Study of the Growth and Fresh Root Yield of Sugar Beet (*Beta vulgaris*) in the Semi-arid Environment of Northern Central Sudan

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Summary

The response of two sugar beet cultivars to sowing date and time of harvest was investigated during the winter seasons of 1996/97 and 1997/98, in the experimental farm of UM Dom south east of Khartoum (Lat. 15° 40° N and Long. 32° 32° E.). The objective was to study the performance of sugar beet, as a potential crop, under the semi-arid environment of northern central Sudan. Cultivars used were Pamela and Sonja M. which were sown on October 20, November 5, November 19, December 5, and December 19. Within each sowing date the crop was harvested at three times in the first season, i.e. 18 weeks after sowing (WAS), 19 and 20 WAS. In the second season, four times of harvest were considered, i.e. 18,19,20 and 21 WAS.

Results indicated that time of sowing, time of harvesting and cultivar had highly significant effects on vegetative growth components as well as on fresh root yield. The most vigorous vegetative growth and the highest root yield 59.3 tons/ha (mean of two seasons) were produced from early planting on October 20. The least vigorous vegetative growth and the lowest root yield 36.6 tons/ha (mean of the two seasons) resulted from late planting on December 19. Pamela cultivar excelled Sonja M. in vegetative growth parameters and in fresh root yield. The latest time of harvest (21 WAS) resulted in the highest root yield while the earliest (18 WAS) produced the lowest. These results provide satisfactory justification for the suitability of sugar beet as a potential crop in the semi-arid environment of northern central Sudan.

Keywords: sugar beet; Sudan; semi-arid environment.

Introduction

Sugar consumption, worldwide, experiences a steady increase as a consequence of the great population growth and the improvement of the standard of living in developing countries. However, it appears to be stable or even declining in the industrialized countries (Anonymous, 1995). Sugar cane and sugar beet have long been considered as main sources of sugar of which every nation is vitally interested in having a continuous supply.

In the Arab region, the area under sugar beet is about 123000 hectares with a total production of 5.6 million tones of sugar. The leading sugar beet producing Arab country is Morocco, which produces 49% of total production of all Arab countries (Anonymous,1995). In Egypt, the current policy has been to discourage further expansion in sugar cane area and if possible to substitute sugar beet for sugar cane in the warmer southern part of the country (Afifi, 1996).

Scientific research on sugar beet in the Sudan dates back to the 1930 s when it was investigated among other crops as a promising crop in the Gezira scheme. The results of the experiments were not encouraging because of the low yield (Karouri and Rayah, 1998). Consequently no further work on the crop has been pursued till 1994/95 when the Arab Authority for Agricultural Investment and Development (AAAID) subjected the crop to more investigations in Khartoum State on the assumption that the crop might prove its worth further north. Yields obtained were in the range of 71 to 81 ton /ha , indicating that sugar beet could be considered as a potential winter crop in northern Sudan (Karouri and Rayah, 1998). However, no further research has been done on crop management practices for the identified superior cultivars. Hence, the objective of this experiment was to evaluate the growth and root yield of two of the leading cultivars of sugar beet in response to sowing and to time of harvest in the semi-arid environment of Khartoum State.

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Materials and Methods

The experiment was carried out during the winter seasons of 1996/97 and 1997/98 at Um Dom (Lat. 15° 40 ` N and Long 32° 32` E) which lies on the east bank of the Blue Nile about 20 km south east of Khartoum. The site is characterized by an arid semi-desert continental climate with relatively cool winter, hot summers, low rainfall, low relative humidity and a potential evapotranspiration, which exceeds precipitation throughout the year. The soils are classified as Aridisols containing varying amounts of salts and exchangeable sodium, which are considered as the main limitations for crop production. Soil has a clayey texture with over 40% clay and 20-30 % sand fraction and a pH of 8-9. Organic matter is generally low, total nitrogen is in the order of 0.03-0.06 % and available phosphorous in the range of 50-180 ppm (Ibrahim and Karouri, 1983).

Experimental treatments were arranged in a split-split plot design with four replications. Five sowing dates were randomized in the main plots, two cultivars in the sub-plots and three times of harvest in the sub-sub plots. The five sowing dates were spaced 15 days apart, on October 20, November 5, November 20, December 4 and December 19. The two cultivars were Pamela and Sonja M. The three times of harvest were spaced every week at 18, 19 and 20 weeks after sowing (WAS) in the first season and at 18, 19, 20 and 21 WAS in second. The first harvesting started on March 4, 16, 31, April 15 and 30 for the October 20, November 5, November 20, December 4 and December 19 planting dates respectively. Plot size was 7x 3.2 m comprising four ridges 6 m long and 0.8 m wide. The

two outer ridges were guard rows while the third was allotted for growth analysis and fourth for yield assessment. Seeds were sown on top of the ridges 2-3 cm deep and 15 cm apart. Fertilizer requirements were as recommended at Um Dom farm where the first dose of nitrogen was added pre-sowing at the rate of 40 kg/ha in the form of urea (46% N) followed by the second at the same rate 6 WAS. Phosphorus fertilizer was used at the rate of 50 kg P_2O_5/ha in the form of superphosphate as basal dressing at sowing. The frequency of irrigation was at 7-10 days in cool weather and 5-7 days intervals in warm days. Other crop management practices were done as needed.

Random samples of ten plants per treatment were taken for growth analysis from the second ridge 12 WAS. Growth analysis included number of leaves per plant, fresh and dry weights of leaves per plant, fresh and dry weights of roots per plant and leaf area index (LAI) which was determined according to Watson and Watson (1953). Beet roots of the third ridge were harvested as mentioned above for yield assessment. Data were analysed according to the statistical Analysis System (SAS Institute, 1979).

Results and Discussion

Statistical analysis of the vegetative growth components for the two seasons, presented in Table 1, showed that they were significantly (P=0.01) affected by sowing date and cultivar. Interaction between cultivars and sowing dates was significant (P=0.01) regarding only number of leaves per plant. Number of leaves, leaves fresh weight and roots fresh weight per plant as well as LAI were highest with early planting (October 20) and lowest with late (December 19) planting in both seasons. Leaves dry weight and roots dry weight per plant exhibited the same trend in both seasons (Tables 2 and 3). Pamela cultivar was significantly higher than Sonja M. regarding all of the above-mentioned growth attributes. The highest number of leaves per plant was produced by Pamela cultivar when planted in October 20 in both seasons, while November planting was the optimum for leaves production by Sonja M. cultivar. Both cultivars responded similarly to planting

Table 1. Mean squares showing the main effects of sowing date and cultivar on sugar beet growth component per plant and leaf area index (LAI), three months after sowing. Seasons 1996/97 and 1997/98.

Sources of variation	Number of leave	leaves fresh weight (g)	Leaves dry weight (g)	Root fresh weight (g)	Root dry weight (g)	LAI
			1996/97			
Sowing date (S)	3077.1**	761960.0**	6523.6**	505315.0**	17389.3**	3.31**
Cultivar (Cv)	1562.5**	10000.0**	608.4**	65610.0**	2592.1**	0.11**
S x C	249.8**	1650.0^{NS}	121.7^{*NS}	1072.5^{NS}	31.6**	0.03^{NS}
			1997/98			
Sowing date (S)	3223.8**	669856.9**	6330.9**	465912.5**	16088.1**	3.74*
Cultivar (Cv)	1946.0**	22325.6**	225.7^{NS}	39062.5**	977.6**	0.53**
S x C	215.3**	7319.5^{NS}	21.5^{NS}	2187.5^{NS}	134.7**	0.01

In this and the following tables, NS, * and
Significant at P = 0.05 and significant at ** mean not significant, P = 0.01 respectively.

Table 2. Effect of sowing date and cultivar on leavesfresh weight, leaves dry weight, root fresh weight, root dry weight and LAI of sugar beet 3 months after sowing. Season 1996/97.

Cultivar (Cv)	Sowing dates (s) Oct. 20 S_1	Nov. 5 S_2	Nov. 20 S_3	Dec. 4 S_4	Dec. 19 S_5	Means	LSD
			Number of leaves per plant				
Pamela (Cv1)	135	126	110	95	76	108	
Sonja M (Cv2)	105	109	103	94	68	96	4.1**
Means	120	118	107	95	72		
LSD (P=0.05)			10.3**				
			LAI				
Cv1	3.8	3.4	3.3	3.0	2.1	3.11	0.07**
Cv2	3.9	3.2	3.0	2.9	2.1	3.0	
Means	3.9	3.3	3.2	3.0	2.1		
LSD (P=0.05)			0.19**				
			Leaves fresh weight (g)				
Cv1	1395	1288	1090	993	613	1076	
Cv2	1255	1173	995	908	548	976	30.6**
Means	1325	1231	1043	951	581		
LSD (P=0.05)			74.2**				
			Leaves dry weight (g)				
Cv1	136	127	114	95	61	107	
Cv2	133	113	100	89	59	99	4.5**
Means	135	120	107	92	60		
LSD (P=0.05)			6.5**				
			Root fresh weight (g)				
Cv1	1198	1098	908	845	523	914	
Cv2	1093	995	850	763	465	833	20.3**
Means	1146	1047	879	804	494		
LSD (P=0.05)			90.4**				
			Root dry weight (g)				
Cv1	845	734	643	534	350	621	
Cv2	772	671	604	506	327	576	12.5**
Means	809	703	624	520	339		
LSD (P=0.05)			18.7**				

Table 3. Effect of sowing date and cultivar on leaves fresh weight, leaves dry weight, root fresh weight, root dry weight and LAI of sugar beet 3 months after sowing. Season 1997/98.

Cultivar (Cv)	Sowing dates (s) Oct. 20 S_1	Nov. 5 S_2	Nov. 20 S_3	Dec. 4 S_4	Dec. 19 S_5	Means	LSD
			Number of leaves per plant				
Pamela (Cv1)	131	121	104	86	71	103	
Sonja M (Cv2)	101	104	93	82	52	86	2.9**
Means	116	113	107	95	72		
LSD (P=0.05)			7.3**				
			LAI				
Cv1	3.8	3.4	3.1	2.6	2.0	3.0	0.05**
Cv2	3.6	3.1	2.8	2.4	1.9	2.8	
Means	3.7	3.2	2.9	2.5	1.9		
LSD (P=0.05)			0.11**				
			Leaves fresh weight (g)				
Cv1	1333	1163	1000	848	556	978	
Cv2	1240	1138	963	788	535	933	27.1**
Means	1287	1151	98	818	546		
LSD (P=0.05)			69.7**				
			Leaves dry weight (g)				
Cv1	134	116	101	86	58	99	
Cv2	124	114	98	81	55	94	NS
Means	129	115	100	84	57		
LSD (P=0.05)			6.08**				
			Root fresh weight (g)				
Cv1	1123	995	680	708	465	830	
Cv2	1023	900	808	678	430	768	30.1**
Means	1073	948	834	693	448		
LSD (P=0.05)			87.4**				
			Root dry weight (g)				
Cv1	797	667	611	446	312	567	
Cv2	726	603	574	447	301	530	10.8**
Means	762	635	593	447	307		
LSD (P=0.05)			17.2**				

dates as manifested by the values of the vegetative growth components; however, the performance of Pamela cultivar was superior, probably, reflecting more adaptation to the semi-arid environment. Early planting seems to have allowed enough time for the establishment of maximum vegetative growth before the onset of the low winter temperature (mid December) which checks the growth in favour of sugar accumulation in roots (Metcalfe and Elkins, 1980). Hussain (1990) in Pakistan and El-Kassaby and Leilah (1992) in Egypt reported similar results.

Fresh roots yield was significantly (P=0.01) affected by cultivar, sowing date and harvest time in both seasons (Tables 4 and 5). The highest root yields of 57.6 in the first and 61 ton/ha in the second season were obtained when sugar beet was sown on October 20. When sowing was delayed to the 5th of November, the 19th of November, the 4th of December or the 19th of December, root yield decreased by 6, 11, 21 and 36% respectively in the first season (Table 4). In the second season the reduction in yield was 6, 16, 23 and 40%, respectively (Table 5). The superiority of root yield obtained with early sowing could be attributed to the relatively long duration of optimum growing conditions which had promoted vigorous vegetative growth (Tables 2 and 3) before the onset of the relatively cool nights. These, among other factors such as depletion of soil nitrogen, retarded vegetative growth (Metcalfe and Elkins, 1980) in favour of root growth. The vigorous vegetative growth would then act as an active source for simple carbohydrates, which are translocated to the metabolically active roots and stored as sugars primarily sucrose. Pamela cultivar outyielded Sonja M. (Tables 4 and 5) because the former developed more vegetative growth faster (Tables 2 and 3) than the latter. Root yield has been found to depend largely, on the rate of growth at an early stage (Saito *et al.*, 1992) as well as on early planting (Lauer, 1995). Early harvesting (18 WAS) resulted in marked reduction in root yield. Delaying harvest to 19 and 20 WAS in the first season increased root yield by 23 and 52%, respectively. In the second season, increase in root yield of 28, 58 and 71% were recorded when harvest was delayed to 19, 20 and 21 WAS, respectively. These findings are in agreement with those reported by Besheit and El Gharbawy (1991) in India and by Leilah and Nasr (1992) in Egypt.

Table 4. Effect of sowing date, cultivar and time of harvest on root yield (t/ha) sugar beet, season 1996/97.

Sowing Dates (S)	Times of harvest (H)			Means
	18 WAS	19 WAS	20 WAS	
Pamela Cv.				
Oct. 20th (S1)	47.5	61.5	80.3	63.1
Nov. 5th (S2)	44.3	57.5	73.5	57.4
Nov. 20th (S3)	45.8	54.0	63.3	54.4
Dec. 4th (S4)	43.0	50.8	58.0	50.6
Dec. 19th (S5)	32.0	36.0	458	37.9
Means	42.5	44.8	64.2	
Sonja M Cv.n				
S1	38.3	51.3	66.5	52.0
S2	40.0	47.8	61.5	49.8
S3	42.5	46.0	54.3	47.6
S4	30.5	43.3	49.5	41.1
S5	29.0	33.5	43.0	35.2
Means	36.1	44.4	54.9	
Overall means (Cv)	Pamela = 50.5		Sonja = 45.1	
LSD		1.64**		
Overall means (S)	S1=57.6	S2=54.1	S3=50.95	S4=45.5 S5=36.6
LSD		2.75**		
	(- 6)	(- 11)	(- 21)	(-36)
Overall means (H)	18 WAS=93.3	19	WAS=48.2	20 WAS=59.6
LSD		1.41**		
		(+ 23)		(+ 52)

WAS Means weeks after sowing
Numbers in parenthesis indicate increased (+) or decreased (-) values.

Table 5. Effect of sowing date, cultivar and time of harvest on root yield (ton/ha) of of sugarbeet, season 1997/98.

Sowing Dates (S)	Times of harvest (H)				Means
	18 WAS	19 WAS	20 WAS	21 WAS	
Pamela Cv.					
Oct. 20th (S1)	45.5	57.8	78.3	83.3	66.2
Nov. 5th (S2)	42.3	56.5	42.8	76.8	62.1
Nov. 20th (S3)	42.3	51.5	59.8	66.8	54.7
Dec. 4th (S4)	37.0	43.8	54.8	61.3	49.2
Dec. 19th (S5)	30.8	37.8	40.8	44.3	38.4
Means	39.2	49.5	61.3	66.5	
Sonja M Cv.n					
S1	37.3	51.8	63.5	70.5	55.8
S2	36.3	48.5	60.8	66.8	53.1
S3	34.3	46.0	54.3	57.8	48.2
S4	31.8	40.5	50.3	53.5	53.1
S5	27.8	32.8	38.0	41.3	34.98
Means	33.6	43.9	53.4	54.98	
Overall means (Cv)	Pamela = 54.1			Sonja = 47.2	
LSD			1.9**		
Overall means (S)	S1=61	S2=57.6	S3=51.5	S4=46.7	S5=36.7
LSD			4.105**		
	(-6)		(-16)	(-23)	(-40)
Overall means (H)	18 WAS=36.5	19WAS=46.7		20WAS=57.4	21WAS=62.2
LSD			0.98**		
	(+28)		(+ 58)		(+ 71)

WAS Means weeks after sowing
Numbers in parenthesis indicate increased (+) or decreased (-) values.

Summary and Conclusion

The foregoing discussion showed that sugar beets fresh root yield ranged from 58 to 61 t/ha. (Tables 4 and 5) in the two seasons. Compared with the world s average of 24 ton/ha (Chapman and Carter, 1976) and with England s of 45 ton/ha (Lockart and Wiseman, 1983), the performance of the crop seems to justify its consideration as a potential crop for the semi-arid environment of northern central Sudan.

References

Afifi, F.1996. Sugar crops in Egypt. Proceedings of the Workshop on Prospects of Sugar Industry and Sweets in the Arab Countries, Cairo, 14-17.

Anonymous .1995. Production yearbook. FAO, Rome, Italy.

Besheit, S.Y. and El Gharbawy, A. A. 1991. Varieties, harvesting date and their Effect on yield and quality of sugar beet. Annals of Agricultural Science, Moshtohar 29 (2), 717-728.

Chapman, S.R. and Carter, L.P. 1976. Crop Production Principles and Practices. W.H. Freeman and Company, San Francisco; pp. 129-213.

El Kassaby, A.T. and Leilah, A.A. 1992. Effect of sowing date and harvesting time on yield and quality of sugar beet. Proceedings of the Fifth conference of Agronomy, Zagazig, 962-969.

Hussain, A. 1990. Analysis of responses of sugar beet to trans-sowing and agronomic treatments. Journal of Agricultural Research (Pakistan), 28 (2), 107-117.

Ibrahim, A.M. and Karouri, M. O. H. 1983. Estimated crop water requirements with special reference to vegetables in Um Dom project, Khartoum State. Acta Horticulturae 143, 319 - 334.

Karouri, M.O. and Rayah, A. 1998. Prospects of sugar beet in the Sudan. Annual Report, Arab Authority for Agricultural Investment and Development. Khartoum-Sudan.

Lauer, J.G. 1995. Sugar beet performance and interactions with sowing date, Genotype and harvest date. Agronomy Journal. 89, 469-475.

Leilah, A.A. and Nasr. S. M. 1992. The contribution of sowing and harvesting Dates to yield and quality of some sugar beet cultivars. Proceedings of Fifth Conference on Agronomy, Zagazig, Egypt, 970-979.

Lockart, J.A. R. and Wiseman, A.J.L. 1983. Sugar Beet. In: Maxwell, R. M.C. (Ed.), Crop Husbandry, 4th edition pp. 132-136. Pergman International Library. Royal Agricultural College, Cirencester, UK.

Metcalfe, D.S. and Elkins, D.M. 1980. Sugar Crops. In: Crop Production Principles and Practices. Mac Millan Company. New York, pp 511-527.

Saito, H.; Kurasowa, K. and Yamakami, M. 1992. Differences of sugar beet cultivars in correlations between characteristics of plants in growing stage and at harvesting time. Proceedings of the Japanese Society of Sugar Beet Technologists; 34, 76-84.

Statistical Analysis Systems. 1975. SAS Users Guide,Statistics, 1979 Edition. Cary, NC, 494 pp.

Watson, M.A. and Watson, D.J. 1953. The dependence of net assimilation rate on leaf area index. Annals of Botany; 22,37-32.

دراسة نمو وإنتاج محصول الجذور الطازج لبنجر السكر (*Beta vulgaris*) في البيئة شبه الجافة بشمال أواسط السودان

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الخلاصة:

تمَّ دراسة استجابة صنفين لبنجر السكر لمواعيد الزراعة ووقت الحصاد خلال موسمي الشتاء 97/1996 و98/1997 في المزرعة التجريبية للهيئة العربية للاستثمار والإنماء الزراعي بأم دوم التي تبعُد حوالي 20 كيلومتر جنوب شرق الخرطوم (خط عرض ´40 °15 شمالاً وخط طول ´32 °32 شرقاً).

كان هدف التجربة التعرف على أداء بنجر السكر، كمحصول واعد، في البيئة شبه الجافة. الأصناف التي استُخدمت هي باميلا وسونجا اللتان زرعتا في 20 أكتوبر، 5 نوفمبر، 20 نوفمبر، 5 ديسمبر و19 ديسمبر. تمَّ حصاد الجذور بعد 18، 19، 20 أسبوع من الزراعة في الموسم الأول وبعد 18، 19، 20، 21 أسبوع في الموسم الثاني.

أوضحت النتائج فوارق معنوية عالية في مكونات النمو الخضري والإنتاج الطازج للجذور بين مواعيد الزراعة والحصاد والصنفين. أكثر كثافة للنمو وأعلى إنتاج للجذور (59.3 طن للهكتار – متوسط الموسمين) نتج عن الزراعة المبكرة في 20 أكتوبر، بينما كان أقلَّ نمو خضري وأدنى إنتاج للجذور (36.6 طن للهكتار – متوسط الموسمين) نتيجة للزراعة المتأخرة في 19 ديسمبر. الصنف باميلا تفوَّق على الصنف سونجا في مكونات النمو الخضري والإنتاج الجذري. الحصاد بعد 21 أسبوعاً من الزراعة أدى إلى أعلى إنتاج للجذور، بينما نتج أدنى إنتاج للجذور عند الحصاد بعد 18 أسبوعاً من الزراعة.

هذه النتائج تعطي مؤشرات إيجابية تبرر اعتبار بنجر السكر من المحاصيل الواعدة في هذه البيئة.

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