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PERFORMANCE OF EXOTIC SUGAR BEET VARIETIES UNDER AGRO-CLIMATIC CONDITIONS OF LOWER SINDH

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ABSTRACT

A comparative study was conducted to assess the performance of ten exotic sugar beet varieties on four locations of lower Sindh. Soils of the experimental locations were clay and clay loam in texture, alkaline in reaction and saline in nature. The experiment was laid out according to a randomized complete block design (RCBD) with three replications. All sugar beet varieties showed different behavior with respect to beet yield and sugar recovery. Maximum beet yield was produced by SDPAK 03/06 followed by California, Magnolia and SDPAK 09/07. In terms of sugar recovery, the varieties Magnolia, SDPAK 01/07, SDPAK 07/07 and SDPAK 09/07 performed better and were almost at par. While, the varieties California, Magnolia, SDPAK 03/04 and SDPAK 09/07 performed best with regard to beet yield and sugar recovery. The results illustrated that sugar beet can be successfully grown on saline soils of lower Sindh. The sugar beet cultivation on marginal soils will bring more economic returns to growers as compared to cultivation of others especially sugarcane.

Key words: Sugar beet varieties, beet yield, sugar recovery, climate, saline soils, lower Sindh.

INTRODUCTION

Sugar beet (*Beta vulgaris*, L.) a member of chenopodiaceous family is the second important sugar crop after sugarcane, producing about 40% of sugar annually all over the world (Amr and Gaffer, 2010). Sugar beet roots contain high concentration of sucrose (Memon *et al.*, 2004). It can be grown in a wide range of climatic conditions and renowned for its tolerance to salinity but water scarcity causes profit loss of the sugar beet crop (Abu *et al*., 2010). However, sugar beet could be efficiently grown under a wide range of irrigation level, where it is readily adapted to limited irrigation because plants utilize deep stored soil water and recover quickly following water stress **(**Monreal *et al*., 2006**).**

Sugar beet is considered to be temperate crop but some varieties have performed best in climatic conditions of subtropics. It can be grown successfully as a winter crop in subtropical (Kapur and Kanwar, 1990). In Pakistan, sugar beet has been in commercial cultivation for the last more than four decades especially in Khyber Pakhtunkhwa (KPK). During 2010-11 cropping season, 151,286 tons sugar beet was sliced producing 13,535 tons of sugar. Average sugar recovery remained 8.95% (Annual Report PSMA-SZ, 2011).

The climatic conditions of lower Sindh are similar to the Nile delta valley in Egypt which is a promising area for sugar beet production since many years (Anonymous, 2007). Due to no frost and mild winter temperatures, lower Sindh is a favorable area for sugar beet cultivation. In the province of Sindh this crop has recently been introduced and being tested at different research institutes under different agro-climatic conditions. The soil and climatic conditions for sugar beet cultivation have proved favorable particularly in south Sindh *(*Memon *et al.,* 2004). Similarly, the other researchers reported better performance of different exotic sugar beet varieties under agro-climatic conditions of Sindh (Tunio *et al.,* 2004 and Oad *et al.,* 2007).

Consequently, Government of Pakistan through PARC has taken steps to introduce sugar beet as an alternate sugar crop in the country. Therefore, Government of Pakistan imported seeds of some exotic sugar beet varieties. The seeds were supplied to various research establishments including National Sugar Crops Research Institute, (the name changed in 2013 as National Sugar and Tropical Horticulture Research Institute) PARC, Thatta for testing their adaptability in lower Sindh. Keeping the above facts in view, an attempt was made to evaluate the performance of exotic sugar beet hybrid varieties under agro-climatic conditions of lower Sindh.

MATERIALS AND METHODS

The experiments were conducted during November 2008-09 to study the performance of exotic sugar beet varieties under agro-climatic conditions of lower Sindh. The experiments were on four locations of lower Sindh viz. (National Sugar Crops Research Institute (NSCRI) experimental farm, Thatta; Rana Tarique Agricultural Farm Shahbandar, Thatta; Colonel

Aslam Agricultural Farm, Kadhan, Badin and Bashir Bhurgri Agricultural Farm Shaikh Bherkio, Hyderabad. Prior to planting, composite soil samples from each location were collected and analyzed for some important soil parameters (Table 1).

At each location, same ten sugar beet varieties viz. California, Ernestina, Magnolia, Mirabella, Sandrina, SD-PAK 03/06, SD-PAK 04/06, SD-PAK 01/07, SD-PAK 07/07 and SD-PAK 09/07 were tested. The experiments were laid out according to randomized complete block design (RCBD) with three replications. In all experiments, each sugar beet variety was planted on 8 meters long 4 ridges (Plot size 32 m^2). The varieties were planted on the top of the ridges, by using three to four seeds (Monocot) per hole, plant to plant and row to row space was maintained at 20cm and 100cm respectively. The plant population (50,000 plants ha^{-1}) was maintained by thinning and gap filling when the plants were at 3-4 leaf stage. The fertilizer @ 120, 100 kg NP ha^{-1} in the form of Urea and DAP was applied. All the DAP and 1/3 urea was applied in furrows at the time of planting, remaining dose of urea was applied in two splits. Irrigations applied to sugar beet at each location varied and scheduled according to availability of water at the area. The locations NSCRI, Thatta; Shahbandar, Thatta; Bashir Bhurgri Shaikh Bherio; Hyderabad and Col. Aslam Kadhan, Badin were received 8, 6, 4 and 5 irrigations respectively. The agronomic practices, insect pest and disease control measures were taken as and when required throughout the growing season.

The beet yield and sugar recovery data were recorded and analyzed statistically using two factorial ANOVA (MSTATC, 1991) micro computer statistical programme, Michigan State University, USA.

RESULTS

Soils of the experimental sites were described as clay to clay loam in texture, alkaline in reaction (pH 7.98-8.86), saline in nature (EC 3.38-12.66 dS m^{-1}), deficient in available P (1.52-4.48 mg kg^{-1}), adequate in available K (96-236 mg kg^{-1}) and exchangeable Sodium (3.4-49.54 meq L^{-1}) depicted in Table 1. This type of soils does not support a higher yield of commonly grown crops in the area because of salinity, low fertility and extremes of water availability. In these conditions sugarcane cultivation does not result in higher economic returns and the sugar beet is thought to be a better substitute.

Plant Growth: A well adapted plant does not show any sign of adverse effect on its life cycle at any stage of growth in new environment. All varieties of sugar beet showed a good germination percentage and vegetative stages at all locations (Fig 1). No any sign of abnormal growth was observed and every variety responded well to fertilizers and irrigation. The biomass production was comparable to other sugar beet growing areas of the world.

Figure 1. Sugar beet stand showing good germination and higher biomass under local conditions of lower Sindh.

Beet yield: A good crop harvest was obtained from all the varieties (Table 3 and Fig. 2). The data revealed that the varieties performed well under agro-climatic conditions of lower Sindh. However, they were significantly different with each other with regard to beet yield. The variety SD-PAK 09/07 produced highest beet yield ($P \geq 0.01$) at NSCRI, Thatta while the varieties California, Sandrina and SD-PAK 01/07 performed fairly better than rest of the varieties at same location. In case of Shah Bandar district Thatta, the varieties Magnolia and Ernestina were statistically at par by producing maximum beet yield whereas, California, SD-PAK 01/07 and SD-PAK 03/06 performed comparatively better than rest of the varieties at the same location. At Kadhan (district Badin), Mirabella and Magnolia varieties remained statistically at par by producing maximum beet yield. While, at the same location the varieties like SD-PAK 07/07, Ernestina and California performed better as compared to rest of the varieties. In case of Shaikh Bherkio district Hyderabad, variety SD-PAK 03/06 produced statistically highest beet yield. While, the varieties viz. SD-PAK 09/07, SD-PAK04/06 and Mirabella performed better than rest of the varieties at the same location.

The analysis of variance for comparison of means for beet yield in all four locations revealed that the differences were highly significant (P≤0.01) for beet yield (Table 3). Interaction of location and variety (AxB) was also highly significant at P≤0.01 level (Table 3). Among varieties, data for beet yield in all four locations indicated that variety SD-PAK 03/06 was on top by producing 46.13 t ha^{-1} average beet yield and was followed by California which produced 45.72 t ha^{-1}. While, the varieties Magnolia and SD-PAK 09/07 remained statistically at par by producing average beet yield of 44.63 and 44.60 t ha^{-1} respectively and were ranked third and fourth, respectively. Furthermore, variety SD-PAK 04/06 found to be low yielding by producing minimum average beet yield (36.59 t ha^{-1}).

Figure 2. Mature beets harvested under local conditions of lower Sindh.

Sugar Recovery: In case of sugar recovery the analysis of variance for individual trials at each location in Table 4 revealed that the differences in variety performance with respect to sugar recovery were highly significant (P≤0.01) at Shahbandar, district Thatta, Kadhan district Badin and Shaikh Bherkio district Hyderabad except NSCRI, experimental farm Thatta, where the non significant (P≤0.01) differences were observed.

Means for sugar recovery of all varieties at each location (Table 4) revealed that all varieties performed variably under agro-climatic conditions of lower Sindh. The varieties SD-PAK 07/07 and SD-PAK 04/06 were statistically at par by producing maximum sugar recovery at NSCRI, experimental farm Thatta, While, rest of the varieties except Magnolia, were almost statistically at par in sugar recovery at the same location. In case of Shahbandar district Thatta, the varieties like Magnolia, SD-PAK 03/06 and SD-PAK 01/07 were statistically at par by producing maximum sugar recovery. Whereas, varieties like Mirabella, SD-PAK 07/07, SD-PAK 04/06 and SD-PAK 09/07 performed better than rest of the varieties at the same location. At Kadhan district Badin, the varieties SD-PAK 01/07 and SD-PAK 09/07 were statistically at par by producing maximum sugar recovery. While, at the same location the varieties like Ernestina, Magnolia and SD-PAK 07/07 performed better than rest of the varieties. In case of Shaikh Bherkio district Hyderabad the variety SD-PAK 09/07 was statistically highest in sugar recovery. In contrast, the variety Mirabella was found statistically lowest. However, rest of the varieties exhibited satisfactory results at the same location.

The analysis of variance for comparison of means with respect to sugar recovery in all four locations in Table 4 revealed that the results were highly significant (P≤0.01%) for sugar recovery. Interaction of location and variety (AxB) remained significant (P≤0.05%). Among varieties, for sugar recovery in all four locations indicated that varieties Magnolia, SD-PAK 04/06, SD-PAK 01/07, SD-PAK 07/07 and SD-PAK 09/07 were statistically at par by producing 13.12, 13.79, 13.26, 13.18 and 13.13 % average sugar recovery, respectively, which were followed by varieties Ernestina, Mirabella, Sandrina and SD-PAK 03/04 with average sugar recovery of 12.78, 12.72, 12.71 and 12.77%, respectively. In contrast, the variety California was statistically lowest and produced minimum average sugar recovery (12.27%).

DISCUSSION

The objective of the study was to evaluate the performance of exotic sugar beet varieties with regard to beet yield and sugar recovery under agro-climatic conditions of lower Sindh. The results of the experiment showed that the biomass in terms of shoot and beet weight of sugar beet varieties highly significant.

The high beet yield in varieties might be due to availability of suitable environment and adoptability to agro-climatic conditions of the area. The differences in beet yield and sugar recovery between the locations were might be due to climatic factors like light, temperature and day length. The site-specific biophysical factors such as irrigation and soils properties like pH, electrical conductivity (EC), exchangeable sodium and status of

soil nutrient have influenced yield and sugar recovery and economic viability of the sugar beet varieties at the farm level. The climate and environmental factors of a location are considered as the main factors affecting sugar beet productivity. The environmental factors account for over 26-80% of yield variability (Marlander *et al*., 20l3, Hoffmann *et al*., 2009 and Freckleton *et al*., 1999). Ebrahimian *et al.* (2009) stated that there is a significant difference among sugarbeet varieties for different parameters tested at different locations of Iran.

Table-1. Soil analysis of experimental sites.

Location	Texture	pH	EC ($dS\ m^{-1}$)	Available P (ppm)	Available K (ppm)	Sol&Exch Na ($meq\ L^{-1}$)	Soluble Ca + Mg ($meq\ L^{-1}$)	SAR
Rana Tarique Agricultural Farm Shahbandar Thatta	Clay loam	8.12	12.66	4.48	120.00	49.54	71.20	6.82
Colonel Aslam Agricultural Farm Kadhan Badin	Clay loam	7.98	11.96	1.52	96.00	14.54	25.40	4.08
NSCRI Experimental Farm, Thatta	Clay	8.86	3.38	2.32	236.00	21.10	31.80	5.44
Bashir Bhurgri Agricultural Farm Shaikh Bherkio Hyderabad	Clay loam	8.38	8.32	2.28	104.00	3.40	25.00	0.98

Table-2. ANOVA for beet yield and sugar recovery of different sugarbeet varieties at different locations.

	NSCRI Experimental farm, Thatta		
Source	**DF**	**Beet yield**	**Sugar recovery**
Replication	2	0.427	0.355
Factor A (Variety)	9	194.928**	0.429*
Error	10	0.712	0.318
Rana Tarique Agricultural farm, Shah bandhar, Thatta			
Source	**DF**	**Beet yield**	**Sugar recovery**
Replication	2	0.006	0.12
Factor A (Variety)	9	150.649**	1.236**
Error	10	0.887	0.359
Colonel Aslam Agricultural farm, Khadhan, Badin			
Source	**DF**	**Beet yield**	**Sugar recovery**
Replication	2	0.297	0.304
Factor A (Variety)	9	397.151**	1.189**
Error	10	1.410	0.204
Bashir Bhurgri Agricultural farm, Shaikh Bhrkio, Hyderabad			
Source	**DF**	**Beet yield**	**Sugar recovery**
Replication	9	0.010	0.009
Factor A (Variety)	10	155.890**	0.712**
Error		0.345	0.105
Pooled data for all four locations			
Source	**DF**	**Beet yield**	**Sugar recovery**
Replication	2	0.30	0.010
Factor A (Variety)	3	3423.521**	7.618**
Factor B (Location)	9	101.061**	1.161**
A x B	27	265.900**	0.883*
Error	78	0.792	0.520

The superior average performance of beet yield was observed at NSCRI, Thatta and followed by Shah Bandar location. This might be due to sufficient available irrigation water, available potassium and sodium. In case of Kadhan Badin location which ranked after NSTHRI and Shah Bandar location, available potassium was in low range. The shortage of potassium was supported by sodium. Subbarao *et al*. (1999) reported that sodium may replace up to 96% of impact produced by potassium on cell osmotic potential. Therefore, sugar beet plants supplied by sodium instead of potassium do not show the symptoms of potassium deficiency. Bashir Bhurgri location produced minimum beet yield and sugar recovery and ranked lowest. Low performance of the varieties at this location might be due to low irrigation water and as well low available potassium and the

sodium especially (Table 1). Richter *et al*. (2001) found that drought stress is the major cause of yield loss on sugar beet. It causes an average annual yield reduction of 10% and in dry year it may decrease yield up to 50% (Jaggard *et al*., 1998). Water stress caused a serious reductions in beet yield (Jaggard, 1998; Pidgeon *et al*., 2001).

The results obtained were satisfactory with regard to beet yield and sugar recovery. Our results are comparable to other workers and are in agreement with Oad *et al.*, (2001), Khan *et al*., (2004) and Zahoor-ul-Haq *et al*., (2006).

Moreover, the sugar recovery% recorded in varieties was almost higher than the previously investigated varieties (Oad *et al.*, 2001 and Khan *et al.*, 2004). Hence these new varieties had better performance regarding sugar contents.

Table-3. Beet yield of different sugar beet varieties at different locations

Sugar beet varieties	Location				Mean
	NSCRI, Experimental Farm Thatta	Rana Tarique Agricultural Farm Shahbandar Thatta	Colonel Aslam Agricultural Farm Kadhan Badin	Bashir Bhurgri Agricultural Farm Shaikh Bherkio Hyderabad	
	Beet yield (t ha^{-1})				
California	65.00b	49.91b	43.60d	24.37f	**45.72AB**
Ernestina	50.50f	52.64a	46.34c	27.00de	**44.11C**
Magnolia	45.00g	53.50a	59.75a	20.82g	**44.63BC**
Mirabella	52.64e	33.30h	60.00a	27.52d	**43.30C**
Sandrina	59.45c	41.36e	38.73e	26.75de	**41.57D**
SDPAK 03/06	53.41e	44.04d	44.16d	42.91a	**46.13A**
SDPAK 04/06	45.00g	38.85f	27.53g	34.98c	**36.59E**
SDPAK 01/07	58.06c	47.19c	31.88f	24.51f	**40.41D**
SDPAK 07/07	55.54d	35.07g	49.00b	26.23e	**41.46D**
SDPAK 09/07	70.13a	40.01ef	29.15g	39.12b	**44.60BC**
Mean	**55.46A**	**43.60B**	**42.21B**	**29.43C**	--
CV%	1.52	2.16	2.76	2.00	--
LSD 0.5%	1.447	1.616	2.037	1.008	1.447
0.1%	1.983	2.213	2.791	1.380	1.919

Note: Means followed by the same letters in the column do not differ significantly at 5% level o f probability

Table-4. Sugar recovery of different sugar beet varieties at different locations

Sugar beet varieties	Location				Mean
	NSCRI, Experimental farm, Thatta	Rana Tarique Agricultural farm Shahbandar, Thatta	Colonel Aslam Agricultural farm Kadhan, Badin	Bashir Bhurgri Agri. farm Shaikh Bherkio, Hyderabad	
	Sugar Recovery (%)				**Means**
California	12.93ab	11.36d	12.76c	12.04de	**12.27B**
Ernestina	12.59ab	11.72cd	14.02ab	12.82abc	**12.78AB**
Magnolia	12.21b	13.05a	13.97ab	13.24ab	**13.12AB**
Mirabella	13.08ab	12.76ab	13.27bc	11.77e	**12.72AB**
Sandrina	12.81ab	11.97bcd	13.38bc	12.69bc	**12.71AB**
SDPAK 03/06	12.71ab	13.15a	12.87c	12.35cd	**12.77AB**
SDPAK 04/06	13.26a	12.43abc	13.10c	12.40cd	**12.79AB**
SDPAK 01/07	12.49ab	13.47a	14.26a	12.85abc	**13.26A**
SDPAK 07/07	13.59a	12.86ab	13.94ab	12.33cd	**13.18AB**
SDPAK 09/07	12.26b	12.40abc	14.63a	13.26a	**13.13AB**
Means	**12.79AB**	**12.53B**	**13.61A**	**12.57B**	--
CV%	4.42	4.80	3.32	2.58	--
LSD 0.5%	0.96	1.028	0.7748	0.559	0.8128
0.1%	NS	1.408	1.062	0.7616	NS

Note: Means followed by the same letters in the column do not differ significantly at 5% level of probability.

Conclusions: The varieties California, Magnolia, SDPAK 03/04 and SDPAK 09/07 performed best in relation to beet yield and sugar recovery. Hence, these varieties can be cultivated as commercial varieties in districts of lower Sindh.

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