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Evaluation of Exotic Sugarcane Germplasm for Agronomic Characters and Productivity

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Abstract: Six exotic sugarcane varieties were evaluated for their agronomic characters and productivity. All exotic sugarcane varieties had similar germination percentage except standard variety CP77-400 which had higher germination. Significant differences were found in number of tillers ha^{-1}, stalk height, girth and total soluble solids. Minimum (102.3 thousands ha^{-1}) number of millable canes were found in variety CP84-1198 and the maximum (160 thousands ha^{-1}) in CP85-1491. Cane yield ranged from the minimum of 70.67 t ha^{-1} in variety CP84-1198 to the maximum of 131.3 t ha^{-1} in variety TCP86-3368. Sugar recovery was maximum (13.78 %) in variety CP85-1491 and minimum (11.82%) in the variety TCP86-3368. Sugarcane variety CP84-1198 produced the minimum (9.26 t ha^{-1}) sugar yield. Purity of juice was also significantly different in most of the varieties. All the varieties except CP 84-1198 had better cane and sugar yield potentials than the standard variety.

Key words: Sugarcane, exotic germplasm, agronomic characters, productivity

Introduction

Sugarcane is grown on an area of more or less 1.0 million hectares in Pakistan of which Punjab, Sindh, and N.W.F.P. share 62.4, 26.0 and 11.2 % respectively (Akhtar *et al.* 2000). It is one of the most important cash crop of Pakistan and, therefore playing a vital role in improving the economy of the farmers and the country. Besides sugar production, sugarcane produces numerous valuable by-products like alcohol, used by pharmaceutical industries, ethanol used as a fuel, bagasse used for paper & chipboard manufacturing and press mud used as a rich source of organic matter and nutrients for crop production (Akhtar, 1999). Despite the expansion in sugar industry and cane acreage, our national average cane yield is 47.78 t ha^{-1} which is quite lower than most of the cane growing countries (PSMA, 1999). Therefore efforts are needed for the selection and introduction of high yielding cane varieties, and transfer of production technology to the growers.

Assessment of adaptation, performance of various cane varieties in different ecologies, and evaluation of agronomic characters of exotic cane varieties is necessary before a variety is introduced for commercial cultivation. As cane yield and cane sugar are the complex traits, therefore, selection and evaluation of these traits are generally done on the basis of such component traits as number of stalks, stalk height, stalk girth, stalk weight, and fiber contents. Effects of these traits on cane and sugar yields have been studied and reported by Milligan *et al.* (1990) and Reddy and Reddy (1986). These characters, including Brix contents, are the most important characters and selection of new varieties with these characters prove very useful for better cane and sugar yields. Differences in stalk height, girth and sugar contents in different varieties occur due to their genetic makeup and management practices. Final cane yield is usually associated with the stalk number, height and girth of the stalks. Brix (%) had been used as a criteria for the evaluation of cane quality characters and sugar yields (Bischoff and Martin, 1986).

Sucrose has been found positively and significantly associated with the Brix contents of the juice (Singh *et al.*, 1985). Quality of cane juice also depends upon many factors like variety (Hatam and Pazir, 1989), age of the crop (Mahmood and Nazir, 1987) and other management and environmental factors. Among the management factors, use of balanced fertilizers at appropriate time is very important to obtain maximum sugar recovery (Akhtar, 1999).

Import and evaluation of exotic germplasm is a continuous research activity for the introduction of new cane varieties in the country. The present study is part of the same research activity in which six sugarcane varieties were evaluated for agronomic characters and productivity.

Materials and Methods

Present studies were carried out at the experimental field area of the National Agricultural Research Centre, Islamabad during the crop season 1998-99. The experiment was planted during September 1998 and harvested during December 1999. Six exotic varieties of sugarcane i.e. CP84-1198, CP85-1491, CP88-1165, CP77-400, CP89-846, CP89-846, and TCP86-3368 were planted in a Randomized Complete Block Design with three replicates. CP77-400 was planted as a standard variety. Ten rows, measuring 10 meters each; were planted for each variety in each replicate.

Two budded double setts were planted end to end with a row spacing of 90 cm. Number of setts planted were recorded from the central rows to later record data on germination. Row number 4, 5 and 6 were marked for data collection in each variety in all the replicates. Total area for data recording from these three rows, leaving 1 meter boarder on each end of the rows was 21.6 m^2.

All the varieties were treated with the similar agronomic practices. 115 kg P_2O_5 and 150 kg of K_2O was applied at the time of planting. Nitrogen was applied @230 kg ha^{-1} in five splits. First dose of nitrogen was applied at planting. Rest of the four nitrogen doses were applied in equal splits on March 20th, April 24th, May 19th and June 17th. Weeds were initially controlled with pre-emergence application of a weedicide, Gesapax Combi (80 wp) @ 3.75 kg ha^{-1}. At later stages weeds were controlled by hoeing and earthing up. Similar levels and number of irrigation were given to all the varieties. Data on various agronomic characters were collected at various growth stages.

Germination: Data on germination were recorded from an area of 21.6 m^2. Number of buds germinated were counted from the data recording area, after an interval of 3 days till the constant data on number of buds germinated was recorded. Then on the basis of total buds planted, germination percentage was calculated.

Tillering at early growth stages: Development of tillers was recorded in each variety at early growth stages and at harvest. These data were recorded during May, June and July from the specified area. These data were recorded to observe the tillering capabilities and the mortality of tillers as the canopy developed

Total soluble solids: Data on total soluble solids (TSS %) were recorded from the start of the maturity of the crop. These data were recorded during October, November and December with the help of hand Refractometer (Bischoff and Martin, 1986).

Millable canes at harvest: Data on millable canes were recorded from an area of 21.6 m^2. Total number of millable stalks were counted from the harvested area and millable canes per hectare were calculated on the basis of the collected data.

Stalk height and girth: Ten representative stalks were taken out of the harvested stalks. Stalk height was measured from the base of the stalk to the top most node, exposed by removing all the leaves. Then the height of these ten stalks was averaged. Stalk girth was measured from the same ten stalks with the help of digital caliper. Stalk girth was measured at the points 25 cm above the base of the stalk; 25 cm below the topmost node and from the center of the stalk and then averaged.

Cane yield: Cane yield was recorded from an area of 21.6 m^2 and on the basis of cane weight from harvested area, cane yield tons per hectare was calculated.

Sugar recovery and sugar yield: Five stalks were taken from each plot for quality analysis. These samples were taken to sugarcane quality laboratory at Sugarcane Research Institute, Faisalabad and Tandlianwala Sugar Mills Kanjwani, Tandlianwala. These stalks were crushed with power cane crushed to extract the juice. Brix reading was taken by brix hydrometer and POL reading was taken by Saccharimeter. Purity of the juice was also determined. These values were used to calculate the sugar recovery, using Australian fibre constant (12.5 %), on the basis of Winter-Crap formula (Geerlings, 1904):

Sugar Recovery (SR) = [Pol in juice - (Brix – Pol in juice) x 0.4] x 0.63
Sugar yield = SR x Cane yield

The data collected were analyzed with analysis of variance technique at 5 % probability level (Steel and Torrie, 1980) using MSTATC computer software.

Results and Discussion

Due to un-favourable environmental conditions, sugarcane does not flower in most of the cane growing areas in Pakistan except lower Sindh. Coastal areas of Sindh are the only sites where viable fuzz could be produced. Due to the non existence of cane breeding program, Pakistan has to depend on the imported material (fuzz or setts) for the selection and introduction of new sugarcane varieties (Akhtar, 1999). The present study where five sugarcane varieties were examined for their agronomic traits and productivity, along with a standard commercial variety CP 77-400, is the part of sa activity.

Germination: The data collected indicated that the germinati percentage in all exotic varieties was statistically similar. Th standard variety CP 77-400 had significantly higher percenta of germination than all other varieties. The germinati percentage in this variety was 64.93, whereas, in all oth varieties it ranged from 50.00 to 55.97 % (Table 1). Sharm and Agarwal (1985) suggested that good germination a tillering with synchronized millable canes of average thickne are desired characters to evaluate agronomic performance sugarcane varieties.

Sugarcane is propagated by cuttings of stalks having two three buds. It is well known that apical dominance exists sugarcane. It is true for any part of the stalk that the apic bud will have dominance over the terminal bud and this affe the germination in all varieties of sugarcane. Good germinati in sugarcane ensures good start for a safe crop. Maximu germination and shoot vigour is affected by various exter and internal factors. Internally there are changes in fo constituents by activity of enzymes and growth regulati substances like, hormones and auxins. Different varieties sugarcane vary greatly in their germination. In some varieti roots develop prior to shoots and in others vice versa. between the two extremes a series of intermediate types found. Varieties differ in their initial rate of germination (va Dillevijin, 1952). In general no strict correlation between init rate of germination and ultimate accomplishment of ca varieties exists.

Different sugarcane varieties differ in their length of internode It has been found that varieties with long internodes usual have better germination. Sugarcane varieties with luxuriou growth have long internodes whereas, varieties with slo growth have shorter internodes (Humbert, 1963). Long internodes will better fulfill the nutritional requirements of th growing bud. Good germination in any variety ensures goo plant population that is important to obtain maximu productivity provided all management factors are prope applied.

Tillers Development at Various Stages: Data on till development was collected on May 10, June 02, July 03 an at harvest. The results indicated that there was a significa difference in the number of tillers per hectare among vario varieties. Number of tillers per hectare increased up to Ju 02 and it started decreasing at later stages. Data on millab canes at harvest indicated that variety CP 85-1491, CP 8 1165 and CP 77-400 had maximum millable canes per hecta (180, 158.3, and 149.3 thousands, respectively) those we statistically greater than other varieties (Table 1). The lowe number of millable canes per hectare were found in variety C 84-1198.

Greater tillering capability is one of the most importa character to be kept in mind while selecting a variety f commercial cultivation. More number of millable canes havin greater stalk height and girth contribute towards higher ca tonnage and higher per unit area productivity (Singh an Sharma, 1983). Tiller development in sugarcane starts with th start of rise in temperature. Most of the varieties atta maximum tillers per stool at their peak growth stage. Wh the canopy cover reaches at its maximum weaker tillers sta dying off due to competition for light, moisture and nutrien and only the stronger ones survive. Due to this reason th number of millable canes at harvest is much lower than th number of tillers at early stages.

Table 1: Germination %age and No. of tillers '000' per hectare in various sugarcane varieties at various growth stages

Name of variety	Germination (%age)	Tillers '000' per hectare			
		May 10th	June 2nd	July 3rd	At harvest
CP84-1198	50.00 b	219.3 e	233.7 e	196.0 d	102.3 d
CP85-1491	55.97 b	370.0 bc	384.3 bc	299.7 ab	160.0 a
CP88-1165	54.07 b	245.0 de	281.0 de	223.3 d	158.3 a
CP89-846	54.30 b	496.0 a	491.0 a	269.3 bc	142.3 bc
TCP86-3368	52.63 b	412.0 b	418.7 b	303.3 a	133.3 c
CP77-400	64.93 a	302.7 cd	322.7 cd	256.0 c	149.3 ab
LSD (0.05)	6.561	73.15	62.28	32.48	15.05
CV (%)	6.70	11.99	9.74	6.87	6.08

Table 2: Stalk height, stalk girth, cane yield, sugar recovery and sugar yield of different sugarcane varieties

Name of Variety	Stalk height (cm)	Stalk girth (mm)	Cane yield (t ha^{-1})	Sugar recovery (%)	Sugar yield (t ha^{-1})
CP84-1198	206.3 ab	23.67 c	70.67 c	13.14 bc	9.257 b
CP85-1491	203.0 b	26.10 a	115.3 ab	13.78 a	15.92 a
CP88-1165	195.3 b	24.67 abc	124.0 ab	12.03 e	14.94 a
CP89-846	199.7 b	24.70 abc	123.3 ab	12.62 d	15.57 a
TCP86-3368	226.3 a	23.33 c	131.3 a	11.82 e	15.51 a
CP77-400	197.0 b	24.03 bc	109.7 b	12.75 cd	13.97 a
LSD (0.05)	21.60	1.652	21.30	0.4394	2.598
CV (%)	5.94	3.78	10.70	1.93	10.24

Different varieties of sugarcane differ in their trend of tillering and ultimate tillers at harvest (van Dillewijn, 1952). The first phase after germination is stooling and the second is elongation of stems. Tillering is influenced by various internal and external factors. Some varieties have early rapid tillering capabilities while others are slow in tillering at commencement and tillering in these varieties increases gradually.

Stalk height and Girth: Most of the varieties had similar stalk height as of the standard variety CP 77-400. However, stalk height in varieties CP 84-1198 and TCP 86-3368 was significantly greater than other varieties (Table 2). Stalk girth was also significantly different in most of the varieties (Table 2). It was maximum in CP 85-1491 followed by CP 89-846 and CP 88-1165. Habib *et al.* (1991) have observed differences in stalk height and girth among exotic cane varieties. Stalk height and girth play important role in improving cane yield per unit area. Taller stalks with greater girth having no or minimum pith possess better weight per stalk. *Storage capacity for sugars also increases as the stalk* height and girth increases hence not only cane yield but also sugar yield per unit area is also increased with increased stalk height and girth. Singh and Sharma (1983) has regarded stalk length and its diameter very important characters contributing cane yield.

Cane yield: Final harvest data on cane yield showed that there was a significant difference in the cane yield among various varieties. Most of the exotic sugarcane varieties had significantly higher cane yield than the standard variety CP 77-400 (Table 2). Maximum cane yield of 131.00 t ha^{-1} was produced by the variety TCP 86-3368 followed by 124.00 t ha^{-1} by CP 88-1165 and 123.3 t ha^{-1} by CP 89-846. Sugarcane variety CP 84-1198 produced the lowest cane yield of 70.67 t ha^{-1}. There are many factors those affect the final cane yield of a variety of sugarcane. Good germination for proper plant population, good tillering capability, and taller and thicker stalks are the most important characters those improve the cane yield (Singh and Sharma, 1983). It has been observed and reported by different researches that various varieties of sugarcane differ genetically in their tillering, stalk height, stalk girth, cane yield, and sugar contents (Habib *et al.*, 1991). Cane and sugar yield also differ considerably in different localities and varieties (van Dillewijn, 1952). Difference in climate, particularly light intensity, plays important role in influencing cane yields. Light intensity is rather one of the most influential factor improving cane and sugar yields. Favourable climate and proper management factors ensure better cane and sugar yield in cane crop (van Dillevigin, 1952).

Sugar recovery and sugar yield: After the harvest of the cane varieties, few stalks were taken from each variety for chemical analysis. It was observed that different varieties significantly differed in their sugar recovery (Table 2). Sugarcane variety CP 85-1491 had the maximum sugar recovery of 13.78 % followed by CP 84-1198, CP 77-400, CP 89-846, CP 88-1165 and TCP 86-3368 (Table 2).

Sugar yield is a product of cane yield and sugar recovery. Sugar yield of all the varieties, except CP 84-1198, was statistically similar (Table 2). Maximum sugar yield of 15.92 t ha^{-1} was produced by the variety CP 85-1491 followed by the variety CP 89-846, TCP 86-3368, CP 88-1165 and CP 77-400 (Table 2). *Minimum sugar yield of 9.25 t ha^{-1} was produced by the variety CP 84-1198.*

Different varieties of cane differ in their genetic potential for cane and sugar yields. Other factors those affect sugar accumulation and yield are the management and the climatic factors. Differences in climate, particularly light intensity, play important role in sugar accumulation, maturity and sugar yield of a cane variety (van Dillewijn, 1952).

Total soluble solids (TSS) and Purity of the Juice: Recorded data on TSS at early maturity stages indicates that the differences in total soluble solids (TSS %) were non significant among the varieties except CP 88-1165 that had significantly lower TSS %age than most of the others. Data collected during November indicated that this difference was significant among the varieties (Table 3). Similar trend was observed in the differences in TSS at harvest. TSS in varieties CP 84-1198, CP 85-1491, and CP 88-1165 was higher than the standard variety CP 77-400. While evaluating more than 200 exotic sugarcane varieties, Habib *et al.* (1992) have observed great differences in Brix percentage in different varieties. They have reported a gradual increase in TSS % from November to February. Sucrose has been found positively and significantly associated with the Brix contents of the juice (Singh *et al.*, 1985). Quality of the cane juice also depends upon many factors like variety (Hatam and Pazir, 1989), age of the crop (Yadav and Sharma, 1982), and other factors like management, balanced fertilization and the environment (Akhtar, 1999).

Table 3: Total soluble solids (TSS) at various maturity stages and purity of the juice at harvest

Name of variety	TSS (%)			
	Oct 10^{th}	Nov. 11th	Dec. 15th	Purity %
CP84-1198	21.40 a	22.07 a	22.20 abc	85.90 a
CP85-1491	21.07 ab	22.07 a	22.30 ab	86.15 a
CP88-1165	16.77 b	21.90 a	22.47 a	83.23 d
CP89-846	19.67 ab	20.77 b	21.77 c	86.57 a
TCP86-3368	19.73 ab	20.93 b	21.77 c	85.02 b
CP77-400	20.40 ab	21.13 ab	21.83 bc	84.23 c
LSD (0.05)	4.316	0.9530	0.5187	0.7589
CV (%)	12.02	2.47	1.31	0.50

Data presented in Table 3 indicates that the purity of the juice was greater in all exotic sugarcane varieties, except variety CP 88-1165, compared to the standard variety CP 77-400. Maximum juice purity of 86.57 % was found in variety CP 89-846 followed by the variety CP 85-1491, CP 84-1198 and TCP 86-3368.

Preliminary evaluation of the exotic sugarcane varieties indicates that all the varieties except CP 84-1198, have good cane and sugar yield potentials. Their cane and sugar yields are much higher than the standard variety CP 77-400. It is recommended that these varieties may be further tested and evaluated for their performance and adaptability in different ecological regions and the successful ones may be introduced as commercial varieties.

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