who found that water stress several weeks before harvest increased sucrose and juice purity percentage due to the dehyduration of sugar beet toops and roots.

TABLE 3. Sucrose percentage and juice purity % of sugar beet roots as affected by drought periods and potassium fertilization during the two growing seasons.

Drought Treatments	Potassium treatments (kg K_2O / Fed.)									
	First season (1994-1995)					Second season (1995-1996)				
	K_0	K_{48}	K_{72}	K_{96}	Drought means	K_0	K_{48}	K_{72}	K_{96}	Drought Means
Sucrose %										
A	18.47	18.70	18.85	19.00	18.75	14.38	14.50	15.14	15.45	14.87
B	18.91	19.19	19.33	19.44	19.22	14.49	14.76	15.26	15.51	15.01
C	19.27	19.20	19.39	19.60	19.37	15.53	15.62	15.70	16.29	15.78
D	20.22	20.13	20.11	20.72	20.30	15.51	15.95	16.46	16.71	16.16
E	19.89	19.89	19.88	20.17	19.98	15.07	15.53	15.79	16.29	15.66
F	20.10	20.11	20.69	20.75	20.41	15.52	15.95	16.18	17.05	16.18
K means	19.48	19.54	19.72	19.95		15.08	15.39	15.75	16.22	
L.S.D. at 0.05										
Drought (D)	0.22					0.40				
K-fertilization	0.17					0.20				
D xK	0.41					0.50				
Juice purity %										
A	81.23	81.73	82.10	82.73	81.94	66.47	71.55	66.47	67.88	68.09
B	83.00	82.82	83.89	83.35	83.26	67.90	67.65	68.60	69.65	68.45
C	83.30	82.78	83.40	83.18	83.16	69.65	68.82	68.82	71.47	69.69
D	84.45	83.82	84.20	85.13	84.40	70.07	69.15	72.13	72.97	71.08
E	82.78	83.50	83.50	83.10	83.22	70.07	70.70	71.15	72.32	71.06
F	84.96	84.80	85.08	85.17	85.00	72.20	72.90	73.10	74.97	73.49
K means	83.29	83.24	83.69	83.78		69.40	70.13	70.18	71.55	
L.S.D. at 0.05										
Drought (D)	0.51					0.73				
K-fertilization	0.47					2.14				
D x K	1.15					5.38				

Increasing the rate of potassium fertilization significantly increased the sucrose and juice purity percentage, during the two growing seasons. The highest average values due to potassium fertilization were found to be (19.95 and 16.22%) for sucrose percentage and (83.78 and 71.55%) for juice purity (Table 3) with application of 96 kg K_2O /Fed in the first and second seasons, respectively.

The interaction between the longest period of drought (treat. F) and application of 96 kg K_2O/Fed resulted in the highest values of sucrose percentage (20.75 and 17.05%) and juice purity percentage (84.17 and 74.97%)

in the first and second seasons, respectively. The higher soil salinity in the 2nd season resulted in decreasing sucrose percentage and juice purity in comparison with the 1st season. The obtained results were in close agreement with these of Abu-Amou et al. (1996), Abd El-Wahab *et al.* (1996), Khalifa and Ibrahim (1995), El-Kammah and Ali (1996) and El-Ramrnady; (1997) and Herlihy (1992).

TABLE 4. Gross sugar yield and white possible extractable sugar of sugar beet (to4 fed.) as affected by drought periods and potassium fertilization during the two growing seasons 1994-1995 and 1995-1996.

Drought Treatments	Potassium treatments (kg K_2O / Fed.)									
	First season (1994-1995)					*Second season (1995-1996)*				
	K_0	K_{48}	K_{72}	K_{96}	Drought means	K_0	K_{48}	K_{72}	K_{96}	Drought Means
Gross sugar yield										
A	5.31	6.29	6.29	6.69	6.15	3.84	4.06	4.45	4.62	4.24
B	5.95	6.12	6.89	7.93	6.72	4.17	4.44	4.68	4.88	4.54
C	6.16	6.30	6.76	7.31	6.63	4.02	4.05	4.52	5.37	4.49
D	5.23	5.38	5.42	6.50	5.63	3.48	4.14	4.28	5.14	4.35
E	5.08	5.16	5.30	5.93	5.36	3.14	6.83	4.15	4.77	3.98
F	3.97	4.06	5.10	5.23	4.59	2.57	3.28	3.55	3.91	3.33
K means	5.28	5.55	5.96	6.60		3.60	3.97	4.27	4.78	
L.S.D. at 0.05										
Drought (D)	0.50					0.52				
K-fertilization	0.37					0.35				
D x K	0.91					0.87				
White possible extractable sugar (ton/fed.)										
A	4.31	4.96	5.16	5.54	4.99	2.55	2.70	2.96	3.09	2.82
B	4.94	5.07	5.78	6.61	5.60	2.84	3.01	3.47	3.40	3.18
C	5.13	5.23	5.64	6.08	5.52	2.79	2.79	3.11	3.86	3.13
D	4.42	4.51	4.56	5.54	4.76	2.70	2.86	3.10	3.75	3.10
E	4.20	4.31	4.43	4.92	4.46	2.27	2.82	3.07	3.58	2.93
F	3.37	3.45	4.34	4.45	3.90	1.80	2.32	2.53	2.89	2.38
K means	4.40	4.59	4.99	5.52		2.49	2.75	3.04	3.43	
L.S.D. at 0.05										
Drought (D)	0.43					0.44				
K-fertilization	0.27					0.31				
D x K	0.66					0.75				

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تأثير الجفاف في المراحل المتوسطة والمتأخرة من موسم النمو والتسميد البوتاسى على إنتاجية وجودة محصول بنجر السكر في شمال دلتا النيل

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*كلية الزراعة بطنطا - ** كلية الزراعة بكفر الشيخ- جامعة طنطا و ***معهد بحوث الأراضى والمياه والبيئة - الجيزة - مصر.

أجريت تجارب حقلية فى محطة البحوث الزراعية بسخا بمحافظة كفر الشيخ فى موسمين زراعيين متتاليين ١٩٩٥/٩٤ ، ١٩٩٦/٩٥م بغرض دراسة صفات الإنتاج والجودة لمحصول بنجر السكر (صنف كاوميرا) تحت تأثير فترات الجفاف عند مراحل النمو المتوسطة والمتأخرة والتسميد البوتاسى باستخدام تصميم القطع المنقشة فى ٤ مكررات ، تمثل فيه القطع الرئيسية فترات الجفاف بواسطة الحرمان من رية 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 (D)١٢ أسبوع ، المعاملة (E) ٦ أسابيع مع ٩ أسابيع المرحلة الوسطى من النمو ثم المعاملة (F)١٥ أسبوع. أما التسميد البوتاسى (القطع التحت رئيسية) فقد أضيفت بمعدل صفر ، LA، ٧ و٩٦ كجم/ بو٢أ/فدان.

ويمكن تلخيص أهم النتائج فيما يلى :

- أقصى فترة جفاف يتحملها نبات بنجر السكر قبل الحصاد دون نقص في الإنتاج هى ٩ أسابيع تحت ظروف منطقة الدراسة. وأن التسميد البوتاسى يعوض النقص في الإنتاج الناتج عن طول فترة الجفاف .
- تحصل على أعلى محصول لإنتاج الجذور (٧ . ٤٠، ١ . ٢٣ طن/فدان) ولمحصول السكر الأبيض (٦١ . ٦ ، ٨٦ . ٣ طن/فدان) عند إضافة ٩٦ كجم بو٢أ/فدان تحت معاملة الجفاف (B) فى الموسم الاول ، المعاملة (C)فى الموسم الثانى على الترتيب وقد أعزى نقص الإنتاج في الموسم الثانى عن الموسم الأول الى ظروف ملوحة

التربة العالية فى الموسم الثانى .

- تحصل على أعلى نسبة زيادة فى إنتاج الجذور (٢٢٪،٢٤٪) وفى إنتاج السكر الأبيض (٤, ٢٥٪ ، ٧, ٣٧٪) عند إضافة ٩٦ كجم بو٢أ/فدان ، مبرهنا على أن نوعية الإنتاج تستجيب للتسميد البوتاسى أكثر من كمية الإنتاج.
- انخفض كل من إنتاج الجذور والأوراق والسكر وكذا قطر الجذور لنباتات بنجر السكر انخفاضا معنويا بزيادة فترة الجفاف ، بينما ازداد معنويا كل من طول الجذور ، النسبة المئوية للسكر ، ونقاوة العصير . وكانت أعلى قيم تحصل عليها لهذه الصفات تحت ظروف معاملة الجفاف (F)مع إضافة ٩٦ كجم بو ٢أ/فدان خلال موسمى النمو.