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Biomass potential of novel interspecific hybrids involving improved clones of *Saccharum*

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ABSTRACT

Saccharum spontaneum has contributed a wide range of important traits such as high vigour, hardiness, ratooning ability and tolerance to biotic and abiotic stresses to modern sugarcane cultivars. The interspecific hybrids involving *S. spontaneum* has the greatest potential as energy canes in view of their high biomass potential. The hybrids are highly productive, have high fibre content, tolerance to biotic stresses and can be grown under suboptimal conditions. In the present study, 32 interspecific hybrids involving improved *Saccharum* were evaluated for sugar and biomass contributing traits for two seasons. The results indicated that the hybrids generally have higher biomass potential compared to the commercial varieties. The variation among the clones for different traits was significant. The clone × year interaction was highly significant for all the traits indicating that the clones performed differently during the two seasons. Thirteen of the hybrids recorded significantly higher dry biomass yield than the population mean of 46.51 t ha^{-1}. Fibre% was positively correlated with dry matter% as well as dry biomass and it did not show any significant association with the juice quality traits indicating the possibility of combining both increased fibre and sugar content in the same genotype. Among the various traits studied, fibre%, number of stalks/plot, stalk yield and fresh biomass yield were found to be positively correlated to dry biomass yield.

1. Introduction

Sugarcane is a C_4 plant grown mostly in the tropical and subtropical countries. It has long been considered as one of the world's most efficient crops in converting solar energy into chemical energy (Ming et al., 2006). Sugarcane is the single major source for the manufacture of white sugar and 80% of the World's sugar production is from sugarcane. The major byproducts of sugarcane are bagasse and molasses. Sugarcane bagasse contains 48% of cellulose and it can be converted into ethanol (Elawad et al., 1980). But in India, sugarcane bagasse is mainly being used to generate electricity. Sugarcane biomass is a versatile renewable energy source that can provide environmental and economic benefits at global level and thereby play an important role in the quest to reduce green house gas emission (Cook et al., 1991). Sugarcane can produce more dry matter biomass per unit area than any other crop species in the world (Elawad et al., 1980). In a study, it was estimated that 21 Mha of sugarcane could produce 1750 mt yr^{-1} of biomass when compared to 2400 mt yr^{-1} of biomass from all cereals added together which cover more than 700 Mha of land (Hall et al., 1993). Hence, sugarcane is being considered as one of the potential biomass producing crops in the tropical region and has a potential role in the energy scenario. India is one of the countries in the world which successfully exploiting the energy potential of sugarcane to produce co-products such as ethanol and surplus electricity (Leal, 2007). Currently the varieties cultivated in India have only 13–15% fibre and development of high biomass varieties has enormous potential for solving energy problems in the country. Hence, it is essential to develop special purpose varieties for producing sugar, ethanol and electricity with varying levels of sugar and fibre (Rao and Kennedy, 2004). Alexander (1985) indicated that the vigour of early generation interspecific hybrids involving *Saccharum spontaneum* could be exploited to develop biomass canes. The present study was an attempt to evaluate some of the interspecific hybrids of *Saccharum* for their potential as energy and fuel canes.

2. Materials and methods

The experimental material consisted of 32 interspecific hybrids involving improved *Saccharum*. Of this eight were *Saccharum officinarum* × *Saccharum robustum* hybrids, four were *S. robustum* × *S. spontaneum* hybrids and 20 were *S. officinarum* × *S. spontaneum* hybrids. The improved *S. officinarum* and *S. robustum* clones used in this study were the products of an intra population improvement

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Table 1
Parentage of clones used in the study.

Sl. no.	Clone	Parentage		Type of species	
		Female	Male	Female	Male
1	GU 04-601	PIO 96-443	PIR 00-1044	*S. officinarum*	*S. robustum*
2	GU 04-626	PIO 96-443	PIR 00-1044	*S. officinarum*	*S. robustum*
3	GU 04-634	PIO 96-443	PIR 00-1044	*S. officinarum*	*S. robustum*
4	GU 04-640	PIO 96-443	PIR 00-1044	*S. officinarum*	*S. robustum*
5	GU 04-650	PIO 96-443	PIR 00-1044	*S. officinarum*	*S. robustum*
6	GU 04-752	PIO 96-443	PIR 00-1044	*S. officinarum*	*S. robustum*
7	GU 04-767	PIO 96-443	PIR 00-1044	*S. officinarum*	*S. robustum*
8	GU 04-772	PIO 96-443	PIR 00-1044	*S. officinarum*	*S. robustum*
9	GU 04-987	PIR 00-1188	IND 99-904	*S. robustum*	*S. spontaneum*
10	GU 04-1019	PIR 00-1188	IND 99-904	*S. robustum*	*S. spontaneum*
11	GU 04-1101	PIR 00-1188	IND 99-904	*S. robustum*	*S. spontaneum*
12	GU 04-1146	PIR 00-1188	IND 99-904	*S. robustum*	*S. spontaneum*
13	GU 04-1162	PIO 00-513	IND 99-904	*S. officinarum*	*S. spontaneum*
14	GU 04-1272	PIO 00-513	IND 99-904	*S. officinarum*	*S. spontaneum*
15	GU 04-1293	PIO 00-513	IND 99-904	*S. officinarum*	*S. spontaneum*
16	GU 04-1325	PIO 00-513	IND 99-904	*S. officinarum*	*S. spontaneum*
17	GU 04-1332	PIO 00-513	IND 99-904	*S. officinarum*	*S. spontaneum*
18	GU 04-1350	PIO 00-513	IND 99-904	*S. officinarum*	*S. spontaneum*
19	GU 04-1361	PIO 00-513	IND 99-904	*S. officinarum*	*S. spontaneum*
20	GU 04-1377	PIO 00-513	IND 99-904	*S. officinarum*	*S. spontaneum*
21	GU 04-1490	PIO 00-539	IND 99-904	*S. officinarum*	*S. spontaneum*
22	GU 04-1534	PIO 00-539	IND 99-904	*S. officinarum*	*S. spontaneum*
23	GU 04-1535	PIO 00-539	IND 99-904	*S. officinarum*	*S. spontaneum*
24	GU 04-1550	PIO 00-539	IND 99-904	*S. officinarum*	*S. spontaneum*
25	GU 04-1588	PIO 00-539	IND 99-904	*S. officinarum*	*S. spontaneum*
26	GU 04-1591	PIO 00-539	IND 99-904	*S. officinarum*	*S. spontaneum*
27	GU 04-1638	PIO 00-539	IND 99-904	*S. officinarum*	*S. spontaneum*
28	GU 04-1643	PIO 00-539	IND 99-904	*S. officinarum*	*S. spontaneum*
29	GU 04-1681	PIO 00-539	IND 99-904	*S. officinarum*	*S. spontaneum*
30	GU 04-2081	PIO 90-196	IND 99-967	*S. officinarum*	*S. spontaneum*
31	GU 04-2102	PIO 90-196	IND 99-967	*S. officinarum*	*S. spontaneum*
32	GU 04-2121	PIO 90-196	IND 99-967	*S. officinarum*	*S. spontaneum*
33	CoC 671	Q63	Co775	Commercial	–
34	Co 86032	Co 62198	CoC671	Commercial	–

Table 2
Analysis of variance for 10 biomass traits in interspecific hybrids of *Saccharum*.

Character	Mean sum of squares		
	Year I	Year II	*G* × *Y*
No. of stalks per plot	2745.12**	3165.60**	602.42**
Single stalk weight (g)	0.15**	0.11**	0.02**
Stalk yield (t ha^{-1})	1166.51**	1800.26**	874.47**
Fibre (%)	23.94**	18.74**	2.30**
Drymatter (%)	26.80**	21.49**	3.97**
Fresh biomass yield (t ha^{-1})	2287.38**	3856.17**	1658.94**
Dry biomass yield (t ha^{-1})	369.37**	451.57**	198.70**
Brix% in juice	12.27**	8.86**	2.73**
Sucrose% in juice	17.11**	12.60**	4.57**
Purity (%)	237.76**	65.18*	116.57**

* Significant at 1% probability level.
** Significant at 5% probability level.

programme wherein the unutilized basic species clones were used as a base population and crosses were made within the species clones and selected for sugar as well as yield traits. The cycle was repeated among the selected clones for further improvement. The resultant clones having diverse genetic base were utilized as parents in the crossing programme to produce interspecific hybrids. The parentage of clones used in the study is given in the Table 1. These clones were evaluated along with two commercial varieties *viz*., CoC 671 and Co 86032 as checks during 2008–2009 and 2009–2010 in a randomized block design with two replications. Each clone was planted end to end in to a single row plot of 6 m in length and inter-row spacing of 90 cm.

Number of stalks was recorded on a plot basis. Five stalks from each clone were randomly tagged at 10th month for biomass yield and juice quality traits. Data on brix in juice (%), sucrose (%), purity (%) were estimated as per standard procedures. For estimating fibre%, five stalks sampled from each clone were shredded using a shredder. A subsample of 500 g of the shredded cane was taken and pressed using a hydraulic press and oven dried and the weight before and after drying were recorded. Brix and sucrose in the juice were measured on the extracted juice. The following formula was used to estimate dry matter percentage and Brix in cane%.

$$\text{DM\% in cane} = \frac{\{(\text{WSB} - \text{WSA}) \times \text{Brix in juice}/100 + \text{WSA} \times \text{DMB}/100\}}{\text{WSB} \times 100}$$

where, WSB is the weight of the sample before crushing (g), WSA is the weight of sample after crushing i.e. Bagasse (g) and DMB is the dry matter content in bagasse (%).

Brix in cane (%) was estimated by

$$\frac{\text{Juice brix (g/100 g)} \times (100 - \text{DM\% cane})}{[100 - \text{Juice brix (g/100 g)}]}$$

$$\text{Fibre\%} = \text{DM\% cane} - \text{brix in cane\%}$$

Fresh biomass yield (t ha^{-1}) was calculated from number of stalks/ha × weight of the stalk (kg) with tops attached. Dry biomass yield (t ha^{-1}) was calculated using the following formula

$$\text{Dry biomass yield} = \text{Dry matter\%} \times \text{Fresh biomass yield (t ha}^{-1})$$

The data were analyzed for variation using a general linear model with random effects. The model was:

$$Y_{ijk} = \mu + R_{ik} + G_j + Y_k + (G \times Y)_{jk} + E_{ijk}$$