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Full Length Article

Evaluation of Sugar Beet Hybrid Varieties under Thal-Kumbi Soil Series of Pakistan

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ABSTRACT

Sugar beet is considered a new crop in the irrigated areas of Thal region. Since emerging crop the varietal performance has to be evaluated and selected for the region. We selected eleven exotic sugar beet varieties and evaluated under Thal-Kumbi soil series (Loamy sand, Alluial, Hyperthermic, Typic Torripsammants) of Leiah district in Punjab Province during Rabi season 2008-2009. All recommended agronomic and cultural practices including weeding, fertilization, irrigation and plant protection measures were adopted homogeneously in all the plots. The experiment comprised eleven sugar beet hybrid varieties from two German seed companies, viz. SD-PAK04/06, SD-12970, SD-PAK09/07, SD-PAK03/06, SD-PAK01/07, SD-PAK07/07, Mirabella, California, Magnolia, Ernestina and Sandrina. Results envisaged that SD-PAK09/07 attained the highest sugar yield (9.35 t ha^{-1}) with highest sugar contents (12.60%) and beet root yield (74.2 t ha^{-1}) followed by California and Magnolia with sugar yield 7.08 and 6.99 t ha^{-1}, respectively. The variety Mirabella gave minimum sugar yield (4.44 t ha^{-1}) with lowest beet yield (40.33 t ha^{-1}). It was found that there was non significant ($P > 0.5$) difference among varieties for leaf weight, beet root yield and root size.

Key Words: Thal region; Exotic sugar beet varieties; Beet root yield; Sugar yield

INTRODUCTION

Sugar beet is the most important of several crops, including spinach beet, Swiss chard, garden beet (beetroot) and fodder beet, within *Beta vulgaris* species (Gill & Vear, 1980). It was selected from high sugar-content fodder beets at the end of the 18th century. Extraction of sugar from beet was one of the major agricultural developments in 19th century in Northern Europe. Experimental work in Germany laid the foundations of the beet sugar industry and the Napoleonic Wars gave the initial stimulus to its further development as an alternative to cane sugar, especially in France. With various technical developments and favorable government policies, the beet sugar industry has expanded and the crop is cultivated and processed in Europe, North and South America, Asia and Africa. The total world sugar obtained from sugar beet is approximately 20% of the world sugar production (FAO, 2009).

Sugar beet has a fairly wide adaptability and is relatively resistant to cold, withstand drought, and are not overly sensitive to salinity; however, productivity under unfavorable conditions is not high (Katerji *et al.*, 1997; Petkeviciene, 2009). As sugar beet require a fairly high cash outlay and are labor-intensive, only productive soils and a favorable environment well justify the high investments involved. The sugar beet is particularly well adapted in irrigated agriculture (Follet *et al.*, 1964). Sugar beet has no self regulatory mechanisms to promote sucrose accumulation but is dependent upon external stimuli from the climatic factors such as light, temperature and day length which determine to a great extent, the type of growth and the amount of sugar that gets stored in the root (Ulrich, 1952; Petkeviciene, 2009). Studies on sugar beet adaptability and nutrient management have been conducted in Peshawar valley and some other parts of the country (Jamal & Bahadar, 1988; Oad *et al.*, 2001; Khan *et al.*, 2004; Zahoor-ul-Haq *et al.*, 2006) and to some extent on fodder beet in the salt-affected soils (Niazi *et al.*, 1997 & 1998).

Jamal and Bahadar (1988) conducted a varietal adaptability trial at in district Bannu, Khyber Pakhtoon Khawah (KPK) comprising four sugar beet varieties, viz. Kave poly, Kave mira, Kave terma and Zwan poly. They reported that beet variety Kave-poly produced maximum beet root yield while Kave-terma was superior in sugar contents (Pol = 12.41%). Similarly, Khan *et al.* (2004) reported that varieties differed significantly for yield and sugar contents in Bannu, Dera Ismail Khan and Kohat districts of southern KPK, Pakistan. The average beet yield remained 36.0 to 72.8 t ha^{-1}. It has been reported from three

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years of sugar beet varietal trials that in different parts of Punjab sugar beet varieties performed differently with respect to germination, yield and sugar recovery (Ahmad & Awais, 2011).

In Pakistan, sugar beet is grown commercially only in the province of Khyber Pakhtoonkhwa and now in Punjab also, while in Sindh and Balochistan provinces it is grown on marginal scale as vegetable. Government of Pakistan has taken steps to introduce sugar beet in the country by accustoming the cultivation of some exotic sugar beet varieties initially at National Agriculture Research Center, Islamabad, Pakistan for testing their adaptability in the country. Scarcity of irrigation water is alarming, resultantly the area under sugarcane remained at a halt year after year. However, sugar beet requires less water and matures within 6 - 7 months and can be a good substitute of sugarcane crop. Keeping the above facts in view, an attempt has been made to evaluate the performance of exotic sugar beet hybrid varieties under selected agro-climatic conditions of Punjab Province.

MATERIALS AND METHODS

A field experiment consisted of exotic sugar beet varieties was conducted at Lodhra Farm, Leiah during winter season of 2008-2009 in Randomized Complete Block Design (RCBD) with three replications keeping plot size of 3 m × 8 m. The selected field belonged to Thal-Kumbi soil series (loamy sand, alluvial, hyper thermic typic torri psammants). The soil of the field was non-saline-non-sodic, alkaline in reaction and had low organic matter (OM), phosphorus (P) and nitrogen (N) contents. The physico-chemical properties of experimental site are given in the Table I. The experiment was planted in the month of October 2008. All recommended agronomic and cultural operations including weeding, fertilization, irrigation and plant protection measures were followed during the entire course of study on a standardized uniform pattern for all the plots.

The trial consisted of 11 hybrids varieties of sugar beet viz. SD-PAK04/06, SD-12970, SD-PAK09/07, SD-PAK03/06, SD-PAK01/07, SD-PAK07/07, Mirabella, California, Magnolia, Ernestina and Sandrina. The first six varieties were received from Strube Saat and the other five were obtained from KWS, Germany. After seed bed preparation all phospatic and potash fertilizers whereas one-third of niterogenous fertilizer in the form of diammonium phosphate (DAP), muriate of potash (MOP) and urea respectively were evenly spread on the field and ridges of 75 cm apart were made with the help of tractor. Then the plots were prepared and layout was made. The rest of the fertilizer N was applied on net plot size basis in two splits each after thirty and sixty days of planting. Then manual sowing of seed of sugar beet varieties was carried out on both sides of the ridges keeping hill to hill distance of about 18 cm according to layout plan. Management practices, like

Table I: Soil Analysis of the experimental site, Lodhra farm-Leiah

Characteristic	Unit	Value
Soil texture	--	Loamy sand
EC	dS m^{-1}	0.86
pH	--	8.01
Organic Matter	%	0.67
P	mg kg^{-1}	5.10
K	mg kg^{-1}	89.00
NO_3-N	mg kg^{-1}	0.31

thinning for once at 4-5 leaf stage, fertilizers application at the rate of N 150 kg ha^{-1}, P_2O_5 100 kg ha^{-1} and K_2O 62.5 kg ha^{-1}, and hoeing for twice were carried out. The experiment was harvested in the 1st week of May 2009.

Data regarding germination percentage, beet root size-thickness, beet weight, beet yield, Brix and POL percent along with sugar recovery were collected. Germination was recorded thirty days after planting, while beet thickness, beet weight and beet and leaf yield were recorded at the time of harvest. Then six sugar beets (two each of thick, medium & thin beet roots) were collected for quality analysis. The samples were washed with water, de-moisted and cut into slices. Then these slices were crushed in the juice extractor and juice was obtained and quantity was measured. The juice was filtered and filtrate consisted of all soluble solids including sucrose. The total soluble solids in the extract (Brix) were measured with the help of refractometer and sucrose contents (Pol %) were measured with the help of Polarometer. Then the sugar recovery (%) in different sugar beet varieties was estimated with the help of formula:

Sugar Recovery (%) = [3P/2{1-(F+5)/100}-B/2{1-(F+3)/100}] × 0.93 ---- (anonymous, 1970), where

P = Pol % of juice.
B = Brix % of juice.
F = Fibre % beet.
0.93 = Recover factor.

The data collected were subjected to statistical analysis and means were compared with LSD test (P = 0.05) as described by Steel and Torrie (1980).

RESULTS

The results on average basis for germination percentage, leaf weight, beet root yield, number of beets per hectare, beet thickness and sugar parameters such as brix, pol, sugar recovery and sugar yield are summarized in Table II. A significant difference was recorded for germination percentage among varieties. It is evident from the results that SD-PAK09/07 and California showed maximum germination percentage with values 64.07 and 64.83% respectively, followed by SD-PAK03/06 (59.63%) while minimum germination was recorded in Mirabella (42.40%).

Data at harvesting stage (Table II) show that maximum leaf weight was noted in Sandrina (30.27 t ha^{-1})

followed by SD-PAK 04/06 (29.40 t ha^{-1}), whereas minimum leaf weight was observed in Mirabella (15.23 t ha^{-1}) but statistically these varieties are at par with each other. Varieties SD-12970, Mirabella and SD-PAK09/07 had the beet root diameter of 10.05, 9.96 and 9.88 centimeters, respectively while Ernestina had minimum root diameter of 8.65 centimeters. Significant differences were noted for number of beets among varieties. Maximum number of beets was recorded in Ernestina (133.3 '000' ha^{-1}) while SD-PAK07/07 and California revealed equal number of beets i.e., 113.3 '000' ha^{-1} and minimum was noted in Mirabella (48.9 '000' ha^{-1}). Maximum beet root yield was revealed by SD-PAK09/07 (74.20 t ha^{-1}), while minimum root yield was observed in Mirabella (40.33 t ha^{-1}).

Quality characteristics of sugar beet: Regarding sugar contents, a significant difference was found among varieties for Brix, Pol and sugar recovery (Table III). A maximum brix percentage was observed in SD-PAK07/07 (22.10%) followed by SD-PAK04/06 (21.40%), while minimum in SD-12970 (18.40%). Concerning POL percent in sugar beet extract, variety Mirabella had the highest POL percentage (17.67%), while minimum was recorded in Sandrina (13.97%). The maximum sugar recovery was observed in SD-PAK09/07 (12.6%) trailed by SD-PAK07/07 (12.10%) whereas sugar beet variety California attained the lowest sugar recovery (10.30%). The highest sugar yield was recorded in case of beet variety SD-PAK09/07 (9.35 t ha^{-1}) followed by California (7.08 t ha^{-1}), while lowest was recorded in Mirabella (4.44 t ha^{-1}).

Correlation among different sugar beet parameters: Table IV shows r^2 values among imperative sugar beet parameters. It was noted that beet root yield has strong positive correlation with germination percentage, leaf weight, number of beets and sugar yield. It means that more is the germination, leaf weight and number of beets the highest will be the beet root yield. Similarly leaf weight, beet yield, number of beets and sugar yield also had positive correlation with germination. As far as leaf weight is concerned, it had strong association with all above said parameters except for sugar recovery.

With regard to sugar yield as a final product, it is evidenced that it has strong correlation with all important

Table II: Mean performance of exotic sugar beet varieties planted at Leiah

Varieties	Germination (%)	Leaf weight (t ha^{-1})	No. of beets ('000' ha^{-1})	Beet diameter (cm)	Beet yield (t ha^{-1})	Rank w.r.t. beet yield
SD-PAK04/06	56.67 abc	29.40	88.7 a-c	9.14	58.47	7
SD-12970	47.63 bc	19.97	71.1 bc	10.05	52.07	10
SD-PAK09/07	64.07 a	26.33	97.8 ab	9.88	74.20	1
SD-PAK03/06	59.63 ab	19.57	71.1 bc	8.73	62.87	5
SD-PAK01/07	56.40 abc	20.64	91.1 a-c	9.06	54.30	9
SD-PAK07/07	56.17 abc	28.63	113.3 ab	8.81	57.67	8
MiraBella	42.40 c	15.23	48.9 c	9.96	40.33	11
California	64.83 a	27.07	113.3 ab	9.39	68.77	2
Magnolia	53.17 abc	24.03	104.4 ab	9.55	67.23	3
Ernestina	56.70 abc	24.33	133.1 a	8.65	61.17	6
Sandrina	50.67 abc	30.27	111.2 ab	8.89	64.40	4
LSD	13.96	18.15	40.2	0.65	28.45	

Figures sharing the same letters are non-significant at 5% level of significance

Table III: Qualitative performance of exotic sugar beet varieties planted at Leiah

Varieties	Brix (%)	Pol (%)	Sugar Recovery (%)	Sugar Yield (t ha^{-1})	Rank w.r.t. sugar yield
SD-PAK04/06	21.40 ab	16.19 a-c	11.90	6.96	5
SD-12970	18.40 d	16.17 a-c	10.60	5.52	10
SD-PAK09/07	19.40 cd	15.97 a-c	12.60	9.35	1
SD-PAK03/06	19.47 cd	14.87 b-d	10.80	6.79	7
SD-PAK01/07	20.87 a-c	15.63 b-d	12.00	6.52	9
SD-PAK07/07	22.10 a	16.17 a-c	12.10	6.98	4
MiraBella	19.13 cd	17.67 a	11.00	4.44	11
California	19.27 cd	15.10 b-d	10.30	7.08	2
Magnolia	20.13 b-d	16.67 ab	10.40	6.99	3
Ernestina	20.67 a-c	14.43 cd	11.00	6.73	8
Sandrina	18.80 d	13.97 d	10.60	6.83	5
LSD	1.85	1.87			

Figures sharing the same letters are non-significant at 5% level of significance

Table III: Coefficient of determination (r^2) values between different sugar beet parameters

Parameter	Germination	Leaf weight	No. of beets	Beet yield	Sugar recovery
Leaf weight	0.48				
No. of beets	0.52	0.74			
Beet yield	0.80	0.63	0.63		
Sugar recovery	0.30	0.21	0.02	0.04	
Sugar yield	0.82	0.63	0.54	0.90	0.48

beet parameters such as germination, leaf weight, beet root yield, number of beets and sugar recovery. In other words we can say, if these parameters have attained high values ultimately higher is the sugar yield. Conversely sugar recovery has weak relationship with all above said parameters except for sugar yield. Perhaps bumper and quick growth weight have attracted accumulation of sucrose in the beet root portion.

DISCUSSION

Sugar beet is a hardy biennial plant that can be grown commercially in a wide variety of temperate climates. During its first growing season, it produces a large (1–2 kg) storage root whose dry mass is 15–20% sucrose by weight. In most temperate climates, beets are planted in the spring and harvested in the autumn. In the countries like Pakistan it is being adapted as a winter crop. Niazi *et al.* (1997 & 1998) reported that wild *Beta vulgaris* species could be grown successfully under the agro-climatic conditions of Dera Ismail Khan. Leia district in the Thal region is adjacent to Dera Ismail Khan except that it is located across the river Indus. Hence, the varieties under the current study performed better with regards to beet yield and sugar recovery and other parameters. The beet yield differed with different varieties but it was comparable to the yields of previous investigations (Jamal & Bahadar, 1988; Oad *et al.*, 2001; Khan *et al.*, 2004; Zahoor-ul-Haq *et al.*, 2006). Ebrahimian *et al.* (2009) stated that there is a significant difference among sugar beet cultivars for different parameters tested at different locations of Iran.

Sugar contents recorded in previous studies (Jamal & Bahadar, 1988; Oad *et al.*, 2001; Khan *et al.*, 2004) were lower than the presently investigated treatments. Hence, these new varieties had better performance regarding sugar contents. This is most important factors for miller's point of view. Further these varieties differed in sugar contents as have been reported previously (Oad *et al.*, 2001; Khan *et al.*, 2004; Ebrahimian *et al.*, 2009). Hence, best performer verities can be selected for commercial cultivation in the area of Leiah.

Regarding correlation studies among various parameters under investigation there was a strong and positive correlation among beet yield and other growth parameters while a weak correlation between sugar recovery and other growth parameter. Hence, beet yield in sugar beet could be considered as the function of germination, leaf weight and number of beets per unit area. In case of sugar recovery all these parameters had little effect. Hence increase in beet yield, beet size, leaf weight and number of beets from a normal size may leads to reduction in qualitative characteristics of sugar beet. Similar observations have been recorded in a number of studies (Milfor & Watson, 1971; Hecker, 1991; Mahmoodi *et al.*, 2008).

In conclusion, SD-PAK09/07 was the best genotype with highest beet root yield, sugar recovery and ultimately gave maximum sugar yield. Conversely Mirabella comes out as a poorest genotype with minimum germination percentage, leaf weight, root yield and eventually provided lowest sugar yield. From the results it was also concluded that higher the leaf weight, higher will be the beet root yield. Hence, SD-PAK09/07 can be cultivated as commercial crop in the investigated area of Punjab.

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