

GENETIC VARIABILITY FOR FLOWERING AND YIELD CHARACTERS IN SUGARCANE

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INTRODUCTION

Sugarcane is an important commercial crop of India, a source of food, fuel, fodder and fibre. Among sugar producing plants, sugarcane is responsible for about 60 per cent of world's sugar production and mainly cultivated in tropics, though it is also grown in sub-tropical areas in India. India is the original home of sugar and sugarcane. Indian mythology supports the above fact as it contains, legends showing the origin of sugarcane.

India is the second largest producer of sugarcane next to Brazil. This crop sustains the second largest organized agro based industry in the country with an area of 5.04 m ha, production of 340.56 mt and productivity of 67.57 t/ha (Anon., 2011) Karnataka state ranks 3rd in both area (4.26 lakh ha) and production (36 million tonnes), where in northern Karnataka has major state in respect of both area (74% ; 3.15 lakh ha) and production (68% ; 244.8 lakh tonnes).

Sugar recovery in northern parts of Karnataka is more, on account of favourable winter weather coinciding crushing season. The cane productivity is moderate compared to southern region and Tamil Nadu state, as extensive crop area is under moisture stress (45%) and salinity, water logged complex (12%) stresses, besides flowering is becoming another major constraint for both sugar and cane productivity. The favourable monsoon season, temperature and photoperiod during monsoon season (July-August) induce profuse flowering in commercial varieties. Recently under the scenario of climate change particularly extreme drought and water logged stresses, the flowering intensity is enhanced with little advancement in time of flowering in present commercial varieties, causing drastic effect on sugarcane productivity (Patil *et al.*, 2011 and 2012).

Flowering in sugarcane is a genetically determined trait and influenced by a number of plant and environmental factors like photoperiod, temperature, moisture and nutrition (Moore and Nuss, 1987). Flowering is known to affect the productivity of cane and sugar. Although flowering in sugarcane is essential for breeding, uncontrolled flowering in commercial fields poses a serious problem for sugarcane farmers and millers with a considerable loss of cane and sugar yield.

Flowering in the sugarcane is a complex physiological process consisting of multiple stages of development, each stage having specific environmental and physiological requirements (Julien, 1970). Thus, if the specific day length, temperature and moisture requirements are not satisfied, flowering will be inhibited or the intensity will be reduced. Under natural conditions, day length being fixed at any given latitude and date (Moore, 1987), it is essentially the location (Altitude), temperature (Coleman, 1969), moisture stress and the nutrition level (Gosnell, 1973 and Moore, 1987) that affect the timing and intensity of flowering.

Flowering and crop habit are economically important sub-systems of whole-plant physiology in sugarcane. Crop flowering impinges on crop yield and quality, particularly in the tropics, and selection against flowering is a key criterion. Perhaps more importantly, poor and variable flowering observed across many environments constitutes a crucial impediment to unrestricted, planned genetic recombination for breeding. This flowering behaviour in many instances results from selection pressure for low flowering propensity. An understanding of the environmental drivers of flowering, and the plants interaction with these, are vital to resolving the problems posed by these diametrically opposed objectives. Photoperiod is the primary driver of flowering in sugarcane, but this may be moderated by the plant's interaction with moisture, nutrition, and temperature (Moore, 1987; Moore and Nuss, 1987).

The present breeding programmes are aimed at improving sugar related traits along with disease and pest resistance, very less or there are no directed breeding efforts towards improving productivity through introgressing non flowering features. In general flowering clones are associated with characters like less sucrose content, reduced fiber % and cane yield (Gururaj *et al.*, 2003) and they perform better only in some specific favourable regions, where as non-flowering clones are high in sucrose content, fiber % and cane yield and they perform better in all regions without any specificity in climatic factors. There is a need to characterize parental clones or common varieties for flowering as, much literature is not available. Therefore, characterization of sugarcane clones with respect to flowering behaviour is essential for utilization of clones for breeding programmes aiming to enhance productivity with non-or-shy-flowering features.

In the context of importance of non-flowering feature for sugarcane commercial cultivation, the present investigations were made with following objectives.

- i. Characterization of floral behaviour in commercial sugarcane varieties.

- ii. Assessment of exploitable variability and other genetic parameters in intervarietal pre-selected hybrid progeny population for flowering and productivity traits.
- iii. Identification of productive progenies with respect to sugar/jaggery yield and quality parameters combining non-or-shy-flowering features.

REVIEW OF LITERATURE

Description of the nature and amount of variation and contribution of the different yield and quality attributing characters of the breeding material to the final economic product is a road map for any successful crop improvement programme. Improvement of both quantitative and qualitative characters is the main interest of any plant breeder for which adequate knowledge on genetics of yield and its component characters is very much essential. Keeping in view the objectives of the present investigation, the literature on genetic studies in sugarcane has been reviewed and presented under following headings.

- 2.1 Characterization of floral behaviour in commercial sugarcane varieties
- 2.2 Assessment of exploitable variability and other genetic parameters in intervarietal pre-selected hybrid progeny population for flowering and productivity traits.
- 2.3 Identification of productive progenies with respect to sugar/jaggery yield and quality parameters combining non or shy flowering features.

2.1 Characterization of Flowering in Sugarcane

Flowering in sugarcane is a genetically determined trait and influenced by a number of plant and environmental factors like photoperiod, temperature, moisture and nutrition. Flowering is known to affect the productivity of cane and sugar. Although flowering in sugarcane is essential for breeding, uncontrolled flowering in commercial fields poses a serious problem for sugarcane farmers and millers with a considerable loss of cane and sugar yield. Flowering results in a great setback as it arrests the growth, favours side shooting, pith formation, sets a ceiling on the yield, and quality with a decreased extraction per cent and juice purity (Moore and Nuss, 1987).

In certain varieties, which do not deteriorate fast even after flowering, this can be an advantage. Such flowered cultivars give an improved yield and quality. But more often than not, flowered canes deteriorate fast and cannot be used for seed purpose even as a contingency plan. In Hawaii, a 2-year crop can suffer a yield loss to the extent of 20% due to flowering. Thus, a profusely flowered cane reduces the yield to the extent of 20% and sucrose upto 1%. Flower suppression/inhibition seems to be an important step in sugarcane breeding programme (Gururaj, 2001). Profuse flowering leading to significant loss (15-20%) in both cane and sugar productivity (Patil *et al.*, 2009, Rao and Nareshkumar, 2003).

The reduction in cane tonnage due to flowering varies with the percentage of flowering and the age of the crop at flowering. Miah and Sarkar (1981) reported that the fresh weight of non-flowered stalks was higher over the flowered ones, Flowering reduced the sucrose content in cane especially when there is a high percentage of flowering. Hes (1951) reported that flowering reduced the purity of the juice.

James and Smith (1969), conducted experiment for effect of photoperiod and light intensity on flowering in sugarcane and result showed that higher light intensity (1399 lux) caused significantly greater delay of panicle emergence than the lower light intensity (86 lux), increasing the duration of the 12.5-hour photoperiod from 0 to 12 weeks resulted in increased delay of panicle emergence.

Srivastava *et al* (2006), conducted experiment on flowering behavior of clones under artificial photoperiodic condition and natural sunlight, and result showed that no adverse effect on pollen fertility and floral organs due to dark treatments are found.

Gururaja Rao and Kumar (2003), conducted experiment on effect of flowering on fiber content and pithiness in sugarcane by using 3 flowering and 3 non flowering varieties and result showed that fiber content increased only marginally in flowering varieties and no definite trend in the fibre content was observed in non flowering varieties by 3rd month after flowering and no significant variation in the pith content among the varieties was noticed until 3 month after flowering.

Scientists from The Agrilife Research Center (2012), conducted experiment on identification of gene regulating flowering in sorghum and result showed that there are 4 key genes for regulation of flowering in the sorghum plant, "ma1", "ma2", "ma3" and "ma4", and also they explained that delayed flowering in the sorghum plant can divert plant metabolism toward higher biomass productivity.

Murphy (2012), studied on coincident light and clock regulation of pseudo response regulator protein 37 (prp37) controls photoperiodic flowering in sorghum and result showed that ma(1), the

major repressor of sorghum flowering in long days, was identified as the pseudo response regulator protein 37 (prp37) through positional cloning and analysis of sbprp37 alleles that modulate flowering time in grain and energy sorghum.

Jessup *et al.* (2012), conducted experiment for molecular characterization of non flowering in sorghum hybrids using segregate analysis and SSR markers, and result showed that 39 and 23 markers were found to be unique to the *S. bicolor* and typical flowering *S. halepense* bulks, respectively. These unique markers could be utilized in breeding programs to identify interspecific hybrids. A subset of 23 unique SSR was found in the non-flowering tetraploid putative *Sorghum* spp. Hybrid, and they may be useful in the characterization of the non-flowering phenotype.

Swapna and Singh (2008), conducted experiment on shoot apex development at various stages of flowering in sugarcane and result showed that the changes were characterized by an increase in the length and width of the shoot tip tissues and primordial initiation. These changes could be observed 4–5 weeks before the initiation of short blade, this gives idea about changes in gene expression patterns during the transition from vegetative to reproductive stage may be observed.

Srivastava *et al.* (2006), conducted experiment using four hours extra dark treatment in artificially made photoperiodic chamber induced early flowering in flowering clones i.e. S. 55/99, S. 187/91, S. 301/86, S. 116/2K, S. 73/89 after 12 to 14th weeks. Maximum and minimum temperature ranged from 31.0 and 21.4 respectively, result revealed that there were not adverse effect on pollen fertility and floral organs due to dark treatment.

Field experiments were conducted by Gururaja Rao *et al.* (2010), to determine the effects on flowering responses of the removal of selected leaves in sugarcane varieties during the induction period. It was found that the spindle leaf had a predominant role in the production of floral stimulus. The removal of leaf spindle once during the induction period, i.e. first week of August resulted in reduced flowering intensity and delayed flowering. The removal of all the leaves except the spindle leaf resulted in earlier flowering as compared to the undefoliated control. The removal of last exposed dewlap leaf (LED) and LED +1, did not influence or affect flowering.

Norman *et al.* (1969) revealed that photoperiods of 9, 11, and 14 hr drastically reduced the number of panicles that emerged in several sugarcane clones, as compared to a photoperiod of 12.5 hr. A light intensity of 1399 lux tended to reduce the number of panicles that emerged more than light intensity of 86 lux when the photoperiod was 12.5 or 14 hr.

Gururaja Rao *et al.* (2003) conducted experiment to investigate the effect of flowering on cane weight, sucrose per cent juice, fibre per cent and pithiness till three months after flowering using three profuse flowering varieties Co 740, Co 7219 and CoC 671 and three non flowering varieties Co 62175, Co 6907 and Co 997, result revealed that single cane weight reduced slightly with age after flowering, while the sucrose per cent juice was not affected until after 3 months of flowering, no definite trend in the fibre content was observed in the non-flowering varieties and no significant variation in the pith content among the varieties was noticed until three months after flowering.

Rizk *et al.* (2007) reported that delaying flowering dates could be achieved by increasing the number of inductive cycles than those required for completing the flower induction.

Nayamuth *et al.* (2003) showed that percentage of flowered varieties and the flowering intensity differed widely between years for the same environment and between environments for the same year.

Gururaja Rao *et al.* (2009), conducted experiment to investigate comparison of flowering behaviour of sugarcane clones in two different locations, result revealed that flowering occurred in both the environments but the percentage of varieties flowered and the flowering intensity differed widely between the two locations they are the location 2 (Siruvani area) with ideal conditions for flowering, was better in terms of potential for flowering with some of the non – flowering varieties also flowering under natural conditions. The Location 1 (Coimbatore) recorded the maximum temperature > 32°C for more number of days during the sensitive induction and initiation period, number of days with Tmax – Tmin between 31°C– 18°C was comparatively lesser in the traditional breeding plot (Location 1). The lower intensity of flowering / the failure of flowering in the traditional breeding plot were associated with low rainfall.

Nils Berding *et al.* (2013), conducted a experiment on improved flowering and pollen fertility in sugarcane under increased night temperatures and result revealed that heated environment produced more profuse flowering (77 vs. 61%, for the whole season; ~1 vs. 35%, during cross-

pollination), increased panicle availability for crossing (84 vs. 57%) and accelerated flowering by an average of 12 days, and the heated environment significantly increased flowering, pollen stainability, and germination count and is expected to have an important practical application.

Hossain and Islam, (2009), conducted experiment on regeneration of high sugar non flowering somaclones of sugarcane varieties Ild 16, Ild 28, Ild 31 and clones 1273-91 and B34-104 were regenerated through callus culture using unexpanded spindle leaf segments as explants Results revealed the regeneration of high sugar non-flowering sub-clones from profusely flowering variety to prevent early recovery deterioration of sugar due to profuse flowering behaviour of cane. The results indicated the possibilities of recovery improvement and flower inhibition of sugarcane through tissue culture technique intervening callus .

Park *et al.* (2008), conducted experiment on effects of ethrel as a flowering inhibitor in sugarcane. Result revealed that significant differences in flowering intensity (averaged over varieties) for the different Ethrel application timings. Ethrel applied on the 19th and 26th July gave 32 and 15 per cent reductions in flowering, respectively. Flowering intensity values for the various varieties (averaged over all application times) were not significantly different.

Gururaja Rao *et al.* (2012), conducted experiment on RNA content in relation to flowering in sugarcane varieties. The RNA content in the shoot apices of profuse flowering varieties increased at induction over that of the pre-induction stage. The magnitude of increase in the RNA content varied significantly among the varieties. The RNA content at the pre-inductive and the inductive period was positively and significantly associated with flowering.

Gomathi *et al.* (2013), a study was conducted to investigate the induced and non-induced response of sugarcane variety Co 86032 by heat acclimation both under in vivo and in vitro conditions. Significant differences responses of SOD, POX and APX activities were observed in both induced and non induced settlings and calli. However heat acclimations (induced) led to higher activities of these enzymes and thereby protect the cells from oxidative damage. Pre treated settling and calli recorded lesser cell membrane damage. Formation of additional protein bands of different molecular weights (90, 70 and 27 kDa) showed the expression of these proteins upon heat acclimation particularly at 40 °C in settlings and 42 °C in calli.

Punit, *et al.* (2005) study made on some biochemical parameters in flowering and non-flowering varieties of sugarcane showed that acid phosphatase, amylase activity, reducing sugar and protein contents increased in the flowering variety during floral induction in the apical parts. The total phenolic content remained always higher in the non-flowering variety than the flowering one.

2.2 Assessment of Exploitable variability and other genetic parameters in intervarietal pre-selected hybrid progeny population for flowering and productivity traits.

In any plant breeding programme, availability of large genetic variability in the crop species is the basic requirement to select better performing types among the divergent group. If vast amount of variability is present, attempts can be made to improve the traits of interest by enforcing selection. Variability generally exists in germplasm collections and when this is exploited to a maximum extent by way of selection, additional variability can be created in segregating populations by crossing best available varieties.

Cane yield and sugar yield, for which improvement is sought, are the complex characters, which are not only influenced by its associated characters but also by the environment. The estimates of variability in respect of yield and its heritable components in the material with which the breeder is working, are therefore prerequisite for any breeding programme. Hence it becomes necessary to split the phenotypic variability into heritable and non heritable components such as genotypic and phenotypic coefficient of variation (GCV and PCV), heritability and genetic advance. Genotypic coefficient of variation indicates the relative magnitude of genetic diversity present in the material and helps to compare the genetic variability present for different characters. The apparent variability in a crop can be divided into variability due to genotype, environment and their interaction.

The genotypic variability is the actual heritable component of the apparent variability and is expressed as heritability. Therefore, heritability can be defined as the proportion of the phenotypic variability that is due to genotype. The genotypic variability is the result of additive and non additive effects.

Nilssen Ehle (1909) and East (1916) described the heritable and environmental components of variance in the early part of the century. The calculation of phenotypic and genotypic coefficient of variability (PCV, GCV) was suggested by Burton (1952).

Lush (1949), defined heritability as the ratio of additive genetic variance to the total phenotypic variance in a narrow sense. The heritability in broad sense was proposed by Hansen *et al.* (1956), as the ratio between the genotypic variance as whole and phenotypic variance. But this does not give a clear picture of transmissibility of variation from one generation to next generation, because the genotypic variance includes additive, dominance and epistatic gene effects.

Heritability influences the selection programme to a larger extent. According to Allard (1956), heritability of yield alone is less and that of yield component is more. However, the gain from selection for a particular character is the function of its heritability, selection pressure and the variance existing in the basal population. Thus, genetic gain was expressed by Burton and De Vane (1953) as the product of heritability, phenotypic standard deviation and selection intensity.

The genetic advance is more useful in predicting the actual value of selection than heritability, according to Johnson *et al.* (1955) although the later value indicates the relative effectiveness of selection based on phenotypic expression of the character.

Charles and Smith (1939), and Powar (1942) separated the genotypic variance from the total variance, using estimate of environmental variance in non-segregating populations. Since then the studies on heritability, genetic advance and their variance components have been estimated for most of the yield contributing characters in several crops.

Thulijaram Rao *et al.* (1966) reported the high heritability for the characters like cane weight and number of millable stalks. Thus, the direct selection of these characters for improvement of cane yield will be very effective.

Balasundaram and Bhagyalakshmi (1978) reported that the stalk yield as well as its components with high degree of genetic variability and broad sense heritability was highly amenable to selection where as stalk thickness and quality attributes with low variability and high heritability had lower level of genetic advance.

Khairwal *et al.* (1978) recorded high broad sense heritability for thickness as well as the number of stalk but moderate heritability for stalk height and weight. Contrastingly sucrose per cent had low heritability. Nair *et al.* (1980) reported high level of heritability, genetic variability and genetic advance for sugar and stalk yield while stalk diameter, stalk length and quality attributes revealed moderate heritability and low genetic variability.

Singh *et al.* (1981), reported high genotypic coefficient of variation for stalk weight, number of stalks, stalk girth and Brix. Heritability was high for number of internodes, stalk height and Brix, while it was moderate for number of stalk and lowest for stalk weight. High phenotypic and genotypic coefficient of variation was noticed for stalk followed by stalk weight. On the other hand, number of internodes, length of internodes and sucrose per cent exhibited low genetic coefficient of variation. Heritability was high for sucrose per cent followed by intermodal length.

Punia and Hooda (1982), reported that high broad sense heritability for Brix and sucrose per cent followed by commercial cane sugar per cent. Sharma and Singh (1982) observed high genetic variability and heritability for quality traits. They further reported high genotypic advance at 11th month for stalk girth and stalk height.

Kang *et al.* (1983) reported high heritability estimates in broad sense on plot means for various traits ranging from 77.00 per cent for sugar yield to 94.00 per cent for stalk diameter. High genotypic and phenotypic coefficients for variance were reported for sugar yield, stalk yield, stalk number and stalk weight by Natarajan (1983). However, Singh *et al.* (1983) observed moderate genetic gain for stalk length followed by Brix and number of millable canes, number of tillers, while sucrose per cent in juice exhibited low variability and genetic advance.

High heritability for purity per cent followed by pol per cent and CCS per cent and high expected genetic gain for CCS per cent followed by pol per cent were reported by Battan and Choudhary (1984).

Reddy and Reddi (1987) reported high genotypic coefficients of variation (29.31) and high genetic heritability (98.98%) coupled with high genetic advance (60.32%) for stalk weight, while low GCV and GA for stalk diameter, stalk number and Brix.

Punia *et al.* (1987) observed maximum heritability of 98.22 per cent for cane thickness. Cane yield per clump recorded high estimates of GCV, heritability and expected genetic gain.

High heritability coupled with high genetic advance was observed for internodes per cane, stalk weight, Brix and commercial cane sugar per cane by Verma *et al.* (1988) in a study of 35 genotypes including 11 parents and 24 hybrids of sugarcane. According to Sreekumar *et al.* (1988) the genetic advance was relatively high for sugar yield, cane yield, number of millable canes per plot and cane weight and for cane length, number and internode length, Brix and purity percentage exhibited low GA.

Hapse and Hapse (1990), observed high value of phenotypic as well as genotypic coefficients of variation for cane yield followed by germination at 30 and 45 days, number of millable canes per clump, total and millable cane height and CCS per cent. Genetic advance studies of Milligan *et al.* (1990) indicated scope for considerable and potential improvement in sucrose yield, cane yield and stalk number of weight.

High genotypic coefficient of variation for germination per cent, sugar yield, cane yield, number of millable canes and single cane weight was observed by Bakshi Ram (1994). In another study, Bakshi Ram and Hemaprabha (1995), noticed high heritability for number of millable canes, stalk diameter, stalk height, stalk yield, sucrose per cent, purity per cent and sugar yield in the interspecific hybrids of *Saccharum* species.

Das *et al.* (1996) observed low genetic variability, intermediate heritability and low genetic gain for sucrose percentage and CCS percentage in early maturing genotypes of sugarcane. Whereas the characters like individual stalk weight, number of internodes and number of millable canes per hectare revealed the high to medium genetic variability.

Singh *et al.* (1996) worked out analysis of variance for seven yield related traits and showed high phenotypic and genotypic coefficients of variation for commercial cane sugar and cane yield, moderate for cane height and number of millable canes and low for Brix percentage. Heritability in broad sense was high for all the traits where as genetic advance was high for cane yield and CCS per cent and moderate for cane diameter, cane height and number of millable canes. Cane yield, number of millable canes, plant height, germination at 45 days and number of shoots at 90 and 120 days exhibited the highest estimates for genotypic and phenotypic coefficients of variations.

Kadian *et al.* (1997) noticed that phenotypic and genotypic coefficients of variation were high for single cane weight followed by cane productivity per clump. Heritability was moderate to high for all the traits except number of millable canes per clump. Low genetic advance was observed for single cane weight and cane yield per clump and was found to be associated with heritability. Similar observations have also been reported by Doule and Balasundaram (1997). Sharma *et al.* (1998) observed that high coefficient of variation and moderate heritability was found for stalk weight, height, girth, number and length of internodes. Low coefficient of variation and high heritability were also noticed for brix.

Singh and Singh (1999) based on early evaluation of genotypes on genetic variability, predictability in plant and ratoon crops of sugarcane reported that genotypic and phenotypic coefficient of variance, and heritability and genetic advance values were high for stalk weight, number of millable canes and cane yield in plant crop while for ratoon crop values of these genetic variability parameters were low. Singh and Singh (2000) reported higher broad sense heritability genetic advance over means and correlation between three sucrose related traits (brix, purity and sugar content) at early maturing stage. Thus they opined that for quality improvement of sugarcane clones and varietal selection in sub tropical climate, early evaluation of clones is an effective approach.

In a study of thirty-two genotypes to estimate variability parameters for seven stalk characters in sugarcane, Choudhary Rewati(2001) reported higher genotypic variance than environmental one for cane yield, millable cane number, single cane weight, stalk diameter, stalk length. Single cane weight, germination at 45 days after planting and millable cane number had high genotypic and phenotypic coefficients of variation. High heritability estimates were recorded for millable cane number, stalk diameter and single cane weight. Maximum gain as per cent mean was observed for single cane weight and millable cane number.

Patil *et al.* (2011), revealed that among the 27 crosses consisting 16 bi-parental crosses, 7 poly crosses and 4 general crosses.,the crosses viz., Co 86032 × Co 86250, Co 95021 × Co 97015,

ISH 100 poly cross, CoC 671 × CoT 8201 and Co 740 × Co 775 produced higher percentage of non-flowering progenies with acceptable productivity features (HRB and cane yield components).

Reddy and Somarajan (1994), reported that cane yield did not have significant positive association with any of the yield attributes except number of millable canes. The hybrids derived from the crosses involving commercial hybrids with *S. robustum* or *S. barber*; were superior to other hybrids.

Bakshi Ram and Hemaprabha (1993), revealed that among 53 clones which subjected to multivariate D2 analysis separately, clones were grouped in 11 clusters and hybridization among the clones from diverse clusters may help in isolating progenies with higher stalk yield and improved juice quality.

Anshuman *et al.* (2002) reported the characters, viz., cane, CCS yield, NMC, number of tillers, germination per cent and cane weight had high, cane height and cane thickness had moderate and juice brix per cent and sucrose per cent had low genotypic and phenotypic coefficients of variability, heritability estimates were recorded high for all the characters.

Gupta *et al.* (2002) studied some genetic parameters in sugarcane and observed highly significant differences for all the characters tested except purity per cent age at 360 days. They further recorded maximum phenotypic coefficient of variation for number of tillers per plot, followed by millable canes per plot, cane yield and commercial cane sugar.

Thippeswamy *et al.* (2001) recorded a good amount of variability for at least eleven morphological characters and maximum heritability for germination percentage, number of internodes and cane yield. Quantitative characters like number of shoots, LAI, cane height, number of millable canes, single cane weight and cane yield recorded moderate to high coefficient of variation, heritability and genetic advance. The numerical estimation of genetic parameters for cane diameter and sucrose per cent juice were comparatively low (Kamat and Singh, 2001).

Doule and Balasundaram (2004), reported that among 28 inerspecific canes, fiber% cane and rind hardness at 300 to 360 days maturity exhibited high degree of genotypic coefficient of variability and moderate levels of heritability coefficient.

Chaudhary *et al.* (2003) reported high heritability (h^2) were associated with stalk weight, stalk length, internode length, cane yield, millable cane number, germination, and stalk diameter, whereas moderate values were obtained for internode number, germination, and stalk diameter. Juice quality character showed lower estimates of heritability.

Krishnakumar *et al.* (2004) reported high heritability and genetic advance expressed as per cent of mean for number of millable canes, commercial cane sugar, cane yield, cane height, cane girth, single cane weight and number of internodes per stalk in a study of 27 subtropical sugarcane cultivars.

Patel *et al.* (2006) in their variability study among 40 diverse sugarcane cultivars, reported high heritability coupled with high genetic advance for single cane weight and CCS indicating the presence of additive gene action as well as effectiveness of direct selection for both traits.

Mali *et al.* (2009) reported highly significant differences among the 21 genotypes for all the characters studied. All the characters under study indicated the ample variation of these characters. High heritability coupled with high genetic advance observed for number of tillers and single cane weight indicated the presence of additive gene action and direct selection may be highly effective.

Johnson *et al.* (2005) reported a high degree of variability and spatial correlation was observed in soil properties, sugar yield and quality.

Patil, *et al.* (2011) revealed that among non-flowering progenies viz., SNK 07156, SNK07256 and SNK 07342 recorded superior juice qualities (brix and sucrose %) across sexual to clonal-II generations over best commercial standard Co 86032.

Verma (1990), conducted an experiment on high heterosis over better parent and standard variety for quantitative and juice quality characters in 24 crosses among eight lines and three testers of sugarcane result showed that few crosses gave appreciable heterosis for yield and sugar contributing characters

Alarmelu *et al.* (2000), conducted experiment on estimation for yield and quality parameters in sugarcane using line X tester design which revealed that female parents contribute more to the total variation of the character stalk diameter and both female and male parents contributed to brix %.

2.2.1 Studies on correlation and path coefficient analysis

Association of characters can be used as a basis for selection. Correlation coefficient is a measure of association between two or more variables and not a measure of dependence of one variable on the other. Importance of any crop needs better understanding of association between yield and yield attributes. Galton (1889) developed the basic concept of correlation and was later elaborated and discussed by Fisher (1918) and Wright (1921). It helps in determining the nature and degree of relationship between any two measurable characters. Generally, quantitative characters of economic importance are often associated with one another either positively or negatively. Hence, the selection for yield on the basis of *per se* performance alone may not be as effective as that based on the component characters whose association with yield are biometrically determined by correlation and path co-efficient analysis.

The indirect selection schemes concentrate on correlation between characters to improve a highly complex trait like yield. The efficiency of indirect selection depends on the direction and magnitude of association between yield and its component characters. Therefore, study of relationships among the quantitative traits is important for assessing feasibility of joint selection of two or more traits. A positive genetic correlation between two desirable traits makes the job of the plant breeder easy for improving both traits simultaneously. Further, understanding the association between the component traits and their relative contribution to the target trait is essential to bring out a rational improvement in the desired trait as they may be differently correlated.

Path co-efficient is the standardized partial regression co-efficient of correlation, which splits correlation co-efficient into direct and indirect effects of component characters on complex dependent character like yield. Wright (1921) developed the concept of path co-efficient analysis, but the technique was first used in plant breeding by Dewey and Lu (1959). If the correlation between dependent variable and the independent variables is due to the direct effects of the character, it reflects a true relationship between them and selection has to be invariably practiced for such a character in order to improve dependent variable. The correlation co-efficient measures the sum total effects (direct and indirect) of all the characters to which it is correlated either positively or negatively and hence selection based on this value alone will be sometimes misleading unless the direct effect is very high and operates in the same direction. Hence, the study of direct and indirect effects through path analysis enables the breeders to judge best about the important component characters during selection.

Singh and Singh (1954) observed significant positive correlation between cane thickness and cane length which were significantly positively correlated with cane weight, but negatively correlated with number of canes.

Herbert (1965) observed poor association of stalk diameter with number of stalks and Brix, but positive association with stalk erectness. He also observed very high and significant positive correlation between Brix and sucrose per cent and found between cane diameter and single cane weight which in turn positively correlated with cane yield. Negative correlation was found between stalk diameter and number of stalks, Brix per cent and sucrose content. Ethirajan (1966) noticed negative association between stalk yield and Brix. Further stalk weight was found to be significantly correlated with stalk yield. Significant positive correlation of sucrose per cent with total sugars and percentage extraction and negative correlation with stalks per plot, reducing sugars and fibre per cent.

Mariotti (1978) observed significant correlation for number of stalk, stalk weight, stalk length and stalk diameter with stalk yield at phenotypic level. Sahi and Patel (1975) recorded significant positive correlation of stalk yield with sugar yield, stalk weight and stalk height. They also noticed significant negative correlation of stalk weight and stalk thickness with stalk number.

Balasundaram and Bhagyalakshmi (1978) noticed significant positive correlation of sugar yield with stalk diameter, stalk length and stalk yield. Further stalk yield had high positive correlation with number and length of stalk whereas, sucrose per cent had negative association with number, length and yield of stalk. Stalk diameter had significant negative correlation with number of stalks, whereas, it had significant positive correlation with stalk height. They observed large direct effect of number of stalks on stalk yield whereas, indirect effect of number of stalks through stalk length was low. Stalk thickness had larger direct effect on stalk yield and its indirect effect through stalk number

was negative and high. Sugar yield, stalk number and stalk diameter had high direct effect while stalk length contributed less to cane yield. Hence, number of canes per plot and cane thickness be the major components of both cane yield and sugar yield whereas the cane length and sucrose per cent are of secondary importance only.

A positive correlation was observed by Khairwal *et al.* (1978) between cane yield and number of stalks, stalk height and stalk thickness but Brix and sucrose content had negative association with cane yield. In progenies of four sugarcane crosses at settling stage, Hooda *et al.* (1979) observed highest direct effect of stalk weight on stalk yield followed by stalk height, while stalk diameter manifested negative direct effect on stalk yield.

The Brix quality had positive genotypic and phenotypic association with number of millable canes per clump, number of internodes per stalk, number of green leaves per cane while stalk height and stalk girth had negative association with Brix value. Path coefficient analysis indicated that number of internodes per stalk had high positive direct effect followed by number of millable canes. Number of green leaves which showed high genotypic correlation exhibited negative direct path towards Brix quality. Thus number of internodes and millable canes are important components that have direct influence on Brix quality, thereby suggesting that these characters should be given due weightage in selection programme (Singh *et al.*, 1981).

Kang *et al.* (1983) observed strong association of cane yield with plant height, stalk diameter, stalk number and stalk weight and high negative association of stalk diameter with sucrose, purity and Brix. According to Punia *et al.* (1983) cane yield was influenced by the number of tillers per clump, the number of millable canes per clump, cane thickness and cane weight. Nageshwara Rao *et al.* (1983) reported high negative association of Brix with stalk diameter at genotypic and phenotypic levels while studying the association of quality attributes in 41 genotypes. Punia and Paroda (1984) found that, CCS per cent had high significant negative association with length of internode and cane yield per clump. But high positive association among Brix per cent, pol per cent, purity per cent and commercial cane sugar per cent was also observed.

Nair and Somarajan (1984) reported that in a hybrid sugarcane population of 26 clones, number of millable stalks alone showed significant positive correlation with stalk yield under water logged condition. Stalk weight exhibited negative association with number of millable stalks. Reddy and Khan (1984) observed significant positive correlation of cane yield and commercial cane sugar with percentage of germination, number of tillers, millable canes and cane height in the 18 genotypes of sugarcane. The number of tillers was significantly correlated with germination percentage and number of millable canes. Cane height was significantly correlated with internode length and cane weight which in turn associated with cane diameter. Cane yield and CCS were strongly associated with each other. Path analysis revealed that number of millable canes, cane height and cane weight had highest direct effects on yield and CCS, whereas internode length, internode number and sucrose percentage in juice showed negative direct effects on cane yield. Clonal selection hence be based on the number of millable canes, cane height and cane weight.

Ramana Reddy (1985) reported a highly significant negative association of sucrose per cent with cane yield and its components viz., stalk diameter, stalk weight and stalk length. Significant positive and high magnitude of phenotypic and genotypic association of cane yield was observed with number of millable canes per plot and length of millable cane.

Sharma and Khatiyar (1986) observed that stalk height was positively correlated with number and length of internodes but negatively correlated with stalk thickness. They also showed that Brix, stalk weight and number of internodes had high direct effect on sucrose content. Most of the characters exerted high indirect effects through intermodal length and number of internodes.

Kandasami and Thiraviam (1987) reported that number of millable canes per plot, stalk height and weight showed highly significant positive correlation with cane yield. Cane girth did not have any influence on cane yield. Though the number of millable canes per plot showed high and significant positive correlation as compared to cane height and single cane weight, it showed highly significant negative correlation with other components like cane girth, cane weight, single cane weight and juice extraction percentage. The single cane weight, on the other hand, showed significant positive correlation with all other yield components.

Sahi *et al.* (1987) reported highest positive direct effect of stalk height and stalk diameter on cane yield. Rekhi and Gill (1987) reported the highly significant positive inter relationship between sucrose and purity; they also reported highest positive effect of purity of juice on sucrose content.

Reddy and Reddi (1987) while studying the association pattern in 12 biparental crosses of sugarcane observed that positive association between sucrose percentage in juice and cane yield at the first clonal generation in the eight crosses. The remaining four crosses revealed the negative and non significant phenotypic association.

Nair and Sreenivasan (1989) made a study on Brix in relation to crop age in sugarcane and their observations showed variation in Brix from 7th month to 10th month for 94 clones. Highly significant negative association of sucrose per cent in juice with number of millable canes and number of internodes per cane was observed.

Association studies in 35 genotypes of sugarcane by Verma *et al.* (1999) indicated significant positive association of internodes per cane, stalk weight, Brix and commercial cane sugar per cane (CCS) with each other, while stalk weight, Brix and CCS exhibited significant positive association with stalk girth. Hooda *et al.* (1988) reported significant positive correlation of cane height, internodes per cane, cane thickness and single cane weight with cane yield, while significant positive correlation was noticed between cane height and internode length as well as number of internodes with cane height and cane weight in a study of 34 sugarcane genotypes.

Nair and Sreenivasan (1989) reported that negative influence of number of millable canes on cane weight. Negative correlation was also observed between germination, tillering and yield components. However, stalk height was closely correlated with cane and sugar yield. Highest direct effect of stalk diameter on cane yield was also reported. Hooda *et al.* (1989) observed the absence of association between cane yield and quality parameters which indicated that either quality traits or cane yield could be improved without any adverse effect.

Cane yield was significantly and positively correlated with CCS, cane height and internode number, while juice sucrose per cent was significantly and positively correlated with CCS, which in turn was positively correlated with millable cane height and internode number in a study of 14 cultivars of sugarcane by Patel *et al.* (1993).

Baljit Singh *et al.* (1994) recorded the maximum direct effect of number of millable canes followed by stalk weight on cane yield in five sugarcane crosses (Co J 83536 X Co 62198, CoH 7803 X CoS 510, CoH 7803 X Hr 83-144, CoH 7803 X Co 8313 and CoH 7201 X CoS 510) while the direct effects of stalk height, stalk girth, Brix per cent and sucrose per cent on cane yield were very low.

In the correlation and path study among eight quantitative characters involving fourteen sugarcane genotypes, Choudhary and Singh (1994) observed that high degree positive correlation of cane yield with germination at 45 days, number of shoots at 90 days and 120 days, height of cane, cane width and number of millable canes. Path analysis revealed that number of millable canes and individual cane weight were direct contributors to the cane yield. All other component characters were indirect contributors via number of millable canes. Thus individual cane weight and number of millable canes could be used as important selection criteria for improving cane yield of early maturing clones of sugarcane.

Sreekumar *et al.* (1994) observed significant and positive correlation both at phenotypic as well as genotypic levels for Brix with pol, purity, CCS per cent and CCS tones per hectare, but negative association with millable cane count and yield tones per hectare.

Khan (1995) observed positive correlation of cane yield with number of millable stalks, stalk height, stalk weight, diameter and internode number in a study of four clonal generations of 45 genotypes produced from 13 diverse parents in sugarcane.

Das *et al.* (1996) reported significant negative associations of number of millable canes per hectare with sucrose per cent in juice and CCS percentage. They also observed significant positive association of CCS (t/ha) with cane yield, cane height, stalk weight, sucrose per cent in juice and CCS percentage. Das *et al.* (1997) reported that sugar yield revealed positive direct effect with productivity, individual cane weight, purity of juice, and CCS per cent and cane height at maturity. Indirect components such as individual cane weight, cane diameter, CCS per cent and sucrose per cent influenced the sugar yield. Significant positive correlation of cane productivity with number of millable canes, stalk height, stalk weight and internode length were observed by Kundu and Gupta (1997). While Rishipal *et al.* (1998) noticed close association of cane yield with number of millable canes, single cane weight and stalk height.

In another study of 12 sugarcane varieties, Hapse and Repale (1999) noticed significant association of cane height, cane girth and cane weight with cane yield. However, sugar yield was

closely associated with juice Brix, CCS per cent and cane yield. The millable canes, CCS and cane yield were significantly and positively correlated with each other, where as stalk height with internodes per cane and cane yield; stalk girth with stalk weight and CCS possessed significant positive association in a study involving 16 sugarcane varieties by Verma *et al.* (1999).

Pratap Singh *et al.* (2001) observed positive and significant association of number of shoots with number of millable canes and stalk height. Number of shoots and number of millable canes were negatively associated with stalk diameter and stalk weight at genotypic as well as phenotypic level. Stalk height and stalk diameter had high positive association with cane weight. This suggested that stalk height and diameter were the major yield contributing characters.

In another study involving 10 sugarcane genotypes, Nahar *et al.* (2002) reported strong positive correlation of cane yield with number of millable canes and cane height but negative correlation with Brix and sucrose percentage at both phenotypic and genotypic levels. On the other hand, cane diameter showed least correlation with cane yield.

In the study consisting of twenty elite lines of sugarcane with four checks, Anshuman Singh *et al.* (2003) found that cane yield had non-significant negative correlation with juice Brix, juice sucrose, juice purity and extraction per cents, where as its association with commercial cane was highly significant positive. Path coefficient analysis revealed high direct effect of commercial cane sugar per cent and juice sucrose per cent on commercial cane sugar yields.

Chaudhary *et al.* (2003) observed significant positive correlations of cane yield with stalk length, stalk weight, internode number and internode length. Internode length was significantly positively correlated with Brix and sucrose in juice. Path coefficient analysis showed that stalk weight and stalk length were the most important components of cane yield. Results suggest that for increasing sucrose per cent, emphasis should be given to Brix per cent and purity per cent in juice while selecting clones of sugarcane.

Thippeswamy *et al.* (2003) in the study consisting sixty sugarcane genotypes observed the highly significant and positive association of cane yield as well as commercial cane sugar yield with the single cane weight, number of millable canes per plot, leaf area and germination per cent. Path coefficient analysis of cane yield per plot revealed that commercial cane sugar per plot and commercial cane sugar per cent at harvest along with dry matter and number of internodes were the major contributors to cane yield per plot, where as sugar yield was largely dependent on both cane yield and sucrose per cent.

Cane yield was significantly and positively correlated with number of millable canes, cane height, cane girth and single cane weight in an association study involving 27 subtropical sugarcane cultivars (Krishnakumar *et al.*, 2004). In a study involving 22 sugarcane clones, Singh and Khan (2004) reported significant positive association of number of millable canes, stalk height and cane weight with cane yield and highly significant and positive association of CCS yield with cane yield, cane weight and stalk height indicating importance of these traits in improving CCS yield.

Choudhary and Joshi (2005) observed highly significant positive correlation of cane yield with the stalk cane weight, stalk length and millable cane number, cane diameter and number of internodes.

Kadian *et al.* (2006) reported positive and highly significant correlation among the juice Brix, pol per cent, purity per cent and CCS per cent. High direct effect of cane thickness and internode length were observed on cane yield for 32 sugarcane genotypes grown in three environments. Number of millable canes per clump and single cane weight emerged as the most important traits influencing cane yield. Apart from these traits due emphasis should be given to cane height, internode length and juice quality traits while selecting the clones suitable for late planting conditions.

In a study on 32 sugarcane genotypes, Kadian and Mehta (2006) observed significant positive correlation of cane yield with single cane weight and cane thickness, while juice quality parameters *viz.*, Brix, pol, purity and CCS per cent showed highly significant and positive association among themselves. High direct effect of cane thickness and internode length were observed for cane yield. Cane thickness and single cane weight emerged as the most important traits influencing the cane yield.

In an association study involving 40 phenotypically diverse sugarcane genotypes, Patel *et al.* (2006) observed significant positive correlation of cane yield with number of shoots per hectare, single cane height, stalk length, stalk diameter, number of internodes and NMC per hectare at both

phenotypic and genotypic levels. Path coefficient analysis revealed the highest positive direct effect of CCS (t/ha) on cane yield. Hence, more emphasis should be given to single cane weight, NMC/ ha and CCS (t/ha) while selecting the clone for higher cane yield.

Anand Prakash Tyagi and Praduman Lal (2007) reported the positive and significant correlation between plant volume and number of millable stalks, plant volume and weight per stalk, plant volume and weight of millable stalks, plant volume and stalk thickness, number of millable stalks and weight of millable stalks. Positive non-significant correlation was observed among number of millable stalks, refractrometer Brix, number of millable stalks and stalk height. Path coefficient analysis revealed that the weight of millable stalks was the most important character with the highest direct effect on sugarcane yield followed by stalk height, number of millable stalks and stalk thickness.

Mali *et al.* (2009) observed in a study involving 21 sugarcane genotypes, significant and positive correlation of cane yield with number of internodes at harvest, cane diameter at harvest, single cane weight, CCS (kg/plot) at 360 DAP and NMC/plot. Path coefficient analysis indicated the highest positive direct effect of sucrose per cent juice at 360 DAP on cane yield.

Significant and positive relationship of Brix with juice extraction per cent and pol per cent; days to flowering with stem thickness, cane weight, juice weight, volume and juice extraction per cent; cane weight with stem thickness; juice weight and volume with plant height, stem thickness and cane weight and Brix per cent with cane weight, juice weight and volume was reported by Kachapur and Salimath (2009) in a study involving seven genotypes of sweet sorghum, while non-significant positive correlation was noticed for Brix with stem girth and cane weight.

Singh *et al.* (2010) evaluated 17 genotypes of mid-late maturing clones of sugarcane for existing variation for cane yield and its attributing characters. The result revealed that number of shoots at 120 days after planting, number of shoots at 240 days after planting, number of millable canes at 12 months, single cane weight (kg) at 12 months, cane height (cm) at 12 months and cane yield (t/ha) at harvest showed positive and highly significant correlation with sugar yield at both genotypic and phenotypic levels. Out of these characters number of millable canes at 12 months and single cane weight showed high positive direct contribution towards the sugar yield at phenotypic level.

Imtiaz *et al.* (2012) observed significant differences among the twelve sugarcane clones for all the plant characters. Highest cane yield (144 t/ha) was recorded in clone NIA82-1026P5 and highest pol per cent (20.82%) and CCS per cent (16.45%) were observed in CP84-1198. Correlation coefficient results indicated that cane yield was positively correlated with cane girth, weight per stool, sugar yield, tiller numbers and purity per cent whereas pol per cent and CCS per cent showed negative correlation with cane yield. Sugar yield showed non- significant correlation with cane girth.

MATERIAL AND METHODS

The present investigation were carried out at Agricultural Research Station Sankeshwar during 2011-2013.

3.1 Experimental material

The experimental material for the present study consisted of 145 pre selected hybrid progenies derived from 18 crosses (11 biparental crosses and 7 general cross) involving commercial varieties.

3.1.1 Clonal-II generation

Only 145 progenies with highly acceptable cane features were advanced to clonal II, where in only 142 were studied for assessing exploitable variability as 3 genotypes recorded poor germination and replaced with commercial clones.

Design : Augmented Randomized Block Design

Number of clones : 145

Number of Blocks/Replication : four

Number of standards/checks : Six commercial checks

Co 2001-15, Co 92005, Co 86032, CoC 671, SNK 044 and SNK 814

Location : Agriculture Research Station, Sankeshwar, UAS Dharwad.

Date of Planting : 14/ 2/ / 2011

Among 145 progenies only non flowering productive progenies along with commercial checks were further studied for assessing jaggery productivity and quality parameters.

3.2 Experimental layout

Experiments were laid out by following Augmented Randomized Block Design with a four blocks for each progenies.

3.3 Experimental details

3.3.1 Experimental layout

Experiment was laid out in a homogenous blocks following augmented RBD, observations were recorded at various stages of crop growth and at harvest.

3.3.2 Plot size

Each genotype was grown in a four rows of 6m length and spaced at 90 cm between rows and 20 cm between plants within a row (i.e, single eye budded). So the plot size was $6 \times 3.6 = 21.6\text{m}^2$

3.3.3 Cultural practices

The details of various cultural operations carried out in the course of investigation are furnished in the following paragraphs.

3.3.3.1 Land preparation

Initially the land was ploughed once with tractor drawn mould board plough and later on worked with tine cultivator. The stubbles and weeds were picked from the experimental site. The land was then harrowed and smoothened to bring the seed bed to a fine tilth. The field was then laid out in to 'v' shaped ridges and furrows at the spacing of 90 cm, with a furrow depth of 25 cm.

3.3.3.2 Fertilizer application

A day before planting cane setts, full dose of phosphorous (75 kg ha^{-1}) and potash (187.5 kg ha^{-1}) along with 10 per cent of recommended dose of nitrogen (25 kg ha^{-1}) were applied in furrows in the form of single super phosphate, murate of potash and urea respectively and mixed with the soil.

The sugarcane crop was top dressed with 50, 75 and 100 kg urea per hectare at sixth, 10th and 14th weeks after planting, respectively.

3.3.3.3 Planting of sugarcane setts

From sugarcane crops raised for seed multiplication, the single eye budded setts were prepared carefully. The setts were treated with one per cent emission (Bavistin) solution before planting. The setts were pushed down in to soil to a depth of 5 cm.

3.3.3.4 Weed control

The hand weeding was carried out at 40 and 80 Days after planting (DAP).

3.3.3.5 Irrigation

The experimental plots were irrigated on the day of planting. Thereafter, seven days irrigation interval was followed during the germination phase (0-30 days) and 8-10 days interval during the tillering and grand growth phases of the crop (30-270 days), 12-15 days interval was followed. The irrigation was skipped during rainy period. No irrigation was scheduled during the last fifteen days before harvesting of crop.

3.3.3.6 Harvesting of sugarcane

The cane was harvested at maturity after 360 days of planting.

3.4 Observations recorded

3.4.1 Flowering Behaviour Studies

The genotypes were evaluated and scored for flowering intensity and time of flowering by recording the total number of flowered stalk in each plot of each clone at three of time. Based on these flowering observations the genotypes were classified as follows.

1. Classification for flowering intensity is as follows

Scale%	Classification as per SBI Coimbatore
0	Non Flowering
0-30	Shy Flowering
30-60	Moderate flowering
>60	Profuse flowering

Note : SBI –Sugarcane Breeding Institute

2. Classification for time of flowering is as follows

Period of flowering	Classification
November 1 st – 4 th week	Early
December 1 st – 4 th week	Mid
January 1 st – 4 th week	Late

3.4.2 Flower initiation studies

Days to flowering initiation in commercial sugarcane genotypes were recorded from July to October with 15 days interval based on flower primordial count of eight commercial genotypes, where in each genotype 50 plants were randomly selected for dissection of apical meristem tissue for identifying presence/ absence of floral primordial growth and observations were recorded accordingly.

3.4.3 Germination count at 45 DAP

The germination was recorded from the gross plot on 45th day after planting (DAP) and expressed as percentage of the buds planted.

3.4.4 Total shoots at 120 DAP

The total shoots present in each clone were counted and recorded as total shoots per plot at 120 days after planting.

3.4.5 Cane formed shoots at 120 DAP

Cane formed shoots in the gross plot 120 Days after planting (DAP) were recorded and expressed as number per plot.

3.4.6 Average millable cane height (cm)

The millable cane height was recorded from ground level to the last internode of millable canes in each clone with the help of a measuring scale and the average height is expressed in centimetres.

3.4.7 Average cane girth (cm)

The diameter of millable canes in each clump was recorded on the middle internode of the cane by using a vernier callipers at the time of harvest and the average girth expressed in centimetres.

3.4.8 Average number of internodes

The number of internodes present on the millable canes up to last internode were recorded and expressed as average number of internodes per stalk at the time of harvest.

3.4.9 Average internodal length (cm)

The internodal length of top, mid and bottom internodes of millable canes in was recorded with the help of a measuring scale and the average inter-nodal length is expressed in centimetres.

3.4.10 Number of millable canes (NMC)

All the canes from each genotypes were cut, dressed, counted and recorded as number of millable canes per plot and later expressed as thousands per hectare.

3.4.11 Average single cane weight (SCW) (kg)

The weight of millable canes in each genotypes was recorded at harvest and the average weight was worked out and expressed as average single cane weight in kilograms.

3.4.12 Cane yield per plot (kg)

All the canes in each plot were cut close to the ground level. The tops and trash were removed and cane weight per plot was recorded and expressed as cane yield per ha in tonnes.

3.4.13 Sugar yield parameters

3.4.13.1 Brix per cent

Brix reading was recorded using the brix hydrometer at 240, 300 and 360 (at harvest) days after planting. The corrected brix reading was worked out using Bur standards.

3.4.13.2 Juice extraction per cent

The juice extraction per cent was calculated by following formula.

$$\text{Juice extraction (\%)} = \frac{\text{Juice weight}}{\text{Cane weight}} \times 100$$

3.4.13.3 Sucrose per cent (Pol%) in juice

It was estimated by Horne's dry lead acetate clarification method using polariscope at 300, 330 and 360 days after planting (Ishwaran, 1981). One hundred ml of the filtered juice was transferred to 250 ml conical flask to which one gram of basic lead acetate was added, stirred well and allowed to stand for about an hour until clear supernatant obtained. This supernatant filtered through Whatman No. 40 filter paper and the clarified juice was filled into a 20 mm polariscope tube and pol reading was recorded. The corrected pol readings were obtained by comparing the pol reading measured with the corresponding corrected brix reading referring to Schmitz table.

3.4.13.4 Purity per cent

The ratio of sucrose per cent to the corrected brix was expressed as purity of the juice, which indicates the proportion of the sucrose in the total solids present in the juice. It was calculated at 240, 300 and 360 days after planting.

3.4.13.5 Commercial cane sugar per cent (CCS %)

The commercial cane sugar percentage is the amount of white sugar obtained commercially from the cane juice after removing total soluble solids. It was calculated by using the following formula at 240, 300 and 360 days after planting.

CCS per cent = [Sucrose per cent – (Brix per cent - Sucrose per cent) x 0.40] x 0.75.

3.4.13.6 CCS yield (t/ha)

Sugar yield was calculated from commercial cane sugar per cent as

$$\text{CCS per plot (kg)} = \frac{\text{CCS per cent} \times \text{cane yield per plot (kg)}}{100}$$

and also expressed as sugar yield per hectare using appropriate factor.

3.4.13.7 Brix yield (t/ha)

Brix yield was calculated from brix per cent as:

$$\text{Brix yield (t/ha)} = \frac{\text{Brix per cent} \times \text{cane yield (t/ha)}}{100}$$

3.4.14 Jaggery quality parameters

3.4.14.1 Colour

The color of the jaggery sample was measured by recording the optical density of 13 per cent jaggery solution at 540 nm. The experiment was repeated three times.

3.4.14.2 Sucrose (%) jaggery

The sucrose in jaggery was determined by Succhroliser by clarifying 0.5N solution of jaggery (13 gms /100ml) with lead acetate and finding out the polarization value.

3.4.14.3 Reducing sugar (%)

The reducing sugar were estimated by titration of dilute jaggery solution (10 g) dissolved in 100ml of water clarified with lead acetate with 10ml of Fehling's solution according to Lann-Eynon's volumetric methods.

3.4.14.4 Jaggery Recovery (%)

It was estimated by using following formula

$$\text{Jaggery recovery (\%)} = \frac{\text{Jaggery weight}}{\text{Juice weight taken for Jaggery}} \times 100$$

3.4.14.5 Jaggery Yield (t/ha)

Jaggery yield was estimated by using the following formula

Cane yield (t/ha) x jaggery recovery per cent

$$\text{Jaggery yield (t/ha)} = \frac{\text{Cane yield (t/ha)} \times \text{jaggery recovery per cent}}{100}$$

3.5 Statistical analysis

The data collected as explained above was subjected to the following statistical analysis.

3.5.1 Mean

On the basis of individual plant observations, the mean for each character in all the populations/progenies was computed as follows.

$$\bar{y} = \frac{1}{n} \left(\sum_{i=1}^n y_i \right)$$

Where,

$\bar{y}$ = Population mean

y_i = Individual value

n = Number of observations

3.5.2 Range

The minimum and maximum value on the basis of individual plant observations was used to indicate the range for a given character.

The structure of ANOVA for Augmented Design-II

Source of variation	df	ss	mss	F
Block	b-1	bSS	bMS	bMS / EMS
Entries	e-1	eSS	eMS	eMS / EMS
Checks	c-1	cSS	cMS	cMS / EMS
Varieties	v-1	vSS	vMS	vMS / EMS
Checks vs Varieties	1	csSS	csMS	cvMS / EMS
Error	(c-1)(v-1)	ESS	EMS	
Total	N-1	TSS		

Where, b=No. of blocks, c=No. of checks=No. of test varieties, e=c+v, N=bc+ v

Different components of ANOVA can be calculated as follows. However, since only the checks (c) but not the test varieties (v) are replicated in this design, adjustment of means of 'v' must be done before ANOVA with the help of the following effects.

Block effects (b_j) = $1/c (T b_j - c - T v b_j)$ (j= 1 to b)

$$\text{Counter check: } \sum_{j=1}^b b_j \cong 0$$

$$\text{Mean effect (m)} = 1/e \left(GT - (b-1) \sum_{j=1}^b c_j - \sum_{j=1}^b n_j b_j \right)$$

Where, n_j is the number of v occurring in j^{th} block

Check effects (c_i) = $c_i - m$ ($i = 1$ to c)

GCF (General correction factor) = GT^2/N

$$bSS = \sum_{j=1}^b T b_j^2 / (c + n_j) - GCF$$

$$bMS = bSS / (b-1)$$

$$TSS = \sum_{i=1}^c \sum_{j=1}^b c_{ij}^2 + \sum_{i=1}^c v_i - GCF$$

cCF (Check correction factor) = Tc^2/bc

$$cSS = \sum_{i=1}^c T c_i^2 / b - cCF$$

$$cMS = cSS / (c-1)$$

$$eSS = (m \times GT) + \left[\sum_{j=1}^b b_j T b_j + \sum_{i=1}^c T c_i c_i + \sum_{i=1}^c v_i v_i - \sum_{j=1}^b T^2 b_j / (c + n_j) \right]$$

$$eMS = eSS / e - 1$$

vCF (Variety correction factor) = Tv^2/v

$$vSS = \sum_{i=1}^v v_i^2 - vCF$$

$$vMS = vSS / (v-1)$$

$$cvSS = cvMS = eSS - cSS - vSS$$

$$ESS = TSS - eSS - bSS$$

$$EMS = ESS / (c-1) (b-1)$$

If the block effect is significant, following four standard errors are helpful in drawing conclusion.

$$SEd_1 \text{ (between any two check means)} = \sqrt{\frac{2EMS}{b}}$$

$$SEd_2 \text{ (between any two means of test varieties)} = \sqrt{2EMS}$$

$$SEd_3 \text{ (between any two entries of the same block)} = \sqrt{2EMS (1 + 1/c)}$$

$$SEd_4 \text{ (between means of a check and a test variety)} = \sqrt{EMS (1 + 1/b + 1/c + 1/bc)}$$

CD is then calculated using these $SEd_s \times \sqrt{t}$ at 5% or 1% levels.

3.5.2 Estimation of Variance Components

Genotypic and phenotypic components of variance were estimated with the help of following formulae.

$$\text{Genotypic Variance } (\sigma_g^2) = \text{vMSS} - \text{EMSS}$$

$$\text{Phenotypic variance } (\sigma_p^2) = \text{sg}^2 + \text{EMSS}$$

Coefficient of variability

Both genotypic and phenotypic coefficient of variability were computed for each character as per method suggested by Burton and De Vane (1953)

$$\text{Genotypic Coefficient of Variation (GCV)} = \frac{\sigma_g}{\bar{X}} \times 100$$

$$\text{Phenotypic Coefficient of Variation (PCV)} = \frac{\sigma_p}{\bar{X}} \times 100$$

Where, σ_g = genotypic standard deviation

σ_p = phenotypic standard deviation

$\bar{X}$ = grand mean of the character

GCV and PCV values were categorized as low, moderate and high as indicated by Sivasubramanian and Menon (1973).

0-10% : Low

10-20% : Moderate

20% and above : High

3.5.3 Heritability (Board Sense)

Heritability coefficient (h^2) was computed for each character as the ratio of genetic variance to the total variance as suggested by Hanson *et al.* (1956).

$$h^2 = \frac{\sigma_g^2}{\sigma_p^2} \times 100$$

Where, σ_g^2 and σ_p^2 are genotypic and phenotypic variances respectively.

The heritability was categorized as low, moderate and high as given by Robinson *et al.* (1949).

0-30% : Low

30-60% : Moderate

60% and above : High

3.5.4 Genetic advance

Genetic advance (GA) for each character was computed by adopting the formulae given by Johnson *et al.* (1955).

$$GA = h^2 KP$$

Where, K = Selection differential which is equal to 2.06 at 5 percent intensity of selection (Lush, 1949).

Genetic advance as per cent of mean (GAM)

$$\text{GAM} = \frac{\text{GA}}{\bar{X}} \times 100$$

Where, $\bar{X}$ = General mean of the character

Genetic advance as per cent mean was categorized as low, moderate and high as given by Johnson *et al* (1955).

0-10% : Low

10-20% : Moderate

20% and above : High

3.5.5 Estimation of correlations

The analysis of variance (ANOVA) and analysis of covariance (ANCOVA) was done by following method described by Cochran and Cox (1957) for all characters.

Sources of variation	DF	MSS	Expectations
Replication (r)	r-1	RMSP	
Genotypes (v)	v-1	VMSP	$\sigma e_1 + r \sigma g_2 g_2$
Error	(r-1) (v-1)	EMSP	$\sigma e_1 e_2$
Total	(rv-1)		

$$\text{COV}_{XY}(g) = \frac{\text{VMSP-EMSP}}{r}$$

$$\text{COV}_{XY}(e) = \text{EMSP}$$

$$\text{COV}_{XY}(p) = \text{COV}_{XY}(g) + \text{COV}_{XY}(e)$$

Phenotypic correlation

$$r_{XY}(p) = \frac{\text{COV}_{XY}(p)}{\sqrt{V_X(p) \times V_Y(p)}}$$

Genotypic correlation

$$r_{XY}(g) = \frac{\text{COV}_{XY}(g)}{\sqrt{V_X(g) \times V_Y(g)}}$$

Where,

$\text{COV}_{XY}(g)$ = Genotypic covariance between characters X and Y

$\text{COV}_{XY}(p)$ = Phenotypic covariance between characters X and Y

$\text{COV}_{XY}(e)$ = Error covariance between characters X and Y

$V_X(p)$ = Phenotypic variance of character X

$V_Y (p)$ = Phenotypic variance of character Y

$V_X (g)$ = Genotypic variance of character X

$V_Y (g)$ = Genotypic variance of character Y

$r_{XY} (p)$ = Phenotypic correlation coefficient among characters X and Y

$r_{XY} (g)$ = Genotypic correlation coefficient among characters X and Y

The significance of correlation coefficients were tested by comparing 'r' values at (n-2) degrees of freedom where, 'n' is number of pair of observation used.

EXPERIMENTAL RESULTS

The experimental results of present investigation for flowering, cane yield, sugar/jaggery yield and their components are presented under the following three sub headings,

- 4.1 Characterization of floral behaviour in commercial sugarcane varieties.
- 4.2 Assessment of exploitable variability and other genetic parameters in intervarietal pre-selected hybrid progeny population for flowering and productivity traits.
- 4.3 Identification of productive progenies with respect to sugar/jaggery yield and quality parameters combining non or shy flowering features

4.1 Characterization of flowering behaviour in commercial sugarcane varieties

4.1.1 Flower primordial count / Flower initiation studies

Days to flowering initiation in sugarcane genotypes were recorded from July to October based on flower primordial count of eight popular commercial genotypes (Table 1 and Fig. 1). The results are as follows, flower primordial initiation in all eight genotypes were not found till 1st week of September, where as in 3rd week of September flower primordial initiation was observed in SNK 632, SNK 044, SNK 814 and CoC 671 which ranged from 50%(CoC 671) to 70% (SNK 632).

On 1st week of October all the above four genotypes recorded 100% flower primordia initiation. In rest of the genotypes, maximum per cent floral primordial was recorded in CoM 0265 (80%) followed by SNK 814 (76%) and Co 86032 (48%), while nil (zero) primordial count was recorded in CoM 88121.

4.1.2 Intensity of flowering (%)

Average flowering intensity was recorded from December to January in eight commercial sugarcane genotypes, their results are as follows.

At 1st week of December SNK 044 recorded higher percentage of flowering (55.33%) followed by SNK 632 (51.01%), CoC 671(45.02%), Co2001-15 (43.87%), CoM 0265 (23.46%), SNK 814(19.41%) and Co 94008 (13.62%) (Table 2a).

The genotypes viz., Co 92005, Co 86032 and Co 88121 did not show flowering during 1st week of December.

At 2nd week of December SNK 044 recorded higher percentage of flowering (59.1%) followed by SNK 632 (52.0%), Co2001-15 (50.7%), CoC 671 (47.8%), SNK 814 (35.4%), CoM 0265 (27.0%) and Co 94008 (20.8%). The genotypes viz., Co 92005, Co 86032 and Co 88121 did not recorded flowering during 2nd week of December. (Table 2b).

At end of 3rd week of (20th Dec) SNK 044 recorded higher percentage of flowering (60.4%) followed by SNK 632 (55.9 %), Co2001-15 (53.5 %), CoC 671 (49.2%), SNK 814(40.0%), CoM 0265 (30.5%) and Co 94008 (21.5%) (Table 2c).

The genotypes viz., Co 92005, Co 86032 and Co 88121 did not recorded flowering during end of 3rd week of December.

On mid January(11th Jan) CoC 671 recorded higher percentage of flowering (88.6%) followed by SNK 044(69.2), SNK 632 (59.8%), Co2001-15 (57.6%), CoM 265(55.13%), SNK 814(52.5%) and Co 94008(25.1%) (Table 2d and Fig. 2).

Co 92005 recorded lowest (8.7%) percentage of flowering during mid January. The genotypes viz., Co 86032 and Co 88121 did not recorded flowering during the season studied

4.1.3 Juice analysis of the Profuse, shy and non flowering genotypes

4.1.3.1 Average single cane weight (Kg)

Overall both profuse flowering and shy/non flowering genotypes shown increasing average single cane weight over months (8 to 12 month) i.e. October to February. Shy/Non flowering varieties are recorded higher SCW (1.19 to 1.38) compared to profuse flowering genotypes (1.28 to 1.33, respectively) (Table 3).

Table 1: Flower primordial count in commercial sugarcane varieties across different dates during flower induction period

Date	SNK044	SNK 632	CoC671	Co94008	CoM265	SNK814	Co86032	CoM 88121
20/7/2012	0	0	0	0	0	0	0	0
5/8/2012	0	0	0	0	0	0	0	0
20/8/2012	0	0	0	0	0	0	0	0
5/9/2012	0	0	0	0	0	0	0	0
20/9/2012	30 (60%)	35 (70%)	25 (50%)	0	0	27 (54%)	0	0
10/10/2012	50 (100%)	50 (100%)	50 (100%)	50 (100%)	40 (80%)	38 (76%)	24 (48%)	0

Values in the parenthesis are percent of total value.

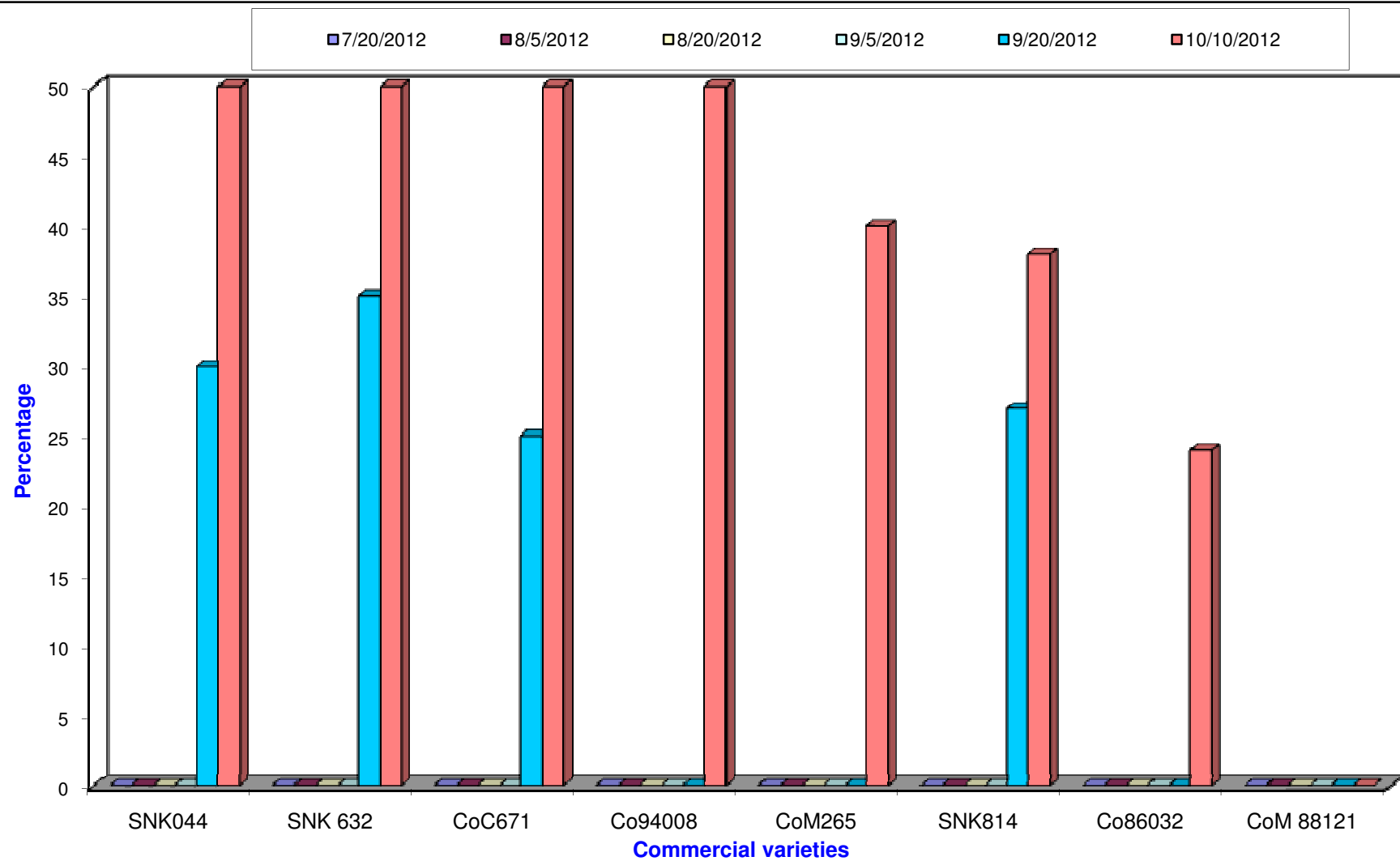


Fig. 1: Flower primordial count in commercial sugarcane varieties across different dates during flower induction period

Table 2a: Flowering intensity (%) studies in commercial sugarcane varieties during December first week

Date of observation: 1/12/2012

Entries	(%) Flag leaf	(%) Arrow emerging	(%) Fully flowered	Total flowered shoots	Total shoots	(%) Flowering
SNK 044	16	11	17	44	79.52	55.3
Co2001-15	10	9	13	32	72.95	43.9
SNK 632	49	3	0	52	101.95	51.0
Co 94008	19	0	0	19	139.52	13.6
SNK 814	17	0	0	17	87.58	19.4
CoM 265	20	0	0	20	85.25	23.5
CoC 671	32	0	0	32	71.08	45.0
Co 92005	0	0	0	0	68.95	0
Co 86032	0	0	0	0	82.65	0
COM 88121	0	0	0	0	87.72	0

* - Two addition popular commercial varieties were also included for flowering intensity study

Table 2b: Flowering intensity (%) studies in commercial sugarcane varieties during December second week

Date of observation : 11/12/2012

Entries	(%) Flag leaf	(%) Arrow emerging	(%) Fully flowered	Total flowered shoots	Total shoots	(%) Flowering
SNK 044	19	12	16	47	79.52	59.1
Co2001-15	13	11	13	37	72.95	50.7
SNK 632	19	20	14	53	101.95	52.0
Co 94008	15	6	8	29	139.52	20.8
SNK 814	15	10	6	31	87.58	35.4
CoM 265	23	0	0	23	85.25	27.0
CoC 671	18	12	4	34	71.08	47.8
Co 92005	0	0	0	0	68.95	0
Co 86032	0	0	0	0	82.65	0
COM 88121	0	0	0	0	87.72	0

* - Two addition popular commercial varieties were also included for flowering intensity study

Table 2c: Flowering intensity (%) studies in commercial sugarcane varieties during December third week

Date of observation: 20/12/2012

Entries	(%) Flag leaf	(%) Arrow emerging	(%) Fully flowered	Total flowered shoots	Total shoots	(%) Flowering
SNK 044	12	9	27	48	79.52	60.4
Co2001-15	13	8	18	39	72.95	53.5
SNK 632	15	18	24	57	101.95	55.9
Co 94008	8	7	15	30	139.52	21.5
SNK 814	24	3	8	35	87.58	40.0
CoC 671	20	6	9	35	71.08	49.2
CoM 265	26	0	0	26	85.25	30.5
Co 92005	0	0	0	0	68.95	0
Co 86032	0	0	0	0	82.65	0
COM 88121	0	0	0	0	87.72	0

* - Two addition popular commercial varieties were also included for flowering intensity study

Table 2d: Flowering intensity (%) studies in commercial varieties during January first week

Date of observation: 11/1/2013

Entries	(%) Flag leaf	(%) Arrow emerging	(%) Fully flowered	Total flowered shoots	Total shoots	(%) Flowering
SNK 044	17	13	25	55	79.52	69.2
Co2001-15	12	14	16	42	72.95	57.6
SNK 632	12	16	33	61	101.95	59.8
Co 94008	12	7	16	35	139.52	25.1
SNK 814	10	10	26	46	87.58	52.5
CoM 265	25	12	10	47	85.25	55.1
CoC 671	16	14	33	63	71.08	88.6
Co 92005	6	0	0	6	68.95	8.7
Co 86032	0	0	0	0	82.65	0
COM 88121	0	0	0	0	87.72	0

* - Two addition popular commercial varieties were also included for flowering intensity study

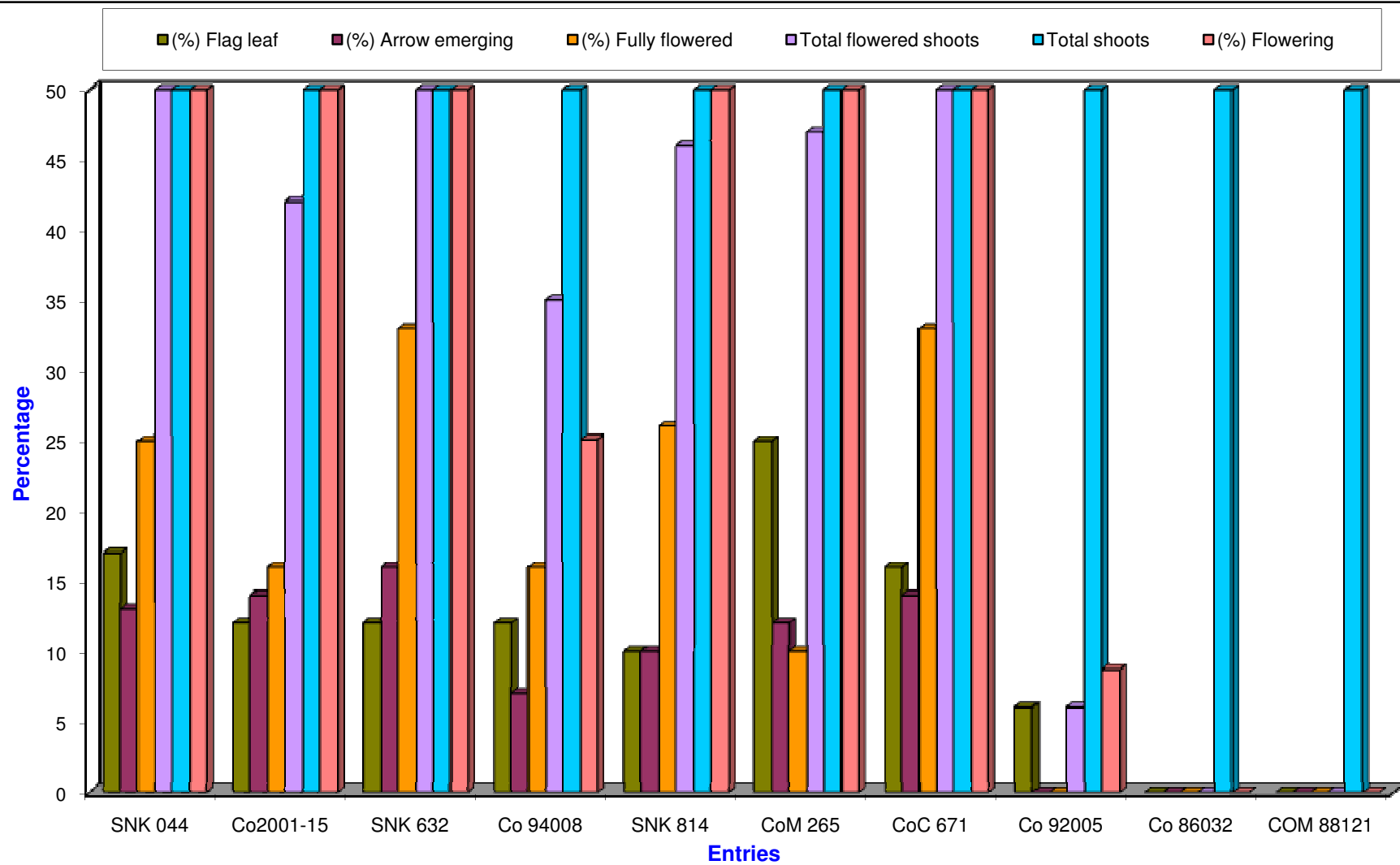


Fig. 2: Flowering intensity (%) studies in commercial varieties during January first week

Among profuse flowering genotypes CoC 671, SNK 814 and CoM 0265 shown reduction in single cane weight (1.4 to 0.99, 1.41 to 1.3 and 1.61 to 1.3 respectively) over months and remaining four profuse flowering genotypes has shown increasing in single cane weight i.e SNK 632, SNK 044, Co 2001-15 and CO 94008 (0.85 to 1.47, 1.08 to 1.09, 1.32 to 1.53 and 1.32 to 1.61 respectively).

Among shy/non flowering genotypes Co 92005 shown reduction in single cane weight (1.44 to 1.31) which recorded lesser flower intensity (8.7%) and other two genotypes Co86032 and CoM88121 shown increase in single cane weight i.e (1.1 to 1.4 and 1.02 to 1.38 respectively), which remain non flowering during the season.

4.1.3.2 Brix (%) juice

Both profuse and shy/non flowering genotypes have shown increasing trend in brix % juice over months (8 to 12 month) i.e. October to February. Shy/Non flowering varieties were recorded higher brix % juice compare to profuse flowering checks. (11.48 to 19.52 and 11.74 to 19.33 respectively) (Table 3).

Among profuse flowering genotypes all seven genotypes shown increasing brix % juice over months i.e SNK 632, SNK 044, Co 2001-15, CO 94008, CoC 671, SNK 814 and CoM 265 (9.9 to 18.7, 13.1-22.2, 10.9-18.2, 13.2-18.5, 13.7-19.8, 9.8-18.2 and 11.6-19.7 respectively).

Among shy/non flowering genotypes all three genotypes shown increasing brix % juice over months i.e Co 92005, Co 86032 and CoM 88121 (11.3-18.7, 10.3-18.7 and 12.8 – 21.2 respectively).

4.1.3.3 Sucrose (%) juice

All the genotypes shown increasing sucrose % juice over months (8 to 12 month) i.e October to February. Shy/Non flowering varieties are recorded higher sucrose % juice compare to profuse flowering checks. (8.91 to 18.47 and 8.92 to 17.54 respectively) (Table 3).

Among profuse flowering genotypes all seven genotypes shown increasing sucrose % juice over months i.e SNK 632, SNK 044, Co 2001-15, CO 94008, CoC 671, SNK 814 and CoM 265 (6.3-16.5, 10.2-17.2, 8.8-17.6, 10.4-17, 11.7-18.4, 6.4-18.4 and 8.7-17.8 respectively).

Among shy/non flowering genotypes all three genotypes shown increasing sucrose % juice over months i.e Co 92005, Co 86032 and CoM 88121 (9.2-18.1, 7.7-17.6 and 9.8-19.7 respectively).

4.1.3.4 Juice extraction (%)

All the commercial varieties shown increasing juice extraction % over months (8 to 12 month) i.e. October to February. Shy/Non flowering varieties were recorded lower juice extraction % (55.98 to 63.59) compare to profuse flowering genotypes (58.24 to 65.58 respectively).

Among profuse flowering genotypes CoC 671 shown reduction in juice extraction % (66.7 to 64.1) over months and remaining six profuse flowering genotypes viz., SNK 632, SNK 044, Co 2001-15, CO 94008, SNK 814 and CoM 0265 has shown increasing trend, i.e (57-83.9, 54.7-58.8, 59.2-62.5, 53.62.6, 54.4-64 and 62.6 – 63.2 respectively) (Table 4).

Among shy/non flowering genotypes Co 92005 shown reduction in juice extraction % (63.2-62.2) and other two genotypes Co86032 and CoM88121 shown increasing trend in juice extraction % i.e. (55.2 to 68 and 49.5 to 60.5 respectively).

4.1.3.5 CCS (%) juice

All commercial genotypes studied shown increasing trend CCS% juice over months (i.e from 8 month to 12 month). Shy/Non flowering varieties recorded higher CCS % juice compare to profuse flowering genotypes (5.9 to 13.3 and 5.7 to 12.3 respectively) (Table 4).

Among profuse flowering genotypes all seven genotypes shown increasing CCS % juice over months i.e SNK 632, SNK 044, Co 2001-15, CO 94008, CoC 671, SNK 814 and CoM 265 (3.5 – 11.4, 6.6- 11.1, 5.8-12.7, 6.8-12.1, 5.5-12.8, 3.7-13 and 8- 13 respectively).

Among shy/non flowering genotypes all three genotypes shown increasing CCS % juice over months i.e. Co 92005, Co 86032 and CoM 88121 (6.1-13.1, 4.8-12.3 and 6.8-14.5 respectively).

Table 3: Studies on single cane weight and juice quality parameters of flowering and non flowering sugarcane commercial varieties

Entries	SCW (kg)				Brix (%)				Sucrose (%)				Flowering (%)			
	Pre Flowering		Post flowering		Pre Flowering		Post flowering		Pre Flowering		Post flowering					
	8M	10M	11M	12M	8M	10M	11M	12M	8M	10M	11M	12M	8M (15th Oct)	10M (15th Dec)	11M (15th Jan)	12M (15 Feb)
Profuse Flowering																
SNK 044	1.08	1.25	1.12	1.09	13.1	19.7	19.4	22.2	10.2	17.4	16.1	17.2	0	58.3	69.2	69.2
Co 2001-15	1.32	1.33	1.53	1.53	10.9	16.7	20.9	18.2	8.8	15.0	18.0	17.6	0	49.4	57.6	57.6
SNK 632	0.85	2.02	1.74	1.47	9.9	14.8	14.3	18.7	6.3	13.7	12.5	16.5	0	53.0	59.8	59.8
Co 94008	1.32	1.35	1.44	1.61	13.2	15.4	16.5	18.5	10.4	14.1	14.9	17.0	0	18.6	25.1	25.1
SNK 814	1.41	1.24	1.32	1.30	9.8	13.6	21.0	18.2	6.4	10.2	17.9	18.4	0	31.6	52.5	52.5
CoM 265	1.61	1.74	1.73	1.30	13.7	16.5	16.3	19.8	11.7	15.7	15.5	18.4	0	33.2	43.4	43.4
CoC 671	1.40	1.19	1.08	0.99	11.6	15.2	21.4	19.7	8.7	13.1	18.6	17.8	0	41.1	88.6	88.6
MEAN	1.28	1.44	1.42	1.33	11.7	16.0	18.5	19.3	8.9	14.2	16.2	17.5	0	40.7	56.6	56.6
S E	0.09	0.12	0.10	0.09	0.6	0.7	1.1	0.5	0.8	0.8	0.8	0.3	0	5.3	7.5	7.5
C D	0.33	0.41	0.35	0.30	2.1	1.4	3.7	0.9	2.6	2.3	2.8	0.9	0	18.2	26.0	26.0
Shy/ Non Flowering																
Co 92005	1.44	1.28	1.31	1.31	11.3	14.0	20.7	18.7	9.2	11.8	17.0	18.1	0	0.0	8.7	8.7
Co86032	1.10	1.22	1.52	1.40	10.3	15.6	19.4	18.7	7.7	13.7	17.6	17.6	0	0.0	0.0	0.0
COM 88121	1.02	1.21	1.31	1.38	12.8	15.9	19.4	21.2	9.8	12.8	16.5	19.7	0	0.0	0.0	0.0
MEAN	1.19	1.24	1.38	1.36	11.5	15.2	19.9	19.5	8.9	12.8	17.0	18.5	0	0.0	2.9	2.9
S E	0.13	0.02	0.07	0.03	0.7	0.6	0.4	0.8	0.6	0.6	0.3	0.6	0	0.0	2.9	2.9
C D	0.78	0.14	0.42	0.17	4.4	3.6	2.6	5.0	3.9	3.4	1.9	3.8	0	0.0	17.6	17.6

Table 4: Studies on juice quality parameters of flowering and non flowering sugarcane commercial varieties

Entries	Juice Extraction (%)				Purity (%)				CCS (%)				Flowering (%)			
	Pre Flowering		Post flowering		Pre Flowering		Post flowering		Pre Flowering		Post flowering					
	8M	10M	11M	12M	8M	10M	11M	12M	8M	10M	11M	12M	8M (15th Oct)	10M (15th Dec)	11M (15th Jan)	12M (15 Feb)
Profuse Flowering																
SNK 044	54.7	64.1	67.1	58.8	77.2	88.5	83.0	77.4	6.6	12.0	10.8	11.1	0	58.3	69.2	69.2
Co 2001-15	59.2	61.3	54.0	62.5	80.3	89.4	85.7	97.0	5.8	10.5	12.2	12.7	0	49.4	57.6	57.6
SNK 632	57.0	59.2	72.2	83.9	63.4	92.3	87.9	88.3	3.5	9.7	8.6	11.4	0	53.0	59.8	59.8
Co 94008	53.0	57.2	61.3	62.6	78.7	91.2	90.5	93.5	6.8	9.9	10.4	12.1	0	18.6	25.1	25.1
SNK 814	54.4	58.2	58.8	64.0	65.1	76.0	85.2	92.7	3.7	6.5	12.2	13.0	0	31.6	52.5	52.5
CoM 265	62.6	56.2	59.2	63.2	85.4	95.0	95.2	93.3	8.0	11.2	11.1	13.0	0	33.2	43.4	43.4
CoC 671	66.7	52.4	61.4	64.1	74.1	86.3	87.0	95.6	5.5	9.0	12.8	12.8	0	41.1	88.6	88.6
MEAN	58.24	58.36	62.01	65.58	74.87	88.38	87.79	91.11	5.7	9.8	11.2	12.3	0	40.7	56.6	56.6
S E	1.88	1.42	2.25	3.13	3.04	2.31	1.52	2.51	0.62	0.67	0.53	0.30	0	5.3	7.5	7.5
C D	6.52	4.91	7.78	10.81	10.52	8.00	5.26	8.69	2.14	2.33	1.83	1.04	0	18.2	26.0	26.0
Shy/ Non Flowering																
Co 92005	63.2	61.3	61.2	62.2	81.8	83.5	82.1	97.0	6.1	7.9	11.3	13.1	0	0.0	8.7	8.7
Co86032	55.2	60.8	66.9	68.0	74.2	87.7	90.4	90.5	4.8	9.5	12.3	12.3	0	0.0	0.0	0.0
COM 88121	49.5	54.5	58.7	60.5	76.6	80.5	84.9	99.0	6.8	8.5	11.2	14.5	0	0.0	0.0	0.0
MEAN	55.98	58.86	62.28	63.59	77.53	83.91	85.83	95.52	5.9	8.6	11.6	13.3	0	0.0	2.9	2.9
S E	3.99	2.18	2.42	2.27	2.23	2.10	2.44	2.56	0.57	0.45	0.35	0.63	0	0.0	2.9	2.9
C D	24.27	13.26	14.72	13.81	13.55	12.75	14.83	15.57	3.44	2.72	2.11	3.84	0	0.0	17.6	17.6

4.1.3.6 Purity (%) juice :

The increasing trend was recorded for purity % juice over months (*i.e* from 8 month to 12 month) in the genotypes studied. Shy/Non flowering varieties are recorded higher purity % juice compare to profuse flowering checks. (77.53 to 95.52 and 74.87 to 91.11 respectively) (Table 4).

Among profuse flowering genotypes all seven genotypes SNK 632, SNK 044, Co 2001-15, CO 94008, CoC 671, SNK 814 and CoM 0265 have shown increasing trend for purity % juice over months *i.e* (63.4-88.3, 77.2-77.4, 80.3-97, 78.7-93.5, 74.1-95.6, 65.1-92.7 and 85.4-93.3, respectively). Similarly all three shy/ non flowering genotypes have recorded increase in purity % juice over months.

4.2 Assessment of exploitable variability and other genetic parameters in intervarietal pre-selected hybrid progeny population for flowering and productivity traits

Analysis of variance showed that source of variation due to blocks showed non significant, which indicates blocks are homogenous. Whereas, all the characters showed statistically significant variation which indicates sufficient amount of variability present in pre-selected progeny population. (Table 5) and adjusted mean for all the characters studied are presented in Appendix II.

Significant difference were found among the checks and varieties to cane yield and CCS yield.

4.2.1 Genetic parameters for cane yield and its components in 145 genotypes and checks of sugarcane (8 Months)

The mean, range, genotypic coefficients of variability (GCV) and phenotypic coefficients of variability (PCV), heritability estimates (h^2_{bs}), genetic advance and the genetic advance over mean (GAM) predicted as per cent of mean in respect of these traits are given in Table 6.

4.2.1.1 Average Single cane weight (kg)

This trait exhibited a range from 0.96kg to 1.99 kg and overall mean of 1.34. Among 145 genotypes lowest single cane weight was recorded in SNK 09214 (0.96 kg) and highest in SNK 09293 (1.99 kg).

Estimates of genotypic (23.36%) and phenotypic (24.92%) coefficient of variations were high for this character. This is evident from the high heritability estimate (87.86%) and high GAM (45.10%).

4.2.1.2 Average millable cane height (cm)

The overall mean value for cane height was 193.31cm with a range 128.30 cm to 253.30cm, imparting high variability among the clones flowering and non flowering types. Out of 145 genotypes, higher cane height recorded in SNK 09443 (253.33) and lowest in SNK09053 (128.3).

The moderate phenotypic (15.31) and genotypic (14.77) coefficients of variation were observed for this trait, with high heritability (93.11%) estimates and genetic advance over mean to the extent of 29.36 per cent.

4.2.1.3 Number of internodes (NI)

The variation for this trait was considerably high as evident from the wide range observed (9.30 to 20.60). The mean number of internodes was 15.67. Among 145 genotypes higher number of internodes was recorded in SNK 09230 (20.6) and lowest in SNK 09053 (9.3).

A moderate phenotypic (14.42) and genotypic (13.78) coefficients of variation were observed for number of internodes. This attribute exhibited high heritability estimate (91.31%) with high GAM (27.12%).

4.2.1.4 Internodal length (cm)

The internodal length imparted higher variability with mean values ranging from 8.50 to 14.84 and with overall mean of 12.52 cm. Among 145 genotypes higher internodal length was recorded in SNK 09235 (14.84) and lowest in SNK 09107 (8.5).

Table 5: Augmented ANOVA for important quantitative characters in sugarcane

Source	df	Mean sum of squares													
		S.C.W	J.W	C.H	CG	INT	IL	Brix (%)	Sucrose (%)	JE (%)	CCS (%)	Purity (%)	NMC ('000/ha)	CY (t/ha)	CCS Yield (t/ha)
Blocks	3	11.5	7.5	347939.4	58.7	2355.6	1087.0	1624.9	1284.1	25903.5	11.9	53279.4	55196.5	89919.4	814.3
Entries	144	4.5**	5.1**	7813.6**	30.4**	46.2**	19.4**	29.9**	24.9**	527.4**	5.0**	1087.1**	1613.2**	2234.5**	21.7**
Checks	5	2.00	3.01	1120.01	12.01	430.01	110.01	224.01	492.01	3421.01	4.48	2140.01	7650.01	7780.01**	430.01**
Varieties	139	7.1	4.0**	92.66**	10.01**	210.16*	120.32*	187.37	165.70	2451.27	14.59	537.44	1123.39*	619.89**	1320.54*
Checks Vs Varieties	1	12.8	10.6	1135529.6**	54.7**	6770.5	2806.9	4338.7	3554.5	77349.6	117.8	158760.2	233846.4	325659.2**	3110.7**
Error	5	1.1	1.4	67129.7	11.7	465.6	210.4	315.3	244.1	5097.3	8.5	10404.3	10859.8	17844.2	154.6

SCW : Single cane weight

CH : Cane height

IL : Intermodal length

NMC : Number of millable cane

CG : Cane girth

JE : Juice extraction

CY : Cane yield

INT : Number of internodes

CCS : Commercial cane sugar

CCS Y : Commercial cane sugar yield

Table 6: Genetic parameters for cane yield and its components in 145 genotypes of sugarcane (8 Months)

Sl. No	Characters	Mean	Range		GCV	PCV	h ²	GA	GAM
			Min	Max					
1	Average Single cane weight (kg)	1.34	0.96	1.99	23.36	24.92	87.86	0.61	45.10
2	Average millable cane height (cm)	193.31	128.30	253.30	14.77	15.31	93.11	56.76	29.36
3	Average number of internodes	15.67	9.30	20.60	13.78	14.42	91.31	4.25	27.12
4	Average internodal length (cm)	12.52	8.50	14.84	17.23	18.44	87.31	4.15	33.17
5	Brix %	12.13	9.91	16.06	13.16	14.26	85.16	3.03	25.02
7	Sucrose %	9.39	5.26	14.92	24.96	26.56	88.34	4.54	48.33
8	Juice extraction %	63.14	53.46	69.87	7.56	9.70	60.70	7.66	12.13
8	CCS %	6.06	2.39	10.56	32.24	35.52	82.42	3.65	60.30
9	Purity %	76.10	51.52	97.21	17.20	18.66	84.95	24.85	32.66

GCV: Genotypic co efficient of variance.
GA : Genetic advance

PCV : Phenotypic co efficient of variance h²: Heritability %
GAM : Genetic advance over mean

The phenotypic coefficient of variation (18.44) and genotypic coefficient of variation recorded (17.23) were high. The hybrid progenies expressed relatively high heritability estimate (87.31%) coupled with high GAM (33.17%) for this trait.

4.2.1.5 Brix (%) juice

The attribute recorded the Brix % with range of 9.91 to 16.06 with overall mean of 12.13. Among 145 genotypes higher Brix % juice was recorded in SNK 09211(16.06) and lowest in SNK 09217 (9.91).

The genotypic coefficient of variation (13.16) and phenotypic coefficient of variation (14.26) were moderate for this trait. The heritability estimate was high (85.16%) whereas, GAM (25.02) was high for this attribute.

4.2.1.6 Sucrose (%) juice

The trait exhibited general mean of 9.39 % with mean values ranging from 5.26 per cent (SNK 09350) to 14.92% (SNK 09107).

The genotypic and phenotypic coefficient of variations were moderate for this trait, *i.e* (24.96%) and (26.56%) respectively. The heritability estimate was high (88.34%) with high genetic advance over mean (48.33%).

4.2.1.7 Juice extraction (%) juice

For this trait the mean values were ranged from 53.46 to 69.87% with a general mean of 63.14%. Among 145 genotypes higher juice extraction % juice was recorded in SNK 09243 (69.87) and lowest in SNK 09334 (53.46).

The genotypic coefficient of variation (7.56) and phenotypic coefficient of variation (9.70) were moderate for this trait. Moderate estimates of heritability (60.7) and genetic advance over mean (12.31%) were recorded for this trait.

4.2.1.8 CCS (%) juice

The mean values for CCS % juice ranged from 2.39 to 10.56 with a mean of 6.06. Among 145 genotypes higher CCS % juice was recorded in SNK 09107 (10.56) and lowest in SNK 09063 (2.39).

The coefficient of variation at phenotypic and genotypic levels was high to the extent of 35.52 and 32.24, respectively. Heritability estimate was high (82.42%) with high amount of genetic advance over mean (60.30%).

4.2.1.9 Purity (%) juice

The Purity % values ranged from 51.52 to 97.21 with a mean value of 76.10. Among 145 genotypes higher juice purity % was recorded in SNK 09115 (97.21) and lowest in SNK 09063 (51.52).

There exist low genotypic and phenotypic coefficients of variation for this trait 17.20 and 18.6. Whereas heritability estimate was high (84.95%) and GAM was also high (32.66).

4.2.1 Genetic parameters for cane yield, sugar yield and its components in 145 genotypes of sugarcane (10 Months)

4.2.2.1 Average single cane weight (kg)

This trait exhibited a range from 0.78 and 1.93 with overall mean of 1.33. Among 145 genotypes higher single cane weight was recorded in SNK 09450 (1.98) and lowest in SNK 09233(0.78) (Table 7).

Estimates of genotypic (24.05%) and phenotypic (25.36%) coefficient of variations was high for this character. This is evident from the high heritability estimate (89.91%) and high GAM (46.99%).

4.2.2.2 Average millable cane height (cm)

The overall mean value for cane height was 223.40, with a range 140.00 to 306.00 imparting high variability among the clones of flowering and non flowering types. Out of 145 genotypes higher cane height recorded in SNK 09077(306) and lowest in SNK09265 (140).

Table 7: Genetic parameters for cane yield and its components in 145 genotypes of sugarcane (10 Months)

Sl. No	Characters		Range		GCV	PCV	h ²	GA	GAM
		Mean	Min	Max					
1	Average Single cane weight (kg)	1.33	0.78	1.93	24.26	25.16	92.94	0.64	48.17
2	Average juice weight (kg)	0.81	0.44	1.11	25.44	26.63	91.23	0.41	50.05
3	Average millable cane height (cm)	223.40	140.00	306.00	15.30	15.87	92.94	67.86	30.38
4	Average cane girth (cm)	2.68	2.26	3.63	9.46	13.22	51.22	0.37	13.95
5	Average number of internodes	18.18	14.30	24.00	12.85	14.07	83.40	4.39	24.18
6	Average internodal length (cm)	12.38	7.50	16.00	13.88	15.60	79.21	3.15	25.46
7	Brix %	15.22	10.29	17.86	13.61	14.69	85.84	3.95	25.98
8	Sucrose %	13.36	8.01	17.23	18.14	19.81	83.86	4.57	34.22
9	Juice extraction %	61.29	47.18	71.88	8.58	11.14	59.36	8.35	13.62
10	CCS %	9.21	5.18	12.39	20.96	23.50	79.51	3.55	38.50
11	Purity %	87.37	77.00	97.09	9.23	9.96	85.95	15.41	17.64

GCV: Genotypic co efficient of variance.
GA : Genetic advance

PCV : Phenotypic co efficient of variance h²: Heritability %
GAM : Genetic advance over mean

The phenotypic (15.87) and genotypic (15.30) coefficients of variation were highest for millable cane height. The heritability estimate was high (92.94%) with high genetic advance over per cent of mean (30.38).

4.2.2.3 Average cane girth (cm)

The average cane girth ranged from 2.26 to 3.63cm with overall mean of 2.68cm. SNK 09005(3.63) shown higher value for this trait and SNK09443 (2.26) shown lowest value.

The genotypic and phenotypic coefficients of variation were 9.46 and 13.22 respectively. The heritability estimate (51.22%) was moderate with moderate GAM of 13.95 per cent.

4.2.2.4 Number of internodes (NI)

The variation for this trait was considerably high as evident from the wide range observed (14.30 to 24.00). The mean number of internodes was 18.18. Among 145 genotypes higher number of internodes was recorded in SNK 09274 (24) and lowest in SNK 09549 (14).

A moderate phenotypic (14.07) and genotypic (12.85) coefficients of variation were observed for number of internodes. This attribute exhibited high heritability estimate (83.40%) with high GAM (24.18%).

4.2.2.5 Internodal length (cm)

The internodal length imparted higher variability with mean values ranging from 7.50 to 16.00 and with overall mean of 12.38 cm. Among 145 genotypes higher internodes length was recorded in SNK 09230 (16) and lowest in SNK 09063 (7.5).

The phenotypic coefficient of variation (15.60) and genotypic coefficient of variation recorded (13.88) were high. The hybrid progenies expressed relatively high heritability estimate (79.21%) coupled with high GAM (25.46%) for this trait.

4.2.2.6 Brix (%) juice

The attribute, brix % juice recorded a range of 10.29 to 17.86 with overall mean of 15.22. Among 145 genotypes higher Brix % juice was recorded in SNK 09452 (17.86) and lowest in SNK 09063 (10.29).

The genotypic coefficient of variation (13.61) and phenotypic coefficient of variation (14.69) were moderate for this trait. The heritability (85.84%) and GAM (25.98) were high for this attribute.

4.2.2.7 Sucrose (%) juice

The trait exhibited general mean of 13.36 per cent with mean values ranging from 8.01 to 17.23 per cent *i.e.* highest and lowest genotypes are SNK 09421 and SNK 09509 respectively.

The genotypic and phenotypic coefficient of variations were moderate for this trait, *i.e.* 18.14 and 19.81 per cent respectively. The heritability estimate was high (83.86%) with moderately high genetic advance over mean (34.22%).

4.2.2.8 Juice extraction (%) juice

For this Juice extraction %, the mean values were ranged from 47.18 to 71.88 with a general mean of 61.29. Among 145 genotypes higher juice extract % juice was recorded in SNK 09243 (71.88) and lowest in SNK 09334 (47.18).

The genotypic coefficient of variation (8.58) and phenotypic coefficient of variation (11.14) were moderate for this trait. Heritability estimate was moderate (59.36%) with moderate amount of genetic advance over mean (13.62%).

4.2.2.9 CCS (%) juice

The mean values for this CCS % ranged from 5.18 to 12.39 with a mean of 9.21. Among 145 genotypes higher CCS % juice was recorded in SNK 09421 (12.39) and lowest in SNK 09509 (5.18).

The coefficient of variation at phenotypic and genotypic levels was high 20.96 and 23.50, respectively. Heritability estimate was high (79.51%) with high amount of genetic advance over mean (38.50%).

4.2.2.10 Purity (%) juice

The Purity % values ranged from 77.00 and 97.09 with a mean value of 87.37. Among 145 genotypes higher purity % juice was recorded in SNK 09509 (97.09) and lowest in SNK 09268 (77.00).

There exist low genotypic (9.23) and phenotypic 9.96 coefficients of variation for this trait whereas, heritability estimate was high (85.95) and GAM was also moderate (17.64).

4.2.2 Genetic parameters of selected clones in clonal generation for various traits

Sixty five clones were advanced to clonal II based on their superiority or on par productivity traits compared to commercial checks. The mean, range, genotypic coefficients of variability (GCV), phenotypic coefficients of variability (PCV), heritability estimates (h^2), genetic advance and the genetic advance over mean (GAM) predicted as per cent of mean in respect of these traits are given in Table 8.

4.2.3.1 Average Single cane weight (kg)

This trait exhibited a range from 0.86 and 2.05 overall mean of 1.36. Among top productive clones higher single cane weight was recorded in SNK 09450 (2.05) and lowest in SNK 09607 (0.86).

Estimates of genotypic (24.68%) and phenotypic (25.50%) coefficient of variations were high for this character. This is evident from the high heritability estimate (93.70%) and high GAM (49.22%).

4.2.3.2 Average millable cane height (m)

The overall mean value for cane height was 2.28m, with a range of 1.45 to 3.41, imparting high variability among the clones of flowering and non flowering types. Among top productive clones higher cane height was recorded in SNK 09110 (3.41) and lowest in SNK 09061 (1.45).

The phenotypic (17.84) and genotypic (17.37) coefficients of variation were highest for cane height. The heritability estimate was high (94.79%) with high genetic advance over per cent of mean (34.84%).

4.2.3.3 Average cane girth (cm)

The average cane girth ranged from 2.20 to 3.10cm with overall mean of 2.68. Among top productive clones thickest cane girth was recorded in SNK 09554 (3.10) and thinnest in SNK 09230 (2.20).

The genotypic and phenotypic coefficients of variation were 10.25 and 12.62 respectively. The heritability estimate was high (65.99%) with low GAM of 17.16 per cent.

4.2.3.4 Number of internodes (NI)

The variation for this trait was considerably high as evident from the wide range observed (14.30 to 25.00). The mean number of internodes was 19.14 among top productive clones higher number of internodes was recorded in SNK 09450 (25.00) and lowest in SNK 09183 (14.30).

A moderate phenotypic (12.53) and genotypic (12.04) coefficients of variation were observed for number of internodes. This attribute exhibited high heritability estimate (92.30%) with high GAM (23.82%).

4.2.3.5 Internodal length (cm)

The internodal length imparted higher variability with mean values ranging from 7.00 to 21 and with overall mean of 12.0 cm. Among top productive clones highest internodal length was recorded in SNK 09183 (21) and lowest in SNK 09 061 (7.00).

The phenotypic coefficient of variation (19.8) and genotypic coefficient of variation recorded (17.03) were high. The hybrid progenies expressed relatively high heritability estimate (74.02%) coupled with high GAM (30.19%) for this trait.

4.2.3.6 Brix (%) juice

The attribute recorded the brix % with range of 17.15 to 22.18 with overall mean of 18.87. Among top productive clones highest brix % juice was recorded in SNK 09212 (22.18) and lowest in SNK 09271 (17.15).

Table 8: Genetic parameters for various quantitative characters of 65 genotypes of sugarcane (12 month)

Sl. No.	Characters	Mean	Range		GCV	PCV	h ²	GA	GAM
			Min	Max					
1	Average Single cane weight (kg)	1.36	0.86	2.05	24.68	25.50	93.70	0.67	49.22
2	Average Juice weight (kg)	0.83	0.51	1.23	28.71	29.82	92.70	0.47	56.95
3	Average millable cane height (m)	2.28	1.45	3.41	17.37	17.84	94.79	0.80	34.84
4	Average cane girth (cm)	2.68	2.20	3.10	10.25	12.62	65.99	0.46	17.16
5	Average number of internodes	19.14	14.30	25.00	12.04	12.53	92.30	4.56	23.82
6	Average internodal length (cm)	12.0	7.00	21.0	17.03	19.8	74.02	0.04	30.19
7	Brix%	18.87	17.15	22.18	11.69	12.57	86.53	4.23	22.41
8	Sucrose%	17.16	14.60	21.97	14.24	15.49	84.56	4.63	26.98
9	JE %	60.82	56.20	70.45	13.52	14.26	89.83	16.05	26.39
10	CCS %	12.68	9.36	16.00	13.24	14.48	83.54	3.16	24.92
11	Purity %	90.77	75.80	99.81	6.16	6.62	86.58	10.71	11.80
12	Number of millable canes ('000/ha)	123.80	76.80	175.18	24.12	24.93	93.62	59.52	48.08
13	Cane yield (t/ha)	157.12	127.51	188.50	13.86	14.41	92.52	43.15	27.46
14	CCS yield (t/ha)	14.50	7.11	21.48	27.38	28.73	90.84	7.80	53.76
15	Flowering %	17.23	0	64	88.04	91.63	92.32	30.01	174.2

GCV: Genotypic co efficient of variance.
GA : Genetic advance

PCV : Phenotypic co efficient of variance
GAM : Genetic advance over mean

h²: Heritability %

The genotypic coefficient of variation (11.69) and phenotypic coefficient of variation (12.57) were moderate for this trait. The heritability (86.53%) and GAM (22.41) estimates were high for this attribute.

4.2.3.7 Sucrose (%) juice

The trait exhibited general mean of 17.16 per cent with mean values ranging from 14.60 to 21.97 per cent. Among top productive clones highest sucrose % juice was recorded in SNK 09212 (21.97) and lowest in SNK 09554 (14.60).

The genotypic and phenotypic coefficient of variations were moderate for this trait, *i.e.* (14.24%) and (15.49%) respectively. The heritability estimate was high (84.56%) with high genetic advance over mean (26.98%).

4.2.3.8 Juice extraction (%) juice

For this juice extraction trait the mean values were ranged from 56.20 to 70.45 with a general mean of 60.82. Among top productive clones highest juice extraction % was recorded in SNK 09377 (70.45) and lowest in SNK 09269 (56.20).

The genotypic coefficient of variation (13.52) and phenotypic coefficient of variation (14.26) were moderate for this trait. Heritability estimate was high (89.83%) with high amount of genetic advance over mean (26.39%).

4.2.3.9 CCS (%) juice

The mean values for this CCS % ranged from 9.36 to 16.00 with a mean of 12.68. Among top productive clones highest CCS% juice was recorded in SNK 09212 (16.00) and lowest in SNK 09554 (9.36).

The coefficient of variation at phenotypic and genotypic levels were high with 14.48 and 13.24, respectively. Heritability estimate was high (83.54%) with high amount of genetic advance over mean (24.92%).

4.2.3.10 Purity (%) juice

The Purity % values ranged from 75.80 and 99.81 with a mean value of 90.77. Among top productive clones highest purity % juice was recorded in SNK 09059 (99.81) and lowest in SNK 09110 (75.80).

There exist low genotypic (6.16) and phenotypic (6.62) coefficients of variation for this trait. Whereas, heritability (86.58) and GAM estimates were high and moderate (11.80) respectively.

4.2.2.11 Number of millable canes ('000/ha)

The mean values for number of millable cane ranged from 76.80 to 175.18 with a mean of 123.80. Among 145 genotypes higher number of millable canes was recorded in SNK 09607 (175.18) and lowest in SNK 09376 (76.80).

The coefficient of variation at phenotypic and genotypic levels was high 24.93 and 24.12 respectively. Heritability estimate was high (93.62%) with high amount of genetic advance over mean (48.08%).

4.2.2.12 Cane yield (t/ha)

The cane yield per hectare values ranged from 127.51 and 188.50 with a mean value of 157.12. Among 145 genotypes higher cane yield was recorded in SNK 09293 (188.50) and lowest in SNK 09198 (127.51).

There exist moderate genotypic and phenotypic coefficients of variation for this trait 13.86 and 14.41. Whereas heritability estimate was high (92.52 %) and GAM was also high (27.46).

4.2.2.13 CCS yield (t/ha)

The CCS yield values ranged from 7.11 and 21.48 with a mean value of 14.50. Among 145 genotypes higher cane yield was recorded in SNK 09308 (21.48) and lowest in SNK 09509 (7.11).

There exist moderate genotypic and phenotypic coefficients of variation for this trait 27.38 and 28.73 respectively. Whereas heritability estimate was high (90.84%) and GAM was also high (53.76).

4.2.2.14 Flowering (%)

The flowering % in the population studied ranged from 0 and 64 with a mean value of 17.23. Among 145 genotypes higher flowering % was recorded in SNK 09376 (55.2) and lowest (0 %) was seen in 28 genotypes.

There exist moderate genotypic and phenotypic coefficients of variation for this trait 88.04 and 91.63. Whereas heritability estimate was high (92.32%) and GAM was also moderate (17.42).

4.2.4 Inter stage association (repeatability) studies

Repeatability values for various characters studied under present investigation are mentioned in Table 9.

4.2.4.1 Germination %

The repeatability value for this trait recorded was low and highly significant (0.2471) between clonal I and clonal-II generation.

4.2.4.2 Tillers

This attribute had lower and highly significant repeatability value (0.2467) between clonal I and clonal-II generation. .

4.2.4.3 Brix (%) (@ 8 month)

The repeatability value for this trait recorded was low and insignificant (0.0880) between clonal I and clonal-II generation.

4.2.4.4 Brix (%) (@ 10 month)

The repeatability value for this trait recorded was low and highly significant (0.3729) between clonal I and clonal-II generation.

4.2.4.5 Sucrose (%) (@ 8 month)

The repeatability value for this trait recorded was low and highly significant (0.1589) between clonal I and clonal-II generation.

4.2.4.6 Sucrose (%) (@ 10 month)

The repeatability value for this trait recorded was higher and highly significant (0.4227) between clonal I and clonal-II generation.

4.2.4.7 Flowering per cent

This attribute had lower and highly significant repeatability value (0.3296) between clonal I and clonal-II generation

4.2.4.8 Number of millable canes

The repeatability value for this trait recorded was also low (0.0757) between clonal I and clonal-II generation

4.2.5 Intra stage association among various characters in clonal generation:

The genotypic correlation coefficients was determined to know the nature of relationship existing between cane yield, sugar yield and their component characters as well as their association among component characters themselves. The degree of association of different quantitative characters with cane yield and its components is given in Table 10 and results are explained below.

4.2.5.1 Single cane weight (kg)

Single cane weight had significant positive association with number of internodes (0.4528**) and cane yield (0.3634***). On contrary, Single cane weight showed significantly negative association with NMC (-0.7723*).

4.2.5.2 Cane height (cm)

Cane height did recorded significant positive association with number of internodes (0.496**), internodal length (0.6205**) and cane yield (0.4623***).

Table 9: Repeatability values for various traits between clonal I and clonal II

Germination	Tillers	8 M (CB)	8 M (CP)	10 M(CB)	10 M(CP)	NMC	% Flowering
		HR Brix	HR Brix	HR Brix	HR Brix		
0.2471**	0.2467**	0.0880	0.1589	0.3729**	0.4227**	0.0757	0.3296**

Table 10: Genotypic correlation among quantitative characters of cane yield and its components

	J.W	C.H	CG	INT	IL	Brix(%)	Sucrose (%)	JE (%)	CCS (%)	Purity (%)	NMC	CCS Y(t/ha)	CY (t/ha)
S.C.W	0.9192	0.4998	0.6844	0.4528**	0.1124	0.1063	0.1200	-0.016	0.1198	0.0846	-0.7723*	0.2807	0.363**
J.W	1	0.4888**	0.6486**	0.4319**	0.1228	0.1225	0.1351	0.3696**	0.1346	0.1032	-0.6981**	0.3076**	0.391**
C.H		1	-0.1186	0.496**	0.6205**	0.3075**	0.3083**	0.088	0.2974**	0.1673*	-0.2295**	0.4737**	0.4623**
CG			1	0.1626**	-0.2922**	-0.1546	-0.1512	0.0138	-0.1439	-0.0691	-0.6463**	-0.0707	0.088
INT				1	-0.3633**	0.1809	0.2275**	0.0259	0.2324**	0.2004**	-0.2678**	0.3677**	0.329**
IL					1	0.1742*	0.1375	0.0785	0.1223	0.011	0.013	0.1882*	0.205*
Brix %						1	0.8928**	0.0672	0.8219**	0.323**	-0.036	0.7003**	-0.181*
Sucrose %							1	0.0517	0.9903**	0.7103	-0.0445	0.8468**	0.1315
JE								1	0.0464	0.0313	0.0454	0.1108	0.1371
CCS									1	0.7989**	-0.044	0.8577**	-0.439**
Purity										1	-0.0395	0.6855**	0.091
NMC											1	0.0796**	0.793**
CCS												1	0.613**

SCW : Single cane weight

CH : Cane height

IL : Intermodal length

NMC : Number of millable cane

CG : Cane girth

JE : Juice extraction

CY : Cane yield

INT : Number of internodes

CCS : Commercial cane sugar

CCS Y : Commercial cane sugar yield

Cane height is positively correlated with quality parameters like brix % (0.3075**), sucrose % (0.3083**), purity% (0.1673*), CCS% (0.2974**) and CCS Yield (0.4737**). On contrary, cane height showed significantly negative association with NMC (-0.2295**).

4.2.5.3 Cane girth (cm)

Cane girth had significant positive association with number of internodes (0.162**). On contrary, cane girth showed significantly negative association with NMC (-0.6463**) and internodal length (-0.2922**).

4.2.5.4 Number of internodes (NI)

Number of internodes recorded strong significant positive association with cane yield (0.3249***), Number of internodes is positively correlated with quality parameters like sucrose % (0.2275**), purity (0.2004**) and CCS Yield (0.3677**). On contrary, number of internodes showed significantly negative association with NMC (-0.2678**) and CCS% (-0.2324**).

4.2.5.5 Internodal length (cm)

Internodal length recorded strong significant positive association with cane yield (0.2056****), Internodal length is positively correlated with quality parameters like brix % (0.1742*) and CCS Yield (0.1882*). On contrary, internodal length showed significantly negative association with NMC (-0.2678**).

4.2.5.6 Number of millable canes

Number of millable canes in the present investigation significant and positively correlated with CCS yield (0.0796**) and cane yield (0.793**).

4.2.5.7 Brix per cent

Correlation coefficient analysis revealed strong positive significant association of brix per cent with cane yield (0.1201***), sucrose (0.8928**), purity (0.323**), CCS percent (0.8219**) and CCS yield (0.7003**) and negatively correlated with NMC (-0.036).

4.2.5.8 Sucrose percent

Correlation coefficient analysis revealed strong positive significant association of sucrose per cent with cane yield (0.1315***), CCS percent (0.9903**) and CCS yield (0.8468**) and negatively correlated with NMC (-0.0445).

4.2.5.9 CCS percent

CCS percent had significant positive association with number of internodes (0.2324**, purity (0.7989**) and cane yield (0.1329**). On contrary, showed negative association with NMC (-0.044).

4.2.5.10 Purity per cent

Correlation coefficient analysis revealed strong positive significant association of purity per cent cane yield (0.0911***), CCS yield (0.6855**). And negatively correlated with NMC (-0.0395).

4.2.5.11 CCS yield (t/ha)

CCS yield had positive association with cane yield (0.6139**), but significantly positive correlation with cane height (0.4737**) and number of internodes (0.3677**).

4.2.6 Path analysis of cane yield with its components

The path coefficient analysis at genotypic level was worked out for cane yield at clonal stage II comprising of 145 pre selected clones with 6 checks by considering important cane yield, quality and physiological traits. The results are presented in Table 11 and explained as below with respect to genotypic path coefficient analysis.

4.2.6.1 Direct effects

Among characters highest positive direct effect on cane yield was recorded by NMC (1.1998) followed by single cane weight (1.063) and CCS yield (0.8721) as while highest negative direct effect on cane yield was recorded by CCS% (-1.937) followed by sucrose % (-0.1768).

Characters viz., juice weight (0.2765), cane height (0.029), cane girth (0.0229), number of internodes (0.0131), internodal length (0.0598), brix per cent (0.2845) and purity (0.2663) have

Table 11: Path analysis among quantitative characters of cane yield and its components in sugarcane

	S.C.W	J.W	C.H	CG	INT	IL	Brix (%)	Sucrose (%)	JE %	CCS(%)	Purity(%)	NMC ('000/ha)	CCS Yield (t/ha)	CY (t/ha)
S.C.W	1.0631	-0.058	-0.032	0.0432	-0.029	-0.0071	-0.0067	-0.0076	0.001	-0.008	-0.0053	0.1487	-0.0177	0.363**
J.W	0.2542	0.2765	0.1352	0.1794	-1.1194	0.034	0.0339	0.0374	1.1022	0.0372	0.0286	-0.1931	0.0851	0.391**
C.H	0.0146	-0.014	0.029	0.0035	-0.015	0.0181	-0.009	-0.009	-0.0026	-0.009	-0.0049	0.0067	0.4138	0.4623**
CG	0.0157	0.0148	-0.003	0.0229	0.0037	-0.0067	-0.0035	-0.0035	0.0003	-0.003	-0.0016	-0.0148	-0.0016	0.088
INT	0.0059	0.0057	0.0365	0.0021	0.0131	-0.0048	0.0024	0.003	0.0003	0.003	0.0026	-0.0035	0.0048	0.329**
IL	0.0067	0.0073	0.0371	-0.1075	-0.022	0.0598	0.0104	-0.0082	1.0047	-0.0073	-0.0007	0.0008	0.0113	0.205*
Brix %	-0.0302	-0.0349	0.0875	-0.144	-0.0515	-0.0496	0.2846	0.254	0.0191	0.2339	0.019	-0.0102	0.1993	-0.181*
Sucrose %	0.0212	0.0239	0.0545	-0.0267	0.0402	0.0243	0.1578	-0.1768	0.0091	0.0751	0.0256	-0.0079	0.1497	0.1315
JE %	0.0018	-0.041	-0.01	-0.0015	-0.003	0.0086	0.0174	0.0257	-0.1100	0.0305	-0.0134	-0.0105	-0.0122	0.1371
CCS%	-0.0321	-0.261	-0.076	0.2788	-0.45	-0.0369	1.5922	-0.0185	-0.0898	-1.937	-0.5476	0.0852	1.6615	-0.439**
Purity%	0.0225	0.0275	-0.0445	-0.0184	-0.0534	-0.0029	0.086	0.1891	0.0083	0.2127	0.2663	-0.0105	0.1825	0.091
NMC('000/ha)	0.1543	-0.14	-0.046	0.1292	-0.054	0.0026	-0.3072	-0.0089	0.0091	-0.009	-0.0079	1.1998	0.0159	0.793**
CCS yield(t/ha)	0.4693	0.5144	0.792	-0.1182	0.6148	0.3146	1.1711	0.416	0.1853	1.4342	0.1463	-0.1331	0.8721	0.613**

SCW : Single cane weight

CH : Cane height

IL : Intermodal length

NMC : Number of millable cane

CG : Cane girth

JE : Juice extraction

CY : Cane yield

INT : Number of internodes

CCS : Commercial cane sugar

CCS Y : Commercial cane sugar yield

shown positive direct effect on cane yield. On contrary the characters viz., juice extraction (-0.1100) recorded negative direct effect on cane yield.

4.2.6.2 Indirect effects

4.2.6.2.1 Single cane weight (kg)

This attribute has shown higher positive indirect effect on cane yield via NMC (0.148) followed by cane girth (0.0232), whereas negative indirect effect on cane yield via sucrose per cent (-0.407) and brix per cent (-0.2067).

4.2.6.2.2 Number of millable canes

This attribute has shown higher positive indirect effect on cane yield via single cane weight (0.1543) followed by CCS yield (0.0159), whereas negative indirect effect on cane yield via brix per cent (-0.3072) and juice weight (-0.281).

4.2.6.2.3 Brix per cent

Brix per cent had its positive indirect impact on cane yield through CCS yield (0.099) followed by sucrose per cent (0.054). A negative major impact was through cane girth (-0.244) and number of internodes (-0.1496).

4.2.6.2.4 Sucrose per cent

A high positive indirect contribution of sucrose per cent on cane yield was through brix (0.0578) and cane height (0.0545). A negative contribution of this trait on cane yield was mainly through cane girth (-0.0267) and number of millable canes (-0.0076).

4.2.6.2.5 Juice extraction per cent

Juice extraction per cent had its positive indirect impact on cane yield through intermodal length (0.1586) and single cane weight (0.108). This attribute contributed negatively to cane yield through purity per cent (-0.0134) and CCS yield (-0.0122).

4.2.6.2.6 Purity per cent

Path analysis revealed that purity per cent exerted positive indirect effect through sucrose percent (0.0991) and CCS yield (0.0825). However, negative indirect contribution was recorded through number of internodes (-0.0534) and cane height (-0.0445).

4.2.6.2.7 CCS per cent

CCS per cent had its highest positive contribution to cane yield through CCS yield (1.661) and NMC (0.0852). This character contributed negatively through purity (-0.547) and juice weight (-0.261).

4.3 Mean performance of selected clones in clonal generation for various characters

Sixty five clones were selected and advanced to next clonal evaluation compared to checks, based on visually acceptable productivity features with early and shy/non flowering behavior. Out of 65 clones, 14 were selected based on flowering behavior with tonnage features and analyzed in detail for cane, sugar and jaggery yield parameters along with commercial checks. The Mean data on all 65 genotypes for important parameters were given in Appendix III.

4.3.1 Mean performance of productive clones for cane and sugar yield parameters.

4.3.1.1 Average single cane weight (kg)

Highest single cane weight was recorded in clone SNK 09450 (2.39) followed by SNK 09042 (2.05) and SNK 09271 (1.94), which showed significant superiority over best cane yielding check SNK 814 (1.52) and on par to best check Co 86032 (1.53) for this attribute.

4.3.1.2 Average number of internodes

The clone SNK 09450 (25) have recorded higher number of internodes among top genotypes followed by SNK 09110 (25) and SNK 09211 (23), which showed significant superiority over best cane yielding check SNK 814 (20) and on par to best check Co 86032 (21) for this attribute.

4.3.1.3 Number of millable canes ('000/ha)

The clone SNK 09607(164) recorded highest millable canes being significantly superior over best cane yielding check SNK 814(146).The other clones viz., SNK 09230, and SNK 09227 (156 and 153 respectively), though ranked among top 10 but statistically on par with the best check SNK044(122.5).

4.3.1.4 Cane yield (t/ha)

Among top productive clones highest cane yield was recorded in clones viz., SNK 09293, SNK 09304, and SNK 09227 (156.1, 152.0 and 142.3 respectively), which showed significant superiority over best cane yielding check SNK 814 (105.8).

4.3.1.5 Juice extraction per cent

Among top productive clones highest juice extraction was recorded in clones viz., SNK 09377 (88.7) followed by SNK 09542 and SNK 09481(71.7 and 68.2 respectively), which showed significant superiority over best cane yield check SNK 814(60.8) and on par to best check CoC 671(64.1) for this trait.

4.3.1.6 Brix per cent

This is an important sugar yield parameter, three clones recorded higher juice brix per cent over best cane yielding check SNK 814 (19.4) and Co2001-15 (21.4) for this attribute viz., SNK 09277 (22.7), SNK 09227 (22.1) and SNK 09230 (21.1).

4.3.1.7 Sucrose per cent

The clone SNK 09212 (22) recorded highest sucrose per cent being significantly superior over best cane yielding check SNK 814 (17.6).The other clones viz., SNK 09221 (20.1) and SNK 09607 (21.1) though ranked among top 10 and statistically superior over the best check Co2001-15(18.6) for this trait.

4.3.1.8 Purity per cent

Purity per cent recorded higher in many clones than best cane yielding check SNK 814 (90.4), the clones viz., SNK 09212 (99.3), SNK 09038 (99.1), SNK 09392 (99), and SNK 09235(97).

4.3.1.9 CCS per cent

The all clones recorded significant superiority for CCS percent over SNK 814 (12.3). The genotypes viz., SNK 09212 (16), SNK 09230 (15.2) and SNK 09607 (15.0) showed numerical superiority over the check Co2001-15 (12.8) for this attribute.

4.3.1.10 CCS yield (t/ha)

The progenies viz., SNK 09212 (21.4), SNK 09230 (21.3), and SNK 09392 (20.11), recorded significant superiority over best check Co 2001-15 (18.6) for this attribute.

4.3.2 Mean performance of 14 top productive genotypes for jaggery parameters

4.3.2.1 Quality parameters

4.3.2.1.1 Sucrose (%) in jaggery

The sucrose % jaggery ranged from 70.7% (SNK 09293) to 92.1% (SNK 09260). The genotypes SNK 09260 has recorded higher sucrose % in jaggery compared to best jaggery check Co 2001-15(85.3%). None of the genotypes except SNK 09268 had recorded superiority over best check CoC 671 (91.5) for this trait (Table 12).

4.3.2.1.2 OD value (at 540 nm)

The OD value ranged from 0.348(SNK 09212) to 0.538(SNK 09370). The genotypes SNK 09370 has recorded higher OD value compare to best check Co 2001-15(0.527).Other genotypes like SNK 09227, SNK 09304, SNK 09221 (0.537, 0.533 and 0.531 respectively) recorded higher OD value among all genotypes compare to best check. Whereas SNK 09212, SNK 09111, SNK 09260 (0.348, 0.473 and 0.477 respectively) recorded lowest OD value among 14 top productive genotypes compared to checks.

Table 12: Mean performance of selected top productive sugarcane genotypes for jaggery quality parameters

Sl. No.	Entry	Sucrose (%)	OD value (At 540 nm)	p ^H	Reducing sugars (%)
1	SNK 09111	74.9	0.473	5.16	10.07
2	SNK 09211	87.4	0.524	5.55	10.99
3	SNK 09212	85.3	0.348	5.6	9.76
4	SNK 09221	78.8	0.531	5.21	12.02
5	SNK 09227	75.3	0.537	5.57	11.95
6	SNK 09229	77.0	0.508	5.18	9.38
7	SNK 09230	74.0	0.505	5.18	10.87
8	SNK 09232	81.1	0.513	5.56	13.17
9	SNK 09260	92.1	0.477	5.55	10.74
10	SNK 09271	79.0	0.523	5.71	13.26
11	SNK 09293	70.7	0.523	5.23	9.86
12	SNK 09304	79.0	0.533	5.03	10.07
13	SNK 09370	70.7	0.538	5.23	8.95
14	SNK 09377	77.0	0.491	5.51	14.57
Checks					
15	Co 2001-15	85.3	0.527	5.38	15.39
16	Co 86032	75.3	0.481	5.26	11.12
17	Co 92005	85.3	0.449	5.18	15.39
18	CoC 671	91.5	0.512	5.29	11.52
19	SNK 044	82.0	0.361	5.74	7.69
20	SNK 814	78.6	0.495	5.81	8.95
	C D at 5%	7.72	10.75	4.24	18.11
	C V%	4.09	0.04	0.15	1.43

4.3.2.1.3 pH of jaggery solution

The range of PH value recorded among progenies is narrower (5.03 to 5.71) compared to that observed among commercial checks (5.18 to 5.81).

4.3.2.1.4 Reducing sugar (%)

The reducing sugar ranged from 8.95 (SNK 09370) to 14.57 (SNK 09377). The genotypes SNK 09377 has recorded higher reducing sugar compare to other genotypes but shown lower value compare to best check Co 2001-15 (15.39) and Co 92005. Other genotypes like SNK 09271 and SNK 09232 (13.26 and 13.17 respectively) recorded higher reducing sugar, than the other checks.

Whereas SNK 09370, SNK 09229 and SNK 09212 (8.95, 8.95 and 9.38 respectively) recorded lowest reducing sugar among 14 top productive genotypes compare to checks.

Yield parameters

4.3.2.1.5 Jaggery recovery (%)

The jaggery recovery (%) ranged from 5.62 (SNK 09377) to 12.41 (SNK 09293). The genotypes SNK 09293 has recorded higher jaggery recovery % compared to best check SNK 814 (10.9). Other genotypes like SNK 09221 and SNK 09227 (11.93 and 11.37 respectively) recorded higher jaggery recovery % among all genotypes compare to all checks. (Table 13)

Where as SNK 09377, SNK 09229 and SNK 09260 (5.62, 6.79 and 7.5 respectively) recorded lowest jaggery recovery % among 14 top productive genotypes compare to checks.

4.3.2.1.6 Jaggery yield (t/ha)

The jaggery yield ranged from 6.96 (SNK 09377) to 19.38 (SNK 09293). The genotype SNK 09293 was recorded higher jaggery yield compared to best cane and jaggery yielding check SNK 814 (11.6). Other genotypes like SNK 09221 and SNK 09227 (16.7 and 16.30 respectively) recorded higher jaggery yield among all genotypes compare to all checks.

Whereas SNK 09377, SNK 09229 and SNK 09260 (6.92, 9.38 and 11.06 respectively) recorded lowest jaggery yield among 14 top productive genotypes compare to checks.

4.3.3 Comparative Mean Performance of top productive clones for cane and jaggery yield and their Heterosis over best check

Yield parameters

4.3.3.1 Cane yield

All 14 top productive genotypes shown higher percent of increase in cane yield compare to better check SNK 814 (105.8 t/ha), the clones viz., SNK 09293 shown 47.6 per cent increase in cane yield followed by SNK 09271, SNK 09304 and SNK 09211. (45, 43.7 and 41.5% respectively) (Table 14).

4.3.3.2 Jaggery yield

Among 14 top productive genotypes, 12 genotypes showed higher jaggery yield compare to SNK 814 (11.68 t/ha), the clones viz., SNK 09293 recorded (19.38) 81.5% increased yield followed by SNK 09221, SNK 09227 and SNK 09271 (56.4, 51.5 and 53.2 respectively) (Table 15).

4.3.3.3 Jaggery recovery

Among 14 top productive genotypes higher jaggery recovery was recorded in SNK 09293 (12.41%) i.e. 23 per cent increase jaggery recovery followed by SNK 09221 (11.93%) compare to best cane and jaggery yielding check SNK 814 (10.09%) (Table 15).

4.3.3.4 CCS yield (t/ha)

All 14 top productive genotypes shown higher percent of increase in CCS yield compare to better check SNK 814 (12.76), the clones viz., SNK 09271 (19.78) shown 55.6 per cent increase in cane yield followed by, SNK 09304 (18.91) and SNK 09211 (18.7 t/ha) (Table 14).

Table 13: Mean performance of Selected top productive genotypes for jaggery yield and jaggery Recovery %

Entry	Cane Yield (t/ha)	Jaggery Recovery (%)	Jaggery Yield (t/ha)	(%)flowering	Presence of spines
SNK 09111	130.28*	11.21	14.6*	0.00	Absent
SNK 09211	149.69*	8.13	12.17	0.00	Sparse
SNK 09212	133.9*	10.18	13.64*	0.00	Absent
SNK 09221	139.99*	11.93*	16.7*	0.00	Sparse
SNK 09227	142.3*	11.37*	16.18*	0.00	Sparse
SNK 09229	138.14*	6.79	9.38	6.14	Absent
SNK 09230	139.52*	9.29	12.96*	0.00	Sparse
SNK 09232	136.75*	10.74	14.69*	0.00	Sparse
SNK 09260	147.38*	7.5	11.06	0.00	Sparse
SNK 09271	153.38*	10.66	16.36*	14.01	Sparse
SNK 09293	156.16*	12.41*	19.38*	0.00	Sparse
SNK 09304	152.0*	8.89	13.52*	0.00	Sparse
SNK 09370	138.14*	9.41	12.99*	0.00	Sparse
SNK 09377	123.82*	5.62	6.96	1.37	Sparse
Checks					
Co 2001-15	96.8	8.51	8.2	57.57	Heavy
Co 86032	100.1	10.33	10.3	0.00	Sparse
Co 92005	83.0	7.77	6.4	8.70	Sparse
CoC 671	83.0	11.27	9.4	88.63	Heavy
SNK 044	98.6	8.66	8.5	69.16	V sparse
SNK 814	105.8	10.92	11.6	52.52	Sparse
C D at 5%	15.80	1.21	2.32		
C V %	18.74	12.01	18.33		

Table 14: Performance of top elite clones for cane and sugar yield parameters

SI No	Clones	Cane Yield (t/ha)	% Increase or decrease	CCS Yield (t/ha)	% Increase or decrease	CCS (%)	% Increase or decrease	Sucrose (%)	% Increase or decrease	Purity (%)	(%) Increase or decrease
1	SNK 09111	130.3*	23.1	13.82*	8.3	10.61	-12.0	15.89	-6.5	82.37	-11.9
2	SNK 09211	149.7*	41.5	18.70*	46.6	12.49	3.6	18.02	6.1	88.81	-5.0
3	SNK 09212	134.0*	26.6	17.80*	39.5	13.29*	10.2	18.74*	10.3	93.28	-0.2
4	SNK 09221	140.0*	32.3	18.49*	45.0	13.21*	9.6	18.78*	10.5	91.65	-2.0
5	SNK 09227	142.3*	34.5	16.87*	32.2	11.86	-1.7	17.34	2.1	86.31	-7.7
6	SNK 09229	138.1*	30.6	15.92*	24.8	11.52	-4.4	16.5	-2.9	90.21	-3.5
7	SNK 09230	139.5*	31.9	17.73*	39.0	12.71	5.4	18.83*	10.8	84.10	-10.1
8	SNK 09232	136.8*	29.3	17.89*	40.2	13.08	8.5	18.91*	11.3	88.41	-5.5
9	SNK 09268	147.4*	39.3	15.96*	25.1	10.83	-10.2	15.48	-8.9	90.58	-3.1
10	SNK 09271	153.4*	45.0	19.78*	55.0	12.89	6.9	18.3*	7.7	92.01	-1.6
11	SNK 09293	156.2*	47.6	17.97*	40.9	11.51	-4.5	16.26	-4.3	92.97	-0.6
12	SNK 09304	152.0*	43.7	18.91*	48.3	12.44	3.2	17.63	3.8	92.35	-1.2
13	SNK 09370	138.1*	30.6	15.40*	20.7	11.15	-7.5	16.02	-5.7	89.55	-4.2
14	SNK 09377	123.8*	17.0	14.48*	13.5	11.70	-3.0	16.5	-2.9	93.27	-0.2
Mean		142.9		17.3		12.1		17.4		89.4	
Checks											
C1	Co 2001-15	96.8		12.30		12.71		17.63		97.03	
C2	Co 86032	100.1		13.07		13.06		18.11		97.00	
C3	Co 92005	83.0		10.61		12.78		17.84		95.55	
C4	CoC 671	83.0		10.80		13.01		18.35		93.29	
C5	SNK 044	98.6		10.90		11.05		17.15		77.36	
C6	SNK 814	105.8		12.76		12.06		16.99		93.51	
Mean		92.3		11.5		12.5		17.8		92.0	
Over all Mean		128.2		15.6		12.2		17.5		90.4	
CD @ 5%		15.85		1.97		0.58		0.73		3.32	
CV		18.63		19.05		7.22		6.27		5.55	

Sugar yeild parameters

4.3.3.5 CCS per cent

Among 14 top productive genotypes higher CCS percent was recorded in SNK 09212(13.29%) i.e 10.2 per cent increase CCS percent followed by SNK 09221(13.21%) compare to SNK 814 (12.06%) (Table 14).

Sucrose per cent

Among 14 top productive genotypes higher sucrose percent was recorded in SNK 09230(18.83%) i.e 10.8 per cent increase sucrose percent followed by SNK 09221(18.78%) and SNK 212(18.74%) compared to best cane yielding check SNK 814 (16.99%).

4.3.3.6 Juice extraction (%)

Among 14 top productive genotypes higher juice extraction percent was recorded in SNK 09221 (76%) i.e 25 per cent increase juice extraction percent followed by SNK 09212 (68.1%) compared to best cane yielding check SNK 814(60.8%) (Table 15).

4.3.3.7 Flowering (%)

Among 14 top productive genotypes flowering percent was recorded in three genotypes SNK 09271(14%), SNK 09229(6%) and SNK 09377(1%) remaining 11 genotypes are shown non flowering feature, whereas in best cane yielding check SNK 814 (16.3%) flowering per cent was recorded (Table 15).

Table 15: Comparative performance of top elite clones for jaggery quality parameters along with percent flowering

SI No.	Clones	Jaggery recovery (%)	% Increase or decrease	Jaggery yield (t/ha)	% Increase or decrease	Flowering (%)	JE (%)	(%) Increase or decrease
1	SNK 09111	11.21	11.1	14.60*	36.7	0	58.5	-3.7
2	SNK 09211	8.13	-19.5	12.17*	13.9	0	64.7	6.5
3	SNK 09212	10.18	0.9	13.64*	27.7	0	68.1*	12.1
4	SNK 09221	11.93*	18.3	16.70*	56.4	0	76.0*	25.0
5	SNK 09227	11.37*	12.7	16.18*	51.5	0	64.5	6.2
6	SNK 09229	6.79	-32.7	9.38	-12.1	6.14	59.8	-1.6
7	SNK 09230	9.29	-7.9	12.96*	21.4	0	57.4	-5.6
8	SNK 09232	10.74	6.4	14.69*	37.5	0	63.5	4.4
9	SNK 09268	7.50	-25.6	11.06	3.6	0	51.0	-16.0
10	SNK 09271	10.66	5.7	16.36*	53.2	14.01	65.5	7.8
11	SNK 09293	12.41*	23.0	19.38*	81.5	0	60.5	-0.4
12	SNK 09304	8.89	-11.9	13.52*	26.6	0	61.3	1.0
13	SNK 09370	9.41	-6.8	12.99*	21.7	0	61.7	1.5
14	SNK 09377	5.62	-44.3	6.96	-34.8	1.37	59.7	-1.8
Mean		9.9		14.1		1.4	62.5	
Checks								
C1	Co 2001-15	8.51		8.23		10.8	52.4	
C2	Co 86032	10.33		10.34		0.0	61.3	
C3	Co 92005	7.77		6.45		1.2	61.3	
C4	CoC 671	11.27		9.36		39.2	64.1	
C5	SNK 044	8.66		8.55		29.7	58.2	
C6	SNK 814	10.09		10.68		16.3	60.8	
Mean		9.3		8.6		16.2	59.5	
Over all mean		9.6		12.3		5.6	61.6	
CD at 5%		1.22		2.38			3.61	
CV		19.41		19.22			8.87	

DISCUSSION

Sugarcane is one of the most important commercial crops in the world. It is the main source of energy for man both for his food as well as industrial needs. Sugarcane varietal improvement involves genetic enhancement of the production potential. Sugarcane is grown mainly for sugar and its output is the ultimate character that must show improvement over the current standards. This could be achieved indirectly through several ways like higher cane yield, better juice quality (sugar content), higher tolerance to insect pests, and abiotic stresses. Sugarcane nevertheless, is a difficult plant to breed. Modern day varieties are species hybrids, complex polyploids, defying many conditions necessary for genetic studies.

The cane and sugar yields are determined by the interaction of a number of characters among themselves and with environment making them highly reliable. The sugarcane breeding has been based mainly on visual discrimination of seedlings, ever since the first hybrid crop was raised. For improving efficiency of breeding for cane yield, identification of superior genotype or selection has to be initiated in first generation (sexual) itself. The early generation selection depends upon the nature and magnitude of association of traits and repeatability between stages and environments.

Flowering in sugarcane is a complex physiological process consisting of multiple stages of development, each stage having specific environmental and physiological requirements (Julien, 1972). Thus, if the specific day length, temperature and moisture requirements are not satisfied, flowering is inhibited or the intensity is reduced. Flowering and crop habit are economically important sub-systems of whole-plant physiology in sugarcane. Crop flowering impinges on crop yield and quality, particularly in the tropics, and selection against flowering is a key criterion. Perhaps more importantly, poor and variable flowering observed across many environments constitutes a crucial impediment to unrestricted, planned genetic recombination for breeding. This flowering behaviour in many instances results from selection pressure for low flowering propensity. An understanding of the environmental drivers of flowering, and the plant's interaction with these, are vital to resolving the problems posed by these diametrically opposed objectives. Photoperiod is the primary driver of flowering in sugarcane, but this may be moderated by the plant's interaction with moisture, nutrition, and temperature (Moore, 1987; Moore and Nuss, 1987).

The present breeding programmes are aimed at improving sugar related traits along with improving disease and pest resistance. Very less or there are no directed breeding efforts towards improving productivity through introgressing non flowering features. Hence there is a need to characterize parental clones or commercial varieties for flowering, as much literature is not available on characterization of flowering. Therefore characterization of sugarcane clones with respect to flowering behavior is essential for utilization of clones for breeding programmes aiming to enhance productivity with non or shy flowering features.

The experimental results of present investigation for flowering with particular reference to cane yield, sugar yields and their components are discussed under the following headings,

- 5.1 Characterization of floral behaviour in commercial sugarcane varieties.
- 5.2 Assessment of exploitable variability and other genetic parameters in intervarietal pre-selected hybrid progeny population for flowering and productivity traits.
- 5.3 Identification of productive progenies with respect to sugar/jaggery yield and quality parameters combining non or shy flowering features

5.1 Characterization of flowering behaviour in important commercial sugarcane varieties.

Days to flowering initiation in sugarcane genotypes was recorded from July to October based on flower primordial count of eight commercial genotypes. During the study season flower primordia in all eight genotypes were not found till 1st week of September, where as in 3rd week of September 50 - 70% of flower primordia were seen in SNK 632, SNK 044, SNK 814 and CoC 671, this indicates that these genotypes are early flowering types compare to other four genotypes, these four genotypes recorded percent flower primordial initiation by October 1st week, hence these genotypes indicating their feature as profuse flowering (Plate 1). Among other four genotypes three genotypes viz., CoM 0265, Co 94008 and Co 86032 could be characterized as moderate flowers both with respect to date and intensity of flowering (Plate 2).



Plate 1. Flower primordial view of Profuse Flowering clones

The relatively lower frequency and delayed recording of floral primordial in Co 86032 indicates its shy and late flowering character, which is very much important from the point of its commercial exploitation particularly for delayed or extended harvesting and crushing. The other variety CoM 88121 where in no floral primordial count was recorded confirming its complete non flowering character (Plate 3).

5.1.1 Intensity of flowering (%)

The genotypes viz., SNK 044, CoC 671, SNK 632 and Co 2001-15 could be characterized as early profuse flowerers as they recorded relatively higher intensity of flowering both in mid December and mid January. The Co 94008, CoM 0265 and SNK 814 characterized as moderately but profuse flowers. Late and sparse flowering feature was recorded in the genotype Co 92005 which is desired in the context both commercial cultivation and for its utility in future breeding programme for introgressing non flowering trait. Though the genotypes Co 86032 found non flowering during the study season, could be because of relatively unfavourable weather parameters (delayed and scanty monsoon rains), late and profuse flower primordial initiation was recorded indicating its flowering characters under favourable season, such genotypes which are of great value from point of view their utility in breeding programmes., apart from its commercial utility for extended crushing.

On the other hand the non flowering genotypes like CoM 88121 are of great importance for commercial cultivation, while their utility is restricted for crop improvement..

5.1.2 Juice analysis of genotypes

The juice analysis of the profuse or shy flowering genotypes indicate that, in general the juice quality /traits viz., brix% juice, sucrose % juice ,juice extraction %, CCS% and purity % have shown increasing trend over months i.e. from 8 month to 12 month.. The juice quality improvement across pre flowering to post flowering stages upto two months in the study may be an account of enhanced culm ripening under the influence of flowering.

Among various traits average single cane weight of profuse flowering genotypes shown higher values during 10th and 11th but during 12th (post flowering period) the weight was reduced in some genotypes. On contrary shy/non flowering genotypes shown increase in single cane weight over months (i.e 1.19 to 1.36).

Among profuse flowering genotypes CoM 265 and CoC 671 was recorded reduction in single cane weight over months but in remaining genotypes shown increasing trend over month for this attribute. Similarly shy flowering genotype Co 92005 shown reduction in single cane weight over months while remaining two genotypes shown increasing trend over month for this trait, on account of their non flowering features which favours accumulation of photosynthates into Culm unlike flowering genotypes where photosynthates divert for flowering process.

Juice extraction % shown higher in profuse flowering genotypes (58.24 to 65.58) compared to shy / non flowering genotypes (55.98 to 63.59) over months. Whereas all profuse flowering genotypes shown increasing trend over month for this trait except CoC 671 which shown reduction in juice extraction % over months (66.7 to 64.1 %). The reduction in juice extraction (%) in this variety could be an account of its early and profuse flowering which might be due to post flowering deterioration i.e through pith formation and inversion in accumulated sugar in culms. Similar result found in shy / non flowering genotypes i.e Co 92005 shown reduction in juice extraction % over months remaining to genotypes shown increasing trend for this attribute.

The other remaining characters like brix % juice, sucrose % juice, CCS% juice and purity has shown higher values for these traits in shy/ non flowering genotypes over a period of 8month to 12 month compared to profuse flowering genotypes. Whereas all profuse and shy / non flowering genotypes shown increase trend over months for all above mentioned traits, the improvement in these juice quality traits in shy/ non flowering genotypes was more compared to profuse flowering varieties is due to absence / slower post flowering deterioration juice quality components.

5.2.1 Assessment of exploitable variability and other genetic parameters in intervarietal pre-selected hybrid progeny population for flowering and productivity traits.

The pre selected progeny population was studied for variability parameters in pre maturity stages (8 and 10 month) as most reliable and discriminative as reported by many workers (Singh *et*



Plate 2. Flower primordial view of Late Flowering clones



Plate 3. Apical meristem (absence of flower primordia)

al., 1994 and 1999) however the population was also assessed for the same parameters at harvesting.

5.2.1.1 Genotypic, phenotypic coefficient of variability

In clonal generation of pre-selected population high variability was found for cane height, NMC, number of internodes (NI), internodal length, brix % at 8month, SCW and CCS %. This indicates expected gains can be achieved by selection for these traits.

Sanjeev Kumar *et al.* (2001) and Kamat and Singh (2001) also reported high GCV and PCV estimates for number of millable canes and cane height, whereas moderate estimates were observed by Kamat and Singh (2001) for single cane weight, on contrary higher variability was observed by Bakshi Ram (1994), Venkatachalam *et al.* (2002), Anbanandan and Saravanan (2010). Bakshi Ram *et al.* (1999) estimated moderate variability for number of millable canes. In accordance, with these in the present investigation moderate estimates of GCV and PCV were observed for cane girth, internodal length and cane yield. However, Bissessur *et al.* (2001) and Sanjeev Kumar *et al.* (2001) reported high GCV and PCV for cane yield, and number of millable canes. On the contrary, Bakshi Ram *et al.* (1999) reported moderate estimates for most of the cane yield and juice quality parameters.

Similar findings were reported by Singh *et al.* (1999) for cane yield and its components like SCW, NMC, cane height and cane girth.

The moderate variability values obtained for, brix % at 10 month, cane yield, cane girth, pol % and juice extraction whereas, low variability were found for, cane height, brix percent, juice weight and purity percent. These low values in the present study indicates the relative difficulty in improving them by selection alone. Low variability for pol % were also reported by earlier workers Hapase and Repale (1999), Anshuman singh *et al.* (2002), Lourdusamy and Anbuselvam (2009), Anbanandan and Saravanan (2010).

It is important to mention that the difference between the estimates of GCV and PCV are very high for cane height, number of internodes and NMC. The results betray the major role of environmental variations in expression of these traits.

Quality of cane juice is an important aspect of cane cultivation. Among quality characters like pol (%) brix % and CCS (%) had moderate GCV and PCV values except CCS (%) which had high values indicating bit difficulty in improving these traits through simple selection. These findings are in harmony with the findings of Nair *et al.* (1980), Singh *et al.* (1981), Ghosh and Singh (1996), Anbanandan and Sarvanan (2010).

Quality parameters are least influenced by the environment as suggested by the narrow difference between the GCV and PCV values noticed in the present study as also reported by Ghosh and Singh (1996).

5.2.1.2 Heritability and genetic advance

Among cane yield and its components single cane weight, cane height, NI, IL, JE and CCS%,NMC had high heritability coupled with high genetic advance as per cent of mean suggesting that these characters were under genetic control (Panse, 1957) showing additive gene action and these can be improved by straight selection. These findings are in line with the results obtained by Bissessur *et al.* (2001) and Lourdusamy and Anbu Selvam (2009), Anbanandan and Saravanan (2010) for cane weight.

Moderate heritability was found for cane girth with low genetic advance as per cent of mean indicating the predominance of non additive gene action or more environmental influence. Hence selection only based on cane girth for improvement of cane yield is not at all useful as also indicated by Nair *et al.* (1980), Singh *et al.* (1983), Xie *et al.* (1989) and Silva *et al.* (2002). However some of the sugarcane workers obtained contrary results indicating high heritability for number of millable canes (NMC) Ramana Reddy, 1985, Bissessur *et al.* (2001), Sanjeev kumar *et al.* (2001) reported both for cane girth and NMC which indicating the scope for further improvement.

The heritability estimates were high for cane height and single cane weight while moderate heritability for number of internodes. These results are in line with the findings of Kumar and Singh (1999) for single cane weight (SCW) and cane height. Moderate heritability was also observed for purity % with low genetic advance as per cent of mean.

High degree of genetic advance for number of millable canes and cane height indicated their reliability in selection. Similar results of maximum genetic gain for NMC were also reported by Lourdasamy and Anbu Selvam (2009).

The ultimate aim of sugarcane growers and sugar factories is higher cane yield and sugar yield, respectively. In the present investigation both cane yield and CCS % had moderately high heritability with moderate to high values of genetic advance as per cent of mean. These two characters also showed moderately high variability. Therefore, further improvement can be achieved by resorting to direct selection based on cane yield or CCS yield or both. Many of the sugarcane workers also reported high heritability and genetic advance above two traits (Nair *et al.*, 1980; Shankaranarayanan and Shanmugasundarawm (1981), Milligan *et al.*, 1990; Singh and Sudama Singh, 1994 Singh *et al.*, 1996; Anshuman Singh *et al.* 2002; Anbanandan (2011), Tyagi *et al.* (2011). Mariotti (1971) found that heritability was higher for cane yield components than for sugar content. High heritability coupled with high genetic advance for the above traits were reported by Bakshi Ram (1994), Hapase and Repale (1999), Bissessur *et al.* (2001), Lourdasamy and Anbu Selvam (2009).

Among quality parameters brix per cent juice had high heritability whereas, pol per cent juice and purity % had moderate heritability estimate values while, genetic advance as per cent of mean for all these parameters was high except CCS per cent which had low. Hence selection based on these quality parameters is not expected to be much use, as also narrated by Batcha (1975) Das *et al.* (1997). However, brix per cent in the present study showed high degree of heritability coupled with high genetic advance as per cent of mean indicating that this can be used as selection criteria for juice quality improvement.

The results suggest that selection should be practiced on the basis of single cane weight and number of millable canes for higher cane yield. Improvement in these traits would lead to a significant improvement in yield in limited selection cycles

5.2.2 Inter stage association (repeatability)

Studies with estimates of repeatability had been reported by Mariotti (1973); Bakshi Ram *et al.* (1996); Ramdoyal *et al.* (1999); Sousa *et al.* (2003); Ilyas *et al.* (2010), Pedrozo *et al.* (2011). Estimations in general were moderate to low at early stages. Kang *et al.* (1988) reported that genotype repeatability was low between two stages.

The studies with estimates of repeatability indicated lower and non significant values for traits like brix % juice and sucrose % juice of 8 month suggesting their lesser reliability for practicing early generation selection.

In contrary traits like germination, tillers, brix % juice, sucrose % juice of 10 month and % flowering shown highly significant repeatability value. The higher significant values across early generation for important productivity related traits indicates their extent of reliability for their utility as selection criteria. Hence these traits could be considered as basis for exercising early generation selection to advance clonal material efficiently.

5.2.3 Intra stage association among various characters in clonal generation

Selection for a specific character is known to result in correlated response in certain other character (Falconer, 1964). Generally plant breeders make selection for one or two attributes at a time and then it becomes important to know the effect on other characters. Simple phenotypic correlations indicate broadly the type of association that exists between various attributes. But simple phenotypic correlations by themselves do not provide any reliable basis for selection. Hence the genotypic correlations which are based on the heritable part of the observed variation enable the assessment of the pattern of inherent relationship that exists between various traits.

Among 14 characters studied single cane weight, number of internodes and CCS per cent had positive and significant genotypic association with cane yield.

Cane height and single cane weight are considered as main yield components as evident by literature by different workers. However, cane height recorded significant association with cane yield whereas, single cane weight recorded significant positive association with cane yield. Whereas, Kundu and Gupta (1997) recorded significant association of millable cane height, whereas Yadav and Sharma (1978), Ramanareddy (1994) and Thippeswamy (2003) recorded positive association of single cane weight with cane yield..

Number of internodes (NI) recorded strong positive and significant association with cane yield, single cane weight, brix per cent, and cane girth, which are in accordance with the observations of Das *et al.* (1996) and Thippeswamy (2003a) for cane yield, Tehlan (1986) for brix per cent.

Internodal length was positive and significantly correlated with CCS yield, cane yield brix %, which is in accordance with results of Madhavi *et al.* (1991) and Ilyas *et al.* (2010).

Cane girth recorded significant association with number of internodes, cane yield, CCS % and juice extraction %. These results are not in accordance with the results obtained by Kang *et al.* (1981) and Thippeswamy *et al.* (2003a).

NMC per plot recorded significant positive association with internodal length and juice extraction, whereas significantly negative association for single cane weight, cane height, cane girth however Thippeswamy *et al.* (2003a) reported significant association of NMC to cane yield. This non significant association could be due to major contribution by SCW and number of internodes.

The ultimate objective in sugarcane breeding is to improve the sugar productivity per unit area. Brix per cent and sucrose per cent are the major constituents responsible for the quality of cane juice. Hence the improvements in these traits would help to improve the sugar productivity.

Brix per cent recorded positive significant association with sucrose per cent and juice extraction per cent. These results are in agreement with the results of Richard (1975) and Nageswar Rao (1982) for sucrose per cent, so improvement for any of the character *i.e.*, brix or sucrose per cent will improve both characters as they are associated positively, which was observed in the present study.

CCS% is one of the important parameters of sugarcane breeding where CCS is given prime importance during selection. In the present study CCS% recorded significant positive association with cane yield and the results are in accordance with the results of Das *et al.* (1996) and Thippeswamy *et al.* (2003a).

In general in the present investigation among 13 characters under study, revealed that single cane weight, number of internodes and quality parameter like brix, sucrose, CCS per cent and purity had positive and significant association with cane yield. So these characters can be considered as important yield (cane and sugar yield) determining factors and selection can be practiced based on these characters. However, special importance should be given for SCW, number of internodes and sucrose, CCS per cent which are principal cane yield components. So improvement in any of the principal cane yield components traits in general would certainly bring improvement in cane yield.

5.2 Mean performance of top productive clones

5.2.2 Mean performance of top productive clones for cane and sugar yield parameters

The mean performance of top productive genotypes along with commercial checks for cane and sugar yield components like, sucrose per cent, CCS per cent and CCS yield and cane yield (t/ha) is presented in Table 14 and Table 15.

It is evident from the table that, the clones SNK 09293, SNK 09271, SNK 09304 and SNK 09211 are significantly superior in terms of their cane yield compared to the best commercial check SNK 814. There was an increase of 47 per cent in SNK09293 compared to SNK 814, where as an increase of 45 per cent, 43 per cent and 41 per cent in SNK 09271, SNK 09304 and SNK 09211 respectively for cane yield than the best check SNK 814 (Plate 4 and 5)

Among the genotypes, SNK 09232, SNK 09221, SNK 09230 and SNK 09212 recorded significantly high sucrose per cent, whereas the same genotypes including SNK 09232 showed significantly high CCS per cent compared to best check SNK 814. The final CCS yield which is the product of CCS per cent and cane yield was significantly high in these three SNK 09271, SNK 09304 and SNK 09211 genotypes indicating they have high potential for sugar yield along with cane yield as depicted in Table 14. Whereas the genotypes SNK 09229, SNK 09271 and SNK 09377 exhibited relatively lower sucrose % (16.5%, 18.3% and 16.5% respectively) which may be because of their flowered nature (4%, 14% and 1% respectively) as depicted in the Table 15. Similar results were reported by Rao and Kumar 2003; Rao 1977 where in non flowered stalks recorded higher sucrose %.



Plate 4. Field View of SNK 09304 and SNK 09293 at ARS Sankeshwar



Plate 5. Field View of SNK 09219 (non-flowering), SNK 09218 (Flowering) and commercial check Co-86032 (shy flowering) at ARS Sankeshwar

There is an increase of 3-6 per cent sucrose per cent and CCS per cent in these superior genotypes viz., SNK 09271, SNK 09304 and SNK 09211, where as an increase of 40-55 per cent CCS yield in SNK 09271, SNK 09304 and SNK 09211 was noticed. Similarly SNK 09268, SNK 09227 and SNK 09212 recorded an increase of 25-39 per cent CCS yield compared to check SNK 814. The genotypes SNK 09212, SNK 09221 and SNK 09232 found most promising as it recorded superior juice quality (sucrose %) and cane yield components over best popular check SNK 814. Over all the juice purity in commercial checks is relatively better compared to non flowering productive top 14 genotypes may be because of enhanced ripening under the influence of profuse flowering.

When per cent flowering was studied in these top productive clones, genotype SNK 09229 (6%), SNK09 271 (14%), and SNK 09377 (1%) were flowering and rest of the genotypes were non-flowering (Table 15). Similar results were reported by Berding and Hurney 2005 where in a penalty of 10 % loss to cane and sugar yield was recorded in flowered clones than non flowered clones. These flowering clones were the least ones with respect to cane yield except SNK 09 271 where in even though it has flowered to the extent of 14% it has given acceptable and superior cane yield (153.4 t/ha) compared to best available check SNK 814 (105 t/ha). Similarly sucrose per cent juice was significantly higher in flowered stalks even after 35-45 days of flower emergence than the non-flowered stalks of the varieties studied (Singh, 1980). Such features could be account of its better field keeping quality, where in post flowering deterioration is minimum. Genotypes with similar features are important for commercial cultivation, as it has been evident in genotypes like Co 86032 a most popular variety of peninsular India (Patil *et al.*, 2011). In contrary in other flowering genotypes and commercial checks post flowering deterioration was evident as they recorded relatively lower productivity features. In the present studies checks were flowered except Co 86032 (0%), where in per cent flowering in checks ranged from 1.2% (Co 92005) to as high as 39 % (CoC 671).

5.2.3 Mean performance of top productive clones for jaggery parameters

The mean data of jaggery recovery (%) and jaggery yield presented in Table 15. The jaggery recovery per cent ranged from 5.7-12.49 per cent and jaggery yield ranged from 6.96-19.38 (t/ha). The genotype SNK 09293 recorded significantly high jaggery recovery to the extent of 13.7% superior than best check SNK 814, followed by SNK 09221 (9.3%) and SNK 09227 (4.1%). The genotype SNK 09293 showed 67.7% increase in jaggery yield over SNK 814 followed by SNK 09221 and SNK 09227 which recorded 44.5 and 40.0 per cent increase respectively.

The juice extraction % was ranged from 51 to 76 per cent (Table 15). The genotypes SNK 09221, SNK 09212 and SNK 09271 exhibited higher juice extraction % (76, 68.1 and 65.5%, respectively) compared to checks indicating their high contribution toward jaggery recovery %. Similar findings were reported made by Uppal, *et al.* (2005) wherein, the genotypes which are harvested at peak maturity has higher juice extraction which in turn given higher jaggery recovery%. For high quality and high jaggery production, the cane is to be harvested at peak maturity (Baboo, 1993; Misra, 1995), to avoid post flowering or maturity deterioration in juice extraction. In the present study these genotypes exhibited high extraction % even peak flowering and maturity period (December). This can be on account of their non flowering features which imparts long field keeping quality.

The genotype SNK 09293 combined superiority for both jaggery recovery and cane yield leading to most promising genotype for jaggery yield over best check SNK 814.

5.2.4 Mean performance of top productive genotypes for jaggery quality parameters

The data on jaggery quality parameters of the elite clones are presented in Table 12. The jaggery is important product of the cottage industry where in the currently demand for jaggery is based on its color, taste, sweetness and its medicinal value (Jaswant, 2011). In this regard the parameters like P^H, reducing sugars (RS), non reducing sugars (NRS), color (Optical density at 540nm), were estimated in these productive clones to identify genotypes having acceptable jaggery yield and quality parameters with non or shy flowering features.

All the genotypes showed moderate (neutral) pH and genotypes SNK 09370 recorded high value and could be best for color of the jaggery followed by SNK 09227 when compared to best jaggery check Co 92005. Color is an important physical parameter of jaggery as the dark color is disliked. The most desirable is golden yellow color of the jaggery. The OD value has direct correlation with that of the color of the jaggery, higher the OD value higher will be the color and vice versa.

Non reducing sugars (NRS) being the major sweetening agent, it is the main factor in deciding the quality of the jaggery. Non reducing sugars (NRS) (sucrose%) of jaggery genotypes CoC

671, SNK 09 211, SNK 09212 and Co 92005 were 80-85 per cent which indicated that they fall to Grade-I (Indian standards 12923:1990) The clones *viz.*, SNK 09 211 (87.2) , SNK 09212 (85.3) are on par compared to the best check Co 92005 (85.3). Indicating that these clones have higher sucrose content coupled with high color which is most desirable.

The reducing sugars (RS) is the undesirable parameter for jaggery, as they lead to reduce the shelf life and quality of the jaggery. Reducing sugars were low in genotype SNK 09370 (8.95) and SNK 09211 (10.99) as compared to check Co 92005 (15.39). As there is negative correlation between the reducing sugars and color of the jaggery *i.e.* higher the RS lower will be the color. Similar results were reported by Banerji *et al.* (2012), Hussain *et al.* (2012).

In conclusion considering the quality parameters of jaggery with respect to its storage and acceptability of color (Golden yellow) and sucrose content, the genotype SNK 09211 ranked first followed by SNK 09212 when compared to the best available jaggery check Co 92005.

The identified clones for jaggery productivity and important quality parameters could be of great commercial value, as they are of non flowering features. The non flowering feature generally imparts longer field keeping quality which can be suitably exploited for extension of crushing seasons, in addition sustaining the jaggery production. The non flowering genotypes desirable for fodder security in the region like northern Karnataka, where profuse flowering in present commercial varieties is greatest constraint affecting the economy of jaggery and sugar industry.

5.2.5 Identification of parents and crosses for combining productivity and non flowering

In sugarcane breeding family or cross selection followed by intensive progeny testing for desired traits is widely practiced to achieve targeted genetic enhancement (Patil, 2005, Patil *et al* 2011). Further the important traits like flowering behavior and productivity parameters are highly reliable for early generation selection as it was also confirmed in the present study. In this context, 11 biparental crosses and 7 general crosses (Open pollinated) were evaluated in frequency of transgressive segregantes combining non flowering and productivity components for the present study pre selected advanced progenies based on acceptable productivity levels were scored for flowering behavior (Time and intensity).

The crosses *viz.*, Co 86032 × Co 86250 (72%), CoM 262GC (28%), SNK632GC (27%), Co86032 × ISH69 (22%), Co 2000-10 × CoT8201(22%), CoSnk 03632 × Co 0403 (21%) and ISH100 × Co 92102 (20%) found promising for as they produced relatively better frequency of transgressive segregants for combining targeted traits (Table 16). These results confirm our previous findings reported, where in early generation selections were practiced for traits like flowering behavior and productivity features (Patil *et al.*, 2011; Patil, *et al.*, 2005; Kimbeng and Cox, 2003). In other studies (Shanthi, *et al.*, 2008) where combination of parents were studied to identify genotypes for higher cane and sugar yield characters.

The results clearly indicate utility of family (cross) selection and contribution of female parent particularly for getting transgressive segregants for combining non flowering and productivity. Similar results were reported by Sandhu *et al.* (2012) where in contribution of female parent was noticed for brix character. The results also demonstrate importance of traits based directed breeding in sugarcane as the parents particularly female involved in the present study are of late sparse flowering types.

When other crosses *viz.*, Co 7704GC (84%), Co5268 × Co93009 (63%), Co94012 (58%), CoA7 602 × ISH 69 (52%) and Co 8371 × Co 86250 (42%), were looked, they recorded higher frequencies profuse flowering progenies though with acceptable productivity features. On the contrary they recorded very low frequencies of productive non flowering progenies. These results also clearly indicate the contribution of females as these parents were characterized as early profuse flowering (Patil *et al* 2011, Khot *et al.*, 1998).

In the present study relatively late but profuse flowering parents like CoSnk 632, CoM 0265, ISH 100 and Co740 (Patil *et al* 2011) produced considerably high frequencies of progenies combining productivity with non flowering. This could be either on account of dependence of flowering profuseress or specific gene combinations which might have lost during crossing (Imran *et al.*, 1988), or chromosomal aberrations (Hossain and Islam, 2009).

When top 14 productive non flowering genotypes were looked for their parentage (Pedigree), the cross Co86032 × Co86250 has contributed maximum number (7) of transgressive segregants for

Table 16: Performance of crosses for frequency for progenies combining acceptable (productivity)and non flowering

Sl. No.	Parents	Total commerical acceptable clones/progenies	1(%)	2(%)	3(%)	4(%)	NF(%)
1	Co 740 X Co 775	10	20	0	30	20	30
2	CoA 7602 X ISH 69	23	43	0	35	22	0
3	Co 2000-10 X CoT 8201	9	44	11	33	0	22
4	CoSnk 03632 X Co 0403	34	32	38	3	6	21
5	SNK 632 GC	11	27	36	10	0	27
6	Co 7704 GC	19	84	0	5	0	11
7	Co 86032 X ISH 69	23	45	23	0	10	22
8	Co 95021 X Co 97015	16	62	13	19	0	6
9	Co 8371 X Co 86250	21	33	29	15	0	14
10	Co 86032 X Co 86250	36	6	4	18	0	72
11	81 V 48 X Co 99006	18	39	36	6	19	0
12	CoM 265 GC	32	28	25	0	19	28
13	ISH -100 X Co 92102	10	30	50	0	0	20
14	CP 5268 X Co 93009	65	60	22	0	2	16
15	Co 94012 GC	151	52	14	0	16	18
16	Co 8371 GC	37	76	11	0	5	8
17	Co 0238 GC	31	94	6	0	0	0
18	Co 98006 GC	12	58.3	16.6	0	8.3	16.8

Note

- 1 Early Profuse flowering
- 2 Late Sparse flowering
- 3 Late Profuse flowering
- 4 Very Late / Very Sparse flowering
- NF Non flowering

targeted traits which also combined superiority for juice quality (sucrose %) where in 3 progenies viz., SNK 09212 (18.74%), SNK 09221 (18.78%) and SNK 09232 (18.91%) excelled over Co 86032 parent (Table 16). Hence this cross could be considered as proven for genetic enhancement sugarcane productivity with non flowering feature. Further, two clones viz., SNK 0922 (79%) and SNK 09212 (68%.1) were excelled for higher juice extraction % which is very much desirable feature for jaggery productivity.

Similarly the family CoM 0265 GC contributed 3 transgressive progenies for both the targeted traits where in the progeny viz., SNK 09271 (18% Sucrose) also combined superior juice quality. Therefore, the family CoM 0265 GC could also be considered as proven for genetic enhancement with non flowering trait.

5.2.6 The mean performance of top productive genotypes across generation (clonal I and clonal II) for cane and sugar yield parameters with flowering intensity.

The mean performance of top productive genotypes across generations (clonal I and clonal II) along with commercial check for cane and sugar yield parameters like cane yield, brix per cent, sucrose per cent, CCS per cent and CCS yield is presented in Table 17 and 18. The data of clonal I generation was obtained from breeder, ARS, Sankeshwar.

It is evident from the table that, all 14 top productive clones are superior over the best check Co 86032 for cane yield across generation, Similar report have been reported by Zhou *et al.* (2013) where in the same superior genotypes in clonal I were superior in clonal II also for cane yield. Instances have been recorded in Stage II trials where individual clones or family of clones have been found to perform better or worse than expected when compared with their family mean in Stage I (Hogarth *et al.*, 1990; Kimbeng *et al.*, 2000). The clones viz., SNK 09268, SNK 09271, and SNK 09370 are significantly superior in terms of their cane yield compared to the best commercial check Co 86032. The clone SNK09268 recorded significantly superior cane yield (150.8 t/ha) compared to Co 86032 (97.8 t/ha), followed by SNK 09271(143.3 t/ha) and SNK 09370 (142.5 t/ha) (Table 17).

Sucrose per cent being the most important juice quality parameter was significantly high in the genotypes SNK 09232, SNK 09377, SNK 09221 and SNK 09227, whereas the same genotypes including SNK 09268 showed significantly high CCS per cent compared to best check Co 86032 across generation. Hogarth *et al.* (1990); Kimbeng *et al.* (2000) reported similar results wherein the same genotypes in both stage I and stage II were superior for sucrose percent and CCS percent. Among 14 top productive genotypes the final CCS yield which is the product of CCS per cent and cane yield was significantly high in these 13 genotypes except SNK 09212 compared to best check Co 86032 indicating they have high potential for sugar yield along with cane yield. The genotypes SNK 09232 and SNK 09377 were recorded significantly higher for sugar yielding parameters like sucrose %, CCS % and CCS yield over generation compared to best check Co 86032. The clone SNK 09268 exhibited significantly higher cane yield with higher CCS % and CCS yield compared to best check Co 86032. The genotypes SNK 09232 and SNK 09377 were found most promising as they recorded superior juice quality (sucrose %) and cane yield components over best popular check Co 86032.

5.2.7 Identification of potential productive progenies for sugar and jaggery yield along with non flowering features.

The mean performance of top productive genotypes along with commercial checks for cane, sugar and jaggery yield components like, sucrose per cent, CCS per cent and CCS yield cane yield (t/ha) , jaggery recovery and jaggery yield is presented in Table 19 .

It is evident from the table that, the clones SNK 09293, SNK 09271, SNK 09304 and SNK 09211 are significantly superior in terms of their cane yield compared to the best commercial check SNK 814. The clone SNK09293 recorded 156.1 t/ha of cane yield compared to SNK 814 (105.1 t/ ha), where as SNK 09271, SNK 09370 and SNK 09111 were recorded 153.2, 152 and 149 t/ha respectively for cane yield than the best check SNK 814. Similarly for jaggery recovery and jaggery yield these genotypes (SNK 09293, SNK 09221, SNK 09227 and SNK 09211) were shown significantly superiority compare to best commercial check SNK 814. The clone SNK 09293 recorded 12.41% of jaggery recovery and 19.38t/ha of jaggery yield, where as check SNK 814 recorded 10.92 per cent of jaggery recovery and 11.6 t/ha of jaggery yield, which indicates that SNK 09293 and SNK 09221 were significantly superior for jaggery yield and jaggery recovery over best check.

Table 17: Performance of top productive progenies for cane yield and its component along with flowering feature across generations

SI No	Parentage	Entry No	SCW (kg)			NMC ('000/ha)			Cane Yield (t/ha)			Flowering %		
			Clona I I	Clona I II	Mean	Clonal I	Clona I II	Mean	Clonal I	Clonal II	Mean	Clona I I	Clona I II	Mean
1	SNK 632 GC	SNK09 111	1.011	1.125	1.068	122.20	115.8	119.0	123.50	130.28	126.89	11	0	5.50
2	Co 86032 X Co 86250	SNK09 211	0.947	1.757	1.352	55.55	85.2	70.4	52.60	149.69	101.14	0	0	0
3		SNK09 212	0.781	1.556	1.169	88.87	86.1	87.5	69.41	133.98	101.69	0	0	0
4		SNK09 221	0.611	0.990	0.801	103.68	141.4	122.5	63.35	139.99	101.67	0	0	0
5		SNK09 227	1.403	1.688	1.546	88.87	84.3	86.6	124.72	142.30	133.51	0	0	0
6		SNK09 229	1.087	1.238	1.162	81.47	111.6	96.5	88.53	138.14	113.33	0	6.14	2.07
7		SNK09 230	0.902	0.929	0.915	77.76	150.2	114.0	70.12	139.52	104.82	0	0	0
8		SNK09 232	1.113	1.037	1.075	148.12	131.9	140.0	164.91	136.75	150.83	0	0	0
9	CoM 0265 GC	SNK09 268	1.710	2.040	1.875	81.47	72.2	76.9	139.31	147.38	143.34	0	0	0
10		SNK09 271	1.313	1.723	1.518	88.87	89.0	88.9	116.72	153.38	135.05	6	14.01	10.01
11		SNK09 293	1.437	1.253	1.345	88.87	124.6	106.7	127.68	156.16	141.92	0	0	0
12	ISH 100 X Co 92102	SNK09 304	1.240	1.260	1.250	107.39	120.6	114.0	133.16	152.00	142.58	3	0	1.50
13	CP 5268 X Co 93009	SNK09 370	0.927	1.296	1.111	88.87	106.6	97.7	82.35	138.14	110.25	0	0	0
14	Co 94012 GC	SNK09 377	1.114	0.920	1.017	55.55	134.6	95.1	61.88	123.82	92.85	0	1.37	0.69
	Checks													
15		Co 671	1.262	1.194	1.228	59.25	71.1	65.2	74.77	83.0	78.91	66.1	88.6	77.35
16		Co 86032	1.289	1.222	1.255	74.06	82.7	78.4	95.46	100.1	97.80	25	18	21.50
		CV	14.18	14.95	11.29	17.35	14.02	11.19	13.94	14.32	18.60			
		C.D.@ 5%	0.21	0.25	0.20	18.18	19.32	15.56	25.39	14.59	16.44			

Table 18: Performance of top productive progenies for sugar yield across generations

SI No	Parentage	Entry No	Brix (%) juice 10M			Sucr ose (%)			CCS (%)			CCS Yield (t/ha)			JE (%)		
			Clonal I	Clonal II	Mean	Clonal I	Clonal II	Mean	Clonal I	Clonal II	Mean	Clonal I	Clonal II	Mean	Clonal I	Clonal II	Mean
1	SNK 632 GC	SNK09 111	17.27	15.6	16.4	16.50	14.2	15.3	11.82	10.0	10.9	14.60	12.97	13.79	53.56	58.5	56.03
2	Co 86032 X Co 86250	SNK09 211	20.95	14.4	17.7	19.90	13.6	16.7	14.22	9.7	11.9	7.48	14.46	10.97	56.11	64.7	60.41
3		SNK09 212	20.75	16.3	18.5	20.14	15.7	17.9	14.52	11.3	12.9	10.08	15.08	12.58	56.51	68.1	62.32
4		SNK09 221	20.02	16.0	18.0	19.70	15.7	17.7	14.29	11.3	12.8	9.05	15.85	12.45	53.08	76.0	64.52
5		SNK09 227	21.02	14.0	17.5	20.14	12.6	16.4	14.45	8.8	11.6	18.02	12.46	15.24	58.76	64.5	61.64
6		SNK09 229	18.02	15.2	16.6	17.23	14.5	15.9	12.35	10.4	11.4	10.93	14.31	12.62	32.91	59.8	46.34
7		SNK09 230	21.68	17.5	19.6	21.30	16.3	18.8	15.44	11.6	13.5	10.82	16.13	13.47	46.36	57.4	51.87
8		SNK09 232	20.75	14.4	17.6	20.67	13.8	17.2	15.07	9.9	12.5	24.84	13.48	19.16	52.22	63.5	57.83
9	CoM 265 GC	SNK09 268	20.84	14.6	17.7	18.22	14.5	16.4	12.54	10.5	11.5	17.46	15.55	16.50	45.65	51.0	48.34
10		SNK09 271	21.56	12.5	17.0	20.34	11.7	16.0	14.49	8.3	11.4	16.91	12.72	14.82	61.29	65.5	63.41
11		SNK09 293	21.22	15.0	18.1	17.23	13.5	15.4	11.41	9.4	10.4	14.57	14.74	14.66	42.78	60.5	51.64
12	ISH 100 X Co 92102	SNK09 304	21.39	15.4	18.4	18.43	12.8	15.6	12.59	8.6	10.6	16.76	13.04	14.90	58.68	61.3	60.02
13	CP 5268 X Co 93009	SNK09 370	20.66	16.5	18.6	21.34	15.5	18.4	15.78	11.0	13.4	12.99	15.21	14.10	60.07	61.7	60.86
14	Co 94012 GC	SNK09 377	18.77	14.1	16.4	18.35	13.6	16.0	13.27	9.8	11.5	8.21	12.16	10.19	59.84	59.7	59.76
15		Co 671	22.61	15.2	18.9	21.49	13.1	17.3	15.36	9.0	12.2	11.49	7.5	9.48	52.06	61.4	56.73
16		Co 86032	20.12	15.6	17.8	19.50	13.7	16.6	14.05	9.5	11.8	13.42	9.4	11.43	59.12	66.9	63.01
		CV	6.79	7.78	5.02	8.09	9.00	6.39	9.78	10.21	7.77	33.04	17.37	18.13	14.58	8.74	9.60
		C.D.@ 5%	1.05	0.89	0.67	1.18	0.95	0.81	1.02	0.76	0.70	3.39	1.76	1.85	5.83	4.12	4.18

Table 19: Mean performance of top productive clones for cane, sugar and jaggery yield parameters

SI No	Entry	Cane yield (t/ha)	CCS yield (t/ha)	Sucrose (%) juice	CCS (%)	Jaggery recovery (%)	Jaggery Yield (t/ha)	Sucrose (%) jaggery	OD value (at 540 nm)	pH of jaggery	Reducing sugars (%)
1	SNK 09111	130.28*	13.82	15.89	10.61	11.21	14.60*	74.9	0.473	5.16	10.07
2	SNK 09211	149.69*	18.70*	18.02	12.49	8.13	12.17	87.4	0.524	5.55	10.99
3	SNK 09212	133.98*	17.80*	18.74*	13.29*	10.18	13.64*	85.3	0.348	5.6	9.76
4	SNK 09221	139.99*	18.49*	18.78*	13.21*	11.93*	16.70*	78.8	0.531*	5.21	12.02
5	SNK 09227	142.30*	16.87*	17.34	11.86	11.37*	16.18*	75.3	0.537*	5.57	11.95
6	SNK 09229	138.14*	15.92*	16.50	11.52	6.79	9.38	77.0	0.508	5.18	9.38
7	SNK 09230	139.52*	17.73*	18.83*	12.71	9.29	12.96*	74.0	0.505	5.18	10.87
8	SNK 09232	136.75*	17.89*	18.91*	13.08	10.74	14.69*	81.1	0.513	5.56	13.17
9	SNK 09268	147.38*	15.96*	15.48	10.83	7.50	11.06	92.1*	0.477	5.55	10.74
10	SNK 09271	153.38*	19.78*	18.30*	12.89	10.66	16.36*	79.0	0.523	5.71	13.26
11	SNK 09293	156.16*	17.97*	16.26	11.51	12.41*	19.38*	70.7	0.523	5.23	9.86
12	SNK 09304	152.00*	18.91*	17.63	12.44	8.89	13.52*	79.0	0.533*	5.03	10.07
13	SNK 09370	138.14*	15.40*	16.02	11.15	9.41	12.99	70.7	0.538*	5.23	8.95
14	SNK 09377	123.82*	14.48*	16.50	11.70	5.62	6.96	77.0	0.491	5.51	14.57
Checks											
C1	Co 2001-15	96.79	12.30	17.63	12.71	8.51	8.23	85.3	0.527	5.38	15.39
C2	Co 86032	100.14	13.07	18.11	13.06	10.33	10.34	75.3	0.481	5.26	11.12
C3	Co 92005	83.04	10.61	17.84	12.78	7.77	6.45	85.3	0.449	5.18	15.39
C4	CoC 671	83.04	10.80	18.35	13.01	11.27	9.36	91.5	0.512	5.29	11.52
C5	SNK 044	98.64	10.90	17.15	11.05	8.66	8.55	82.0	0.361	5.74	7.69
C6	SNK 814	105.80	12.76	16.99	12.06	10.92	11.6	78.60	0.495	5.81	8.95
	CV	18.73	19.17	6.14	7.04	19.04	18.56	7.72	10.75	4.24	19.11
	C.D.@ 5%	15.80	1.97	0.71	0.57	1.21	2.32	4.09	0.04	0.15	1.43

The genotypes SNK 09293, SNK 09271 and SNK 09221 found most promising as it recorded superior cane and jaggery yield components over best popular check SNK 814.

Among the genotypes, SNK 09230, SNK 09221, SNK 09212 and SNK 09370 recorded significantly high sucrose per cent, whereas the same genotypes including SNK 09268 showed significantly high CCS per cent compared to best check SNK 814. The final CCS yield which is the product of CCS per cent and cane yield was also significantly high in these genotypes indicating they have high potential for sugar yield.

The clone SNK 09221 found most promising genotype as it recorded higher cane yield, jaggery recovery and jaggery yield along with higher sugar yield parameters (sucrose %, CCS% and CSS yield) compare to commercially best checks SNK 814 and Co 86032 (Plate 8)

With respect to jaggery quality parameters the genotype SNK 09212 recorded higher sucrose per cent (85.3%) with acceptable jaggery recovery (10.18%) and OD value 0.348 coupled with relatively lower reducing sugars(9.76 %) makes it superior among top productive genotypes. Since it is having lower reducing sugar which helps to increase keeping quality of the jaggery and it exhibited significantly superior cane yield (133.98 t/ha) compare to check commercially best checks SNK 814 and Co 86032.

Non flowering feature being the most important key criteria of the present investigation totally 14 top productive progenies were selected based on their cane and sugar yield parameters with non flowering as a additional feature. Among 14 progenies three progenies were flowered namely SNK 09271 (14%) was highest followed by SNK 09229 (6%) and SNK 09377(1.2%) and the rest of the genotypes were completely non flowering.

In conclusion the genotypes SNK 09221 (Plate 6) and SNK 09212 (Plate 7) are superior among top productive progenies for cane yield, sugar yield, jaggery yield and quality parameters along with non flowering feature.

Future line of work

1. The most promising productive non-flowering / sparse late flowering (photothermo-insensitive) genotypes (SNK 09221 and SNK 09212) could be released for commercial cultivation after confirming their cane and sugar productivity potential through extensive yield trials.
2. Identified sparse late flowering productive clones which are photothermo insensitive would be utilized for further genetic enhancement combining non-flowering feature in future breeding programmes.
3. Genotypes like SNK 09271 which is highly productive for cane, sugar yield and jaggery yield with 14% flowering intensity can be utilized in future breeding programmes as a parents suitable for genetic enhancement.
4. Biochemical and molecular characterization of flowering and non flowering clones needs to be carried out to understand the complexity of flowering.
5. Extremely diverse flowering behavior i.e early profuse flowering and late very sparse flowering clones can be suitably be utilized for development of mapping population.



Plate 6. Comparison of jaggery (lump) of SNK 09221 with commercial checks



Plate 7. Comparison of jaggery (lump) of SNK 09212 with commercial checks



Plate 9. Comparative view of SNK 09221 (non-flowering) with commercial checks at ARS Sankeshwar

SUMMARY AND CONCLUSIONS

The present investigation was carried out with a view to get information about the nature and amount of exploitable variability in respect of cane and sugar yield component traits in clonal II and further to study the repeatability and nature of association between cane and sugar yields attributes. It was also proposed to study the characterization of flowering to identify non flowering genotypes.

The experimental material was planted in augmented randomized block design at Agricultural Research Station, Sankeshwar. Observations were recorded for cane and sugar yield traits at various stages viz., single cane weight, cane height, cane girth, number of internodes, internodal length, juice weight, juice extract per cent, brix per cent, sucrose per cent, number of millable canes, CCS %, CCS yield, cane yield, jaggery recovery % and jaggery yield along with flowering behavior.

The salient findings of present investigations are summarized below

1. The genotypic variations observed for millable cane height, internodal length, NMC, cane yield and juice brix per cent, were very wide, indicating selection for these characters is expected to achieve profitable gains. Comparatively moderate variability was observed for cane girth and single cane weight, suggesting more directed efforts are needed to achieve improvement in these traits.

Whereas heritability and genetic advance as per cent of mean for above traits suggested better chances of improving these traits through straight selection, while for later traits viz., cane girth and single cane weight, the values were moderate and lower respectively, indicating predominance of non-additive gene action or environmental influence.

2. The association studies revealed that, the traits viz., average single cane weight, cane height and number of millable canes were the strongest parameters with cane yield positively indicating these traits can be considered for selection to bring the improvement in the cane yield. Whereas, the sucrose per cent found out to be negatively associated with yield indicating cautious selection has to be made for sucrose per cent without compromising yield loss. These traits can be considered as principal cane yield determining components and it is suggested to use these as selection criteria for cane yield improvement in sugarcane.
3. The path analysis involving characters pertaining to growth, cane and sugar yield parameters viz., internode formed shoots at 120 DAP, shoots at mid formative stage, number of internodes, NMC and single cane weight at harvest, and juice quality traits viz., juice extraction (%), brix and sucrose per cent can serve as important selection criteria for improvement in cane yield.
4. The repeatability values in clonal generations across clonal I and clonal II generation for important traits, viz., HR brix per cent at 10 month and flowering per cent were comparatively highly significant with moderate to higher heritability values indicating these traits as more dependable as selection criteria, whereas, rest of the traits exhibited poor repeatability values indicating major role of environmental factors which influence on these traits.

Flowering behaviour and Jaggery analysis

In the present study pre selected advanced progenies based on acceptable productivity levels were scored for flowering behavior (Time and intensity).

1. The crosses viz., Co 86032 × Co 86250 (72%), CoM 262GC (28%), SNK632GC (27%), Co86032 × ISH69 (22%), Co 2000-10 × CoT8201(22%), CoSnk 03632 × Co 0403 (21%) and ISH100 × Co 92102 (20%) found promising as they produced relatively better frequency of transgressive segregants for combining targeted traits like non flowering feature with high cane and sugar yield.
2. Characterization of flowering based on days to flowering (primordial count) and intensity of flowering, genotypes viz., SNK 632, SNK 044, SNK 814 and CoC 671, are early flowering types and other three commercial genotypes viz., CoM 0265, Co 94008 and Co 86032 could be characterized as moderate flowering both with respect to date and intensity of flowering. The other variety CoM 88121 where in no floral primordial count was recorded confirming its complete non flowering character.
3. Among all genotypes studies in our investigation 14 were found productive for cane yield, sugar and jaggery yield. Among these 14 genotypes, SNK 09229 (6%), SNK09 271 (14%), and SNK 09377 (1%) were flowering and rest of the genotypes were non-flowering.
4. Genotypes SNK 09221 and SNK 09212 are superior among top productive progenies for cane yield, sugar yield, jaggery yield and quality parameters along with non flowering feature.

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Appendix I: Mean weather data of ARS Sankeahwar for 2011- 2012

Month	Rain fall (mm)	Rainy (days)	Temperature		RH (%)
			Max	Min	
JAN	0.0	0	30.4	12.3	56
FEB	0.0	0	32.8	13.8	45
MAR	0.0	0	35.7	17.3	43
APR	39.4	4	36.2	22.4	49
MAY	30.6	2	35.4	23.0	53
JUN	51.3	3	30.6	23.2	72
JUL	140.6	12	27.7	22.2	81
AUG	97.9	12	27.0	21.6	82
SEP	101.2	8	28.5	20.7	82
OCT	84.5	7	30.3	20.6	66
NOV	43.1	3	30.2	19.5	63
DEC	4.1	1	30.7	24.5	53
Total	592.7	52			

Appendix II: Adjusted mean values of 145 selected clones of – crosses at II clonal stage.

SI No	Entries	Adjusted Mean													
		SCW	J W	C H	C G	NOI	I L	Brix %	Sucrose %	J E %	CCS %	Purity %	NMC ('000/ha)	C Y (t /ha)	CCS yield /ha
1	SNK09 005	1.709	0.94	180.1	3.72	16.4	11.13	15.0	12.13	52.63	8.05	80.90	74.33	120.2	9.65
2	SNK09 007	1.501	1.03	210.1	2.89	17.1	12.44	15.6	13.63	66.33	9.41	87.67	91.18	128.5	12.07
3	SNK09 012	1.159	0.67	140.1	3.17	15.1	9.42	13.7	10.99	54.30	7.25	80.00	85.74	91.6	6.64
4	SNK09 038	1.777	1.18	226.1	3.09	18.4	12.44	16.7	13.98	64.50	9.45	83.97	74.08	124.8	11.77
5	SNK09 040	1.288	0.86	246.1	2.50	15.7	15.86	14.8	11.69	64.67	7.64	78.79	94.65	113.3	8.64
6	SNK09 042	1.615	1.03	261.1	2.76	18.1	14.59	17.6	15.44	61.51	10.66	87.61	93.46	142.4	15.13
7	SNK09 050	1.455	0.79	191.1	3.13	21.7	8.93	12.9	10.25	51.63	6.74	79.53	63.77	86.9	5.87
8	SNK09 051	1.334	0.86	216.1	2.87	17.4	12.58	16.2	14.52	61.96	10.14	89.77	65.51	81.4	8.26
9	SNK09 053	0.966	0.57	180.1	2.85	15.1	12.09	14.3	12.67	55.29	8.80	88.75	97.24	85.1	7.50
10	Co86032	2.016	1.20	250.1	3.16	21.7	11.67	16.8	15.74	57.91	11.21	93.86	52.89	101.7	11.39
11	SNK09 058	1.636	1.01	225.1	3.05	19.4	11.75	15.5	14.58	59.83	10.39	94.00	80.83	124.8	12.94
12	SNK09 059	1.480	0.96	236.1	2.89	20.1	11.89	17.3	16.78	62.44	12.13	97.18	83.91	116.5	14.11
13	SNK09 060	1.492	0.96	208.1	3.07	20.1	10.49	16.6	15.57	62.12	11.10	93.97	86.49	121.1	13.41
14	SNK09 061	0.869	0.53	150.1	2.66	20.1	7.59	14.7	13.60	56.90	9.64	92.69	115.89	90.2	8.69
15	SNK09 062	1.439	0.94	258.1	2.82	19.1	13.67	17.1	15.44	63.22	10.82	90.44	77.21	104.0	11.24
16	SNK09 063	1.174	0.75	240.1	2.49	15.1	16.09	10.4	8.10	60.94	5.27	77.93	120.82	130.8	6.87
17	SNK09 077	1.836	1.19	306.1	2.80	22.4	13.81	16.2	13.06	62.90	8.66	80.85	71.84	125.3	10.82
18	SNK09 080	1.343	0.99	241.1	2.67	23.1	10.57	17.7	16.71	71.98	11.95	94.74	107.84	135.0	16.09
19	SNK09 088	1.497	1.06	215.1	2.95	16.1	13.53	12.6	11.77	68.80	8.39	93.83	95.38	134.1	11.21
20	SNK09 094	1.333	0.68	270.1	2.35	21.4	12.77	16.1	15.01	47.27	10.68	93.58	110.94	137.8	14.67
21	SNK09 099	1.606	1.02	233.1	2.97	22.7	10.40	15.7	13.99	61.08	9.74	89.25	84.87	128.5	12.49
22	SNK09 103	1.774	1.14	291.1	2.80	21.7	13.56	16.4	14.28	62.18	9.85	87.36	78.60	132.2	12.98

23	SNK09 104	1.412	0.89	246.1	2.67	24.1	10.34	16.3	15.75	60.50	11.35	96.52	101.51	134.1	15.18
24	SNK09 105	1.495	0.95	235.1	2.95	19.4	12.27	12.8	10.25	60.92	6.78	80.34	68.86	96.6	6.55
25	SNK09 107	1.373	0.89	206.1	2.63	21.4	9.76	18.0	17.32	62.03	12.49	96.56	94.51	121.1	15.09
26	SNK09 109	1.990	1.19	285.1	3.05	21.4	13.47	14.2	13.42	57.75	9.61	94.90	72.59	137.8	13.19
27	SNK09 110	1.491	0.93	291.1	2.61	23.7	12.42	16.8	15.44	60.02	10.89	91.79	99.42	139.2	15.11
28	SNK09 111	1.216	0.75	208.1	2.67	19.7	10.70	15.7	14.28	58.58	10.05	91.29	115.90	130.4	13.07
29	SNK09 115	1.131	0.71	195.1	2.72	14.4	13.73	16.2	15.75	59.80	11.39	97.18	116.04	120.7	13.71
30	SNK09 139	1.231	0.76	205.1	2.67	17.1	12.15	10.8	8.32	58.69	5.38	77.08	77.50	88.3	4.76
31	SNK09 149	1.405	0.94	233.1	2.85	20.1	11.74	11.7	10.53	64.32	7.36	89.78	74.63	98.0	7.21
32	SNK09 183	1.249	0.79	211.1	2.66	15.1	14.16	19.3	17.25	60.45	12.03	89.51	64.72	74.9	9.02
33	SNK09 190	1.412	0.95	226.1	2.91	19.4	11.80	16.5	13.79	65.04	9.31	83.68	87.53	115.6	10.74
34	SNK09 198	0.960	0.61	160.1	2.85	14.1	11.52	18.5	16.11	60.28	11.09	87.20	57.51	50.0	5.58
35	SNK09 211	1.848	1.23	278.1	2.89	19.1	14.72	14.5	13.66	64.80	9.75	94.26	85.29	149.8	14.55
36	SNK09 212	1.647	1.15	236.1	2.91	15.7	15.22	16.4	15.75	68.21	11.35	96.40	86.20	134.1	15.17
37	SNK09 213	1.396	0.98	203.1	2.96	16.1	12.78	16.2	14.77	68.37	10.40	91.50	93.91	122.5	12.72
38	SNK09 214	1.017	0.69	201.1	2.46	13.7	14.87	14.3	10.95	64.89	7.06	76.79	135.80	125.8	8.84
39	SNK09 215	1.289	0.89	255.1	2.49	16.1	16.03	17.4	15.69	66.70	10.99	90.47	100.74	120.7	13.24
40	SNK09 216	1.598	1.10	268.1	2.76	17.4	15.58	15.1	11.64	66.91	7.50	76.89	90.84	136.8	10.23
41	SNK09 217	0.893	0.55	220.9	2.15	14.9	14.63	13.7	10.50	65.16	6.70	76.56	105.34	105.2	7.06
42	SNK09 218	1.259	0.74	245.9	2.47	16.9	14.36	17.4	17.12	61.80	12.38	98.13	75.03	102.5	12.70
43	SNK09 219	1.358	0.86	275.9	2.49	18.9	14.42	15.2	14.38	65.81	10.22	94.35	89.52	131.1	13.45
44	SNK09 221	0.884	0.65	232.9	2.05	19.5	11.78	15.9	15.55	75.85	11.21	97.52	141.29	139.9	15.74
45	SNK09 222	0.856	0.50	215.9	2.19	20.9	10.18	17.0	15.37	62.58	10.71	90.21	142.53	137.1	14.73
46	SNK09 223	1.168	0.73	250.9	2.43	21.5	11.51	16.7	13.59	65.59	8.98	81.25	81.49	103.8	9.34
47	SNK09 224	0.598	0.31	202.9	1.92	14.9	13.43	17.8	16.39	58.98	11.52	91.87	121.30	85.4	9.83
48	SNK09 227	1.582	0.98	210.9	2.99	17.2	12.09	13.9	12.47	64.41	8.65	89.49	84.19	142.2	12.35
49	SNK09 228	1.774	1.03	262.9	2.82	18.9	13.74	15.7	15.55	60.59	11.27	98.76	48.06	90.4	10.20

50	SNK09 229	1.132	0.63	239.9	2.39	19.5	12.14	15.1	14.38	59.67	10.25	94.97	111.48	138.0	14.20
51	SNK09 230	0.823	0.43	282.9	1.89	17.5	15.97	17.4	16.21	57.27	11.45	92.94	150.08	139.4	16.02
52	SNK09 231	1.237	0.74	259.9	2.46	19.5	13.16	17.5	11.54	62.81	6.67	66.24	96.56	129.7	8.69
53	SNK09 232	0.931	0.55	245.9	2.07	17.9	13.56	14.3	13.65	63.35	9.75	95.52	131.77	136.6	13.38
54	SNK09 233	0.548	0.29	194.9	1.90	13.9	13.82	14.8	12.42	59.83	8.35	84.04	160.96	105.2	8.80
55	SNK09 234	1.542	1.04	234.9	3.01	19.9	11.64	14.5	11.91	69.37	7.92	82.28	79.79	131.6	10.46
56	SNK09 235	1.132	0.68	212.9	2.39	13.9	15.11	16.0	15.55	63.06	11.20	97.22	104.76	129.7	14.57
57	SNK09 242	0.894	0.45	172.9	2.63	14.2	11.99	10.7	9.84	55.79	6.91	92.11	57.64	57.6	3.95
58	SNK09 243	1.057	0.81	240.9	2.45	17.5	13.59	14.2	12.97	78.48	9.09	91.43	71.80	83.5	7.58
59	SNK09 245	0.932	0.58	219.9	2.20	17.2	12.61	14.7	12.67	66.17	8.64	86.30	85.35	88.6	7.65
60	SNK09 251	1.062	0.65	242.9	2.45	17.5	13.70	16.2	15.55	65.05	11.14	96.03	73.47	85.8	9.56
61	SNK09 264	1.337	0.69	219.9	2.74	19.5	11.12	14.1	12.18	55.20	8.31	86.50	70.33	101.5	8.45
62	SNK09 265	0.704	0.34	139.9	2.49	17.9	7.67	12.4	12.28	55.57	8.89	98.70	80.89	65.5	5.80
63	SNK09 267	0.963	0.47	172.9	2.55	14.5	11.74	13.4	11.29	54.15	7.61	84.40	106.21	113.5	8.66
64	SNK09 268	1.934	0.93	267.9	2.84	19.9	13.29	14.5	14.38	50.92	10.44	99.21	72.14	147.3	15.44
65	SNK09 269	1.163	0.74	227.9	2.55	18.5	12.15	14.3	13.16	66.72	9.25	92.11	105.47	133.9	12.43
66	SNK09 271	1.617	1.02	265.9	2.65	19.2	13.68	12.4	11.57	65.42	8.18	93.41	88.92	153.3	12.61
67	SNK09 274	1.459	0.83	235.9	2.64	24.5	9.49	16.7	15.55	59.77	11.00	93.16	91.70	143.6	15.84
68	SNK09 276	0.604	0.27	179.9	2.06	14.9	11.89	14.5	14.38	52.99	10.44	99.21	73.42	52.1	5.40
69	SNK09 277	1.317	0.67	210.9	2.74	18.9	11.00	16.8	16.21	54.71	11.64	96.52	66.77	95.1	11.07
70	SNK09 279	0.850	0.45	172.9	2.39	14.9	11.43	11.8	10.33	58.58	7.09	87.70	52.09	49.8	3.49
71	SNK09 282	1.673	0.93	244.9	2.79	17.5	13.81	16.2	13.54	57.90	9.09	83.69	62.74	111.7	10.17
72	SNK09 285	1.046	0.63	167.9	2.69	14.2	11.64	14.4	12.91	63.78	8.97	89.75	84.91	97.8	8.78
73	SNK09 286	1.200	0.62	255.9	2.39	17.9	14.12	16.1	14.57	55.41	10.17	90.57	85.50	111.7	11.38
74	SNK09 288	1.176	0.64	214.9	2.49	15.9	13.33	15.3	14.32	58.40	10.15	93.66	95.39	122.3	12.45
75	SNK09 289	1.539	0.73	264.9	2.49	20.9	12.51	11.5	9.84	51.02	6.68	85.74	76.00	125.1	8.39
76	SNK09 292	1.572	0.97	252.9	2.59	17.9	13.95	14.8	14.38	64.26	10.35	97.21	80.29	134.8	14.01

77	SNK09 293	1.147	0.65	239.9	2.99	18.4	12.87	14.8	13.40	60.39	9.34	90.26	124.52	156.0	14.64
78	SNK09 304	1.154	0.67	234.9	2.59	15.9	14.58	15.2	12.67	61.24	8.47	83.15	120.53	151.9	12.93
79	SNK09 308	1.130	0.56	279.9	2.29	17.9	15.45	18.0	16.88	53.78	11.96	93.50	109.04	134.8	16.17
80	SNK09 322	1.457	0.84	250.9	2.49	16.2	15.29	18.0	17.12	60.74	12.21	95.03	83.25	130.2	15.95
81	SNK09 334	1.439	0.38	218.0	1.99	16.3	13.37	17.3	16.31	26.83	11.63	94.55	63.25	91.5	10.64
82	SNK09 335	1.379	0.87	230.0	2.49	17.3	13.29	17.0	15.59	63.34	10.98	91.97	87.33	121.0	13.30
83	SNK09 347	1.316	0.78	176.0	2.79	16.3	10.79	16.0	15.65	59.56	11.31	97.56	68.79	91.0	10.29
84	SNK09 350	1.558	0.99	251.0	2.69	24.0	10.45	14.7	13.50	63.83	9.51	91.84	57.26	89.6	8.52
85	SNK09 367	1.694	1.17	223.0	3.09	19.3	11.55	14.0	12.57	69.13	8.77	90.04	49.97	85.0	7.46
86	SNK09 370	1.289	0.79	205.0	2.59	17.6	11.64	16.5	15.47	61.64	11.00	93.98	106.58	138.1	15.20
87	SNK09 376	2.091	1.30	256.0	3.29	18.6	13.76	14.1	13.56	62.39	9.75	96.44	42.71	89.6	8.74
88	SNK09 377	0.913	0.54	216.0	2.19	18.6	11.61	14.1	13.62	59.67	9.81	96.87	134.58	123.8	12.15
89	SNK09 378	1.701	0.91	231.0	2.79	24.0	9.62	17.0	15.31	53.74	10.70	90.27	70.86	121.0	12.95
90	SNK09 380	1.566	1.05	276.0	2.59	23.3	11.84	17.2	15.47	67.44	10.80	90.15	75.77	119.2	12.87
91	SNK09 392	1.442	1.00	266.0	2.49	18.3	14.53	17.1	14.61	69.42	9.95	85.64	93.09	134.9	13.43
92	SNK09 393	1.456	1.00	250.0	2.89	16.0	15.62	15.1	12.52	68.89	8.40	83.14	75.78	110.9	9.31
93	SNK09 407	1.269	0.82	240.0	2.49	19.0	12.63	14.4	11.34	64.57	7.40	78.98	90.87	116.0	8.58
94	SNK09 414	0.942	0.56	190.0	2.49	15.0	12.66	16.5	12.96	59.32	8.44	78.74	101.25	96.1	8.11
95	SNK09 421	1.389	0.89	246.0	2.39	17.3	14.21	19.3	18.34	64.11	13.12	95.22	88.69	123.8	16.25
96	SNK09 426	1.169	0.77	235.0	2.59	16.6	14.15	12.7	9.16	65.81	5.67	72.37	101.74	119.7	6.78
97	SNK09 428	1.375	0.88	195.0	2.79	18.3	10.65	15.4	13.69	63.89	9.51	89.13	64.18	88.7	8.43
98	SNK09 429	0.902	0.58	201.0	2.29	18.3	10.98	14.0	12.33	64.02	8.51	87.95	75.21	68.4	5.82
99	SNK09 430	1.291	0.79	226.0	2.69	20.3	11.13	15.1	13.23	61.70	9.11	87.50	68.33	88.7	8.08
100	SNK09 432	1.113	0.71	150.0	3.09	16.0	9.37	14.2	12.57	63.65	8.70	88.40	77.54	86.8	7.55
101	SNK09 436	0.890	0.57	196.0	2.29	18.3	10.70	15.8	14.48	64.54	10.18	91.53	107.64	96.6	9.83
102	SNK09 437	1.276	0.78	211.0	2.79	16.0	13.18	17.5	16.25	61.10	11.49	92.75	58.33	74.8	8.60
103	SNK09 439	1.153	0.69	217.0	2.49	17.3	12.54	14.0	10.85	59.99	7.00	77.40	68.10	79.0	5.53

104	SNK09 442	1.828	1.09	291.0	2.69	22.0	13.22	15.7	14.48	59.94	10.21	92.11	67.72	124.3	12.69
105	SNK09 443	0.770	0.48	246.0	1.89	18.0	13.66	16.0	13.69	62.67	9.33	85.83	155.18	120.6	11.26
106	SNK09 444	0.836	0.54	223.0	2.29	15.6	14.29	15.3	12.69	65.00	8.52	83.22	106.31	89.6	7.63
107	SNK09 449	1.895	1.19	236.0	2.99	19.3	12.22	16.4	14.67	62.82	10.22	89.72	60.48	115.0	11.76
108	SNK09 450	2.370	1.44	250.0	3.19	21.0	11.90	16.9	16.31	60.74	11.75	96.79	55.97	133.0	15.64
109	SNK09 452	1.661	1.00	256.0	2.89	21.3	12.01	20.0	17.77	60.07	12.34	89.07	75.33	125.7	15.50
110	SNK09 454	2.224	1.41	256.0	3.19	22.6	11.32	17.1	14.85	63.33	10.20	87.10	57.56	128.4	13.10
111	SNK09 458	1.083	0.67	238.0	2.29	22.3	10.67	12.5	9.68	62.01	6.26	77.76	80.10	87.3	5.46
112	SNK09 474	1.039	0.73	193.0	2.59	16.0	12.06	12.7	11.67	70.83	8.23	92.25	89.21	93.3	7.68
113	SNK09 475	1.221	0.76	205.0	2.69	17.6	11.64	14.3	11.65	62.70	7.75	81.76	78.62	96.6	7.48
114	SNK09 476	1.179	0.75	241.0	2.39	20.3	11.87	17.6	14.07	64.07	9.26	80.18	100.50	119.2	11.03
115	SNK09 481	1.294	0.86	251.0	2.29	21.0	11.95	17.5	14.79	66.48	10.00	84.37	93.03	121.0	12.10
116	SNK09 491	1.260	0.78	221.0	2.49	17.6	12.55	13.5	10.89	62.03	7.20	80.97	91.88	116.4	8.39
117	SNK09 492	1.603	1.04	195.0	3.19	16.3	11.96	12.9	9.64	64.90	6.10	75.03	78.05	125.7	7.67
118	SNK09 494	1.284	0.79	215.0	2.59	19.0	11.31	14.8	12.28	61.96	8.24	83.26	75.86	97.9	8.07
119	SNK09 495	1.845	1.13	261.0	2.89	21.6	12.08	16.7	15.50	61.49	10.98	93.09	71.09	131.7	14.46
120	SNK09 500	0.950	0.65	185.0	2.49	16.3	11.34	13.2	7.90	68.96	4.21	59.74	108.13	103.5	4.36
121	SNK09 503	1.585	1.07	223.0	2.92	18.6	12.01	12.7	8.93	66.88	5.44	70.51	67.42	105.4	5.73
122	SNK09 509	2.318	1.07	268.0	3.32	18.0	14.91	12.5	6.95	45.75	3.47	55.73	44.49	102.1	3.54
123	SNK09 511	1.528	0.96	243.0	2.82	17.0	14.32	10.4	10.21	62.31	7.42	98.57	89.60	134.9	10.00
124	SNK09 513	1.304	0.74	181.0	2.92	17.0	10.67	17.9	15.31	56.03	10.44	85.73	86.87	111.4	11.62
125	SNK09 515	1.375	0.94	211.0	2.72	16.3	12.97	15.5	13.29	67.94	9.08	85.97	98.36	133.1	12.07
126	SNK09 517	2.072	1.26	223.0	3.42	18.6	12.01	19.1	15.49	60.27	10.27	81.27	63.57	130.3	13.38
127	SNK09 519	1.870	1.12	220.0	3.32	20.0	11.02	15.3	14.51	59.55	10.37	94.98	66.02	122.0	12.65
128	SNK09 529	1.372	0.85	170.0	3.12	16.6	10.26	13.2	9.64	61.50	6.01	73.12	83.52	112.7	6.77
129	SNK09 530	1.067	0.67	193.0	2.52	16.4	11.84	11.8	9.67	62.22	6.45	82.08	112.76	117.8	7.59
130	SNK09 536	2.067	1.27	191.6	3.52	16.6	11.56	12.3	8.68	61.15	5.28	70.43	65.54	134.0	7.07

131	SNK09 542	1.435	0.85	208.0	2.92	22.7	9.20	13.9	12.72	58.76	8.94	91.39	75.55	106.7	9.54
132	SNK09 547	1.520	0.96	226.0	2.82	19.6	11.55	14.3	12.55	62.77	8.65	87.64	70.34	105.4	9.11
133	SNK09 549	0.992	0.53	146.0	2.72	13.6	10.76	10.3	7.75	52.91	4.91	75.07	87.24	85.5	4.20
134	SNK09 554	1.187	0.75	205.0	2.76	19.7	10.45	11.0	9.97	62.68	6.98	90.48	107.89	125.7	8.76
135	SNK09 557	1.520	0.91	185.0	3.36	19.6	9.46	14.3	12.28	59.43	8.38	85.76	77.74	116.4	9.75
136	SNK09 565	0.901	0.50	170.0	2.52	18.0	9.47	12.7	12.66	54.63	9.23	99.55	141.93	124.8	11.51
137	SNK09 572	1.170	0.74	196.3	2.72	20.3	9.69	14.4	13.02	62.74	9.10	90.30	105.46	121.1	11.01
138	SNK09 594	0.948	0.50	166.0	2.40	18.0	9.24	11.8	7.97	51.86	4.70	67.39	128.74	119.2	5.60
139	SNK09 603	1.159	0.57	223.0	2.72	18.7	11.97	12.3	8.68	48.39	5.28	70.43	109.73	124.8	6.58
140	SNK09 606	1.040	0.61	146.0	2.69	15.0	9.75	14.9	10.05	57.98	5.92	67.34	132.54	134.9	7.98
141	SNK09 607	0.731	0.43	224.0	2.35	16.7	13.47	18.4	17.25	57.14	12.28	93.97	164.02	129.8	15.93
142	SNK09 609	1.960	1.26	216.0	3.36	20.7	10.48	14.0	13.59	64.01	9.81	97.16	67.72	131.2	12.87
Checks															
143	Co 2001-15	1.08	0.56	2.12	2.31	19	0.00	21.4	18.6	52.4	12.8	87.0	115.75	158.00	18.62
144	Co 92005	1.31	0.80	1.88	2.83	21.6	0.09	20.7	17.0	61.3	11.3	82.1	96.91	113.19	6.29
145	Co C 671	1.12	0.72	2.11	2.67	16.7	0.13	19.4	16.1	64.1	10.8	83.1	91.27	134.44	14.26
146	Co 86032	1.53	0.94	2.39	2.78	20.7	0.12	20.9	18.0	61.3	12.2	85.7	114.41	145.99	13.26
147	SNK 814	1.52	0.92	2.26	2.87	20	0.11	19.4	17.6	60.8	12.3	90.4	146.94	147.38	6.68
148	SNK 044	1.32	0.77	1.93	2.96	20.3	0.09	21.0	17.9	58.2	12.2	85.1	122.53	134.90	13.96
Mean		1.34	0.82	223.74	2.69	18.28	12.33	15.16	13.34	61.26	9.21	87.64	88.22	113.03	10.47
S Ed		0.03	0.02	2.82	0.03	0.20	0.15	0.17	0.20	0.48	0.16	0.69	1.97	1.84	0.27
C V		15.28	16.44	15.30	11.59	13.57	14.27	13.42	18.31	9.52	21.58	9.48	17.08	19.71	11.22
c.d.@ 5% b/w varieties & checks		0.077	0.049	7.861	0.071	0.570	0.404	0.467	0.562	1.340	0.457	1.910	5.489	5.120	0.752
c.d.@ 5% b/w var.		0.081	0.051	8.098	0.073	0.592	0.415	0.476	0.575	1.380	0.469	1.976	5.688	5.244	0.7751
c.d. @ 5% b/w Checks		0.0687	0.074	42.33	0.314	1.012	2.152	3.288	3.709	7.358	2.861	7.357	10.935	13.988	3.10

Appendix III: Mean performance of 65 advanced sugarcane hybrid progenies for various traits

Sl. No.	Entry No	CW	JW	C.H (mtr)	CG (cm)	INT	IL (cm)	Brix %	Sucrose %	JE %	CCS %	Purity %	NMC ('000/ha)	CY (t/ha)	CCS yield (t/ha)
1	SNK09 005	1.52	1.01	1.98	3.1	16.6	0.12	20.8	19.7	66.6	14.0	94.7	74.24	120.12	16.84
2	SNK09 007	1.52	1.03	2.23	3.1	21.3	0.10	20.4	19.2	68.1	13.7	94.4	91.09	128.44	17.60
3	SNK09 038	1.79	1.23	2.5	3	20	0.13	21.3	21.1	69.0	15.4	99.3	73.99	124.74	19.16
4	SNK09 042	2.05	1.16	2.84	3	20	0.14	19.4	15.7	56.8	10.3	80.9	93.37	142.30	14.72
5	SNK09 050	1.47	0.86	1.97	2.8	23.3	0.08	20.5	19.4	58.3	13.9	95.0	63.68	86.86	12.05
6	SNK09 058	1.38	0.85	2.35	2.5	19.3	0.12	19.8	18.8	61.6	13.4	95.1	80.74	124.74	16.75
7	SNK09 059	1.17	0.77	1.91	2.7	18	0.11	21.0	20.9	65.6	15.3	99.8	83.82	116.42	17.76
8	SNK09 061	0.86	0.51	1.45	2.5	19.6	0.07	19.7	18.1	59.3	12.7	91.9	115.80	90.09	11.46
9	SNK09 062	1.09	0.64	2.41	2.5	19.3	0.12	17.2	14.6	58.6	9.9	85.2	77.11	103.95	10.33
10	SNK09 088	1.55	0.92	2	2.9	19	0.11	20.2	18.4	59.1	12.9	91.0	95.29	133.98	17.25
11	SNK09 094	1.02	0.66	2.56	2.2	20.3	0.13	17.7	14.8	64.6	10.0	83.8	110.85	137.68	13.72
12	SNK09 099	1.14	0.72	1.96	2.6	21.3	0.09	18.1	15.1	63.0	10.1	83.4	84.78	128.44	13.03
13	SNK09 103	1.77	1.21	2.81	2.8	24.3	0.12	20.7	19.7	68.0	14.1	95.1	78.51	132.13	18.57
14	SNK09 104	1.58	1.07	2.9	2.6	24.3	0.12	19.7	17.6	67.7	12.2	89.3	101.42	133.98	16.36
15	SNK09 107	1.46	0.93	2.33	2.8	24.3	0.10	19.0	14.7	63.6	9.5	77.7	94.42	121.04	11.53
16	SNK09 110	1.48	0.94	3.41	2.4	25	0.14	19.4	14.7	63.3	9.4	75.8	99.33	139.06	13.01
17	SNK09 111	1.27	0.83	2.28	2.6	18.6	0.12	19.7	17.6	65.5	12.2	89.4	115.81	130.28	15.92
18	SNK09 149	1.27	0.80	2.33	2.7	20.3	0.11	20.1	18.1	62.9	12.6	90.0	74.54	97.94	12.34
19	SNK09 183	1.01	0.63	2.97	2.4	14.3	0.21	21.2	20.1	61.9	14.4	94.9	64.63	74.84	10.75
20	SNK09 190	1.50	0.87	2.1	2.9	19	0.11	20.0	18.4	57.9	12.9	91.9	87.43	115.50	14.93
21	SNK09 211	1.49	0.84	2.76	2.6	23.3	0.12	20.7	18.9	56.2	13.3	91.6	85.20	149.69	19.94

22	SNK09 212	1.44	0.85	2.61	2.5	17.6	0.15	22.2	22.0	59.5	16.0	99.1	86.11	133.98	21.41
23	SNK09 213	1.86	1.11	2.51	2.9	19.6	0.13	19.4	17.1	59.7	11.8	88.4	93.82	122.43	14.48
24	SNK09 214	1.13	0.74	2.13	2.4	20	0.11	19.7	17.8	65.4	12.5	90.5	135.71	125.66	15.66
25	SNK09 215	1.30	0.82	2.75	2.5	17.6	0.16	21.0	19.8	62.6	14.1	94.5	100.65	120.58	17.04
26	SNK09 216	1.35	0.92	2.7	2.2	19.3	0.14	19.3	17.6	67.9	12.3	91.2	90.74	136.75	16.87
27	SNK09 217	1.14	0.70	2.44	2.2	19.3	0.13	19.7	17.6	61.3	12.2	89.3	105.44	105.34	12.87
28	SNK09 219	1.44	1.01	2.55	2.5	18.66	0.14	18.1	16.3	70.0	11.3	90.0	89.62	131.21	14.88
29	SNK09 221	1.06	0.74	2.36	2.2	19	0.12	21.1	20.1	70.5	14.4	95.6	141.97	139.99	20.20
30	SNK09 222	1.16	0.66	2.23	2.4	19.33	0.12	20.2	17.8	56.5	12.3	88.2	142.63	137.21	16.85
31	SNK09 227	1.51	0.87	2.26	2.78	18.33	0.12	22.1	19.5	57.9	13.5	88.4	84.30	142.30	19.23
32	SNK09 229	1.43	0.77	2.32	2.5	17.66	0.13	20.1	19.5	53.6	14.1	97.1	111.58	138.14	19.45
33	SNK09 230	1.27	0.62	2.71	2.05	17.33	0.16	21.6	21.1	48.6	15.2	97.5	150.19	139.52	21.23
34	SNK09 231	1.19	0.77	2.52	2.41	18.3	0.14	19.5	15.7	64.8	10.3	80.4	96.67	129.82	13.38
35	SNK09 232	0.98	0.57	2.43	2.12	19	0.13	20.6	19.4	58.2	13.8	94.3	131.87	136.75	18.92
36	SNK09 234	1.18	0.80	1.943	2.7	17	0.11	20.3	18.7	67.7	13.2	92.5	79.90	131.67	17.42
37	SNK09 235	1.46	0.93	2.33	2.54	15.6	0.15	20.2	19.7	64.0	14.2	97.7	104.86	129.82	18.49
38	SNK09 245	1.65	0.97	2.35	2.26	17	0.14	19.7	18.1	58.8	12.7	91.8	85.46	88.70	11.28
39	SNK09 268	1.32	0.71	2.37	2.48	19	0.12	16.5	14.6	53.6	10.1	88.8	72.24	147.38	14.93
40	SNK09 269	1.66	0.11	2.34	2.86	17.66	0.13	19.5	18.3	6.7	13.0	94.0	105.58	133.98	17.44
41	SNK09 271	1.94	1.29	2.72	2.93	20.33	0.13	15.9	14.9	66.4	10.6	94.0	89.02	153.38	16.28
42	SNK09 274	1.57	1.02	2.28	2.84	20.33	0.11	19.2	18.3	64.6	13.1	95.5	91.81	143.68	18.83
43	SNK09 277	1.50	0.89	1.56	3.13	16.33	0.10	22.1	19.5	59.1	13.5	88.4	66.88	95.17	12.86
44	SNK09 286	1.78	0.98	2.1	2.98	18.66	0.11	19.7	17.6	55.3	12.2	89.4	85.61	111.80	13.67
45	SNK09 292	1.84	1.17	2.56	3.055	21	0.12	16.2	14.9	63.5	10.5	92.3	80.40	134.90	14.20
46	SNK09 293	1.79	1.02	2.28	3.02	17.66	0.13	16.7	15.1	57.2	10.6	90.6	124.63	156.16	16.51

47	SNK09 304	1.37	0.84	2.32	2.55	16.66	0.14	19.7	17.6	60.9	12.2	89.3	120.63	152.00	18.57
48	SNK09 308	1.19	0.63	2.38	2.71	14.33	0.17	20.3	18	53.1	12.5	88.7	109.15	134.90	16.80
49	SNK09 335	1.33	0.83	2.6	2.5	16	0.16	21.3	20.1	61.9	14.3	94.3	87.33	121.04	17.29
50	SNK09 370	1.25	0.82	2.19	2.56	18.66	0.12	19.9	18.3	65.0	12.9	92.1	106.59	138.14	17.82
51	SNK09 377	1.04	0.92	2.14	2.4	20.33	0.11	19.7	19	88.7	13.7	96.7	134.58	123.82	16.96
52	SNK09 392	1.73	1.07	3.13	2.67	21.33	0.15	20.6	20.5	61.9	14.9	99.4	93.10	134.90	20.11
53	SNK09 421	1.17	0.76	2.206	3.12	19.33	0.11	19.2	17.2	64.7	11.9	89.5	88.69	123.82	14.78
54	SNK09 428	1.89	1.16	2.345	3.12	20.6	0.11	20.2	17.8	61.6	12.3	88.2	64.19	88.70	10.89
55	SNK09 442	1.68	1.02	2.78	2.64	21.66	0.13	21.7	19.6	61.0	13.7	90.4	67.73	124.28	17.01
56	SNK09 449	1.99	1.22	2.716	3.145	21.66	0.13	18.9	17.2	61.0	12.1	91.3	60.48	115.04	13.92
57	SNK09 450	2.39	1.51	2.91	3.144	25.33	0.11	17.7	17.2	63.1	12.4	97.5	55.98	133.06	16.56
58	SNK09 476	1.01	0.68	2.313	2.277	19.33	0.12	18.0	16.3	67.4	11.4	90.5	100.50	119.20	13.55
59	SNK09 481	1.41	0.96	2.71	2.533	20	0.14	19.0	18.4	68.2	13.2	96.7	93.04	121.04	16.00
60	SNK09 515	1.59	1.06	2.26	2.85	21.33	0.11	18.3	17.9	66.4	12.9	97.8	98.34	133.06	17.20
61	SNK09 542	1.51	1.09	2.146	3.05	20.33	0.11	19.7	19	71.7	13.7	96.7	75.53	106.72	14.62
62	SNK09 554	1.73	0.99	2.14	3.166	18.33	0.12	16.7	13.7	57.4	9.1	81.9	107.87	125.66	11.41
63	SNK09 557	1.32	0.27	1.93	2.933	20	0.10	17.8	16.3	20.6	11.4	91.5	77.72	116.42	13.31
64	SNK09 606	0.89	0.47	1.916	2.622	19	0.10	18.2	17	53.0	12.1	93.5	132.52	134.90	16.27
65	SNK09 607	0.80	0.40	1.973	2.33	17	0.12	21.7	21.3	50.5	15.5	98.5	164.00	129.82	20.10
Parents															
66	SNK632	1.74	1.03	1.96	3.48	18	0.11	14.3	12.5	59.2	12.4	87.9	131.21	127.18	15.23
67	Co 8371	1.69	0.93	1.93	3.36	18.3	0.11	13.1	12.1	55.2	12.0	92.6	74.84	80.10	8.44
68	Co 86249	1.17	0.71	1.9	2.68	20	0.10	12.5	10.7	60.8	10.5	85.6	68.38	95.90	12.04
69	Co86002	1.18	0.70	1.93	2.85	17.66	0.11	15.3	12.7	59.8	12.6	83.4	72.07	102.28	9.65
70	CoA 7602	0.93	0.55	1.95	2.75	14.66	0.13	13.5	9.6	59.0	9.4	71.5	73.92	134.73	16.80

71	Co 403	0.96	0.64	2.63	2.48	16.66	0.16	13.3	12.6	66.5	12.5	94.9	86.86	136.49	20.47
72	Co 86250	1.37	0.91	2.95	2.6	19.66	0.15	17.8	15.2	66.2	15.0	85.5	103.49	114.31	17.54
73	Co 86011	0.99	0.66	2.06	2.44	18	0.11	16.3	15.5	67.1	15.3	95.2	105.34	158.64	25.70
74	CoM 265	1.73	0.98	2.05	2.93	19	0.11	16.4	16.3	56.3	16.2	99.8	108.11	110.77	14.26
75	Co 94012	0.86	0.56	1.61	2.55	16.6	0.10	14.7	13.0	64.4	12.9	88.6	98.87	114.43	19.67
76	Co 86032	0.94	0.57	1.78	2.58	16.66	0.11	17.4	17.3	60.5	17.2	99.5	96.10	102.01	8.42
77	ISH 69	0.56	0.32	1.15	2.53	13.66	0.08	14.1	12.1	56.2	8.2	85.8	56.36	100.05	15.35
78	CP 52/68	0.42	0.22	1.36	1.85	17	0.08	16.3	15.5	52.2	15.3	95.0	57.29	135.33	18.78
79	Co 93009	0.88	0.55	1.4	2.84	21.66	0.06	14.8	14.0	62.0	13.9	94.6	59.14	66.95	8.68
80	ISH 100	1.32	0.85	2.316	2.95	16.33	0.14	16.6	13.2	64.4	13.0	79.3	91.48	69.56	8.89
Checks															
81	Co 2001-15	1.08	0.56	2.12	2.31	19	0.00	21.4	18.6	52.4	12.8	87.0	115.75	158.00	18.62
82	Co 92005	1.31	0.80	1.88	2.83	21.6	0.09	20.7	17.0	61.3	11.3	82.1	96.91	113.19	6.29
83	CoC 671	1.12	0.72	2.11	2.67	16.7	0.13	19.4	16.1	64.1	10.8	83.1	91.27	134.44	14.26
84	Co 86032	1.53	0.94	2.39	2.78	20.7	0.12	20.9	18.0	61.3	12.2	85.7	114.41	145.99	13.26
85	SNK 814	1.52	0.92	2.26	2.87	20	0.11	19.4	17.6	60.8	12.3	90.4	146.94	147.38	6.68
86	SNK 044	1.32	0.77	1.93	2.96	20.3	0.09	21.0	17.9	58.2	12.2	85.1	122.53	134.90	13.96
	Mean	1.36	0.83	2.28	2.68	19.14	0.12	18.87	17.16	60.66	12.68	90.77	95.38	123.93	15.40
	S Ed	0.037	0.026	0.044	0.033	0.254	0.003	0.247	0.275	1.002	0.190	0.626	2.516	2.144	0.386
	CV	15.09	19.29	17.71	11.50	12.29	15.50	12.15	14.87	15.31	13.87	6.40	14.46	16.05	15.26
	c.d.@ 5% b/w varieties and checks	0.104	0.073	0.123	0.094	0.713	0.008	0.695	0.774	2.816	0.533	1.761	7.074	6.029	1.086
	c.d.@ 5% B/W varieties	0.110	0.084	0.123	0.104	0.823	0.007	0.515	0.678	3.655	0.567	1.825	8.065	5.949	0.980
	C.D.@ 5% B/W Checks	0.281	0.205	0.320	0.341	2.549	0.069	1.279	1.286	5.996	1.066	4.376	29.438	22.838	7.122
	C.D.@ 5% B/W Parents	0.312	0.183	0.366	0.304	1.596	0.020	1.293	1.665	3.518	1.949	6.095	17.142	20.356	4.135

GENETIC VARIABILITY FOR FLOWERING AND YIELD CHARACTERS IN SUGARCANE (SACCHARUM OFFICINARUM L.)

PRIYANKA P. L.

2013

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ABSTRACT

The present investigation was taken up at ARS, Sankeshwar to study the floral behaviour of commercial sugarcane varieties and to study variability and character association for productivity and their component traits in pre-selected clonal progeny population. Further, to identify productive progenies with respect to sugar/jaggery yield and quality parameters combining shy/non flowering features.

Characterization of flowering based on intensity and days to flowering indicated that, genotypes *viz.*, SNK 632, SNK 044, SNK 814 and CoC 671, are early profuse flowering types and other three commercial genotypes *viz.*, CoM 0265, Co 94008 and Co 86032 could be characterized as moderate flowering types. The other variety CoM 88121 where in no floral primordial were recorded, confirming its non flowering feature.

The GCV and PCV for cane height, internodal length, number of millable canes (NMC), cane yield and juice brix%, were higher, whereas moderate variability was observed for cane girth and single cane weight (SCW).

The association studies revealed that, single cane weight, number of millable canes and cane height were the strongest with cane yield. The path analysis shows that, NMC, number of internodes and SCW had higher direct effect on cane yield. The repeatability studies indicated that juice brix% (10th month) and flowering per cent were significantly repeatable across clonal generations.

Among 145 pre-selected clonal progenies studied in the present investigation, 14 were found better for cane, sugar and jaggery yield. Among these 14 genotypes, SNK 09229 (6%), SNK09 271 (14%), and SNK 09377 (1%) were sprase flowering types and rest of the genotypes were non-flowering. Genotypes SNK 09221 and SNK 09212 are superior over best check for cane, sugar, jaggery yield and quality parameters along with non flowering feature.