Prospects for combining high sucrose content with increased fibre to generate multi-purpose cane varieties

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ABSTRACT

As the sugar cane industries of the Caribbean diversify their output to include fuel ethanol and electricity generated from Bagasse, the breeding and selection programmes must also change. New varieties must provide the raw material to satisfy sugar production (high pol), ethanol production (molasses or low purity, high Brix juice) and Bagasse (high fibre). The optimum proportions of these components will depend on the specific requirements of individual industries.

This paper explores the possibilities of combining high sugar content, as either pol or Brix, with high fibre content. The distribution of these two characteristics was studied in progeny between very high sucrose content commercial sugarcanes and the wild species *Saccharum spontaneum* which has very high fibre content. The relationship between the two characters was also investigated.

The results indicate that it is possible to combine both high fibre and high sugar content in the same genotype. There was no correlation, positive or negative, between Brix or pol and fibre. This suggests that they are independent of one another and so selection can be made for new varieties that will have both increased sugar and increased fibre, thus satisfying the future demands of the sugar industries of the Caribbean.

Keyword: sugar, fibre, ethanol, cogeneration

INTRODUCTION

The sugar cane industries of the Caribbean are changing rapidly in response to several factors. The reduction in pricing from the European Union is a major driving force in this change. Additionally, it has been realised that the sugar cane plant can be used for much more than sugar production.

Sugar cane is one of the plant kingdoms most efficient converters of sunlight into biomass and energy store. The energy is store as sugars, cellulose and hemi-cellulose and lignin. Plant breeders are now concerned with developing varieties that can have multi-purposes. We have designated these types of varieties as Multi-Purpose Canes (MPC). Their sugars can be used to produce sugar (sucrose) or ethanol and their fibre burned as a fuel to produce electricity. Future technology may allow fuel ethanol to be produced directly from the cellulose in the fibre. The origins of MPC parents are described by Kennedy (2001a).

The current Multi-purpose varieties that are available, although they have acceptable fibre levels, are low in Brix. These varieties and their potential have been discussed by Rao and Kennedy (2004) and Kennedy (2005). It is the aim of the breeding programme to produce varieties with fibre levels over 20% but also with Brix levels that will make ethanol or rum production economic. The trial reported here explores the possibility of combining the high Brix of High Quality (HQ) clones with the high fibre of the wild ancestor of sugar cane, *Saccharum spontaneum.*

MATERIAL AND METHODS

Ten Biparental crosses were successful using HQ clones as the female parent and *S. spontaneum*as the male. The development of these high sucrose clones is described elsewhere (Kennedy, 2000; Kennedy, 2001b; Kennedy, 2002; Kennedy, 2003; Kennedy, 2004)The parentage of each family is given below in Table 1.

Table 1. Parentage of ten biparental crosses

CROSS NUMBER	FEMALE	MALE
46	WI96916	SES189
47	HQ3041	SES189
49	WI96911	SES189
50	WI96916	US56193
51	HQ3041	US56193
53	WI99911	US56193
74	WI99934	SES4A
75	WI99916	SES4A
76	WI96911	IK7672
89	WI96911	SES14
21	WI96903	WI81456

Where possible fifty seedlings were sampled (5-10 canes per seedling) from each family and analysed by the Spectracane

RESULTS

The results are summarized in **Table 2.** All families had relatively high mean family values for Brix and for fibre % cane. These traits were uncorrelated (r = .0.058) as shown in Figure 1.

Figure 2 and 3 show the overall distributions for Brix in juice and fibre % cane for all the seedlings analysed. The majority of seedlings (84%) had Brix values between 19.0 and 23.0 combined with fibre values between 20.0% and 35.0%. The highest Brix value recorded was 26.0 and this seedling had a fibre of 34.7%. The highest fibre has 42.6% and this seedling had a Brix of 23.5. Figure 4 shows the distribution of total dry matter as % of fresh weight for each of the ten families.

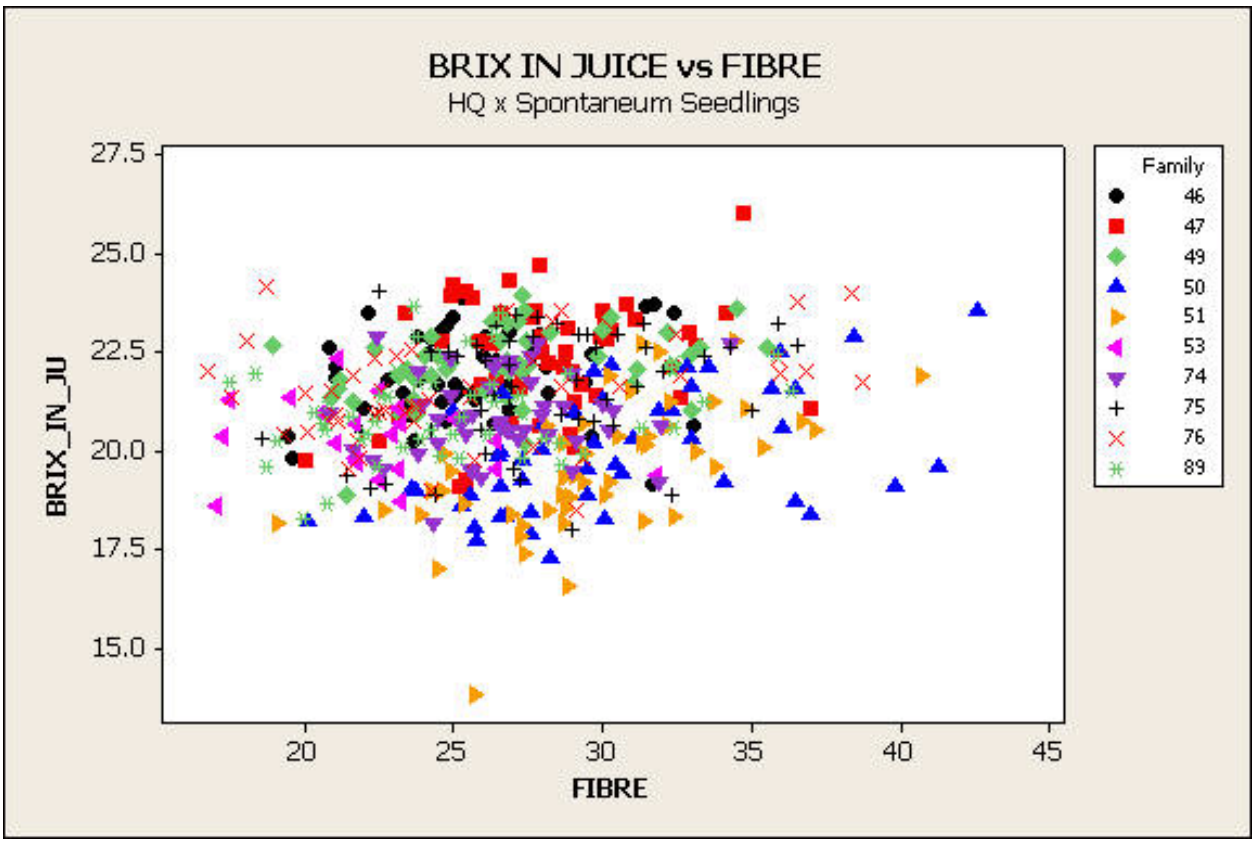

Figure 1. Relationship between Brix in Juice and Fibre % Cane in 10 biparental crosses.

Table 2. Summary of cane analysis for 10 HQ x *S. spontaneum* families

Variable	Family	Count	Mean	StDev	Minimum	Maximum
BRIX in JUICE	46	50	21.9	1.093	19.2	23.9
	47	50	22.4	1.456	19.1	26.0
	49	50	22.2	0.922	18.9	23.9
	50	50	19.953	1.521	17.2	23.5
	51	50	19.530	1.666	13.8	22.8
	53	21	20.314	0.960	18.6	22.3
	74	46	20.878	1.077	18.1	22.9
	75	50	21.536	1.485	18.0	24.1
	76	50	21.538	1.265	18.5	24.2
	89	50	20.99	1.136	18.3	26.7
POL in JUICE	46	50	20.097	1.329	17.2	22.410
	47	50	20.142	1.906	15.0	24.640
	49	50	20.845	1.167	17.2	23.540
	50	50	17.547	2.258	13.2	22.680
	51	50	17.124	2.021	11.2	21.720
	53	21	18.842	1.353	16.3	21.350
	74	46	19.135	1.357	16.3	21.850
	75	50	19.549	2.105	15.0	23.3
	76	50	19.348	1.467	15.1	23.0
	89	50	18.661	1.440	15.9	22.4
FIBRE % CANE	46	50	25.630	3.195	19.5	33.1
	47	50	28.181	3.210	20.0	37.0
	49	50	26.825	3.924	19.0	35.5
	50	50	30.232	4.958	20.1	42.6
	51	50	29.625	4.018	19.1	40.7
	53	21	22.383	3.363	17.1	31.8
	74	46	26.614	2.780	20.8	34.3
	75	50	27.796	3.873	18.6	36.6
	76	50	25.673	5.707	16.7	38.8
	89	50	25.063	4.346	17.5	36.4
JUICE PURITY	46	50	91.808	2.186	84.7	96.5
	47	50	89.736	3.293	78.5	95.5
	49	50	94.045	2.268	88.8	99.9
	50	50	87.666	5.792	71.5	96.4
	51	50	87.494	4.327	71.3	96.2
	53	21	92.699	3.708	86.9	104.5
	74	46	91.584	2.788	86.1	95.8
	75	50	90.541	4.117	79.6	96.7
	76	50	89.792	3.346	81.8	95.3
	89	50	88.844	3.226	80.5	95.2

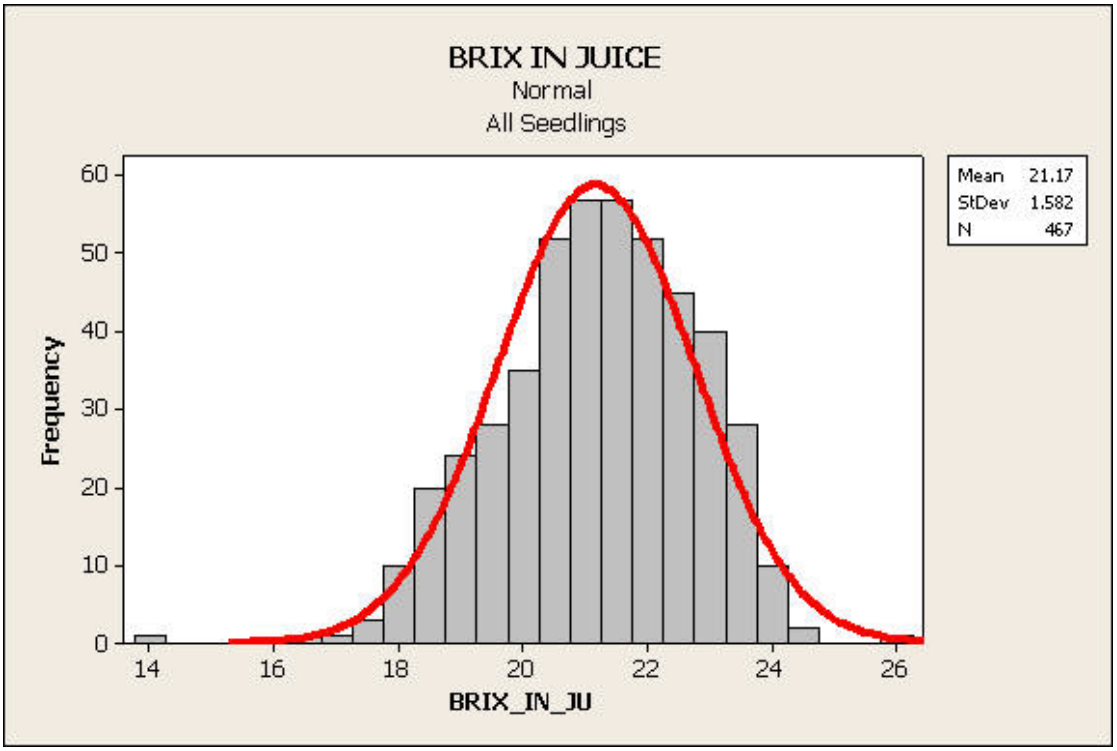

Figure 2. Distribution of Brix in juice for all 467 seedlings (HQ x *S.spontaneum*)

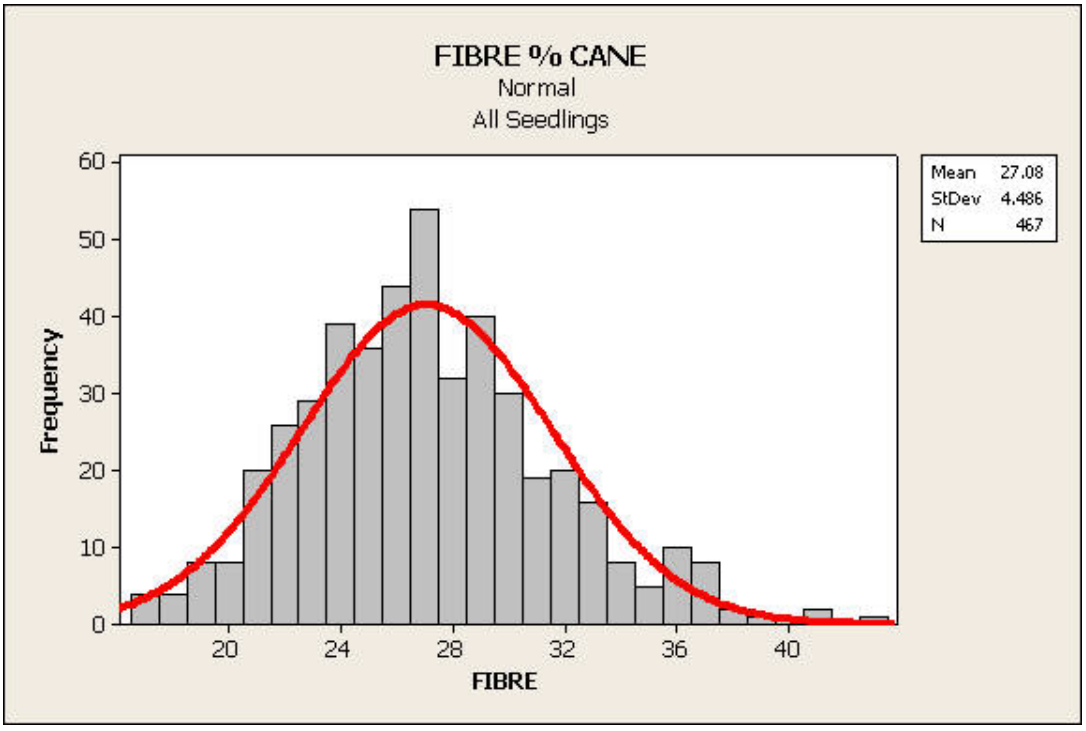

Figure 3. Distribution of Fibre % Cane for all 467 seedlings (HQ x *S.spontaneum*)

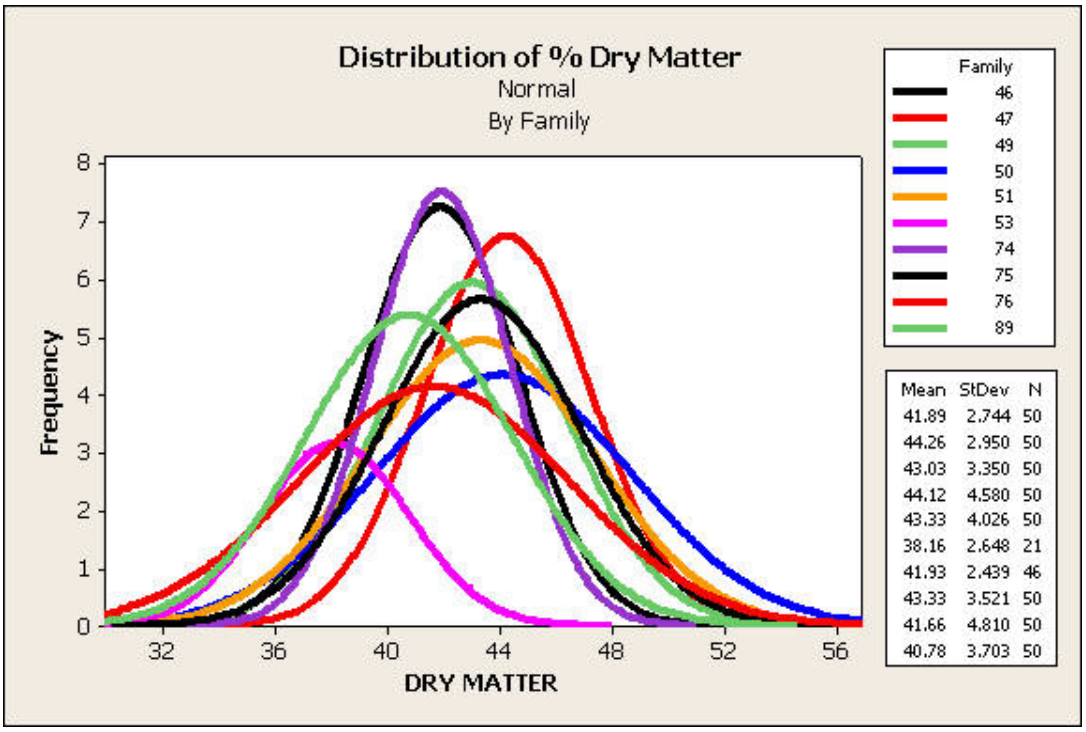

Figure 4. Distribution of total dry matter (% fresh weight) for 10 HQ x *S. spontaneum* families

DISCUSSION

These results show clearly that combinations of high Brix (over 20%) and high fibre (over 25%) are genetically possible. All but onefamily had mean dry matter content over 40 %. This means that yield of total fermentable products or Brix and fibre separately is very high from these genotypes.

The data, as presented in Figure 1, show that almost any combination of fibre and Brix can be selected from among these seedlings. The lack of correlation is important for the breeder. It means that the two traits can be selected for independently. The independence of the two characters is surprising since they would, on the face of it, seem to compete for the same source material; the product of photosynthesis. However, sugar cane has two distinct phases of its annual cycle in the Caribbean. Firstly the growths phase (typically corresponding to the wet season). This is then followed by a ripening phase when vegetative growth ceases and sugar is accumulated (usually in the dry season). Fibre, a function of the structure of the stem is accumulated during the growth phase. Sugar is accumulated after growth has largely stopped due to the water stress induced by the dry season. The two components of dry matter are, therefore, not competing for the photosynthetic product but using it at different times of the year.

These results are encouraging for the prospect of developing new MPC varieties that have both high fibre and high sugar content. The challenge for the breeder will be to combine these two important traits with all of the others needed in a successful variety: vigour, disease and pest resistance, Harvestability, good rationing and many other agronomic characteristics.

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