

RESEARCH ARTICLE

EFFECTS OF SELFING ON IMPORTANT ECONOMIC TRAITS IN SUGARCANE (*SACCHARUM SPP.*)

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Abstract

The potential of 30 Co canes to produce inbred population and the effect of selfing on important economic traits, viz. number of millable canes (NMC), cane thickness and H.R. Brix were studied for two years. Pollen fertility studies in the 30 parents indicated that ISH 100, Q 69, Co 740 and Co 0303 had less than 10% fertility to be utilised as safe females. Co 0320, Co 0209, Co 95021, Co 0403, CoJ 03193 and Co 0120 had more than 20% pollen fertility but failed to set selfed seeds which may be due to self incompatibility resulting in inhibition of pollen germination, failure and restricted pollen tube growth or insufficient pollen load. The selfed progenies of all the parental clones exhibited wide variation in NMC, moderate variation for cane thickness and relatively narrow variation for H.R Brix. The similar trend in the variation of progeny production in all the parents may be due to genetic similarity of the parents for these characters. The family mean of progenies for NMC was greater than parental mean in Co 775, MS 6847 and Co 0112 and not in other parents. The same parents also had more number of transgressive variants in positive direction indicating that selection for NMC would lead to genetic improvement in selfed progenies of these parents. Similarly, selection for H.R Brix would be beneficial in Co 0304 and Co 2000-10 with almost similar parental and population mean and higher proportion of desirable progenies. In addition to NMC, cane diameter was important in Co 0112 having progeny mean equal to

parental mean and higher proportion of thicker canes. For other parents, selection giving equal emphasis on component characters of sugar yield would help in achieving genetic improvement. Thus the behaviour of selfs would be beneficial in understanding the parental value and characters to be emphasised in selection.

Key words: Sugarcane, selfing, pollen fertility, inbreds, variation, transgressive variants

Introduction

Selfing in most cross-pollinated crops produces weak plants or reduced fitness which is known as inbreeding depression. This may result from increased expression of deleterious recessive alleles or from the loss of heterozygotic combinations on selfing which are favourable and are essential for fitness (Charlesworth and Charlesworth 1999). Despite selfing considered to be the most intensive form of inbreeding, inbreeding depression does not occur with same intensity among the organisms and traits. The effect of inbreeding on traits varies among trait types (Roff 1997) and populations (Pray and Goodnight 1995). Lucy et al. (2007) reported that inbreeding depression was greater in life history traits which have larger dominance variance components compared to the morphological traits having lesser dominance variance. The effects of selfing and the use of pure lines after successive generations of selfing have been widely studied in a number of simple diploids and spectacular yield increases were obtained by hybrids developed involving two or more selfed lines in maize. Inbreeding approach can be used as one of the breeding strategies to develop inbreds of good performance even though it cannot be exclusively followed for commercial varietal development. In spite of inbreeding approach being considerably controversial in sugarcane on account

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of complex polyploidy, there is no theoretical reason to believe that superior genotypes cannot be obtained through selfing. Cassalet et al. (1996) mentioned that it was possible to segregate different traits in a particular variety without loss of vigour by means of selfing and to find disease resistant lines derived from susceptible parents in sugarcane. Clonal evaluation of selfs of commercial varieties indicated an improvement in sucrose with successive cycles of selfing (Shanthi and Alarmelu 2011). Inbreeding programs were also successful in Canal Point (Stevenson 1965) and Australia (Mcintyre and Jackson 2001). This study was undertaken to obtain and evaluate first-generation inbred lines that may be used for further crosses and determine the effect of inbreeding on three traits of selection, viz. the levels of soluble solids (H.R. Brix), number of millable canes (NMC) and cane thickness followed in sugarcane varietal improvement programme.

Materials and methods

Thirty Co canes, viz. Co 0218, Co 0320, Co 0209, Co 95021, Co 86002, Co 0303, Co 0403, Co 98010, CoJ 03193, ISH 100, Co 98006, Co 99006, Q 69, Co 775, Co 94008, Co 0120, Co 8371, Co 99008, Co 86010, Co 740, CoC 671, Co 2000-10, Co 94012, Co 85004, Co 0304, MS 6847, Co 2001-12, Co 0113, Co 97009 and CoT 8201 were chosen for the selfing study during 2008 flowering season. Self-pollinations were conducted at Sugarcane Breeding Institute, Coimbatore. On flowering, stalks were isolated in cloth bags at tip emergence stage and before starting of anthesis in the flowering stalk to avoid foreign pollen and obtain only self-pollinated seeds. Pollen fertility in these clones was estimated using 1% acetocarmine stain. Selfed seeds were germinated in trays containing a mixture of soil, sand and farm yard manure in the ratio of 1:1:1. After a month, seedlings were transplanted in polybags and kept for 30 days before transplanting in the field. Selfs along with their parents were field planted with row spacing of 0.5m and 0.9m between rows during February 2009. The parental plot comprised four rows of 2.0m each. The seedlings were evaluated for H.R. Brix, NMC and cane thickness at 10 months after planting. Mean, range and standard deviation were calculated as per standard procedures (Panse and Sukhatme 1954). Number of seedlings with

significantly higher values ($p = 0.05$) than the parental means for individual characters were used to calculate percentage of positive transgressive segregants in the first generation of selfing (S_1).

Results and discussion

Pollen fertility and selfing studies

Among the 30 clones selfed during 2008 flowering season, nine produced offsprings. Stevenson (1965) indicated that low pollen fertility and pollen load in most of parental clones of sugarcane as the major limiting factors to obtain selfs of many parents. Pollen fertility studies in the 30 clones indicated that ISH 100, Q 69, Co 740 and Co 0303 had less than 10% fertility and hence they failed to produce selfed progenies. Co 0320, Co 0209, Co 95021, Co 0403, CoJ 03193 and Co 0120 were found to have more than 20% pollen fertility but did not yield selfed progenies. Failure to produce selfed progenies by parents with relatively higher pollen fertility may be due to self incompatibility resulting in non-dehiscence of anther at the time of pistil receptivity, inhibition of pollen germination and or restricted pollen tube growth. Alarmelu and Shanthi (2011) explained that self pollen did not support the development of pollen tube in some of the Co canes like Co 88028, Co 91004, Co 99002, Co 62198 and Co 86011 and lack of seed set in these parents may be due self incompatibility. Such parents with less than 10% pollen fertility may be utilised as safe females. The self incompatible parents even with considerable level of pollen fertility may be utilised to have definite bi-parental pollination with minimum level of selfing in the crossing programme.

Evaluation of inbreds

Three hundred and fifty inbreds of these clones, viz. Co 775 (85), Co 99008 (37), Co 0304 (35), Co 2000-10 (27), MS 6847 (65), CoT 8201 (16), Co 0112 (82), Co 0113 (1) and Co 86010 (2), which were able to establish in the field, were evaluated for H.R. Brix, cane thickness and NMC (Fig.1). The variable number of progenies obtained in the present study may be due to the difference in genetic stability of the selfs and the pre-potency of the parents.

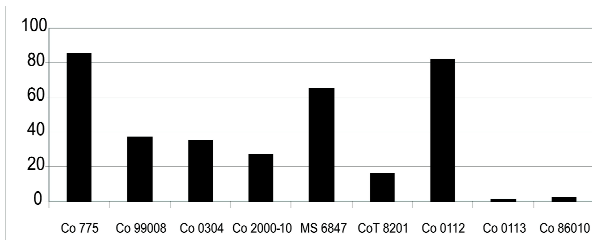


Fig. 1. Inbred production potential of different parents

Among the three characters studied, very narrow level of variation was observed for H.R. Brix in the selfed progenies of Co 775. Almost a similar trend was noticed in S₁ progenies of other clones (Fig. 2). Hemaprabha et al. (2003) also reported high level genetic homogeneity for this trait in the commercial hybrids of sugarcane. Narrow range observed for H.R. Brix may be due tight linkage of sucrose which failed to separate during gamete formation. This may also be due to the fact that sucrose genes content in sugarcane is highly heritable with relatively lesser level of environmental effects. With respect to NMC, there was wide variation and for cane thickness moderate level of variation was observed. Though the genotypes differed in their ability of inbred production potential, they produced progenies in a similar trend i.e. high variation for number of millable

canes, moderate variation for cane thickness and narrow variation for H.R. Brix by all the parents. This result revealed the similar genetic constitution of parents. Alvi et al. (2008) reported 74.5% genetic similarity among the 20 sugarcane genotypes cultivated in Pakistan using random amplified polymorphic DNA markers. High level of genetic similarity among the parents may be due to the repeated use of a few set of parents in developing varieties which are themselves related as parents (Nair 2002).

The basic parameters of variation observed in progenies of the parental clones that yielded more than 20 individuals are given in the Table 1. The family mean of progenies for NMC was greater than parental mean in Co 775, MS 6847 and Co 0112 but not for other traits and other parents. However, Co 0304 and Co 2000-10 for H.R Brix and Co 0112 for cane thickness had almost similar parental and population means.

Hemaprabha et al. (2003) found that parental clones with high progeny mean and low standard deviation and narrow range could be successfully utilised in hybridization programme to gain improvement in

Table 1. Behaviour of inbred populations for important economic traits

Parameter	Co 775			Co 99008			Co 0304		
	NMC	H.R. Brix	Dia-meter	NMC	H.R. Brix	Dia-meter	NMC	H.R. Brix	Dia-meter
Parental mean	3.67	20.67	2.97	9.33	21.53	2.87	5.67	21.53	3.23
Population mean	4.47	18.40	2.40	5.92	18.56	2.04	3.34	20.06	2.70
Maximum value	10.00	22.00	3.78	11.00	23.40	3.20	6.00	25.00	8.20
Minimum value	1.00	13.00	1.00	1.00	11.40	1.09	1.00	13.00	1.90
SD	1.92	1.84	0.51	2.34	2.71	0.47	1.53	2.72	1.02
CV	0.43	0.10	0.21	0.39	0.15	0.23	0.46	0.14	0.38
	Co 2000-10			MS 6847			Co 0112		
Parental mean	5.00	17.33	2.81	3.00	16.87	3.55	5.33	20.00	2.65
Population mean	4.70	17.11	2.36	3.52	14.12	2.97	5.52	15.61	2.60
Maximum value	13.00	24.00	3.05	9.00	18.00	17.00	15.00	20.90	17.00
Minimum value	1.00	11.60	1.70	1.00	2.37	1.78	1.00	2.26	1.34
SD	3.04	2.50	0.38	1.76	2.64	1.83	2.79	2.45	1.64
CV	0.65	0.15	0.16	0.50	0.19	0.61	0.51	0.16	0.63

SD: standard deviation; CV: coefficient of variation

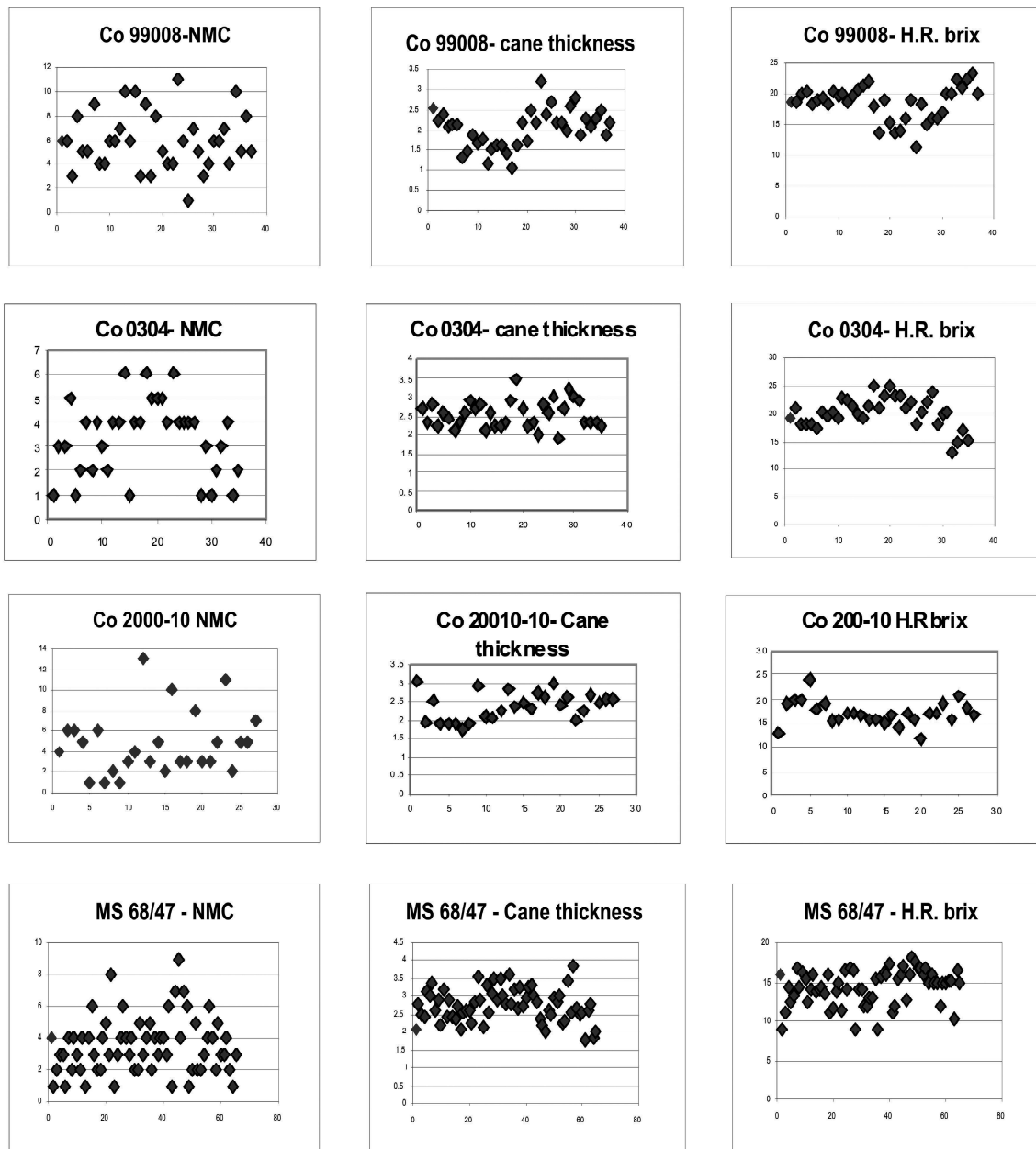


Fig. 2. Trends in progeny performance of parental clones

quality traits. In the present study, for H.R. Brix, and cane diameter, none of the parents had fulfilled the criteria. For NMC, the parents Co 775, MS 6847 and Co 0112 had higher family mean than the respective parent. Among these, very narrow range in MS 6847 and Co 0112, and low standard deviation in MS 6847 were observed. Hence MS 6847 may be utilised in the hybridisation programme to gain improvement in cane population.

The number of selfed progenies that were better than the parents is given in Table 2. Among the three characters studied, more number of transgressive

segregants were found for NMC. Co 775, MS 6847 and Co 0112 produced progenies significantly superior to the parent for NMC, Co 0304 and Co 2000-10 for H.R. Brix, and Co 775 and Co 2000-10 for cane thickness.

Knowledge on the behaviour of the selfs of a particular parent may be useful for achieving better genetic gains with different parents. In the present study, the parents Co 775, MS 6847 and Co 0112 exhibited high population mean and more number of transgressive variants for NMC, suggesting selection for NMC could lead to genetic improvement with

Table 2. Positive transgressive segregants in S₁ inbreds for important economic traits

Clones	NMC		H.R. Brix		Cane thickness	
	No.	%	No.	%	No.	%
Co 775	58	69.05	7	8.24	12	14.12
Co 99008	4	11.76	4	11.76	2	5.88
Co 0304	7	8.57	10	28.57	2	5.71
Co 2000-10	8	29.63	9	33.33	4	14.81
MS 6847	31	47.69	4	6.15	3	4.62
Co 0112	34	41.46	4	4.88	15	18.29

these parents. In the case of Co 0304 and Co 2000-10 with almost similar parental and population means for H.R Brix and higher proportion of high Brix progenies, selection for Brix would be beneficial. On the other hand, for Co 0112, with almost similar progeny and parental means and yielding a higher proportion of selfs with increased thickness, selecting for cane thickness along with NMC would prove useful. For other parents, selection of component characters of sugar yield would help in achieving better genetic improvement.

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