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CONTENTS

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casuarinas are the strategies followed. Now the breeding attention has been refocused to energy plantation and veneer as well.

Trees, in general, have been somewhat difficult and slow to improve on account of long gestation period, irregularity in flowering and fruiting, and prevalence of out breeding, high degree of heterozygosity and low heritability of desirable traits and frequent absence of substantial Germplasm. The most used method has been provenance centered and provenance transfer and of late population based. Amenability to clonal propagation facilitated availability of genetic materials for trials, testing and utilization. Considerable and exploitable reservoir of genetic variation exist among the population of tree species. Planned generation of variability for exploiting genetic potential will greatly augment the selection for favorable combinations of traits enhancing the productivity.

Clonal forestry is an attractive commercial investment opportunity helping to rapidly select a grater proposition of additive and non additive genetic variation. Effects need to be made to exploit until unexploited traits or genes for the productivity of forestry system in the immediate future. Reducing time for the selection and reducing the number of breeding cycles thus speeding the breeding progress s are also possible by application of molecular breeding.

Importance, relevance and immediate positive application of added genetic variation, gene pool and plus candidate trees selected from population coupled with vegetative cloning, matching low cost efficient nursery technology and regeneration has become efficient packages strategy and system by itself to utilize gains of genetic technology. In this paper, the future of tree research in Tamilnadu is presented and discussed.

425 – Ms No 40

A Study on Genetics of Red Rot Resistance in Sugarcane

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Red rot caused by *Colletotrichum falcatum L* in sugarcane is the most important disease of concern causing heavy loss to farmers throughout the country except certain pockets. Development of resistant varieties of sugarcane through breeding needs the knowledge on the genetic basis of resistance to red rot. Hence, the present study was taken up with the objective of finding the genetic basis of resistance to red rot in sugarcane. Nine cross combinations (involving susceptible and resistant donors) were evaluated for resistance to red rot using the Controlled Condition Testing (CCT) method. Five crosses in which female was susceptible and male MR or R produced predominantly resistant progenies. The resistant progenies ranged from 61.64% in Co 7201 x 96-195 to

83.72% in Co 86002 x 96-38. In two crosses Co 88028 x 95-104 and Co 94005 x 96-550 with one of the parents resistant to red rot there was a higher proportion (77.61 to 91.67%) of susceptible progenies. The cross Co 7201 x 96-104 (MR x MR) produced maximum proportion (80.0 %) of resistant progenies. In the crosses with Co 86002 (S) as female parent and three other moderately resistant male parents, the proportion of resistant progenies was higher compared to susceptible ones. In the cross involving female parent as MR and male as MS (Co 7201 x 96-195) the proportion of resistant seedlings was 61.64% and susceptible 38.36%.The study showed that even when both susceptible parents were used, large number of clones with resistance to red rot can be obtained. In all the crosses, the derivatives of *S.spontaneum* were used as male parent which were either MR or R. The parents 96-38, 96-195, 95-108 (F_1 of improved *S.officinarum x S.spontaneum)* and Co 7201 produced more of resistant progenies. The segregation pattern of red rot inheritance varied with the crosses (1:3, 1:1, 3:1 and 1:5) and hence assumed to be governed by single gene as well as by two genes which are most probably from *S.spontaneum.* The paucity of resistance in the current breeding population indicates the need to identify new sources of resistance. The introduction of new *S.spontaneum* clones will thus increase the probability of producing varieties with stable resistance.The results indicate that level of red rot resistance in the population can be increased by careful choice of parent clones and cross-based selection. The genetic stocks developed from this study can be exploited for developing red rot stable resistant clones.

426 – Ms No 53

Development of pre-breeding stocks with improved sucrose content over two selection cycles in sugarcane

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Breeding population in sugarcane tends to show a steady improvement for cane yield and there have been very little increments in juice sucrose content for several decades. A more strategic breeding approach is underway at the Sugarcane Breeding Institute, Coimbatore to enhance the juice sucrose levels of sugarcane cultivars through a simple recurrent selection scheme. The main objective of the study is to generate a group of clones that has brix and sucrose concentration outside the range of existing comercial hybrid clones in sugarcane. From a base population comprising twenty Indian “Co” canes and fourteen commercial hybrids from other countries, improvement in sucrose content was obtained over two cycles of recurrent selection. The parental clones had an average sucrose of 19.40%. Selection right from ground nursery was made rigidly for juice brix alone. Among the crosses involving Indian commercial hybrids, the best was CoC 671 x Co 99002 with a maximum record value of 24.0% brix and contributed more than thirty five percent selections performing better than the

cross average. In the crosses between Indian and Exotic hybrids, two crosses viz., PR 1080 x CoT 8201 and PR 1080 x Co 94008 were the best with 23.4% brix which gave more than twenty percent selections with high juice brix. The cycle I progenies had juice sucrose values ranging from 17.0% to 23.0% with a mean of 21.6%. The cycle II progenies recorded average juice sucrose of 22.0% with 13.40% improvement over base population. After two cycles of selection, the progress made for sucrose content in comparison with the base population is substantial. Combined evaluation of twenty two high sugared clones identified from cycles I and II was taken up during the year 2009. Juice analysis at 240 days of crop age indicated potential pre-breeding stocks with early high sugar content which could be exploited in future. The clones 00-0402, 00-1805, 01-0031, 01-0047 and 02-0288 recorded more than eight percent improvement in sucrose content over the zonal check variety CoC 671 in early maturity group. The best clone viz., 00-0402 is an early high sugar clone identified from cycle I with a maximum improvement of 14.93% over the check variety CoC 671 for sucrose content. SCGS 00-0402 flowers during mid November with less than 5% pollen fertility can be used as female parent. Another clone viz., 02-0288 recorded more than 12 percent improvement over CoC 671 has a pollen fertility of 95% with very high flowering intensity. Progeny evaluation of these two clones validated its potential as a donor for juice sucrose and its use in sugarcane breeding programmes is expected to contribute clones with high juice sucrose content.

Poster Presentation

427 – Ms No 52

Studies on flowering intensity and pollen fertility for managing national hybridisation garden of Sugarcane

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National hybridisation garden for sugarcane, a centralised facility for making crosses by the breeder from all over the country is established at Sugarcane Breeding Institute due to its profuse flowering and good seed set at Coimbatore. Number of crosses made utilising a particular clone depends upon the intensity of flowering and pollen fertility. The percentage of pollen fertility of a clone is also a deciding factor for its use as a male or female parent. Present study was undertaken to analyse the variability for flowering intensity and pollen fertility in 613 clones planted in NHG 2009-10 that includes commercial hybrids, exotic hybrids, genetics stocks and interspecific hybrids. Among them, 519 were found flowering and they were classified into five classes according to the intensity of flowering. High intensity (80.10 to 100%) was observed with 54.52 per cent of the clones while 15.99 per cent fall in the low intensity (0.1 to 20%) of flowering.

445 – Ms No 38

Heterosis in okra *Abelmoschus esculentus* (L.) Moench

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Ten quantitative characters *viz.,* days to first flowering, days to first picking, plant height, primary branches per plant, stem girth, fruit length, fruit girth, fruit weight, fruits per plant and fruit yield per plant were investigated through generation mean analysis using six basic generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) of six crosses of okra, HRB-55 x AOL-05-4, VRO-5 x Red Long, VRO-6 x AOL-05-3, GO-2 x AOL-04-3, Arka Anamika x AOL-03-1 and Parbhani Kranti x AOL-03-6. The cross HRB-55 x AOL-05-4 showed heterobeltiosis in desirable direction for almost all the fruit yield and its contributing characters particularly, 94.06 per cent for fruit yield per plant and 86.12 per cent fruits per plant. Moderate to high narrow sense heritability was observed for primary branches per plant in the crosses HRB-55 x AOL-05-4 (E_1), VRO-6 x AOL-05-3 (E_1) and Parbhani Kranti x AOL-03-6 (E_2); fruit girth in the crosses VRO-5 x Red Long (E_1), VRO-6 x AOL-05-3 (E_1), GO-2 x AOL-04-3 (E_1) and Arka Anamika x AOL-03-1 (E_1); fruit weight in the crosses HRB-55 x AOL-05-4 (E_2), VRO-5 x Red Long (E_1) and GO-2 x AOL-04-3 (E_2). The highest heritability was identified 99.35 per cent for fruit length in the cross HRB-55 x AOL-05-4. The results of heterosbeltiosis revealed that the cross HRB-55 x AOL-05-4 may be exploited for fruit yield and its component traits.

446 – Ms No 39

Combining ability for yield and quality in Sugarcane

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Combining ability variances and effects were estimated for important yield and quality traits in sugarcane using line x tester mating design. Seven clones were used as females (lines) and three as males (testers). Five characters viz., number of millable canes, stalk diameter, stalk height, single cane weight and Brix % were considered in the present study. Twenty one crosses, obtained from seven lines x three testers were studied for sca, gca effects, *per-se* performance and heterosis. The study revealed no association between combining ability effect and heterotic response. Among the lines, Co 740, Co 86032 and Co 98010 and among the testers, Co 99006 were found to be good general combiners for agronomic traits. Four crosses viz., Co 86002 x Co 94008, Co 86032 x Co 99006, Co 98010 x Co 775 and Co 93020 x Co 99006 were promising for all the traits. Estimates of variance due to gca and sca and their ratio revealed predominantly non-additive gene action for these characters. Since sugarcane is a vegetatively

propagated crop, heterosis can be fixed and exploited in F1 generation. Six crosses viz., Co 740 x Co 99006, Co 93020 x Co 94008, Co 8371 x Co 775, Co 86002 x Co 94008, Co 86032 x Co 99006 and Co 98010 x Co 99006 showed significant heterotic response for the traits under study. The present study rendered identification of new lines, testers and crosses for development of new varieties with improved yield and quality traits.

447 – Ms No 41

Role of Family selection in Sugarcane Breeding

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Family selection has been adopted in sugarcane breeding programs as an indirect method of selection of superior clones in early stages of selection among seedling progenies. In this study, forty clones from 53 sugarcane crosses (families) were evaluated for yield and quality parameters in plant and ratoon crops at Sugarcane Breeding Institute,Coimbatore during 2005-2008 season. Families evaluated in replications and individuals selected based on visual appraisal for yield parameters from selected families. Individual selection rate within families ranged from 10- 30%. Top 30% of clones were selected from six best families viz., Co 7201 x Co 86002, Co 98010 x Co 94019, Co 86002 x Co 90018, Co 8371 x Co 86002, Co 8371 x CoC 8001 and Co 740 x Co 88025 with progressively fewer clones being selected from moderate to average families (Co 62260 x Co 6418, Co 837 x Co 94008). Individual selection within families based on brix % was best along with visual grading. In assessing the worthiness of families with old clones, parents like Co 62260 and Co 837 performed poorly even with new parents compared with crosses with new parents indicating the need for changing the base population. The study helped in generating breeding value of parents in crosses for their recycling in hybridization programme. Combined family selection and individual clonal selection in sugarcane were effective in identifying families with highest proportion of elite clones based on plant and ratoon crops performance.

448 – Ms No 42

Evaluation of interspecific progenies of sugarcane for yield and quality traits

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Inter-specific hybridization in sugarcane involving wild relatives generates large genetic variability.Among the wild species, *Saccharum spontaneum* L. has

contributed valuable traits to modern sugarcane (*S.* spp. L.) cultivars such as adaptation to environmental stress, diseases resistance and ratooning ability. Recently use of *S. spontaneum* in sugarcane breeding has gained importance for the improvement of wide adaptability, energy generation from biomass ,high fibre and resistance to important diseases.The genetic base broadening programme in Sugarcane Breeding Institute involved the utilization of improved germplasm of *S.officinarum, S.spontaneum and S.robustum* which resulted in production of wide array of clones with genetic improvement for yield and quality. Besides having diverse genetic diversity many of these clones are promising donors for red rot resistance, high fibre, high biomass and good juice quality. In this study, progeny from 15 biparental crosses involving commercial sugarcane clones,improved *S.officinarum* and improved *S. spontaneum* clones along with parents were evaluated for tillering ability, cane height and H.R brix %. Moderate to high (>0.7) broad-sense heritabilities and high genetic variances were observed for all the traits. Between cross variance was found to be high compared to within cross variance which will facilitate identification and selection of better cross combinations. Six crosses were promising with mean nmc of 25.0 /clump, cane height of 300cm and H.R brix of 18.0 %. The performance of these clones is quite promising. In addition to broadening the genetic base and generating high variability for useful agronomic characters, these clones serve as genetic stocks in breeding commercial varieties.

449 – Ms No 43

Promising Sugarcane Clones for Peninsular Zone, India

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Fourteen early (Co 0204, Co 0205, Co 0209, Co 0302, Co 0306, Co 0308, Co 0310, Co 0312, Co 0314, Co 0315, CoM 0254, CoM 9902, CoM 9903 and CoVC 9982) and 17 midlate (Co 0112, Co 0211, Co 0212, Co 0213, Co 0214, Co 0215, Co 0218, Co 0219, Co 0311, Co 0317, Co 0320, Co 0325, Co 0328, CoM 0265, MS 0217, CoVC 99134 and CoVSI 03301) elite sugarcane clones developed in different research stations were evaluated across peninsular zone (14 centres) in Advanced Varietal Trial (AVT) as I and II plant and ratoon crops (2007-2009) in randomized block design with three replications. Three (CoC 671, Co 94008 and Co 85004) and two (Co 86032 and Co 7219) varieties were used as standard in early and midlate trials respectively. Analysis was done with pooled data of quality and yield contributing parameters recorded at 300 and 360 days after planting respectively for early and midlate clones. The clone Co 0314 ranked among top three in trials with an average improvement of 5.44% for CCS t/ha and 6.33 % for cane yield over CoC 671 whereas Co 0209 recorded an improvement for CCS t/ha (13.23%) and cane yield t/ha (13.40%) across the zone. Both the

clones have combined resistance to red rot and smut, and tolerance to other abiotic stresses.

Among midlate clones Co 0212, Co 0218 and CoM 0265 ranked top three in trials for CCS (t/ha) and cane yield (t/ha) whereas Co 0218, Co 0112, Co 0311 and Co 0317 topped for CCS % and sucrose %. For yield, CoM 0265 recorded 9.22% improvement whereas Co 0218 performance was on par with best standard Co 86032. The clones Co 0218 and CoM 0265 showed improvement of 4.22% and 5.09% respectively for CCS (t/ha) over standard Co 86032. The clone Co 0218 recorded 5.0 % (1 unit) and 9.0 % (1.5 unit) improvement for sucrose % over Co 86032 and CoM 0265 respectively across the zone. Co 0218 also exhibited 5.0% improvement for CCS % over Co 86032. Co 0218 was resistant to red rot and smut. Co 0209 and Co 0314 in early group and Co 0218 in midlate group combine yield, quality and resistance to abiotic and biotic stresses and were identified as promising sugarcane clones for commercial cultivation in peninsular zone of India.

450 –Ms No 44

Evaluation of genetic potential of sugarcane interspecific hybrids (ISH) constituted from *Saccharum* complex

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Narrow genetic base of the modern sugarcane cultivars is the main concern for the sugarcane breeders worldwide. In order to broaden the genetic base, new ISH hybrids were developed by crossing *Saccharum officinarum* (SO) and commercial hybrids (Co canes) with *S. barberi / S sinense* (SB), *S. robustum* (SR) and *S. spontaneum* (SP). A total of 50 clones from different ISH combinations *viz.,* SO x SP (6 clones), SO x SR (6 clones), (SO x SR) x (SO x SR) (8 clones), CoC 671 x (SO / Co x SR) (14 clones) and SO x SB (16 clones), were evaluated and data on yield contributing and juice quality characters were recorded at 12th month after planting at Sugarcane Breeding Institute, Coimbatore. The stalk height of the progenies for different populations ranged from 176.9 cm [(SO x SR) x (SO x SR)] to 230 cm (SO x SR) with the mean cane thickness of 2.52 cm and 2.17 cm respectively. Progenies from [CoC 671 x (SO / Co x SR)], a third stage nobilised cane showed significant improvement for cane diameter compared to SO x SP, a first stage nobilised cane. The highest single cane weight (1.83 kg) was recorded with the progenies of commercial hybrid crosses while the *S. spontaneum* involving progenies had 0.67 kg. For quality parameters viz., Brix%, pol %, sucrose %, purity % and CCS % the population of [CoC 671 x (SO / Co x SR)] recorded the maximum and the lowest was observed with the SO x SB. Within the ISH groups involving SB, differential performance for quality traits with different *S. fficinarum* background was noticed. It is concluded that use of

advanced nobilisation clones for breeding of commercial types and early stage nobilisation ISH clones involving SP and SR as parental material for breeding energy cane could reward sugarcane variety development.

451 – Ms No 45

Studies on cross zonal adaptation of elite clones of sugarcane from Peninsular Zone at East Coast Zone

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A total of 1308 sugarcane selections from different stages of breeding cycle developed at Coimbatore (Tamil Nadu) and Ugar (Karnataka) in Peninsular zone (PZ) were evaluated at Tanuku, located in East coast zone (ECZ). Elite clones were selected from ground nursery [clonal (C_0) stage] (337), first clonal trial (C_1) (205), pre final clonal trial (C_2) (211), pre zonal varietal trial (C_3) (PZVT) (230), Co canes (82) stages and other breeding programmes (243) which were developed either from biparental cross or open pollinated fluff. The clones were evaluated in single row trial in augmented randomised block design with two standards (CoA 98021 and Co 7805). Data on yield contributing and juice quality traits and red rot resistance (race CoC 671) were recorded. High variability was observed both within and between selection stages for all the traits ensuring effective selection in the population. Variability was observed for HR brix (%) at 10 months (9-22%), number of millable canes (2-20), stalk height (90-270 cm), stalk diameter (1.1-4.2 cm), single stalk weight (0.5-2.2 kg) and HR Brix at 12 months crop age (14-25.2 %). Based on the cane and quality parameters, elite clones were selected from C_0 (39.76%), C_1 (24.39%), C_2 (7.10%), C_3 (31.30%), Co canes (46.34%) and other population (32.34 0%). Of the total clones, 78.95 % (Co canes), 50.74% (C_0), 30.55% (C_3) and 24% (C_2) genotypes were red rot resistance to race CoC 671. The result indicated that selection from clones from C_1 stage will be more effective in initiating breeding cycle for yield, quality and red rot resistance in East Coast Zone and the elite clones selected from PZ can be of cross adaptation boundaries and perform better in ECZ.

Assessment of genetic improvement of sugarcane varieties developed over decades for yield and quality

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In order to assess improvement achieved through breeding new sugarcane varieties, a study was conducted at Sugarcane Breeding Institute, Coimbatore using 67 commercial varieties which were/ are under cultivation in the tropical India .The varieties were grouped into different time periods viz. those in cultivation prior to 1960, and in decades 1961-70, 1971-80, 1981-90 and 1991 - 2000 and were evaluated in a randomized block design adopting standard cultural practices. .Germination and early vigour of the varieties were recorded and the crop was harvested at 360 days when incremental improvement in yield and juice quality parameters was estimated as a function of the genetic potential of the new varieties. Decade-wise mean data for twelve yield and quality traits showed that the varieties bred during 1991-2000 were the best for sucrose % at 300 and 360 days, commercial cane sugar (CCS) % and Brix % at 360 days. Juice quality characters showed a quantum jump from the period prior to 1960 to 1961-70. Percentage of clones above the general mean indicated that all the varieties of the period 1991-2000 were better than the general mean for sucrose, while 87. 2% varieties bred prior to 1960 were better for the number of millable canes (NMC). When improvement made over the previous decade was compared, there was improvement in all characters except NMC. Maximum improvement was observed for single cane weight (44.05%), cane yield (25.16 %) and CCS yield (49.3%) during 1961-70 period over the previous period. In general, a steady improvement in sucrose % was observed over the decades, while improvement in NMC was negative till 1981-90, thereafter showed an increasing trend. 1961-70 period was the best for cane yield and its parameters mainly contributed by the varieties Co 62175 and Co 6304, followed by 1991-2000 period. Juice purity among juice quality traits and NMC among yield traits showed the least improvement. The best varieties for twelve economic traits were identified. Co 94012 was the best variety for sucrose content among all the varieties evaluated.

453 – Ms No 51

Studies on early vigor, yield and quality in inbreds of sugarcane (*Sacharaum spp)*

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Early vigor in sugarcane is being given greater importance in sugarcane breeding programme. Early vigor is meant good tillering, early formation of cane and its elongation in sugarcane. These characters enable the crop to overcome drought and weed competition during the initial stages of crop growth, which is essential for the successful commercial cane cultivation. Three early growth attributes viz., early shoot height (ESH), number of nodes (ENN) and number of tillers (ETN) at 90 days after planting were studied in relation to cane thickness, number of millable canes, brix at 10^{th} and 12^{th} month in 50 inbreds of Co 7201 and Co 1148 along with their parents. Interestingly all the 15 inbreds of Co 7201 showed higher level of expression for ESH and ENN than the parent. The reverse is the case with respect to the ETN. Among the 35 inbreds of Co 1148, three in S4 stage and eight in S5 stage expressed the superior ESH than their parent and none of the inbreds of Co 1148 was found better than their parent. Among the three characters of early vigor, ENN was found significantly associated with yield contributing characters viz., NMC and cane thickness, and quality characters viz., brix at 10^{th} and 12^{th} month. However, ESH and ETN showed negative association with NMC and cane thickness and other quality characters. Hence selection for higher number of nodes at early stage will result in higher and thicker NMC which may further result in higher yield in these inbreds.

454 – Ms No 54

SCGS 00-0402 - A potential pre-breeding stock for early high sugar content in sugarcane

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Sugarcane cultivars with substantially high levels of juice sucrose suitable for early harvest are very less in the present breeding populations. New parental clones that are capable of accumulating much higher levels of sucrose than found in the local commercial varieties are to be developed. Successful efforts to improve sucrose content through the adoption of different selection strategies coupled with the choice of appropriate parents have been reported. SCGS 00-0402 is an early high sugar clone identified from the first selection cycle of a simple recurrent selection scheme. The clone has registered a substantial gain for all the juice parameters viz., juice brix %, sucrose %, CCS% and purity %

compared to the zonal standards under the early maturity group. SCGS 00-0402 was developed at the Sugarcane Breeding Institute, Coimbatore has been registered as a source of high levels of juice sucrose at 240 days of crop age by the Plant Germplasm Registration Committee of ICAR vide registration number INGR. 09053. The genotype flowers during mid season (November) and flowering intensity is 90%. Pollen fertility is less than 5% and can be used as a female parent. At 240 days of crop age, SCGS 00-0402 recorded an average juice brix of 22.57% against the early checks CoC 671 (20.73%) and Co 85004 (19.85). It registered an improvement of 13.71% compared to Co 85004 and 8.88% as compared to CoC 671. SCGS 00-0402 recorded an average juice sucrose of 21.62% at 240 days compared to the standards CoC 671 (19.37%) and Co 85004 (18.42%). The clone recorded an improvement of 17.35% over Co 85004 and 11.62% over CoC 671. For commercial cane sugar percent, SCGS 00-0402 recorded an average of 15.51% as compared to 13.74% in the check variety CoC 671 and 13.03% in Co 85004. It showed an improvement of 18.97% compared to Co 85004 and 12.82% as compared to CoC 671. Early sucrose accumulation is a promising characteristic in sugarcane improvement programmes. The clone SCGS 00-0402 is a potential pre-breeding stock and its use in hybridization is expected to generate more number of segregants for early high sugar content in sugarcane.

455 – Ms No 55

Evaluation of flowering and floral traits in tropical and subtropical *Saccharum* spp hybrids at Attapady hills of Western Ghats

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Low and variable flowering coupled with poor seed set limits the parental selection and planned cross pollination in sugarcane. In many countries, variable flowering is a major impediment in developing new sugarcane varieties. Flowering is a complex phenomenon determined by the various physiological and environmental factors. Under natural conditions, the timing and intensity of flowering is affected by day length being fixed at any given latitude and date, altitude, temperature, moisture stress and the nutrition level of the soil. A detailed information on flowering behaviour and floral traits related to seed set would be of immense value in selecting parental clones for desired crosses. In view of that, present study was conducted under natural conditions in distant hybridisation facility available at Sugarcane Breeding Institute, Research Centre, Agali, Kerala involving 38 tropical and subtropical sugarcane clones. Genetic correlation coefficients were computed for seven floral traits viz., flowering week, pollen fertility (%), size of the fertile pollen (μ), size of the sterile pollen (μ), size of the anther (mm), stigma length (mm) and style length (mm) with no.of germinants/unit weight of fluff which is the indirect measure of seed set. The results indicated that only one trait flowering week was highly and significantly correlated with no. of