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COMPARATIVE PERFORMANCE OF SUGARCANE SOMACLONES AND EXOTIC GERMPLASM UNDER AGRO-CLIMATIC CONDITIONS OF TANDO JAM

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Abstract

A field trial was conducted at Nuclear Institute of Agriculture (NIA), Tando Jam, during the season of 2010/2011 and 2011/2012. Twenty nine sugarcane genotypes (13 soma-clones and 16 exotic clones) were evaluated in a randomized complete block design with four replications. Ten important agronomic characters were measured out of which three were cane yield contributing traits and seven were quality parameters. Statistically significant differences were observed for all the characters among genotypes. Clone CP92-1198 (exotic) and somaclone NIA-1026P3 had shown substantial superiority for cane and sugar yield (t/ha). Low values of coefficient of variations exhibited accuracy of experiment. Quality and quantitative traits showed strong negative correlation, causing selection breeding difficult in sugarcane.

Key words: *Saccharum officinarum,* **S**omaclones, Exotic clones, Correlation, quantitative and qualitative traits.

Introduction

Sugarcane is the main sugar-producing crop (Junejo *et al.,* 2010). It is a large grass cultivated in tropical and subtropical regions and belongs to the genus *Saccharum* L composed of hybrids derived from *Saccharum officinarum* (Noble clones), *S. sinense* (Chinese clones), *S. barberi* (North Indian clones), and *S. spontaneum* (Sengar *et al.,* 2011). Sugarcane highly complex genome, low fertility and large genotype x environment interactions make traditional varietal improvement and genetic studies difficult and laborious (Mendoza, 2000). Flowering and seed set under natural conditions of Pakistan is a very serious problem in sugarcane that hampers varietal improvement. In Pakistan the basic facilities for hybrid seed production and variety development are lacking. Though the coastal belt in Sindh, is endowed with specific climatic conditions where sugarcane plants flower. But at local spots where plants flower, non synchronization in genotypes for cane flowering reduces the possibility of hybridization (Tiawari *et al.,* 2009). Therefore, sugarcane variety development in Pakistan is mainly based on import of germplasm from the cane breeding stations abroad and also through exotic or locally collected fuzz (Kaloi *et al.*, 2007). In most of the cane breeding programs large number of seedlings are grown from fuzz (ture seed), selections are made in subsequent generations to obtain superior clones/genotypes for release as new varieties.

Since last three decades biotechnology techniques have been utilized to complement and support traditional method in the varietal improvement of sugarcane (Shahid *et al.,* 2011). The continuous efforts made by the sugarcane breeders to develop high cane and sugar yielding varieties during the last few years have improved cane production in Pakistan. Yet, it is direly required to enhance cane and sugar yields per hectare through genetic means (Panhwar & Memon, 2004). The increase in cane production is possible with improvement in sugarcane by adopting biotechnology and hybridization techniques.

Biotechnological techniques including the plant tissue culture and genetic engineering are being utilized for the genetic improvement of sugarcane (Sobhakumari, 2012). It has been recognized that all plants regenerated from tissue culture are not exact replicas of a parental form and exhibit variability in agronomic traits (Bairu *et al*., 2011). The developments in plant tissue culture have opened up new possibilities in creating genetic variability (Seema *et al.*, 2011). The use of tissue culture for creation of somaclonal variation can be used to increase the speed and efficiency of the breeding process to improve the accessibility of existing germplasm of sugarcane and create new variation for crop improvement (Wang *et al*., 2005).

In the present study field performance of some exotic clone and regenerated somaclones were evaluated under agro climatic conditions of Tando Jam. Performance of genotype in diverse environments is somehow a true evaluation practice of its inherent potential for adoptiveness. Therefore, varietal trials are normally conducted over various locations and different years, after achieving meaning full results before deciding the release of new cultivars in a particular region. Considering the importance of the study it is expected that it would be helpful in developing new sugarcane genotypes /clone for commercial release.

Materials and Methods

The field experiment was laid out in randomized complete block design (RCBD) with four replications, having net plot size of 10 x10 meter one meter apart at Nuclear Institute of Agriculture (NIA), Tandojam during 2010 to 2012. The pre-experiment analysis of the soil showed that soil was clay loam in texture, non saline, sand (32.9%), silt (27.7%), clay (39.3%) EC (0.92 dS/m), pH 7.72 and organic matter (0.76%). The standard cultural practices such as irrigation, fertilizer and pesticide application were carried out as per recommendations (Khan *et al*., 2013). All agronomic

practices were kept normal for the different somaclone and exotic genotypes. Irrigation was applied with the interval of 10 days during summer and 15 days during winter season. The doses of fertilizer were 200:120:150 NPK respectively. Where, P and K were applied in a single dose at the time of planting. Where N was applied in 3 split doses and all fertilizer application was completed in the month of May. Hand weeding was applied whenever necessary to ensure normal and healthy crop at harvest. The planting was done during autumn seasons. Observations for ten important agronomic characters viz., No: tillers/plant, weight per plant (kg), sugar recovery %, brix total soluble solids (TSS) %, Commercial Cane Sugar (CCS) %, Sucrose % cane, Purity % cane, fiber % cane, cane yield (t/ha) and sugar yield (t/ha) were recorded at plant maturity.

Data analysis: Three stools were randomly taken from each plot to determine sugar contents according to sugarcane laboratory manual for Queensland Sugar Mills (Anon., 1970) while three rows from each plot were harvested to record yield data. The mean and variance were computed from each treatment. Data were analysed following Steel & Torrie (1980) using statistix 8.1 (software).

Results

In the present study total 29 sugarcane clones were evaluated for their yield and quality parameters. Thirteen were regenerated from callus culture of CP67-1026 and 16 were exotic clone introduced from canal point, whereas Thatta-10 and CP67-1026 were used as local check. Sugarcane requires a well-drained loamy soil with neutral soil reaction (pH 6.5 to 7.5) and adequate nutrients and without soil compaction is considered an ideal soil for sugarcane production. Whereas most of the cultivated soil texture in Sindh is loamy with higher pH (7.0 8.5) therefore the soil which was used for this study was loamy with pH 7.72.

Somaclones

Quantitative traits: The mean squares for all the characters under study revealed that all the genotypes were significantly different at 5% levels of probability for all ten characters (Tables 1 and 2). The data regarding the average performance of all genotypes is presented in Tables 3 & 4. Clone NIA-1026P6 showed significantly higher number of tiller/plant (8.66), which was 62.47 increased over its parent CP67-1026, followed by NIA-1026 P23 (7.66) and NIA-1026P30 (7.66). Whereas, CP67-1026 (parent) has 5.33 tiller/plant, however, tillers/plant were decreased in NIA-1026 P11 as compared to parent. Maximum weight/stool (kg) was recorded in NIA-1026P3 (12.66) followed by NIA-1026P23 (11.23) and minimum stalk weight was observed in NIA-1026P11 (6.23) (Table 4). Highest cane yield (t/ha) was observed in NIA-1026P6 (126.67) followed by NIA-1026P23 (112.33) and NIA-1026P6 (111.33) whereas clone NIA-1026P11 and NIA-1026P24 could not surpass the parent (Table 4). Clone NIA-1026P6, NIA-1026P23 and NIA-1026P6 showed of 65.95%, 47.16%, and 45.85%, increases over parent at Tando Jam respectively (Table 4). All the Soma-clones surpass the parent in sugar yield (t/ha) except NIA-1026P11. Highest sugar yield (t/ha) was recorded in NIA-1026P3 (14.62) followed by NIA-1026P23 and NIA-1026 P30. Clones NIA-1026P3, NIA-1026P23 and NIA-1026 P30 exhibited 131.33%, 102.69% and 87.66% increase over parent.

Qualitative traits: Significant ($p \leq 0.05$) differences were recorded for all the quality parameters. In case of TSS %, Sucrose %, CCS % and sugar recovery % clone NIA-1026P12 out yielded all the Somaclones in the trial and most importantly all the entries showed higher values than the parent. Clone NIA-1026P12 exhibited 36.73%, 23.10%, 35.30% and 54.55% increase in TSS %, Sucrose %, CCS % and sugar recovery % over the parent respectively (Table 3). In case of fiber %, the maximum fiber% was observed in the parent (12.93) and lowest in NIA-1026P12 (10.14). Highest purity % was recorded in NIA-1026P37 (81.13) followed by NIA-1026P24 (80.69) (Table 3).

Table 1. Analysis of variance (mean squares) for different qualitative characters in somaclones of sugarcane.

Source	DF	Sucrose %	TSS %	Fiber %	CCS %	Sugar recovery %	Purity %
Rep	2	0.00072	0.00695	0.00083	0.00040	0.00012	0.0506
Clones	13	5.72033	4.18316	2.12157	6.11070	5.39425	48.4232
Error	26	0.00127	0.01071	0.00010	0.00138	0.00121	0.0939
Total	41						

Table 2.Analysis of variance (mean squares) for different quantitative characters in somaclones of sugarcane.

Source	DF	Tiller/plant	Weight (t/ha)	Cane yield (t/ha)	Sugar yield (t/ha)
Rep	2	0.09524	0.0038	0.17	0.0030
Clones	13	8.24908	10.5959	1059.59	19.5995
Error	26	0.32601	0.0107	1.09	0.0170
Total	41				
CV		9.44	4.16	6.17	5.36

Table 3. Qualitative traits assessment of sugarcane somaclones under Tando Jam condition.

Clones	Sucrose %	TSS %	Fiber %	CCS %	Sugar recovery %	Purity %
NIA-1026P23	15.75f	19.84gh	10.33h	11.400f	10.71f	79.36c
NIA-1026P3	16.10e	20.32e	10.93g	11.547c	10.85c	79.17c
NIA-1026P2	16.53c	21.73b	11.14f	11.470de	10.78de	76.07e
NIA1026P7	16.86b	21.53c	10.92g	11.993b	11.27b	78.28d
NIA1026P8	15.41h	20.93d	11.73d	10.330g	9.70g	73.64f
NIA1026P11	14.07k	19.69hi	11.93b	9.160 i	8.61i	71.46h
NIA1026P12	17.87a	22.81a	10.14k	12.843a	12.07a	78.34d
NIA1026P24	16.36d	20.27e	10.23j	12.007 b	11.27b	80.69a
NIA1026P27	14.38j	19.88fg	11.507e	9.507h	8.93h	72.31g
NIA-1026P6	14.51i	20.04f	11.917c	9.560h	8.99h	72.41g
NIA1026-P30	15.67g	19.55i	10.257 i	11.440ef	10.75ef	80.15b
NIA1026P37	15.62g	19.25j	10.253ij	11.507cd	10.81cd	81.13a
NIA-1026P29	13.25l	18.78k	11.507e	8.563j	8.05j	70.53i
CP67-1026	13.07m	18.53l	12.93a	8.310k	7.81k	70.55i

DMR test (0.05): Means followed by the same letters are not significantly different from each other

Table 4.Quantitative traits assessment of sugarcane somaclones under tando jam condition.

Clones	Tillers/plant	Weight /stool (kg)	Cane yield (t/ha)	Sugar yield (t/ha)
NIA-1026P23	7.66b	11.23b	112.33b	12.81b
NIA-1026P3	7.33bc	12.66a	126.67a	14.62a
NIA-1026P2	4.33e	7.76gh	77.67gh	8.90g
NIA1026P7	4.33e	7.83fg	78.33fg	9.39f
NIA1026P8	5.33d	8.00f	80.00f	8.26h
NIA1026P11	3.33f	6.23i	62.33i	5.70l
NIA1026P12	6.66c	9.06d	90.67d	11.64d
NIA1026P24	3.66ef	6.26i	62.67i	7.52j
NIA1026P27	6.66c	8.56e	85.67e	8.14h
NIA-1026P6	8.66a	11.13b	111.33b	10.64e
NIA1026-P30	7.66b	10.36c	103.67c	11.86c
NIA1026P37	6.66c	9.23d	92.33d	10.62e
NIA-1026P29	7.00bc	9.06d	90.67d	7.76i
CP67-1026	5.33d	7.63h	76.33h	6.34k

DMR test (0.05):Means followed by the same letters are not significantly different from each other.

Table 5. Analysis of variance (mean squares) for different qualitative characters in exotic of sugarcane clones.

Source	DF	Sucrose %	TSS %	Fiber %	CCS %	Sugar recovery %	Purity %
Rep	2	0.7125	1.6422	0.44124	0.79620	0.70589	27.4249
Clones	16	10.9245**	11.2847**	1.84595**	9.44603**	8.34659	55.3952
Error	32	0.6159	0.5742	0.19925	0.69754	0.61443	11.4263
Total	50						
CV		4.70	3.83	3.94	6.60	6.59	4.01

Exotic clones

Quantitative traits: The mean squares of all the characters of exotic clones under study revealed that all the genotypes were significantly different at 5% levels of probability (Tables 5 and 6). The data regarding the average performance of all genotypes is presented in Tables 7 and 8. Tillers/plant were significantly ($p \leq 0.05$) higher in CP92-207 (9.00) followed by CP92-1198 (8.66) and CP87-2143 (8.00). Lowest value was observed in CP88-1508 (4.00) (Table 8). Clone CP92-207, CP92-1198 (8.66) and CP87-2143 exhibited 42.18%, 36.81% and 26.38% increase over Thatta-10 (check) respectively. Whereas CP88-1508 showed 36.81% decrease for tiller/plant as compare to check. Maximum weight/stool (kg) was recorded in CP92-1198 (13.70) followed by CP92-207 (11.66) and minimum stalk weight was observed in CP88-1508 (5.33) (Table 4). Thus clone CP92-1198 and CP92-207 showed 97.69 and 68.25% increase over Thatta-10. Highest cane and sugar yield (t/ha) was observed in CP92-1198 and it showed 97.61 and 239% increase over check. Whereas the lowest cane and sugar yield (t/ha) were observed in CP88-1508 53.33 t/ah and 10.43(t/ha) respectively (Table 8).

Table 6. Analysis of variance (mean squares) for different quantitative characters in exotic of sugarcane clones.

Source	DF	Tiller/plant	Weight (t/ha)	Cane yield (t/ha)	Sugar yield (t/ha)
Rep	2	0.31373	0.0782	0.73	0.5869
Clones	16	5.11336	11.6021	1141.54	38.1944
Error	32	0.15748	0.2393	20.39	0.8499
Total	50				
CV		5.68	5.86	5.39	8.64

Table 7. Qualitative traits assessment of exotic sugarcane clones under Tandojam condition.

Clones	Sucrose %	TSS %	Fiber %	CCS %	Sugar recovery %	Purity %
CP92-1632	17.26cde	20.30cd	10.81ef	13.04bcde	12.26bcde	85.00ab
CP92-2114	17.05de	19.76def	12.03abc	12.69cdef	11.93cdef	86.29ab
CP86-394	16.45ef	18.73efgh	11.73bcd	12.55defg	11.80defg	87.83ab
CP86-328	18.43abc	21.96b	11.10def	13.76bcde	12.93bcde	83.91abc
CP86-1628	18.93ab	22.33b	10.39fg	14.35b	13.49b	84.77ab
CP73-345	13.69h	17.43i	10.70ef	9.79i	9.20i	78.72c
CP80-1743	14.53gh	16.73i	9.76g	11.28gh	10.61gh	86.83ab
CP92-207	14.56gh	17.56hi	12.04abc	10.66hi	10.02hi	83.16bc
CP92-1601	16.42ef	19.00efg	11.76bcd	12.41efg	11.66efg	86.54ab
CP92-1208	15.62fg	18.90efg	10.48fg	11.62fgh	10.93fgh	82.59bc
CP92-1401	15.24fg	17.83ghi	11.62cd	11.45fgh	10.76fgh	85.38ab
CP92-249	17.86bcd	19.96de	11.89abc	13.77bcde	12.94bcde	89.48a
CP87-2143	17.89bcd	21.23bc	11.42cde	13.35bcde	12.55bcde	84.32abc
CP88-1508	18.66ab	21.70b	12.51a	13.92bcd	13.08bcd	86.09ab
CP85-1491	18.18bcd	20.40cd	11.62cd	14.02bc	13.18bc	89.10a
CP92-1198	19.49a	23.68a	10.47fg	16.58a	15.59a	82.29bc
Thatta-10	13.30h	18.70fgh	12.37ab	9.68i	9.10i	71.14d

DMR test (0.05): Means followed by the same letters are not significantly different from each other

Table 8. Quantitative traits assessment of exotic sugarcane clones under Tandojam condition.

Clones	Tiller/plant	Weight (t/ha)	Cane yield (t/ha)	Sugar yield (t/ha)
CP92-1632	6.66ef	7.00g	74.33gh	9.67efgh
CP92-2114	7.33cd	7.66fg	76.67fgh	9.77efgh
CP86-394	7.50bcd	7.00g	70.00gh	8.74fghi
CP86-328	7.83bc	9.50c	95.00c	13.09b
CP86-1628	6.66ef	7.33g	73.33gh	10.53cde
CP73-345	8.00b	8.66de	86.67de	8.48hi
CP80-1743	7.00de	7.33g	73.33gh	8.27hi
CP92-207	9.00a	11.66b	116.67b	12.46b
CP92-1601	6.00gh	7.00g	70.00gh	8.68ghi
CP92-1208	8.00b	9.33cd	93.33cd	10.86cde
CP92-1401	7.00de	8.83cde	88.33cde	10.09efg
CP92-249	5.00i	8.66de	86.67de	11.93bc
CP87-2143	8.00b	7.70fg	77.00fg	10.26def
CP88-1508	4.00j	5.33h	53.33i	7.41ij
CP85-1491	5.66h	8.33ef	83.33ef	11.70bcd
CP92-1198	8.66a	13.70a	137.00a	22.72a
Thatta-10	6.33fg	6.93g	69.33h	6.71j

DMR test (0.05): Means followed by the same letters are not significantly different from each other

Table 9. Correlation coefficients study of different traits in sugarcane clones.

	Sucrose %	TSS %	Fiber %	CCS %	Sugar recovery %	Purity %	Tiller/ plant	Weight (t/ha)	Cane yield (t/ha)
TSS %	0.869**								
Fiber %	-0.028	-0.001							
CCS %	0.963**	0.811**	-0.124						
Sugar recovery %	0.963**	0.811**	-0.124	0.999**					
Purity %	0.5225*	0.034	-0.068	0.554*	0.554*				
Tiller/plant	-0.210	-0.091	0.337	-0.144	-0.144	-0.250			
Weight (t/ha)	0.079	0.153	0.269	0.215	0.215	-0.087	0.656*		
Cane yield(t/ha)	0.080	0.153	0.273	0.216	0.216	-0.086	0.655*	0.995**	
Sugar yield(t/ha)	0.518*	0.528*	-0.285	0.656*	0.656*	0.153	0.428	0.864**	0.869**

Qualitative traits: Significant ($p \leq 0.05$) differences were recorded for all the quality parameters. In case of TSS %, Sucrose %, CCS % and sugar recovery % clone CP92-1198 demonstrate highest values for all characters and exhibited 26.63%, 46.54%, 71.28% and 71.32% increase in TSS %, Sucrose %, CCS % and sugar recovery % over the check respectively (Table 7). In case of fiber%, the maximum fiber% was observed in the check (12.37) whereas highest purity % was recorded in CP92-249 (89.48) followed by CP85-1491 (89.10) (Table 7).

Correlation studies: The results showed that quantitative and qualitative traits were negatively correlated (Table 9). Cane yield showed highly significant positive correlation with cane weight (0.995) whereas, significantly positive correlation with tiller/plant (0.655) and non significant correlation were observed with sucrose % (0.080), TSS % (0.153), CCS % (0.216) and sugar recovery % (0.216). Non significant negative correlation was observed with purity % (-0.087) (Table 9). All the quality parameters exhibited highly significant positive correlation to each other (Table 9). Fiber % showed negative correlation with sucrose % (-0.028), TSS % (-0.001), CCS % (-0.124) sugar yield (-0.285) and sugar recovery % (-0.124) and non significant correlation with cane yield, tiller and weight/plant (Table 9). Whereas, purity % is negatively correlated with tiller/plant (-0.250), weight/plant (-0.087) and cane yield (-0.086) and positive correlation were recorded with quality parameter (Table 9). Morphological traits are the output of the genetic constitution therefore phenotypic correlation can be addressed as the ascription of the genetic correlation between two traits (Kimbeng *et al.,* 2009). However, genetic expression sturdily dependent on the environment i.e., G x E interaction effects which may unstable across the environments.

Conclusion

Analysis of variance revealed significant differences among the sugarcane clones for all the ten characters studied. The variation in the genotypes resulted in variable productivity of the sugarcane (Babar *et al.,* 2011). The accuracy of the experiment can be examined with values of coefficient of variations which was very low for quality parameters and quantitative traits values range from 4.16 to 9.44 and 5.39 to 8.64 for somaclones and exotic clones respectively.

Among the genotypes (somaclone) NIA-1026P3 and NIA-1026P23 were the superior clones in terms of cane yield (t/ha). In case of exotic clones CP92-1198 and CP92-207 were performed well under agro-climatic conditions of Tando jam. These clones turn up with higher value of tiller/plant, and weight/plant, thus, contributes for higher cane yield in these genotypes. According to (Silva *et al*., 2008), number of millable cane and single stalk weight are the main contributing factor for cane yield. Our results are in complete agreement with the finding of (Silva *et al.*, 2008). These characters were revealed positive correlation with cane yield suggesting any improvement in these characters may result in positive response of the cane yield. (Khan *et al.,* 2009) also found that a positive correlation of between stalk height and cane yield whereas (Singh *et al*., 2004) reported that a significant positive correlation between stalk diameter and cane yield. According to Skinner, (1972) cane thickness, number of tillers and cane height are by far the main cane yield components. According to (Ahmed *et al.,* 2010), number of millable cane and stalk height are positively correlated in the material studied where as the stalk diameter had showed negative association with millable cane between the genotypes. This indicated possibility of simultaneous improvement under selection for number of millable cane and stalk height.

Somaclones viz., NIA-1026P12, NIA-1026P24 and among exotic clones CP92-1198 and CP86-1628 exhibited better juice quality and sugar recovery% the association of quality traits was found strong and positive throughout the materials. Clone CP92-1198 ranked top clone for cane and sugar yield (t/ha). None of the high quality somaclones appeared among the top genotypes for cane yield, according to this study, negative correlation between quality parameters was noticed. Negative association of the cane character with quality characters makes the job difficult for cane improvement. In this scenario sugar yield is best parameter for the selection of sugarcane because sugar yield is the result of cane yield and sugar recovery. Therefore a strict parameters are required to set for sugar yield where the clones having more than 9% recovery with 130 t/ha cane yield should be selected for future varieties to boast the farmers income and sugar industry. On this basis exotic clones CP92-1198 and soma-clone NIA-1026P3 were selected for further studies.

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