A Note on the Adaptation of Sugar Beet to Agro-Ecology of Northern State

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Abstract

A field study of which 2004-05 was its third season was carried out at Dongola mainly to determine extent of sugar beet adaptation to agro-ecology of Northern State of the Sudan. Season's averages were 81 t/ha of fresh roots, 18.2% sucrose, 13.56 ton/ha of sugar, 66793 harvested beet/ha and an average root weight of 1.2 kg. Sugar beet varieties used in this study were generally similar in all parameters studied. Yield and sucrose recovery data of different varieties grown at different locations suggests that sugar beet is a promising crop in this area and deserves concentrated efforts in research and development.

Introduction

Sugar beet (*Beta vulgaris*) and sugar cane (*Saccharum officinarum*) are the principal crops managed mainly for sugar production in the world. About 40% of the world trade in sugar come from sugar beet. Sugar beet is generally grown in the temperate areas, while the sugar cane is grown in tropical and the sub-tropical parts of the world. Sucrose is the sugar found in both crops. In sugar beet this sugar is stored in enlarged taproot. Beside its sugar, sugar beet has several useful products; tops (leaves and crowns), pulp (root residues after sugar extraction) and molasses (a by-product of sugar processing). These products are useful for livestock feeding.

The Food Research Center (FRC) in Khartoum made quality jam from sugar beet of Dongola. Home made jam was also seen with several natives of the area. A scientist at Dongola Research Station prepared edible sugar beet honey.

Agricultural importance of sugar beet lies in the fact that it has a rotational value. This character is of great importance in the agriculture of the Northern State of the country. Also a greater success of sugar beet at the upper terrace soils (saline) is expected in comparison with salt-sensitive crops such aswheat.

For a given crop species or crop variety there are certain conditions under which it thrives best. The main objective of this study, which is the first of its kind in Northern State of the Sudan, was then to determine the extent of sugar beet adaptation to the environment of Northern State of Sudan.

Materials and Methods

A field study of which 2004-05 was its third season was carried out in Dongola. In the first season, 2002-03, experimentation was conducted at two locations,

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Dongola Research Station Farm (DRSF) (19º 10" N and 30º 19" E) and Gezirat Almasakin (GA) on the immediate bank of River Nile and about three kilometers northeast of DRSF. The second and third seasons trials were conducted at DRSF. Soils at DRSF are upper terrace class 3 soils known for their salinity. The surface of these soils is layered with sand. The soils at GA belong to class 1 soils, being the best soils in terms of fertility status. Dongola area is characterized by very hot summers (April to September) with maximum and minimum temperature of 45ºC and 30ºC, respectively. The rest of the months are winter months, with maximum and minimum temperatures of 30ºC and 5ºC in December and January, respectively. Mean annual rainfall of the region is about 12 mm.

The experiment was set up in Randomized complete block design with four and three replications in the first season and in the other two seasons, respectively. First season plots were 22 x 12 m^2 (DRSF) and 6 x 12 m^2 (GA). Those of second and third seasons were 6 x 3 m^2 and 7.2 x 2.4 m^2 , respectively.

The land was disc-harrowed, leveled then ridged. Ridges were 60 cm wide. Pre-sowing irrigation to moisten the soil was only adopted in the last two seasons of the trial. Varieties of sugar beet used are shown in Table 1. In 2002-03, DRSF trial was sown on 21 October and on 5 November while that at GA was sown on 6 December. In 2003-04 and 2004-05 seasons at DRSF sugar beet seeds were sown on 7 January and on 7 December respectively. Two seeding holes were adopted for every targeted seeding hole. Thinning of the seedlings left an intra-row spacing of 16 and 20 cm in the first and the other two seasons, respectively. After sowing the trial was irrigated to ensure germination and five days after sowing light irrigation was carried out. In the first season and following seasons irrigation during active growth was carried out when necessary. However, in the third season irrigation was scheduled for every 10 days. Water application restriction commenced in early part of sixth (harvest) month.

The experiment received 219 and 105 kg/ha of N and P_2O_5 (in form of Urea and TSP, respectively). Whole dose of N and TSP were broadcast before ridging in first two consecutive seasons of the trial. In the third season half of N was broadcast with whole dose of TSP. The other half was top-dressed in the sixth week after sowing.

Pre-sowing irrigation (second and third seasons) greatly contributed in weed control. Weeds still emerging were hoed out. Infestation of larvae beet worms *Spodoptera exigua* was checked by spraying the crop with Sevin and Silicron in the first and in the other latter two seasons.

Harvest of the trial in the first and second season was carried out in the end of 6^{th} month after sowing as scheduled. However, for purpose of knowing if there was some further gain or loss in sugar content with delaying harvest, harvesting of the trial in the third season (2004-05) was delayed by 20 days. For all the seasons middle plot rows with 0.5 or 1.0 m at either ends of each excluded constituted harvest area. Roots were hand-lifted without or by use of harvesting spades.

Characters studied at harvest were beet root yields, average root weight, plant population, sucrose (sugar) percent and sugar yield. Root yield (t/ha) were obtained by multiplying plant population at harvest by average root weight (kg) and divided by 1000. Average root weight resulted from weighing each of seven roots (ten in 2002-03) randomly sampled separately, the weights added and average obtained. Plant population was determined by counting all roots harvested. Sucrose percent was determined at Kenana Sugar Factory and Guneid Sugar Research Station laboratories in

the first and in the following seasons, respectively. Sugar yield was determined by the following formula: Sugar yield (ton/ha) = Beet yield (ton/ha) x Sucrose percent.

Analysis of variance was carried out using MSTAT. All parameters measured, with exception of sugar yield in 2003-04, were analyzed.

Results and Discussion

Beet root yield

In season 2002-03 (Table 2) and 2004-05 (Table 4) variety did not statistically influence sugar beet. However, some (p=0.05) variety influence was detected in season 2003-04 (Table 3). In season 2002-03, Posada (132.46 t/ha) outyielded Dorotea (128.48 t/ha) at DRSF site. This trend was reversed at GA site; Dorotea gave higher beet yield (102.29 t/ha) over Posada (96.19 t/ha). Mean beet yields of either variety in this season over the two sites were then: Dorotea 115.38 t/ha and Posada 114.32 t/ha, with a season's average yields of 114.86 t/ha. In 2003-04, the highest beet yield was recorded for FD9992 (67.70 t/ha) and the lowest for Chems (43.17 t/ha). The season's average of beet yield was 54.93 t/ha. In season 2004-05, average beet yield was 74.50 t/ha. The average beet yield of the three seasons could then be 81.48 t/ha.

Syngenta's 1998-99 trial results were: Kenana 67.4 t/ha, Guneid 114.6 t/ha and Sennar 111.2 t/ha (Elnegay, 2002). In California, vigorous crops commonly yield more than 80 t/ha of fresh storage beets in a five to six months growing season; longer growing seasons resulted in higher beet and sucrose yields (Evans, 1978). The commercial records in California are 132 t/ha of fresh beet (at 13% sucrose) and 115 t/ha beets (at 16.5% sucrose) in 240 days (8 months). Calculations based on work (1988) Metochis and Orphanos revealed 86.9 t/ha fresh roots/ha. Those based on that of Dor, Carmeli, Lachover and Zur (1971) revealed 88.9 t/ha of roots. Roots yield of up to 165 t/ha was obtained in Cyprus (Mitochis and Orphanos, 1988). Carter and Traveller (1981) obtained results as low as 49.45 t/ha. Lockhart and Wiseman (1983) described 45 t/ha of roots giving 7.5 t/ha of sugar as good average yield.

Sucrose (Sugar) Percent

In season 2002-03, the sucrose percent was 17.4, slightly higher than that of Dorotea (16.4%) at DRSF site (Table 2). The reverse being true at GA site, where Dorotea's sucrose percent was 17.0 compared to 15.2% for Posada. These figures could make up average sucrose percents of 16.7 and 16.3 for Dorotea and Posada, respectively. These in turn could make up the season's sucrose content of 16.5%. In season 2003-04, the highest sucrose percent was recorded for Baraca (19.0%) and the lowest for Francesco (16.2%). The season's mean was 17.8 percent (Table 3). However, in season 2004-05 (Table 4), the highest values were recorded for Kawemera (20.8%) and the lowest for Cultivan 7112*261 (15.99%).

Sugar yield

In season 2002-03 sugar yield of beet was not subjected to statistical analysis (Table 2). However, sugar yield did not seem to be influenced by variety. Posada out-ranked Dorotea; Posada sugar yield was 23.03 t/ha while that of Dorotea was 21.08 t/ha at DRSF site. This response was reversed, as for beet yield, at GA site where Dorotea and Posada scored 17.39 and 14.62 t/ha, respectively. This season's sugar yield was then 19.04 t/ha. In season 2003-04 significantly highest and lowest sugar yield were

recorded for FD 9992 and Chems respectively. FD 9992 sugar yield was 13.07 t/ha while that of Chems was 7.08 t/ha. The season's sugar yield was 9.89 t/ha, lower than that of seasons 2002-03 and 2004-05 by 48 and 27%, respectively. In season 2004-05, the average sugar yield was 13.56 t/ha (Table 4).

Commercial records of 132 (at 13% sucrose) and of 115 (at 16.5% sucrose) ton/ha of root in California could give 17.2 and 19.0 t/ha of sugar respectively (Evans, 1978). Sugar yield, of up to 20 t/ha were obtained in Cyprus (Mitochis and Orphanos, 1988). Calculations based on the results of Dor, Carmeli, Lachover and Zur (1971) revealed sugar beet yield of 14.99 t/ha. Lockhart and Wiseman (1983) described 7.5 t/a of sugar associated with 45 t/ha as fairly good average yield.

Harvested beets/ha

In season 2002-03 variety did not influence beets harvested/ha of sugar beet. Dorotea slightly over-ranked Posada in this parameter at both sites (DRSF and GA/m). Average of Dorotea and Posada were 67094 and 65730 harvested beets/ha, respectively. The season's harvested beets/ha was 66412 (64% of target plant population). In season 2003-04, significantly ($p = 0.05$) highest (81592, 98%) and significantly lowest (55296, 66%) beets harvested t/ha were scored by varieties Dorotea and Marathon respectively. The season's harvested beets/ha was 69881 (84%). In season 2004-05 non-significantly highest and lowest beets harvested were scored by Brigita (77778 beets/ha) and Chems (59722 beets/ha), respectively. And the season's beets harvested/ha was 64087. According to Halley and soffe (1988) one should aim for a final stand of at least 75,000 plant/ha. And up to 100,000 plants/ha produce no harvesting difficulties. Further, if under 62,000 plants/ha yield is seriously affected. Dor, Carmeli, Lachover and Zur's (1971) realized beet population was 75%.

Root weight

With the exception of 2003-04, variety did not influence sugar beet root weight in season 2002-03 and season 2004-05 (Table 2, 3 and 4). In season 2003-04 significantly ($p = 0.05$) highest root weight was recorded for FD 9992 (0.90 kg); the lowest value was equally scored by Kawemera and Raval (0.69 kg). The season average was 0.79 kg. In season 2004-05, root weight ranged from 0.94 (scored by Armura) to 1.42 kg (scored by Desprez-mono). However, sugar beet root weight was not greatly influenced by variety in this season. The season's root weight was 1.14 kg. According to Bishop, Carter, Chepman and Bennett (1983) sugar beet root ranges from 0.5 to over 2.2 kg in extreme cases and average mature root size will be around 0.9 to 1.4 kg. And according to Evans (1978) each sugar beet plant achieves much less than its potential root size (0.5 to 1kg than 10kg fresh or more.

Extent of variety(ies) generally dominance as first of two (season 2002-03) or as member(s) of first ten varieties category (seasons 2003-04 and 2004-05) is shown in Table 6. However, as shown by results not only these varieties ranked top but all sugar beet varieties so far tested could make up "Recommended Varieties of Sugar beet for Northern State of Sudan". "(When selecting choose at least two varieties (of sugar beet); one of them may suit individual farm conditions better than the other" (Halley and Soffe, 1988).

Sugar beet performance in other areas of the Sudan, Arab world and other countries of the world are presented in Tables 7, 8, and 9, respectively.

Northern State environment avails most if not all conditions effecting vigorous sugar beet growth. Sugar beet is a sun-loving crop requiring longer period of cool nights and good deep soils that are less vulnerable to water logging. And salt is one of its main nutrients. These conditions for good performance of sugar beet as well as likely reliability of water and electricity supply with completion of Hamadab Dam Project as well as generation of indigenous appropriate management technologies (work has commenced) will continue to play great role in sustaining if not in raising the level of sugar beet performance attained.

Conclusions

- Sugar beet productivity under Northern State environment is very good
- Sugar beet should be promoted as an agro-industry for Northern State
- Sugar beet is more successful under salt affected soils of Northern State
- Six month is the probable growth period for sugar beet in Northern State
- Northern state can make a better site for beet sugar factory.

Recommendations

Based on the results of the present study, we recommend sugar beet as a new promising agro-industrial crop for salt-affected areas of the Northern State of Sudan.

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Table 1. Sugar beet varieties sown for sugar beet adaptation trial in Dongola, Northern State of Sudan.

Season 2002-03	Season 2003-04		
1) Dorotea	Dorotea	7) F Davoi	13) LP 015
2) Posada	Posada	8) FD 9992	14) Manela
	3) Armura	9) Florimon Desprez	15) Marathon
	4) Baraca	10) Francesco	16) Pipite
	5) Chems	11) Helsinki	17) Raval
	6) Desprez-Monon	12) Kawemera	18) Sultan
	2004-05		
Dorotea	FD 9992	Marathon	22) Rasoul
Posada	Florimon Desprez	Pipite	23) Shirin
Armura	Francesco	Raval	24) Zargan
Baraca	Helsinki	Sultan	25)Cultivan 7112*261
Chems	Kawemera	19) Brigita	26) 7112*261
Desprez-Monon	LP 015	20) Laetitia	
F Davoi	Manela	21) BR1	

(1)and (2) from Sweden, (3) – (18) From Egypt, (19) and (20) from Lebanon (21) – (26) from Iran.

Table 2. Sugar beet yields and some yield components in Northern state of Sudan, 2002-03.

Variety	Beet yield (t/ha)	Av. Root wt. (kg)	Beets harvested (no./ha)	Sucrose percent	Sugar** yield (t/ha)
(a) Dongola Research Station Farm (DRSF) class 3 soils					
Dorotea	128.48	2.0	64918	16.4	21.08
Posada	132.46	2.1	63334	17.4	23.05
Mean	130.47	2.05	64126	16.9	22.07
S.E.	3.8795	0.0677	1289.27	0.3599	-
Sig. Level	NS	NS	NS	NS	-
C.V%	8.41	9.34	5.69	5.96	-
(b) Gezirat Almasakin (GA/m) class 1 soils					
Dorotea	102.29	1.5	69271	17.0	17.39
Posada	96.19	1.4	68125	15.2	14.62
Mean	99.24	1.45	68698	16.1	16.00
S.E.±	3.8627	0.0560	1688.07	0.7355	-
Sig. Level	NS	NS	NS	NS	-
C.V%	11.01	10.97	6.10	11.20	-
Season's nean	114.86	1.8	6641 (64%)	16.5	19.04

NS = non significant
* Percentage of target plant population
** Calculated after statistical analysis of data

Table 3. Sugar beet yields and some yield components in Northern state of Sudan, 2003-04

Variety	Beet yield (t/ha)	Av. Root wt. (kg)	Beets harvested (no./ha)	Sucrose percent	Sugar yield (t/ha)
Armura	51.29^{ABC}	0.73^{AB}	69148^{ABCDE}	17.54	9.04^{ABCDE}
Baraca	64.15^{AB}	0.83^{AB}	77037^{ABC}	18.96	13.07^{AB}
Chems	43.17^{C}	0.77^{AB}	55815.08^{FG}	17.30	7.08^{E}
Desprez -monon	52.93^{ABC}	0.83^{AB}	63703.17^{DEFG}	17.89	9.68^{ABCDE}
Dorotea	62.64^{ABC}	0.77^{AB}	81592.06^{A}	18.25	12.08^{ABCD}
F Davoi	56.10^{ABC}	0.87^{AB}	64703.97^{CDEFG}	17.84	10.44^{ABCDE}
FD 9992	67.70^{A}	0.90^{A}	74815.29^{ABCD}	17.66	13.56^{A}
Florimon Desprez	67.52^{A}	0.87^{AB}	77888.89^{AB}	17.01	12.74^{ABC}
Francesco	52.44^{ABC}	0.70^{AB}	74815.08^{ABCD}	16.18	7.92^{DE}
Helisinki	49.88^{ABC}	0.73^{AB}	68037.3^{BCDEF}	17.64	8.42^{CDE}
Kawemera	50.22^{ABC}	0.67^{B}	75444.44^{ABCD}	17.75	8.66^{BCDE}
LP 015	49.11^{ABC}	0.77^{AB}	63703.97^{DEFG}	18.80	7.91^{DE}
Manela	61.42^{ABC}	0.83^{AB}	73815.08^{ABCD}	16.66	10.74^{ABCDE}
Marathon	44.53^{BC}	0.80^{AB}	55296.03^{G}	18.26	8.06^{DE}
Pepite	50.63^{ABC}	0.83^{AB}	60370.63^{EFG}	18.58	9.67^{ABCDE}
Posada	62.79^{ABC}	0.87^{AB}	72111.11^{ABCDE}	17.58	10.89^{ABCDE}
Raval	49.00^{ABC}	0.67^{B}	73.444.44^{ABCD}	18.65	8.79^{BCDE}
Sultan	53.28^{ABC}	0.70^{AB}	76111.12^{ABCD}	17.93	9.26^{ABCDE}
Mean	54.93	0.97	69880.74 (83.86%)	17.80	9.89
S.E.±	5.9776	0.0643	3785.9349	1.0824	1.3454
Sig. Level	*	*	*	NS	*
C.V%	18.85	14.19	9.38	8.60	19.24

NS = not significant
* = significant at p = 0.05

Table 4. Sugar beet yields and some yield components in Northern state of Sudan, 2004-05

Variety	Beet yield (t/ha)	Root wt. (kg)	Beets harvested (no./ha)	Sucrose percent	Sugar yield (t/ha)
Armura	72.66	0.94	71527.78	17.56	12.74
Baraca	83.25	1.19	69444.44	17.19	14.15
Chems	70.59	1.17	59722.22	17.28	12.20
Desprez -monon	82.74	1.42	63888.89	19.73	16.28
Dorotea	68.20	1.12	62500.00	16.94	11.62
F Davoi	75.82	1.11	64583.34	18.20	13.78
FD 9992	78.07	1.16	70138.89	18.63	14.48
Florimon Desprez	82.43	1.15	70833.33	17.78	14.52
Francesco	67.38	1.11	68055.56	18.64	12.56
Helisinki	72.00	1.07	70138.89	19.22	13.82
Kawemera	85.06	1.08	77083.33	20.84	17.69
LP 015	80.04	1.26	61805.56	18.26	14.54
Manela	67.40	1.08	69444.44	17.40	11.76
Marathon	66.03	1.00	66916.66	19.08	13.56
Pepite	68.10	1.13	60416.67	18.17	12.30
Posada	63.79	0.97	66666.66	17.04	10.93
Raval	80.70	1.34	68055.56	18.30	14.82
Sultan	64.50	1.08	66666.66	17.63	11.52
Brigita	75.39	1.03	77777.78	17.96	13.60
Laetitia	77.04	1.25	72916.67	17.89	13.82
BR1	66.68	1.07	68055.56	19.98	13.32
Rasoul	94.93	1.23	76388.89	17.98	17.12
Shirin	68.02	1.13	63194.44	18.02	12.21
Zargan	74.62	1.17	62500.00	18.61	13.89
Cultivan 7112*261	82.20	1.15	65972.22	15.99	13.14
7112*436	69.76	1.13	61805.56	18.82	13.22
Mean	74.50	1.14	64086.54	18.20	13.56
S.E.±	6.5049	0.0885	6.2161	1.1107	1.2733
Sig. Level	NS	NS	NS	NS	NS
C.V%	12.35	13.50	13.01	8.64	13.30

NS = not significant

Table 5. Summary data for yield and yield components in the three seasons. 2002-02 to 2004-05 in Northern state of Sudan

	2002-03	2003/04	2004-05	Mean
Beet yield (t/ha)	114.86	54.93	74.50	81.43
Sugar content (%)	16.5	17.8	18.2	17.5
Sugar yield (t/ha)	19.04	9.89	13.56	14.16
Beets harvested	66412	69881	64087	66793
Root weight (kg)	1.8	0.8	1.1	1.2

Table 6. Extent of Variety dominance as first of two (2002-03) or as member of first ten varieties Category.

2002-03			
Variety		**Dominance(%)**	
Dorotea		**100**	
2003-04		**2004-05**	
Variety	**Dominance (%)**	**Variety**	**Dominance (%)**
Baraca	100	FD 9992	100
FD 9992	80	Rasoul	80
Florimon Desptez	80	Kawemera	80
Posada	80	Baraca	80
Dorotea	80	Desprez-Monon	80
Manila	80	Florimon Desprez	80
FD Davoi	80	Raval	80
Sultan	80	LP 015	60
Desprez Monon	80	Laetitia	60
Francesco	40	Zargan	60
Pepite	40	Helsinki	60
Marathon	40	Cultuvan 7111*261	20
Kwemera	40	Chems	20
Raval	40	Brigita	20
LP 015	40	Armura	20
Chems	20	Manela	20
		BR1	20
		Francesco	20

Table 7. Sugar beet outside Northern State of Sudan (Central Sudan).

Site	**Sugar content (%)**			**Yield (t/ha)**		
	1 Nov. sowing	**15 Nov. sowing**	**30 Nov. sowing**	**Harvest 4months**	**Harvet 6months**	**Mean**
Kenana	-	18.1	18.1	61.1	67.4	64.2
Guneid	14.8	16.9	14.7	67.2	114.6	90.9
Sennar	16.4	17.1	16.3	76.2	111.2	93.7
Mean	15.6	17.4	16.7	68.2	97.7	82.9

Source: Obeid and Muna 1999, Syngenta trial in Sudan, 1998-99
(As reported by Elnegay, 2002).

Table 8. Sugar beet outside Northern State of Sudan [Arab world countries-yield (t/ha)].

Country	1997	1998	1999	2000	2001	Mean
Morocco	41.5	18.1	18.1	61.1	67.4	64.2
Tunisia	45.3	16.9	14.7	67.2	114.6	90.9
Egypt	42.6	17.1	16.3	76.2	111.2	93.7
Syria	42.3					
Lebanon	54.0	17.4	16.7	68.2	97.7	82.9
Iraq	24.3					

Source: http/www.fao.org.ag. (As reported by Elnegay 2002).

Table 9. Sugar beet outside Northern State of Sudan, (World countries).

Country	Yield (t/ha)	Country	Yield (t/ha)
Alnamsa	62.7	Turkey	41.3
Denmark	53.8	U.S.A	49.1
Germany	55.3	Morocco	51.3
Kaskistan	15.0	Syria	42.8
France	71.0	Egypt	46.6
Bulgaria	15.3	Chilly	63.1
Italy	47.9	Tunisia	45.9

Source: as in (b) above.