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ASSESSMENT OF CONTENDER SUGARCANE CLONES FOR MORPHOLOGICAL TRAITS AND BIOTIC TOLERANCE UNDER AGRO-CLIMATIC CONDITIONS OF TANDO JAM

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Abstract

Sugarcane germplasm comprises different phases (Advance and station yield trial) were planted at the experimental farm of NIA, Tando Jam to evaluate the growth and biotic tolerance performance during September, 2012-13. The selected clones were originated from 09 tissue culture, 7 Canal Point USA, 4 Australia, 3 Barbados and 6 local germplasm sources. Considerable differences for all traits among the advanced lines tested were observed, two clones originated through *In vitro* mutagenesis showed better performance in term of cane yield as compared to other clones and local checks. In station yield trial only three clones, CSSG-2453, BNIA-87 and soma-clone NIA-1026-P3 produced higher cane yield than the control, Thatta-10. Sugarcane germplasm were evaluated for 09-characters and analyzed for genotypic and phenotypic correlation. These characters revealed that cane yield was associated positively with most of the agronomic traits such as cane height, internodes length and cane thickness. The study of path analysis for yield related traits the highest positive direct effect on cane yield was exerted by cane height. Study of diseases scoring only 05 lines produced disease symptoms.

Key words: Exotic, Somaclone, Sugarcane, Morphological traits, Biotic tolerance.

Introduction

Sugarcane (*Saccharum officinarum* L.) is the world largest crop by production (Kinkema *et al*., 2014). The annual production of sugarcane in the world is 1.83 billion tons on 26.1 million hectares (ha). The average yield of sugarcane in the world is 70.24 tons/ha while Pakistan produces 58.4 million ton by harvesting 1.04 million ha and the yield is 55.8 tons/ha (Anon., 2012). The main constraints in the optimal sugarcane production in Pakistan includes abiotic and biotic stresses (Kumar *et al.,* 2014). Fungi are the most prevalent pest of sugarcane crop. Over 100 fungi were found to cause diseases in sugarcane all over the world (Subhani *et al.,* 2008). The most destructive fungal diseases that reduce 30-70% sugarcane production include brown rust caused by *Puccinia melanocephala*; whip smut, caused by *Ustilago scitaminae* and red rot caused by *Colletotrichum falcatum* (Khan *et al.,* 2009; Alarmelu *et al.,* 2010; Virtudazo *et al.,* 2001). The main cause of recurrent of these diseases in Pakistan is the cultivation of susceptible sugarcane varieties that demands the incorporation of new sugarcane cultivar with improved agronomic characteristics and resistance to biotic and abiotic stresses. The conventional breeding is rendered difficult in Pakistan due to constrain of environmental conditions. (Zamir *et al*., 2012). In Pakistan, sugarcane selection breeding is done through import of true seed (fuzz) USA, Australia, Barbados, South Africa, Brazil and Sri Lanka. It was also documented that obtaining a multi-merits sugarcane variety with high biomass, high sugar content and excellent disease and pest resistance by relying solely on traditionally hybridization is difficult using asexually reproduced modern sugarcane varieties (Xue *et al.*, 2014). Some alternative techniques such as plant cell and tissue culture induce mutation and genetic engineering are applied to complement and support traditional method in the varietal improvement of sugarcane in Pakistan. Present study was focused on the evaluation of 45 sugarcane clones for enhancing sugar and cane productivity in province of Sindh by selecting high cane and sugar yielding clone.

Materials and Method

Sugarcane germplasm comprises different phases (Advance, station and preliminary yield trial) were planted at the experimental farm of NIA, Tando Jam to evaluate the growth and rust resistance performance during September, 2012-13. These clones were originated from 09 tissue culture, 7 canal point USA, 4 Australia, 3 Barbados and 6 local germplasm sources. Sugar contents were analyzed according to Sugarcane Laboratory Manual for Queensland Sugar Mills (Anon., 1970). Yield data was recorded as narrated by Khan *et al*. (2009a). Normal agronomical practices were practiced throughout the growth period. A number of agronomic characters were evaluated at vegetative growth and harvesting stage. Number of tillers and plant height were evaluated at vegetative stage while cane height (cm), number of internodes, internodes length (cm), cane yield (t/ha) brix (%) sugar yield (t/ha) and sugar recovery (%) were observed at harvesting stage. The trials were tested for their response against brown rust of sugarcane under natural infection using the scale 0-4 as reported by Stakman *et al*. (1962) where 0 indicates no disease symptoms, 1 shows one or a very few pustules 2 shows the more than a few pustules 3 indicates numerous pustules on lower and upper side of leave and 4 illustrates severe rust development. The data were statistically analyzed according to Steel & Torrie (1980). Correlation analysis was also carried out.

Results and Discussion

Advance trial: Considerable differences for all traits among the advanced lines tested were observed at α 0.05. The data is given in Tables 1 & 2. However, these differences were irrespective of their origin. Number of tiller is one of the major yield contributing trait (Smiullah *et al.,* 2013) was observed higher in L-116 originated from locally produced fuzz at Murree Hills station of SRI Faisalabad. , Pakistan. It was lowest in BL4 which was only 3-4 tillers per plant. In all other clones non significant differences were observed in number of tillers at α 0.05 which is ranged from 4-7 in numbers. Another yield contributing trait is the cane height, which was highest in NIA-2010 and lowest in BL-4 and L-116. Cane thickness substantially highest in CP92-1198 with 3.14cm followed by BL-4. Number of internodes was non-significantly different among all clones of advanced yield trial whereas, length of internodes was highest in NIA-2010 and lowest in clone NIA-1254. These yield contributory traits effects on the overall cane yield that was observed high NIA-2010 which is about 139.67 tones ha^{-1} with highest weight/plant which was around 14Kgs. NIA-2011 showed second highest yield which was 117.6 tones ha^{-1}. These two clones originated through *In vitro* mutagenesis showed better performance in term of cane yield as compared to other clones and local checks, however the quality traits such brix and sugar recovery was higher in CP92-1198 which was 21.94% and 10.09% respectively. Sugar yield, one of the good parameter to evaluate the performance of sugarcane clones was observed higher in NIA-2010 and NIA-2011.

Station yield trial: In station yield trial only three clones, CSSG-2453, BNIA-87 and somaclone 1026-P3 produced higher cane yield than the control, Thatta-10. These all clones originated from different source as mentioned in Tables 3&4 (Khan *et al*., 2007). However 9 clones showed the higher sugar recovery than local check, Thatta-10. The highest sugar recovery recorded in 1026-P12 (10.11%) than all other clones. The other clones that showed the higher sugar recovery than check includes, CSSG-2476, BNIA-87, BNIA-2143, C57 and soma-clones of 1026(P8, P11, P12, P24, P27). However the sugar yield reflects the actual performance of cane in terms of cane yield and recovery and that was observed considerably higher in BNIA-87 as well as in 1026-P12. Six (06) clones showed substantially increased sugar yield than the local check, Thatta-10 these were CSSG-2453, C-57 and somaclones of 1026 (P8, P11, P24 & P27). The other agronomic characteristics of clones in station trial were as follows: the cane height was observed highest in cloneCSSG-2476 which is 291.8 cm and minimum was recorded in Thatta-10. The number of internodes was higher in three clones (207, CSSG-2453, BNIA-87). Internodal length was statistically higher in CP88-1508 and 1026-P7. Cane thickness was highest in CSSG-2453. Number of tiller was higher in CSSG-2476 and in CP88-1508 (Abubakar *et al*., 2013).

Table 1. Advance trail analysis of variance table.

Source	DF	Cane height	Internodes number	Internodes length	Thickness	Tiller	Brix	Sugar recovery % cane	Sugar yield (t/ha)	Cane weight (kg)	Cane yield (t/ha)
Replication	**2**	1046.31	1.74	0.6163	0.032	1.442	2.392	0.504	1.743	1.118	111.86
Clone	11	63.05**	10.76^{ns}	37.165**	0.33**	8.453**	6.115**	1.292**	11.41**	13.88**	1388.8**
Error	22	404.32	5.9287	0.4081	0.007	1.005	0.545	0.115	0.645	0.68	68.04
Total	35										
Grand mean		265.48	25.600	12.181	2.53	5.7478	19.566	8.99	8.126	9.03	90.30
CV		7.57	9.51	5.24	3.31	17.44	3.77	3.77	9.88	9.13	9.13

Table 2. Performance of advance sugarcane clones in advance yield trial.

Clones	Cane height (cm)	Internodes number	Internodes length (cm)	Thickness (cm)	Tiller/ plant	Brix %	Rec %	Sugar yield (t/ha)	Wt/plant (kg)	Cane yield (t/ha)
NIA-2012	253.56de	22.67d	10.07f	2.25g	6.77b	20.59bc	9.47bc	9.00bc	9.50c	95.00c
NIA-2004	272.52cd	26.24abcd	13.33cd	2.78c	5.49bc	20.36bcd	9.36bcd	8.75bc	9.33c	93.33c
CP92-1198	286.78bcd	24.00cd	14.38bc	3.14a	5.83bc	21.94a	10.09a	9.64b	9.56c	95.67c
NIA-S3	262.67cde	27.33abc	8.51h	2.50ef	4.33cd	20.69ab	9.52ab	8.16c	8.56cd	85.67cd
L-116	192.55f	29.00a	9.14fgh	2.02h	10.33a	19.06e	8.77e	6.23e	7.10ef	71.00ef
Thatta-10	293.81bc	28.66ab	13.04d	2.63de	4.33cd	17.49f	8.04f	7.74cd	9.63c	96.33c
NIA-2011	315.67b	25.55abcd	14.66b	2.48f	5.80bc	21.27ab	9.78ab	11.52a	11.76b	117.67b
NIA-2010	351.67a	24.29cd	21.00a	2.22g	5.96bc	17.45f	8.02f	11.18a	13.96a	139.67a
CP71-1632	230.22e	24.96abcd	9.77fg	2.50ef	5.08bcd	19.35cde	8.90cde	5.70e	6.40f	64.00f
CP78-2114	266.26cd	24.98abcd	11.80e	2.20g	5.64bc	18.88e	8.68e	6.17e	7.10ef	71.00ef
NIA-1254	267.11cd	24.82bcd	8.70gh	2.65cd	5.71bc	19.21de	8.83de	6.67de	7.53def	75.33def
BL-4	193.00f	24.66bcd	11.72e	2.99b	3.66d	18.46ef	8.49ef	6.72de	7.90de	79.00de
SE%	16.41	4.12	0.52	0.06	0.81	0.60	0.27	0.65	0.67	6.73
LSD%	34.04	1.98	1.08	0.14	1.69	1.25	0.57	1.36	1.39	13.9

Table 3. Station trail analysis of variance.

Source	DF	Cane height	Internodes number	Internodes length	thickness	Tiller (Nos.)	Brix %	Rec %	Sugar yield (t/ha)	Wt/plant (kg)	Cane yield (t/ha)
Replication	2	449.1	2.1270	13.2594	0.2126	2.6178	2.683	0.55865	0.61621	0.77834	78.420
Clone	20	2220*	15.1**	6.65**	0.157*	3.02*	6.162	1.304**	2.91**	2.30**	230.8**
Error	40	700.9	3.4798	1.2981	0.0695	1.066	1.311	0.27715	0.47728	0.35151	35.142
Total	62										
Grand Mean		232.3	25.750	10.975	2.4543	5.7970	19.38	8.9148	5.3592	5.9816	59.820
CV		11.39	7.24	10.38	10.22	17.81	5.91	5.91	12.89	9.91	9.91

Table 4. Performance of sugarcane clones in station yield trial.

Clones	Cane height (cm)	Internodes number	Internodes length (cm)	Thicknes s (cm)	Tiller/ plant	Brix %	Rec %	Sugar yield (t/ha)	Wt/plant (kg)	Cane yield (t/ha)
CP92-207	229.3c-f	28.66a	9.74efg	2.87ab	6.66abc	19.08d-g	8.77defg	5.72a-e	6.51a-d	65.1a-d
CP92-1401	210.7d-g	21.55f	12.04abc	2.49abc	4.88d-g	17.59g	8.09g	3.86hi	4.77g	47.71g
CP85-1491	220.4c-f	26.44a-d	12.17abc	2.48abc	4.89d-g	19.16d-g	8.81d-g	5.09d-g	5.71c-g	57.1c-g
CP88-1508	229.5c-f	24.88bcde	12.96a	1.92e	7.33a	19.66b-f	9.04b-f	4.51fgh	4.98fg	49.85fg
QSG-20	233.6c-f	23.99c-f	10.49c-g	2.66abc	5.22b-g	18.59efg	8.55efg	4.04ghi	4.74g	47.41g
CSSG-2402	239.4c-f	23.33ef	11.65a-d	2.47abc	5.55b-g	17.65g	8.12g	2.93i	3.60h	36.03h
CSSG-2453	235.7c-f	28.22a	11.93a-d	2.85a	4.00g	18.65efg	8.58efg	5.91a-d	6.86a	68.62a
CSSG-2476	291.83a	27.42ab	12.63ab	2.41c	7.52a	19.94b-e	9.17b-e	5.18c-f	5.63d-g	56.3d-g
BNIA-87	230.4c-f	28.55a	9.33efg	2.62abc	6.22a-e	21.07abc	9.69abc	6.72a	6.93a	69.30a
BNIA-2143	204.2efg	22.77ef	9.18efg	2.45abc	4.99c-g	21.42ab	9.85ab	5.45 b-f	5.53efg	55.3e-g
Thatta-10	174g	18.66f	9.73efg	2.63abc	4.33fg	17.49g	8.04g	4.70e-h	5.86b-f	58.6b-f
NIA-1026-P2	248.7a-d	25.66a-e	10.96b-e	2.26cde	6.33a-e	17.44g	8.02g	5.15c-g	6.42a-e	64.2a-e
NIA-1026-P3	260.5a-c	23.44def	11.82a-d	2.43bc	4.77efg	17.82fg	8.19fg	5.68a-e	6.89a	68.92a
NIA-1026-P7	283.8ab	26.78abc	13.350a	1.95de	4.88defg	19.31c-g	8.88c-g	5.14c-g	5.80b-f	58.1b-f
NIA-1026-P8	256.4abc	25.66a-e	10.70c-f	2.50abc	6.88ab	20.32a-e	9.34a-e	6.01a-d	6.43a-e	64.3a-e
NIA-1026-P11	247.2b-e	27.00abc	9.44efg	2.60abc	6.77ab	20.29a-e	9.33a-e	6.27abc	6.71ab	67.13ab
NIA-1026-P12	202.33fg	23.11ef	9.03fg	2.49abc	6.33a-e	21.99a	10.11a	6.71a	6.62abc	66.2abc
NIA-1026-P23	233.3c-f	22.78ef	11.80abcd	2.36cd	5.22b-g	17.67g	8.13g	4.72e-h	5.82b-f	58.2b-f
NIA-1026-P24	218c-f	27.00abc	9.26efg	2.43bc	6.00a-f	20.61abcd	9.48a-d	6.10a-d	6.43a-e	64.3a-e
NIA-1026-P27	206.4d-g	27.33ab	8.77g	2.32cde	6.55a-d	20.01b-e	9.20b-e	6.18a-d	6.71ab	67.13ab
C-57	223.6c-f	27.44ab	10.11defg	2.31cde	6.33a-e	21.14abc	9.72abc	6.40ab	6.60a-d	66.0a-d

Similar letter are non-significantly different

Correlation studies: The magnitude of genotypic correlations given in Table 5 showed that traits were highly associated genotypically as also observed by Kinkema *et al.* (2014). Cane yield and the quality traits were major parameters for evolution of sugarcane crop (Raza *et al.,* 2014). Most of the agronomic traits in sugarcane were quantitative in nature. The correlation studies would be helpful for evaluating the performance of commercial sugarcane clones. These studies revealed that cane yield was associated positively with most of the agronomic traits such as cane height internodal length and cane thickness. Where the correlations highly significant at α 0.01 with cane height & cane thickness genotypically. However Number of internodes, brix% and sugar recovery has not any association with cane yield. On other hand the quality traits, brix and sugar recovery percent cane were found to be associated with cane height, internodes length, number of tiller. However these correlations were negative with cane height and internodes length.

Path coefficient analysis clarify whether the relationship of cane yield with its components is due to the direct effects of component characters on cane yield or is a consequence of its indirect effects via some other traits (Chaudhary *et al* 1994). The highest positive direct effect on cane yield was exerted by cane height (0.987) followed by cane thickness, number of tillers and internodes length (0.912, 0.667 and 0.534 respectively). Raza *et al*. (2014) also found that number of canes and number of nodes has a direct effect on cane production. It is clearly seen from the Table 6 that sugar yield, brix % and sugar recovery % did not have any direct effect on the cane yield while, these traits have contributed to the cane yield via some other traits. Chaudhray (2002) found that number of internodes and lengths of internodes have a negative effect at the cane yield.

Table 5. Phenotypic and genotypic correlation (r) analysis of sugarcane somaclones.

Traits	Variation	Brix %	Cane height	Inter node length	Tiller/ plant	No of inter nodes	Cane thickness	Cane yield	Sugar recovery %	Sugar yield
Brix%	Phenotypic	1	-	-	-	-				
	Genotypic									
Cane height	Phenotypic	-0.521*	1	-	-	-				
	Genotypic	-0.471*								
Inter node length	Phenotypic	-0.33	0.712*	1	-	-				
	Genotypic	-0.48*	0.950**							
Tiller/plant	Phenotypic	0.503*	-0.30	-0.283	1	-				
	Genotypic	0.587*	-0.591*	-0.127						
No: of inter nodes	Phenotypic	0.317	0.090	0.038	0.37	1				
	Genotypic	0.383	0.135	-0.55*	0.44					
Cane thickness	Phenotypic	0.050	-0.080	-0.273	0.310	0.047	1			
	Genotypic	0.061	-0.36	-0.303	0.47*	0.173				
Cane yield	Phenotypic	0.265	0.718**	0.526*	0.63*	0.171	0.531*	1		
	Genotypic	0.393	0.834**	0.708*	0.94**	0.347	0.88**			
Sugar recovery %	Phenotypic	0.839**	-0.46*	-0.59*	0.42*	0.171	0.25	0.29	1	
	Genotypic	0.998**	-0.57*	-0.73*	0.65*	0.280	0.28	0.35		
Sugar yield	Phenotypic	0.58*	-0.34	-0.50*	0.67**	0.40*	0.42*	0.89**	0.67*	1
	Genotypic	0.860**	-0.54*	-0.87**	0.78**	0.49*	0.48*	0.89**	0.79**	

* = Significance at 5 % level, ** = Significance at 1 % level, ns = Non-significant

Path coefficient studies

Table 6. Direct (in parenthesis) and indirect effect matrix on cane yield.

Variables	Brix %	Cane height	Internod e length	No: of tillers	No: of internode	Cane thickness	Sugar recovery %	Sugar yield
Brix %	**(0.112)**	0.184	0.046	0.0114	0.006	0.031	0.753	0.0300
Cane height	0.052	**(0.987)**	0.050	0.0115	0.004	0.035	0.384	0.817
Internode length	0.098	0.0372	**(0.534)**	0.024	0.018	0.044	0.49	0.315
No: of tillers	0.063	0.023	0.067	**(0.667)**	0.0144	0.034	0.465	0.775
No: of internode	0.020	0.005	0.029	0.008	**(0.324)**	0.264	0.187	0.612
Cane thickness	0.179	0.072	0.121	0.345	0.044	**(0.912)**	0.728	0.242
Sugar recovery %	0.125	0.022	0.038	0.013	0.001	0.021	**(0.019)**	0.198
Sugar yield	0.057	0.021	0.045	0.022	0.013	0.028	0.528	**(0.039)**

Disease scoring: Among all these tested lines only 5 lines produced disease symptoms (Table 7). Based on their reaction against the brown rust five (05) lines including CP85-1491,NIA-1026P3,NIA-1026P23, BNIA-2143 and CSSG-2453 in the station trial showed the rust infection. Among these line CSSG-2453 showed severe rust development and it was rated highly susceptible according to the disease rating scale and the lines NIA-1026P3 and BNIA-2143 were categorized as moderately resistant to moderately susceptible and the line CP85-1491 was rated as resistant. Remaining lines in these trials were free of brown rust of sugarcane. Out of the 32 lines 14 were found infected with the eye spot diseases, similarly 14 lines were infected with red rot of sugarcane and only one line showed whip smut symptoms.

Among the genotypes NIA-2010 and NIA-2011 were the superior clones in terms of cane yield (t/ha). In case of exotic clones CP92-1198 performed well under agro-climatic conditions of Tando jam. These clones exhibited higher value of plant height, and weight/plant, thus, contributes for higher cane yield in these genotypes. (Silva *et al*., 2008) reported that number of millable cane and single stalk weight are the main contributing factor for cane yield. Our results are in absolutely in harmony with the finding of (Silva *et al*., 2008). Khan *et al*. (2009 and 2013) narrated 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. 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. None of the high quality soma-clones 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. Therefore strict parameters are required to set for cane and 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.

Table 7. Diseases scoring in the contender sugarcane clones.

Clone	Trial	Red rot	Eye spot	Brown rust	Whip smut
NIA-1026P23		-	+	1	+
CSSG-2453		-	+	4	-
NIA-1026P3		+	+	2	-
CSSG-2476		+	+	-	-
CSSG-2402		-	+	-	-
QSG20		-	-	-	-
CP88-1508		-	+	-	-
CP92-1401		+	-	-	-
CP85-1491		-	-	1	-
NIA-1026P7	Station yield trial	-	+	-	-
L116		+	-	-	-
BNIA-2143		+	+	2	-
NIA-1026P2		-	-	-	-
C-57		+	-	-	-
NIA-207		-	-	-	-
NIA-1026P8		+	-	-	-
NIA-1026P11		+	+	-	-
NIA-1026P12		-	-	-	-
NIA-1026P24		-	+	-	-
NIA-1026P27		+	-	-	-
NIA-S3		+	+	-	-
NIA-2012		-	-	-	-
L116		+	-	-	-
CP71-1632		+	+	-	-
CP78-2114		+	+	-	-
NIA-1254	Advanced clones		+	-	-
NIA328		+	-	-	-
THATT10		-	-	-	-
NIA2010		-	-	-	-
NIA2011		-	-	-	-
NIA2004		-	-	-	-
NIA1198		-	-	-	-

Category	Pustules	Category	Pustules	Category	Pustules
0	No symptom	1	One or few	2	More than 10 pustules
3	Numerous pustule	4	Severe rust		

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