An Analysis of Parental Dose for Future Sugarcane Varieties

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Development of sub-tropical varieties of sugarcane with characteristic features like high sugar, thick cane etc from the narrow genetic base of the breeding population in sugarcane prompted the parental study of common varieties. The study indicated the role of parental dose in imparting some of the characteristic features to the common varieties. Also, it suggested a time saving methodology to select and utilize parents for the future breeding programmes.

Key Words: Parental dose, Sugarcane, *Saccharum*

Introduction

The development of first commercial hybrid of sugarcane 'Co 205' in 1918, marked the success of interspecific hybridization programme (Hogarth *et al.*, 1997; Janakiammal, 1941) taken-up by Barber in 1912. The process of development of new varieties derived from such inter-specific and some times tri-specific hybridization schedule gained momentum with this success. With the development of high yielding, high sugar and adapted varieties for different agro-climatic zones, sugarcane breeders started using these varieties as parents in location specific breeding programmes. On one hand, these parents gave some highly adapted varieties for specific locations but along with this, they also caused narrowing of the genetic base of the developed varieties (Nair *et al*, 1998; Hemprabha and Rangasamy, 2001). The good yield, adaptability and high sucrose content of some the newly developed varieties with the narrow genetic base of the parents deserves detailed analysis (Kennedy, 2001; Breaux, 1984; Heinz, 1987).

For the purpose of this study, twelve leading varieties (Table 1) of sub-tropical India were selected for parental details. Care was taken that no such variety was selected whose parentage has any unknown parent (like GCs, PCs, etc.). These varieties are well adapted for sub-tropical conditions and they represent most of the diversity in the form of high sugar (CoJ 64, CoS 96268, CoS 8436), high fibre (BO 91, CoSe 92423), early maturity (CoJ 64, CoS 8436, CoS 687), mid-late maturity (CoLk 8001, CoSe 92423, BO 91), thick canes (CoS 8436, CoLk 8001) and so on. In the parental study up to the basic germplasm level, it was found that all these 12 varieties were developed from 18 basic genotypes (Table 2). It is very pertinent to indicate here that out of these 18 genotypes, nine are found in the parentage of all the 12 varieties. The table also indicates the dose of basic parents in each variety. Here, dose refers to the number of times a basic parent is present in the parentage.

The importance of the dose can be viewed upon from different angles. The foremost being the characteristic feature of a variety, which is a direct representative of a specific parental dose (Natarajan *et al.*, 1967; Parthasarathy 1948). The best example, which can be cited from Table 1, is of varieties CoS 8436 and CoLk 8001, which have

Table 1. General characteristics of some common sub-tropical sugarcane varieties

S. No.	Variety	Parentage	General Characteristics
1.	BO 91	BO 55 x BO 43	Mid late maturing, medium thick, solid and hard cane
2.	CoS 687	Co 976 x Co 312	Early maturing, medium thin, solid and soft cane
3.	CoS 767	Co 419 x Co 313	Mid late maturing, medium thick, medium hard and solid cane
4.	Co 1158	Co 421 x Co 419	Mid late maturing, medium thick, medium soft and solid cane
5.	CoLk 8001	Co 62174 x Co 1148	Mid late maturing, thick, medium soft and solid cane
6.	Co 1148	P 4383 x Co 301	Mid late maturing, medium thick, soft and solid cane
7.	CoJ 64	Co 976 x Co 617	Early maturing, high sugar, medium thick, soft and solid cane
8.	CoPant 84212	Co 1148 x Co 775	Mid late maturing, medium thick, soft and solid cane
9.	CoS 96268	Co 1158 x Co 62198	Early maturing, high sugar, medium thick and medium hard cane
10.	CoSe 92423	BO 91 x Co 453	Mid late maturing, medium thick, medium soft and solid cane
11.	CoS 8436	MS 68/47 x Co 1148	Early maturing, high sugar, thick and hard cane with fine pith
12.	CoS 88230	Co 1148 x Co 775	Early maturing, medium thick, soft and solid cane

Table 2. Parental dose of basic germplasm in the pedigree of some sub-tropical sugarcane varieties

S. No.	Basic parents in pedigree	Dose of basic parents in pedigree											
		BO 91	CoS 687	CoS 767	Co 1158	CoLk 8001	Co 1148	CoJ 64	CoPant 84212	CoS 96268	CoSe 92423	CoS 8436	CoS 88230
1.	Black Cheribon	4	5	4	3	12	5	5	8	8	5	13	8
2.	Chunnee	3	4	3	1	7	5	2	6	3	3	7	6
3.	Kaludai Boothan	1	2	2	1	3	2	1	2	1	1	2	2
4.	*S. spontaneum* (CBE)	5	6	3	2	4	2	5	2	3	6	3	2
5.	Vellai	1	2	1	–	–	–	1	–	–	1	–	–
6.	*S. spontaneum* (Java)	1	1	1	2	6	1	2	3	5	1	7	3
7.	Banjer massin Hitam	1	2	2	4	10	2	3	4	6	1	12	4
8.	Loethers	1	2	2	4	10	2	3	4	6	1	12	4
9.	Lahiana	1	1	1	2	3	1	2	2	4	1	6	2
10.	Fidji	1	1	1	2	3	1	2	2	4	1	6	2
11.	Ashy Mauritius	1	1	–	–	–	–	1	–	1	1	–	–
12.	Green Sport	2	1	–	1	2	–	2	–	1	3	1	–
13.	Zwart Cheribon	–	1	–	–	1	–	–	–	–	–	–	–
14.	A–2	–	1	–	–	–	–	1	–	–	–	–	–
15.	Striped Mauritius	–	–	–	–	1	–	–	1	1	–	1	1
16.	White Transparent	–	–	–	1	1	–	–	–	1	–	–	–

Black Cheribon in 13 and 12 doses respectively, imparting their characteristic thick and juicy canes. Also, these two varieties have one more parent Q 116 in common, although it is in single dose. To further unravel the characteristics with reference to parental dose, an attempt was made to detail the first, second and third generation hybrids (Table 2), which are represented in the parentage of the twelve varieties under study.

A close perusal of Tables 1 and 2 confirms the viewpoint that adaptability and resistance had been introgressed from *S. spontaneum* (Coimbatore and Java forms) and *Erianthus* while sugar had been transferred from *S. officinarum* and adaptability to sub-tropical climate of India came from *S. barberi*. Case study of BO 91 would further strengthen the parental dose concept in imparting the characteristic features to a particular variety. BO 91, a popular variety of north-central India, where there is wide spread abiotic stress condition, has *S. barberi* genotype 'Chunnee' in three doses along with *S. officinarum* genotypes 'Black Cheribon', Kaludai Boothan, Vellai, Banjer massin Hitam, Loethers, Lohiana, Fidji, Ashy Mauritius and Green Sport in 4,1,1,1,1,1,1,1 and 2 doses respectively. Five doses of *S. spontaneum* (Coimbatore form 2n=64) further reinforced it with resistance to major pathotypes of red rot and adaptability to abiotic stresses prevalent in the area.

Another leading variety CoJ 64 has only two doses of *S. barberi* (Chunnee) making it suitable for only a limited zone of north-western India, but the reinforcement from 7 doses of *S. spontaneum* (Coimbatore and Java forms) provided the much needed field resistance to it. The earliness and high sucrose content of this miracle variety can be attributed to the rare combination of *S. officinarum* genes from Black Cheribon (5 doses) with Vellai (1 dose) and A-2 (1 dose). Varieties CoLk 8001 and CoS 8436, which are well known to be suitable for better management conditions, have very high doses of Black Cheribon, Banjer massin Hitam and Loethers along with 7 doses of Chunnee and 10 doses of *S. spontaneum*. This kind of favourable combination of genes for sugar, resistance and adaptability made them varieties of choice for sugar factories and farmers both.

Generation wise analysis of the parents clearly indicated that Black Cheribon was the most important *S. officinarum* parent in the first generation hybrids under nobilisation process. The frequency of its presence in parentage of onward generations had been a major factor for accumulation of sugar genes. Banjer massin Hitam and Loethers were next, providing some rare combinations in first generation (POJ 100) and second-generation hybrid parents (EK-28). Another important basic parent 'Vellai' marked the development of first generation commercial hybrids, which were later on extensively used as parents indicating that the use of *S. spontaneum* (Coimbatore form 2n=64) is a successful option for transferring red rot resistance and widespread adaptability in the nobilisation process. Variety/ parent Co 205 was unique in the sense that it was the real F_1 commercial hybrid involving only two species of *Saccharum viz. S. officinarum* and *S. spontaneum*, confirming their ability to produce commercial gene combinations for sub-tropical conditions, although, both may be of tropical origin.

Other than Co 205, no successful commercial hybrid released for sub-tropical India had been a mix of blood from just two species. Rather, they have a combination of genes from more than two of the major *Saccharum* species *viz. officinarum*, *spontaneum*, *sinense*, *barberi* and *robustum.* Also, they have a combination of *S. spontaneum* blood from Coimbatore form (2n = 64) and Java form (2n = 112), Moreover, with few exceptions, the present day hybrid varieties in cultivation under sub-tropical India, stem from the Javan-Indian hybridization products. This is something, which needs attention when a huge amount of genetic diversity available in the germplasm collection is still waiting for utilization.

Table 3. 1st, 2nd and 3rd generation hybrids and their parentage

Hybrid Parents	Parentage
1st Generation Hybrids	
POJ 213	Black Cheribon x Chunee
Co 291	Kaludai Boothan x *S. spontaneum* Coimbatore
POJ 1410	Black Cheribon x Chunee
Kassoer	Black Cheribon x *S. spontaneum* Java
POJ 100	Banjer massin Hitam x Loethers
EK 2	Lahiana x Fidji
POJ 181	Black Cheribon x Chunee
Co 285	Green Sport x *S. spontaneum* Coimbatore
M 2	Kaludai Boothan x *S. spontaneum* Coimbatore
Co 205	Vellai x *S. spontaneum* Coimbatore
Co 206	Asy Mauritius x *S. spontaneum* Coimbatore
2nd Generation Hybrids	
Co 213	POJ 213 x Kansar
Co 214	Striped Mauritius x Saretha/ *spontaneum* Blood Seedling (M 4600)
POJ 2364	Kassoer x POJ 100
EK 28	POJ 100 x EK 2
Co 221	POJ 213 x M 2
Co 243	A 2 x Co 206
Co 244	POJ 213 x Co 205
Co 453	Black Cheribon x Co 285
POJ 385	POJ 100 x Chunee
Co 605	Zwart Cheribon x Co 285
3rd Generation Hybrids	
POJ 2878	POJ 2364 x EK 28
Co 299	Co 213 x POJ 1410
Co 312	Co 213 x Co 244
Co 290	Co 221 x D 74
Co 313	Co 213 x Co 244
Co 331	Co 213 x Co 214
POJ 2725	POJ 2364 x EK 28
Co 371	Co 213 x Co 214

Further, going in to the details of these widely used parents indicate that 'Kassoer,' which itself is considered to be natural hybrid of the Cheribon form of *S. officinarum* and Glagah the Javan form of *S. spontaneum,* when used in the classical nobilisation of sugarcane, resulted into the development of world famous hybrid POJ 2878, which became a landmark for adaptability and quality. Other important first generation hybrid parents POJ 13, POJ 1410 and POJ 181 were derived from a common cross between Black Cheribon and Chunee, while Co 291, Co 285, M 2, Co 205 and Co 206 have same *S. spontaneum* parent. The parents of second generation *viz.* Co 213, POJ 2364, EK 28, Co 221 and Co 244 have either POJ 213 or POJ 100 as one of the ancestors again emphasizing the repetitive dose of Black Cheribon and Banjer massin Hitam. The value of Chunee in imparting adaptability can also be viewed through POJ 213, POJ 1410, POJ 181, etc. which gave rise to many varieties for Hawaiian sugarcane cultivation.

The planning for future sugarcane varieties revolves around two major features viz. their sugar producing ability and high level of field resistance against major pathotypes of red rot pathogen. Based on the analysis of parents of the existing varieties, it can be clearly pointed that so far, whatever gains have been obtained in the sugar recovery front, are only due to the doses of Black Cheribon, Banjer massin Hitam and Loethers in the parentage. This indicates that, for development of high sugar parental genotypes two simultaneous strategies can be followed. The first strategy would be initiating nobilisation process afresh with basic germplasm like Black Cheribon and *S. spontaneum*, which may take years to yield desired results. It is because of the fact that there are huge untapped basic germplasm resources maintained in the World Collection and the possibility of making all the cross combinations among them is remote. Moreover, when new genotypes are brought in the breeding pool, their efficiency in expression of desired characters needs rigorous testing in terms of adaptability and over the year repeatability. This requires long-term research projects targeted to produce good parental lines with high combining abilities. But in a crop like sugarcane, where parental assessments are usually based on performance *per se* rather than biometrically analyzed gene-actions, it would be pertinent to use only those parents which are expected to give favorable results. Thus, the focus may now be shifted to the second strategy, which involves broadening of genetic base of those varieties, which already have high parental dose of Black Cheribon, Banjer massin Hitam and Loethers. The probability of combining high sugar yields with higher field resistance to red rot pathotypes, will be much more when intra-specifically improved *S. spontaneum* (improved through Indian x Javan crosses) parents will be crossed with such varieties. This will save time required in the rigorous testing schedule and would produce parental lines as well as varieties adapted to the sub-tropical conditions and farmer's need.

Conclusion

The problem of narrow genetic base of sugarcane varieties will continue to hinder the breeding achievements in desired direction but by selecting parents with higher doses of a particular basic germplasm can provide some solution to overcome this situation. The future sugarcane varieties can be developed on the basis of parental doses for desired expression of specific characters. Also, for introgression of new genes from the so far unutilized *Saccharum* gene pool, such studies will be required to identify best backgrounds.

References

Breaux RD (1984) Breeding to enhance sucrose content of sugarcane varieties in Louisiana. *Field Crops Research* **9:** 59-67.

Heinz DJ (1987) Sugarcane Improvement through Breeding. *Developments in Crop Science* 11 Elsevier, New York.

Hemaprabla G, SR Sree Rangasamy (2001) Genetic similarity among five species of *Saccharum* based on isozyme and RAPD markers. *Indian J Genet*. **61(4):** 341-47.

Hogarth DM, MC Cox and JK Bull (1997) Sugarcane improvement: Past achievements and future prospects. Crop Improvement for 21st Century 29-55.

Janakiammal EK (1941) Intergeneric hybrids of *Saccharum. J. Genet*. **41:** 217-253.

Kennedy AJ (2001) Building parental populations with very high sucrose content through recurrent selection. *Sugarcane International* **1:** 23.

Nair NV, R Balakrishnan and TV Sreenivasan (1998) Variability for quantitative traits in exotic hybrid germplasm of sugarcane. *Genetic Resources and Crop Evolution* **45:** 459-464.

Natarajan BV, TN Krishnamoorthy and JT Rao (1967) Relative effect of parents on some economic characters in sugarcane. *Euphytica* **16:** 104-108.

Parthasarathy N (1948) Origin of noble sugarcanes (*Saccharum officinarum*). *Nature* **161:** 608.