GENETIC VARIABILITY, PATH ANALYSIS AND STABILITY PARAMETERS IN SUGARCANE

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Genetic variability, path analysis and stability parameters in sugarcane" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar titles of any other University or Society.

Vellayani,
26-12-1986.

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CERTIFICATE

Certified that this thesis entitled "Genetic variability, path analysis and stability parameters in sugarcane" is a record of research work done independently by Sri.S.G.SREEKUMAR under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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S.G. Sreekumar

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INTRODUCTION

Sugarcane (Saccharum officinarum L.) is one of the major crops of economic importance and it occupies a predominant position among the commercial crops of our country. Physiologically belonging to the C4 pathway group, it is a bigger reservoir of energy with higher yield potential than many other crops. Every bit of cane from top to bottom is used in one way or the other. According to Rao et al.(1979) sugarcane has a vital role to play in the present context of energy crisis in the world. The production of dry matter from the sugarcane crop ranges from 35 to 90 tons per hectare per annum. One ton of sugarcane on dry weight basis can yield 0.21 ton of ethanol, 0.23 ton of methanol and 0.13 ton of ethylene.

India has the highest acreage under sugarcane in the world but ranks only third in production. The area under sugarcane in India is about 3.2 million hectares and the production is 184 million tons of cane with an estimated output of 8.5 million tons of sugar, besides Khandasari, gur and jaggery (Anon., 1983).

In Kerala, sugarcane is one of the main cash crops occupying an area of 9800 hectares. About 8400 ha. are in the river banks of Quilon, Kottayam, Alleppey and Pathanamthitta districts. The remaining 1400 ha. are in the Palghat district. The present production in terms of 'gur' is 54000 tons (Nair, 1978). The cane production of 4,61,000 tons per year is not sufficient to run the three sugar factories and to meet the sugar requirements of this State. The average duration of cane crushing in Kerala is only 78 days as against 223 days in Tamil Nadu, 203 days in Maharashtra and 167 days in Karnataka (Anon., 1983). Therefore, all efforts and technologies must be diverted for maximising the cane yield and sugar yield per unit area, time and input. Lack of high yielding varieties with wide adaptability and stability suited to the different agro-ecological situations of the State is the major constraint in the production of sugarcane.

Rao (1968) emphasised the need for application of biometrical procedures for the improvement of sugarcane inspite of its highly complex polyploid and heterozygous nature. The rationalisation of selection procedures based on biometric parameters may ensure quicker and reliable selection of superior varieties.

The present studies were undertaken with the objectives of estimating genetic variability, correlations, direct and indirect effects of components contributing to cane and sugar yields and identifying stable genotypes with high cane and sugar yield suited to the different agro-ecological situations of Kerala through the estimation of stability parameters. Study of genetic variability and analysis of yield, quality and their components by correlations and Path analysis will provide basic information necessary for the improvement of this crop through selection. The estimates of stability parameters can be used for identifying stable genotypes suited to the different sugarcane tracts of Kerala. Stable genotypes having higher cane and sugar yields which satisfy the conflicting interests of the cane grower and the miller can then be selected and recommended to the Sugar Industry.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Sugarcane accounts for 60 per cent of the World's sugar production and is considered as a 'Sure Crop', which has rescued the sugar industry when Sugar beet, a temperate zone crop failed due to disease hazards. Its cultivation is confined between 35° south and 35° north latitudes. More important cane growing countries of the world are Argentina, Australia, Brazil, Cuba, China, Egypt, Hawaii, India, Jamaica, Philippines, Puerto Rico, South Africa and Thailand. In majority of these countries except India and the Latin American countries, centrifugal sugar (white sugar) is manufactured from sugarcane. In India, besides centrifugal sugar, non-centrifugal sugar variously known as gur, khandasari, jaggery etc. are also manufactured. Cuba is the largest producer of centrifugal sugar. Next to Cuba, other large producers are India, Brazil, Australia, Philippines, Hawaii and Puerto Rico. World cane area during 1980 was 131 million hectares and production was 731 million tons of cane (Anon.,1981). The yield of raw sugar per hectare varies from country to country depending upon the climatic conditions, management practices, mill efficiencies and the potentialities of the varieties cultivated.

Sugarcane has been known to India long before other countries took to its cultivation. India has comparatively the higher acreage among the cane growing countries of the world but ranks only 3rd in sugar production. The area under sugarcane in India during 1982 was about 3.2 million hectares and production was 184 million tons of cane with an estimated output of 8.5 million tons of sugar, besides khandasari, gur and jaggery (Anon., 1983). In India, major part of the cane area lies in the subtropical region on flat plains of alluvial soil with an elevation of 9 to 27 m above mean sea level. The important cane growing states in India are Uttar Pradesh, Bihar, Haryana, Punjab, Madhya Pradesh, Maharashtra, Gujarath, Karnataka, Andhra Pradesh, Tamilnadu, Orissa and Kerala. In terms of area and production of gur, Uttar Pradesh stands first followed by Maharashtra, Tamilnadu and Karnataka. The yield of cane per hectare is maximum in Tamilnadu followed by Maharashtra and Karnataka. Cane is cultivated under climatic extremes in Northern India and the season favourable for the growth of cane is restricted from July to October. In the tropical peninsular region where the rest of the cane area lies, the climatic amplitude is not so wide as in North India. The soil in the northern cane area is alluvial but generally poor in organic matter with good moisture retaining capacity. The soil of peninsular India is either clayey loam or sandy loam. Planting season is from February to March in North India and January to February in South India.

As far as Kerala is concerned, sugarcane is one of the main cash crops and supplies the raw material requirement of the Sugar Industry. The total area under sugarcane is 9800 ha.of which about 8400 ha.are in Quilon, Alleppey, Kottayam, Pathanamthitta and Idikki districts. The remaining 1400 ha. is in Palghat district, particularly in the Chittoor area. The total production of sugarcane in the state in terms of gur is 54000 tons. The present production of cane is not sufficient to run the 3 sugar factories in the State.

Nair(1978) identified the following research gaps and pointed out that:

i) Production of cane in the river banks of Kerala located in Quilon, Alleppey and Kottayam districts can be considerably enhanced by identifying varieties with high cane and sugar yields suited to the rich alluvial soils.

ii) Identification and popularisation of suitable varieties for high altitude conditions of Idikki and Wynad can go a long way in increasing production.

iii) Staggering the production by identifying short, medium and long duration varieties will help in the full utilisation of the crushing capacity of the sugar factories.

iv) Identification of varieties tolerant to drought suited to the hilly areas may enhance the production in such regions.

The complex factors governing sugar production are many such as the area under the crop, varieties grown, yield, recovery percentage, climatic hazards like drought and flood, damage by pests and diseases and utilisation of cane for other purposes like manufacture of gur, khandasari etc. It is therefore, appropriate that all useful technologies should be transferred to the field for maximising the production of sugarcane per unit area, time and input. The basic approaches to maximise sugar production per ha. per annum are either through increasing the cane yield or through increasing the sucrose content of the cane. The Hawaiian approach is to maximise cane yield and the Australian approach is to maximise sucrose content of cane. In India the Hawaiian approach has been accepted for cane breeding and selection.

The cytological complexities of the crop like high polyploidy, heterozygosity, sterility, epistasis etc. render the assumption that the estimation of genetic parameters are not strictly applicable to this crop (Mangelsdorf 1956; Raghavan and Govindaswamy, 1956). However, genetical studies by Skinner (1956) and Panje and Ethirajan (1960) support the view that the crop is amenable to genetic experiments. Rao (1968) emphasized that recent developments in biometrical genetics offer scope for applying suitable procedures to the sugarcane crop inspite of its polyploid, heterozygous condition and this approach can be applied at all levels viz. choice of parents, choice of crosses and handling of early seedling and clonal generations. The choice of the parents can be rationalised by considering the genetic diversity, the discriminant function for plant selection based on genotypic net work of economic characters and phenotypic stability of varieties over a number of seasons and locations in the expression of economic characters. The rationalisation of selection procedures based on biometric parameters may ensure better and quicker selection of suitable varieties.

2.1 Genetic variability, heritability and genetic advance

The choice of the most suitable breeding method for the rational improvement of yield and its components in any crop largely depends on the genetic variability, association between characters, heritability and genetic advance under selection. In the case of quantitatively inherited characters which are controlled by a large number of minor genes with cumulative but small individual effects, the effect of an individual gene is so small when compared to the environmental fluctuations in that character, that it becomes impossible to assess the contribution of each and every gene to the total variance. Genetic variation so essential for exploitation by selection, is however, not directly accessible for measurement.

Only the external expression of genetic values as modified by the environment is measurable as phenotypic value. The variability available in a population could be partitioned into heritable and non-heritable components with the aid of genetic parameters such as genotypic coefficient of variation (G.C.V), phenotypic coefficient of variation (P.C.V), heritability (H^2) and genetic advance (G.A) which serves as a basis for selection.

Selection acts on genetic differences and the gains from selection for a specific character depend largely on the heritability of the character(Allard, 1960). The degree to which the variability for a quantitative character is transmitted to the progeny is called ' heritability'. Heritability can be defined as that proportion of total variation in a progeny which is the result of genetic factors and may be transmitted.

Hanson et al (1956) proposed the mathematical relationship of various estimates on computation of heritability which is usually expressed as a percentage. In the'broad sense' it refers to the relative proportion of genotypic variance to phenotypic variance. In the 'narrow sense' it is the proportion of additive genetic variance to phenotypic variance.

Coefficient of variation is used to compare the relative variables, when different metric traits are measured in different units. Dividing the standard deviation of the trait by mean, renders the coefficient of variation independent of the unit of measurement.

Lush (1937) and Johnson et al (1955 a) developed accurate procedures for the calculation of genetic advance under specified intensities of selection, which in metric traits largely depends on the heritability, phenotypic variability of the trait under selection and the selection differential expressed as phenotypic standard deviation.

The present sugarcane clones in commercial cultivation are complex polyploids. The heterozygous and polyploid nature of this crop results in the generation of vast genetic variability. Craig (1944) studied the refractometer brix and weight per stool in seedling population and reported greater coefficient of variation for weight of stool than that for refractometer brix.

George (1959) reported moderate heritability estimate for number of stalks and high heritability estimates for stalk thickness and brix. Cane thickness, length, number of canes, brix etc. were studied in sugarcane crosses at four locations by George(1962). He observed that heritability values in the broad sense ranged from 6 to 82 per cent. Yang and Chu(1962) while studying the combining ability in sugarcane hybrids reported that heritability for cane yield, stalk length, and tiller number were 35,45 and 47 per cent respectively. Brown (1965) noticed heritability estimates of 50 per cent and 70 per cent for brix and fibre respectively in commercial hybrid sugarcane populations.

The performance of the progenies of four inter-varietal crosses at seedling and settling stages were studied by Ethirajan (1965). He computed the broad sense heritability and genetic advance for seven characters viz. stalk population, stalk height, weight, girth, stalk specific gravity, yield and brix and reported heritability of 69.9% for cane yield and 91.4% for refractometer brix. The genetic advance as percentage of mean was high for stalk population followed by stalk height and yield. Brix recorded low genetic advance and high heritability.

Rao et al (1966) studied 16 hybrid clones at one location (Coimbatore) and indicated the highly heritable nature of certain characters like stalk weight and number of millable canes. Rao et al (1967) conducted four different experiments with 10 common genotypes in varying soil heterogenous conditions, different years, different seasons of planting and different agro climatic conditions. Under different soil heterogenity conditions maximum heritability was noticed for weight of stalk (83.8%) followed by germination percentage (76.5) and the lowest heritability of 55.4% for height of the stalk. In the 2nd experiment over two successive years accounting for climatic variation, the number of millable canes had the highest variation followed by cane weight and girth. The heritability percentage was maximum for number of millable canes (81.2) followed by cane weight (78.7). The exp riments at different seasons of planting revealed that the heritability was maximum for weight of stalk (89%) followed by sucrose (83.5%) and number of millable canes (77.5%). Height of the cane had the lowest heritability (68%). The experiments at different locations recorded the highest heritability of 84% for early tillers followed by sucrose (83%).

In this case also the height of the cane had the lowest heritability of 56 per cent.

Shah et al (1966) worked out broad sense heritability estimates and genetic advance for six characters viz. extent and speed of germination, height, tillers, number of green leaves and leaf breadth in 24 south Indian clones and 22 north Indian clones. Heritability percentages ranged from 59.5 (Mean tillers per plant at 60 days) to 92.6 (Mean leaf breadth at 120 days) in north Indian group and from 84.8 (Mean number of tillers per plant at 60 days) to 92.5 (Mean leaf breadth at 120 days) in south Indian group. The mean tillers per plant at 60 days recorded the highest genetic advance of 64.1% and 174% in south Indian group and north Indian group respectively.

Bhide (1969) estimated broad sense heritability for 12 components of yield and quality in 40 clones of <u>Saccharum officinarum</u> and reported that heritability was maximum (91.7%) for C.C.S. % and minimum for sugar yield per acre (63.8%). The range of genetic advance was from 1.05 (brix) to 4.54 (purity). The heritability for quantitative characters ranged from 5.2% (girth) to 53.7% (cane yield) and the genetic advance ranged from 0.11 (cane weight) to 7.60 (cane yield).

Mariotti (1973a) observed the highest heritability for stalk diameter (63%) followed by stalk weight (53%). He has also noticed high variability for cane yield, number of stalks and stalk weight and low variability for quality components. Allam et al (1974) studied plant, first ratoon and second ratoon crops of over 100 experimental clones and reported high broad sense heritability estimates for tons of cane per hectare, kg. sugar per ton of cane and kg. sugar per hectare in plant crop. They have noticed that heritability estimates increased from plant crop to second ratoon crop and concluded that wide range of variability with high heritability offer scope for considerable improvement of the traits by selection. Cesnik and Vencovsky (1974) studied open pollinated seedlings of five crosses and reported that heritability was generally high for most of the traits. Batcha (1975) estimated broad sense heritabilities of 89.6% for cane yield, 84.2% for sugar yield and 34.6% for sucrose percentage. The highest heritability (97.5%)

was noticed for single cane weight. The genetic advance as percentage of mean was lowest for stalk thickness (5%) and highest for cane yield (30%).

Mariotti (1975) studied eleven characters in five hybrid populations of sugarcane in clonal plots for the estimation of heritability and noticed that heritability was higher for yield components than for efrectness and sugar quality. The low coefficient of genetic variation for pol and juice purity appear to explain the very low response to selection for these characters, which showed moderate heritability.

Khairwal and Babu (1976) estimated broad sense heritability in 30 clones (released and unreleased) and reported that heritability was highest for leaf width (86.96%) followed by leaf length (82.83%), cane thickness (79.20%) and number of millable canes (72.54%). They have also reported moderate heritability percentages of 68.23 for height of cane and 65.26 for weight. The lowest heritability was recorded by sucrose (50%).

Lyrene (1977) recorded the percentage of stools that flowered in ten commercial clones, 25 F_1 populations and in S_1 population from five male parents.

The heritability estimates obtained by regressing F_1 population mean on mid parental values were 54 to 60%.

Sahi et al.(1977) while studying 20 early maturing sugarcane varieties at two locations, estimated heritability for H.R.brix at 8th month, hydrometer brix at 9th month, sucrose, purity, yield, C.C.S per plot, millable canes, weight of cane etc. in plant and first ratoon crops. They have reported highest heritability for yield (96.24% in plant crop and 91.44% in ratoon crop) followed by C.C.S per plot (94.19% plant crop and 91.33% ratoon crop). Genetic advance was maximum for C.C.S per plot (52.72% for plant crop and 86.31% for ratoon crop). They observed that heritability for sucrose, purity, number of millable canes and weight of cane were 10 to 14% lower in ratoon crop and emphasised the importance of the consideration of the ratoon crop data also in selection programmes.

Galvez and Amador(1978) have grown 22 varieties over three crops and observed that heritability was much greater for brix and stalk diameter than for height and pol percent. They have also reported the high phenotypic variability for yield and majority of its components and emphasised the importance and reliability of brix in selection programmes.

Balasundaram and Bhagyalakshmi (1978a) studied the extent of variability and heritability in a group of 58 varieties of sugarcane representing Indian and exotic germplasm. They have reported that stalk yield and its components viz. number of millable stalks per row, single stalk weight and commercial canesugar per row had high genetic variability and heritability in the broad sense and were highly amenable to selection as indicated by genetic advance. The stalk thickness and the quality attributes viz. sucrose % and C.C.S % had low variability and high heritability and had lower levels of genetic advance. Stalk thickness, number of millable stalks per row and single stalk weight had broad sense heritability of 88.56, 88.01 and 85.98 percentages respectively. Stalk length which is highly influenced by the environment had the lowest heritability of 46.41% and genetic advance of 11.11%. The number of millable stalks and single stalk weight showed high levels of genetic advance, ie. 86.45 and 65.63% respectively. Behl et al.(1979) estimated heritability and genetic advance in 21 early maturing varieties of 300 days duration and reported that number of millable canes had high genotypic coefficient of variability, heritability (47%) and genetic advance (30.97%) under selection. Cane yield, which had recorded the heritability of 33.3% had a low genetic advance of 3.32%.

Nair et al (1979) evaluated 126 genotypes of Saccharum officinarum for eight quantitative characters viz. number of millable canes per row, thickness of cane, single cane weight, number of internodes, length of cane, sucrose % in juice, yield of cane per row and C.C.S. per row and reported high levels of variability for yield and its associated characters and low level of variability for sucrose % in juice.

Singh and Sangwan (1980) reported significant variability for stalk characters in 50 genotypes. Among the yield and its components studied, stalk yield per row, millable stalks per row and stalk weight recorded high genotypic and phenotypic coefficients of variation, heritability and genetic advance. All the other components viz. stalk diameter, stalk length, internodes per stalk and length of internode recorded comparatively lower values for genotypic and phenotypic coefficients of variation, heritability and genetic advance. The highest heritability (93%) was noticed for stalk weight followed by stalk yield per row (90.31%) and millable stalks per row (88.75%). The lowest heritability (68.72%) was noticed for stalk diamotor. The genetic advance was highest for stalk yield per row (58.34%) followed by stalk weight (46.9%) and millable stalks per row (40.07%). The genetic advance was lowest for length of internode (17.55%).

Nair et al (1980) from their studies with 126 genotypes of Saccharum officinarum reported genetic variability, heritability and genetic advance for ten characters. Sugar yield (C.C.S/plot), Stalk yield and two of its important components viz. single stalk weight and number of millable canes per plot recorded high levels of heritability, genetic advance and genetic variability. The stalk diameter, stalk length and quality attributes possessed moderate heritability, with low genetic advance and variability. The genotypic coefficient of variation ranged from 7.88 (brix) to 37.92 (C.C.S/plot). The heritability percentage ranged from 65.07 (stalk length) to 86.94 (number of millable stalks/plot) and the genetic advance ranged from 12.82 (brix) to 65.17 (C.C.S/plot). From the results of the study they confirmed the possibilities for improving sugar yield (C.C.S/plot) and stalk yield, through selection by virtue of the high genetic parameters associated with these characters.

Reddy (1980) estimated heritability in the broad sense and genetic advance in respect of cane yield, number of millable canes, single cane weight, length of millable cane and juice quality in ten varieties at Anakappalle. The number of millable canes recorded maximum heritability (95.27%) and genetic advance (52.52%) with moderate (26.12) genotypic coefficient of variations, indicating that this character is less vulnerable to environmental influence and could be relied upon as one of the important criterion for selection. Next to number of millable canes, the single cane weight had high heritability (93.15%) and genetic advance (18.25%). With regard to the quality characters, brix recorded the lowest coefficient of variation and genetic advance during January. The magnitude of heritability for brix was maximum during February (78.99%), followed by pol (79.17), indicating that the potentiality of the varieties can be best assessed in February when they attain peak sucrose percentage in the juice.

Hogarth et al (1981) observed progenies from 50 parental clones for sugar content, stalk number, stalk length and stalk diameter and reported that sugar content showed little variability when compared with the variability for cane yield. Estimated heritability values by parent progeny analysis were low for all the characters.

Lyrene (1981) calculated the heritability for lodging in 40 varieties comprising of ten commercial varieties, 25 F_1's and 5 S_1 populations and reported that the extent of lodging had high heritability. He has reported moderate heritability for brix and low heritability for stalk length. Singh et al (1981a) noticed wide range of phenotypic variability for six out of the eight characters studied. The heritability was higher for number of internodes per stalk, stalk weight, number of green leaves per stalk and brix. The genetic advance was moderate for stalk height, stalk girth, number of internodes per stalk and brix.

Sankaranarayanan and Shanmugha sundaram (1981) estimated narrow sense heritability in 370 progenies from 23 crosses involving 19 parents by parent progeny regression and intra-class variations and reported that heritability values were generally low for brix. The heritability value indicated that the maternal contribution for brix was more (0.287) than the paternal contribution (0.032). Heritability of the same order was obtained for leaf width in progenies with either of the parents viz. maternal (0.552), paternal (0.548) and mid parental (0.628).

Singh et al.(1981b) determined genetic variability for cane height, girth, number of internodes, internode length, cane weight and sugar content. Highest genotypic coefficient of variation and genetic advance were observed in cane height, followed by cane weight. Highest heritability was noticed for sugar content followed by internode length. In general, heritability values were moderate for the other characters.

Sangwan (1981) studied eight selections from four crosses for seven stem characters and reported that heritability estimates were high for number of millable canes per row and cane yield per row and the expected genetic advance was high for cane length and cane yield. Cuenya et al. (1983) while studying the effectiveness of selection for increased brix values in 20 families each of 30 distinctly different genotypes reported that heritability ranged between zero and 0.859 indicating the unreliability of selection based on the presumption that brix value displays high heritability. Rao et al. (1983) studied 190 progenies of 19 crosses along with four standards and reported that P.C.V. and G.C.V. were maximum for clump weight followed by millable stalks per clump and brix. The broad sense heritability estimates were high for brix (74.7) followed by stalk diameter (64.4) and stalk length (57.2). The genetic advance was reported to be high only for stalk length (26.28) and low for brix (3.38) and stalk diameter (0.47). Singh et al. (1983) reported high heritability estimates for number of millable canes (83.97) followed by sucrose percentage (78.57) and number of tillers (66.93) based on the evaluation of 126 genotypes selected from 15 crosses. The genetic advance was found to be high for number of millable canes (11.54) followed by number of tillers (9.92) but low for sucrose percentage in juice (5.46) and cane yield (7.17).

Variability, broad sense heritability and genetic advance were estimated in a mutagen induced variable population by Khairwal et al. (1985) and reported that genotypic coefficient of variation was high for yield of cane per clone (39.27) followed by tillers per clone (17.17) and millable canes per clone (16.28). Heritability estimates were reported to be moderate to high for all the characters except number of internodes (23.45). The highest heritability was recorded for cane thickness (89.74) followed by cane length (87.78), cane yield (83.16) and tillers per clump (79.10). The genetic advance was also found to be high for cane yield per clone (95.16), tillers per clone (40.64), millable canes per clone (34.64) and cane height (30.39). The characters such as number of internodes (4.95), internode length (12.12) and cane thickness (20.60) had comparatively lower values of genetic advance.

2.2 Correlation

Correlation is a measure of the extent of relationship between any two variables. Genotypic correlation is a measure of the interdependence of biological characters at the genotypic level, while phenotypic correlation is a measure of the interdependence at the phenotypic level. Fisher (1918) developed a method of application of the theory of correlation of variables in understanding their influence in biological system. Suitable procedures for the computation of genotypic and phenotypic correlation coefficients were introduced by Burton (1952).

In sugarcane, cane yield and sugar yield are complex characters having many components, the multiplicative interaction of which result in the final artifact of yield. An understanding of the interse association among the above components is essential for breeding elite varieties.

Barber (1916) extensively studied the association between morphological characters and juice quality in North Indian canes and reported a low but positive association between cane length and sucrose, a low negative association between leaf length, leaf-width and sucrose. However, he could not find any association between stalk thickness and sucrose content.

Stokes (1934) from biometric studies in *Saccharum officinarum* observed a low positive correlation between sucrose with fibre and stalk height. Low positive associations were also noticed between fibre with diameter, stalk weight and length of internode. He has also reported significant positive correlation between stalk thickness and stalk height. Mangelsdorf (1935) reported significant positive association of brix percentage with sucrose percentage and purity coefficient. McIntosh (1935) noticed positive correlations between early vigour and cane yield in cane varieties of Barbados. Highly significant positive correlation of yield with length and number of canes per unit area was reported by Gill (1949). Dillewijn (1950) reported linear relationship between cane length and stalk weight and number of canes and yield. Significant positive association of number of millable canes and cane length with cane yield has been reported by Rattan (1951). Stevenson (1954) studied the relationship between yield components and quality components and reported a low positive association between cane weight and brix in juice.

Singh and Singh (1954) reported significant positive correlation of cane yield with cane length, thickness of cane and single cane weight. They have also noticed non-significant positive association between number of canes per plot and internode number. Significant negative association of number of canes with stalk thickness and single cane weight were also reported by them. Correlation between juice weight and leaf characters were studied by Rao and Negi (1956). They reported significant negative correlation of juice weight per stalk with number of green leaves, total green leaf area and dry weight of green leaves. Hebert and Henderson (1959) studied eleven characters among progenies of seven crosses and found negative association of number of canes with stalk thickness, brix and sucrose. Bhat et al (1960) reported non-significant correlation for canes per clump and brix between ten months old seedlings and settlings. High yield and high sugar were found to be negatively correlated (Rao and Narasimhan, 1963). While summarising the results obtained from three seperate experiments, Varma (1963) observed that yield has consistent, positive and significant correlation with number of millable canes and cane height. He has also noticed that under certain treatments and in certain years, yield was influenced by germination percentage and number of tillers per plant. Brown (1965) observed a non-significant genotypic correlation and a small positive phenotypic correlation between brix in juice and fibre. Ethirajan (1965) studied the association among progenies of four intervarietal crosses in seedling and clonal generations and reported highly significant positive correlation between cane yield and its components viz. number of canes, height, stalk thickness, single cane weight and stalk specific gravity. He has also noticed significant negative correlation between cane yield and brix.

Hebert (1965), studied 90 varieties in replicated field trials at six locations over 13 years and reported highly significant positive correlations of stalk weight with stalk diameter, yield of cane per acre and milling quality. From the low degree of association noticed between yield of cane per acre and yield of sugar per ton of cane, he has suggested the possibilities of selecting varieties with high yield of cane per acre and high yield of sugar per ton of cane. Positive correlations of weight of millable cane with cane number, cane diameter and cane length were also reported (Anon., 1965).

Negative correlation between brix and stalk diameter in hybrid progenies were recorded by Luna (1965). Khapaga et al.(1966) studied the stalk weight, length, diameter, internode number and degree of brix in three varieties and reported that all characters except degree brix was correlated with stalk weight. Ekambaram(1967) studied 200 selections from six crosses for yield attributes viz. the length and thickness of cane, number of internodes, individual weight of cane, tillering and juice quality. He reported highly significant positive correlation between cane length and internode length. He has also reported non-significant negative correlation between number of canes and thickness of cane. Non-Significant negative correlation between weight of cane and C.C.S per cent was also observed. He concluded that thick long internodes and good tillering has got potentialities for high yield.

Jagathesan et al.(1967) studied 56 clones of six species of Saccharum and reported significant positive correlation of brix with stalk girth and leaf width. Singh and Jain (1968) randomly selected twenty plants of Co.319 and estimated correlation for six characters and reported an inverse association of number of canes per clump with thickness of cane, number of internodes per clump, yield of cane per clump and juice percentage per clump. Significant positive correlation between height of the main shoot and thickness of cane, number of internodes per clump, yield of cane per clump and juice percentage per clump were also reported. The positive association of thickness of cane with number of internodes per clump, yield of cane per clump and juice percentage were also confirmed in their studies. Juice percentago per clump was partially correlated with number of internodes per clump. Brown et al.(1969) reported high positive genotypic correlations between cane yield and sucrose per plot, number of stalks per plot, and stalk length. The association between number of canes per plot and sucrose content was found to be negative both at the genotypic and phenotypic levels. James and Falgout(1969) studied the association of five characters in the progenies of four sugarcane crosses and observed high positive correlation between brix and fibre percentage.

Smith and James(1969) estimated phenotypic correlations among number of stalks, diameter of stalk and brix value within and between plant and first ratoon crops of progenies of four sugarcane crosses. They have reported that selection of seedlings in plant crop with ten or more stalks, stalk diameter greater than 27 mm and brix value greater than 110% of the mean will enhance the frequency of seedlings with those characters in the first ratoon crop by 35, 25 and 20% respectively. Singh and Sangha (1970) calculated partial and multiple correlations in 20 plants of Co.312 and reported that the minimum contribution towards cane yield was provided by juice percentage followed by girth, number of internodes and number of canes per clump in decreasing order. Singh et al (1970) confirmed from their studies with nine varieties that leaf Nitrogen content was positively correlated with stem weight and negatively with sucrose percentage and juice quality. They have suggested that leaf Nitrogen content can be used as an indicator of stem and sugar yields.

Selection responses and genotypic and phenotypic correlations were estimated for seven quantitative characters in seedling population by Hogarth (1971). He has reported that many genotypic correlations between important characters were positive and high, with notable exception of that between stalk number per stool and weight of stalk, which was high and negative. From covariance analysis of cane characteristics, Juang (1971) confirmed that number of millable canes and stalk thickness were positively correlated with yield. Phenotypic and genotypic correlations between cane yield and quality components calculated from one hundred clones by Mariotti (1971 a) revealed an average genotypic correlation of 0.814 between number of stalks per plot and cane yield and 0.457 between weight per stalk and cane yield. He has also reported non-significant positive genotypic and phenotypic correlations of stalk length with stalk diameter and pol percentage and significant positive correlations with stalk weight. The genotypic and phenotypic correlation coefficients between stalk diameter and stalk weight were also reported to be highly significant and positive. In another study of eleven characters in nine crosses, Mariotti (1971 b) reported that stool weight is closely associated with the number of stalks per stool, weight per stalk and height. He has noticed that juice quality was not strongly associated with fibre content or yield.

Nagatomi and Kodama (1971) reported that yield of cane was more strongly and positively correlated with number of stalks than with stalk weight. They have also noticed that in higher latitudes, plants have higher brix, sucrose and available sugar percentage. High correlations of stalk number, stalk diameter and length and low correlations of stalk density with cane yield were observed by James(1971). Batch and Sahi (1972) evaluated the performance of eleven Indian and foreign varieties for five consecutive years and reported a low negative correlation between cane yield and sucrose percentage. Among the yield attributes, the number of canes per row and height of millable canes showed highly significant positive correlation with yield. Girth of cane showed an interesting association with yield. The correlation was positive and low when the crop was raised under favourable irrigated conditions, but negative and low when the crop was raised under unfavourable conditions.

Mariotti(1972) reported positive correlation of yield with all its components, the most important one being number of stalks followed by average stalk weight. Height was positively correlated with yield, while stalk diameter was negatively correlated with number of stalks. He could not find any negative association between yield and quality components. Positive correlations between pol %, purity % and fibre content were also confirmed in his studies. The analysis of data from 17 biparental and five polycross sugarcane populations indicated that stalk number and stalk length are more strongly associated with yield, while the stalk diameter had a low correlation with yield Anon., 1974). Batcha (1975) from a study of the performance of eleven sugarcane varieties in North Bihar reported that number of millable canes, single cane weight and stalk thickness had highly significant positive correlation with cane yield and sugar yield. A strong negative correlation between stalk thickness and number of millable canes and a non-significant negative association between sucrose and all the components of cane and sugar yield were also reported in his studies. Cane yield was positively correlated with number of millable canes in early varieties and with cane height in late varieties (Anon., 1975).

Hunsigi and Srivastava (1975) in their studies with 24 cultivars noticed that yield of cane was positively associated with stalk length, weight of cane and stalk population. Lapastra et al (1975) concluded from their studies with 226 clones that tonnage components (Primary tillers, secondary tillers and stalk weight) had non-significant negative correlation with sucrose. Richard (1975) observed eight characters associated with yield in the progeny of eight crosses involving parents differing in sucrose content and reported that significant positive correlation exists between refractometer brix and sucrose content and also between sucrose content and purity.

Sahi and Patel (1975) while studying 40 early maturing sugarcane cultivars at two locations, viz. subtropical north zone and tropical south zone, noticed that in subtropical varieties, significant correlations existed between height and weight of cane, yield and height, yield and weight of stalk, C.C.S per plot and yield and C.C.S % and sucrose %. Eventhough the same trend holds good in sub-tropical group also, the intensity of association was found to be low and significant. They have concluded from their studies that height and weight of cane could be reliable selection indices for high yield in early maturing varieties. Khairwal and Babu (1975) reported negative correlation of cane yield with sucrose content and significant positive correlation of cane yield with number of millable canes, cane height and cane weight. The number of millable canes is reported to have significant positive genotypic correlations with cane height and cane thickness and non-significant positive correlation with brix.

Dosado et al. (1976)studied the characters affecting sugar content and cane yield per hectare in eleven varieties and suggested that canes with long stalks and leaves had significantly lower sugar content, while the freely flowering varieties had higher sugar content at harvest. They have also reported that varieties with longer stalks,more millable stalks per stool and dark green leaves produced more cane yield per hectare and those with greater stalk diameter and wider leaves gave significantly higher sugar yield. Lyrene (1977) studied 20 varieties and reported that yield was significantly and positively correlated with stalk diameter, stalk number and stalk length.

Tai et al.(1978) studied eight characters in 93 clones in plant crop at stage II at one site and in plant crop and first ratoon crop of stage III at four sites and observed significant positive correlation coefficients of brix with sucrose and sugar per ton of cane (C.C.S percentage) and sucrose with sugar per ton of cane (C.C.S percentage) and tons of sugar per hectare (sugar yield per ha). Stalk number was negatively correlated with stalk weight but both characters were positively correlated with tons of cane per hectare and tons of sugar per hectare. They have suggested that selection for both characters viz. tons of cane per ha. and tons of sugar per ha. could be performed simultaneously.

Correlation studies by Bathila(1978) revealed that cane length, thickness and number of internodes had high positive correlation with cane weight. He has also reported high positive correlation between cane length and number of internodes and negative correlation between cane thickness and leaf length. Yadav and Sharma(1978) observed statistically significant positive relationship between yield and number of millable canes, weight of cane and length of cane.

Balasundaram and Bhagyalakshmi(1978a) determined correlation among stalk and sugar yield and their components at the phenotypic and genotypic levels in a group of 58 varieties of sugarcane representing Indian and exotic germplasm and reported non-significant and positive genotypic and phenotypic correlations of stalk yield and stalk thickness. They have noticed that stalk yield and its components were highly correlated with C.C.S. per row. Stalk yield, number of millable stalks and stalk length were significantly and negatively correlated with sucrose % and C.C.S%, whereas stalk thickness and stalk weight, which were highly correlated to each other were also associated with sucrose % and C.C.S %. The number of millable stalks per row was reported to have highly significant negative correlations with stalk thickness and single stalk weight, sucrose and C.C.S. percentage. Singh et al.(1978) found significant positive correlations between C.C.S. and brix value, sucrose % and purity coefficient among 21 early varieties. Sharma et al. (1979) noticed that number of canes per clump was negatively correlated with cane thickness in five biparental crosses. They have also noticed positive association of brix with cane length and thickness in three crosses and negative association in two crosses.

Sundaresan et al.(1979) studied 380 seedlings derived from eight biparental intervarietal crosses with a common maternal parent at seedling and settling stage and observed that correlation between seedling and settling values for number of millable canes, cane yield, cane thickness, brix value and sucrose content were positive and significant in most cases. From their studies they have concluded that cane thickness is the most reliable character for selecting material both at seedling and settling stages. Dosado et al. (1980) based on the results of ten experiments over three years reported that stalk weight and millable stalks per stool were closely associated with cane yield. They have concluded that number of millable canes per stool can be relied upon as a selection criterion for high cane and sugar yields.

Piros and Costa (1980) estimated correlation between components of yield, quality and leaf area in six varieties grown in four different regions of Brazil for three different periods of development viz. initiation of plant development, period of plants greater development and harvest period. They have reported positive correlation between leaf area in the 3rd period and yield, yield and stalk length, leaf area in the first and second periods and stalk diameter. Negative correlation of pol % with cane yield and stalk length were also noticed.

The multiple correlations and partial regression studies by Parashar et al. (1980) revealed that characters like stalk height, diameter and number of internodes had direct bearing on cane yield. They have also reported significant positive correlation of T.S.S %, sucrose % and purity % with C.C.S %. Singh et al. (1981a) in a trial with 48 varieties reported that brix quality had positive phenotypic and genotypic association with number of millable canes per clump and number of internodes per stalk, whereas stalk height and girth had negative association with brix value. They also noticed positive correlation of sugar content with height of cane, girth, number of internodes, length of internode and cane weight. But the correlations were significant only for length of internode and cane weight at genotypic level. Singh and Sangwan (1981) studied 50 Co. canes and reported that only five attributes viz. tillers per stool, millable stalks per plot, stalk weight, stalk diameter and stalk length showed high and positive association with stalk yield both at phenotypic and genotypic levels.

Bathila (1981) studied the effect of five different yield attributing characters on cane yield in four varieties and reported that partial correlation coefficient of cane yield with cane thickness and cane length were significant in all the varieties. He has also noticed that multiple correlation coefficient between cane yield on the one hand and cane thickness, leaf width and cane length on the other were significant in all the varieties. Singh and Sharma (1982) estimated the genotypic and phenotypic correlations between yield and its components in 52 lines and reported that cane yield per plot was positively correlated with number of millable canes per plot and cane length. Cuenya et al. (1983) assessed the effectiveness of selection for increased brix in 20 families each with 30 genotypically distinct plants and observed that correlation between cane yield and brix value ranged between 0.54 and-0.53. But in most families correlation values were found to be not significant.

Kang et al. (1983) reported significant and positive genotypic and phenotypic correlations of cane yield per hectare with plant height, stalk diameter, stalk number and stalk weight, whereas the brix, sucrose, purity and C.C.S. had significant but negative correlations. The sugar yield per hectare had significant, positive genotypic and phenotypic correlations with all tho above yield and quality components. Gill et al. (1983) analysed the data on 12 traits collected from 28 foreign and two Indian varieties of sugarcane and reported that C.C.S. percentage had positive correlations with cane yield, juice purity, sucrose percentage and number of millable canes both in the plant and ratoon crops. Sucrose percentage in juice and juice purity was also positively correlated in plant and ratoon crops. They have concluded that for improving sugar yield in the ratoon crop, number of millable canes and sucrose percentage are the important components to be considered during selection programmes. Evaluation of fortysix clones by Punia et al. (1983) revealed that number of tillers per clump, cane thickness and cane weight were significantly and positively correlated with cane yield per clump both at the genotypic and phenotypic levels. They have also reported significant and positive genotypic and phenotypic correlations between number of tillers per clump with number of millable canes per clump and cane thickness with cane height and cane weight. The genotypic and phenotypic correlations between cane yield and sucrose percentage was found to be non-significant and positive. The correlations of cane height and sucrose percentage was reported to be non-significant and negative. The correlation coefficients of number of millable canes per clump with cane height, cane weight and sucrose percentage was reported to be negative and non-significant while with cane thickness it was non-significant and positive.

Singh et al.(1983) studied 126 genotypes and reported significant and positive genotypic and phenotypic correlations for number of tillers with number of millable canes. Cane yield had significant positive genotypic and phenotypic correlations with sucrose percentage in juice and significant positive genotypic correlations with number of millable canes. Evaluation of fiftytwo clones by Singh and Sharma (1983) revealed that cane yield had significant phenotypic association with millable stalk and stalk length. They have also reported significant genotypic association of cane yield with stalk diameter. Rao et al.(1983) studied 190 progenies of 19 crosses along with four standards and reported that clump weight had significant and positive genotypic and phenotypic correlations with stalk length and millable stalks per clump and non-significant but positive genotypic and phenotypic correlations with brix. The millable stalks per clump showed significant positive genotypic and phenotypic correlation with stalk length, significant negative genotypic and phenotypic correlations with stalk diameter and non-significant positive correlations with brix. The genotypic correlation between stalk length and stalk diameter was reported to be non-significant and negative.

Reddy and Khan(1984) reported that cane yield and C.C.S per plot are significantly and positively correlated with germination percentage, number of tillers per plant, number of millable canes per plant and cane height. Based on the correlation studies of sugar yield components in twenty varieties, Lu(1984) reported that both cane yield per plot and sugar yield per plot were positively correlated with number of stalks per plot, single stalk weight and length of cane.

Nair and Somarajan (1984) analysed six yield components in a hybrid population of 26 clones selected for waterlogged conditions and reported that number of millable stalks alone had significant positive association with stalk yield and sucrose percentage. They have suggested the possibility of simultaneous improvement for these characters. Singh et al (1985) reported that sucrose percentage was significantly and positively correlated with plant height, number of internodes, brix and purity coefficient. They have also noticed significant positive correlation of cane weight with number of millable canes and juice percentage.

2.3. Path analysis

The phenotypic association between variables may be due to the direct influence of one variable on another by correlated common causes or they may be genetically controlled or brought about by environmental influences. Negative environmental correlations usually counteract or reduce the positive genotypic correlation between two variables. The selection for a trait in one direction may cause an undesired diminution of another trait by direct or indirect effect through a third variable.

The path coefficient analysis devised by Wright (1921) is an effective means of examining the direct and indirect relationships, permitting a critical examination of the specific factors that produce a genotypic correlation. This technique was proved to be very useful in the statistical analysis of cause and effect in a system of correlated variables.

Kempthorne (1957) has given an account of the path coefficient methodology of Wright (1921, 1923, 1934). Dewey and Lu (1959) stated that the path coefficient is simply a standardised partial regression coefficient and as such measures the direct influence of one variable upon another and permits the partitioning of the correlation coefficient among cause and effect into direct and indirect effects.

If the cause and effect relationship is well defined, it is possible to represent the whole system of variables in the form of a diagram known as path-diagram. Path coefficient can be defined as the ratio of the standard deviation of the effect due to a given cause to the total standard deviation of the effect. The advantage of the path diagram is that a set of simultaneous equations can be written directly from the diagram and a solution of those equations provides information on the direct and indirect contribution of those causal factors to the effect.

The application of this method requires a cause and effect situation among the variables and the experimenter assigns directions in the causal system based upon apriori grounds or experimental evidences. Bhide (1969) in the biometrical studies of cane yield and quality components in sugarcane reported that cane weight has got maximum positive direct influence on sugar per acre followed by cane length, stalk thickness and number of millable canes per plot. He has also reported the maximum direct effects of sucrose followed by brix and purity percentage on the C.C.S.percentage.

James (1971) studied the yield components in random and selected sugarcane populations and reported that number of stalks had maximum contribution towards cane yield followed by stalk diameter. Mariotti (1973b) used both phenotypic and genotypic correlations in separate analysis to estimate the direct and indirect effects of different components on cane yield. When phenotypic correlations were partitioned, the four components viz. number of stalks, length, diameter and density contributed to yield more or less equally, with number of stalks slightly more important than the rest. When genotypic correlations are partitioned it appears that the number of stalks had maximum direct contribution to cane yield followed by diameter. The components viz. length and density showed negative contributions. Mariotti(1973c) studied the influence of environment on the relationship between yield and its components in sugarcane at three locations and reported that environment clearly affected genotypic correlation among yield components and consequently they also affected direct and indirect effect of components on yield.

Miller and James(1974) concluded from path coefficient analysis that when cane yield is the primary consideration, selection should be based on stalk number, length and diameter. Miller and James(1975) further reported that during early stages of selection, stalk diameter is a better criterion for yield forecasting than stalk number. Batcha(1975) from path analysis of cane yield and sugar yield among subtropical varieties under north Bihar conditions reported the importance of number of millable canes followed by single cane weight on cane and sugar yields.

He has also noticed that the direct effect of stalk thickness on sugar yield was minimum.

Khairwal and Babu (1975) from path analysis studies with 30 varieties reported that number of millable canes had the strongest direct effect on cane yield followed by cane thickness and cane weight. The direct effect of cane height on cane yield was negligible, while that of sucrose content on cane yield was negative. The indirect effect of number of millable canes was also prominent in the path analysis of cane height versus cane yield. They have added that for sucrose content, cane weight and thickness required much more emphasis with an appropriate compensation in the number of millable canes and cane height. Miller (1977) from path coefficient and regression analysis of ten crosses showed that stalk number, diameter and length, brix and density in that order were important in determining C.C.S.percentage on a per plant basis.

Balasundaram and Bhagyalakshmi (1978b) from path analysis of cane yield and sugar yield components confirmed that the number of millable canes has got maximum direct effect followed by thickness and length of cane, for cane yield as well as sugar yield. They have observed that stalk thickness which had a low genotypic correlation with cane yield had large direct effect, whereas stalk length which had high correlation with cane yield had only a low direct effect. The sucrose % which showed a negative correlation with sugar yield had a low positive direct effect. Singh et al.(1978) from path coefficient analysis with 21 early maturing genotypes of sugarcane for four important quality characters viz. brix %, sucrose %, purity % and C.C.S % have reported that brix had a greater direct effect on C.C.S % than sucrose % and purity coefficient.

Path coefficient analysis of 944 clones from four intervarietal crosses done by Hooda et al.(1979) revealed that cane weight was the main component contributing directly towards yield followed by plant height and brix. Sahi(1981) analysed the yield contributing factors in the progenies of early maturing tropical and subtropical cane varieties and reported the influence of stalk thickness on cane weight and the direct effect of cane weight on cane yield. Singh et al.(1981c) reported from path coefficient analysis that number of internodes per stalk had high positive direct effect followed by number of millable canes. They have observed that number of green leaves which showed high genotypic and phenotypic correlations exhibited negative direct path towards brix quality. They have suggested that number of internodes per stalk and number of millable canes should be given due weightage in selection programmes.

Singh and Sangwan (1981) from path analysis with 50 cane varieties reported that millable stalks per plot and stalk weight were the two major components which contributed maximum towards stalk yield. Punia (1981) conducted path analysis for yield and quality attributes in sugarcane and observed that cane weight and number of millable canes per clump are the most important components of cane yield. Brix and purity percentage were the more important quality attributes contributing towards C.C.S %. Singh and Sharma (1982) from path analysis in 52 lines noticed that number of millable canes and cane thickness were the more important yield components. The path analysis of cane yield and its attributes done by Punia et al.(1983) revealed that cane weight had maximum positive direct effect on cane yield followed by number of millable canes per clump and number of tillers per clump. The cane thickness was found to have low direct effect and high positive indirect effect on cane yield through cane weight. They have emphasised the importance of cane weight, number of millable canes per clump and number of tillers per clump for the improvement of cane yield per clump. Singh and Sharma (1983) reported that the number of millable stalks and stalk diameter are the more important components of cane yield provided negative association between the two traits are overcome by simultaneous selection to achieve optimum combination.

Kang et al.(1983) reported maximum direct effect of stalk diameter followed by stalk number on cane yield. They have also reported high positive direct effect of sucrose and negative direct effect of brix on C.C.S. percentage. Among the two components of sugar yield, the C.C.S.percentage had high positive direct effect than cane yield.

Lu (1984) reported that single stalk weight had major contribution to stalk yield per plot and stalk yield per plot had maximum contribution for sugar yield per plot.

Rao and Ethirajan (1984) analysed the brix, sucrose and six other morphological characters in the seedling progenies of six crosses involving high and low sucrose cultivars and reported that brix at 12th month had a direct effect on sucrose at 12th month and the sucrose at 12th month was influenced by the number of millable canes and cane diameter.

2.4 Genotype x environment interactions

In most crops it is recognized that some varieties will perform relatively differently from others in a range of growing conditions or environments. The phenotype or variety as it is seen reflects the non-genetic or environmental, as well as genetic influences on its development.

These environmental and genetic influences are not independent in their action, so that the observed response to a change in environment is different for most varieties.

Genotype x environment interaction is one of the components that regulate the phenotype. A specified genotype does not exhibit the same phenotype under all environment and different genotypes respond differently to a specified environment. In simple words, the genotype x environment interaction is the variation that arise from the lack of correspondence between genetic and non-genetic factors on the development of an individual.

The study of genotype x environment interaction in its biometrical aspect is very relevant to production problems of Agriculture in general and to plant breeding in particular (Breese, 1969). A knowledge on genotype x environment interaction and stability are essential in breeding varieties for general adaptation, particularly in crops grown under diverse agro-climatic conditions. The study gives an insight into the probable mechanism by which a particular plant species combat the fluctuations of the environment.

Environment is constituted by physical, chemical and biological factors. All biological systems are subjected to the influence of the environment. Therefore, an understanding of the different environments is appropriate in the study of genotype x environment interaction. Comstock and Moll (1963) classified the environment as follows:

Micro environment: This includes variables having small unrecognized individual effects like physical and chemical attributes of the soil, climatic variables like temperature, humidity, incidence of pests and diseases, quantity of solar radiation, differences in the application of fertilizers, irrigation water etc. to which the plants are exposed.

Macro environment: This includes variables with large individual effects like location, season or years, dates of planting etc. In sugarcane, the crop type (plant crop or ratoon) can also be considered as a macro-environmental component (Pollock 1978).

Allard and Bradshaw (1964) gave a different classification of the environments.

Predictable environment: This includes permanent features of the environment such as climate, soil type and day length. The controllable variables like the level of fertilizer application, sowing dates, sowing density, the method of harvesting etc. are also included under this.

Unpredictable environment: This includes weather fluctuations such as the difference between seasons, the amount and distribution of rain fall and the prevailing temperature.

A high level of genotype x environment interaction is desirable to have maximum yield in a predictable environment, whereas for unpredictable environment, a low level of interaction is desirable, so as to have the maximum uniformity of performance over a number of locations or seasons. In order to identify stable genotypes under such a situation, the testing of varieties is spread and carried out over several locations and years. Stability of production is often referred to as buffering and varieties which perform well and giving high economic returns both in predictable and unpredictable environments is said to be well buffered.

There are two ways through which varietal stability can be achieved. They are:

i) Individual buffering which is the characteristic of individual plants.

ii) The population buffering which is achieved through a combination of different genotypes in a variety or a population of varieties (Allard and Bradshaw 1964).

In sugarcane, a variety represents a single genotype which is multiplied by vegetative means and grown to raise a plant crop and 2 to 3 ratoon crops over years. Therefore, individual buffering is important and sought for in sugarcane varieties. Tillering is the most important factor giving rise to adequate number of millable canes for a good yield of cane. So it is logical that achievement of consistent cane yield (stability) or varietal buffering essentially is a function of tillering ability of sugarcane (Khan, 1981).

Various attempts have been made by different workers to solve the problem created by genotype x environment interaction and to pin point genotypes with stability in productivity. Sprague and Federer (1951), Comstock and Robinson (1952), Hanson et al. (1956) and Comstock and Moll (1963) are chiefly responsible for development of analysis of variance approach to estimate the G x E interactions. The estimates made by the above workers, eventhough provide estimates and information on the magnitude of G x E interaction, they do not provide means of measuring the response of individual genotypes with the environment or the measurement of stability of individual genotypes.

A simple measure of phenotypic stability termed 'Stability factor' (S.F) was suggested by Lewis (1954). According to him

$$S.F = \frac{\bar{X}\ H.E.}{\bar{X}\ L.E.}$$

Where, $\bar{X}$ is the mean value, H.E. and L.E. are high and low yielding environments respectively.

Lewis (1954) has considered only 2 environments for the measurement of phenotypic stability. He has suggested that a genotype will have maximum phenotypic stability, when S.F. equals unity.

Plaisted and Peterson (1959) attempted to measure the stability of individual genotypes. In this approach a combined analysis of variance at all environments was computed for each pair of genotypes and an estimate of variance due to interaction was obtained for each pair and each variety. The variety having the smallest mean value will be most stable. But this technique is very laborious when the number of varieties to be tested increases.

Wricke (1962) developed another method to estimate 'ecological valance' or 'ecovalance', which is the contribution of each genotype to the G x E interaction sum of squares. The variety with least ecovalance will be more stable and vice-versa. But this technique has been used only to a very limited extent.

Recently, the regression analysis has been very widely used for stability analysis. The approach was originally proposed by Yates and Cochran (1938), later modified by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968) and Freeman and Perkins (1971). Yates and Cochran (1938) stated that the "degree of association between varietal differences and general fertility can be further investigated by calculating the regression of yields of the seperate varieties on the mean yield of all varieties". This method was largely ignored until Finlay and Wilkinson (1963) rediscovered the technique and used it to analyse the adaptation of 277 barley varieties in seven environments. They used this method to describe the general adaptability of a variety using its linear regression coefficient. According to them an 'ideal' variety would have a high mean yield and a regression coefficient of one.

Eberhart and Russell (1966) also followed the linear regression approach and proposed an additional parameter of stability viz. deviation from regression. The stability analysis provide two parameters - the regression coefficient and deviation from regression. According to them an ideally adaptable variety would be one having high mean, unit regression coefficient (b = 1.0) and deviation from regression as small as possible (i.e. approximating to zero).

Perkins and Jinks (1968) proposed another model for the estimation of phenotypic stability. From stability point of view, the variance due to genotype x environment interaction being the most important, they proposed that a regression of genotype x environment interaction on environmental index should be obtained rather than regression of mean performance on environmental index as is done in the model of Eberhart and Russell (1966). In this approach also the same two parameters of stability viz. regression coefficient and deviation from regression are used. The regression coefficient in this model is different from that of Eberhart and Russell (1966) in the sense that Perkins and Jinks (1968) proposed to calculate the regression of genotype x environment interaction value on environmental index. The deviation from regression remains the same.

Freeman and Perkins (1971) proposed another model for stability parameter by raising the objection that the estimates of mean performance of a variety in a given environment over the environmental index is not independent in the models of Eberhart and Russell (1966) and Perkins and Jinks (1968). They suggested an independent estimate of the environmental index in the following two ways.

i) By dividing the replication into groups and using one group for measuring the average performance of varieties in various environments. The other group is used for estimating the environmental index by averaging over the varieties.

ii) Using one or more check varieties for assessing the environmental index. In this model also the parameters of stability viz. regression coefficient and deviation from regression are same as in the other two models. Another objection was about the partitioning of the degress of freedom. Eventhough, SS. due to environment (linear) of Eberhart and Russell's model being the same as SS. due to environment (joint regression) of Perkins and Jink's model, yet the degress of freedom is one in the former and (S-1) in the latter.

The ranking of genotypes with respect to their stability is same in all the three models.

Breese (1969), Paroda and Hays (1971) and Langer et al. (1979) observed that the linear regression should simply be considered as a measure of response of a genotype to varying environments, whereas deviation around the regression line is a true measure of production stability. They have also pointed out that a genotype with the lowest deviation may be most stable and vice-versa.

Bains and Gupta (1972) considered that all the three parameters of stability are equally important in determining stability. Shukla (1972) considered the contribution of each genotype to G x E interaction. He proposed a "Stability variance" (σ_1^2) for each genotype and observed that an approximate F-test was provided by the ratio of σ_1^2 to the pooled error mean squares (σ_e^2) calculated in the usual manner for combined analysis. The stability variances are tested against pooled error and the genotypes which showed significant 'F' values for stability variance are rated as unstable. Francis and Kannenberg (1978) suggested genotype grouping technique, which has been often used to describe a genotype that has constant performance over environments. A variety that respond to increasing fertility level will have greater yield variance across those levels than one that does not. The responsive one is stable and is usually more desirable. Therefore, a responsive variety will have larger variance. A measure of consistency can be obtained from coefficient of variation. The mean yield is plotted against c.v. and the genotypes are divided into four groups.

They have suggested that this simple descriptive method is very useful in plant breeding for grouping a large number of genotypes from yield data collected over several environments and it is more practical to characterise genotypes on a group basis rather than individually.

Ekosugyiatro et al. (1986) conducted yield stability analysis using the data collected from 27 sites in Jawa by adopting the methods of Finlay and Wilkinson (1963) and Eberhart and Russell (1966) and reported that the model of Eberhart and Russell (1966) was more precise.

Among the different models used for the estimation of stability parameters the model proposed by Eberhart and Russell (1966) is relatively simple, effective and the most widely adopted model.

2.5 Stability in sugarcane

A problem facing plant breeders is that of partitioning the genotypic variation from the phenotypic variation and of detecting and defining the G x E interaction by adopting any one of the several methods. In a vegetatively propagated crop like sugarcane, the problem becomes one of partitioning the phenotypic variation into genotypic and environmental components. Within any group of genotypes, the genotypic variance is fixed but must be separated from the environmental and genotype x environment variances to allow effective selection (Kennedy,1978).

Bhide(1969) conducted adaptation and stability analysis in different groups of sugarcane grown at three locations viz. Coimbatore, Palghat and Cannanore based on regression values and varietal mean over all environments as suggested by Finlay and Wilkinson(1963). He has reported that groups Fiji and Mauritius have got average stability, while all other groups showed above average stability. Hawaii group showed poor performance at all the three environments. Fiji, India, New Guinea and New Caladonia form an intermediate group having average performance and above average stability at all the environments. Palghat had a better performing environment followed by Cannanore according to the low site mean score recorded for all groups. Location x group interaction was significant for productive characters, whereas the same was non-significant for quality characters, suggesting that varieties behaved more or less similarly at all the three environments.

Arceneaux and Hebert(1943) observed cultivar x station, cultivar x year and cultivar x station x year interaction to be statistically significant, but they were small when compared to the varietal variance. Pollock (1975) analysed 27 trials over a four year period consisting of 13 plant crops, 11 first ratoons and three second ratoons. The harvest data from three standard varieties viz. Pinder, Q.82, and Q.90 were subjected to standard regression analysis of variance to investigate the relative stability. The varieties, Pinder and Q.82 deviated more about their regression lines than does Q.90 and hence considered to be less stable across environments. He has concluded from the trials that clone selection against average of several standard cultivars was better than against a single one.

Mariotti et al.(1976a) conducted regression analysis of the data from 15 years of trials with 28 cultivars in the INTA regional agricultural experimental station, Femailla. The three genotypes which were included in all the trials analysed were used to measure the quality of the environment in terms of cane yield in 'tons per hectare' and probable sugar yield per ton of cane. Results indicated that the response of the genotypes to the environment and the age of the crop (1-4 years) have an important effect. Stability of performance of different genotypes was moderate and highly repeatable in different years. They have also noticed that a positive correlation exists between yield and stability.

Mariotti et al.(1976b) assessed the reactions of 100 genotypes from hybrid populations to a natural environment, an environment with nitrogen fertilization and an environment with weed competition. They have observed that genotypes displaying good phenotype in poor environments were little affected by environmental stimuli, suggesting that poor environments were more suitable than controlled environments for the initial selection of suitable genotypes.

Mariotti(1977) reviewed sugarcane clonal selection experiments for 10 years in Argentina and reported that environment influences diameter and number of stalks, between which a non-linear association exists. Environment also influences selection of genotypes with specific adaptability.

Ruschel(1977) tested three groups of varieties in Brazil during 1956, 1964 and 1970. Mean variety yields were analysed in comparison with mean test yields at different loctions under a range of environmental conditions. Regression coefficient and yield differential were plotted in co-ordinate axis and he reported that the variety

CB 45-3 had a constant stability (homeostasis) at all environments with a coefficient of regression a little above unity. He suggested that the plant breeder has the choice of either selecting genotypes of restricted adaptability for defined ecological conditions or searching for genotypes with wider adaptability capable of sustaining a production inspite of wide variations in environment. He also stated that it would be ideal to select varieties which have good performance under all conditions.

Kennedy(1978) conducted analysis of variance of data on sugarcane variety trials from Barbados and Jamaica and estimated components of variance in order to quantify the genotype x environment interaction. Analysis of 16 sets of trials from Barbados and eight from Jamaica showed that G x E effects were small in both countries. It was suggested on the basis of these analysis that variety trials could use resources more efficiently by growing them at fewer sites, since the absence of site x variety interaction makes each site equally effective for identifying the best genotype.

Tripathi et al.(1978) studied nine Indian and five exotic sugarcane varieties using four years data for phenotypic stability. The partitioning of the genotype x environment interaction indicated that the major portion of the interaction was accounted for by the linear component. Among the cane yield and sugar yield components, the number of millable canes and stalk height recorded highly significant variety x environment (linear) interaction, while girth of cane, yield and sucrose % did not show any significant interaction. Out of the 14 varieties, Co.1148 recorded high yield as well as average stability and it was followed by Co.995 and Co.1007. Varieties B-37172, CP.44/401 and Co.997 had high sucrose % in juice, moderate yield and above average stability for yield, sucrose content and number of millable canes, Among yield contributing characters, stability of millable canes and stalk height appeared to be more important than that of stalk girth under subtropical conditions of India.

Bond (1979) examined the stability of standard cultivars of sugarcane and suggested that 'b' values were more precisely estimated when several rather than one standard cultivar was used to measure the cane yield. Fuchs and Ponce (1979) studied 16 clones grown at 11 sites in Cuba and stability of yield over sites (G x E interaction) were compared by two methods. They suggested that the ecovalance method of Wricke (1962) was preferable to conventional regression analysis, when the number of clones was small.

Epinosa and Calvez(1980) studied the interaction of the genotypes with planting dates and harvest cycles. They have studied fourteen cultivars of sugarcane in two harvest cycles (12-14 months and 16-17 months) and two planting dates (October and June) using experiments with plant crops and two ratoons. The interaction analysis showed that planting dates x harvest cycles were highly significant for all the characters.

Mariotti(1980) from clonal selection experiments with 80 genotypes selected at random from four progenies at four environments in Argentine, reported that certain environments tend to favour the selection of widely adaptable types. He has observed that among the four localities tested, it was possible to select for cane yield and better quality at one location viz. Femailla than at the other three localities. The average performance of the clones could be predicted from this locality.

Soopramanien and Julien(1980) studied four sugarcane cultivars planted on four different dates at three locations and reported that sucrose yield is affected by sites as well as planting dates. Warm conditions favoured dry matter accumulation while cool conditions favoured sucrose accumulation. Galvez (1980) analysed the data from three harvests in eight trials with 20 varieties at different sites in Western Cuba by three different methods viz. regression method, the method of ecovalance and coefficient of determination. Significant genotype x environment interaction for yield and brix value was revealed by each model and there was good agreement between the three methods. Interactions between genotypes and environmental components viz. year, sites, planting dates and harvest cycles were all found to be significant. He has concluded that the linear regression method of stability estimation provides more precise discrimination than the methods of ecovalance and coefficient of determination. Galvez(1982) further investigated six lines at two sites over three years. After a 6 x 3 x 2 factorial analysis he has reported that genotype x environment interaction was significant using the stability model of Eberhart and Russell(1966).

Orliz(1982) made analysis of variance using 16 varieties during the period from 1973 to 1977 for cane yield per hectare, sugar yield per hectare, pol %, brix and purity employing a 16 x 2 x 3 factorial design and reported that genotype x environment interaction is a component of phenotypic variability. It was also observed by him that the second order interaction, genotype x cycle x year was not an essential component in over all variation.

Tai et al.(1982) analysed data on seven characters from 11 varieties grown at six localities for three years and reported significant variety, variety x locality and variety x year effects for all characters viz. cane yield, single stalk weight, per cent sucrose, per cent purity, per cent C.C.S and sugar yield. From the stability analysis of the data using the model of Eberhart and Russell (1966) they have reported that for C.C.S percentage, cane yield and sugar yield, none of the varieties had good mean performance with good stability.

Sharma and Bharaj(1983) studied the adaptability for sucrose content, reducing sugar content and juice purity on 12 varieties planted in nine environments and reported that none of the varieties showed general stability for all the traits. Different varieties showed stability for different components.

Kang and Miller(1984) studied the genotype x environment interaction in eleven cultivars planted at four locations and reported that the cultivar x location interaction was significant both in the plant crop and the ratoon crop for brix and sugar yield, whereas cultivar x location interaction was significant, only in the ratoon crop, for C.C.S percentage and cane yield.

Mariotti (1985) reported that yield stability is generally associated with compensation mechanism among yield components and gave the examples of such components as stalk number, weight and diameter. It was also reported that stalk number is the component which mostly influenced the final yield expression with regard to the phenotype as well as stability. Neverthless, strong correlation in phenotypic expression did not necessarily lead to an associated response in the environment for all characters. This supports the view that average phenotypic expression of a character and its environmental stability are genetically different factors.

Rao and Rahman (1985) tested seven sugarcane clones in three seasons and reported that genotype x environment interaction was significant for sucrose percentage, millable canes per plot and cane yield per plot. They have also reported significant genotype x environment (linear) interaction and significant environment (linear) component. The clone Co.6907 was reported to have high mean cane yield, low 'b' values and non-significant S_d^2 values indicating its adaptability and better performance in poor environments. The phenotypic

Stability analysis for cane yield in 13 varieties conducted by Deswal and Sangwan(1985) revealed that genotype x environment interaction was highly significant. Based on the mean yield, regression coefficient and deviations from regression, Co.1148 was reported to be the most desirable variety. They have also reported that the mean squares due to the genotypes, environments and genotype x environment were highly significant, indicating diversity among the genotypes, environments and the differential response of the genotypes in different environments. The pooled deviations were also found to be significant. The lower magnitude of G x E interaction noticed in their studies was attributed to the inclusion of well established varieties in the experiment.

MATERIALS AND METHODS

MATERIALS AND METHODS

The studies were conducted at the Sugarcane Research Station, Thiruvalla from 1981 to 1983 and also at the Sugarcane Research Centre, Chittoor and the Horticultural Research Station, Ambalavayal, during 1982 and 1983.

3.1 Materials

The biological material used for the study consisted of 48 clones of sugarcane (*Saccharum officinarum* L.) collected from the germplasm maintained at the Sugarcane Research Station, Thiruvalla. Twelve superior clones were selected on the basis of the performance of the plant crop and evaluated along with three standard varieties in the three different agroclimatic zones of Kerala, at the Sugarcane Research Station, Thiruvalla, Sugarcane Research Centre, Chittoor and Horticultural Research Station, Ambalavayal.

3.2 Methods

3.2.1 Field experiments

3.2.1.1 Replicated trial

The 48 clones were planted in a randomised block design with 3 recplications at the Sugarcane Research Station, Thiruvalla during January 1981. Each plot consisted of 3 rows of 3 meters length, spaced 90 cm apart. In each row, twelve numbers of three budded sets were planted in furrows under the ridge and furrow system. Data on the following characters were collected from the plant crop.

i) Germination count: The number of sprouts in each plot on the 45th day.

ii) Shoot count: The number of shoots per plot on the 180th day.

iii) Number of late shoots: The number of late shoots (Water shoots) per plot at the time of harvest.

iv) Number of millable canes: Number of fully mature, healthy canes per plot at the time of harvest.

v) Weight of cane: Mean weight of cane from a sample of 5 canes selected at random from each plot.

vi) Length of cane: Mean length of cane from the random sample of 5 canes.

vii) Number of internodes: Mean number of internodes per cane from the random sample of 5 canes.

viii) Length of internode: Mean length of the middle most internode from the random sample of 5 canes.

ix) Girth of cane: Mean girth of the middlemost internode from the random sample of 5 canes.

x) Yield of cane: Weight of millable canes per plot and per hectare at the 12th month. The weight of cane sample drawn at the 10th month for quality analysis was also added.

xi) Juiciness: Estimated at the 10th and 12th months. A sample of 2 healthy canes was cut from each plot, crushed in a power crusher and the juice extracted. Juiciness was estimated as the volume of juice(ml) obtained from one kilogram of cane.

xii) Brix: One litre of juice was taken and the brix reading recorded using a standard brix spindle. This was estimated at the 10th and 12th months.

xiii) Pol percentage: Estimated by Horne's dry lead method (Spencer and Meade, 1945).

xiv) Purity percentage: Purity of the juice was expressed as the percentage of pol to Brix at the 10th and 12th months.

xv) Commercial cane sugar percentage: C.C.S was determined as per the following formula suggested by Mathur (1978) at the 10th and 12th months.

$$C.C.S = S - \left[0.4\ (B-S) \right] F$$

Where

B = Brix

S = Pol percentage

F = 0.73 = Factor relative to fibre percentage of cane

xvi) Yield of sugar: Sugar yield per hectare was calculated by multiplying C.C.S percentage by cane yield per hectare and dividing by 100.

$$\left.\begin{array}{l}\text{Sugar yield}\\ \text{per hectare}\end{array}\right\} = \frac{\text{C.C.S \% x Cane yield per hectare}}{100}$$

After the harvest of the plant crop, the stubbles were retained and the first ratoon crop of all the 48 clones was grown. The data in respect of all the 16 characters were recorded in the first ratoon crop also by adopting the same methodology.

The data collected from the plant crop and first ratoon crop were utilised for the estimation of genetic variability and path analysis for each crop.

3.2.1.2 Location trials

Fifteen superior clones (12 selected clones and 3 standard varieties) were planted in a randomised block design with two replications at three locations. Each plot consisted of 6 rows of 3 metres length, spaced 90 cm apart. In each row, twelve numbers of three budded setts were planted in furrows. Eight characters including cane yield, sugar yield and their principal components were studied in these trials by adopting the methodology outlined earlier. The data collected were used for estimation of stability parameters.

3.2.2 Statistical analysis

3.2.2.1 Analysis of variance and covariance

The extent of phenotypic variation for any character is the sum of genetic and environmental effects and shall be determined by the methods given by Kempthorne (1957) as follows:

$$V(P) = V(G) + V(E) + 2\ \mathrm{Cov}\ (G,E)$$

Where,

$V(P) = \sigma^2_{p(x)}$ = Variance due to phenotype

$V(G) = \sigma^2_{g(x)}$ = Variance due to genotype

$V(E) = \sigma^2_{e(x)}$ = Variance due to environment and

$\mathrm{Cov}(G,E)$ = Covariance between genotype and environment

If the genotype and environment are associated at random, Cov (G, E) is equal to zero, so that -

$V(P) = V(G) + V(E)$, or

$\sigma^2_{p(x)} = \sigma^2_{g(x)} + \sigma^2_{e(x)}$

If we have observations on two characters x and y on each individual, the extent of covariance between x and y due to genotype and environment shall be estimated (Kempthorne 1957).

Therefore $\mathrm{Cov}\,(x,y) = \mathrm{Cov}(G\,(x,y)\,) + \mathrm{Cov}\,(E\,(x,y)\,)$

or $\sigma_{p(x,y)} = \sigma_{g(x,y)} + \sigma_{e(x,y)}$

where, $\sigma_{p(x,y)}$ is the phenotypic covariance between x and y

$\sigma_{g(x,y)}$ is the covariance between x and y attributable to genotypes and

$\sigma_{e(x,y)}$ is the covariance between x and y attributable to environment.

If the experiment is designed in a Randomised complete block design with 'v' treatments and 'r' replications, the estimates of $\sigma^2_{p(x)}$, $\sigma^2_{p(y)}$, $\sigma^2_{g(x)}$, $\sigma^2_{g(y)}$, $\sigma^2_{e(x)}$, $\sigma^2_{e(y)}$, $\sigma_{p(x,y)}$, $\sigma_{g(x,y)}$ and $\sigma_{e(x,y)}$ are obtained from the analysis of variance-covariance (Table 1).

Coefficient of variation is a unitless measurement and is used for comparing the extent of variation between

Table 1. Analysis of variance/covariance

Source	df	$M.S_{xx}$	Expectation of $M.S_{xx}$	$MSP_{(x,y)}$	Expectation of $MSP_{(x,y)}$	MS_{yy}	Expectation of MS_{yy}
Block	$(r-1)$	B_{xx}		$B_{x,y}$		B_{yy}	
Treatment	$(v-1)$	V_{xx}	$\sigma^2_{e(x)} + r\,\sigma^2_{g(x)}$	$V_{x,y}$	$\sigma_{e(x,y)} + r\,\sigma_{g(x,y)}$	V_{yy}	$\sigma^2_{e(y)} + r\,\sigma^2_{g(y)}$
Error	$(r-1)(v-1)$	E_{xx}	$\sigma^2_{e(x)}$	$E_{x,y}$	$\sigma_{e(x,y)}$	E_{yy}	$\sigma^2_{e(y)}$
Total	$rv-1$	T_{xx}	$\sigma^2_{p(x)}$	$T_{x,y}$	$\sigma_{p(x,y)}$	T_{yy}	$\sigma^2_{p(y)}$

Hence we have the following estimates:

$$\sigma^2_{g(x)} = \frac{1}{r}\left(V_{xx} - E_{xx}\right), \qquad \sigma^2_{e(x)} = E_{xx}$$

$$\sigma^2_{g(y)} = \frac{1}{r}\left(V_{yy} - E_{yy}\right), \qquad \sigma^2_{e(y)} = E_{yy}$$

$$\sigma_{g(x,y)} = \frac{1}{r}\left(V_{x,y} - E_{x,y}\right), \qquad \sigma_{e(x,y)} = E_{x,y}$$

different characters measured with different scales.

Phenotypic coefficient of variation

$$(\text{P.C.V}) \text{ for character } x = \frac{\sigma_{p(x)} \times 100}{\bar{X}}$$

Genotypic coefficient of variation

$$(\text{G.C.V}) \text{ for character } x = \frac{\sigma_{g(x)} \times 100}{\bar{X}}, \text{ where}$$

$\sigma_{p(x)}$ and $\sigma_{g(x)}$ are the phenotypic and genotypic standard deviations and $\bar{X}$ is the mean.

3.2.2.2 Heritability (H^2)

Heritability in the broad sense is the fraction of the total variance which is heritable and was estimated as a percentage following Jain (1982) as -

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

Heritability provides a measure of genetic variance ie, the variance upon which all the possibilities of changing the genetic composition of the population through selection depends.

3.2.2.3 Genetic advance under selection (G.A.)

Genetic advance is a measure of the change in the mean genotypic level of the population produced by selection and depends upon heritability of the character and selection differential.

$$G.A. = \frac{K\ H^2\ \sigma_{p}}{\bar{X}}.\ -$$

Where $\bar{X}$ is the mean of the character x and K is the selection differential which is 2.06 at 5% intensity of selection in large samples (Allard, 1960).

3.2.2.4 Correlations

The phenotypic correlation coefficient between x and y was estimated as -

$$r_{p(x,y)} = \frac{\sigma_{p(x,y)}}{\sigma_{p(x)} \times \sigma_{p(y)}} \qquad \text{where,}$$

$\sigma_{p\ (x,y)}$ is the phenotypic covariance between x and y,

$\sigma_{p(x)}$ and $\sigma_{p(y)}$ are the standard deviations of x and y.

The significance of phenotypic correlations coefficient was tested with reference to the critical value of 'r' at n-2 degrees of freedom where 'n' is the number of pairs of observations (Snedecor and Cochran, 1968).

The genotypic correlation coefficient was estimated as -

$$r_{g(x,y)} = \frac{\sigma_{g(x,y)}}{\sigma_{g(x)} \times \sigma_{g(y)}} \qquad \text{where,}$$

$\sigma_{g(x,y)}$ is the genotypic covariance between x and y,

$\sigma_{g(x)}$ and $\sigma_{g(y)}$ are the standard deviations of x and y.

The significance of genotypic correlation coefficient r_g was tested against its standard error as suggested by

Narain et al.(1979) and applying the students't' test.

$$t = \frac{|\, r_{g(x,y)} \,|}{SE\,(r_{g(x,y)})}$$

Where,

$$SE(r_{g(x,y)}) = \frac{1}{(F+1)} \Bigg[\frac{1}{2}\,(1-r^2_{g(x,y)})^2 - \frac{1}{2}\left(1-r^2_{g(x,y)}\right) \frac{1}{D} - \frac{r_{p(x,y)}\;r_{g(x,y)}}{C} + 4\left(\frac{r_{g(x,y)}}{D} - \frac{r_{p(x,y)}}{C}\right)^2 + \frac{2(1-r^2_{g(x,y)})^2\;(1-r^2_{p(x,y)})}{C^2} \Bigg]^{1/2}$$

Where, $\frac{1}{D} = \frac{1}{2}\left(\frac{1}{H^2_x} + \frac{1}{H^2_y}\right)$

H^2_x = Heritability of x

H^2_y = Heritability of y

$C = (H^2_x \times H^2_y)^{1/2}$ and

F = degrees of freedom for error

3.2.2.5 Path analysis

The method of path analysis was developed by Wright(1921) to study the cause and effect relationship among a system of variables and helps to measure the direct influence along each separate path in such a system and to find the degree to which the variation of a given effect is determined by each particular cause. The genotypic correlation coefficients of different component characters with cane yield and sugar yield were partitioned into direct and indirect effects. The direct and indirect effects were calculated as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

The simultaneous equations which give solutions for path coefficients are -

$$r_{iy} = r_{i1}\, p_{1y} + r_{i2}p_{2y} + \dots + p_{iy} + \dots + r_{ik}p_{ky};$$

$$i = 1,2 \dots\dots\dots, k$$

Where r_{iy} is the correlation of i^{th} independent variable (x_i) with dependent variable (y), p_{iy} is the direct effect of x_i on y and $r_{ik}p_{ky}$ is the indirect effect of x_i via x_k on y.

Path analysis was done for cane yield as well as sugar yield, both for plant crop and the first ratoon crop.

3.2.2.6 Stability parameters

Study of Genotype x Environment(G X E) interaction and stability parameters are useful in identifying stable genotypes.

i. Environment wise analysis of variance

ANOVA TABLE

Source	df	Expectation of mean squares
Replication (r)	r-1	$\sigma_e^2 + p\,\sigma_r^2$
Genotypes (P)	p-1	$\sigma_e^2 + r\,\sigma_p^2$
Error (e)	(r-1)(p-1)	σ_e^2

ii. Pooled analysis

The pooled analysis of variance over environments was done for partitioning the total variability into variance due to genotype, environment and genotype x environment interactions. The ANOVA was constructed as detailed below.

POOLED ANOVA TABLE

Source	df	M.S
Genotypes (G)	p-1	MS_G
Environment (E)	q-1	MS_E
G x E	(p-1)(q-1)	$MS_{G \times E}$
Error (Pooled)	q(p-1)(r-1)	MS_{E_1}

The interaction mean squares of genotype over environments was tested against pooled error mean square. If the genotype X environment mean square is found to be significant, then mean square of genotypes and mean square of environments were tested against genotype X environment interaction mean square. In cases where variance due to genotype X environment interaction was found significant, the analysis of variance was proceeded to estimate stability parameters.

Following the methodology of Eberhart and Russell (1966), the two parameters of stability, viz. the regression coefficient (b) and the mean square deviations from linear regressions (S_d^2) were computed. The above 2 parameters along with high mean value above the grand mean was considered for identifying stable genotypes.

If there are 'p' varieties whose performance has been tested in 'q' environments, Y_{ij} is the mean observation of the i^{th} variety in j^{th} environment and was obtained by summation over environments. The following model was used to study the stability of varieties under different environments.

$$Y_{ij} = m + \beta_{i.} I_j + \delta_{ij}$$

Where

Y_{ij} = mean of the i^{th} variety in the j^{th} environment.

m = mean of all the varieties over all the environment

β_i = the regression coefficient of the i^{th} variety on the environmental index, which measures the response of the i^{th} variety to varying environments.

I_j = the environmental index which is defined as the deviations of the mean of all the varieties at a given location (j^{th} location) from grand mean so that $\sum_j I_j = 0$

δ_{ij} = the deviation from regression of the i^{th} variety on j^{th} location

Environmental index:

$$I_j = \frac{\sum_i Y_{ij}}{p} - \frac{\sum_i \sum_j Y_{ij}}{pq}$$

$$= \frac{\text{Total of all the varieties at the } j^{th} \text{ location}}{\text{Number of varieties}} - \frac{\text{Grand total}}{\text{Total number of observations}}$$

Regression coefficient for each variety was computed as -

$$b_i = \frac{\sum_j Y_{ij} I_j}{\sum_j I_j^2}$$

Where

$\sum_j Y_{ij} I_j$ is the sum of products and

$\sum_j I_j^2$ is the sum of squares

$\sum_j I_j^2$ is common for each value of regression coefficient, on the other hand, $\sum_j Y_{ij} I_j$ for each variety is the sum of products of environmental indices (I_j) with the corresponding mean $(\bar{X})$ of that variety at each location. These values were obtained in the following way.

$$\left[\bar{X}\right]\left[I_j\right] = \left[{}_jY_{ij}\ I_j\right] = \left[S\right]$$

Where,

$\left[\bar{X}\right]$ = matrix of treatment means

$\left[I_j\right]$ = vector for environmental indices

and $\left[S\right]$ = vector for sum of products ie. $\sum_j Y_{ij} I_j$

The regression coefficient was tested by 't' test

$$t_{(n-2)} = \frac{|b-1|}{SE(b)}$$

Where,

$$SE(b) = \sqrt{\frac{\text{M.S. due to pooled deviation}}{{}_jI_j^{2}}}$$

Mean square deviations from linear regression S_d^2 was also computed.

In the regression analysis, the total variance of the dependent variable (Y) was partitioned into variance due to regression and the variance due to deviations from regression.

M.S(Y) = M.S (regression) + M.S (deviation from regression)

The variance of environmental means for each genotype was obtained as

$$\sigma^2_{vi} = \sum_j Y^2_{ij} - \left(\frac{Y^2_i}{p}\right)$$

The variance due to deviations from regression ($\sum \delta^2_{ij}$) for the i^{th} genotype was computed by the formula:

$$\sum_j \delta^2_{ij} = \left[\sum_j Y^2_{ij} - \frac{Y^2_i}{p}\right] - \frac{\left(\sum_j Y_{ij} I_j\right)^2}{\sum_j I^2_j}$$

= Variance due to dependent variable - Variance due to regression

The stability parameter (S^2_{di}) for the i^{th} genotype is:

$$S^2_{di} = \left[\sum_j \delta^2_{ij} /(q-2)\right] - (MSE_1/r)$$

Where,

$\sum_j \delta^2_{ij}$ = Variance due to deviation from regression

MS_{E_1} = Mean square for pooled error

The devitation from linear regression was rested as follows:

$$F = \left[\sum_{j} \delta_{ij}^{2} \; / \; (q-2) \right] \; / \; \text{pooled error}$$

3.2.2.7 Analysis of variance for phenotypic stability

The pooled analysis of variance was further extended by partitioning the total sum of squares into i) sum of squares due to genotypes ii) sum of squares due to environment + (genotype X environment) and iii) pooled error. The sum of squares due to genotypes X environment is further partitioned into S.S. due to genotype x Environment (linear) ie regression and S.S. due to deviation from regression ie pooled deviations. The pooled deviation was further partitioned into 15 components with (q-2) degree of freedom for each as given below.

Source	df	M.S.	F
Total	pq - 1		
Genotype	p - 1	MS_1	MS_1/MS_3
Environment +(Genotype X Environment)	p (q-1)		

Source	df	M.S.	F
Environment(linear)	1		
Genotype X Environment (linear)	(p -1)	MS_2	MS_2/MS_3
Pooled deviation	p (q-1)	MS_3	
Genotype 1	q-2		
" 2	q-2		
" 3	q-2		
" "	"		
" "	"		
" 15	q-2		
Pooled error	q (p-1) (r-1)	MS_{E1}	

A variety with Mean $>$ grandmean, unit regression coefficient (b_i = 1) and deviation from regression (S^2_{di} =0) was considered as a stable genotype.

The genotype grouping technique based on Mean-c.v as suggested by Francies and Kannenberg (1978) was adopted for grouping the genotypes and identifying high yielding genotypes with stability (consistency) in performance for those characters which do not have any significant G X E interaction.

RESULTS

RESULTS

Forty eight clones were collected from the germplasm maintained at the Sugarcane Research Station, Thiruvalla and evaluated. The data collected on 21 characters from the plant crop and the first ratoon crop were analysed and used to study genetic variability, correlations and path analysis. Twelve clones were selected based on the plant crop studies at Thiruvalla and evaluated alongwith three popular clones viz. Co.997, Co.62174 and Co.62175 at three locations. The data collected on cane yield, sugar yield and their principal components were analysed and stability parameters were estimated and used for identifying stable genotypes. The results of the experiments are presented -

4.1 Plant crop

4.1.1 Genetic variability

The data collected from the plant crop of 48 clones evaluated at the Sugarcane Research Station, Thiruvalla were statistically analysed and the abstract of ANOVA is presented in Table 2. The clones showed highly significant differences for all the 21 characters except juiciness at 12th month which showed significant

Table 2. Analysis of variance for the plant crop

Sl. No.	Characters	Mean squares			F (Clones)
		Replications	Clones	Error	
1.	Germination count (45th day)	464.11	233.00	46.33	5.03**
2.	Shoot count (180th day)	3217.29	762.01	109.79	6.94**
3.	Number of late shoots (at harvest)	4.85	9.12	0.55	16.58**
4.	Number of millable canes per plot	441.26	613.55	127.53	4.81**
5.	Weight of cane	0.11	0.17	0.02	8.50**
6.	Length of cane	0.58	0.17	0.03	5.66**
7.	Number of internodes	27.69	21.46	3.75	5.72**
8.	Length of internode	0.74	6.59	0.95	6.93**
9.	Girth of cane	2.28	1.77	0.32	5.53**
10.	Cane yield per plot	2914.75	1030.18	143.09	7.19**
11.	Juiciness at 10th month	12985.30	4269.26	1958.41	2.18**
12.	Juiciness at 12th month	45086.33	3265.86	1895.51	1.72*
13.	Brix at 10th month	11.69	9.57	1.58	6.05**
14.	Brix at 12th month	11.32	11.39	3.18	3.58**
15.	Pol at 10th month	19.31	11.91	2.51	4.74**
16.	Pol at 12th month	20.31	16.82	5.04	3.34**
17.	Purity percentage at 10th month	72.39	30.25	14.19	2.13**
18.	Purity percentage at 12th month	87.75	53.71	24.96	2.15**
19.	C.C.S.Percentage at 10th month	13.82	7.38	1.69	4.36**
20.	C.C.S.Percentage at 12th month	15.04	10.34	3.30	3.13**
21.	Sugar yield per plot	2.95	17.85	3.97	4.49**

* Significant at 5 per cent probability level

** Significant at 1 per cent probability level

difference only at 5 per cent level of probability. The mean values of 21 characters alongwith their respective C.D. values are presented in Tables 3 and 4. The cane yield and sugar yield of 48 clones in the plant crop are presented in Figure 1. The variability for morphological characters such as number of internodes, length of internode and girth of cane is presented in Figure 2.

4.1.1.1 Germination count:

The clone CoA.7601 recorded the lowest germination count on the 45th day (27.3) and the clone CoC.771 had the highest count (67.3). The clones Co.658, Co.7717, Co.740, Co.785 and Co.453 were on par with CoC.771.

4.1.1.2 Shoot count:

The shoot count on the 180th day ranged from 46.7 (CoA.7601) to 115.7 (Co.449). The clones Co.658, Co.997, CoC.777, CoC.771, B-37172, Co.785 and Co.995 were on par with Co.449.

4.1.1.3 Number of late shoots:

The clones showed a range of 1.3(Co.785) to 63.0 (CoC.771) for number of late shoots at harvest. The number was comparatively higher in Co.658, Co.997,

Table 3 Mean values of cane yield and morphological characters in the plant crop

Sl No.	Name of clone	Germination count (45th day)	Shoot count (180th day)	Number of late shoots (at harvest)	Number of millable canes per plot	Weight of cane (kg)	Length of cane (m)	Number of internodes	Length of internode (cm)	Girth of cane (cm)	Cane yield per plot (kg)	Cane yield (t/ha)
C 1	CoC.774	48.7	98.3	37.0	73.3	1.48	2.43	20.5	13.0	8.58	83.6	103
" 2	F-1-2	42.0	74.7	28.7	68.0	1.36	2.75	24.8	11.1	6.91	72.8	90
" 3	T-67172	46.3	81.0	24.7	70.0	1.60	2.61	22.3	12.7	7.72	84.3	104
" 4	Co 658	57.3	109.3	43.3	99.3	1.42	2.65	24.3	11.5	7.41	117.4	145
" 5	Co.62174	33.3	49.3	3.7	46.7	1.43	2.34	22.4	10.7	8.61	58.5	72
" 6	Co 997	42.3	113.0	57.7	99.3	1.07	2.45	24.2	9.5	6.92	90.5	112
" 7	Co 6807	40.0	93.3	41.0	75.7	1.38	2.59	23.7	11.7	7.31	87.6	108
" 8	Co 1340	51.3	96.7	49.7	84.0	1.03	2.47	22.3	12.1	6.94	79.1	98
" 9	Co 1307	45.3	75.3	35.0	69.3	1.64	3.17	23.6	13.9	8.19	98.9	122
" 10	Co 7717	66.3	94.7	45.0	76.0	1.63	2.60	22.5	13.0	8.27	90.5	112
" 11	Co 62175	55.7	89.7	25.0	80.7	1.86	3.03	30.1	11.2	8.82	116.3	144
" 12	S-87	46.0	68.0	34.7	59.0	1.83	3.12	29.5	10.6	8.25	92.5	114
" 13	Co 419	53.7	84.0	14.3	73.7	1.73	2.83	25.1	12.2	8.32	108.2	133
" 14	CoC 779	49.7	90.0	7.3	84.0	1.60	2.76	24.9	12.5	7.99	107.8	131
" 15	Co 7219	44.7	78.7	10.3	66.3	1.36	2.84	22.8	12.9	7.45	76.1	94
" 16	Co.527	31.0	91.7	4.3	66.3	1.06	2.26	19.7	10.8	6.64	45.7	56
" 17	CoC. 777	46.3	99.7	38.7	81.7	1.47	2.90	24.5	12.7	7.93	118.2	146
" 18	S-105	54.3	77.0	24.3	66.7	1.44	2.76	26.7	10.7	8.01	82.5	102
" 19	S-33	37.0	94.0	34.3	87.3	1.21	2.70	22.3	12.3	6.49	73.6	91
" 20	MS.6847	43.0	70.3	20.0	54.3	1.99	2.98	22.8	14.3	9.46	87.9	108
" 21	Co.740	57.0	84.0	42.7	70.7	1.47	2.78	25.0	11.9	7.40	87.0	107
" 22	IC.225	51.0	96.3	29.7	76.3	1.44	2.76	26.2	11.1	7.26	93.7	116
" 23	Co 6907	47.7	82.3	23.3	79.0	1.56	2.86	25.8	12.4	7.73	89.1	110
" 24	Co 6304	51.0	77.3	27.0	58.7	1.48	2.64	23.4	12.5	7.47	67.9	83
" 25	CoA. 7602	42.3	87.0	1.7	79.3	1.58	2.84	19.5	15.4	7.96	86.6	107
" 26	S-99	43.0	96.3	3.0	82.7	1.61	2.71	23.7	13.2	8.09	101.6	125
" 27	CoC 775	47.7	86.0	43.0	77.0	1.25	2.87	20.5	15.8	7.18	76.9	95
" 28	KHS 3296	41.3	64.3	30.0	53.7	1.69	2.38	24.4	10.8	7.98	74.6	92
" 29	CoC.671	31.3	54.0	13.7	46.3	1.66	2.59	21.4	13.1	8.19	64.8	80
" 30	CoC 771	67.3	107.3	63.0	95.3	1.57	3.12	21.1	15.8	8.11	126.4	156
" 31	CoC 773	46.7	66.3	21.0	61.0	1.39	2.72	22.5	12.5	7.64	66.4	82
" 32	CoC 772	53.3	72.7	15.0	66.7	1.65	2.87	24.5	12.6	7.78	83.4	103
" 33	Co 7704	42.7	66.7	15.3	59.3	1.74	2.77	22.9	11.6	8.95	82.0	101
" 34	CoA.7601	27.3	46.7	23.7	45.0	1.71	2.74	22.7	12.9	7.48	57.4	71
" 35	Co 62198	47.3	74.7	34.3	61.0	1.41	2.42	20.1	13.4	6.84	58.9	73
" 36	Co 62101	30.3	62.7	38.0	62.7	1.45	2.65	22.5	12.5	7.49	75.5	93
" 37	Co.6806	39.0	95.7	8.3	78.3	1.09	2.47	20.5	12.7	6.17	57.9	71
" 38	CoC.778	51.0	83.7	11.0	60.7	1.57	2.58	21.7	12.0	7.49	83.7	103
" 39	B-37172	54.7	107.3	23.7	91.0	1.01	2.69	23.6	12.8	5.98	70.7	87
" 40	Co.1305	51.3	76.3	48.3	69.7	0.95	2.27	18.5	11.9	6.47	58.0	71
" 41	Co 785	58.7	100.0	1.3	90.7	1.45	3.14	22.4	16.7	7.27	97.9	121
" 42	Co.453	57.7	91.7	7.7	69.3	1.40	2.70	19.1	14.8	7.37	79.5	98
" 43	CoM.7114	55.0	86.3	9.0	68.3	1.63	3.16	27.2	10.5	7.87	101.6	125
" 44	S-77	51.3	89.0	15.0	71.3	1.36	2.24	21.1	11.2	7.97	87.8	108
" 45	Co.995	54.0	101.7	37.3	96.7	1.47	2.80	28.3	11.3	7.18	114.9	142
" 46	Co 449	50.7	115.7	50.0	102.3	0.90	2.47	17.9	12.8	5.65	68.2	84
" 47	CoM.7125	38.7	73.0	6.0	53.0	1.47	2.59	23.7	12.1	7.98	59.7	74
" 48	Co.527 M-10	52.7	96.7	5.7	82.0	1.36	2.39	19.4	12.0	7.27	69.2	85
	C D (5%)	11.0	16.93	1.20	18.25	0.254	0.305	3.13	0.49	0.911	19.34	23.9

Table 4 Mean values of sugar yield and its attributes in the plant crop

Sl. No.	Name of clone	Juiciness (ml)		Brix(%)		Pol (%)		Purity (%)		C C.S (%)		Sugar yield	
		at 10th month	at 12th month	at 10th month	at 12th month	at 10th month	at 12th month	at 10th month	at 12th month	at 10th month	at 12th month	per plot (kg)	(t/ha)
C 1	CoC.774	476	444	17.5	17.7	14.8	14.6	84.7	82.3	10.1	9.7	8.13	10 04
" 2	F-1-2	418	433	18.7	19.0	16.7	17.2	89.3	90.6	11.6	12.1	8.87	10.95
" 3	T-67172	477	470	14.9	14.1	12.3	11.5	82 6	81.0	8.2	7.6	6.54	8.07
" 4	Co.658	446	443	16.5	17.4	14.4	15.4	86 9	87.9	9.9	10.7	12.53	15.47
" 5	Co.62174	473	452	17.2	17.2	14.8	14.9	85 9	86 1	10.1	10.2	6.30	7.78
" 6	Co.997	483	425	19.5	20 3	17.9	18.6	91.7	91 5	12.6	12.8	11.33	13.99
" 7	Co.6807	432	451	15.3	14.6	12.9	11.2	84.3	75.6	8.8	7 2	5.61	6.92
" 8	Co.1340	439	423	15.8	15.6	12.9	11.8	82.0	75.2	8.6	7.5	6.01	7.42
" 9	Co.1307	365	453	13.6	15.2	9.9	12.9	72.4	84.5	6.1	8.7	8.83	10.91
" 10	Co.7717	470	459	15.7	14.8	12.9	12.0	82.0	80 6	8 6	7 9	7.24	8.94
" 11	Co.62175	553	509	16.7	18 5	14.8	16.7	88.7	90.4	10.3	11.7	13.58	16 76
" 12	S-87	474	473	19.5	19.7	15.1	17.6	78.1	89.3	9.8	12.2	11.32	13.97
" 13	Co.419	458	482	14.3	17 8	11.6	15.5	81.0	87.1	7 7	10.7	11.36	14.02
" 14	CoC.779	541	490	13.3	14.7	10.1	11.5	76.1	78.5	6.5	7.5	7.98	9.85
" 15	Co.7219	439	424	18.0	18.7	16.1	16.0	89.5	85.6	11.2	10.9	8 30	10.25
" 16	Co.527	475	454	15.0	15.3	12.4	12.5	84 7	81.6	8.3	8.4	3.82	4.71
" 17	CoC.777	491	468	13.6	17.2	10.9	14.7	80.1	85.2	7.2	10.0	11 87	14.65
" 18	S-105	457	458	17.2	16.3	15.0	13.4	87.3	81.7	10.3	8.9	7.44	9.19
" 19	S-38	466	403	17.5	18.2	14.3	16.3	82.1	89.1	9.6	11 3	8.28	10.22
" 20	MS.6847	558	439	15.9	12.2	13.1	8.5	82.3	66.0	8.8	5.2	4.29	5.30
" 21	Co.740	432	434	17.5	19.2	15.5	15.5	88.7	80 6	10 7	10.2	8.49	10.48
" 22	IC.225	378	438	17.6	16.6	15.1	14.7	85.5	87.9	10.2	10.2	9.77	12.06
" 23	Co.6907	461	470	17.2	19.9	15.0	18.4	86.0	92.7	10.3	13.0	11.53	14.23
" 24	Co.6304	461	430	13.9	15.0	11.3	11.9	81.2	80.0	7.4	7.8	5.34	6.59
" 25	CoA.7602	442	459	18.2	17.0	13.7	14.2	86.5	83.4	10.8	9.5	8.23	10.16
" 26	S-99	474	441	18.5	19.2	16.1	16.8	87.3	87.8	11.1	11.6	11.52	14.22
" 27	CoC.775	442	377	16.2	16.6	13.5	14.3	84.1	85.0	9.1	9.7	7.34	9.06
" 28	KHS-3296	509	446	16.4	18.5	14.8	16 9	90.3	91 ?	10.3	11 9	8.91	10 99
" 29	CoC.671	459	475	19.3	19.0	17.6	17.8	91.1	93.8	12.3	12.7	8.21	10.13
" 30	CoC.771	491	378	16.4	17.1	12.3	14.3	86 9	82.5	9.8	9.6	12.02	14.84
" 31	CoC.773	459	415	18.7	17.3	16.5	15.1	88.1	87 3	11.4	10.4	6.83	8.43
" 32	CoC.772	447	408	15.6	16.0	13.0	13.5	83.1	84.0	8.7	9.1	7.57	9.34
" 33	Co.7704	491	433	19.9	20.2	18.1	18.6	90.8	92.2	12.6	13.1	10.62	13.11
" 34	CoA.7601	480	462	17.6	15.3	16.0	13.0	91.0	84.9	10.8	8.9	5.16	6.37
" 35	Co.62198	405	409	16.6	16.6	14.5	14.4	87.7	86.3	10.0	9.8	5.75	7.10
" 36	Co.62101	462	447	14.8	15.5	12.5	12.1	84.4	75.3	8.5	7.9	6.09	7.52
" 37	Co.6806	464	408	19.6	18.0	17.2	15.1	87.5	84.2	11.9	10.2	7.98	9.85
" 38	CoC.778	490	462	13.5	13.7	10.6	11.0	78.6	79.5	6.9	7.2	5.78	7.13
" 39	B-37172	419	434	17 7	19.5	16.0	17.6	90.5	90.3	11.2	12 2	8.71	10.75
" 40	Co.1305	448	387	15.7	17 1	13.7	15.0	87.4	87.9	9.4	10.4	6.02	7.43
" 41	Co.785	409	429	16.6	18.7	13.5	15 7	82.0	84.2	9.0	10 6	10.36	12.79
" 42	Co.453	427	426	13 2	13.5	11.1	10 3	84.3	75.1	7.3	6.6	5.31	6.55
" 43	CoM.7114	464	383	16.4	16.0	13.6	13.2	83.1	82.3	9.1	8.9	8.76	10.81
" 44	S-77	491	377	16.1	17.1	13.8	14.7	85.0	86.1	9.4	10.0	8.88	10.96
" 45	Co.995	421	458	17.3	17.9	14.5	15 5	83.5	86.4	9.7	10.6	12.15	14.99
" 46	Co.449	429	355	14.8	14.6	12.2	11.4	82.1	78.5	8.1	7.4	5 07	6.26
" 47	CoM.7125	462	454	17.7	18.9	15.0	16.5	84.6	86.9	10.2	11.3	6.74	8.32
" 48	Co-527M-10	483	383	17.1	18.1	15.0	15.7	84.5	86.3	10.3	10.7	7.42	9.16
	C.D (5%)	71.5	70.4	2 03	2 88	2.56	3.63	6.09	8.08	2 10	2.94	3.224	3 980

Fig.1. Cane yield and sugar yield in the plant crop.

No.	Clones
C.1	CoC.774
" 2	F-1-2
" 3	T-67172
" 4	Co.658
" 5	Co.62174
" 6	Co.997
" 7	Co.6807
" 8	Co.1340
" 9	Co.1307
" 10	Co.7717
" 11	Co.62175
" 12	S-87
" 13	Co.419
" 14	CoC.779
" 15	Co.7219
" 16	Co.527
C.17	CoC.777
" 18	S-105
" 19	S-33
" 20	MS.6847
" 21	Co.740
" 22	IC.225
" 23	Co.6907
" 24	Co.6304
" 25	CoA.7602
" 26	S-99
" 27	CoC.775
" 28	KHS.3296
" 29	CoC.671
" 30	CoC.771
" 31	CoC.773
" 32	CoC.772
C. 33	Co.7704
" 34	CoA.7601
" 35	Co.62198
" 36	Co.62101
" 37	Co.6806
" 38	CoC.778
" 39	B-37172
" 40	Co.1305
" 41	Co.785
" 42	Co.453
" 43	CoM.7114
" 44	S-77
" 45	Co.995
" 46	Co.449
" 47	CoM.7125
" 48	Co.527-M-10

FIG 1 CANE YIELD AND SUGAR YIELD IN THE PLANT CROP

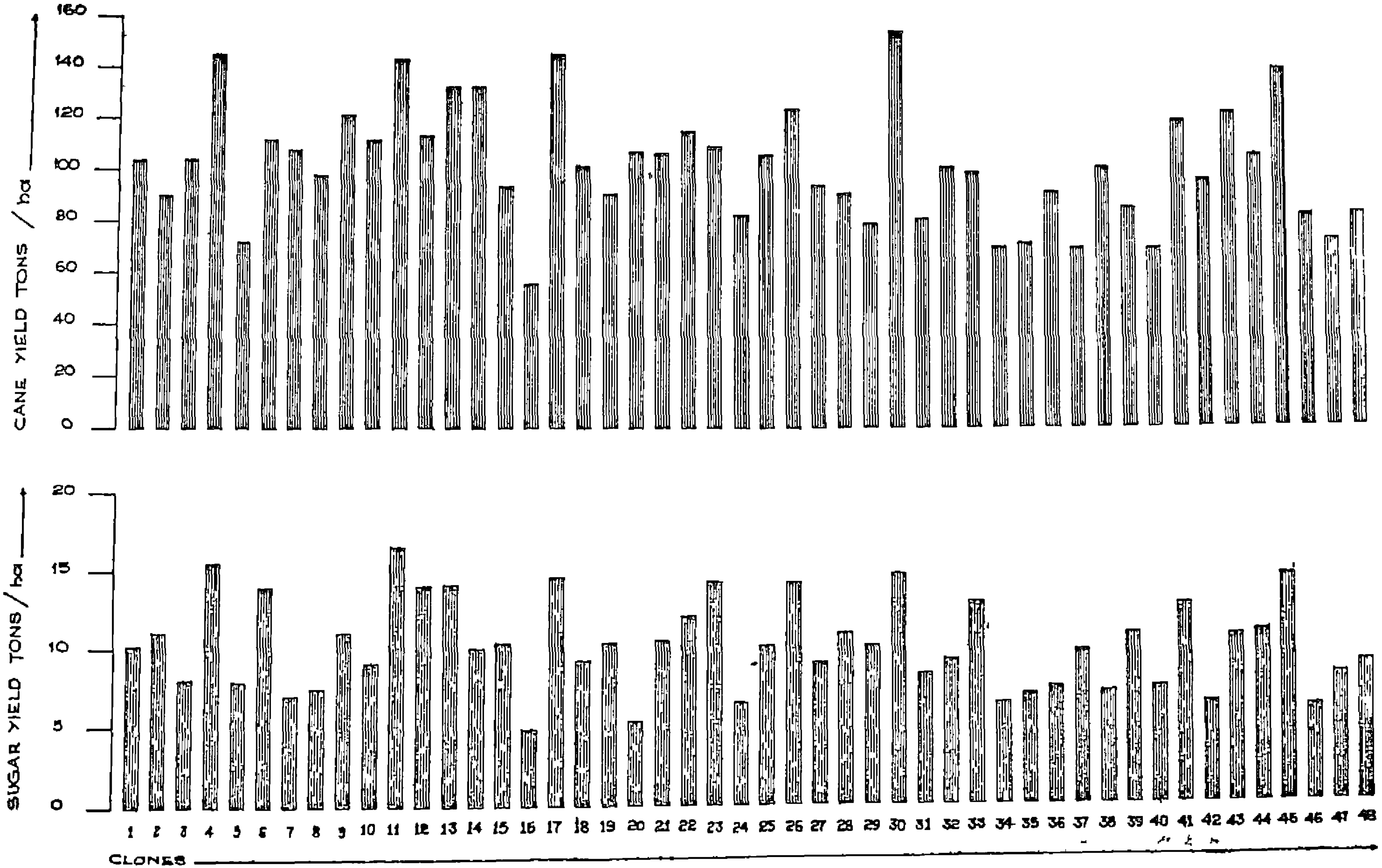

Fig.2. Variability for morphological characters in the plant crop.

No.	Clones
C.1	CoC.774
" 2	F-1-2
" 3	T-67172
" 4	Co.658
" 5	Co.62174
" 6	Co.997
" 7	Co.6807
" 8	Co.1340
" 9	Co.1307
" 10	Co.7717
" 11	Co.62175
" 12	S-87
" 13	Co.419
" 14	CoC.779
" 15	Co.7219
" 16	Co.527
C.17	CoC.777
" 18	S-105
" 19	S-33
" 20	MS.6847
" 21	Co.740
" 22	IC.225
" 23	Co.6907
" 24	Co.6304
" 25	CoA.7602
" 26	S-99
" 27	CoC.775
" 28	KHS.3296
" 29	CoC.671
" 30	CoC.771
" 31	CoC.773
" 32	CoC.772
C.33	Co.7704
" 34	CoA.7601
" 35	Co.62198
" 36	Co.62101
" 37	Co.6806
" 38	CoC.778
" 39	B-37172
" 40	Co.1305
" 41	Co.785
" 42	Co.453
" 43	CoM.7114
" 44	S-77
" 45	Co.995
" 46	Co.449
" 47	CoM.7125
" 48	Co.527-M-10

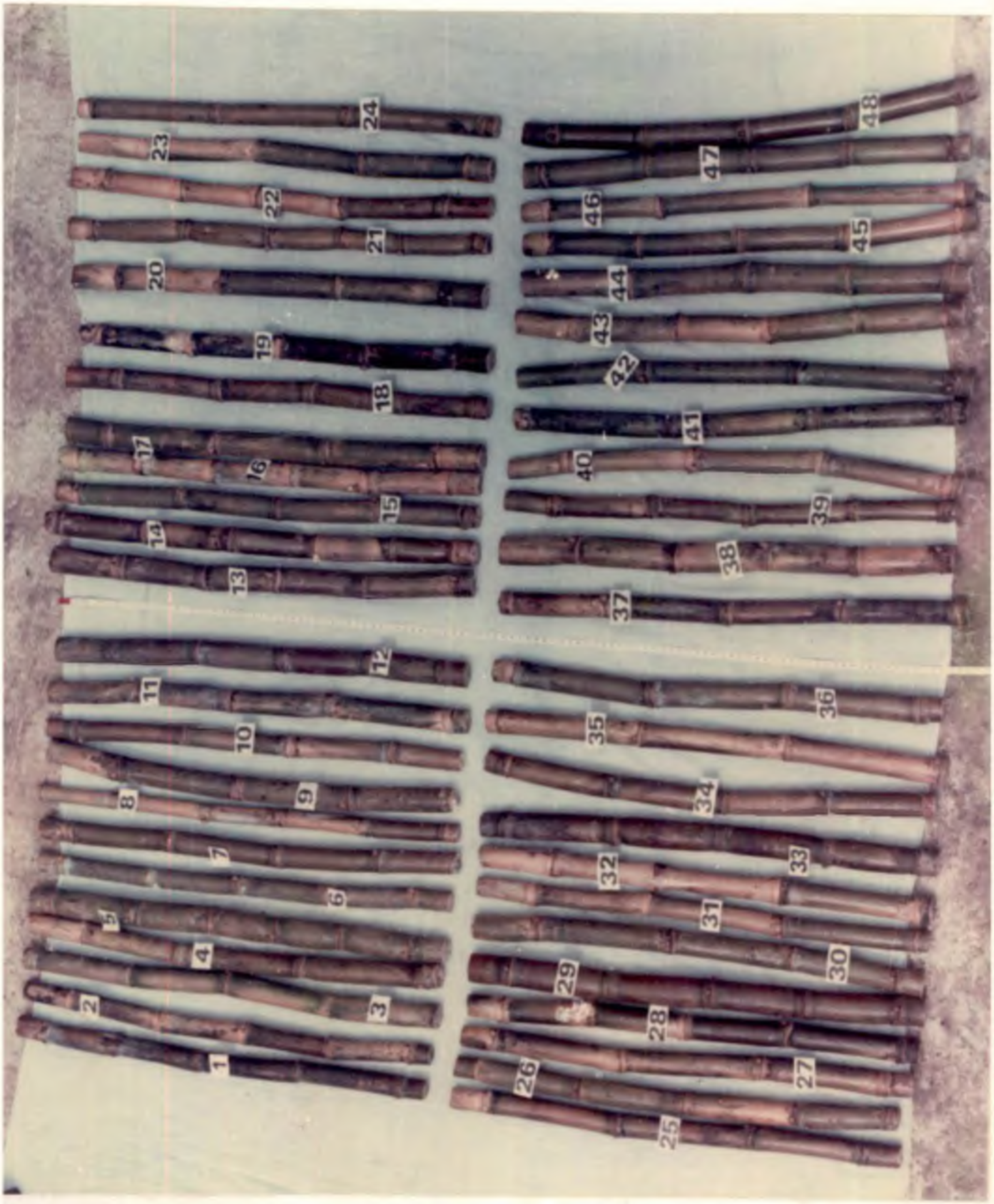
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Figure 2

Co.6807, Co.1340, Co.7717, Co.740, CoC.775, Co.1305 and Co.449.

4.1.1.4 Number of millable canes:

The number of millable canes per plot ranged from 45.0 (CoA.7601) to 102.3 (Co.449). The clones Co.658, Co.997, S-33, B-37172, Co.785, CoC.771 and Co.995 were on par with Co.449.

4.1.1.5 Weight of cane:

The weight of cane ranged from 0.90 kg (Co.449) to 1.99 kg (MS.6847). The clones Co.62175, S-87, and Co.7704 were on par with MS.6847.

4.1.1.6 Length of cane:

The length of cane ranged from 2.24 m (S-77) to 3.17 m (Co.1307). Nine clones were on par with Co.1307 in respect of length of cane. They include Co.62175, S-87, CoC.777, MS.6847, CoC.775, CoC.771, CoC.772, Co.785 and CoM.7114.

4.1.1.7 Number of internodes:

The number of internodes ranged from 17.9 (Co.449) to 30.1 (Co.62175). The clones S-87, CoM.7114 and Co.995

were on par with Co.62175.

4.1.1.8 Length of internode:

The length of internode ranged from 9.5 cm (Co.997) to 16.7 cm (Co.785). No clone was on par with Co.785 in respect of this character. The clones Co.1307, MS.6847, CoA.7602, CoC.775, CoC.771 and Co.453 had comparatively longer internodes.

4.1.1.9 Girth of cane:

The girth of cane ranged from 5.65 cm (Co.449) to 9.46 cm (MS.6847). The clones CoC.774, Co.62174, Co.62175 and Co.7704 were on par with MS.6847.

4.1.1.10 Yield of cane:

The cane yield per plot ranged from 45.7 kg (Co.527) to 126.4 kg (CoC.771). The clones Co.62175, Co.419, Co.658, CoC.779, CoC.777 and Co.995 were on par with CoC.771.

4.1.1.11 Juiciness at 10th month:

The juiciness at 10th month ranged from 365 ml (Co.1307) to 558 ml (MS.6847). The clones Co.62175, CoC.779, CoC.777, KHS.3296, CoC.771, Co.7704, CoC.778 and S-77 were on par with MS.6847.

4.1.1.12 Juiciness at 12th month:

The juiciness at 12th month ranged from 355 ml (Co.449) to 509 ml (Co.62175). Twenty four clones were on par with Co.62175 in respect of juiciness at 12th month.

4.1.1.13 Brix at 10th month:

The brix at 10th month ranged from 13.2(Co.453) to 19.9 (Co. 7704). Nine clones viz. F-1-2, Co.997, S-87, Co.7219, CoA.7602, S-99, CoC.671, CoC.773 and Co.6806 were on par with Co.7704.

4.1.1.14 Brix at 12th month:

The brix at 12th month ranged from 12.2(MS.6847) to 20.3 (Co.997). Nineteen clones were on par with Co.997 in respect of brix at 12th month.

4.1.1.15 Pol percentage at 10th month:

The pol percentage at 10th month ranged from 9.9 (Co.1307) to 18.1 (Co.7704). Eleven clones viz. F-1-2, Co.997, Co.7219, Co.740, CoA.7602, S-99, CoC.671, CoC.773, CoA.7601, Co.6806 and E-37172 were on par with Co.7704.

4.1.1.16 Pol percentage at 12th month:

The pol percentage at 12th month ranged from 8.5

(MS.6847) to 18.6 (Co.997 and Co.7704). Twenty clones were on par with Co.997 and Co.7704.

4.1.1.17 Purity percentage at 10th month:

The purity percentage at 10th month ranged from 72.4 (Co.1307) to 91.7 (Co.997). Twenty clones were on par with Co.997 in respect of this character.

4.1.1.18 Purity percentage at 12th month:

The purity percentage at 12th month ranged from 66.0 (MS.6847) to 93.8 (CoC.671). Twenty one clones were on par with CoC.671 in respect of this character.

4.1.1.19 C.C.S. Percentage at 10th month:

The C.C.S. Percentage at 10th month ranged from 6.1 (Co.1307) to 12.6 (Co.997 and Co.7704). Eleven clones viz. F-1-2, Co.997, Co.7219, Co.740, CoA.7602, S-99 CoC.671, CoC.773, CoA.7601, Co.6806 and B-37172 were on par with Co.7704 in respect of this character.

4.1.1.20 C.C.S.Percentage at 12th month:

The C.C.S.Percentage at 12th month ranged from 5.2 (MS.6847) to 13.1 (Co.7704). Twenty three clones were on par with Co.7704 in respect of C.C.S.percentage at 12th month.

4.1.1.21 Yield of sugar:

The sugar yield per plot ranged from 3.8 kg (Co.527) to 13.58 kg (Co.62175). Eleven clones viz. Co.658, Co.997, S-87, Co.419, CoC.777, Co.6907, S-99, CoC.771, Co.7704, Co.785 and Co.995 were on par with Co.62175 in respect of sugar yield per plot.

4.1.2 Genetic parameters

The mean, S.E. of mean, range and the genetic parameters such as genotypic and phenotypic coefficients of variation (G.C.V. and P.C.V.), heritability (H^2) and genetic advance (G.A.) for the best 5 per cent of the values as percentage of mean are presented in Table 5. The histogram representing the genetic parameters (G.C.V, H^2 and G.A) in the plant crop are presented in Figure 3.

The G.C.V. was highest for number of late shoots at harvest (35.5) followed by sugar yield per plot (26.2) and cane yield per plot (20.6). The high genotypic coefficients of variation recorded for these characters indicate the presence of large amount of variability in respect of the above characters. The purity percentage at 10th month had the lowest G.C.V. (3.4) followed by purity percentage at 12th month (4.6). The characters

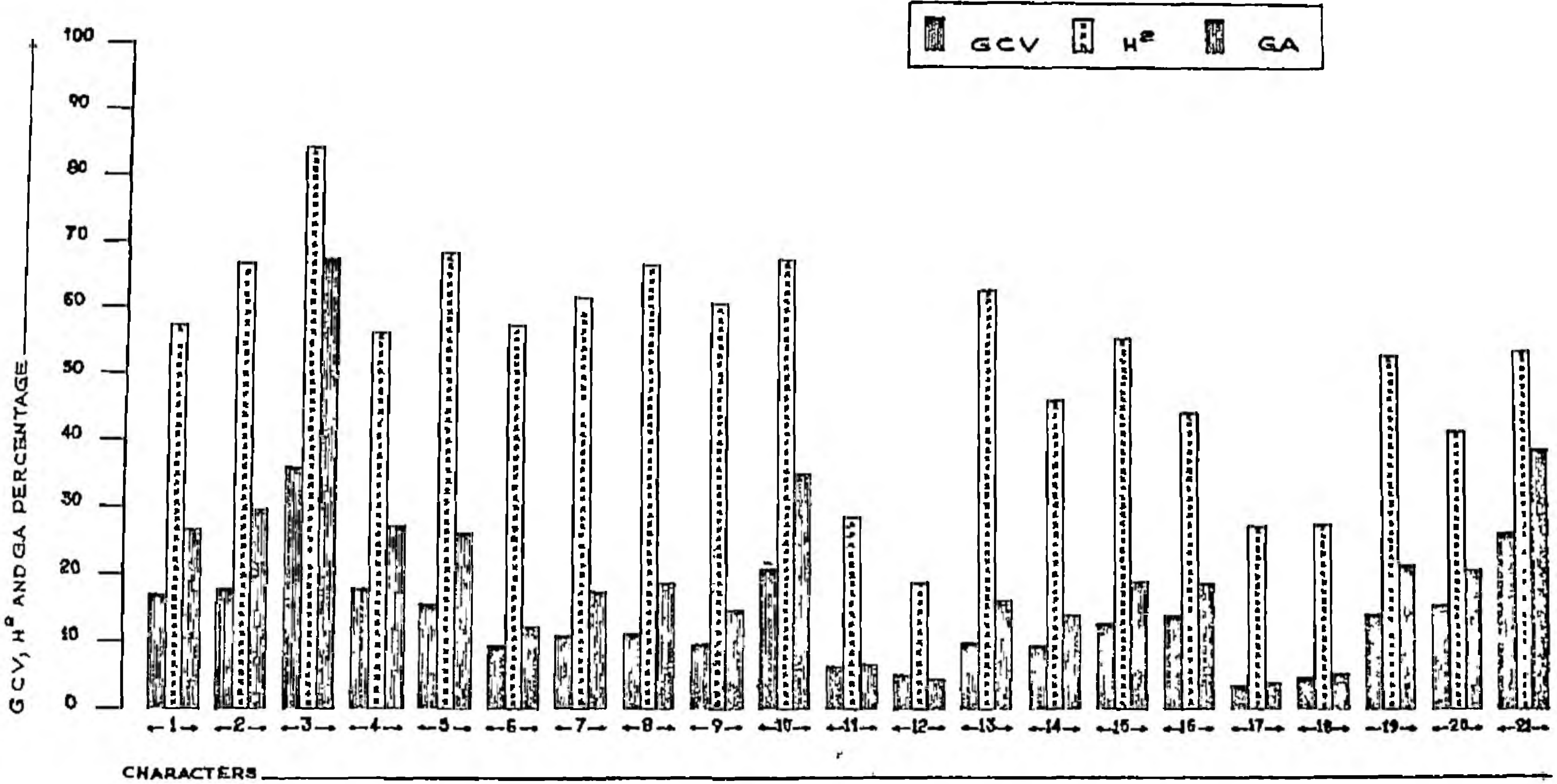
Table 5. Estimates of genetic parameters in the plant crop

Sl. No.	Characters	Mean	S.E.	Range	Coefficients of variation		Herita-bility	Genetic advance
					Geno-typic	Pheno-typic		
1.	Germination count (45th day)	47.1	3.93	27.3 - 67.3	16.7	22.1	57.3	26.1
2.	Shoot count (180th day)	84.8	6.04	46.7 - 115.7	17.4	21.3	66.4	29.2
3.	Number of late shoots (at harvest)	4.8	0.43	1.3 - 63.0	35.5	38.8	83.7	66.9
4.	Number of millable canes per plot	72.7	6.52	43.7 - 102.3	17.5	28.4	56.0	27.0
5.	Weight of cane (kg)	1.5	0.09	0.9 - 1.9	15.1	18.2	68.2	25.6
6.	Length of cane (m)	2.7	0.11	2.2 - 3.2	8.9	10.6	56.9	12.4
7.	Number of internodes	23.1	1.12	17.9 - 30.1	10.5	13.4	61.2	17.0
8.	Length of internode(cm)	12.4	0.18	9.5 - 16.7	11.0	13.6	66.3	18.5
9.	Girth of cane (cm)	7.6	0.33	5.6 - 9.5	9.2	11.8	60.5	14.7
10.	Cane ~~of~~ yield per plot (kg)	83.6	6.91	45.7 - 126.4	20.6	25.0	67.4	34.8
11.	Juiciness at 10th month (ml)	460.2	25.55	365.0 - 558.0	6.0	11.3	28.2	6.6
12.	Juiciness at 12th month (ml)	436.1	25.14	355.0 - 508.0	4.9	11.1	19.4	4.4
13.	Brix at 10th month(%)	16.6	0.73	13.2 - 19.9	9.8	12.4	62.7	16.0
14.	Brix at 12th month(%)	17.0	1.03	12.2 - 20.3	9.7	14.3	46.3	13.6
15.	Pol at 10th month (%)	14.1	0.91	9.9 - 18.1	12.5	16.8	55.5	19.2
16.	Pol at 12th month (%)	14.5	2.36	8.5 - 18.6	13.7	20.7	43.8	18.6
17.	Purity at 10th month(%)	67.5	2.17	72.4 - 91.7	3.4	6.5	27.4	3.7
18.	Purity at 12th month(%)	67.3	2.88	66.0 - 93.8	4.6	8.7	27.7	5.0
19.	C.C.S. at 10th month(%)	9.6	0.75	6.1 - 12.6	14.3	19.7	52.9	21.5
20.	C.C.S. at 12th month(%)	9.8	1.05	5.2 - 13.1	15.5	24.1	41.6	20.7
21.	Sugar yield per plot (kg)	8.2	1.15	3.8 - 13.6	26.2	35.7	53.8	39.6

Fig.3. Genetic parameters in the plant crop.

No.	Characters
1	Germination count (45th day)
2	Shoot count (180th day)
3	Number of late shoots (at harvest)
4	Number of millable canes per plot
5	Weight of cane
6	Length of cane
7	Number of internodes
8	Length of internode
9	Girth of cane
10	Cane yield per plot
11	Juiciness at 10th month
12	Juiciness at 12th month
13	Brix at 10th month
14	Brix at 12th month
15	Pol at 10th month
16	Pol at 12th month
17	Purity at 10th month
18	Purity at 12th month
19	C.C.S at 10th month
20	C.C.S at 12th month
21	Sugar yield per plot

FIG 3 GENETIC PARAMETERS IN THE PLANT CROP



like germination count on the 45th day, shoot count on the 180th day, number of millable canes per plot, cane weight and C.C.S. percentage at 12th month recorded relatively high genotypic coefficients of variation.

The phenotypic coefficient of variation was also highest for number of late shoots at harvest (38.8) followed by sugar yield per plot (35.7) and number of millable canes per plot (28.4). The purity percentage at 10th month had the lowest P.C.V. (6.5) followed by purity percentage at 12th month (8.7).

The number of late shoots at harvest recorded the highest heritability (83.7) followed by cane weight (68.2) and cane yield per plot (67.4). Juiciness at 12th month recorded the lowest heritability (19.4) followed by purity percentage at 10th month (27.4) and purity percentage at 12th month (27.7). Low heritability values recorded for juiciness at 12th month and purity percentage at 10th and 12th months indicate the larger influence of the environment in the expression of these characters.

The genetic advance under selection was also maximum for number of late shoots at harvest (66.9) followed by sugar yield per plot (39.6) and cane yield per plot (34.8). Purity percentage at 10th month recorded the minimum genetic advance (3.7) followed by juiciness at 12th month (4.4) and purity percentage at 12th month (5.0).

Moderate to high heritability coupled with high genetic advance were recorded for characters like number of late shoots at harvest, sugar yield and cane yield per plot, shoot count on the 180th day, number of millable canes per plot, germination count on the 45th day and weight of cane. This indicates that selection based on the above characters will be effective in improving cane and sugar yields. Moderate to high heritability and low genetic advance were recorded for characters like length of cane, girth of cane, brix at 10th month, number of internodes and length of internode. Both heritability and genetic advance were low for juiciness at 10th and 12th months and purity percentage at 10th and 12th months.

4.1.3 Correlation

The genotypic and phenotypic correlation coefficients of cane yield, sugar yield and their inter relationship with other characters in the plant crop are presented in Table 6.

Table 6. Genotypic and phenotypic correlation coefficients of cane yield,sugar yield and other characters in the plant crop

S. No.	Characters	Germination count (45th day)	Shoot count (180th day)	Number of late shoots(at harvest)	Number of millable canes per plot	Weight of cane	Length of cane	Number of inter-nodes	Length of inter-node	Girth of cane	Cane yield per plot	Juiciness		Brix		Pol		Purity		C C.S		Sugar yield per plot
												at 10th month	at 12th month	at 10th month	at 12th month	at 10th month	at 12th month	at 10th month	at 12th month	at 10th month	at 12th month	
1.	Germination count (45th day)	-	0.51**	0.21	0.50**	0.10	0.33	0.15	0.21	0.07	0.59**	-0.16	-0.31	-0.31	-0.07	-0.20	-0.08	-0.23	-0.10	-0.28	-0.06	0.43*
2.	Shoot count (180th day)	0.53**	-	0.24	1.00**	-0.54**	-0.10	-0.13	0.10	-0.45**	0.40**	-0.15**	-0.30	-0.20	-0.03	-0.13	-0.06	-0.25	-0.20	-0.21	-0.10	0.28
3.	Number of late shoots(at harvest)	0.15	0.23**	-	0.33	-0.21	0.01	0.12	-0.12	-0.20	0.22	-0.17	-0.28	-0.08	-0.01	-0.07	-0.01	-0.04	-0.02	-0.06	-0.02	0.17
4.	Number of millable canes per plot	0.46**	0.81**	0.27	-	-0.51**	0.07	-0.02	0.15	-0.47**	0.57**	-0.25	-0.39	-0.11	0.15	-0.05	0.15	-0.25	0.07	-0.14	0.12	0.52**
5.	Weight of cane	0.07	-0.34**	-0.16*	0.33**	-	0.58**	0.52**	0.14	1.00**	0.48**	0.62*	0.90*	-0.02	-0.17	-0.01	-0.08	-0.31	-0.06	-0.13	-0.04	0.33
6.	Length of cane	0.32**	0.08	0.01	0.13	0.48**	-	0.48**	0.40*	0.40*	0.67**	-0.12	0.32	-0.02	0.05	-0.16	0.04	-0.48	-0.01	-0.20	0.04	0.54**
7.	Number of internodes	0.17*	-0.01	0.11	0.04	0.46**	0.57**	-	-0.56**	0.41*	0.56**	0.25	0.94	0.16	0.27	0.22	0.36	-0.15	0.37	0.05	0.39	0.68**
8.	Length of internode	0.17*	0.08	-0.13	0.10	0.07	0.27**	-0.36**	-	0.04	0.13	-0.24	-0.24	-0.27	-0.37	-0.26	-0.41	-0.25	-0.47	-0.26	-0.41	-0.16
9.	Girth of cane	0.04	-0.35**	-0.15	-0.37**	0.65**	0.23**	0.26**	0.08	-	0.47**	0.73**	0.77	0.10	-0.02	0.18	0.06	-0.22	-0.01	-0.07	0.01	0.35
10.	Cane yield per plot	0.54**	0.50**	0.21*	0.50**	0.38**	0.55**	0.51**	0.10	0.31**	-	0.29	0.49	-0.27	0.05	-0.32	0.04	-0.50	-0.01	-0.34	0.03	0.81**
11.	Juiciness at 10th month	-0.03	-0.13	-0.09	-0.10	0.22**	-0.07	0.03	-0.09	0.31**	0.03	-	0.37	0.10	-0.18	0.39	-0.04	0.21	-0.12	0.14	-0.04	0.20
12.	Juiciness at 12th month	-0.13	-0.28**	-0.10	-0.18*	0.32**	0.07	0.29**	-0.13	0.29**	0.09	0.19*	-	-0.03	0.03	0.23	0.20	-0.13	0.26	-0.77	0.21	0.55
13.	Brix at 10th month	-0.17*	-0.03	-0.05	-0.01	-0.02	-0.001	0.14	-0.16*	0.02	-0.10	-0.14	-0.10	-	0.89**	1.00**	0.90**	0.89**	0.85**	0.99**	0.90**	0.31
14.	Brix at 12th month	-0.05	0.08	-0.05	0.11	-0.03	0.04	0.23**	-0.12	-0.02	0.06	-0.08	-0.05	0.56**	-	0.92**	0.99**	0.86**	0.93**	0.91**	0.98**	0.61**
15.	Pol at 10th month	-0.17*	-0.06	-0.02	0.01	-0.02	-0.05	0.10	-0.17*	0.01	-0.13	-0.11	-0.11	0.93**	0.54**	-	0.94**	0.95**	0.92**	1.00**	0.94**	0.28
16	Pol at 12th month	-0.07	0.03	-0.04	0.06	0.01	0.03	0.24**	-0.15	-0.02	0.04	-0.08	-0.01	0.54**	0.97**	0.52**	-	0.91*	0.97**	0.93**	0.99**	0.61**
17.	Purity at 10th month	-0.15	-0.06	-0.03	0.01	-0.02	-0.14	0.01	-0.17*	-0.05	-0.16*	-0.02	-0.10	0.56**	0.34**	0.81**	0.34**	-	0.97	0.93**	0.92*	0.62
18.	Purity at 12th month	-0.08	-0.04	-0.01	-0.03	0.05	-0.01	0.19*	-0.17*	-0.05	-0.01	-0.09	0.03	0.39**	0.76**	0.38**	0.89**	0.24**	-	0.92	0.98	0.56**
19	C.C.S. at 10th month	-0.18*	-0.06	-0.01	0.01	-0.01	-0.06	0.09	-0.18*	-0.01	-0.14	-0.09	-0.001	0.88**	0.52**	0.99**	0.50**	0.87**	0.38**	-	0.94**	0.27
20.	C C.S. at 12th month	-0.08	0.01	-0.04	0.04	0.03	0.03	0.23**	-0.15	-0.02	0.03	-0.07	-0.002	0.52**	0.94**	0.51**	0.99**	0.33**	0.91**	0.48**	-	0.61**
21.	Sugar yield per plot	0.31**	0.36**	0.12	0.38**	0.27**	0.40**	0.52**	-0.05	0.19*	0.71**	-0.05	0.06	0.27**	0.60**	0.24**	0.71**	0.11	0.64**	0.23**	0.69**	-

Values above the diagonal are genotypic correlation coefficients
Values below the diagonal are phenotypic correlation coefficients

* Significant at 5 per cent probability level
** Significant at 1 per cent probability level

4.1.3.1 Correlation of cane yield with morphological and quality characters

Cane yield recorded highly significant and positive genotypic correlations with germination count on the 45th day, shoot count on the 180th day, number of millable canes per plot, weight of cane, length of cane, number of internodes and girth of cane indicating that improvement in any one or more of these characters will result in a simultaneous increase in cane yield. The number of late shoots at harvest, length of internode, juiciness at 10th and 12th months, brix, pol and C.C.S. percentage at 12th month had non-significant but positive genotypic correlations with cane yield, whereas brix and pol percentage at 10th month, purity percentage at 10th and 12th months and C.C.S. percentage at 10th month had non-significant but negative correlations. The sugar yield per plot also recorded highly significant positive genotypic correlations with cane yield per plot.

The phenotypic correlation coefficients of cane yield per plot was significant and positive with germination count on the 45th day, shoot count on the 180th day, number of late shoots at harvest, number of millable canes per plot, cane weight, length of cane, number of internodes, girth of cane and sugar yield per plot whereas it was positive but non-significant with length of internode, juiciness at 10th and 12th months, brix, pol and C.C.S. percentages at 12th month. The phenotypic correlation coefficients of cane yield per plot with brix at 10th month, pol percentage at 10th month, purity percentage at 12th month and C.C.S. percentage at 10th month were negative but non-significant. The purity percentage at 10th month recorded significant negative correlation with cane yield per plot.

4.1.3.2 Correlation of sugar yield with morphological and quality characters

Sugar yield per plot recorded significant positive genotypic correlation coefficients with germination count on the 45th day, number of millable canes per plot, length of cane, number of internodes, cane yield per plot and brix, pol, purity and C.C.S. percentages at 12th month. The sugar yield per plot had positive but non-significant genotypic correlations with shoot count on the 180th day, number of late shoots at harvest, cane weight, girth of cane, juiciness at 10th and 12th months, brix, pol, purity and C.C.S. percentages at 10th month whereas it had non-significant and negative correlations with length of internode.

At the phenotypic level, sugar yield per plot recorded significant positive correlations with all the components except number of late shoots at harvest, juiciness at 12th month and purity percentage at 10th month. The phenotypic correlation coefficient of length of internode and juiciness at 10th month were non-significant and negative with sugar yield per plot.

4.1.3.3 Correlation among cane yield and sugar yield components

The germination count on the 45th day recorded highly significant and positive genotypic correlations with shoot count on the 180th day and number of millable canes per plot, whereas it had non-significant positive correlations with number of late shoots at harvest, cane weight, length of cane, number of internodes, length of internode and girth of cane. The genotypic correlation coefficients of germination count on the 45th day with the quality components such as juiciness, brix, pol, purity and C.C.S. percentages at 10th and 12th months were negative but non-significant.

At the phenotypic level, germination count on the 45th day recorded significant positive correlations with shoot count on the 180th day, number of millable canes per plot, length of cane, number of internodes and length of internode. The number of late shoots at harvest, cane weight and girth of cane recorded positive but non-significant correlations with this character. All the quality components except brix, pol and C.C.S. percentage at 10th month recorded non-significant and negative phenotypic correlations with germination count on the 45th day.

The shoot count on the 180th day recorded highly significant positive genotypic correlations with number of millable canes per plot only. The genotypic correlations of this character was positive but non-significant with number of late shoots at harvest and length of internode, whereas it was non-significant and negative with length of cane, number of internodes and all the quality components except juiciness at 10th month. The characters like cane weight, girth of cane and juiciness at 10th month recorded highly significant but negative genotypic correlations with shoot count on the 180th day.

The phenotypic correlations of shoot count on the 180th day was highly significant and positive with number of late shoots at harvest and number of millable canes per plot, whereas it was positive but non-significant with length of cane, length of internode, brix, pol and C.C.S. percentages at 12th month. Cane weight, girth of cane and juiciness at 12th month recorded highly significant but negative phenotypic correlations with shoot count on the 180th day, whereas juiciness, brix, pol and C.C.S. percentage at 10th month and purity percentage at 10th and 12th months recorded non-significant but negative phenotypic correlations.

The number of late shoots at harvest recorded non-significant but positive genotypic correlations with number of millable canes per plot, length of cane and number of internodes, whereas this character had non-significant negative correlations with cane weight, length of internode, girth of cane and all the quality characters such as juiciness, brix, pol, purity and C.C.S. percentage at 10th and 12th months.

The phenotypic correlations of number of late shoots at harvest were non-significant but positive with number of millable canes per plot, length of cane, number of internodes and purity percentage at 10th month. Cane weight had significant negative phenotypic correlation with number of late shoots at harvest. The length of internode, girth of cane, juiciness, brix, pol and C.C.S. percentage at 10th and 12th months and purity percentage at 12th month recorded non-significant negative phenotypic correlations with number of late shoots at harvest.

The number of millable canes per plot recorded non-significant and positive genotypic correlations with length of cane, length of internode, brix, pol, purity and C.C.S. percentages at 12th month. The genotypic correlations of number of millable canes per plot were highly significant but negative with cane weight and girth of cane, whereas the other components such as number of internodes, juiciness at 10th and 12th months, brix, pol, purity and C.C.S. percentages at 10th month had non-significant negative genotypic correlations.

At the phenotypic level, the number of millable canes per plot recorded non-significant positive correlations with length of cane, number of internodes, length of internode, brix at 12th month, pol and C.C.S. percentages at 10th and 12th months and purity percentage at 10th month. The characters, cane weight, girth of cane and juiciness at 12th month recorded significant but negative correlations and the other characters such as juiciness and brix at 10th month and purity percentage at 12th month recorded non-significant negative correlations.

Cane weight had significant positive genotypic correlations with length of cane, number of internodes, girth of cane and juiciness at 10th and 12th months, whereas it had non-significant positive correlations with length of internode. All the quality components viz. brix, pol, purity and C.C.S. percentage at 10th and 12th months had non-significant negative genotypic correlations.

The phenotypic correlations of cane weight with length of cane, number of internodes, girth of cane and juiciness at 10th and 12th months were highly significant and positive, whereas it was non-significant but positive with length of internode, pol percentage, purity percentage and C.C.S. percentage at 12th month. The other components such as brix at 10th and 12th months and pol, purity and C.C.S. percentages at 10th month recorded non-significant negative phenotypic correlations.

The length of cane had significant positive genotypic correlations with number of internodes, length of internode and girth of cane, where as this character had non-significant positive correlations with juiciness brix, pol and C.C.S. percentage at 12th month. The genotypic correlations of length of cane with quality characters such as juiciness, brix, pol and C.C.S. percentage at 10th month and purity percentage at 10th and 12th months were non-significant and negative.

The length of cane recorded highly significant positive phenotypic correlations with number of internodes, length of internode and girth of cane and non-significant positive correlations with juiciness, brix, pol and C.C.S. percentages at 12th month. All the other characters such as juiciness, brix, pol and C.C.S. percentage at 10th month and purity percentage at 10th and 12th months recorded non-significant negative phenotypic correlations with this character.

The number of internodes had significant positive genotypic correlation with girth of cane only. All the other components except purity percentage at 10th month had non-significant positive genotypic correlations with number of internodes. The length of internode had highly significant but negative genotypic correlation with this character.

The phenotypic correlations of number of internodes were significant and positive with girth of cane, juiciness, brix, pol, purity and C.C.S. percentages at 12th month. The other characters such as juiciness, brix, pol, purity and C.C.S. percentages at 10th month recorded non-significant positive phenotypic correlations with number of internodes. The length of internode is the only character having highly significant but negative phenotypic correlations with this character.

Length of internode had non-significant but positive genotypic correlations with girth of cane and non-significant and negative genotypic correlations with quality components such as juiciness, brix, pol, purity and C.C.S. percentages at 10th and 12th months.

At the phenotypic level, length of internode recorded non-significant positive correlation with girth of cane and significant but negative correlations with brix, pol and C.C.S. percentage at 10th month and purity percentage at 10th and 12th months. The remaining characters such as juiciness at 10th and 12th months, brix, pol and C.C.S. percentage at 12th month recorded non-significant negative phenotypic correlations with length of internode.

Girth of cane had highly significant positive genotypic correlations with juiciness at 10th month only, whereas it had non-significant positive genotypic correlations with juiciness at 12th month, brix at 10th month, pol percentage at 10th and 12th months and C.C.S. percentage at 12th month. All the other characters such as brix at 12th month, purity percentage at 10th and 12th months and C.C.S. percentage at 10th month showed non-significant negative genotypic correlations with girth of cane.

The phenotypic correlation coefficients of girth of cane were highly significant and positive with juiciness at 10th and 12th months, whereas it was non-significant and positive with brix and pol percentage at 10th month. The quality characters like brix and pol percentage at 12th month, purity and C.C.S. percentages at 10th and 12th months recorded non-significant negative phenotypic correlations with girth of cane.

Juiciness at 10th month had non-significant positive genotypic correlations with juiciness at 12th month, brix, pol, purity and C.C.S. percentage at 10th month. The other characters like brix, pol, purity and C.C.S. percentages at 12th month recorded non-significant negative genotypic correlations with juiciness at 10th month.

At the phenotypic level, juiciness at 10th month had significant positive correlations with juiciness at 12th month only. All the other characters such as brix, pol, purity and C.C.S. percentages at 10th and 12th months recorded non-significant negative correlations with juiciness at 10th month.

Juiciness at 12th month had non-significant positive genotypic correlations with brix at 12th month, pol percentage at 10th and 12th months and purity and C.C.S.percentages at 12th month. All the other characters such as brix, purity and C.C.S. percentages at 10th month recorded non-significant negative genotypic correlations with this character.

The phenotypic correlation coefficients of juiciness at 12th month were non-significant and negative with all the quality characters except purity percentage at 12th month, which had non-significant positive correlation.

Brix at 10th month recorded highly significant positive genotypic and phenotypic correlations with brix at 12th month and pol, purity and C.C.S. percentages at 10th and 12th months.

Brix at 12th month also recorded highly significant positive genotypic and phenotypic correlations with pol, purity and C.C.S. percentages at 10th and 12th months.

Pol percentage at 10th month had highly significant positive genotypic and phenotypic correlations with pol percentage at 12th month and purity and C.C.S. percentages at 10th and 12th months.

Pol percentage at 12th month recorded highly significant positive genotypic and phenotypic correlations with purity and C.C.S. percentages at 10th and 12th months.

Purity percentage at 10th month had significant positive genotypic correlations with C.C.S.percentage at 10th and 12th months. The genotypic correlation of purity percentage at 10th month was non-significant and positive with purity percentage at 12th month.

At the phenotypic level, purity percentage at 10th month recorded highly significant positive correlations with purity percentage at 12th month and C.C.S. percentage at 10th and 12th months.

Purity percentage at 12th month had non-significant positive genotypic correlations with C.C.S. percentage at 10th month and 12th months, whereas at the phenotypic level C.C.S. percentage at 10th and 12th monthsrecorded highly significant positive correlations with purity percentage at 12th month.

C.C.S.percentage at 10th month recorded highly significant positive genotypic and phenotypic correlations with C.C.S.percentage at 12th month.

4.1.4 Path analysis

The relative contributions of each component towards cane yield and sugar yield were assessed by path analysis. For the study of cause and effect relationship, number of millable canes per plot, cane weight, length of cane, number of internodes, length of internode and girth of cane were considered as components of cane yield. Juiciness, brix, and pol percentage at 12th month were considered as components of C.C.S.% (Commercial cane sugar recovery percentage). The cane yield and C.C.S.

percentage are considered as components of sugar yield.

The direct and indirect effects of the six components on cane yield, three components on C.C.S. percentage and two components on sugar yield and their respective genotypic correlation coefficients are presented in Tables 7,8 and 9 respectively. The path diagram with path coefficients (direct effects) and the genotypic correlations are presented in Figure 4.

The girth of cane had the maximum direct effect on cane yield (1.16) and positive indirect effect through length of cane and negative indirect effects through all the remaining components such as number of millable canes, cane weight, number of internodes and length of internode thereby reducing the genotypic correlation coefficient of girth of cane on cane yield.

The number of millable cane is the second component having high positive direct effect (0.93) on cane yield. This component exerts positive indirect effects on cane yield through cane weight, length of cane and number of internodes. The number of millable canes exerts high negative indirect effect (-0.55) via. girth of cane and low negative indirect effect (-0.06) via length of internode.

Table 7. Direct and indirect effects of the components on cane yield in the plant crop

Sl. No.	Components	Direct effects	Indirect effects via						Total correlation
			Number of millable cane per plot	Weight of cane	Length of cane	Number of internodes	Length of internode	Girth of cane	
1.	Number of millable canes per plot	0.93	-	0.20	0.04	0.01	-0.06	-0.55	0.57
2.	Weight of cane	-0.39	-0.48	-	0.38	-0.13	-0.06	1.16	0.48
3.	Length of cane	0.66	0.06	-0.23	-	-0.12	-0.17	0.47	0.67
4.	Number of Internodes	-0.26	-0.02	-0.20	0.32	-	0.24	0.48	0.56
5.	Length of internode	-0.33	0.14	-0.05	0.26	0.14	-	-0.05	0.11
6.	Girth of cane	1.16	-0.44	-0.39	0.27	-0.11	-0.02	-	0.47

Residual effect : -0.135

Table 8. Direct and indirect effects of the components on C.C.S. percentage in the plant crop

Sl. No.	Components	Direct effects	Indirect effects via			Total correlation
			Juiciness at 12th month	Brix at 12th month	Pol at 12th month	
1.	Juiciness at 12th month	0.05	-	0.01	0.15	0.21
2.	Brix at 12th month	0.25	0.01	-	0.72	0.98
3.	Pol at 12th month	0.73	0.01	0.25	-	0.99

Residual effect: 0.033

Table 9. Direct and indirect effects of the components on sugar yield in the plant crop

Sl. No.	Components	Direct effects	Indirect effects via		Total correlation
			Cane yield per plot	C.C.S. percentage at 12th month	
1.	Cane yield per plot	0.79	-	0.02	0.81
2.	C.C.S. percentage at 12th month	0.58	0.03	-	0.61

Residual effect: 0.071

Fig.4. Path diagram showing the direct effects and interrelationships of cane yield per plot, C.C.S percentage and sugar yield per plot in the plant crop.

C.Y - Cane yield per plot

1. Number of millable canes per plot
2. Weight of cane
3. Length of cane
4. Number of internodes
5. Length of internode
6. Girth of cane

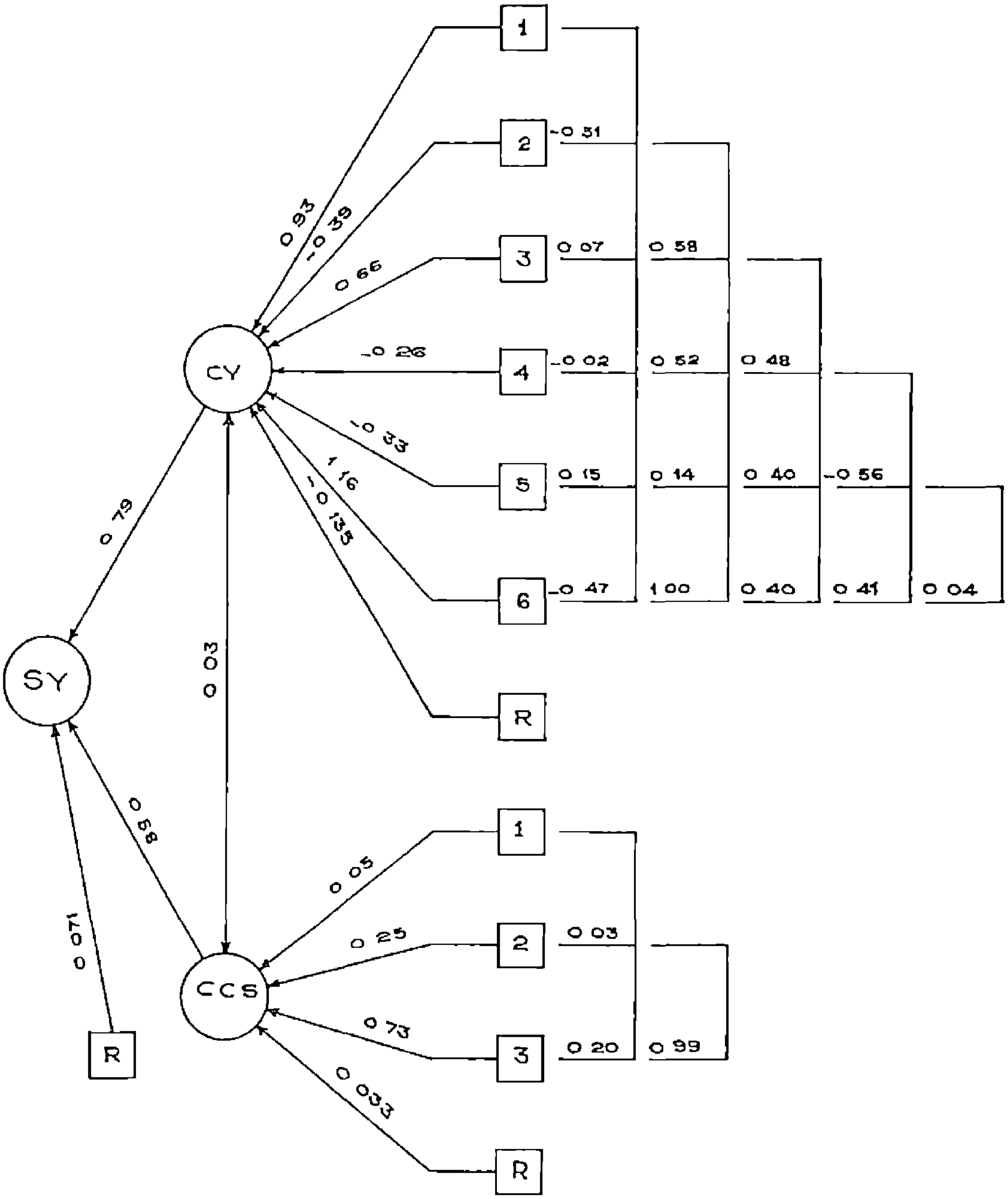
C.C.S - Commercial cane sugar percentage

1. Juiciness at 12th month
2. Brix at 12th month
3. Pol at 12th month

S.Y - Sugar yield per plot

R - Residual effect.

FIG 4 PATH DIAGRAM SHOWING THE DIRECT EFFECTS AND INTERRELATIONSHIPS OF CANEYIELD PER PLOT, C C S PERCENTAGE AND SUGARYIELD PER PLOT IN THE PLANT CROP



DIRECT EFFECTS SHOWN IN ARROWS INTERRELATIONSHIPS SHOWN IN STEPS

Length of cane is the third major component having direct effect on cane yield (0.66). It exerts high positive indirect effect (0.47) via girth of cane and very low positive indirect effect via. number of millable canes per plot, whereas through the remaining three components viz. cane weight, number of internodes and length of internode, it had negative indirect effects. Eventhough the length of cane recorded highest genotypic correlation with cane yield among the six components considered for path analysis, it had only a relatively lower contribution for cane yield.

Eventhough the remaining three components such as cane weight, number of internodes and length of internode, had positive genotypic correlations with cane yield, they putforth only negative direct effect on cane yield. The negative direct effect of cane weight on cane yield was highest (-0.39), followed by length of internode (-0.33) and number of internodes (-0.26). Cane weight put forth maximum positive indirect effect on cane yield through girth of cane (1.16) followed by length of cane (0.38) while, through number of millable canes, number of internodes and length of internode, the effects were indirect and negative. The number of internodes exerts positive indirect effects on cane yield via. the length of cane (0.32), length of internode (0.24) and girth of cane (0.48) and negative indirect effects on cane yield through number of millable canes (-0.02) and cane weight (-0.20). The length of internode had positive indirect effects on cane yield through length of cane (0.26), number of millable canes per plot (0.14) and number of internodes (0.14), while through cane weight and girth of cane, it had low negative indirect effects.

The residual effect is small indicating that most of the genetic variability for cane yield and its components were accounted by the model used for the study of cause-effect relationship. The girth of cane, number of millable canes and length of cane which had high positive direct contributions for cane yield may be considered in selection programmes for increasing cane yield.

Among the three components of C.C.S.percentage, the pol percentage at 12th month exerts maximum positive direct effect (0.73) followed by brix at 12th month (0.25) and juiciness at 12th month (0.05). Even though the genotypic correlations of brix at 12th month and pol percentage at 12th month with C.C.S percentage are of equal magnitude, the direct contribution of pol percentage at 12th month is higher than that of brix at 12th month. Pol percentage at 12th month exerts high positive indirect effect through brix at 12th month (0.25) and the brix at 12th month exerts positive indirect effect through pol percentage at 12th month (0.72) on C.C.S percentage. Juiciness at 12th month exerts low positive indirect effects on C.C.S percentage through brix at 12th month (0.01) and pol percentage at 12th month (0.15). The pol percentage at 12th month which had maximum direct effect on C.C.S percentage may be taken into consideration in selection programmes for increasing sugar recovery. The residual effect is very small indicating that most of the variability for C.C.S percentage has been accounted by the model used for the study.

Among the two components considered for sugar yield, the cane yield exerts higher direct effect (0.79) than C.C.S percentage at 12th month (0.58). Cane yield exerts low positive indirect effect (0.02) on sugar yield through C.C.S percentage and the C.C.S percentage exerts low positive indirect effect (0.03) through cane yield.

By increasing the cane yield per plot rather than C.C.S.percentage, the sugar yield per plot can be increased. The low residual effect indicated that most of the variability for sugar yield and its two components has been accounted by this model.

4.2. First ratoon crop

4.2.1 Genetic variability

The data collected from the first ratoon crop of 48 clones evaluated at Sugarcane Research Station, Thiruvalla were statistically analysed and the abstract of ANOVA is presented in Table 10. The clones showed highly significant differences in respect of all the 21 characters except juiciness at 10th month. The mean values of 21 characters along with their respective C.D. values are presented in Tables 11 and 12. The wide differences in the mean values exhibited by the different clones for the characters indicate the presence of large amount of variability in the biological material used for the study. The cane yield and sugar yield of 48 clones in the first ratoon crop are presented in Figure 5.

Table 10. Analysis of variance for the first ratoon crop

Sl. No.	Characters	Mean squares			F(Clones)
		Replications	Clones	Error	
1.	Germination count (45th day)	67.42	3121.22	398.16	7.84**
2.	Shoot count (180th day)	4975.39	1759.46	291.76	6.03**
3.	Number of late shoots (at harvest)	18.34	3.86	0.54	7.15**
4.	Number of millable canes per plot	342.51	862.72	260.09	3.32**
5.	Weight of cane	0.93	0.19	0.06	3.16**
6.	Length of cane	0.19	0.16	0.07	2.28**
7.	Number of internodes	20.55	31.52	6.57	4.79**
8.	Length of internode	1.39	8.82	1.77	4.98**
9.	Girth of cane	0.22	1.65	0.32	5.16**
10.	Cane yield per plot	1041.84	1251.07	281.30	4.45**
11.	Juiciness at 10th month	3855.29	4593.22	4015.41	1.14
12.	Juiciness at 12th month	4377.56	6096.56	3353.79	1.82**
13.	Brix at 10th month	13.27	6.66	1.61	4.14**
14.	Brix at 12th month	6.62	8.67	2.24	3.87**
15.	Pol at 10th month	19.63	11.03	2.90	3.80**
16.	Pol at 12th month	14.43	11.38	3.28	3.47**
17.	Purity percentage at 10th month	62.62	45.42	17.63	2.57**
18.	Purity percentage at 12th month	78.42	22.79	13.85	1.64**
19.	C.C.S. percentage at 10th month	12.65	7.35	1.96	3.75**
20.	C.C.S. percentage at 12th month	9.51	6.75	2.15	3.14**
21.	Sugar yield per plot	22.76	21.50	3.91	5.49**

** Significant at 1 per cent probability level

Table 11 Mean values of cane yield and morphological characters in the first ratoon crop

Sl. No.	Name of clone	Germination count (45th day)	Shoot count (180th day)	Number of late shoots (at harvest)	Number of millable canes per plot	Weight of cane (kg)	Length of cane (m)	Number of internodes	Length of internode (cm)	Girth of cane (cm)	Cane yield per plot (kg)	Cane yield (t/ha
C 1	CoC.774	80.3	104.3	33.0	45.3	1.21	1 76	17.5	10.4	8.87	44.1	54
" 2	F-1-2	46.0	64.3	9.0	49.0	0.79	2.20	25.6	10.3	6.93	33.2	41
" 3	T-67172	81.7	80.3	22.0	55.3	1.34	2.30	21.5	12.2	8.84	49.9	62
" 4	Co.658	181.0	154.7	27.3	83.0	1.07	2.11	21.2	11.2	8.02	83.3	103
" 5	Co.62174	37.7	48.0	10.7	36.0	1.47	2.05	20.1	10.5	8.93	34.7	43
" 6	Co.997	83.7	132.0	33.7	98.3	0.85	2.07	25.0	9.3	7.24	70.3	87
" 7	Co.6807	111.0	126.3	11.0	72.7	1.11	2.04	21.1	10.9	7.65	52.7	65
" 8	Co.1340	81.7	103.3	5.7	72.0	0.96	1.86	17.9	11.4	7.45	49.5	61
" 9	Co.1307	92.7	92.7	18.0	52.0	1 30	2.30	19.4	15.2	8.01	55.7	69
" 10	Co.7717	119.0	118.7	19.7	85.7	1.25	2.16	22.4	11.5	8.08	73 8	91
" 11	Co.62175	74.3	99.3	4.0	73.7	1.57	2.57	27.1	10.6	7.75	85.4	105
" 12	S-87	83.3	95.3	21.0	75.0	1.62	2.32	24.1	11.6	8.54	84.2	104
" 13	Co.419	124.3	137.7	10.0	94.7	1.19	2.47	23.5	11.8	7.87	88.8	110
" 14	CoC.779	96.0	116.0	4.3	85.7	1.38	2.17	23.5	11 0	8.53	65.1	80
" 15	Co.7219	40.7	74.3	9.7	78.3	1.15	2 15	20.5	10.6	7.44	62.3	77
" 16	Co.527	38.7	94.3	1.7	50.7	0.98	1.74	18.3	9.6	6.15	17.3	21
" 17	CoC.777	102.0	129.3	8.0	103.0	1.43	2.49	25.3	10.3	7.16	115.7	143
" 18	S-105	77.3	85.7	6.0	64.7	1.28	2.49	26.5	12.2	7.85	54.7	67
" 19	S-33	76.7	109.3	10.0	81.0	1.23	2.10	24.0	12.0	6.61	62.1	77
" 20	MS.6847	70.7	87.0	11.3	68.0	1.75	2.13	17.7	12.7	8.12	58.9	73
" 21	Co.740	127.7	102.7	16.3	82.0	1.11	2.01	21.4	11.4	7.98	60.8	75
" 22	IC.225	101.7	114.0	22.0	80.3	0.92	2.07	25.2	10.5	6.98	55.0	68
" 23	Co.6907	72.7	91 0	18.3	80.0	1.52	2.49	26.0	12.1	7.21	80.7	100
" 24	Co.6304	68.7	91.7	12.7	62.0	1.35	2.25	20.5	11.4	7.56	44.8	55
" 25	CoA.7602	43.3	82.0	7.3	70.3	1.50	2.06	16.3	14.8	8.02	59.3	73
" 26	S-99	41.7	85.3	5.7	74.0	1.58	2.16	21.8	11.7	8.44	70.0	86
" 27	CoC.775	86.3	97.0	16.0	79.3	0.97	2.16	19.9	12.8	7.80	65.3	81
" 28	KHS.3296	87.0	93.0	10.0	39.0	1.38	2.25	27.7	10.9	8.98	47.7	59
" 29	CoC.671	72.0	71.0	9.0	44.7	1.53	2.11	18.9	13.1	8.60	40.7	50
" 30	CoC 771	195.7	129.3	58.0	113.0	1.55	2.56	17.4	17.2	7.83	117.7	145
" 31	CoC.773	59.7	70.0	6.7	63.7	1.29	2.04	18.8	13 4	7.74	49.2	61
" 32	CoC.772	90.7	106.3	13.3	71.7	1.33	2.45	22.0	13.6	7.79	64.2	79
" 33	Co.7704	107.7	94.7	21.0	77.3	1.57	2.12	20.8	12.5	8.77	80.4	99
" 34	CoA.7601	58.7	84.0	6.7	57.3	1.47	2.25	18.9	13.6	8.72	49.7	61
" 35	Co.62198	115.3	116.7	14.7	75.3	1.14	2.13	17.9	12.9	7.08	59.9	74
" 36	Co.62101	52.3	83.0	9.7	74.0	1 10	2.12	19.3	12.5	7.08	54.4	67
" 37	Co.6806	27.3	52.0	3.0	38.0	0.66	1.65	17.3	9.9	6.65	18.4	23
" 38	CoC.778	73.0	105.7	8.0	72.0	0.94	2.06	19.8	12.4	7.69	51.3	63
" 39	B-37172	58.0	82.7	2.3	70.7	0.72	2.05	21.3	11.6	5.99	42.0	52
" 40	Co.1305	80.7	140.0	8.3	69.3	0.75	1.84	17.2	12.3	6.99	39.7	49
" 41	Co.785	75.7	105.3	2.3	86.0	1.35	2.69	25.9	16.2	7.08	83.2	103
" 42	Co.453	95.3	114.3	7.7	82.3	1.19	2.34	17.5	15.5	7.34	65.3	81
43	CoM.7114	88.7	96.0	10.0	70.0	1.43	2.29	21.5	11.9	7.61	58.8	73
44	S-77	61.7	84.3	10.0	57.0	1.24	1.81	17.9	11.0	8.73	60.3	74
" 45	Co.995	86.0	113.3	7.7	99.0	1.42	2.39	29.4	9.2	6.95	90.7	112
" 46	Co.449	85.3	160.7	18.3	84.3	0.82	2.02	16.8	13.9	6.05	44.1	54
" 47	CoM.7125	66.0	70.7	13.7	74.7	1.40	2.31	21.0	13.0	7.62	51.4	63
" 48	Co-527-M-10	85.3	122.0	10.3	83.7	0.86	2.39	21.5	11.2	7.52	69.5	86
	C D (5%)	32.26	27.61	1.19	26.07	0.386	0.426	4.14	2.15	0.909	27.11	33.5

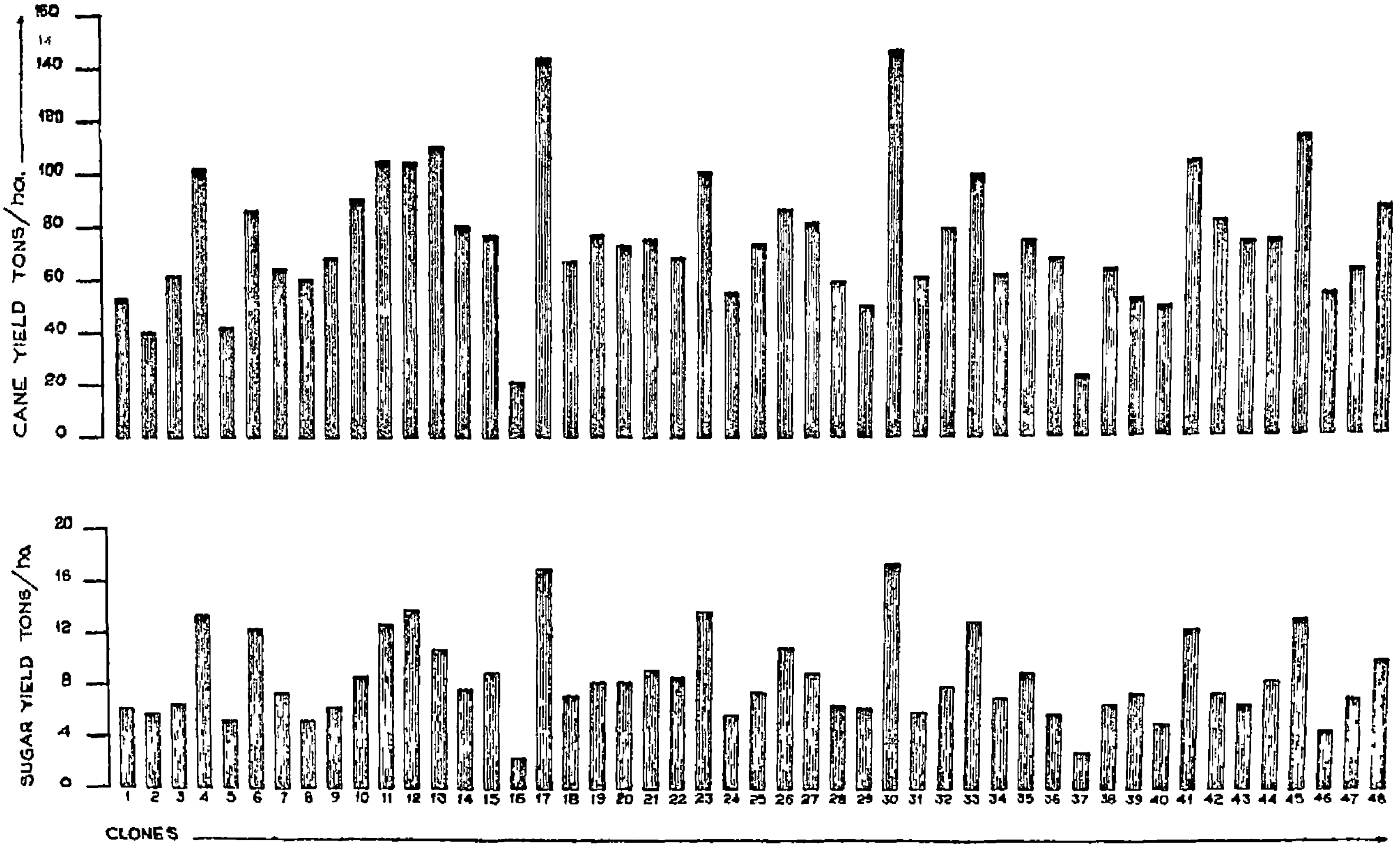
Table 12 Mean values of sugaryield and its attributes in the first ratoon crop

Sl. No.	Name of clone	Juiciness (ml)		Brix (%)		Pol (%)		Purity (%)		C. C. S (%)		Sugar yield per plot (kg)	Sugar yield (t/ha)
		at 10th Month	at 12th Month	at 10th Month	at 12th Month	at 10th Month	at 12th Month	at 10th Month	at 12th Month	at 10th Month	at 12th Month		
C 1	CoC.774	567	531	17.9	18.0	14.6	16.0	81.5	88.8	9.7	11.1	5.00	6.17
" 2	F-1-2	565	455	18.5	21.8	15.9	20.0	85.6	92.1	10.8	14.1	4.71	5.81
" 3	T-67172	524	514	17.9	17.4	16.0	15.5	88.5	88.8	11.1	10.7	5.37	6.63
" 4	Co.658	586	529	17.7	20.4	14.7	18.4	83.8	90.4	9.9	12.9	10.85	13.39
" 5	Co.62174	505	483	18.1	19.6	15.7	18.1	86.4	92.3	10.8	12.8	4.31	5.32
" 6	Co.997	686	490	20.4	21.9	18.6	20.1	91.1	92.0	13.0	14.2	9.99	12.33
" 7	Co.6807	558	579	14.6	19.2	10.9	16.6	72.7	86.5	6.8	11.4	5.98	7.38
" 8	Co.1340	499	444	15.0	16.3	11.3	13.7	74.5	84.3	7.1	9.3	4.41	5.44
" 9	Co.1307	527	468	15.7	16.3	13.2	13.8	84.2	84.1	8.9	9.7	5.06	6.25
" 10	Co.7717	628	574	15.9	15.9	13.8	13.7	86.5	86.2	9.5	9.4	6.90	8.52
" 11	Co.62175	615	562	17.8	18.4	15.9	16.9	89.2	91.8	11.1	11.9	10.22	12.62
" 12	S-87	627	619	19.7	19.8	18.1	18.4	91 7	92.8	11.1	13.0	11.00	13.58
" 13	Co.419	648	603	15.0	16.1	12.3	14.2	81.5	88.1	8.1	9.8	8.62	10.64
" 14	CoC.779	585	510	15.1	16.8	13.1	13.8	86.3	82.4	9.0	9.2	6.11	7.54
" 15	Co.7219	556	570	19.1	18.6	17.3	16.7	90.7	89.3	12.1	11.8	7.19	8.88
" 16	Co.527	574	520	16.8	16.9	14.9	14.9	88.0	88.2	10.4	10.3	1.86	2.30
" 17	CoC.777	713	506	18.4	18.4	16.3	16.8	88.6	91.2	11.3	11.8	13.71	16.92
" 18	S-105	623	497	16.8	17.2	14.9	15.0	88.6	86.4	10.3	10.3	5.78	7.13
" 19	S-33	558	515	19.1	17.9	16.9	15.5	88.4	87.0	11.7	10.7	6.59	8.13
" 20	MS.6847	637	542	15.0	18.5	11.6	16.4	76.0	88.2	7.4	11.3	6.57	8.11
" 21	Co.740	560	551	19.5	19.2	17.7	17.3	90.8	90.3	12.4	12.1	7.35	9.07
" 22	IC.225	602	499	17.6	19.4	16.4	17.5	93.3	90.2	11.7	12.2	6.70	8.27
" 23	Co.6907	565	494	19.6	20.3	18.0	19.0	91.7	93.8	13.1	13.5	10.97	13.54
" 24	Co.6304	606	630	18.0	17.0	16.0	14.8	88.8	86.9	11.1	10.1	4.57	5.64
" 25	CoA.7602	559	438	16.1	16.7	13.6	14.5	83.1	86.3	9.1	10.0	5.82	7.18
" 26	S-99	556	520	18.7	19.2	16.1	17.8	87.0	92.3	10.7	12.5	8.80	10.86
" 27	CoC.775	525	490	17.2	16.9	15.5	15.3	90.2	89.6	11.1	10.7	7.15	8.83
" 28	KHS.3296	518	550	17.1	16.9	15.7	15.2	88.4	90.0	11.0	10.5	5.09	6.28
" 29	CoC.671	600	615	19.2	18.6	17.4	17.1	90.7	92.2	12.2	12.1	4.95	6.11
" 30	CoC.771	558	533	17.5	18.8	16.1	16.9	91.9	89 6	11 4	11.7	13.82	17 06
" 31	CoC.773	537	489	18.7	16.1	16.9	14.2	90.3	87.7	11.8	9.8	4.79	5.91
" 32	CoC.772	610	538	16.6	16.1	14.3	13.5	86.2	82.0	9.8	9.1	5.52	6.81
" 33	Co.7704	633	739	19.2	20.4	17.9	18.4	93.5	90.2	12.7	12.8	10.32	12 74
" 34	CoA.7601	599	443	17.8	17.2	16.7	15.7	93.6	91.4	11.9	11.1	5.57	6.88
" 35	Co.62198	526	500	17.7	19.1	15.6	17.3	88.1	90.2	10.8	12.1	7.23	8.92
" 36	Co.62101	544	489	16.5	14.8	14.5	12.5	87.1	81 7	9.3	8.4	4.60	5.68
" 37	Co.6806	516	508	18.3	18.7	15.1	16.7	81.7	89.2	10.1	11.6	2.28	2.81
" 38	CoC.778	614	527	14.8	16.2	12.1	14.5	81.2	89 0	8.1	10.0	5.20	6.42
" 39	B-37172	526	500	18.2	20.6	16.9	19.5	93.3	94.2	12.0	13.8	5.82	7.18
" 40	Co.1305	528	563	17.6	16.2	15.7	14.0	89 4	86.4	10.9	9.6	3.93	4.85
" 41	Co.785	575	503	17.7	18.9	15.6	16.9	87.8	89.3	10.7	11 8	9.77	12.06
" 42	Co.453	578	480	16.7	15.3	14.3	13.4	85.7	86.4	9.8	9.2	5.88	7.26
" 43	CoM.7114	613	512	15.1	15.8	12 1	13.0	80.1	81.0	8.0	8 6	5.13	6 33
" 44	S-77	577	505	17.2	17.6	15.5	16.0	90.1	90.6	10.8	11.2	6.63	8.18
" 45	Co.995	600	513	16.0	18.6	13.4	16.5	83.0	88.6	9 0	11 4	10 43	12.87
" 46	Co.449	574	469	15.5	15.6	12.9	12.6	83.3	80.7	8 7	8.3	3.59	4.43
" 47	CoM.7125	577	548	18.0	18.4	15.6	16.0	86.5	87.1	10 6	11 0	5.71	7.05
" 48	Co 527-M-10	591	514	18.7	18.8	16.9	16.9	90.6	90.2	11.8	11.8	8.09	9.99
C.D.(5%)		102.4	93.6	2.05	2.42	2.76	2 93	6 79	6.01	2.26	2 37	3 198	3.947

Fig.5. Cane yield and sugar yield in the first ratoon crop.

No.	Clones	No.	Clones	No.	Clones
C.1	CoC.774	C.17	CoC.777	C.33	Co.7704
" 2	F-1-2	" 18	S-105	" 34	CoA.7601
" 3	T-67172	" 19	S-33	" 35	Co.62198
" 4	Co.658	" 20	MS.6847	" 36	Co.62101
" 5	Co.62174	" 21	Co.740	" 37	Co.6806
" 6	Co.997	" 22	IC.225	" 38	CoC.778
" 7	Co.6807	" 23	Co.6907	" 39	B-37172
" 8	Co.1340	" 24	Co.6304	" 40	Co.1305
" 9	Co.1307	" 25	CoA.7602	" 41	Co.785
" 10	Co.7717	" 26	S-99	" 42	Co.453
" 11	Co.62175	" 27	CoC.775	" 43	CoM.7114
" 12	S-87	" 28	KHS.3296	" 44	S-77
" 13	Co.419	" 29	CoC.671	" 45	Co.995
" 14	CoC.779	" 30	CoC.771	" 46	Co.449
" 15	Co.7219	" 31	CoC.773	" 47	CoM.7125
" 16	Co.527	" 32	CoC.772	" 48	Co.527-M-10

FIG.5 CANE YIELD AND SUGAR YIELD IN THE FIRST RATOON CROP



4.2.1.1 Germination count:

The clone Co.6806 recorded the lowest germination count (27.3) and the clone CoC.771 had the highest germination count (195.7) on the 45th day. The clone Co.658 was on par with CoC.771.

4.2.1.2 Shoot count:

The shoot count on the 180th day ranged from 48.0 (Co.62174) to 160.7 (Co.449). The clones Co.658, Co.419 and Co.1305 were on par with Co.449.

4.2.1.3 Number of late shoots:

The clones showed a range of 1.7 (Co.527) to 58.0 (CoC.771) for the number of late shoots at harvest. No clone was on par with CoC.771 in respect of this character.

4.2.1.4 Number of millable canes:

The number of millable canes per plot ranged from 36.0 (Co.62174) to 113.0 (CoC.771). The clones Co.997, Co.419, CoC.777 and Co.995 were on par with CoC.771.

4.2.1.5 Weight of cane:

The weight of cane ranged from 0.66 kg (Co.6806) to 1.75 kg (MS.6847). Sixteen clones viz. Co.62174, Co.62175, S-87, CoC.779, CoC.777, Co.6907, CoA.7602, S-99, KHS.3296, CoC.671, CoC.771, Co.7704 and CoA.7601, CoM.7114, Co.995 and CoM.7215 were on par with MS-6847.

4.2.1.6 Length of cane:

The length of cane ranged from 1.65 m (Co.6806) to 2.69 m (Co.785). Fifteen clones were on par with Co.785 for this character. The clones were T.67172, Co.1307, Co.62175, S-87, Co.419, CoC.777, S-105, Co.6907, CoC.771, CoC.772, Co.453, CoM.7114, Co.995, CoM.7125 and Co.527-M-10.

4.2.1.7 Number of Internodes:

The number of internodes ranged from 16.3 (CoA.7602) to 29.4(Co.995). The clones F-1-2, Co.62175, CoC.777, S-105, Co.6907, KHS.3296 and Co.785 were on par with Co.995.

4.2.1.8 Length of internode:

The length of internode ranged from 9.2 cm (Co.995) to 17.2 cm (CoC.771). The clones Co.1307, Co.785 and Co.453 were on par with CoC.771.

4.2.1.9 Girth of cane:

The girth of cane ranged from 5.99 cm (B-37172) to 8.98 cm (KHS.3296). Twelve clones were on par with KHS.3296 in respect of this character. They are CoC.774. T.67172, Co.62174, Co.7717, S-87, CoC.779, MS.6847, S-99, CoC.671, Co.7704, CoA.7601 and S-77.

4.2.1.10 Yield of cane:

The cane yield per plot ranged from 17.3 kg (Co.527) to 117.7 kg (CoC.771). The clones CoC.777 and Co.995 were on par with CoC.771 in respect of cane yield per plot.

4.2.1.11 Juiciness at 10th month:

The juiciness at 10th month ranged from 499 ml (Co.1340) to 713 ml (CoC.777). The clones Co.997, Co.7717, Co.62175, S-87, Co.419, S-105, MS.6847, Co.7704, CoC.778 and CoM.7114 were on par with CoC.777.

4.2.1.12 Juiciness at 12th month:

The juiciness at 12th month ranged from 438 ml

(CoA.7602) to 739 ml (Co.7704). No other clone was on par with Co.7704 in respect of this character.

4.2.1.13 Brix at 10th month:

The brix at 10th month ranged from 14.6 (Co.6807) to 20.4 (Co.997). Twelve clones were on par with Co.997 in respect of this character. They are F-1-2, S-87, Co.7219, CoC.777, S-33, Co.740, Co.6907, S-99, CoC.671, CoC.773, Co.7704 and Co.527-M-10.

4.2.1.14 Brix at 12th month:

The brix at 12th month ranged from 14.8 (Co.62101) to 21.9 (Co.997). The clones F-1-2, Co.658, Co.62174, S-87, Co.6907, Co.7704 and B-37172 were on par with Co.997.

4.2.1.15 Pol percentage at 10th month:

The pol percentage at 10th month ranged from 10.9 (Co.6807) to 18.6 (Co.997). Nineteen clones were on par with Co.997 in respect of this character. They are F-1-2, T-67172, Co.62175, S-87, Co.7219, CoC.777, S-33, Co.740, Co.6907, IC.225, Co.6304, S-99, CoC.671, CoC.771, CoC.773, Co.7704, CoA.7601, B-37172 and CoM.527-M-10.

4.2.1.16. Pol percentage at 12th month:

The pol percentage at 12th month ranged from 12.5 (Co.62101) to 20.1 (Co.997). The clones F-1-2, Co.658, Co.62174, S-87, Co.740, IC-225, Co.6907, S-99, Co.7704, Co.62198 and B-37172 were on par with Co.997.

4.2.1.17. Purity percentage at 10th month:

The purity percentage at 10th month ranged from 72.7 (Co.6807) to 93.6 (CoA.7601). The clone CoA.7601 was on par with T-67172, Co.997, Co.62175, S-87, Co.7219 Co.527, CoC.777, S-105, S-33, Co.740, IC-225, Co.6907, Co.6304, S-99, CoC.775,KHS.3296, CoC.671, CoC.771, CoC.773, Co.7704, Co.62198, Co.62101, B-37172, Co.1305, Co.785, S-77 and Co.527-M-10.

4.2.1.18 Purity percentage at 12th month:

The purity percentage at 12th month ranged from 80.7 (Co.449) to 94.2 (B-37172). The clone B-37172 was on par with CoC.774, F-1-2, T-67172, Co.658, Co.62174, Co.997, Co.62175, S-87, Co.7219, Co.527, CoC.777, MS-6847, Co.740, IC-225, Co.6907, S-99, CoC.775, KHS.3296, CoC.671, CoC.771, Co.7704, CoA.7601, Co.62198, Co.6806, CoC.778, Co.785, S-77, Co.995 and CoM.527-M-10.

4.2.1.19 C.C.S. Percentage at 10th month:

The C.C.S.percentage at 10th month ranged from 6.8 (Co.6807), to 13.1 (Co.6907). The clones F-1-2, T-67172, Co.62174, Co.997, Co.62175, S-87, Co.7219, CoC.777, S-33, Co.740, IC-225, Co.6304, CoC.775, KHS.3296, CoC.671, CoC.771, CoC.773, Co.7704, CoA.7601, Co.62198, B-37172, Co.1305, S-77 and Co.527-M-10 were on par with Co.6907.

4.2.1.20 C.C.S. Percentage at 12th month:

The C.C.S. percentage at 12th month ranged from 8.3 (Co.449) to 14.2 (Co.997). The clone Co.997 was on par with F-1-2, Co.658, Co.62174, Co.62175, S-87, Co.7219, CoC.777, Co.740, IC-225, Co.6907, S-99, CoC.671, Co.7704, Co.62198, B-37172, Co.785 and Co.527-M-10.

4.2.1.21 Yield of sugar:

The sugar yield per plot ranged from 1.86 kg (Co.527) to 13.82 kg (CoC.771). The clone CoC.771 was on par with Co.658, S-87, CoC.777 and Co.6907 in respect of this character.

4.2.2 Genetic parameters

The mean, S.E. of mean, range and the genetic parameters such as genotypic and phenotypic coefficients of variation (G.C.V and P.C.V), heritability(H^2) and genetic advance (G.A) for the best 5 per cent of the values as percentage of mean calculated are presented in Table 13. The histogram representing the genetic parameters in the first ratoon crop are presented in Figure 6.

The C.C.V was highest for germination count on the 45th day (36.5) followed by sugar yield per plot (35.7) and number of late shoots at harvest (31.3). The higher genotypic coefficient of variation indicate that large amount of genetic variability was present for the above characters. The juiciness at 10th month and purity percentage at 12th month recorded the lowest genotypic coefficient of variation (2.4) followed by purity percentage at 10th month (4.4). The characters such as cane yield per plot, shoot count on the 180th

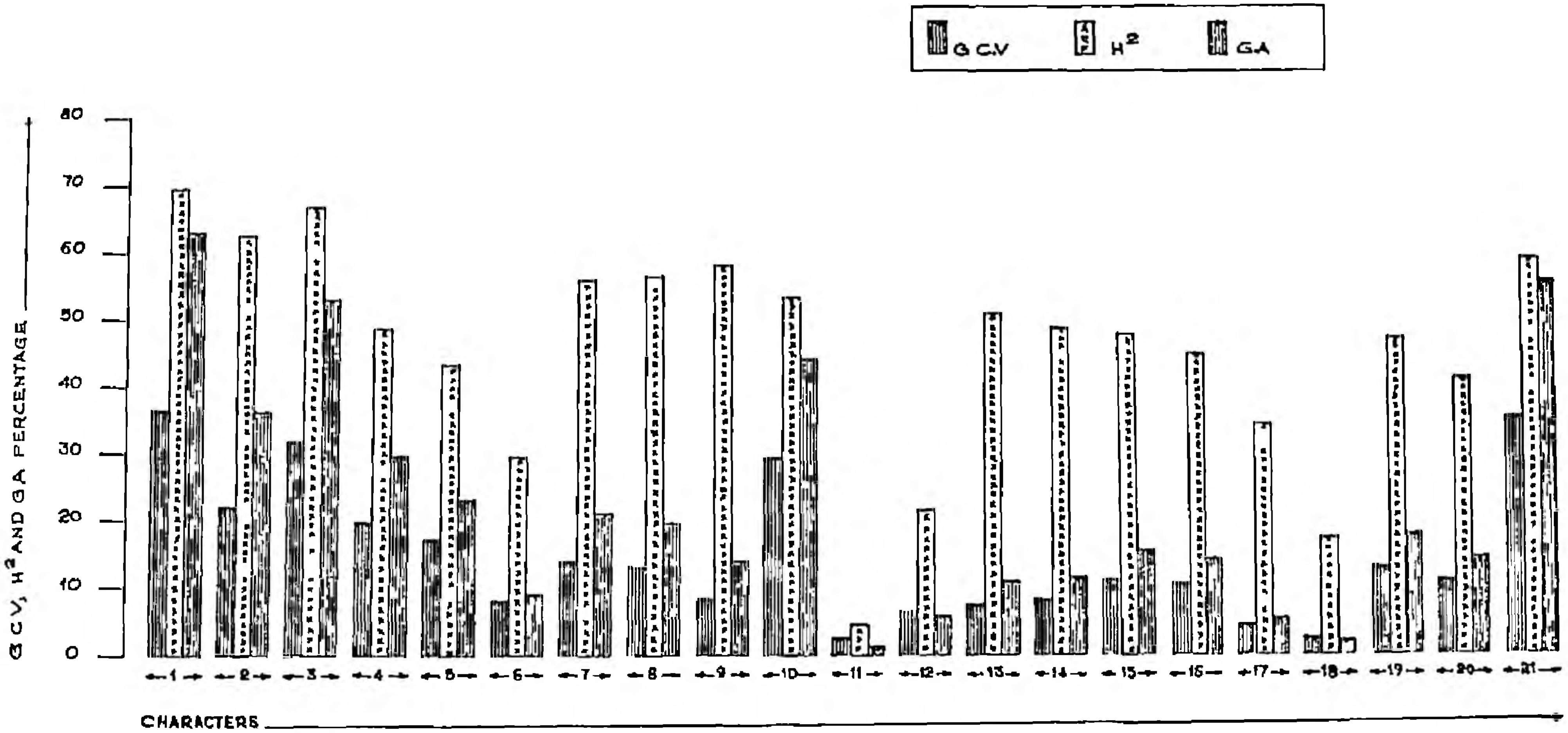
Table 13. Estimates of genetic parameters in the first ratoon crop

Sl. No.	Characters	Mean	S.E.	Range	Coefficients of variation		Heritability	Genetic advance
					Genotypic	Phenotypic		
1.	Germination count (45th day)	82.5	11.52	27.3 -195.7	36.5	43.8	69.5	62.7
2.	Shoot count (180th day)	100.3	9.86	48.0 -160.7	22.1	27.9	62.6	36.0
3.	Number of late shoots(at harvest)	3.3	0.42	1.7 - 58.0	31.3	38.2	67.1	53.0
4.	Number of millable canes per plot	72.0	9.31	36.0 -113.0	19.7	29.8	48.6	29.8
5.	Weight of canes (kg)	1.2	0.14	0.7 - 1.7	17.0	25.9	43.3	23.1
6.	Length of cane (m)	2.2	0.15	1.6 - 2.7	7.8	14.4	29.3	8.7
7.	Number of internodes	21.2	1.48	16.3 - 29.4	13.6	18.2	55.9	20.9
8.	Length of internode (cm)	12.1	0.77	9.2 - 17.2	12.7	16.8	56.9	19.7
9.	Girth of cane (cm)	7.7	0.32	6.0 - 8.9	8.7	11.4	58.4	13.7
10.	Cane yield per plot (kg)	61.3	9.68	17.3 -117.7	29.3	40.1	53.5	44.2
11.	Juiciness at 10th month (ml)	570.3	36.58	499.0 -713.0	2.4	11.4	4.6	1.1
12.	Juiciness at 12th month (ml)	521.4	33.43	438.0 -739.0	5.8	12.5	21.4	5.5
13.	Brix at 10th month (%)	17.4	0.73	14.6 - 20.4	7.4	10.4	51.1	11.0
14.	Brix at 12th month (%)	18.0	0.86	14.8 - 21.9	8.1	11.6	48.8	11.7
15.	Pol at 10th month (%)	15.2	0.98	10.9 - 18.6	10.8	15.6	48.2	15.5
16.	Pol at 12th month (%)	16.0	1.04	12.5 - 20.1	10.3	15.3	45.1	14.2
17.	Purity at 10th month (%)	69.3	2.42	72.7 - 93.6	4.4	7.5	34.4	5.3
18.	Purity at 12th month (%)	70.5	2.15	80.7 - 94.2	2.4	5.8	17.7	2.1
19.	C.C.S. at 10th month (%)	10.5	0.81	6.8 - 13.1	12.8	18.5	47.8	18.2
20.	C.C.S. at 12th month (%)	11.1	0.84	8.3 - 14.2	11.1	17.3	41.6	14.8
21.	Sugar yield per plot (kg)	6.8	1.14	1.9 - 13.8	35.7	46.1	60.0	56.9

Fig.6. Genetic parameters in the first ratoon crop.

No.	Characters
1	Germination count (45th day)
2	Shoot count (180th day)
3	Number of late shoots (at harvest)
4	Number of millable canes per plot
5	Weight of cane
6	Length of cane
7	Number of internodes
8	Length of internode
9	Girth of cane
10	Cane yield per plot
11	Juiciness at 10th month
12	Juiciness at 12th month
13	Brix at 10th month
14	Brix at 12th month
15	Pol at 10th month
16	Pol at 12th month
17	Purity at 10th month
18	Purity at 12th month
19	C.C.S at 10th month
20	C.C.S at 12th month
21	Sugar yield per plot

FIG 6 GENETIC PARAMETERS IN THE FIRST RATOON CROP



day and number of millable canes per plot had relatively high genotypic coefficient of variation.

The phenotypic coefficient of variation was highest for sugar yield per plot (46.1) followed by germination count on the 45th day (43.8) and cane yield per plot (40.1). The purity percentage at 12th month recorded the lowest phenotypic coefficient of variation (5.8) followed by purity percentage at 10th month (7.5) and brix at 10th month (10.4). The characters such as number of late shoots at harvest, number of millable canes per plot, shoot count on the 180th day and cane weight had relatively high phenotypic coefficient of variation.

The germination count on the 45th day had the highest heritability (69.5) followed by number of late shoots at harvest (67.1), shoot count on the 180th day (62.7) and sugar yield per plot (60.0). The juiciness at 10th month recorded the lowest heritability (4.6) followed by purity percentage at 12th month (17.7) and juiciness at 12th month (21.4). The low heritability estimates recorded in the above characters indicate the larger influence of the environment in the expression of those characters.

The genetic advance under selection was highest for germination count on the 45th day (62.7) followed by sugar yield per plot (56.9), number of late shoots at harvest (53.0) and cane yield per plot (44.2). The juiciness at 10th month had the lowest genetic advance (1.1) followed by purity percentage at 12th month (2.1), purity percentage at 10th month (5.3) and juiciness at 12th month (5.5).

Moderate to high heritability along with high genetic advance were recorded for characters like germination count on the 45th day, number of late shoots at harvest, sugar yield per plot, shoot count on the 180th day, cane yield per plot and number of millable canes per plot. This indicates that selection based on the above characters will be effective for increasing the cane and sugar yield. Relatively high heritability and low genetic advance were recorded for characters such as girth of cane, length of internode, number of internodes, brix at 10th and 12th months, pol percentage at 10th and 12th months and C.C.S.percentage at 10th month. Both heritability and genetic advance were low for length of cane, juiciness at 10th and 12th months and purity percentage at 10th and 12th months.

4.2.3 Correlation

The analysis of covariance was done for the 21 characters of the first ratoon crop and the genotypic and phenotypic correlation coefficients were estimated. The genotypic and phenotypic correlation coefficients of cane yield, sugar yield and their interrelationship with other characters are presented in Table 14.

4.2.3.1 Correlation of cane yield with morphological and quality characters

Cane yield recorded significant and positive genotypic correlations with germination count on the 45th day, shoot count on the 180th day, number of late shoots at harvest, number of millable canes per plot, cane weight and length of cane. The genotypic correlation coefficients of cane yield with number of internodes, length of internode and girth of cane were non-significant and positive. The quality components such as juiciness, brix, pol, purity and C.C.S.percentages at 10th and 12th months also recorded non-significant and positive genotypic correlations with cane yield.

Table 14 Genotypic and phenotypic correlation coefficients of cane yield, sugar yield and other characters in the first ratoon crop

Sl No.	Characters	Germination count (45th day)	Shoot count (180th day)	Number of late shoots (at harvest)	Number of millable canes per plot	Weight of cane	Length of cane	Number of internodes	Length of internode	Girth of cane	Cane yield per plot	Juiciness at 10th month	Juiciness at 12th month	Brix at 10th month	Brix at 12th month	Pol at 10th month	Pol at 12th month	Purity at 10th month	Purity at 12th month	C.C.S at 10th month	C.C.S at 12th month	Sugar yield per plot
1	Germination count (45th day)	–	0.73**	0.74**	0.66**	0.06	0.32	0.06	0.26	0.13	0.65**	0.10	0.38	–0.13	0.07	–0.10	–0.01	0.02	–0.19	–0.07	–0.01	0.59**
2	Shoot count (180th day)	0.66**	–	0.43*	0.76**	–0.37	0.07	0.04	0.01	–0.35	0.48**	0.05	0.21	–0.34	–0.17	–0.31	–0.29	–0.20	–0.49	–0.28	–0.28	0.37*
3	Number of late shoots (at harvest)	0.54**	0.31**	–	0.33**	0.15	0.12	–0.09	0.22	0.27	0.39*	–0.13	0.37	0.19	0.22	0.19	0.17	0.19	–0.08	0.19	0.15	0.41*
4	Number of millable canes per plot	0.51**	0.58**	0.35**	–	–0.06	0.51*	0.24	0.18	–0.47	0.82**	0.42	0.12	–0.05	0.09	–0.02	–0.02	0.08	–0.17	–0.01	–0.01	0.75**
5	Weight of cane	0.08	–0.16*	0.08	0.08	–	0.75**	0.30	0.25	0.74**	0.50*	1.00	0.27	0.17	0.17	0.21	0.16	0.23	0.28	0.21	0.20	0.46*
6	Length of cane	0.32**	0.20*	0.14	0.43**	0.39**	–	0.52*	0.43	0.02	0.87**	1.00	0.15	–0.04	0.11	0.09	0.11	0.26	0.09	0.14	0.10	0.74**
7	Number of internodes	0.11	0.09	0.01	0.25**	0.21*	0.56**	–	–0.53**	–0.11	0.39	0.92	0.14	0.23	0.47	0.29	0.40	0.29	0.47	0.32	0.44	0.48**
8	Length of internode	0.25**	0.14	0.17*	0.19*	0.24**	0.36**	–0.35**	–	0.06	0.23	0.08	–0.27	–0.24	–0.38	–0.13	–0.39	0.10	–0.45	–0.09	–0.38	0.05
9	Girth of cane	0.10	–0.16*	0.24**	–0.12	0.45**	0.16*	0.08	0.11	–	0.16	0.94	0.44	0.03	–0.01	0.08	–0.02	0.14	0.26	0.10	0.06	0.11
10	Cane yield per plot	0.53**	0.44**	0.35**	0.74**	0.45**	0.56**	0.34**	0.25**	0.19**	–	0.65	0.16	0.13	0.23	0.20	0.25	0.29	0.40	0.22	0.27	0.94**
11	Juiciness at 10th month	0.09	0.06	–0.04	0.03	0.18*	0.16*	0.13	0.06	0.03	0.13	–	1.00	–0.67	–0.26	–0.64	–0.59	–0.41	–0.47	–0.64	–0.40	0.40
12	Juiciness at 12th month	0.21*	0.06	0.10	0.06	0.20*	0.13	0.16*	–0.06	0.38	0.15	0.38**	–	0.23	0.23	0.18	–0.13	0.02	0.11	0.16	0.22	0.29
13	Brix at 10th month	–0.14	–0.20*	0.17*	–0.03	0.04	0.07	0.14	–0.07	0.09	0.02	–0.14	0.07	–	0.82**	0.98**	0.82**	0.84**	1.00	0.97**	0.93**	0.41
14	Brix at 12th month	0.04	–0.05	0.18*	0.06	–0.06	–0.02	0.23**	–0.29**	0.01	0.07	–0.14	–0.04	0.42**	–	0.77**	0.99**	0.53	0.99**	0.71**	1.00**	0.52**
15	Pol at 10th month	–0.10	–0.16*	0.16*	0.03	0.05	0.11	0.15	–0.03	0.06	0.06	–0.01	0.10	0.94**	0.33**	–	0.83**	0.93**	1.00	0.99**	0.86**	0.44
16	Pol at 12th month	0.02	–0.07	0.17*	0.05	–0.04	0.01	0.24**	–0.27**	0.04	0.07	–0.13	–0.02	0.45**	0.96**	0.39**	–	0.62*	1.00**	0.80**	1.00**	0.52**
17	Purity at 10th month	0.01	–0.05	0.15	0.13	0.05	0.15	0.11	0.05	0.01	0.13	0.12	0.11	0.65**	0.14	0.86**	0.22**	–	0.91	0.94**	0.66**	0.45
18	Purity at 12th month	–0.03	–0.70	0.09	0.01	–0.01	0.07	0.20*	–0.19*	0.07	0.08	–0.07	0.01	0.38**	0.66**	0.39**	0.81**	0.32**	–	1.00	0.99	0.58
19	C.C.S. at 10th month	–0.07	–0.14	0.16*	0.04	0.06	0.12	0.15	–0.01	0.04	0.08	0.03	0.10	0.89**	0.32**	0.98**	0.39**	0.90**	0.42**	–	0.83**	0.44*
20	C.C.S. at 12th month	0.01	–0.09	0.17*	0.05	–0.04	0.03	0.23**	–0.25**	0.04	0.07	–0.13	–0.01	0.46**	0.94**	0.40**	0.99**	0.24**	0.85**	0.40**		0.53**
21	Sugar yield per plot	0.51**	0.40**	0.42**	0.69**	0.37**	0.50**	0.40**	0.11	0.16*	0.91**	0.35**	0.15	0.20*	0.41**	0.21**	0.43**	0.20*	0.37**	0.22**	0.42**	

Values above the diagonal are genotypic correlation coefficients
Values below the diagonal are phenotypic correlation coefficients

* Significant at 5% probability level
** Significant at 1% probability level

The genotypic correlations of cane yield with sugar yield was also highly significant and positive.

The phenotypic correlation coefficients of cane yield per plot was highly significant and positive with germination count on the 45th day, shoot count on the 180th day, number of late shoots at harvest, number of millable canes per plot, cane weight, length of cane, number of internodes, length of internode, girth of cane and sugar yield per plot. The quality characters such as juiciness, brix, pol, purity and C.C.S. percentages at 10th and 12th months had non-significant and positive phenotypic correlations with cane yield per plot.

4.2.3.2 Correlation of sugar yield with morphological and quality characters

Sugar yield per plot had significant and positive genotypic correlations with germination count on the 45th day, shoot count on the 180th day, number of late shoots at harvest, number of millable canes per plot, cane weight, length of cane and number of internodes. The length of internode and girth of cane recorded non-significant but positive genotypic correlations with sugar yield per plot. Among the quality characters, brix and pol percentage at 12th month and C.C.S. percentage at 10th and 12th months had significant and positive genotypic correlations with sugar yield per plot, whereas the characters such as juiciness and purity percentage at 10th and 12th months and brix and pol percentage at 10th month had non-significant but positive genotypic correlations.

At the phenotypic level, the sugar yield per plot had significant and positive correlations with all the cane yield components except length of internode. The phenotypic correlation of length of internode was non-significant but positive with sugar yield per plot. The quality characters such as juiciness at 10th month, brix, pol, purity and C.C.S. percentages at 10th and 12th months recorded significant and positive phenotypic correlations with sugar yield per plot. The juiciness at 12th month is the only character which had non-significant and positive phenotypic correlation with sugar yield per plot.

4.2.3.3 Correlation among cane yield and sugar yield components

The germination count on the 45th day recorded highly significant positive genotypic correlations with shoot count on the 180th day, number of late shoots at harvest and number of millable canes per plot. The characters such as cane weight, length of cane, number of internodes, length of internode, girth of cane, juiciness at 10th and 12th months brix at 12th month and purity percentage at 10th month had non-significant but positive genotypic correlations with germination count on the 45th day. The quality characters like brix at 10th month, purity percentage at 12th month and pol and C.C.S percentages at 10th and 12th months had non-significant but negative genotypic correlations with germination count on the 45th day.

At the phenotypic level, germination count on the 45th day recorded significant and positive correlations with shoot count on the 180th day, number of late shoots at harvest, number of millable canes per plot, length of cane, length of internode and juiciness at 12th month, whereas cane weight, number of internodes, girth of cane, juiciness and purity percentage at 10th month and brix, pol and C.C.S percentages at 12th month had non-significant but positive phenotypic correlations. The quality characters such as brix, pol and C.C.S percentages at 10th month and purity percentage at 12th month had non-significant and negative phenotypic correlations with germination count on the 45th day.

The shoot count on the 180th day had significant and positive genotypic correlations with number of late shoots at harvest and number of millable canes per plot. The characters such as length of cane, number of internodes, length of internode and juiciness at 10th and 12th months recorded non-significant but positive genotypic correlations with shoot count on the 180th day. The genotypic correlation coefficients of shoot count on the 180th day with cane weight, girth of cane, brix, pol, purity and C.C.S. percentages at 10th and 12th months were non-significant and negative.

The phenotypic correlation coefficients of shoot count on the 180th day was significant and positive with number of late shoots at harvest, number of millable canes per plot and length of cane, whereas the characters such as number of internodes, length of internode and juiciness at 10th and 12th months recorded non-significant but positive phenotypic correlations. The shoot count on the 180th day had significant but negative phenotypic correlations with cane weight, girth of cane, brix and pol percentage at 10th month. The other characters such as brix and pol percentage at 12th month and purity and C.C.S. percentages at 10th and 12th months had non-significant and negative phenotypic correlations with shoot count on the 180th day.

The number of late shoots at harvest had highly significant and positive genotypic correlation with number of millable canes per plot only. The characters such as cane weight, length of cane, length of internode, girth of cane, juiciness at 12th month, purity percentage at 10th month, brix, pol percentage and C.C.S. percentage at 10th and 12th months had non-significant and positive genotypic correlations with number of late shoots at harvest. The genotypic correlation coefficients of juiciness at 10th month and purity percentage at 12th month were non-significant and negative with number of late shoots at harvest.

The phenotypic correlation coefficients of number of late shoots at harvest with number of millable canes per plot, length of internode, girth of cane, brix, pol and C.C.S.percentages at 10th and 12th months were significant and positive. The characters such as cane weight, length of cane, number of internodes, juiciness at 12th month and purity percentage at 10th and 12th months had non-significant but positive phenotypic correlations with number of late shoots at harvest. Juiciness at 10th month had non-significant and negative phenotypic correlation with this character.

The number of millable canes per plot had significant positive genotypic correlation with length of cane. The other characters such as number of internodes, length of internode, juiciness at 10th and 12th months, brix at 12th month and purity percentage at 10th month had non-significant and positive genotypic correlations with the number of millable canes per plot. The genotypic correlations of number of millable canes per plot with cane weight, girth of cane, brix at 10th month, purity percentage at 12th month and pol and C.C.S. percentage at 10th and 12th months were non-significant but negative.

At the phenotypic level, the number of millable canes per plot recorded significant positive correlations with length of cane, number of internodes and length of internode. The cane weight had non-significant and positive phenotypic correlations, whereas girth of cane and brix at 10th month had non-significant but negative phenotypic correlations with number of millable canes per plot. All the other characters such as juiciness, pol, purity and C.C.S. percentages at 10th and 12th months and brix at 12th month had non-significant and positive phenotypic correlations with number of millable canes per plot.

Cane weight had highly significant positive genotypic correlations with length of cane and girth of cane only. The genotypic correlation coefficients of cane weight were non-significant but positive with all other yield and quality characters such as number of internodes, length of internode, juiciness, brix, pol, purity and C.C.S.percentages at 10th and 12th months.

At the phenotypic level, cane weight recorded significant positive correlations with length of cane, number of internodes, length of internode, girth of cane and juiciness at 10th and 12th months. The brix, pol, purity and C.C.S. percentage at 10th month had non-significant but positive phenotypic correlations, whereas the brix, pol, purity and C.C.S. percentages at 12th month had non-significant and negative phenotypic correlations with cane weight.

The length of cane had significant positive genotypic correlation with number of internodes, whereas the characters such as length of internode, girth of cane, brix at 12th month, juiciness, pol, purity and C.C.S. percentages at 10th and 12th months recorded non-significant but positive genotypic correlation with this character.

The phenotypic correlation coefficients of the length of cane with number of internodes, length of internode, girth of cane and juiciness at 10th month were significant and positive. The characters such as juiciness at 12th month, brix at 10th month and pol, purity and C.C.S.percentages at 10th and 12th months had non-significant but positive phenotypic correlations with length of cane. The brix at 12th month had non-significant and negative phenotypic correlation with length of cane.

The number of internodes recorded highly significant but negative genotypic correlation with length of internode and non-significant and negative genotypic correlation with girth of cane. All the quality characters such as juiciness, brix, pol, purity and C.C.S. percentage at 10th and 12th months had non-significant but positive genotypic correlations with number of internodes.

The phenotypic correlations of number of internodes were significant and positive with juiciness, brix, pol, purity and C.C.S. percentages at 12th month. The length of internode had significant but negative phenotypic correlation and the other characters such as girth of cane, juiciness, brix, pol, purity and C.C.S.percentages at 10th month had non-significant but positive phenotypic correlations with number of internodes.

The genotypic correlation coefficients of length of internode were non-significant but positive with girth of cane, juiciness and purity percentage at 10th month. The length of internode had non-significant and negative genotypic correlations with characters such as juiciness and purity percentage at 12th month and brix, pol and C.C.S. percentages at 10th and 12th months.

At the phenotypic level, length of internode showed non-significant and positive correlations with girth of cane and juiciness and purity percentage at 10th month. The quality characters such as brix, pol, purity and C.C.S. percentages at 12th month had significant, negative phenotypic correlations with length of internode, whereas this character had non-significant and negative phenotypic correlations with juiciness at 12th month, brix, pol and C.C.S.percentages at 10th month.

The girth of cane had non-significant but positive genotypic correlations with brix and pol percentage at 10th month and juiciness, purity and C.C.S. percentages at 10th and 12th months, whereas the characters such as brix and pol percentage at 12th month had non-significant and negative genotypic correlations.

The phenotypic correlation coefficients of girth of cane were non-significant but positive with all the quality characters such as juiciness, brix, pol, purity and C.C.S. percentages at 10th and 12th months.

Juiciness at 10th month had non-significant but positive genotypic correlation with juiciness at 12th month, whereas the other quality characters such as brix, pol, purity and C.C.S.percentages at 10th and 12th months had non-significant and negative genotypic correlations.

Tho phenotypic correlation coefficients of juiciness at 10th month was significant and positive with juiciness at 12th month, whereas it was non-significant and positive with purity and C.C.S. percentage at 10th month. The characters such as brix and pol percentage at 10th and 12th months and purity and C.C.S.percentages at 12th month recorded non-significant and negative phenotypic correlations with juiciness at 10th month.

The genotypic correlation coefficients of juiciness at 12th month were non-significant but positive with the quality characters such as brix, pol, purity and C.C.S. percentages at 10th and 12th months.

The phenotypic correlation coefficients of juiciness at 12th month were non-significant but positive with brix, pol, and C.C.S.percentages at 10th month and purity percentage at 10th and 12th months. The juiciness at 12th month had non-significant and negative phenotypic correlations with brix, pol and C.C.S.percentages at 12th month.

The brix at 10th month had highly significant positive genotypic correlations with brix at 12th month, purity percentage at 10th month and pol and C.C.S. percentages at 10th and 12th months, whereas purity percentage at 12th month had non-significant but positive genotypic correlation with this character.

The phenotypic correlation coefficients of brix at 10th month were highly significant and positive with quality characters such as brix at 12th month and pol, purity and C.C.S.percentages at 10th and 12th months.

The brix at 12th month recorded significant and positive genotypic and phenotypic correlation coefficients with pol and C.C.S.percentages at 10th and 12th months and purity percentage at 12th month, whereas the purity percentage at 10th month had non-significant but positive genotypic and phenotypic correlations with this character.

The pol percentage at 10th month had significant positive genotypic correlations with pol percentage at 12th month, purity percentage at 10th month and C.C.S. percentage at 10th and 12th months. Purity percentage at 12th month had non-significant but positive genotypic correlation with pol percentage at 10th month.

At the phenotypic level, all the quality characters such as pol percentage at 12th month and purity and C.C.S. percentages at 10th and 12th months had significant positive correlations with pol percentage at 10th month.

The genotypic and phenotypic correlation coefficients of Pol percentage at 12th month were highly significant and positive with purity and C.C.S.percentages at 10th and 12th months.

The purity percentage at 10th month had non-significant but positive genotypic correlations with purity percentage at 12th month and significant and positive genotypic correlations with C.C.S.percentage at 10th and 12th months.

At the phenotypic level, purity percentage at 10th month recorded highly significant and positive correlations with purity percentage at 12th month and C.C.S.percentage at 10th and 12th months.

The purity percentage at 12th month had non-significant but positive genotypic correlations with C.C.S. percentage at 10th and 12th months.

The phenotypic correlations of purity percentage at 12th month was highly significant and positive with C.C.S. percentage at 10th and 12th months.

The C.C.S.percentage at 10th month recorded highly significant and positive genotypic and phenotypic correlations with C.C.S.percentage at 12th month.

4.2.4 Path analysis

The number of millable canes per plot, cane weight, length of cane, number of internodes, length of internode and girth of cane are considered as components of cane yield. The juiciness, brix and pol percentage at 12th month are taken as the components of C.C.S.percentage. The cane yield and C.C.S.percentage are considered as components of sugar yield.

The direct and indirect effects of six components on cane yield, three components on C.C.S.percentage and the two components on sugar yield along with their respective genotypic correlations are presented in Tables 15, 16 and 17 respectively. The path diagram representing the path coefficients (direct effects) and the genotypic correlations are presented in Figure 7.

In the first ratoon crop, the number of millable canes per plot had maximum direct effect (1.16) on cane yield. This component exerts positive indirect effects on cane yield through number of internodes (0.17) and length of internode (0.11). The number of millable canes per plot also exerts a very high negative indirect effect (-0.49) on cane yield through length of cane and low negative indirect effects through cane weight (-0.05) and girth of cane (-0.08).

The cane weight is the second component having high direct effect (0.79). Cane weight exerts positive indirect effects on cane yield via number of internodes

Table 15. Direct and indirect effects of the components on cane yield in the first ratoon crop

Sl. No.	Components	Direct effects	Indirect effects via						Total correlation
			No. of millable canes per plot.	Weight of cane	Length of cane	No. of internodes	Length of internode	Girth of cane	
1.	Number of millable canes per plot	1.16	-	-0.05	-0.49	0.17	0.11	-0.08	0.82
2.	Weight of cane	0.79	-0.07	-	-0.73	0.22	0.16	0.13	0.50
3.	Length of cane	-0.97	0.59	0.59	-	0.38	0.27	0.01	0.87
4.	Number of internodes	0.73	0.27	0.24	-0.51	-	-0.32	-0.02	0.39
5.	Length of internode	0.62	0.20	0.20	-0.42	-0.38	-	0.01	0.23
6.	Girth of cane	0.18	-0.54	0.58	-0.02	-0.08	0.04	-	0.16

Residual effect: 0.041

Table 16. Direct and indirect effects of the components on C.C.S. percentage in the first ratoon crop

Sl. No.	Components	Direct effects	Indirect effects via			Total correlation
			Juiciness at 12th month	Brix at 12th month	Pol at 12th month	
1.	Juiciness at 12th month	-0.03	-	0.28	-0.03	0.22
2.	Brix at 12tn month	1.23	-0.01	-	-0.22	1.00
3.	Pol at 12th month	-0.21	-0.01	1.22	-	1.00

Residual effect: 0.016

Table 17. Direct and indirect effects of the components on sugar yield in the first ratoon crop

Sl. No.	Components	Direct effects	Indirect effects via		Total correlation
			Cane yield per plot	C.C.S.percentage at 12th month	
1.	Cane yield per plot	0.86	-	0.08	0.94
2.	C.C.S.Percentage at 12th month	0.30	0.23	-	0.53

Residual effect : 0.157

Fig.7. Path diagram showing the direct effects and interrelationships of cane yield per plot, C.C.S percentage and sugar yield per plot in the first ratoon crop.

C.Y - <u>Cane yield per plot</u>

1. Number of millable canes per plot
2. Weight of cane
3. Length of cane
4. Number of internodes
5. Lengthof internode
6 Girth of cane

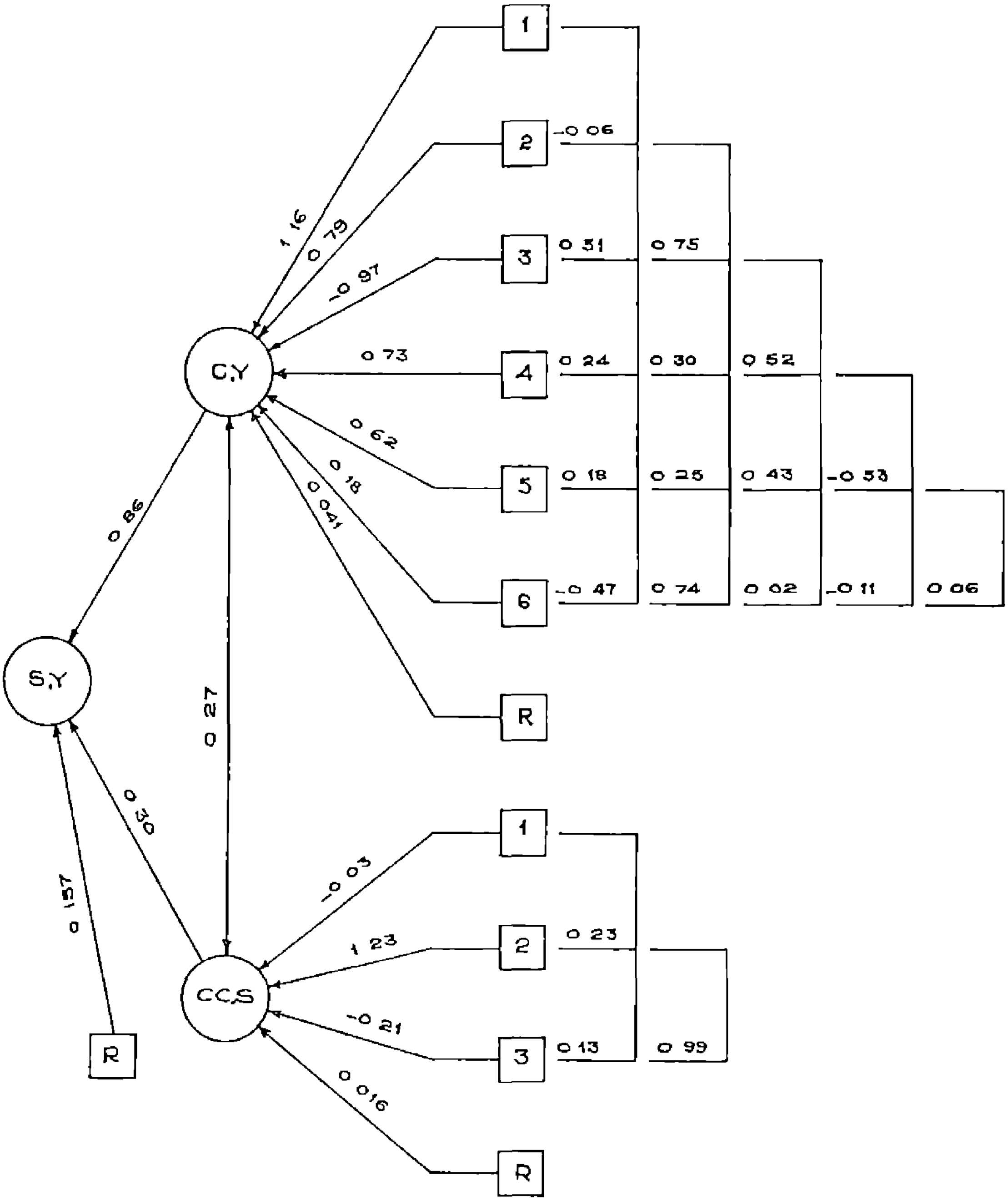
C.C.S - <u>Commercial cane sugar percentage</u>

1. Juiciness at 12th month
2. Brix at 12th month
3. Pol at 12th month

S.Y - <u>Sugar yield per plot</u>

R - Residual effect.

FIG 7 PATH DIAGRAM SHOWING THE DIRECT EFFECTS AND INTER-RELATIONSHIPS OF CANE YIELD PER PLOT, C C S PERCENTAGE AND SUGAR YIELD PER PLOT IN THE FIRST RATOON CROP



DIRECT EFFECTS SHOWN IN ARROWS INTERRELATIONSHIPS SHOWN IN STEPS

(0.22), length of internode (0.16) and girth of cane (0.13), while this component had high negative indirect effect (-0.73) through length of cane and low negative effect through number of millable canes per plot (-0.07).

The number of internodes, the third component with maximum direct effect (0.73) on cane yield, exerts positive indirect effects through number of millable canes per plot (0.27) and cane weight (0.24), while the indirect effects of number of internodes on cane yield through length of cane (-0.51), length of internode (-0.32) and girth of cane (-0.02) were negative.

The length of internode exerts positive direct effect on cane yield (0.62) and indirect effects through number of millable canes per plot (0.20), cane weight (0.20) and girth of cane (0.01). The high negative indirect effect of length of internode on cane yield through length of cane (-0.42) and number of internodes (-0.38) considerably reduced the genotypic correlations of length of internode with cane yield.

The girth of cane had a low positive direct effect (0.16) on cane yield. This component exerts high positive indirect effect on cane yield through cane weight (0.58) and low indirect effect through length of internode. The girth of cane had high negative indirect effect on cane yield via. number of millable canes per plot (-0.54) and low negative indirect effects through length of cane (-0.02) number of internodes (-0.08), thereby reducing the positive genotypic correlations of girth of cane and cane yield.

The length of cane exerts high negative direct effect (-0.97) on cane yield, even though the genotypic correlation between length of cane and cane yield is highly significant and positive. The length of cane had positive indirect effects on cane yield through the remaining five components such as number of millable canes per plot (0.59), cane weight (0.59), number of internodes (0.38), length of internode (0.27) and girth of cane (0.01).

The low residual effect indicates that most of the genetic variability for cane yield and its components has been accounted by this model. The number of millable canes per plot, cane weight and number of internodes, which had high positive direct effects on cane yield may be considered during Selection programmes for increasing the yield of cane.

Among the three components of C.C.S. percentage, the brix at 12th month had maximum positive direct effect (1.23), where as the pol percentage at 12th month (-0.21) and juiciness at 12th month(-0.03) had negative direct effects on C.C.S. percentage. The pol percentage at 12th month exerts high positive indirect effect on C.C.S. percentage through brix at 12th month (1.22) and very low negative indirect effect through juiciness at 12th month (-0.01).

The juiciness at 12th month exerts high positive indirect effect on C.C.S. percentage through brix at 12th month (0.28) and low negative indirect effect (-0.03) through Pol percentage at 12th month.

The residual effect is very low indicating that most of the variability for C.C.S. percentage has been accounted by this model. The brix at 12th month, which had maximum direct effect on C.C.S. percentage may be considered during selection programmes for increasing the sugar recovery.

Among the two components of sugar yield, the cane yield had high positive direct effect (0.86) rather than C.C.S. percentage at 12th month (0.30). The cane yield exerts very low positive indirect effect on sugar yield through C.C.S. percentage (0.08) which in turn exerts comparatively high positive indirect effect (0.23) through cane yield. By increasing the cane yield per plot rather than C.C.S. percentage, the sugar yield per plot can be increased. The residual effect is very low indicating that most of the variability for sugar yield has been accounted by this model.

4.3. Location trials

The fifteen clones selected for multilocation trials were evaluated at three locations viz. Sugarcane Research Station, Thiruvalla, Sugarcane Research Centre, Chitoor and Horticultural Research Station, Ambalavayal. The data collected from the plant crop were subjected to location wise analysis of variance and the abstract of ANOVA for eight characters at three locations are presented in Table 18. At Thiruvalla, the clones revealed significant differences in respect of all the characters except pol percentage. At Chittoor, the clones showed significant differences in respect of all the characters except length of cane. At Ambalavayal, the clones revealed significant differences in respect of all the eight characters studied.

Table 18. Analysis of variance for the plant crop at three locations

Sl. No.	Characters	Mean squares											
		Thiruvalla				Chittoor				Ambalavayal			
		Replications	Clones	Error	F (clones)	Replications	Clones	Error	F (clones)	Replications	Clones	Error	F (clones)
1.	Number of millable canes per plot	8101.63	976.20	188.35	5.18**	1080.00	1509.05	473.28	3.19*	30.00	2501.83	624.93	4.00*
2.	Weight of cane (kg)	0.23	0.07	0.01	7.00**	0.03	0.10	0.01	10.00**	0.02	0.09	0.01	9.00**
3.	Length of cane (m)	1.47	0.15	0.02	7.50**	0.03	0.13	0.06	2.16	0.01	0.15	0.02	7.50**
4.	Girth of cane (cm)	0.16	1.17	0.46	2.54*	0.40	0.80	0.25	3.20*	0.24	1.10	0.15	7.33**
5.	Cane yield per plot (kg)	31538.17	3245.27	465.85	6.97**	3032.08	2175.01	769.89	2.82*	54.67	1780.27	511.58	3.48*
6.	Brix (%)	1.81	1.22	0.36	3.38*	0.01	9.50	0.96	9.89**	3.61	1.87	0.34	5.50**
7.	Pol (%)	0.92	2.24	0.97	2.31	1.10	5.37	1.34	4.01**	2.31	1.55	0.55	2.81*
8.	Sugar yield per plot (kg)	361.23	63.92	7.55	8.47**	24.41	38.92	9.50	4.09**	5.27	32.91	6.64	4.95**

* Significant at 5 per cent probability level

** Significant at 1 per cent probability level

The genetic parameters such as G.C.V., P.C.V., heritability and genetic advance estimated for the eight characters on 15 clones at the three locations are presented in Table 19. The histogram representing the genotypic coefficient of variation, heritability and genetic advance for the eight characters at the three locations are presented in Figure 8.

The sugar yield per plot recorded the maximum G.C.V (25.7) followed by cane yield per plot (20.7) and number of millable canes per plot (13.7) at Thiruvalla. At Chittoor also, the maximum G.C.V was recorded by sugar yield per plot (20.5) followed by cane yield per plot (15.8) and number of millable canes per plot (15.0). At Ambalavayal, the highest G.C.V was recorded by sugar yield per plot (23.7) followed by number of millable canes per plot (21.7) and cane yield per plot (20.3).

Heritability in the broad sense was the maximum for sugar yield per plot (78.9) followed by length of cane (78.7) and cane yield per plot (74.9) at Thiruvalla. At Chittoor, the highest heritability was for cane weight

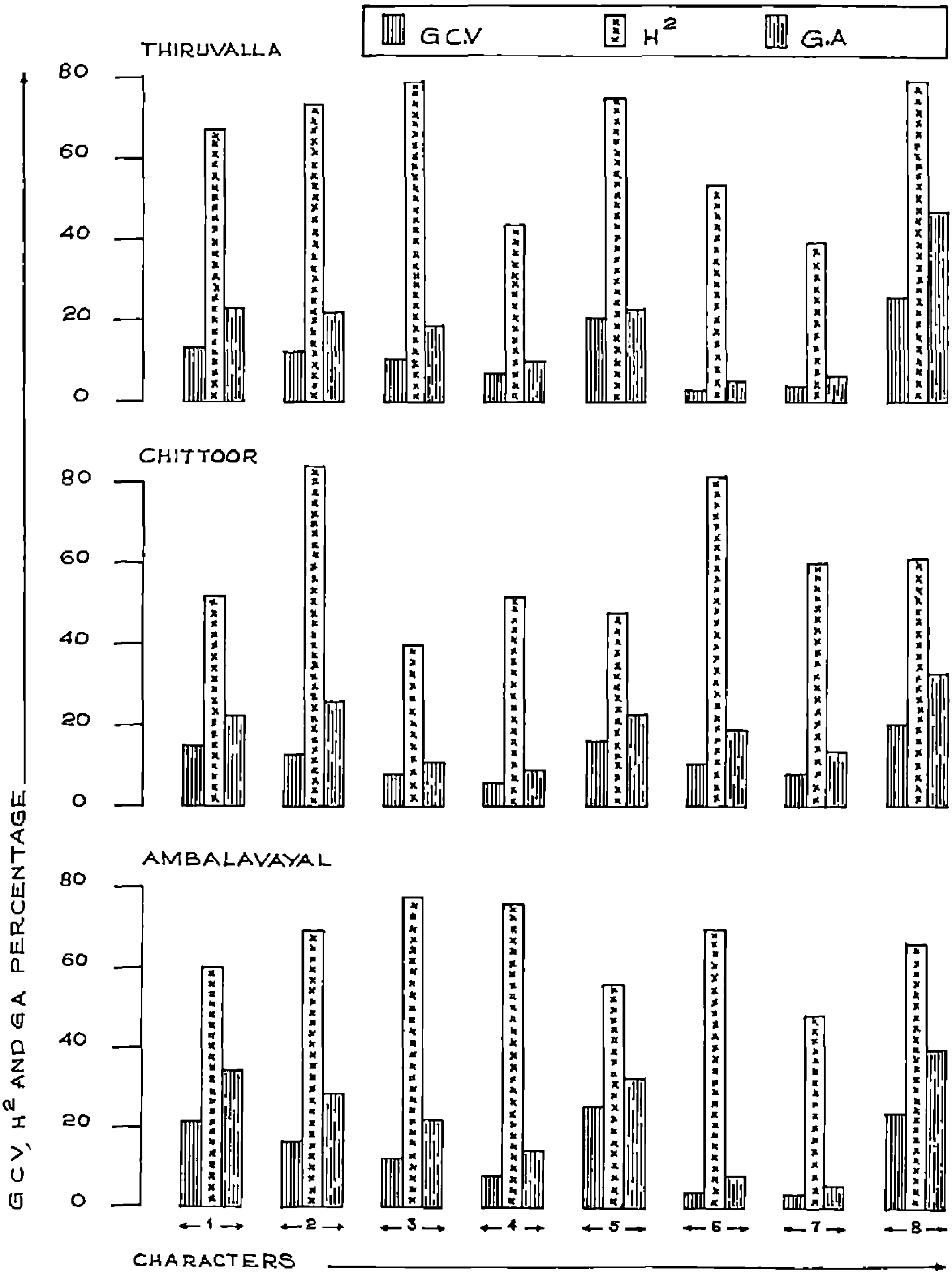
Table 19 Estimates of genetic parameters in the plant crop at 3 locations

Sl. No.	Character	Coefficients of variation						Heritability			Genetic advance		
		Genotypic			Phenotypic								
		Thiruvalla	Chittoor	Ambalavayal	Thiruvalla	Chittoor	Ambalavayal	Thiruvalla	Chitoor	Ambalavayal	Thiruvalla	Chitoor	Ambalavayal
1	Number of millable canes per plot	13.7	15.0	21.7	16.7	20.8	28.0	67.6	52.2	60.0	23.2	22.4	34.6
2	Weight of cane	12.7	13.6	16.6	14.8	14.8	19.8	73.4	84.7	69.6	22.4	25.7	28.5
3	Length of cane	10.5	8.5	12.2	11.9	13.4	13.8	78.7	39.9	77.9	19.3	11.0	22.2
4	Girth of cane	7.3	6.1	8.2	11.1	8.4	9.5	43.8	51.7	75.8	10.2	8.9	14.8
5	Cane yield per plot	20.7	15.8	20.3	23.9	23.0	27.3	74.9	47.7	55.3	36.9	22.6	31.1
6	Brix	3.5	10.1	4.3	4.7	11.2	5.8	54.3	81.6	69.6	5.2	18.8	7.4
7	Pol	4.8	8.5	4.0	7.6	11.0	5.8	39.6	60.1	47.5	6.2	13.6	5.7
8	Sugar yield per plot	25.7	20.5	23.7	28.9	26.4	29.1	78.9	60.8	66.4	47.1	32.9	39.7

Fig.8. Genetic parameters in the plant crop at three locations.

No.	Characters
1.	Number of millable canes per plot
2.	Weight of cane
3.	Length of cane
4.	Girth of cane
5.	Cane yield per plot
6.	Brix
7.	Pol
8.	Sugar yield per plot

FIG 8 GENETIC PARAMETERS IN THE PLANT CROP AT THREE LOCATIONS



(84.7) followed by brix (81.6) and sugar yield per plot (60.8). At Ambalavayal, the heritability estimate was maximum for length of cane (77.9) followed by girth of cane (75.8) and cane weight and brix (69.6 each).

The genetic advance was highest for sugar yield per plot (47.1) followed by cane yield per plot (36.9) at Thiruvalla. At Chittoor, the sugar yield per plot recorded the maximum genetic advance (32.9) followed by cane weight (25.7). Sugar yield per plot recorded the maximum genetic advance (39.7) followed by number of millable canes per plot (34.6) and cane yield per plot (31.1) at Ambalavayal.

At all the three locations, the sugar yield per plot, cane yield per plot, number of millable canes per plot and cane weight had high genotypic coefficients of variation, heritability and genetic advance indicating the reliability of these characters in selection programmes aimed at the improvement of cane yield and sugar yield.

4.3.1 Cane yield and sugar yield components over locations

4.3.1.1 Number of millable canes

The mean number of millable canes per plot of the 15 genotypes at the three locations are presented in

Table 20 and graphically presented in Figure 9. The clones showed wide variability in respect of this character at all the three locations. At Thiruvalla, the clone Co.997 recorded the maximum number of millable canes per plot (181)followed by Co.7219 (175), while at Chittoor, the clone Co.785 recorded the maximum number of millable canes per plot (187) followed by Co.997 (178). At Ambalavayal, the clone Co.995 had the maximum number of millable canes per plot (226) followed by Co.997 (187). The clone Co.997 recorded the highest mean number of millable canes per plot (182) over the three locations followed by Co.995 (179).

4.3.1.2 Weight of cane

The mean cane weight of the 15 genotypes at the three locations are presented in Table 21 and the histogram representing the cane weight is given in Figure 10. The clone Co.62175 had the maximum cane weight at Thiruvalla (1.75 kg) followed by Co.62174 (1.60 kg) and Co.7219 (1.60 kg). At Chittoor, the maximum cane weight was recorded by the clone S-99 (1.96 kg) followed by Co.6907 (1.95 kg). At Ambalavayal, the clone S-87 had highest cane weight (1.60 kg) followed by Co.62175 (1.42 kg). The clone Co.62175 had the highest mean cane

Table 20. Number of millable canes per plot at 3 locations

Sl. No.	Clones	Thiruvalla	Chittoor	Ambalavayal	Mean
1.	CoC.774	126	110	108	115
2.	Co.62174	108	97	85	97
3.	Co.997	181	178	187	182
4.	Co.62175	126	150	161	146
5.	S-87	141	156	123	140
6.	Co.7219	175	160	134	156
7.	CoC.777	145	164	132	147
8.	Co.740	162	171	128	154
9.	Co.6907	151	172	161	161
10.	CoA.7602	132	131	136	133
11.	S-99	156	150	132	146
12.	CoC.771	159	175	173	169
13.	CoC.671	105	108	109	107
14.	Co.995	153	159	226	179
15.	Co.785	151	187	122	153
	G.M.	144.7	151.2	141.3	145.6

Fig.9. Number of millable canes per plot at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG. 9 NUMBER OF MILLABLE CANES PER PLOT AT THREE LOCATIONS

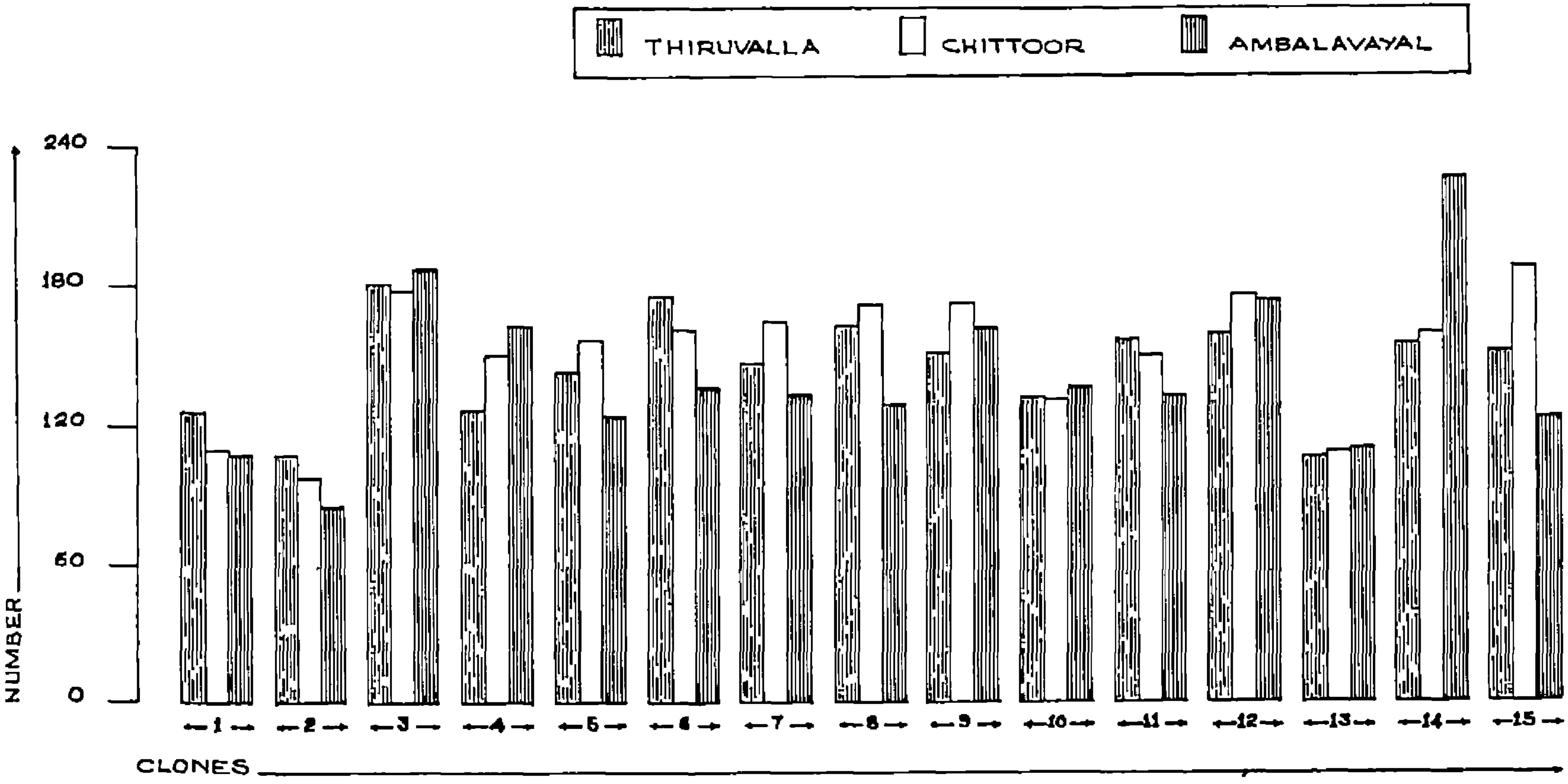


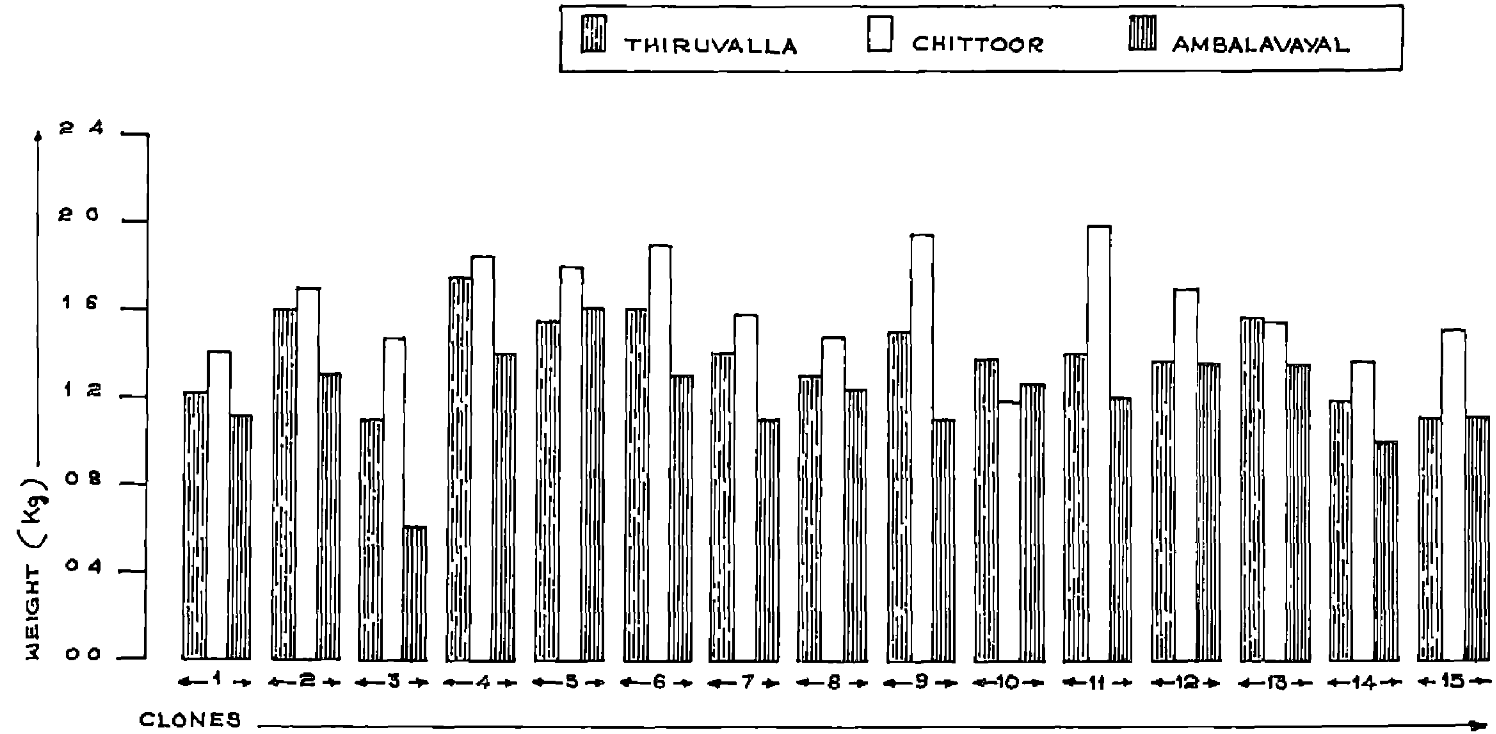
Table 21. Weight of cane (kg) at 3 locations

Sl. No.	Clones	Thiru-valla	Chittoor	Ambala-vayal	Mean
1.	CoC.774	1.23	1.38	1.15	1.25
2.	Co.62174	1.60	1.69	1.32	1.54
3.	Co.997	1.08	1.46	0.60	1.05
4.	Co.62175	1.75	1.85	1.42	1.67
5.	S-87	1.55	1.76	1.60	1.64
6.	Co.7219	1.60	1.86	1.30	1.59
7.	CoC.777	1.42	1.56	1.10	1.36
8.	Co.740	1.32	1.47	1.25	1.35
9.	Co.6907	1.50	1.95	1.15	1.53
10.	CoA,7602	1.37	1.19	1.27	1.28
11.	S-99	1.40	1.96	1.20	1.52
12.	CoC.771	1.37	1.70	1.35	1.47
13.	CoC.671	1.57	1.56	1.35	1.49
14.	Co.995	1.18	1.37	1.02	1.19
15.	Co.785	1.12	1.49	1.12	1.24
	G.M.	1.40	1.62	1.21	1.41

Fig.10. Weight of cane at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG 10 WEIGHT OF CANE AT THREE LOCATIONS



weight (1.67 kg) over the three locations, followed by S-87 (1.64 kg) and Co.7219 (1.59 kg).

4.3.1.3 Length of cane

The mean length of cane of the 15 genotypes at the three locations are presented in Table 22 and the histogram showing the mean length of cane is presented in Figure 11. The clone Co.6907 had the maximum length of cane (2.89 m) followed by S-87 (2.88 m) at Thiruvalla, while at Chittoor, CoC.777 recorded the maximum length of cane (2.62 m) followed by S-87 (2.57 m). The length of cane was maximum in CoC.771 (2.52 m) followed by Co.7219 (2.49 m) at Ambalavayal. The mean length of cane over the three locations was maximum in S-87 (2.63 m) followed by CoC.771 (2.46m) and Co.6907 and Co.62174 (2.43 m each).

4.3.1.4 Girth of cane

The mean girth of cane of the 15 genotypes at the three locations are presented in Table 23 and the graphical representation of the mean girth of cane is given in Figure 12. The clone CoC.774 had the maximum girth at Thiruvalla (9.18 cm) followed by Co.62174 (9.15 cm). At Chittoor, CoC.671 recorded the maximum

Table 22. Length of cane (m) at 3 locations

Sl. No.	Clones	Thiru-valla	Chittoor	Ambala-vayal	Mean
1.	CoC.774	1.95	1.79	1.88	1.91
2.	Co.62174	2.35	2.52	2.43	2.43
3.	Co.997	1.95	1.80	1.58	1.78
4.	Co.62175	2.46	2.44	2.12	2.34
5.	S-87	2.88	2.57	2.45	2.63
6.	Co.7219	2.37	2.31	2.49	2.39
7.	CoC.777	2.57	2.62	2.04	2.41
8.	Co.740	2.66	2.19	1.98	2.28
9.	Co.6907	2.69	2.52	1.89	2.43
10.	CoA.7602	2.33	2.25	2.12	2.23
11.	S-99	2.22	2.25	2.28	2.25
12.	CoC.771	2.38	2.47	2.52	2.46
13.	CoC.671	2.33	2.18	1.84	2.12
14.	Co.995	2.45	2.24	1.94	2.21
15.	Co.785	2.54	2.25	2.24	2.34
	G.M.	2.42	2.29	2.12	2.28

Fig.11. Length of cane at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG 11 LENGTH OF CANE AT THREE LOCATIONS

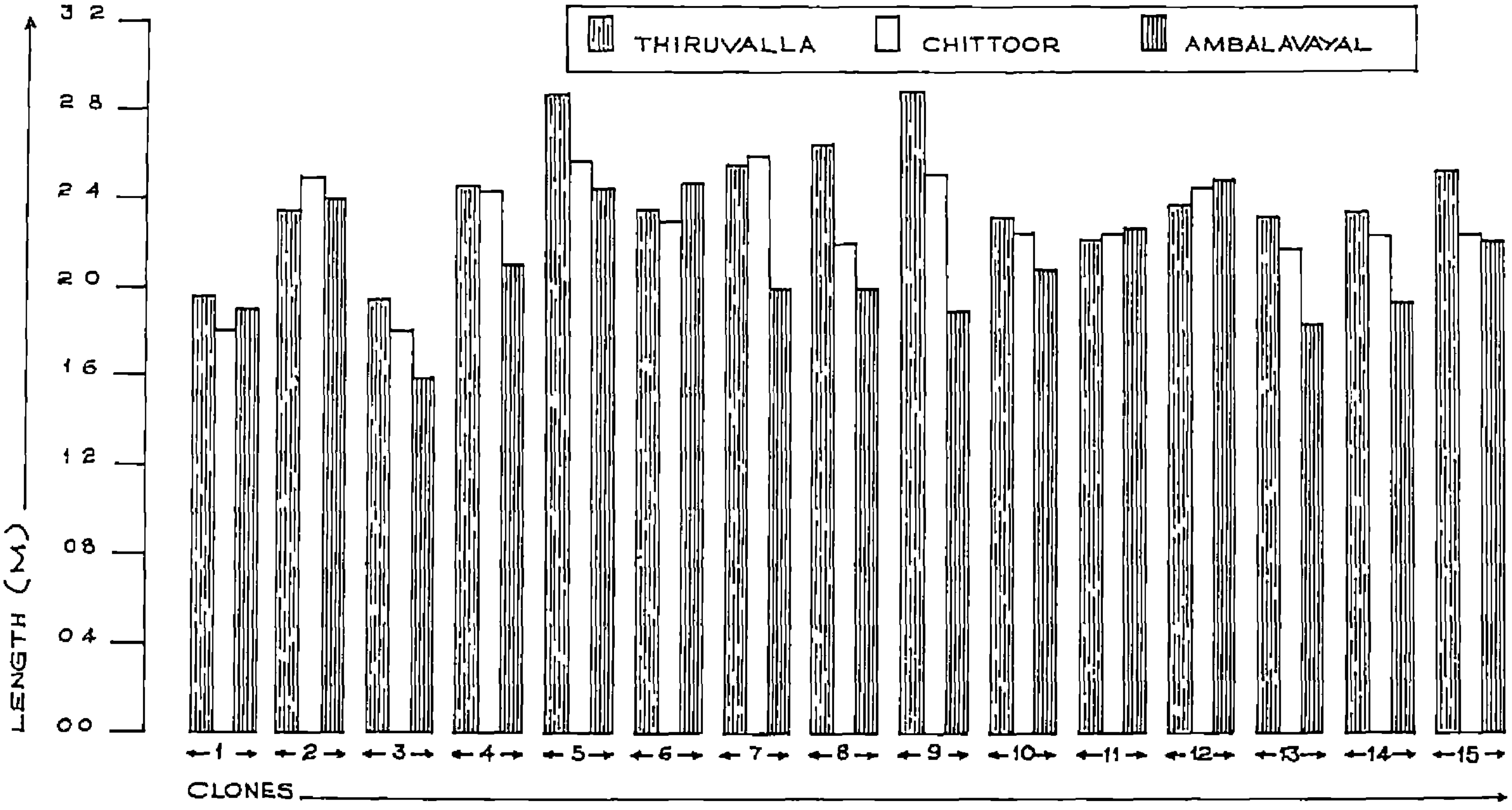


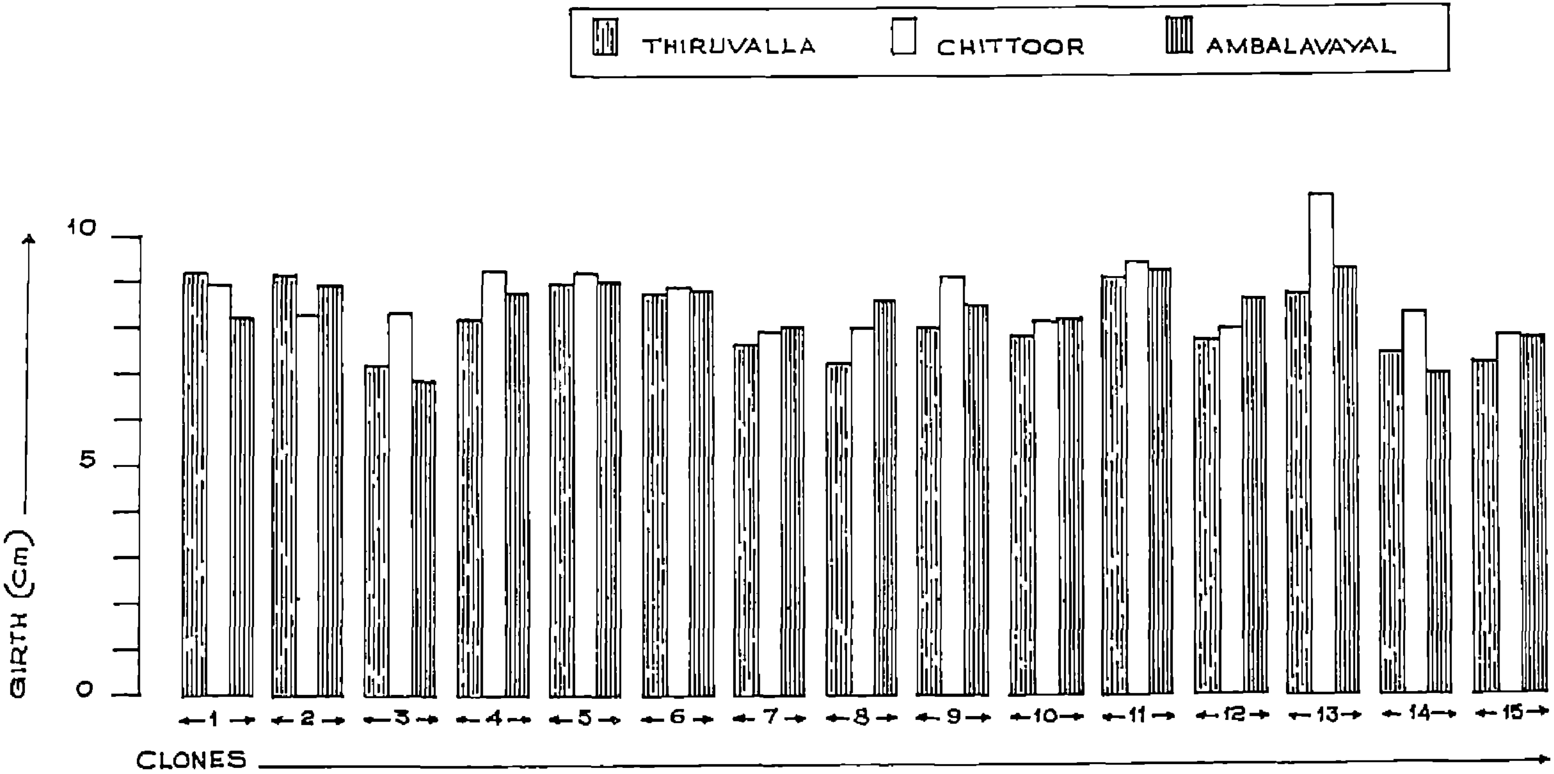
Table 23. Girth of cane (cm) at 3 locations

Sl. No.	Clones	Thiruvalla	Chittoor	Ambalavayal	Mean
1.	CoC.774	9.18	8.90	8.16	8.75
2.	Co.62174	9.15	8.30	8.86	8.77
3.	Co.997	7.15	8.34	6.85	7.45
4.	Co.62175	8.17	9.22	8.73	8.71
5.	S-87	8.90	9.13	8.95	8.99
6.	Co.7219	8.73	8.85	8.84	8.81
7.	CoC.777	7.59	7.94	8.05	7.86
8.	Co.740	7.24	7.97	8.56	7.92
9.	Co.6907	7.96	9.12	8.48	8.52
10.	CoA.7602	7.76	8.10	8.15	8.00
11.	S-99	9.13	9.42	9.22	9.26
12.	CoC.771	7.72	7.89	8.57	8.06
13.	CoC.671	8.70	10.86	9.30	9.62
14.	Co.995	7.41	8.29	6.89	7.53
15.	Co.785	7.19	7.80	7.76	7.58
	G.M.	8.13	8.67	8.36	8.38

Fig.12. Girth of cane at three locations

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG 12 GIRTH OF CANE AT THREE LOCATIONS



girth (10.86 cm) followed by S-99 (9.42 cm). At Ambalavayal also CoC.671 recorded the maximum girth (9.30 cm) followed by S-99 (9.22 cm). The mean girth of cane over the three locations was maximum in CoC.671 (9.62 cm) followed by S-99 (9.26 cm).

4.3.1.5 Yield of Cane

The mean cane yield per plot of 15 genotypes at the three locations are presented in Table 24 and the histogram showing the mean cane yield is given in Figure 13. At Thiruvalla, the clone Co.62175 recorded the maximum cane yield per plot (262 kg) followed by CoC.771 (243 kg). At the other two locations viz. Chittoor and Ambalavayal the clone CoC.771 had maximum cane yield per plot (217 kg and 188 kg respectively) followed by Co.6907 (213 kg and 154 kg respectively). The mean cane yield over the three locations was maximum in CoC.771 (216 kg) followed by Co.62175 (199 kg) and Co.6907 (195 kg).

4.3.1.6 Brix

The mean brix of the 15 clones at the three locations are presented in Table 25 and the graphical presentation of the mean brix is given in Figure 14. At Thiruvalla, Co.997 recorded the maximum brix (20.4)

Table 24. Cane yield per plot (kg) at 3 locations

Sl. No.	Clones	Thiru-valla	Chittoor	Ambala-vayal	Mean
1.	CoC.774	120	108	105	111
2.	Co.62174	136	134	95	122
3.	Co.997	171	138	69	126
4.	Co.62175	262	182	153	199
5.	S-87	206	167	147	173
6.	Co.7219	165	178	141	161
7.	CoC.777	193	198	116	169
8.	Co.740	200	175	132	169
9.	Co.6907	217	213	154	195
10.	CoA.7602	136	177	103	139
11.	S-99	165	160	120	148
12.	CoC.771	243	217	188	216
13.	CoC.671	151	113	98	121
14.	Co.995	186	155	128	156
15.	Co.785	153	192	109	151
	G.M.	180	167	124	157

Fig.13. Cane yield per plot at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG 13 CANE YIELD PER PLOT AT THREE LOCATIONS

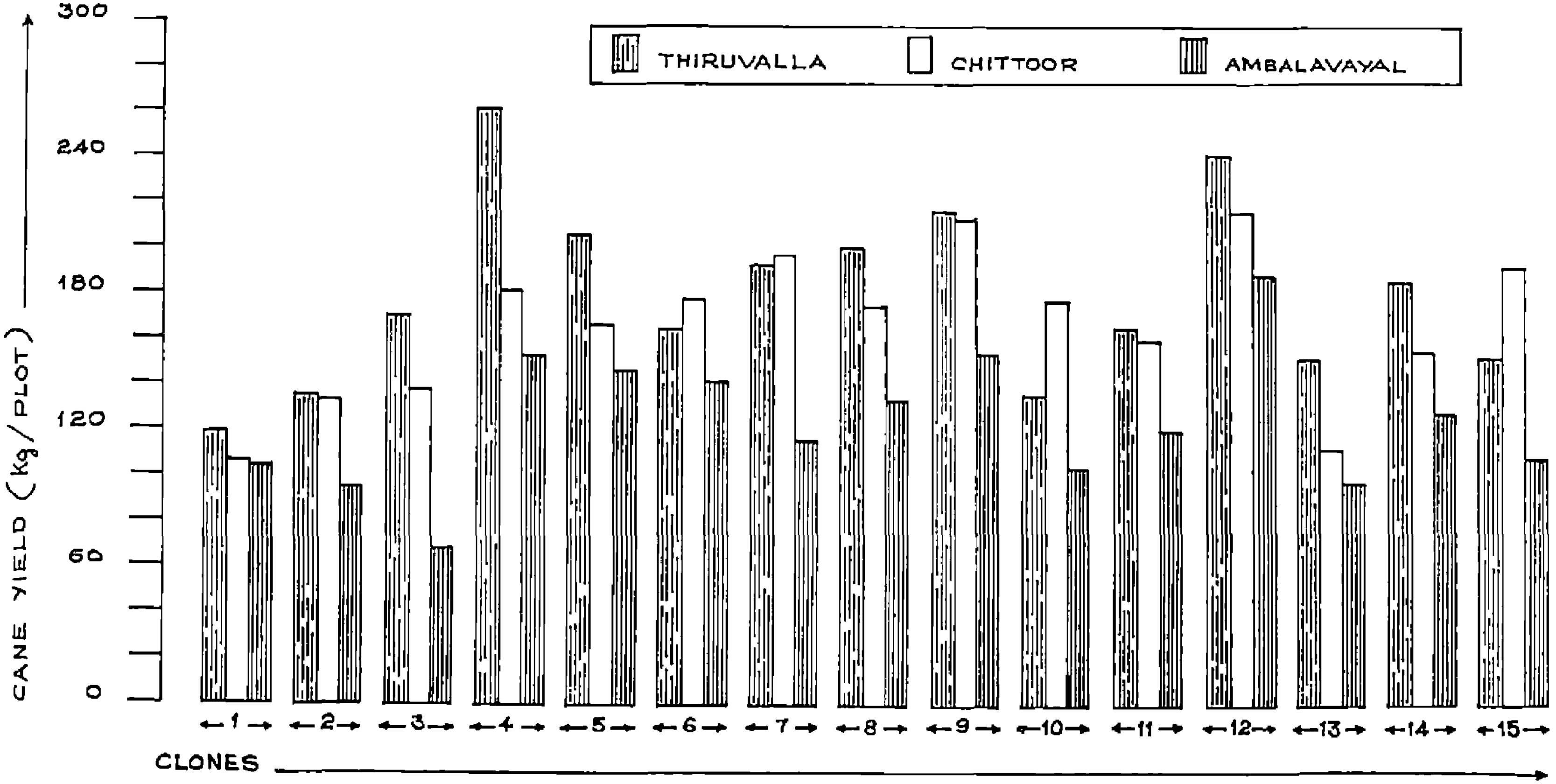


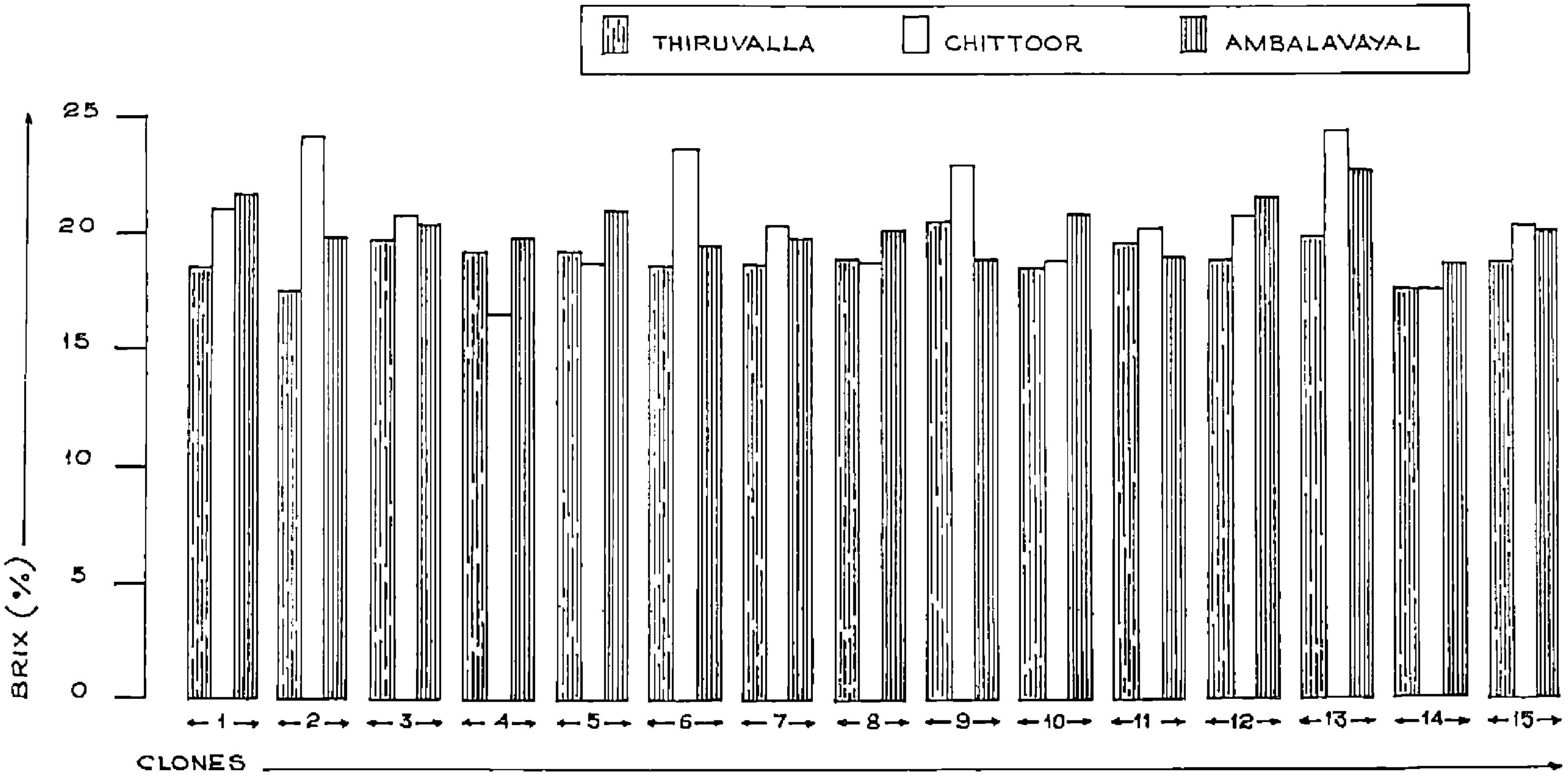
Table 25. Brix at 3 locations

Sl. No.	Clones	Thiru-valla	Chittoor	Ambala-vayal	Mean
1.	CoC.774	18.5	21.0	21.7	20.4
2.	Co.62174	17.5	23.5	19.9	20.3
3.	Co.997	19.7	20.8	20.4	20.3
4.	Co.62175	19.1	16.5	19.8	18.5
5.	S-87	19.1	18.7	21.0	19.6
6.	Co.7219	18.6	23.1	19.5	20.4
7.	CoC.777	18.7	20.4	19.8	19.6
8.	Co.740	18.9	18.8	20.2	19.3
9.	Co.6907	20.4	23.0	18.9	20.8
10.	CoA.7602	18.5	18.8	20.9	19.4
11.	S-99	19.6	20.3	19.0	19.6
12.	CoC.771	18.9	20.9	21.6	20.5
13.	CoC.671	19.9	23.8	22.9	22.2
14.	Co.995	17.6	17.6	18.7	17.9
15.	Co.785	18.8	20.4	20.1	19.8
	G.M.	18.9	20.5	20.3	19.9

Fig.14. Brix at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	Co.A.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG 14 BRIX AT THREE LOCATIONS



followed by CoC.671 (19.9). At Chittoor, CoC.671 recorded the highest brix (23.8) followed by Co.62174 (23.5). At Ambalavayal also CoC.671 had maximum brix (22.9) followed by CoC.774 (21.7). The maximum mean brix over the three locations was recorded by CoC.671 (22.2), followed by Co.6907 (20.8).

4.3.1.7 Pol percentage

The mean pol percentage of the 15 clones at the three locations are presented in Table 26, and the histogram representing the mean pol percentage is given in Figure 15. At Thiruvalla, the maximum pol percentage was recorded by Co.6907 (18.3) followed by CoC.671 (18.1), while at Chittoor the maximum pol percentage was recorded by CoC.671 (19.8), followed by Co.6907 (19.4). At Ambalavayal, the clone CoC.771 had the maximum pol percentage (19.4) followed by CoA.7602 (19.1). The maximum mean pol percentage over the three locations was recorded by CoC.671 (18.9) followed by Co.6907 (18.5).

4.3.1.8 Yield of Sugar

The mean sugar yield per plot of the 15 genotypes at the three locations are presented in Table 27 and the

Table 26. Pol percentage at 3 locations

Sl. No.	Clones	Thiru-valla	Chittoor	Ambala-vayal	Mean
1.	CoC.774	16.0	17.0	17.8	16.9
2.	Co.62174	15.5	16.6	17.5	16.5
3.	Co.997	17.3	16.9	16.9	17.0
4.	Co.62175	17.7	14.2	17.7	16.5
5.	S-87	16.4	16.4	18.1	17.0
6.	Co.7219	16.3	18.5	17.3	17.4
7.	CoC.777	16.0	15.9	17.3	16.4
8.	Co.740	16.7	15.3	16.9	16.3
9.	Co.6907	18.3	19.4	17.8	18.5
10.	CoA.7602	15.4	15.3	19.1	16.6
11.	S-99	16.9	15.9	16.1	16.3
12.	CoC.771	17.2	18.4	19.4	18.3
13.	CoC.671	18.1	19.8	18.8	18.9
14.	Co.995	14.5	15.4	17.2	15.7
15.	Co.785	16.0	16.0	18.2	16.7
	G.M.	16.5	16.7	17.7	17.0

Fig.15. Pol percentage at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG 15 POL PERCENTAGE AT THREE LOCATIONS

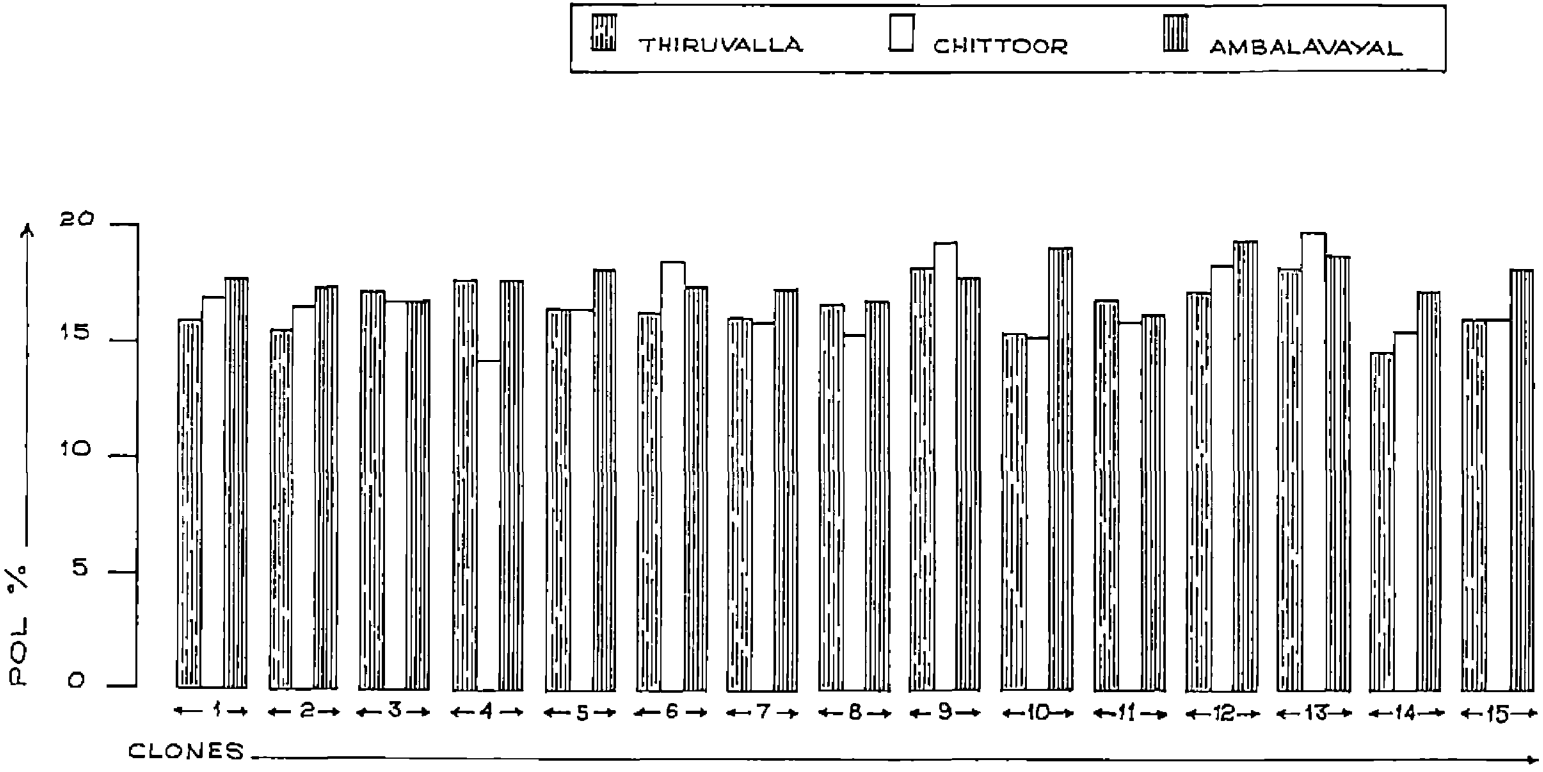


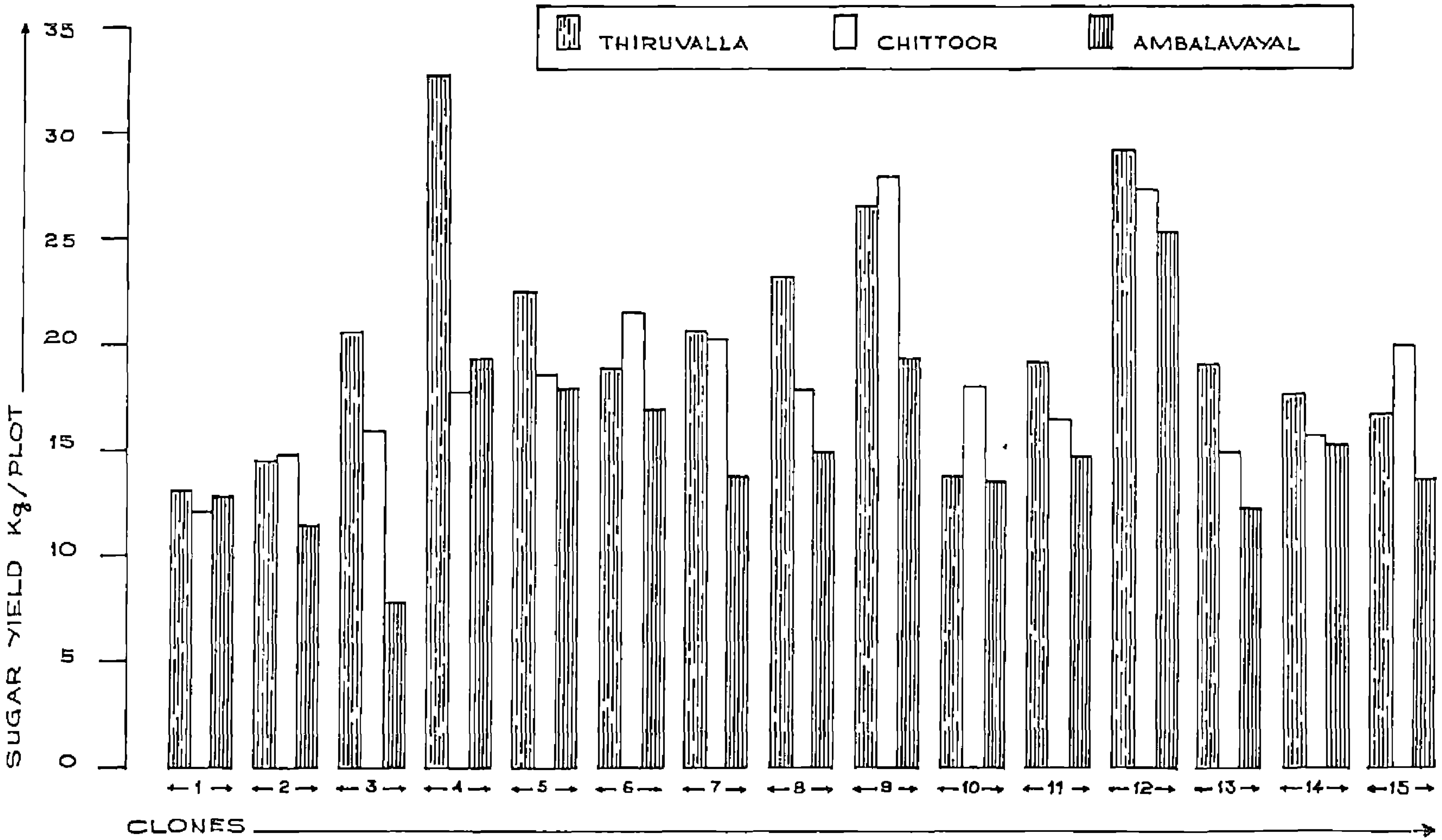
Table 27. Sugar yield per plot (kg) at 3 locations

Sl. No.	Clones	Thiru-valla	Chittoor	Ambala-vayal	Mean
1.	CoC.774	13.1	12.1	12.8	12.7
2.	Co.62174	14.6	14.8	11.5	13.6
3.	Co.997	20.6	16.0	7.8	14.8
4.	Co.62175	32.8	17.9	18.9	23.2
5.	S-87	22.5	18.6	18.0	19.7
6.	Co.7219	18.9	21.6	16.9	19.1
7.	CoC.777	20.7	20.3	13.8	18.3
8.	Co.740	23.1	17.9	15.0	18.7
9.	Co.6907	26.6	28.0	18.9	24.5
10.	CoA.7602	13.9	18.0	13.8	15.2
11.	S-99	19.1	16.5	14.8	16.8
12.	CoC.771	29.2	27.6	25.4	27.4
13.	CoC.671	19.2	15.0	12.4	15.5
14.	Co.995	17.8	15.9	15.4	16.4
15.	Co.785	16.8	20.0	13.8	16.9
	G.M.	20.6	18.7	15.3	18.2

Fig. 16. Sugar yield per plot at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG 16 SUGAR YIELD PER PLOT AT THREE LOCATIONS



sugar yield is graphically presented in Figure 16. At Thiruvalla, Co.62175 recorded the maximum sugar yield (32.8 kg) followed by CoC.771 (29.2 kg). At Chittoor, the maximum sugar yield was recorded by Co.6907 (28.0 kg) followed by CoC.771 (27.6 kg), while at Ambalavayal the clone CoC.771 had the highest sugar yield (25.4 kg) followed by Co.62175 and Co.6907 (18.9 kg each). The maximum mean sugar yield over the three locations was recorded by CoC.771 (27.4 kg) followed by Co.6907 (24.5 kg).

4.3.2 G x E interaction and phenotypic stability

The pooled analysis of variance of the data for eight characters collected from the 15 clones at the three locations revealed that the genotype x environment interaction was highly significant in respect of all the characters except number of millable canes per plot, girth of cane and cane yield per plot. This indicates the need for stability analysis in respect of characters like cane weight, length of cane, brix, pol percentage and sugar yield per plot, which had highly significant G x E interaction. The fifteen selected clones evaluated at the three locations are presented in Figure 17. The ANOVA for phenotypic stability in respect of cane yield, sugar yield and six component characters are presented

Fig.17. Fifteen selected clones evaluated at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

Figure 17

in Table 28. The genotypes revealed highly significant differences for all the characters except brix and pol percentages. For brix, the genotypes did not show any significant difference, whereas for pol percentage the difference was significant only at 5 per cent level. The environments also revealed significant differences in the expression of characters such as cane weight, length of cane, girth of cane, brix and pol percentages, cane yield per plot and sugar yield per plot. The number of millable canes per plot was not affected by the differences in the environment. The linear component alone contributed to the genotype x environment interaction in cane weight and length of cane as shown by their significant F values, whereas the contribution of linear component was negligible in the case of characters like brix and pol percentages and sugar yield per plot. The variance due to pooled deviations are significant for brix and pol percentages and sugar yield per plot, indicating the contribution of non-linear component alone in the G x E interaction and suggesting that the stability of those characters cannot be predicted across environments.

4.3.3. Stability parameters

The stability parameters viz. mean, regression

Table 28. Analysis of variance for phenotypic stability with respect to cane yield, sugar yield and their components

Source of variation	df	Mean squares							
		Number of millable canes per plot	Weight of cane	Length of cane	Girth of cane	Cane yield per plot	Brix	Pol percentage	Sugar yield per plot
Genotypes	14	1822**	0.11**	0.15**	1.17**	2849**	2.90	2.49*	52.0**
Environment	2	387	0.67**	0.34**	0.83**	13108**	11.25**	6.23**	110.6**
G x Env.	28	336	0.02**	0.03**	0.18	376	1.71**	1.05**	7.9*
Env + (G x Env.)	30	@	0.06	0.05	@	@	2.35	1.39	14.8
Env (Linear)	1	@	1.34	0.69	@	@	22.50	12.46	221.1
G x Env.(linear)	14	@	0.02*	0.05**	@	@	1.45	1.04	7.6
Pooled deviation	15	@	0.01	0.12	@	@	1.94**	0.99*	7.7*
Pooled error	42	214	0.01	0.01	0.14	291	0.28	0.48	3.9

* Significant at 5 per cent probability level

** Significant at 1 per cent probability level

@ Values not estimated since G x E interaction was non-significant coefficient (b) and deviation from regression (S_d^2) of the 15 genotypes were estimated in respect of characters such as cane weight, length of cane, brix, pol percentage and sugar yield per plot which had significant G x E interactions.

4.3.3.1 Weight of cane

The mean cane weight (kg), regression coefficient (b) and the deviation from regression (S_d^2), along with variance of environmental means (σ_v^2) and coefficient of of variation of the 15 clones are presented in Table 29. The mean cane weight (kg) against c.v from data on 15 clones at three locations are presented in Figure 18. The clone Co.62175 recorded the highest cane weight (1.7 kg). Eight clones viz Co.62174, Co.62175, S-87, Co.7219, Co.6907, S-99, CoC.771 and CoC.671 recorded higher mean cane weight than the grand mean.

The regression coefficient significantly differed from unity only in one clone viz. Co.997, indicating that it is highly sensitive to environmental changes. The clones Co.62175 and Co.740 had unit regression coefficient showing average response to the three environments.

Table 29. Stability parameters for weight of cane

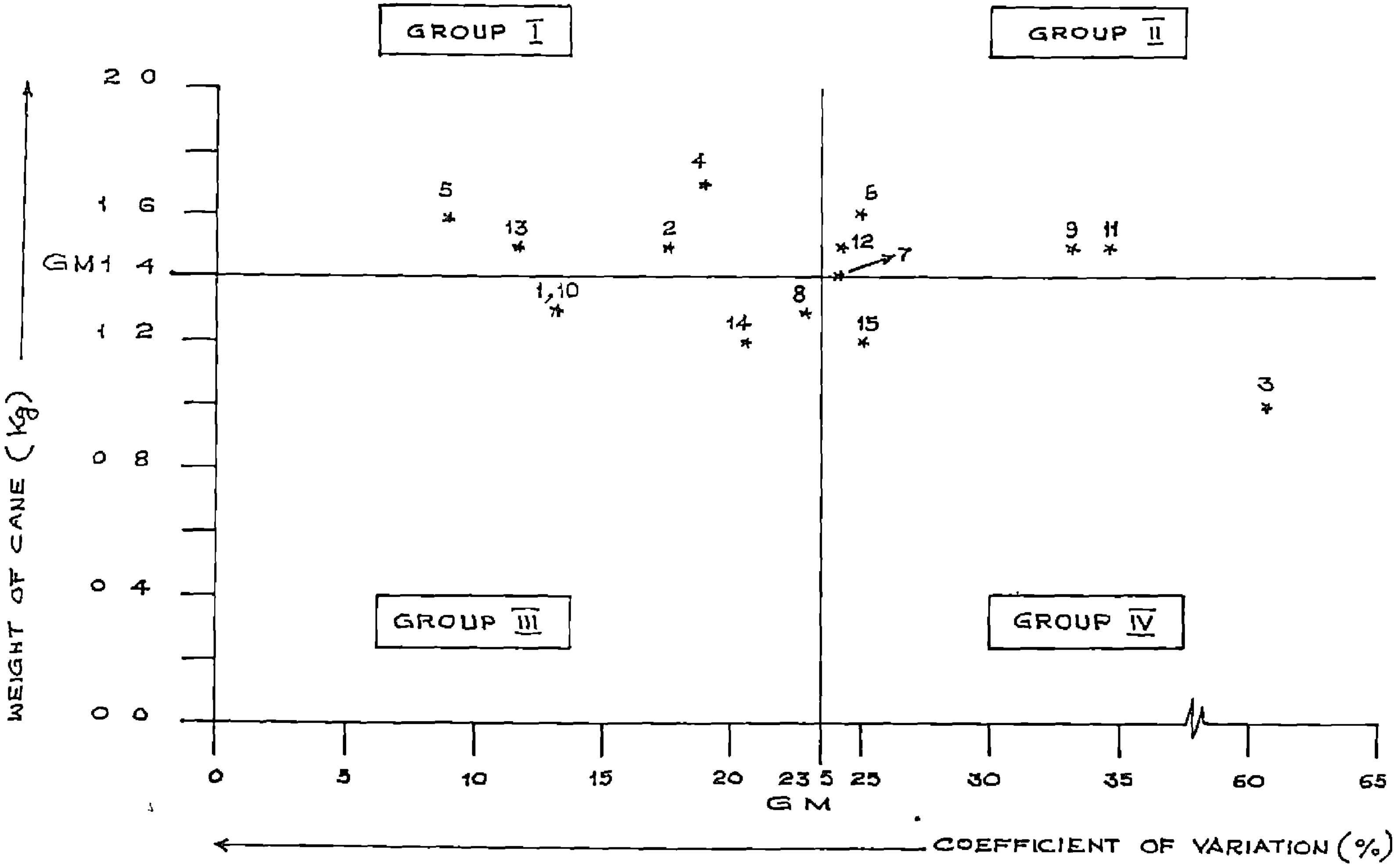
Sl. No.	Clones	Mean (kg)	Regression coefficient (b)	Deviation from regression (S_d^2)	Variance of environmental means (σ_v^2)	Coefficient of variation (c.v)
1.	CoC.774	1.3	0.54	-0.006	0.03	13.3
2.	Co.62174	1.5	0.87	-0.001	0.07	17.6
3.	Co.997	1.0	2.03**	-0.005	0.37	60.8
4.	Co.62175	1.7	1.00	0.002	0.10	18.6
5.	S-87	1.6	0.39	0.005	0.02	8.8
6.	Co.7219	1.6	1.32	-0.006	0.16	25.0
7.	CoC.777	1.4	1.11	-0.001	0.11	23.7
8.	Co.740	1.3	1.00	-0.004	0.09	23.1
9.	Co.6907	1.5	1.65	-0.0001	0.25	33.3
10.	CoA.7602	1.3	0.09	0.021	0.03	13.3
11.	S-99	1.5	1.62	0.024	0.27	34.6
12.	CoC.771	1.5	1.18	-0.003	0.13	24.0
13.	CoC.671	1.5	0.49	0.003	0.03	11.5
14.	Co.995	1.2	0.81	-0.006	0.06	20.4
15.	Co.785	1.2	0.86	0.015	0.09	25.0
	Mean	1.4	-	-	-	23.5
	S.E	0.07	0.316	-	-	-

** Significant at 1 per cent probability level

Fig.18. Weight of cane against c.v. at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG 18. WEIGHT OF CANE AGAINST CV AT THREE LOCATIONS



No clone expressed significant deviation from regression (S_d^2 values) indicating that the performance of the clones are predictable across environments. The eight clones which recorded higher means than the grand mean with non-significant regression coefficients and low deviations from regression are stable genotypes in respect of cane weight.

4.3.3.2 Length of cane

The mean length of cane (m), regression coefficient (b) and deviation from regression (S_d^2) along with variance of environmental means and c.v are presented in Table 30. The mean length of cane (m) against c.v from data on 15 clones in three locations are presented in Figure 19. The clone S-87 had the highest mean length of cane (2.6 m). Six clones viz. Co.62174, S-87, Co.7219, CoC.777, Co.6907 and CoC.771 recorded higher mean length of cane than the grand mean.

The regression coefficients of clones Co.740 and Co.6907 differed significantly from unity indicating that these two clones are very sensitive to changes in the environments. The regression coefficients were negative in clones Co.62174, Co.7219, S-99 and CoC.771 indicating that these clones have below average sensitivity to

Table 30. Stability parameters for length of cane

Sl. No.	Clones	Mean (m)	Regression coefficient (b)	Deviation from regression (s^2_d)	Variance of environmental means (σ^2_v)	Coefficient of variation (c.v)
1.	CoC.774	1.9	0.22	-0.004	0.01	5.3
2.	Co.62174	2.4	-0.24	-0.003	0.01	4.2
3.	Co.997	1.8	1.21	-0.015	0.07	14.7
4.	Co.62175	2.3	1.15	-0.004	0.07	11.5
5.	S-87	2.6	1.42	-0.007	0.10	12.2
6.	Co.7219	2.4	-0.42	-0.007	0.02	5.9
7.	CoC.777	2.4	1.79	0.043	0.20	18.6
8.	Co.740	2.3	2.24*	0.002	0.25	21.7
9.	Co.6907	2.4	3.31**	-0.010	0.51	29.7
10.	CoA.7602	2.2	0.70	-0.015	0.02	6.4
11.	S-99	2.2	-0.22	0.011	0.03	7.9
12.	CoC.771	2.5	-0.44	-0.015	0.01	4.0
13.	CoC.671	2.1	1.63	-0.011	0.13	17.2
14.	Co.995	2.2	1.67	-0.015	0.13	16.4
15.	Co.785	2.3	0.97	-0.007	0.05	9.7
	Mean	2.3	-	-	-	12.4
	S.E	0.08	0.505	-	-	-

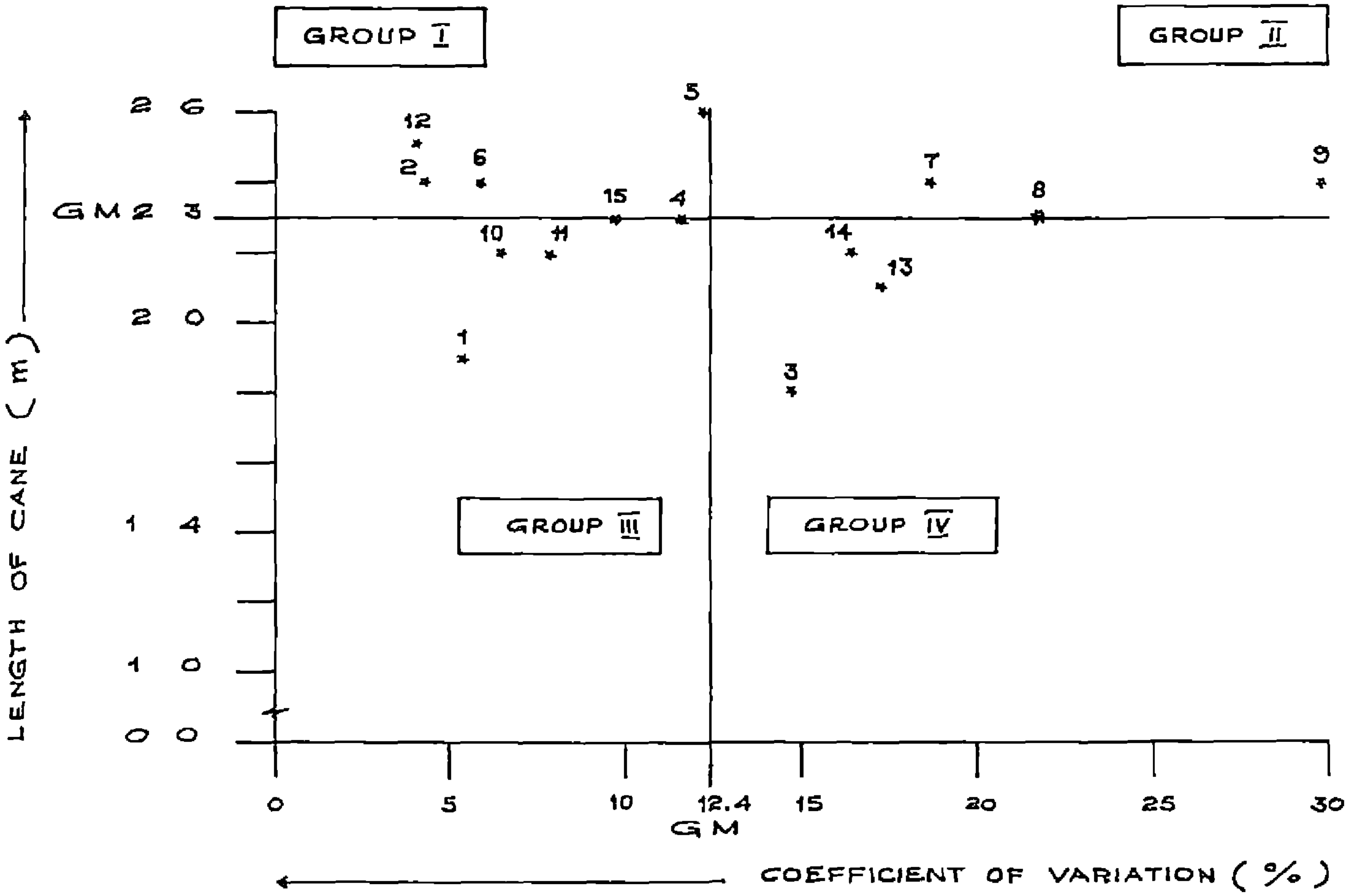
* Significant at 5 per cent probability level

** Significant at 1 per cent probability level

Fig. 19. Length of cane against c.v. at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG.19. LENGTH OF CANE AGAINST C V AT THREE LOCATIONS



environmental changes. The deviation from regression is not significantly different from zero in all the 15 genotypes indicating that the performance of these genotypes are predictable across environments. The clones Co.62174, S-87, Co.7219 and CoC.771 recorded higher mean length of cane than the grand mean along with lower c.v indicating their consistency in performance across environments.

4.3.3.3 Brix

The mean brix, regression coefficient (b) and deviation from regression (S_d^2) along with variance of environmental means and c.v of 15 clones are presented in Table 31. The mean brix against c.v from data on 15 clones at three locations are presented in Figure 20.

The clone CoC.671 recorded the maximum brix (22.2). Seven clones viz. CoC.774, Co.62174, Co.997, Co.7219, Co.6907, CoC.771 and CoC.671 had higher mean brix than the grand mean. No genotype differed significantly from unit regression indicating that all of them had average response. However, the regression coefficient of clone Co.62175 was negative indicating its adaptability to poor environments.

Table 31. Stability parameters for Brix

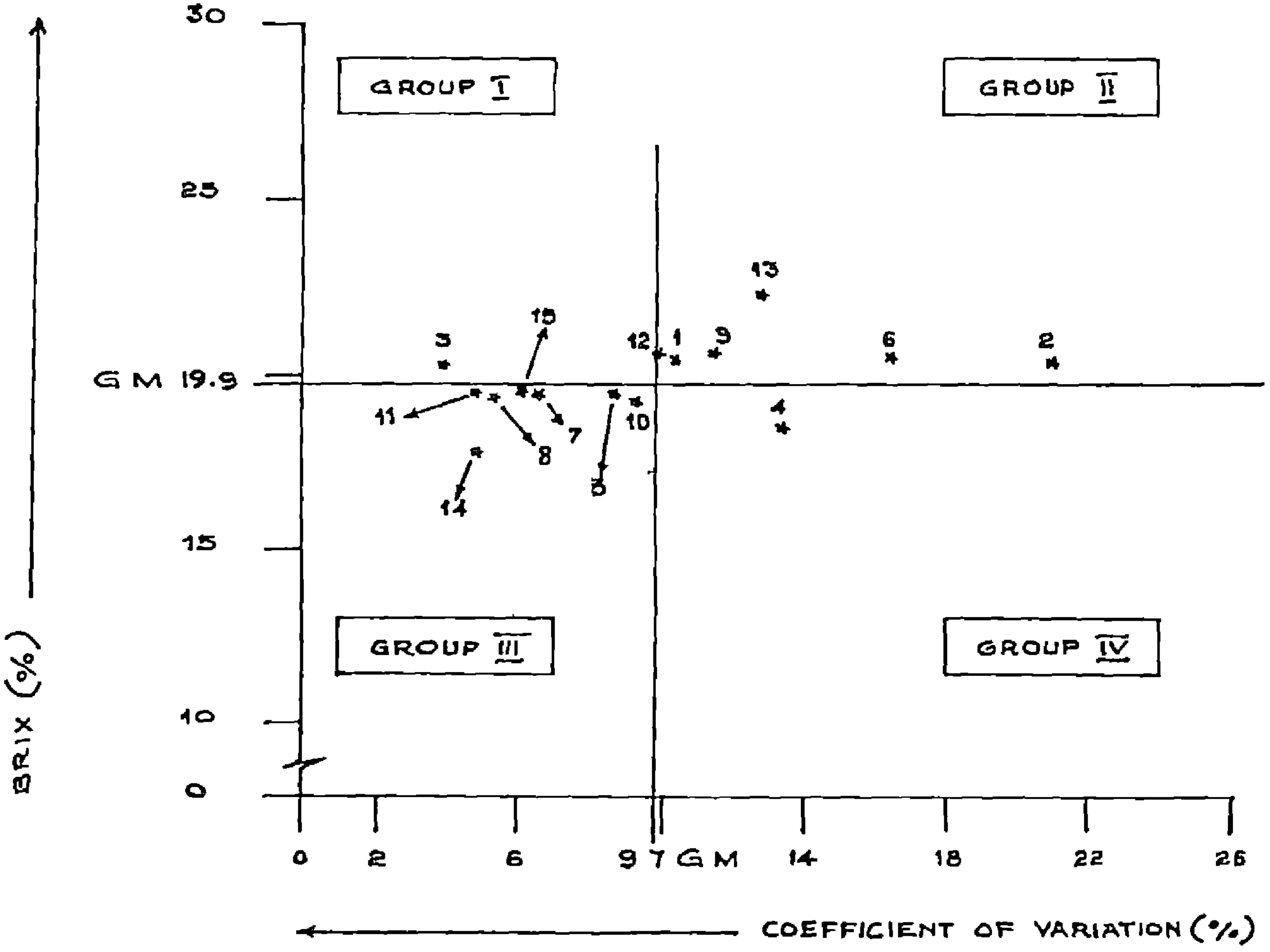
Sl. No.	Clones	Mean (%)	Regression coefficient (b)	Deviation from regression (S^2_d)	Variance of environmental means (σ^2_v)	Coefficient of variation (c.v)
1.	CoC.774	20.4	1.70	-0.126	4.48	10.4
2.	Co.62174	20.3	3.06	3.842**	18.14	21.0
3.	Co.997	20.3	0.65	-0.246	0.66	4.0
4.	Co.62175	18.5	-0.86	4.801**	6.18	13.4
5.	S-87	19.6	0.33	2.499**	2.94	8.7
6.	Co.7219	20.4	2.06	4.687**	11.33	16.5
7.	CoC.777	19.6	1.02	-0.209	1.63	6.5
8.	Co.740	19.3	0.26	0.721	1.10	5.4
9.	Co.6907	20.8	0.92	4.105**	5.65	11.4
10.	CoA.7602	19.4	0.71	2.293**	3.32	9.3
11.	S-99	19.6	0.14	0.566	0.97	5.0
12.	CoC.771	20.5	1.54	0.218	4.03	9.8
13.	CoC.671	22.2	2.22	0.170	7.82	12.6
14.	Co.995	17.9	0.27	0.397	0.78	4.9
15.	Co.785	19.8	0.99	-0.273	1.47	6.1
	Mean	19.9	-	-	-	9.7
	S.E	0.96	1.107	-	-	-

** Significant at 1 per cent probability level

Fig.20. Brix against c.v. at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG 20 BRIX AGAINST C V AT THREE LOCATIONS



The mean square deviations from regression (S_d^2) values of six clones viz. Co.62174, Co.62175, S-87, Co.7219, Co.6907 and CoA.7602 differed significantly from zero indicating that the performance of those six genotypes are not predictable with accuracy across environments. The clone Co.997 alone recorded high mean with low c.v than grand mean. This indicates the consistency of the performance of Co.997 across environments in respect of brix.

4.3.3.4 Pol percentage

The mean pol percentage, regression coefficient (b) and deviation from regression (S_d^2) along with variance of environmental means and c.v of 15 clones are presented in Table 32. The mean pol percentage against c.v from data on 15 clones at three locations are presented in Figure 21. Four clones viz. Co.7219, Co.6907, CoC.771 and CoC.671 had higher mean pol percentage than the grand mean. No genotype differed significantly from unit regression in respect of pol percentage indicating that all of them have average response. The negative regression coefficient recorded for the clones Co.997, Co.6907 and S-99 indicate their below average sensitivity to varying environments.

Table 32. Stability parameters for Pol percentage

Sl. No.	Clones	Mean (µ)	Regression coefficient (b)	Deviation from regression (S_d^2)	Variance of environmental means (σ_v^2)	Coefficient of variation (c.v)
1.	CoC.774	16.9	1.30	-0.163	1.71	7.7
2.	Co.62174	16.5	1.38	-0.087	1.98	8.5
3.	Co.997	17.0	-0.20	-0.414	0.09	1.8
4.	Co.62175	16.5	1.19	6.403**	8.06	17.2
5.	S-87	17.0	1.51	-0.420	1.95	8.2
6.	Co.7219	17.4	1.10	1.936*	2.42	9.0
7.	CoC.777	16.4	1.24	-0.416	1.35	7.1
8.	Co.740	16.3	0.65	0.637	1.46	7.4
9.	Co.6907	18.5	-0.96	0.384	1.48	6.6
10.	CoA.7602	16.6	3.33	-0.281	9.44	18.5
11.	S-99	16.3	-0.40	-0.030	0.58	4.7
12.	CoC.771	18.3	1.58	-0.017	2.55	8.7
13.	CoC.671	18.9	0.01	0.990	1.47	6.4
14.	Co.995	15.7	2.18	-0.443	3.99	12.7
15.	Co.785	16.7	1.97	-0.432	3.26	10.8
	Mean	17.0	-	-	-	9.0
	S.E	0.703	1.09	-	-	-

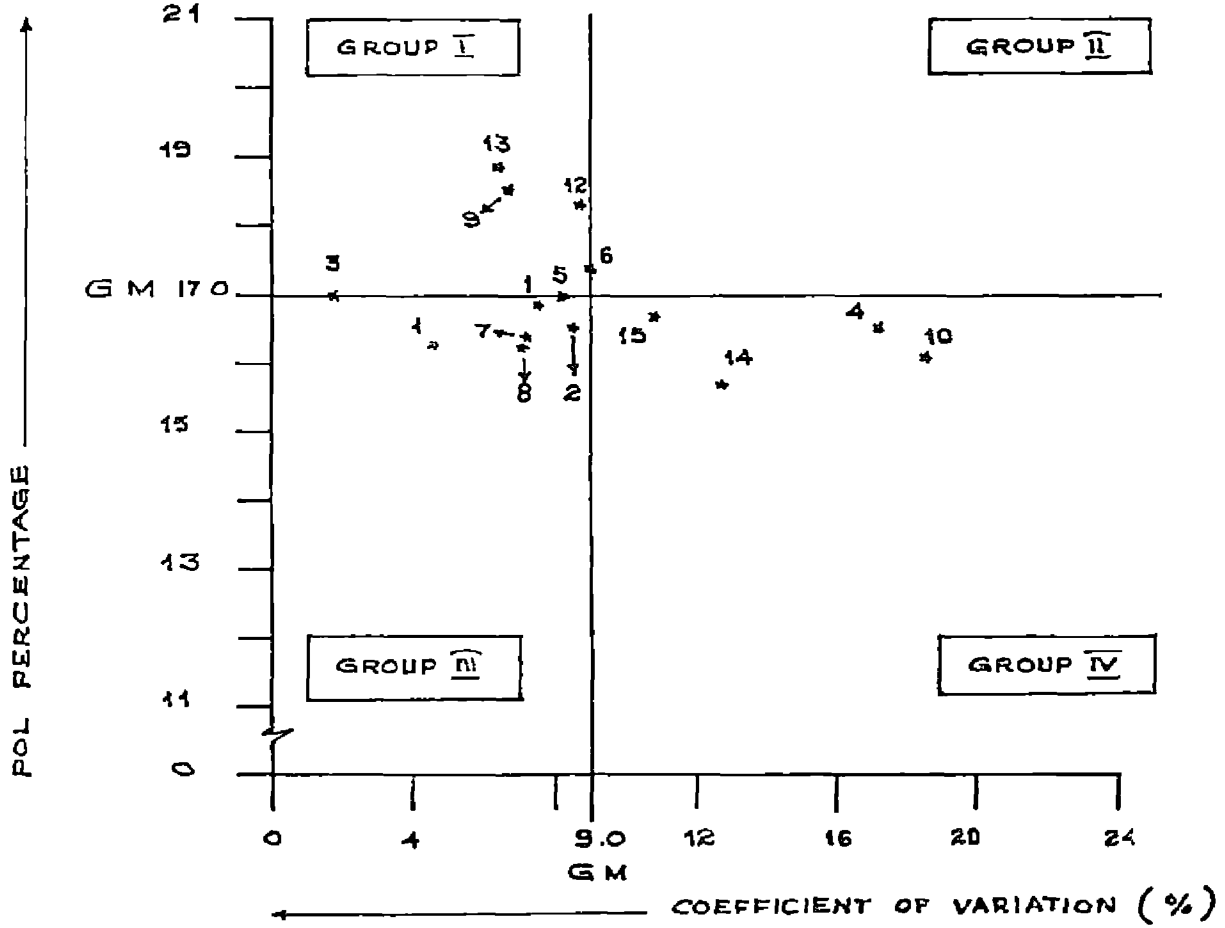
* Significant at 5 per cent probability level

** Significant at 1 per cent probability level

Fig.21. Pol percentage against c.v. at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG 21. POL PERCENTAGE AGAINST C V AT THREE LOCATIONS



The mean square deviations from regression (S_d^2) values differed significantly from zero in two clones viz. Co.62175 and Co.7219 showing that the performance of those genotypes across environments are unpredictable.

The clones Co.6907, CoC.771 and CoC.671 recorded higher means than the grand mean along with low coefficients of variation showing their consistency in performance across environments.

4.3.3.5 Yield of sugar

The mean sugar yield per plot (kg), regression coefficient (b), deviation from regression (S_d^2) along with their variance of environmental means and c.v are presented in Table 33. The mean sugar yield per plot (kg) against c.v from data on 15 clones at three locations are presented in Figure 22. Seven clones viz. Co.62175, S-87, Co.7219, CoC.777, Co.740, Co.6907 and CoC.771 recorded higher mean sugar yield than the grand mean. None of the genotypes differed significantly from unit regression coefficient indicating their average response across environments.

The mean square deviation from regression (S_d^2) differed significantly from zero only in Co.62175

Table 33. Stability parameters for sugar yield per plot

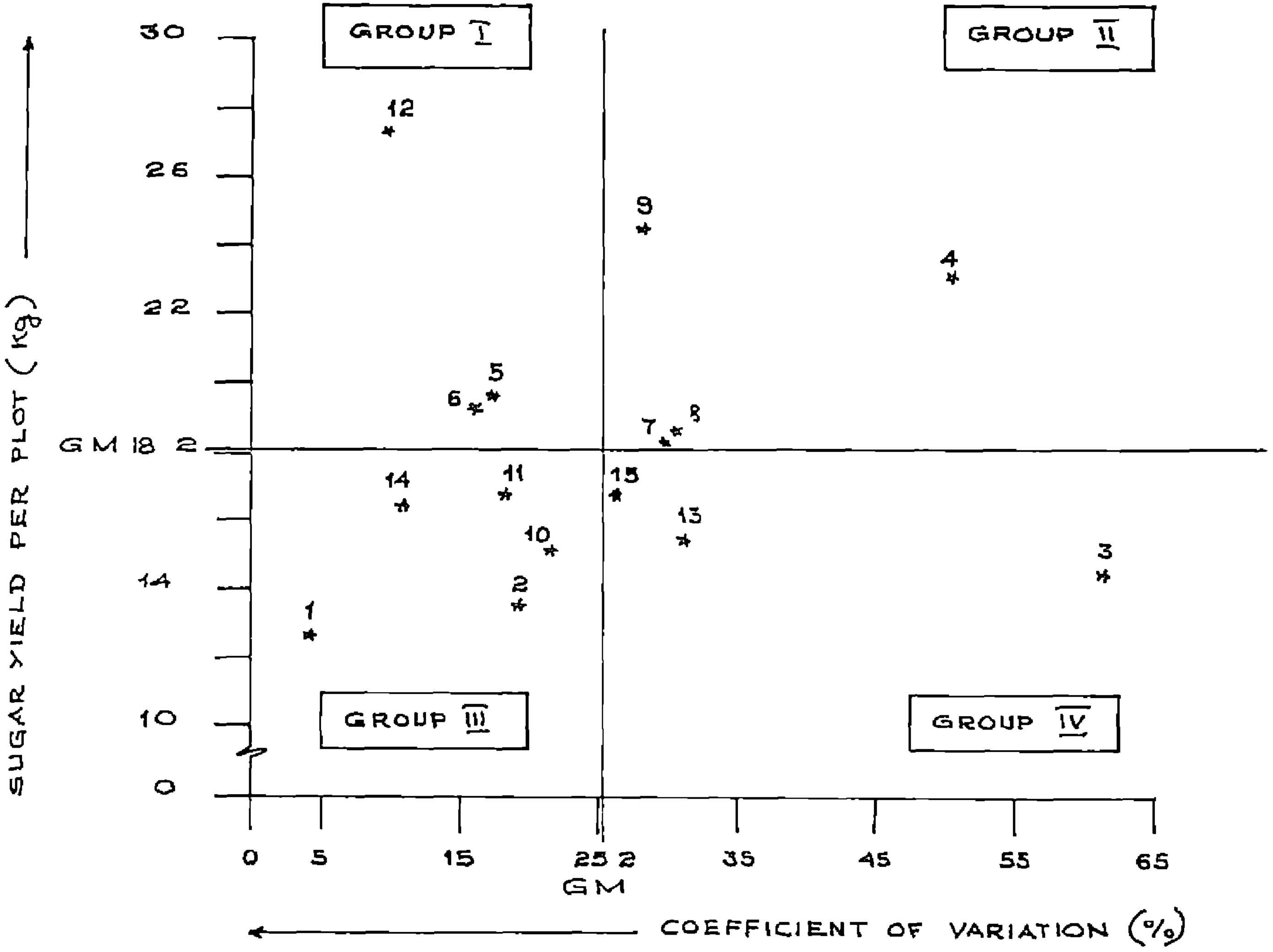
Sl. No.	Clones	Mean (kg)	Regression coefficient (b)	Deviation from regression (S^2_d)	Variance of environmental means (σ^2_v)	Coefficient of variation (c.v)
1.	CoC.774	12.7	0.04	-3.62	0.34	4.6
2.	Co.62174	13.6	0.62	-2.80	6.77	19.1
3.	Co.997	14.8	2.37	-3.89	83.13	61.6
4.	Co.62175	23.2	2.30	58.09**	139.77	50.9
5.	S-87	19.7	0.75	-0.64	11.66	17.3
6.	Co.7219	19.1	0.47	3.79	11.04	17.4
7.	CoC.777	18.3	1.35	-0.84	30.10	30.0
8.	Co.740	18.7	1.45	-0.82	34.11	31.2
9.	Co.6907	24.5	1.72	4.88	47.55	28.1
10.	CoA.7602	15.2	0.14	7.23	11.46	22.3
11.	S-99	16.8	0.77	-3.31	9.35	18.2
12.	CoC.771	27.4	0.70	-3.92	7.19	9.8
13.	CoC.671	15.5	1.22	-2.17	23.70	31.4
14.	Co.995	16.4	0.42	-3.29	3.25	11.0
15.	Co.785	16.9	0.68	8.00	18.89	25.7
	Mean	18.2	-	-	-	25.2
	S.E	1.96	0.724	-	-	-

** Significant at 1 per cent probability level

Fig.22. Sugar yield per plot against c.v. at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG 22. SUGAR YIELD AGAINST C V AT THREE LOCATIONS



indicating its unstable nature in respect of sugar yield.

Only three clones viz. S-87, Co.7219 and CoC.771 had higher mean sugar yield than grand mean along with lower c.v indicating their consistency in performance across environments.

4.3.4 Genotype grouping technique

Genotype x environment interaction was not significant for characters like number of millable canes per plot, girth of cane and cane yield per plot. Therefore, genotype grouping technique was adopted for grouping the genotypes into four groups based on their mean performance and coefficient of variation. The genotypes (clones) coming in group I (higher means than grand mean along with lower c.v) were considered as stable across environments.

4.3.4.1 Number of millable canes per plot

The mean, variance of environmental means(σ_v^2) and coefficient of variation (c.v) in respect of 15 clones are presented in Table 34 and the mean number of millable canes against c.v from data on 15 clones at three locations are presented in Figure 23. The clones Co.997, Co.6907, S-99 and CoC. 771 had higher mean number

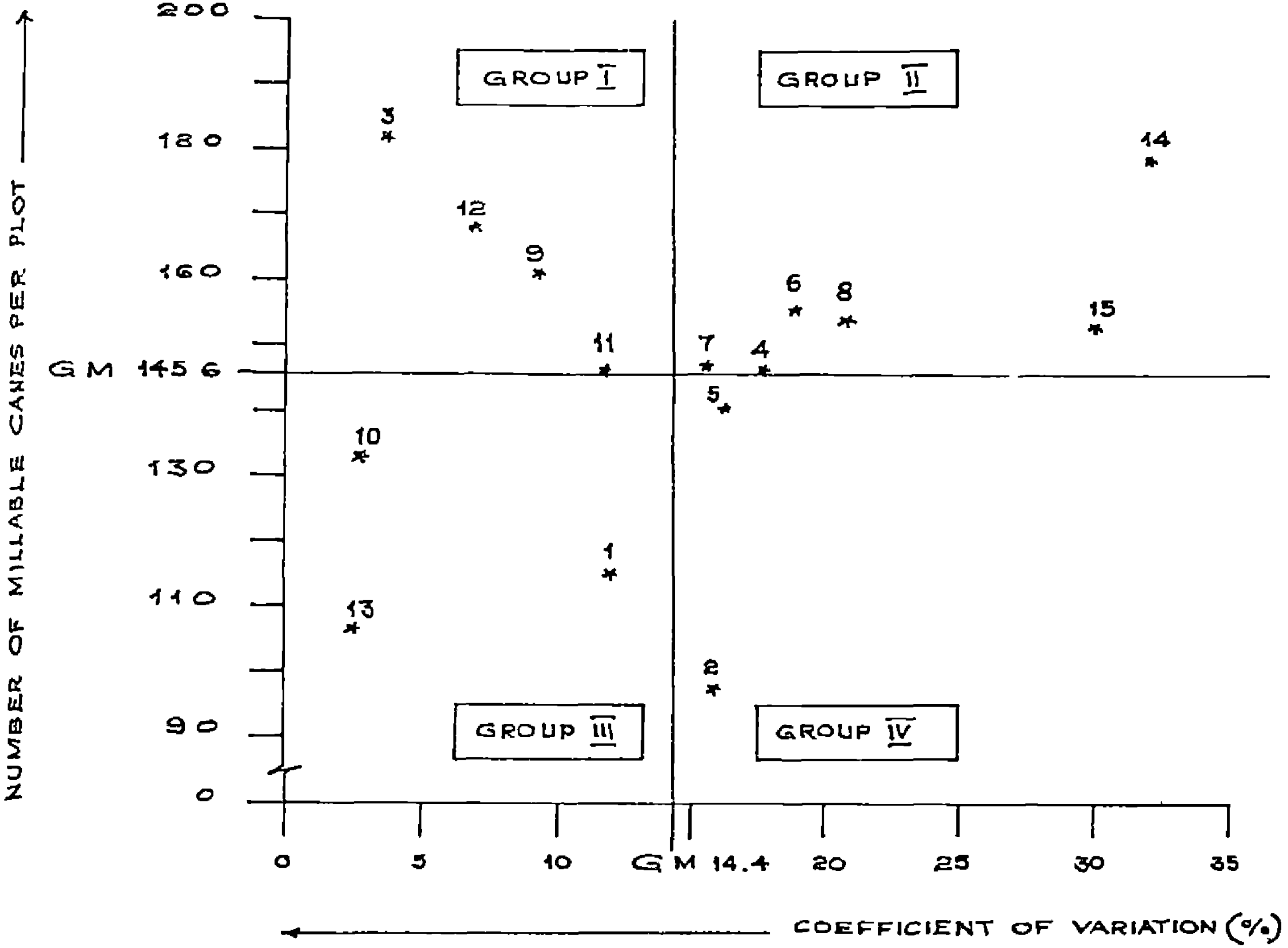
Table 34. Mean, variance of environmental means and coefficient of variation for number of millable canes per plot

Sl. No.	Clones	Mean	Variance of environmental means (σ_v^2)	Coefficient of variation (c.v)
1.	CoC.774	115	190.2	12.0
2.	Co.62174	97	242.2	16.0
3.	Co.997	182	42.0	3.6
4.	Co.62175	146	660.5	17.6
5.	S-87	140	529.2	16.4
6.	Co.7219	156	960.7	13.8
7.	CoC.777	147	520.2	15.5
8.	Co.740	154	1020.5	20.7
9.	Co.6907	161	220.7	9.2
10.	CoA.7602	133	14.0	2.8
11.	S-99	146	298.2	11.8
12.	CoC.771	169	142.2	7.0
13.	CoC.671	107	7.2	2.5
14.	Co.995	179	3305.2	32.1
15.	Co.785	153	2120.7	30.0
	Mean	145.6	-	14.4

Fig.23. Number of millable canes against c.v.
at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG. 23. NUMBER OF MILLABLE CANES AGAINST C V AT THREE LOCATIONS



of millable canes than the grand mean along with lower mean c.v indicating their consistency in performance across environments.

4.3.4.2 Girth of cane

The mean girth of cane (cm), variance of environmental means and c.v of 15 clones are presented in Table 35 and the mean girth of cane against c.v from data on 15 clones at three locations are given in Figure 24. Four clones viz. Co.62174, S-87, Co.7219 and S-99 had higher mean girth of cane than the grand mean along with lower mean c.v indicating their stability and consistency in performance across environments.

4.3.4.3 Yield of cane

The mean cane yield per plot (kg), variance of environmental means and c.v of 15 clones are presented in Table 36. The mean cane yield per plot against c.v from data on 15 clones at three locations are presented in Figure 25.

The clones S-87, Co.7219, Co.740, Co.6907 and CoC.771 recorded higher cane yield per plot than the grand mean along with lower mean c.v indicating the stability and consistency in performance across environments.

Table 35. Mean, variance of environmental means and coefficient of variation for girth of cane

Sl. No.	Clones	Mean	Variance of environmental means (σ_v^2)	Coefficient of variation (c.v)
1.	CoC.774	8.75	0.56	8.5
2.	Co.62174	8.77	0.38	7.0
3.	Co.997	7.45	1.24	14.9
4.	Co.62175	8.71	0.55	8.5
5.	S-87	8.99	0.03	1.9
6.	Co.7219	8.81	0.01	1.1
7.	CoC.777	7.86	0.11	4.2
8.	Co.740	7.92	0.87	11.8
9.	Co.6907	8.52	0.67	9.6
10.	CoA.7602	8.00	0.09	3.7
11.	S-99	9.26	0.04	2.1
12.	CoC.771	8.06	0.40	7.9
13.	CoC.671	9.62	0.57	8.2
14.	Co.995	7.53	1.00	13.3
15.	Co.785	7.58	0.23	6.3
	Mean	8.3	-	7.3

Fig.24. Girth of cane against c.v.
at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG 24 GIRTH OF CANE AGAINST C V AT THREE LOCATIONS

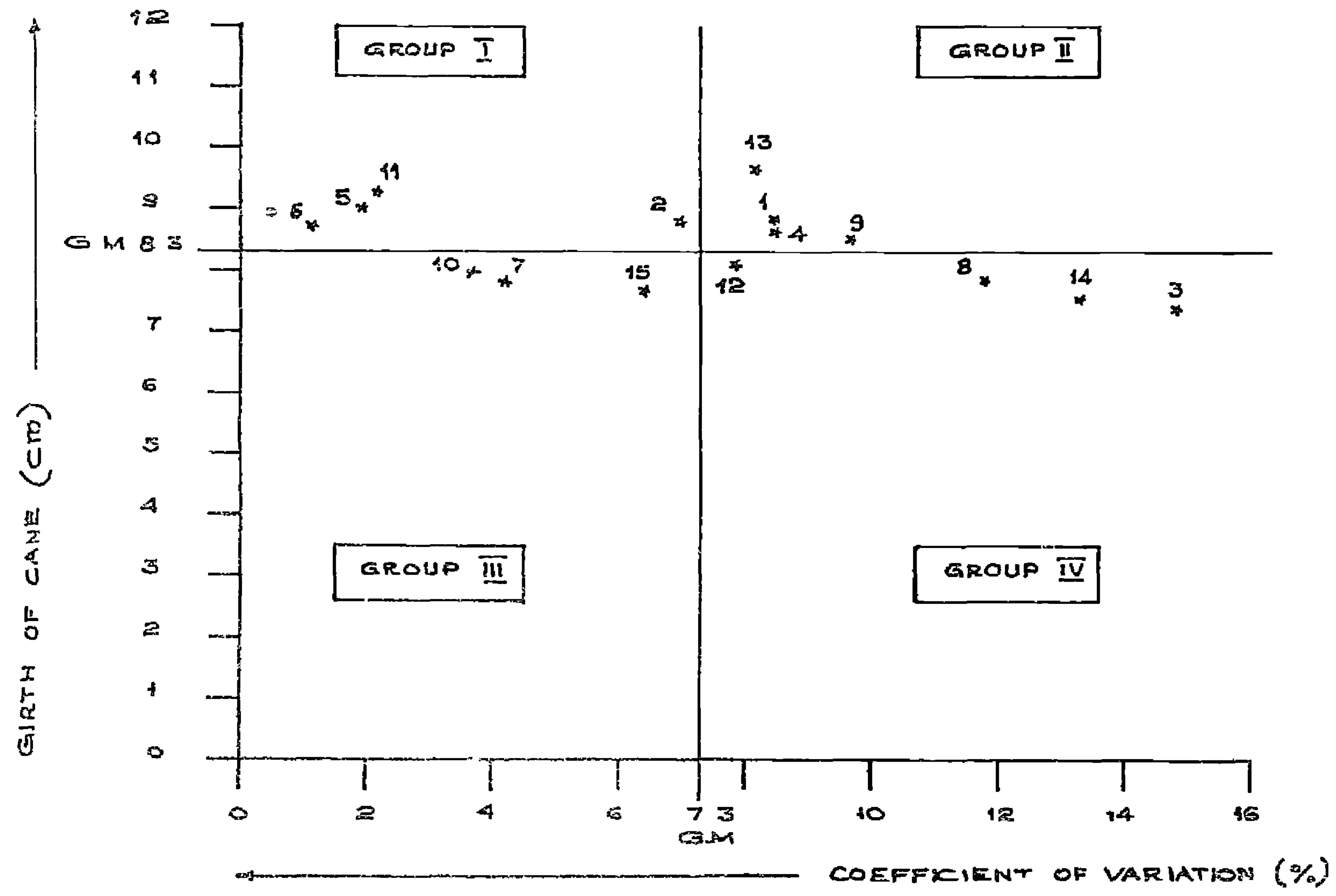


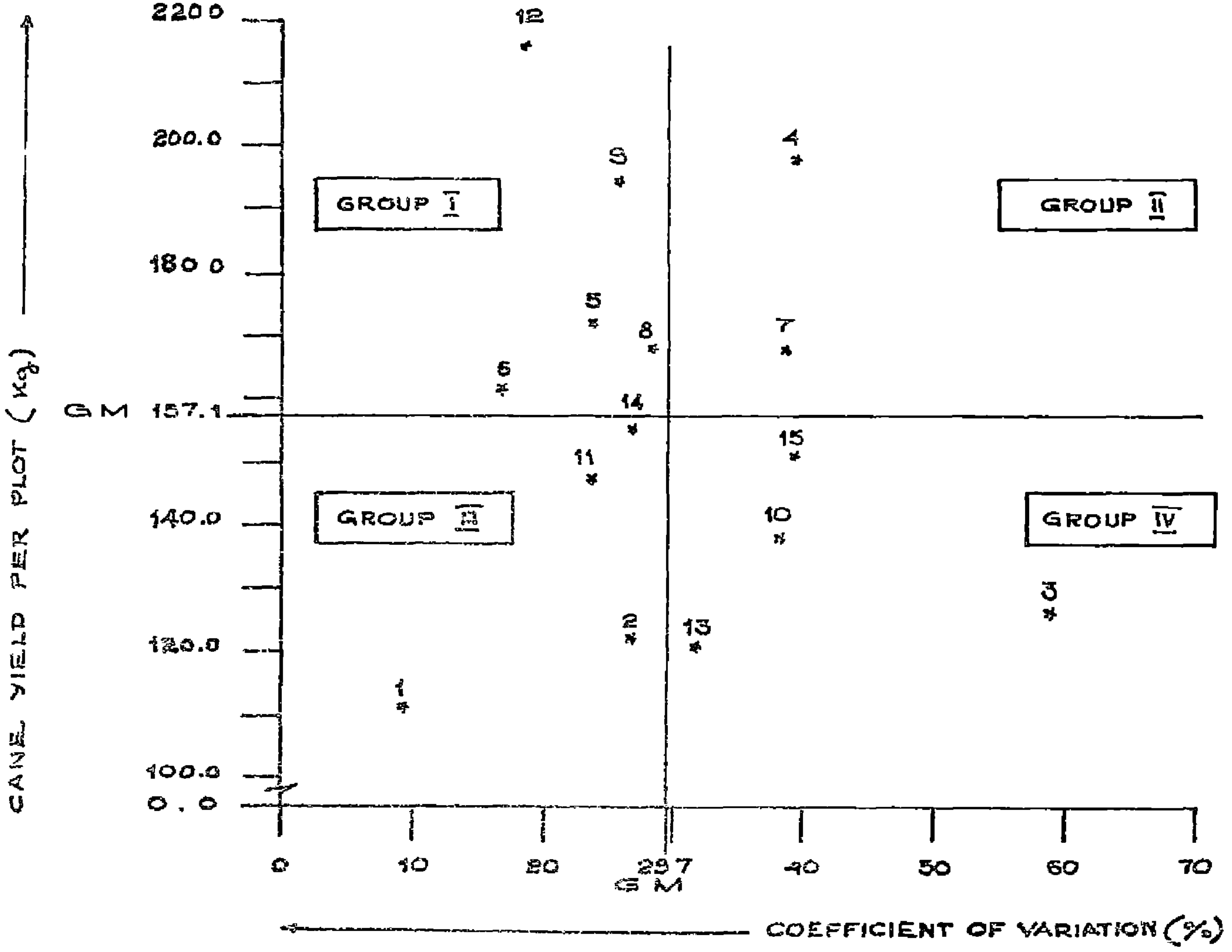
Table 36. Mean, variance of environmental means and coefficient of variation for cane yield per plot

Sl. No.	Clones	Mean (kg)	Variance of environmental means (σ_v^2)	Coefficient of variation (c.v)
1.	CoC,774	111	121.2	9.9
2,	Co,62174	122	1091.6	27.1
3,	Co,997	126	5474.0	58.7
4.	Co.62175	199	6289.5	39.9
5.	S-87	173	1756.2	24.2
6.	Co.7219	161	707.4	16.5
7.	CoC.777	169	4267.6	38.6
8.	Co.740	169	2397.6	29.0
9.	Co,6907	195	2493,4	25.6
10.	CoA.7602	139	2730.8	37.6
11.	S-99	148	1234,2	23.7
12.	CoC.771	216	1493.5	17.9
13.	CoC.671	121	1520.5	32,2
14.	Co.995	156	1691.6	26.4
15.	Co.785	151	3449.4	38.9
	Mean	157.1	-	29.7

Fig. 25. Cane yield per plot against c.v at three locations.

No.	Clones
1.	CoC.774
2.	Co.62174
3.	Co.997
4.	Co.62175
5.	S-87
6.	Co.7219
7.	CoC.777
8.	Co.740
9.	Co.6907
10.	CoA.7602
11.	S-99
12.	CoC.771
13.	CoC.671
14.	Co.995
15.	Co.785

FIG. 25. CANE YIELD AGAINST C V AT THREE LOCATIONS



The stability analysis done for component characters on cane yield and sugar yield gave an insight in to the characters contributing to yield stability across environments. Among the cane yield and its most important components viz. number of millable canes per plot and girth of cane the absence of G x E interaction itself is an indication that these characters are stable across environments. The other components of cane yield such as cane weight and length of cane had significant linear components of G x E interaction alone suggesting the stability of these characters.

In sugar yield and its more important components viz. brix and pol percentage, the pooled deviations were highly significant suggesting the unpredictability and unstable nature of these quality characters across environments. Therefore, for breeding stable varieties across environments due weightage must be given for characters like number of millable canes per plot, cane weight, girth of cane and cane yield per plot.

DISCUSSION

DISCUSSION

Sugarcane is the most important sugar yielding crop and accounts for about 60% of the world's sugar production. It is one of the predominant commercial crops of India. As far as Kerala is concerned, the present production of sugarcane is not sufficient to run the three sugar factories in the State. Sugar production can be substantially increased by developing clones with high cane yield and sugar recovery combined with stability in performance under diverse conditions. Rao (1968) emphasised that recent developments in the science of biometrical genetics offer scope for applying suitable procedures for the improvement of this crop, inspite of its highly complex polyploid and heterozygous nature.

The choice of the most suitable breeding method, for the rational improvement of yield and its components in any crop largely depends on the available genetic variability, association between characters, heritability, genetic advance under selection and adaptability parameters. Selection is the basic but intricate process in the development of superior varieties which is based on the variability available in the crop. Selection based on yield alone is not very efficient, but based on yield components could be more efficient (Evans, 1978).

The present study was conducted with the following objectives.

i) Estimation of genetic variability in a varietal collection of sugarcane.

ii) Correlation of cane yield and sugar yield with their components and cause effect relationship through path analysis.

iii) Estimation of stability parameters and identification of stable genotypes with high cane and sugar yields suited to the different sugarcane tracts of Kerala.

In this study, forty eight clones of sugarcane were collected and evaluated for two years (plant crop and the first ratoon crop). Genetic variability and correlations were estimated and path analysis done using the data collected on 21 characters viz. cane yield, sugar yield and their morphological and quality components. Fifteen clones selected on the basis of the performance of the plant crop were evaluated at three locations (Thiruvalla, Chittoor and Ambalavayal). Stability parameters were estimated using the data collected from the plant crop in the location trials. Stable genotypes with high cane and sugar yields suited to different sugarcane growing tracts of Kerala were identified. The results of the study are discussed and conclusions drawn as follows.

5.1 Genetic variability

Significant differences in respect of all the twentyone characters in the plant as well as the first ratoon crop (except juiciness in the first ratoon crop) indicate large amount of genetic variability for all the characters in the fortyeight clones. The vast differences in the mean values of clones for all the characters further confirm the existence of wide variability in the material. Significant variability for various characters in sugarcane was reported by Brown(1965), Ethirajan(1965), Rao et al (1967), Bhide(1969), Balasundaram and Bhagyalakshmi(1978a), Nair et al.(1979), Hogarth et al.(1981) and Khairwal et al. (1985). Genetic variation so essential for selection is however, not directly accessible to measurement. Only the external expression, ie. genetic variance as modified by the environment is measurable as phenotypic variance. The variability available in a population could therefore be partitioned into heritable and non-heritable components with the aid of genetic parameters like genotypic coefficient of variation (G.C.V), heritability (H^2) and genetic advance (G.A) which can be used as reliable guidelines for selection.

The genotypic coefficient of variation provides a valid basis for comparing and assessing the range of genetic diversity for quantitative characters. The phenotypic coefficient of variation measures the extent of total variability. The genotypic coefficient of variation was lower than the phenotypic coefficient of variation for all the characters studied, both in the plant crop and in the first ratoon crop, indicating the influence of the environment on the genotype for the expression of the character. Comparatively high values of genotypic and phenotypic coefficients of variation were recorded in the plant crop as well as in the first ratoon crop for number of millable canes, cane weight, germination count on the 45th day, shoot count on the 180th day, number of late shoots at harvest, C.C.S. percentage at 12th month, cane yield and sugar yield per plot, offering scope for selection based on these traits for crop improvement. The high variability observed in the number of millable canes, cane weight, C.C.S. percentage, cane yield and sugar yield is in agreement with the observations of Wright(1956) on the existence of large amounts of variability in hybrid populations of asexually propagated out breeding crop species. The low variability for quality attributes such as brix, pol and purity percentages at 10th and 12th months indicate the difficulty in improving these charactors by selection as reported by Mangelsdorf(1959). The present findings corraborate the earlier reports of Mariotti(1973a, 1975), Khairwal and Babu (1976). Balasundaram and Bhagyalakshmi (1978a) and Nair et al.(1979) on the existence of high variability for yield attributes and low variability for quality attributes in sugarcane.

The estimation of heritable variation is not possible with the help of genotypic coefficient of variation alone. Burton (1952) had suggested that genotypic coefficient of variation together with heritability estimates would give a better idea of selection advance to be expected. Selection acts on genetic differences and gains from selection for a specific character depends largely on the heritability of the character (Allard, 1960). The degree to which the variability for a quantitative character is transmitted to the progeny is referred to as heritability and it measures the heritable portion of variability. In an asexually propagated crop such as sugarcane, the estimation of heritability in the broad sense is meaningful, since all the genetic variability is usable between asexual generations by means of selection (Hogarth, 1971). The heritability estimates in the present study were moderate to high for majority of the characters. This is in agreement with the report of Robinson(1966). Heritability values were moderate to high for all the characters studied both in the plant crop and in the first ratoon crop, except juiciness and purity percentages at 10th and 12th months. In addition to the above, length of cane also recorded low heritability in the first ratoon crop. The high heritability estimates for majority of the characters indicate that the observed variability is often heritable and the influence of the environment is negligible in the expression of these characters. Moderate to high heritability estimates recorded for majority of the characters are in agreement with the reports of George(1962) for stalk thickness (girth), brix and number of stalks; Ethirajan (1965) for cane yield and refractometer brix; Rao et al. (1967) for stalk weight (cane weight), number of millable canes, germination and sucrose percentage(pol); Bhide(1969) for C.C.S.percentage and cane yield; Batcha(1975) for cane weight, cane yield and sugar yield; Khairwal and Babu(1976) and Balasundaram and Bhagyalakshmi(1978a) for stalk thickness (girth), number of millable canes and cane weight; Behl et al.(1979) for number of millable canes; Singh and Sangwan(1980) for cane weight and cane yield; Reddy(1980) and Nair et al.(1980) for number of millable canes and cane weight; Singh et al.(1981b) for the length of internode and sugar content; Rao et al. (1983) for brix and girth of cane and Khairwal et al. (1985) for number of tillers, cane thickness and cane yield.

Johnson et al.(1955a) pointed out that high heritability estimate along with high genetic advance was more useful than heritability value alone in predicting the resultant effect of selection. Again in red pepper, while discussing the heritability of certain characters, Ramanujam and Thirumalachar(1967) reported the limitations of estimating heritability in the broad sense, since it includes both additive and epistatic gene effects. They have suggested that heritability estimate in the broad sense will be reliable if accompanied by high genetic advance. The genetic advance was high for number of late shoots, sugar yield and cane yield both in the plant and the first ratoon crops. Relatively high genetic advance was recorded both in the plant and the first ratoon crops for number of millable canes, shoot count on the 180th day and cane weight.

The characters viz. length of cane, number and length of internode, girth of cane, juiciness, brix, pol and purity percentages at 10th and 12th months recorded low genetic advance both in the plant and the first ratoon crops. This confirms the low level of genetic variability recorded for the above characters and thereby indicate the difficulty in improving them through selection. The high genetic advance noticed in the present study for shoot count on the 180th day and cane yield is in agreement with the results of Ethirajan(1965). However, the low genetic advance for length of cane is contrary to the finding of Ethirajan(1965) and in consonance with that of Balasundaram and Bhagyalakshmi(1978a). High genetic advance observed in this study for number of millable canes, cane weight, girth and cane yield agrees with the reports of Rao et al. (1967), Bhide(1969) and Batcha(1975) for cane yield; Balasundaram and Bhagyalakshmi(1978a) for girth, number of millable canes and cane weight; Behl et al.(1979) and Reddy (1980) for number of millable canes; Singh and Sangwan(1980) for cane yield, number of millable stalks and cane weight; Singh et al.(1983) for number of millable canes and Khairwal et al.(1985) for cane yield and millable canes per clone. The low genetic advance recorded for the sucrose (pol) percentage is in conformity with the results of Balasundaram and Bhagyalakshmi(1978a) and Singh et al.(1983). According to Panse(1957) the characters with high heritability and high genetic advance were controlled by additive gene action and therefore are amenable to genetic improvement through selection. High heritability estimates with high genetic advance noticed for number of late shoots, sugar yield and cane yield and relatively high genetic advance with high heritability estimates noticed for number of millable canes, shoot count on the 180th day and cane weight in the plant crop as well as in the first ratoon crop indicates mostly additive gene effects and are therefore amenable to genetic improvement through selection. The high heritability and high genetic advance recorded for the above characters were in conformity with the results of Rao et al. (1967) for cane weight and number of millable canes; Bhide (1969) and Batcha (1975) for cane yield; Balasundaram and Bhagyalakshmi (1978a) for number of millable canes and cane weight and Singh and Sangwan (1980) for cane yield and cane weight.

High heritability and low genetic advance recorded for length of cane, length of internode, number of internodes, girth, brix and C.C.S. percentages at 10th month, both in the plant and the first ratoon crops agree with the findings of Rao et al.(1967) for length of cane and Balasundaram and Bhagyalakshmi(1978a) for length of cane and C.C.S percentage. The high heritability and low genetic advance recorded for the above characters may be attributed to non-additive gene effects as suggested by Panse(1957).

The low estimates for heritability and genetic advance under selection observed for juiciness and purity percentage at 10th and 12th months, in both the plant crop and the first ratoon crop indicate that these characters are highly influenced by the environmental factors. It can be concluded that economically important characters in sugarcane such as number of millable canes, cane weight, cane yield and sugar yield, which had high genotypic coefficient of variation, heritability and genetic advance are amenable to genetic improvement through selection. These characters therefore may have to be considered in selection programmes for the genetic improvement of sugarcane.

5.2 Correlation

Correlation provides information on the nature and extent of relationship between characters. The success in a sugarcane breeding programme largely depends on the efficiency of clonal selection. When the breeder applies selection pressure for a trait, the population under selection is not only improved for that trait, but is also improved in respect of other characters associated with it. Thus correlations facilitate simultaneous improvement of two or more characters. Therefore, a measure of interrelationship between cane yield, sugar yield and their components is very essential. The estimates of genotypic and phenotypic correlation coefficients between various characters provide the intensity and direction of associations. The phenotypic correlations better serve the purpose of orientation rather than prediction, whereas the genotypic correlations are more reliable in the prediction of the resultant effect of selection. The genotypic correlations provide a reliable measure of genetic association between the characters and help to differentiate the vital associations useful in breeding from the non-vital ones(Falconer, 1981). Therefore, analysis of yield in terms of genotypic and phenotypic correlation coefficients of component characters leads to an understanding of characters that can form the basis of selection. The genotypic and phenotypic correlations were computed between cane yield, sugar yield and the morphological and quality characters and among themselves both for the plant crop and the first ratoon crop. In general, the genotypic correlation coefficients were higher than the phenotypic correlation coefficients both in the plant and the first ratoon crops. Low phenotypic correlations have been explained as due to the masking or modifying effect of the environment in genetic association between characters (Johnson et al.1955b; Oraon et al. 1977).

In the plant crop and the first ratoon crop both at the genotypic and phenotypic levels, cane yield recorded highly significant positive correlations with germination count on the 45th day, shoot count on the 180th day, number of millable canes per plot, cane weight and length of cane. In addition to the above characters, the number of internodes and the girth of cane had significant positive genotypic and phenotypic correlations with cane yield in the plant crop. The characters such as the number of internodes, length of internode and girth of cane recorded non-significant but positive genotypic correlations with cane yield, where as the above components had significant and positive phenotypic correlations with cane yield in the first ratoon crop. The highly significant positive genotypic correlations of cane yield with germination count on the 45th day, shoot count on the 180th day, number of millable canes per plot, cane weight and length of cane observed both in the plant crop and the first ratoon crop indicate that an improvement in one or more of these characters will result in an improvement in cane yield. The significant and positive genotypic and phenotypic correlations of cane yield with number of millable canes and length of cane are in agreement with the results of Gill(1949), Rattan(1951), Varma(1963), Ethirajan(1965), Brown et al. (1969), Mariotti(1971a), Nagatomi and Kodama(1971), James(1971), Batcha and Sahi(1972), Khairwal and Babu (1975), Lyrene(1977), Balasundaram and Bhagyalakshmi (1978a), Yadav and Sharma(1978), Singh and Sangwan(1981), Kang et al.(1983), Rao et al.(1983) and Reddy and Khan (1984). The highly significant positive genotypic and phenotypic correlations of shoot count on the 180th day with cane yield observed in this is in conformity with the results of Punia et al.(1983) who have reported significant positive genotypic and phenotypic correlations of number of tillers per clump with cane yield. The report of Reddy and Khan(1984) on highly significant and positive genotypic and phenotypic correlations of cane yield with germination percentage and number of tillers per plant is in conformity with the present findings.

The highly significant and positive genotypic and phenotypic correlations of cane yield and cane weight observed in this study are in consonance with the findings of Singh and Singh(1954), Ethirajan(1965), Mariotti(1972); Batcha(1975), Sahi and Patel(1975), Khairwal and Babu(1975), Balasundaram and Bhagyalakshmi (1978a), Yadav and Sharma(1978), Kang et al.(1983) and Punia et al.(1983). In accordance with the present findings, significant and positive genotypic and phenotypic correlations of cane yield and girth of cane have been reported earlier by Singh and Singh(1954), Ethirajan (1965), Hebert(1965), James(1971), Lyrene(1977), Kang et al. (1983) and Punia et al.(1983). However, Batcha and Sahi (1972) and Khairwal and Babu(1975) reported non-significant and negative genotypic correlation of girth of cane with cane yield. Balasundaram and Bhagyalakshmi(1978a) observed non-significant but positive genotypic and phenotypic correlation coefficients of cane yield with girth of cane. This is not in agreement with the results obtained in this study. Juiciness at 10th and 12th months had non-significant positive genotypic and phenotypic correlations with cane yield contrary to the reports of Singhand Jain(1968). The quality characters such as brix, pol and C.C.S percentages at the 10th month and purity percentage at 12th month had negative but non-significant genotypic and phenotypic correlations with cane yield in the plant crop. The non-significant negative genotypic and phenotypic correlations of cane yield with brix, pol, and C.C.S percentages at 10th month and purity percentage at 12th month reported by Batcha (1975) and Khairwal and Babu(1975) are in agreement with the present results. The characters such as brix, pol and C.C.S percentages at 12th month had non-significant but positive genotypic and phenotypic correlations with cane yield. In the first ratoon crop, all the quality characters, viz. brix, pol, purity and C.C.S. percentages estimated at 10th and 12th months recorded non-significant but positive genotypic and phenotypic correlations with cane yield. The non-significant and positive genotypic and phenotypic correlations of cane yield with sucrose percentage(pol percentage) is in accordance with the findings of Punia et al.(1983). However, Kang et al.(1983) reported significant but negative genotypic and phenotypic correlations of brix, pol and C.C.S percentages with cane yield. The non-significant positive genotypic and phenotypic correlation coefficients of brix and cane yield observed in this study are comparable to the results of Rao et al.(1983), who have reported non-significant positive genotypic and phenotypic correlations of clump weight with brix. Balasundaram and Bhagyalakshmi(1978a) reported highly significant negative genotypic correlations and non-significant negative phenotypic correlations of sucrose and C.C.S percentages with cane yield, which is not in agreement with the results of this study. The non-significant genotypic and phenotypic correlation coefficients of cane yield with quality components such as brix, pol, purity and C.C.S percentages observed in this study indicate that the yield and quality components are inherited independently or they are under the control of different set of genes as reported by Jain(1982). Therefore, simultaneous improvement of yield and quality is rather difficult.

Sugar yield recorded highly significant and positive genotypic and phenotypic correlations with cane yield, in the plant as well as the first ratoon crop. This is in conformity with the results of Balasundaram and Bhagyalakshmi(1978a) and Kang et al.(1983). Consequent to the high positive correlations of sugar yield with cane yield, the sugar yield was also significantly and positively correlated both at genotypic and phenotypic levels with other cane yield components like germination count on the 45th day, number of millable canes per plot, length of cane and number of internodes in the plant crop and the first ratoon crop. In addition to the above components, the sugar yield had significant positive genotypic and phenotypic correlations with shoot count on the 180th day, number of late shoots at harvest and cane weight in the first ratoon crop. The reports of Balasundaram and Bhagyalakshmi(1978a) and Kang et al.(1983) on highly significant positive genotypic and phenotypic correlations of sugar yield with length of cane and cane weight are in agreement with these findings. However, the non-significant but positive genotypic and phenotypic correlations of sugar yield with number of millable canes per row reported by Balasundaram and Bhagyalakshmi(1978a) are contrary to the results obtained in this study. The quality characters such as brix, pol and C.C.S percentages at 12th month had significant and positive genotypic and phenotypic correlations with sugar yield, in the plant crop as well as the first ratoon crop. Similar findings were reported by Tai et al.(1978) and Kang et al.(1983). Contrary to this, Balasundaram and Bhagyalakshmi(1978a) reported non-significant negative genotypic correlations and non-significant positive phenotypic correlations of pol and C.C.S percentages with sugar yield. The highly significant and positive genotypic and phenotypic correlations of sugar yield with cane yield and the important cane yield components such as number of millable canes, cane weight and length of cane indicate that by increasing the cane yield and its components the sugar yield can also be increased.

The germination count on the 45th day had significant and positive genotypic and phenotypic correlations with shoot count on the 180th day and number of millable canes per plot, in the plant and the first ratoon crops. Shoot count on the 180th day and number of millable canes per plot were significantly and positively correlated at the genotypic and phenotypic levels. This is in agreement with the results of Punia et al.(1983) and Singh et al.(1983). This is quite logical because as the germination count increases, more number of shoots will be produced which in turn leads to more number of millable canes and high cane yield.

The number of millable canes per plot had significant but negative genotypic and phenotypic correlations with cane weight and girth of cane in the plant crop, whereas in the first ratoon crop these correlations were non-significant and negative. Singh and Singh(1954), Balasundaram and Bhagyalakshmi(1978a) and Rao et al.(1983) have also reported significant and negative genotypic and phenotypic correlations of the number of millable canes with cane weight and girth of cane. However, the non-significant positive genotypic and phenotypic correlations of number of millable canes with girth of cane, its non-significant negative genotypic and phenotypic correlations with cane weight reported by Punia et al. (1983) and the non-significant negative correlations between number of canes and thickness of cane reported by Ekambaram(1967) are contrary to the present findings in the plant crop. The non-significant negative genotypic and phenotypic correlations of number of millable canes with thickness of cane reported by them are in accordance with the results obtained in the first ratoon crop. The non-significant but positive genotypic and phenotypic correlations of number of millable canes per plot with length of cane observed in the plant crop is in conformity with the results of Balasundaram and Bhagyalakshmi(1978a) but contrary to the results of Punia et al.(1983), Rao et al.(1983) and Kang et al.(1983). The significant and positive genotypic and phenotypic correlations of number of millable canes per plot and length of cane recorded in the first ratoon crop is in agreement with the results of Rao et al.(1983). The number of millable canes per plot had non-significant but positive genotypic and phenotypic correlations with brix, pol and C.C.S percentages at 12th month in the plant crop. In the first ratoon crop this character had non-significant positive genotypic and phenotypic correlations with brix at 12th month but non-significant negative genotypic correlations and non-significant positive phenotypic correlations with pol and C.C.S percentages. The non-significant positive genotypic and phenotypic correlations recorded between number of millable canes per plot and brix at 12th month in the plant and the first ratoon crops i$ in agreement with the results of Rao et al.(1983). Khairwal and Babu(1975) also have reported non-significant and positive genotypic correlation of number of millable canes and brix similar to the present findings. Contrary to this, Kang et al.(1983) reported non-significant negative genotypic and phenotypic correlations of number of millable canes with brix. The non-significant positive genotypic and phenotypic correlations of number of millable canes with pol and C.C.S percentages at 12th month recorded in the plant crop is also contrary to the results of Balasundaram and Bhagyalakshmi(1978a) and Kang et al.(1983), but in conformity with the results of Singh et al.(1981a). The non-significant and negative genotypic correlations of number of millable canes per plot with pol, purity and C.C.S percentages observed in the first ratoon crop is in agreement with the results of Kang et al.(1983). The reports of Khairwal and Babu(1975) and Punia et al.(1983) on non-significant negative genotypic correlations of number of millable canes with pol percentage are in consonance with the results obtained in this study on the first ratoon crop.

Cane weight had significant and positive genotypic and phenotypic correlations with length and girth of cane, in the plant crop as well as the first ratoon crop. This is in agreement with the results of Bathila(1978) and Balasundaram and Bhagyalakshmi(1978a) and Kang et al.(1983). Significant and positive genotypic and phenotypic correlations of cane weight with girth of cane was reported earlier by Hebert(1965) and Punia et al.(1983). The significant and positive correlations of cane weight with length and girth of cane are quite logical because the length and girth of cane are two important components of cane weight. However, cane weight had significant but negative correlation with number of millable canes per plot, another important component of cane yield. Therefore, as the number of millable canes per plot increases, the cane weight will decrease and vice versa. This suggests that simultaneous improvement of these two components of cane yield by selection is rather difficult and a suitable compromise between them must be determined in selection programmes (Kang et al.1983). The genotypic correlations of cane weight with the quality components such as brix, pol, purity and C.C.S percentages at 10th and 12th months were non-significant and negative in the plant crop, whereas it was non-significant and positive in the first ratoon crop. The non-significant and negative correlations of cane weight with brix is in consonance with the results of Khapaga et al.(1966) but contrary to the report of Khairwal and Babu(1975). The non-significant negative genotypic correlation of cane weight with pol percentage is in agreement with the results of Batcha(1975), Lapastra et al.(1975) and Punia et al.(1983). The non-significant negative genotypic and phenotypic correlations of brix, pol, purity and C.C.S percentages with cane weight reported by Kang et al.(1983) are also in agreement with the present findings. But the non-significant positive genotypic and phenotypic correlations of cane weight with pol and C.C.S percentages observed in the first ratoon crop agree with the results of Balasundaram and Bhagyalakshmi(1978a).

Length of cane recorded significant positive genotypic and phenotypic correlations with number of internodes, length of internode and girth of cane in the plant crop, whereas this character had significant and positive genotypic and phenotypic correlations with number of internodes only in the first ratoon crop. The length of internode and girth of cane recorded non-significant but positive genotypic correlations and significant positive phenotypic correlations with length of cane in the first ratoon crop. The number of internodes and length of internode are the two components of length of cane and hence the positive correlations between these two components and length of cane are quite natural. Between the number of internodes and length of internode, significant negative genotypic and phenotypic correlations are seen which is logical because as the number of internodes increases length of the internode will be reduced and vice versa. The significant and positive genotypic and phenotypic correlations of length of cane with number of internodes and girth of cane observed in the plant crop is comparable to the significant positive genotypic and phenotypic correlations between height of the main shoot and thickness of cane and number of internodes per clump reported by Singh and Jain(1968). Ekambaram(1967) also reported highly significant positive correlation between cane length and internode length. Significant positive genotypic and phenotypic correlations of length of cane with girth reported earlier by Stokes(1934), Balasundaram and Bhagyalakshmi(1978a) and Punia et al(1983) are in agreement with the results obtained in this study. However, the non-significant but positive genotypic and phenotypic correlations of length of cane and girth reported by Mariotti(1971a), non-significant and negative genotypic correlations between length of cane and girth reported by Khairwal and Babu(1975) and Rao et al.(1983) were contrary to the present findings. The significant and positive genotypic and phenotypic correlations of cane length and number of internodes recorded both in the plant and the first ratoon crops are in conformity with the results of Bathila(1978).

The quality components such as juiciness, brix, pol and C.C.S percentages at 12th month had non-significant and positive genotypic correlations with length of cane, in the plant crop and the first ratoon crop. The non-significant and positive genotypic correlation of length of cane and pol percentage reported by Mariotti (1971a) also lend support to the present findings.

The report of Kang et al.(1983) on non-significant positive genotypic correlations of C.C.S percentage with length of cane, was in agreement with the results obtained in this study. However, non-significant and negative genotypic correlations of length of cane with brix and pol percentages reported by Khairwal and Babu(1975) and Kang et al.(1983) are contrary to these results. The report of Rao et al.(1983) on significant and positive genotypic correlation of brix with length of cane also disagree with the present results. Significant but negative genotypic correlations of cane length with sucrose and C.C.S percentages reported by Balasundaram and Bhagyalakshmi(1978a), non-significant negative genotypic correlation between length of cane and sucrose percentage reported by Punia et al.(1983) and significant positive genotypic correlation of cane length with sucrose percentage reported by Singh et al.(1985) are also contrary to the present findings.

The number of internodes recorded significant positive genotypic and phenotypic correlations with girth of cane in the plant crop. This is in conformity with the results of Singh and Jain(1968). In the first ratoon crop, the number of internodes recorded non-significant negative genotypic correlation and non-significant positive phenotypic correlation with girth of cane. Number of internodes recorded highly significant but negative genotypic and phenotypic correlations with length of internode both in the plant and first ratoon crops. This is quite logical because when the number of internodes increases the length of internode decreases and vice versa. The quality characters such as brix, pol, purity and C.C.S percentages at 12th month had non-significant positive genotypic and significant positive phenotypic correlations with number of internodes, both in the plant and first ratoon crops. The non-significant positive genotypic correlation of brix and number of internodes at 12th month recorded are in conformity with the reports of Singh et al.(1981a).

The length of internode had non-significant positive genotypic and phenotypic correlations with girth of cane both in the plant and first ratoon crops. The quality characters like brix, pol, purity and C.C.S percentages at 12th month recorded non-significant negative genotypic correlations with length of internode in the plant as well as first ratoon crop. All the above quality components had non-significant negative phenotypic correlations with length of internode in the plant crop, whereas they had significant negative phenotypic correlations in the first ratoon crop. However, the significant positive genotypic correlation of pol percentage with length of internode reported by Singh et al. (1981a) was not inagreement with the present findings.

The girth of cane recorded non-significant positive genotypic correlations with juiciness, pol and C.C.S percentages at 12th month and non-significant negative genotypic correlations with brix and purity percentages at 12th month. All the above characters except juiciness at 12th month had non-significant negative phenotypic correlations with girth of cane in the plant crop. In the first ratoon crop, juiciness, purity and C.C.S. percentages at 12th month recorded non-significant positive genotypic correlations whereas brix and pol percentages at 12th month had non-significant negative genotypic correlations with girth of cane. All the above characters recorded non-significant positive phenotypic correlations with girth of cane. Singh and Jain(1968) also have reported non-significant positive correlations of girth of cane with juice percentage, similar to the results of this study. However, the non-significant and positive genotypic correlations of girth of cane with pol and C.C.S percentages observed in this study are contrary to the reports of Balasundaram and Bhagyalakshmi(1978a) and Kang et al.(1983), eventhough they are in conformity with the non-significant positive genotypic correlation between girth of cane and sucrose(pol) percentage reported by Khairwal and Babu(1975). The non-significant negative genotypic correlations of brix, with girth of cane observed in this study is in agreement with the results of Kang et al. (1983) but contrary to the results of Khairwal and Babu(1975). The non-significant negative genotypic correlation and the non-significant positive phenotypic correlation of girth of cane with pol percentage observed in the first ratoon crop are in conformity with the results of Punia et al.(1983). However, the report of Balasundaram and Bhagyalakshmi(1978a) on significant positive genotypic correlation between girth of cane and pol percentage and significant positive genotypic and phenotypic correlations of girth of cane with C.C.S percentage are contrary to the results obtained in this study. The non-significant negative phenotypic correlation and the significant positive genotypic correlation between girth of cane and purity percentage reported by Mariotti(1971a) are also contrary to the present findings in the first ratoon crop.

In general, the quality components such as brix, pol, purity and C.C.S. percentages estimated at the 10th and 12th months had significant positive genotypic and phenotypic correlations among themselves, in the plant as well as the first ratoon crop. This is in conformity with the results of Richard(1975), Tai et al.(1978), Singh et al.(1978), Parashar et al.(1980), Kang et al. (1983) and Gill et al.(1983). These correlations are quite logical because pol, purity and C.C.S.percentages are the components estimated from brix percentage in juice. These findings on variability and correlation studies suggest that selection based on cane yield and its components like number of millable canes and cane weight, which have high variability and significant positive correlations with cane and sugar yields, will give quicker improvements in cane and sugar yields rather than selection based on quality components like brix, pol and C.C.S percentages which had low variability and correlations with cane yield. The present emphasis on cane yield components is amply justified and has to continue without much emphasis on quality components.

5.3 Path analysis

The correlation coefficients are used to determine the intensity and direction of character associations in crops. Correlations measure, the extent of relationship between yield and other morphological characters. The genotypic correlation is a measure of the interdependence of biological characters at the genotypic level and the phenotypic correlation is a measure of the same, at the phenotypic level. Phenotypic associations between variables may be genetically controlled or they may be brought about by environmental influence or by the direct influence of one variable on another by correlated common causes. A positive genotypic correlation between two variables can be counteracted by a negative environmental correlation. Further, selection for a trait in one direction may cause an undesired diminution of another trait by direct or indirect effect through a third variable. The path coefficient analysis devised by Wright(1921) is an effective means of examining the direct and indirect relationships. Permitting a critical examination of the specific factors that produce a genetic correlation, this technique proved useful in the statistical analysis of cause and effect in a system of correlated variables. Path analysis is a standardised partial regression analysis which specifies the relative importance and measures the direct influence of one variable upon another besides partitioning of the correlation coefficients into direct and indirect effects (Dewey and Lu, 1959). The number of millable canes per plot, cane weight, length of cane, number of internodes, length of internode and girth of cane were considered as causal factors and cane yield as the effect. The juiciness, brix and pol percentages at 12th month were considered as the causal factors for C.C.S percentage as the effect. The cane yield and C.C.S percentage are considered as causal factors and sugar yield as the effect in the plant crop as well as the first ratoon crop.

In the plant crop, girth of cane had the maximum direct effect on cane yield. The high positive direct effect of girth of cane was reduced considerably by the negative indirect effects through the other components like number of millable canes per plot, weight of cane, number of internodes and length of internode, resulting in a comparatively lower genotypic correlation. The maximum direct effect of girth of cane on cane yield was reported earlier by Miller and James (1975) and Kang et al.(1983). In the first ratoon crop, the number of millable canes per plot was the component with maximum direct effect on cane yield. This is in agreement with the results of James(1971), Mariotti (1973b), Batcha(1975), Khairwal and Babu(1975), Balasundaram and Bhagyalakshmi(1978b), Singh and Sangwan (1981) and Singh and Sharma(1982). The girth of cane exerts negative indirect effect through number of millable canes per plot which in turn exerts negative indirect effect through girth of cane in the plant crop and the first ratoon crop. So in order to have maximum cane yield a compromise between number of millable canes per plot and girth of cane is necessary during selection programmes (Kang et al.,1983).

The number of millable canes per plot was the second component with high positive direct effect on cane yield in the plant crop, whereas in the first ratoon crop the weight of cane had the second highest direct effect. This is in conformity with the findings of Kang et al.(1983) that number of millable canes had maximum positive direct effect on cane yield next to girth of cane. The positive direct effect of weight of cane on cane yield observed in the first ratoon crop is also in agreement with the results of Batcha(1975) and Singh and Sangwan(1981).

Length of cane was the third major component exerting maximum positive direct effect in the plant crop on cane yield, whereas in the first ratoon crop the number of internodes was the component in that position. The positive direct effect of length of cane on cane yield observed in this study is in agreement with the results of Balasundaram and Bhagyalakshmi (1978b) and Hooda et al.(1979). Contrary to this, a negative direct effect of length of cane on cane yield was reported by Mariotti(1973b). The positive direct effect of length of cane (0.66) is almost equal to its genotypic correlation (0.67) with cane yield. If the correlation coefficient between a causal factor and the effect is almost equal to its direct effect, the correlation explains a true relationship and therefore a direct selection based on that trait will be very effective (Singh and Choudhary, 1977).

The other components in the plant crop such as weight of cane, number of internodes and length of internode had negative direct effects on cane yield.

Eventhough the weight of cane and number of internodes exert negative direct effects, they had very high positive indirect effects on cane yield through girth of cane and the length of cane, the two components which had maximum direct effect on cane yield indicating that selection based on girth of cane and length of cane will be effective in increasing the yield of cane.

In the first ratoon crop, the other components such as number of internodes, length of internode and girth of cane exerted positive direct effects on cane yield. Earlier report by Singh et al.(1981c) on maximum positive direct effect of number of internodes on cane yield is in agreement with the present findings. The length of cane was the only component which had negativ direct effect on cane yield, even though its genotypic correlation was very high and positive. The length of cane exerts positive indirect effects through the other components viz. number of millable canes per plot, weight of cane, number of internodes, length of internode and girth of cane indicating the importance of the indirect causal factors during selection programmes for increasing the yield of cane as suggested by Singh and Choudhary(1977).

Among the three components of C.C.S percentage, the pol percentage at 12th month had maximum positive direct effect in the plant crop, whereas in the first ratoon crop, the brix percentage at 12th month had maximum positive direct effect. The high positive direct effect of pol percentage at 12th month on C.C.S percentage in the plant crop is in conformity with the results of Bhide(1969) and Kang et al.(1983). The maximum positive direct effect of brix at 12th month on C.C.S percentage in the first ratoon crop is in agreement with the results of Singh et al.(1970) and Punia(1981). Contrary to this, Kang et al.(1983) reported negative direct effect of brix on C.C.S.percentage. In the plant crop, the pol percentage at 12th month exerted positive indirect effect through brix at 12th month which in turn exerted high positive indirect effect through pol percentage at 12th month, suggesting that by increasing the pol percentage, sugar recovery (C.C.S percentage) can be increased. The brix and juiciness at 12th month also had positive direct effect on C.C.S percentage in the plant crop but the positive indirect effects of these two components through pol percentage at 12th month is higher, indicating the importance to be given to pol percentage in selection programmes for increasing sugar recovery. In the first ratoon crop juiciness and pol percentage at 12th month had negative direct effects on C.C.S percentage. But they had positive indirect effects through brix at 12th month on C.C.S percentage. Eventhough the correlation coefficient of pol percentage was positive with C.C.S percentage at 12th month, the direct effect was negative indicating that the indirect causal factors also had to be considered simultaneously for improving the C.C.S percentage, as suggested by Singh and Choudhary(1977). The brix at 12th month which had high positive direct effect may be considered in selection programmes for improving the sugar recovery in the first ratoon crop.

Among the two components of sugar yield, the cane yield per plot had high positive direct effect on sugar yield rather than C.C.S percentage, in the plant as well as the first ratoon crop. The report of Lu(1984) on the higher contribution of stalk yield for sugar yield is in agreement to the present findings. In contrast to this, Kang et al.(1983) reported high positive direct effect of C.C.S percentage on sugar yield than cane yield. The residual effect represents the failure of the estimated genetic correlation among the variables to account for the total genetic variation in a trait (Siowell et al., 1976). In the present study, the residual effect was low indicating that most of the genetic variability in respect of cane and sugar yields were accounted by the model used for the study of cause and effect relationships.

Based on the results obtained on heritability, genetic advance, correlations and path analysis, the ideal plant type suited to our conditions which can give good cane and sugar yields can be suggested. The plant type for high yielding clones should have high tillering ability and maximum shoot production, resulting in the production of more number of millable canes with optimum girth and pol percentage. Earlier, Nagatomi et al. (1982) also suggested a 'Plant ideotype' based on their studies of correlation and path analysis.

5.4 Genotype x Environment Interaction

The fifteen selected clones evaluated at three locations, revealed significant differences in respect of all the eight characters studied except pol percentage at Thiruvalla and length of cane at Chittoor. This indicates the presence of large amount of variability in the clones tested. The genetic parameters estimated at the three locations revealed that sugar yield per plot, cane yield per plot and cane weight had high values for genotypic coefficient of variation, heritability and genetic advance at all the three locations indicating the reliability of these characters in selection programmes for the improvement of cane and sugar yields. High variability, heritability and genetic advance observed for cane yield and cane weight are in conformity with the results of Ethirajan (1965), Mariotti (1973a), Balasundaram and Bhagyalakshmi(1978a), Behl et al. (1979), Nair et al. (1980), Singh and Sangwan (1980), Singh et al. (1983) and Khairwal et al. (1985).

The genotype x environment interactions encountered in yield trials are a challenge to plant breeders. The relative performance of different genotypes gets altered in different environments due to the presence of genotype x environment interaction. In plant breeding programmes, evaluation of many potential genotypes in different environments is necessary for identifying and selecting the superior genotypes. The existence of interaction results in errors in the relative ranking of genotypes because of the differences in the performance of a specified genotype under all environment and the performance of different genotypes in a specified environment. Therefore, a study of interaction is essential in breeding varieties for general adaptation, particularly in a crop like sugarcane which is grown under diverse agroclimatic conditions. The larger the interaction, the smaller are the chances of progress under selection in breeding programmes (Comstock and Moll, 1963).

Plant breeders can manipulate the environmental interaction either by developing genotypes specifically adapted to specified locations or with general adaptation. Ruschel(1977) suggested that plant breeders have the choice of either selecting genotypes of restricted adaptability for defined ecological conditions or searching for genotypes with wider adaptability capable of sustaining production inspite of wide variations in environment. It would be ideal to select varieties which have good performance under all conditions. The practical approach is to select genotypes which interact less with the environment. As pointed out by Freemen (1973), the subject of genotype x environment interaction has been worked out by Statisticians, quantitative geneticists and plant breeders. Quantitative geneticists are primarily interested in estimating the interaction while plant breeders are interested in selecting superior genotypes in the presence of such interactions. The present evaluation of 15 genotypes at three locations showed differential expression of different characters resulting in differences in the relative ranking of genotypes with respect to yield and other characters. The differential expression of the same character at three locations indicatesthe magnitude of differences in the expression of the characters by fluctuations in the environment. Such differential expression may reduce efficiency of selection based on mean yield alone.

The ANOVA for phenotypic stability showed that the differences between the genotypes were significant for all the characters except brix. The environments were also significantly different in respect of the expression of the characters except number of millablo canes. The genotype x environment interaction was significant for quality characters like brix and pol percentages and sugar yield, whereas it was non-significant for cane yield and two important components of yield viz. number of millable canes and girth. The significant interaction indicates the differential response of the genotypes in different environments (Leswal and Sangwan, 1985).

The stability in terms of economic output depends on the steady state of certain aspects of morphology and physiology while allowing others to vary and not on the general constancy of the phenotype in varying environments. Thus the stable varieties show low genotype x environment interaction for yield and quality characters and not necessarily to others (Khan, 1981). Earlier, Kennedy(1978) also reported that the genotype x environment interaction was low in sugarcane because a new variety is undergoing different cycles of selection before release and because of the selection of widely adapted varieties in each cycle the interaction might have been reduced considerably.

The present findings are in agreement with the reports of Kang and Miller(1984) on significant genotype x environment interaction for brix and sugar yield and non-significant interaction for cane yield. The significant interaction for number of millable canes per plot and cane yield per plot reported by Rao and Rahman(1985) and by Deswal and Sangwan(1985) do not find support in the present findings. The significant interaction for brix observed in this study is in conformity with that of Galvez(1980). Tai et al.(1982)

reported highly significant genotype x environment interaction for cane weight, sucrose percentage and sugar yields. This is in consonance with the results of the present study. In respect of length of cane and cane weight the linear component of the interaction alone was significant indicating its contribution to the total interaction. However, the linear component of genotype x environment interaction is non-significant for brix, pol percentage and sugar yield. But the variance due to pooled deviation is significant for these characters indicating the contribution of non-linear component of interaction and revealing the unpredictable nature of these characters.

5.5 Stability parameters

Stability parameters are useful to identify varieties which are widely adaptable to varying agro-ecological situations (Finlay and Wilkinson, 1963; Eberhart and Russell, 1966). The selection of stable genotypes will be based on parameters such as mean, regression coefficient and deviation from regression which are used as criteria for the ranking of genotypes. In the absence of such valid parameters, selection will be made mainly on the basis of high yield alone resulting in the selection of unstable genotypes which are likely to fail under adverse and varying environmental conditions. Therefore, in addition to high mean yields, information on the performance of the cultivars across environments would enable the breeder to select more consistent and adapted genotypes. Simmonds(1981) reported that stable cultivars which are less dependent upon good environments to do well, have been more prominent in potato and sugarcane than in various cereals and that such responses have been due to unconscious selection. Various methods for the measurement of stability parameters have been suggested by several workers.

Finlay and Wilkinson(1963) stated that regression coefficient approximating to unity indicate average stability. When this is associated with high mean yield, varieties have general adaptability and when associated with low mean yield they are poorly adapted to all environments. Eberhart and Russell (1966) suggested that a desired variety should have a higher mean than the grand mean, regression coefficient equal to one and variance due to deviation from regression as small as possible. Later, Breese(1969), Paroda and Hays(1971), Paroda et al.(1973) and Langer et al.(1979) stated that regression coefficient is a measure of response to varying environments and the mean square deviation from linear regression is a true measure of stability, the genotype with the least deviation being the most stable and vice-versa. But, Bains and Gupta(1972) considered that all the three parameters are equally important and stated that the potential of a genotype to express greater mean over environments should be the most important criterion, since the other two parameters may not have any particular utility, if the genotype is potentially weak.

The non-significant values for mean square deviations from regression observed in all the 15 genotypes in respect of cane weight indicate that the linear regression model is sufficient to explain the performance of these genotypes for the phenotypic expression of this character across environments. The regression coefficient differed significantly from unity in clone Co.997, indicating that it is highly sensitive to environmental changes. The other clones, Co.62174, Co.62175, S-87, Co.7219, Co.6907, S-99, CoC.771 and CoC.671 which had higher mean cane weight, non-significant regressions and lower mean square deviations from linear regression were the stable genotypes in respect of weight of cane.

The mean square deviations from regression for length of cane was non-significant indicating that the performance of all the 15 genotypes could be predicted across environments. The regression coefficient of the clones, Co.740 and Co.6907 differed significantly from unity indicating that they are very sensitive to environmental changes. The negative regression coefficients in clones, Co.62174, Co.7219, S-99 and CoC.771 show below average sensitivity to environmental changes and their adaptation to poor environments. None of the clones satisfied all the three parameters of Eberhart and Russell (1966). However, the clones Co.62174, S-87, Co.7219, CoC.777 and CoC.771 with more length of cane than grand mean, regression coefficients not significantly differing from unity and lower mean square deviation from regression can be considered as stable in respect of this character.

In respect of brix, the mean square deviations from regression were highly significant in six genotypes, Co.62174, Co.62175, S-87, Co.7219, Co.6907 and CoA.7602 indicating that the performance of these genotypes was not predictable across environments and they are unstable for brix. The clones CoC.774, Co.997, CoC.771 and CoC.671 with higher means, non-significant regression coefficients and lower values for deviations from regression were stable genotypes.

The significant mean square deviations from regression recorded in clones Co.62175 and Co.7219 for pol percentage indicate that they are unstable. None of the 15 genotypes satisfied all the three parameters of Eberhart and Russell(1966). However, clones Co.997, Co.6907 and S-99 with negative regression coefficients and low values for mean square deviations from regression are adapted to poor environments. The clones Co.6907, CoC.771 and CoC.671 with higher means, non-significant regression coefficients and low values of mean square deviations from regression can be considered as stable genotypes in respect of this character.

The deviation from regression is highly significant in the clone Co.62175 for sugar yield, thereby indicating the unpredictability of the performance of this clone. The clones S-87, Co.7219, CoC.777, Co.740, Co.6907 and CoC.771 with higher mean sugar yield than grand mean, regression coefficients not significantly differing from unity and non-significant mean square deviation from regression are the more stable genotypes in respect of sugar yield.

The genotype x environment interactions were not significant for number of millable canes, girth of cane and cane yield. So stability analysis was not performed and the genotype grouping technique suggested by Francis and Kannenberg(1978) was adopted for grouping the genotypes into four, based on their mean and coefficient of variation. A responsive variety will have larger yield variance across environments and what is required is a measure of consistency of performance that will account for yield. A stable genotype is one that provides high and consistent performance(Francis and Kannenberg, 1978). According to this definition clones coming in Group I are stable with high yield and low coefficient of variation. Although, group III is also consistent it is undesirable and unstable since it performs poorly in all the environments resulting in low yields.

In respect of number of millable canes, the clones Co.997, Co.6907, S-99 and CoC.771 recorded higher means than the grand mean with low coefficient of variation. They come in group I and are having consistency in performance across environments.

The clones Co.62174, S-87, Co.7219 and S-99 which had higher mean girth of cane than the grand mean along with low coefficient of variation and coming in Group I are consistent in performance across environments in respect of girth. All the remaining eleven genotypes distributed in Groups II, III and IV are not consistent in performance and therefore can be considered as unstable in respect of this character. Regarding cane yield, the clones, S-87, Co.7219, Co.740, Co.6907 and CoC.771 with higher mean yields than the grand mean along with low coefficient of variation coming in group I are stable. The clones Co.62175 and CoC.777 also had higher mean cane yield than the grand mean. But they are inconsistent in performance across environments as shown from their larger coefficient of variation. In the absence of genotype grouping technique, the above genotypes were selected on the basis of their yield alone resulting in errors in the relative ranking of genotypes. The genotype-grouping technique is a very useful method for grouping large number of genotypes based on yield data collected from several environments and identifying stable genotypes with consistency in performance across environments.

Among the 15 genotypes, the clones CoC.771, Co.7219 and S-87 which had higher cane yield and sugar yield than grand mean with stability of performance, satisfying the conflicting interests of the cane grower and the miller, can be selected and recommended to the sugar industry.

The stability of production is often referred to as buffering and varieties which gave high and stable economic returns in different environments viz. predictable and unpredictable, are said to be well buffered (Khan, 1981). There are two ways through which varietal buffering can be achieved. One is individual buffering, which is the characteristic of the genotype of the individual plant and the second is the population buffering which is achieved through a combination of different genotypes in a variety or a population (Allard and Bradshaw, 1964). In sugarcane, a variety represents a single genotype which is multiplied by vegetative means and grown to raise the plant and ratoon crops over years. Therefore, the individual buffering is more important in sugarcane. In breeding well buffered varieties or adapted varieties, testing programme to assess the tillering ability in plant and ratoon crops and number of millable canes at harvest to assess the cane yield is suggested. Tillering is the most important factor giving rise to adequate number of millable canes for a good cane yield. So it is said that the achievement of constant yield or varietal buffering is a function of tillering ability (Khan, 1981).

Mariotti(1985) suggested that yield stability is generally associated with compensation mechanism among yield components such as stalk number and stalk diameter. He stated that stalk number is the component which mostly influence the final yield expression with regard to the phonotype as well as stability.

The larger number of millable canes recorded in CoC.771 had resulted in stability of yield across environments. The number of late shoots which can be considered as a reliable parameter of ratooning ability was also comparatively high in CoC.771. The highly significant positive genotypic correlation between the number of late shoots in the plant crop and the cane yield in the first ratoon crop indicatesthat the former character can be considered as a reliable guideline for identifying a stable yielder in the ratoon crop. In the case of S-87 and Co.7219, the girth, another important yield component was higher than the grand mean along with low coefficient of variation. Therefore, girth of cane may be the component contributing to yield stability in S-87 and Co.7219 across environments. The study suggests that the number of millable canes and girth of cane, the two more important components contributing to cane yield and sugar yield are the components responsible for yield stability across environments. Therefore, breeding varieties with more number of millable canes and girth will result in the development of varieties with stability in performance across environments.

SUMMARY

SUMMARY

A research programme was undertaken with the following objectives.

i) Studying the genetic variability, correlations of cane yield and sugar yield with their components, the interse associations of these characters and path analysis in a variotal collection of sugarcane.

ii) Estimation of stability parameters and identification of stable genotypes with high cane and sugar yields suited to different sugarcane tracts of Kerala.

The field experiments were conducted at the Sugarcane Research Station, Thiruvalla (1981 to 1983) and at the Sugarcane Research Centre, Chittoor and Horticultural Research Station, Ambalavayal (1982 to 1983). The data collected on 21 characters (Cane yield, sugar yield and important yield and quality components) from the 48 clones evaluated (plant crop and first ratoon crop) at Thiruvalla were used for the study of genetic variability, correlations and path analysis. Twelve clones selected on the basis of the performance of the plant crop were evaluated along with three popular clones, Co.997, Co.62174, and Co.62175 at three locations. The data collected on the number of millable

canes per plot, cane weight, length of cane, girth of cane, cane yield per plot, brix, pol and sugar yield per plot were anlysed for the study of genotype x environment interaction and estimation of stability parameters.

The analysis of variance for the 21 characters in the plant crop and the first ratoon crop revealed significant differences in respect of all the characters except juiciness at 10th month in the first ratoon crop. The wide differences in the mean values in all the characters indicate the presence of large amount of variability in the biological material used for the study. The genotypic coefficient of variation was highest for number of late shoots at harvest, followed by sugar yield per plot and cane yield per plot in the plant crop, whereas in the first ratoon crop the germination count on the 45th day recorded the highest genotypic coefficient of variation followed by sugar yield per plot and number of late shoots at harvest. The juiciness, purity percentage and brix at 10th and 12th months recorded comparatively lower values of genotypic coefficient of variation both in the plant and the first ratoon crops.

Genotypic coefficient of variation along with heritability would provide a better understanding of the genetic advance to be expected by phenotypic selection. In the plant crop, the number of late shoots at harvest recorded the highest heritability followed by cane weight and cane yield per plot, whereas in the first ratoon crop the germination count on the 45th day had the highest heritability followed by number of late shoots at harvest, shoot count on the 180th day and sugar yield per plot. The high heritability indicates the low influence of the environment on the above characters. The juiciness at 12th month and purity percentage at 10th and 12th months had low heritability estimates in the plant crop, whereas the juiciness at 10th month and 12th month and purity percentage at 12th month recorded low heritability estimates in the first ratoon crop indicating the high influence of the environment in the expression of these characters.

Heritability along with genetic advance is more reliable and effective in predicting the resultant effect of selection. The genetic advance under selection was maximum for number of late shoots at harvest followed by sugar yield per plot and cane yield per plot in the plant crop, whereas in the first ratoon crop the germination count on the 45th day had the highest genetic advance followed by sugar yield per plot, number of late shoots at harvest and cane yield per plot. The purity percentage and juiciness at 10th and 12th months had low values for genetic advance both in the plant crop and the first ratoon crop. Moderate to high heritability coupled with high genetic advance recorded for germination count on the 45th day, shoot count on the 180th day, number of late shoots at harvest, number of millable canes per plot, cane yield per plot and sugar yield per plot, both in the plant crop and the first ratoon crop indicates that selection based on the above components will be effective in the improvement of cane and sugar yields. Moderate to high heritability and low genetic advance recorded for length of cane, girth of cane, number of internodes, length of internode and brix at 10th month in the plant crop and for girth of cane, length of internode, number of internodes, brix and pol percentages at 10th and 12th months and C.C.S percentage at 10th month in the first ratoon crop suggest the unreliability of these characters in selection programmes. The moderate to high heritability and low genetic advance indicate non-additive gene action in the expression of the above characters.

The intensity and direction of relationship between characters can be measured by genotypic and phenotypic correlations and this information is necessary in a breeding programme when selection is based on two or more characters. Therefore, analysis of yield in terms of genotypic and phenotypic correlations of component characters is necessary in understanding the characters that can be used as the basis for selection.

The cane yield per plot had significant and positive genotypic correlation with germination count on the 45th day, shoot count on the 180th day, number of millable canes per plot, cane weight and length of cane in the plant as well as the first ratoon crop indicating that improvement in any one or more of these characters will result in a simultaneous improvement in cane yield. The quality components such as juiciness, brix, pol and C.C.S. percentages at 10th month recorded positive but non-significant correlations with cane yield in both plant and the first ratoon crops thereby indicating that simultaneous improvement of yield and quality is difficult by means of direct selection. The cane yield and quality components exhibited varying degrees of association among themselves. The number of late shoots at harvest in the plant crop had highly significant and positive genotypic and phenotypic correlations with cane yield in the ratoon crop indicating that the number of late shoots at harvest can be considered as a reliable criterion for the selection of clones with good yielding ability in the ratoon crop. The cane yield also had significant and positive genotypic correlations with sugar yield in both the crops. Because of the highly significant and positive genotypic correlation of cane yield with sugar yield, the components of cane yield, viz. germination count on the 45th day, number of millable canes per plot, cane weight and length of cane also had significant positive correlation with sugar yield. The quality components such as brix, pol and C.C.S. percentages at 12th month also had significant and positive genotypic correlations with sugar yield. The significant positive genotypic and phenotypic correlations of sugar yield with cane yield and its important components suggest that by increasing the cane yield per plot, the sugar yield per plot can be increased.

The path coefficient analysis is an effective means of examining the direct and indirect relationships permitting a critical examination of the specific factors that produce a genotypic correlation and this technique was proved to be very useful in the statistical analysis of cause and effect in a system of correlated variables. The girth of cane, number of millable canes per plot and length of cane had high positive direct effect on cane yield among the six components considered for path analysis in the plant crop, whereas the number of millable canes per plot, cane weight and number of internodes had high positive direct effect on cane yield in the first ratoon crop. Therefore, for the improvement of cane yield in the plant crop, the components such as girth of cane, number of millable canes per plot and length of cane may be considered during selection programmes. On the other hand, for the improvement of cane yield in the first ratoon crop due consideration has to be given for the components viz. number of millable canes per plot, cane weight and number of internodes.

Among the three components, the pol percentage at 12th month had high positive direct effect on C.C.S. percentage in the plant crop, whereas in the first ratoon crop, brix percentage at 12th month had maximum positive direct effect. Therefore, for increasing the C.C.S. percentage or sugar recovery due weightage has to be given for pol and brix percentages respectively in the plant and the first ratoon crops.

Among the two components, the cane yield per plot had high positive direct effect on sugar yield per plot than C.C.S. percentage in both the crops. This again confirms the fact that by increasing the cane yield per plot rather than C.C.S.percentage, the sugar yield per plot can be increased.

The evaluation of the fifteen selected clones at three locations revealed significant differences in respect of all the eight characters except pol percentage at

Thiruvalla and length of cane at Chittoor indicating the presence of large amount of variability in the material. The estimation of genetic parameters revealed that the characters viz. sugar yield per plot, cane yield per plot, number of millable canes per plot and cane weight had high values of genotypic coefficient of variation, moderate to high heritability and high genetic advance, suggesting the reliability of these characters in selection programmes aimed at the improvement of cane yield and sugar yield.

The pooled analysis of variance revealed that genotype x environment interaction was absent for the characters, viz. number of millable canes per plot, girth of cane and cane yield per plot. The interaction was highl significant for length of cane, cane weight, brix and pol percentages and sugar yield per plot. The absence of interaction for number of millable canes per plot, girth of cane and cane yield per plot suggest the stability of these components at the different locations. The estimation of stability parameters such as $\overline{X}$, b and S_d^2 in respect of characters like length of cane, cane weight, brix, pol and sugar yield per plot revealed that none of the clones had stability for all the component characters. The different clones tested showed stability for different component characters.

The grouping of genotypes based on mean and coefficient of variation indicated that none of the clones had consistency in performance across environments for all the three components viz. number of millable canes per plot, girth of cane and cane yield per plot. The clones CoC.771, Co.7219 and S-87 with higher cane and sugar yields satisfying the conflicting interests of the cane grower and the miller along with stability in performance across environments can be recommended to the sugar industry as stable genotypes.

The varietal stability is achieved by 'buffering'. In sugarcane, individual buffering is important and the achievement of consistency in performance and stability in production is achieved by the tillering ability and the production of adequate number of millable canes. Compensation mechanism among yield compenents such as stalk number and stalk diameter also results in yield stability. The more number of millable canes in CoC.771 and increased girth in Co.7219 and S-87 had resulted in the stability of these clones across environments. The number of millable canes and girth are the two components having maximum direct contribution for cane yield. Therefore, breeding clones with more number of millable canes and girth will simultaneously result in the development of clones with stability of performance across environments.

REFERENCES

REFERENCES

Allam, A.I., Schilling, P.E. and Koonee, K.L.(1974). Estimates of heritability in sugarcane. Sug. J., 36 (10): 35-37.

Allard, R.W.(1960). Principles of Plant Breeding. John Wiley and Sons, London. pp.403.

Allard, R.W. and Bradshaw, A.D.(1964). Implication of genotype - environmental interaction in applied plant breeding. Crop Sci., 4: 503-508.

*

Anonymous (1965). Sug. Exp.Stan. Bull., Guyana, 34: 62.

*

Anonymous (1974). Annu.Rep., Hawaiian Sugar planters association, Honolulu. pp.65.

Anonymous (1975). Annu. Rep., Sugarcane Breeding Institute, India. pp.82.

Anonymous (1981). Indian Sugar Year Book, 1: 9-15.

Anonymous (1983). Co-op Sug., 14(6): 310-315.

*

Arceneaux, G. and Hebert, L.P. (1943). A statistical analysis of varietal yields of sugarcane obtained over a period of years. Agron. J., 35: 148-160.

Bains, K.S. and Gupta, V.P. (1972). Stability of yield and yield components in bread wheat. Indian J. Genet., 32: 306-312.

Balasundaram, N and Bhagyalakshmi, K.V. (1978a). Variability, heritability and association among yield and yield components in sugarcane. Indian J. agric. Sci., 48(5): 291-295.

Balasundaram, N. and Bhagyalakshmi, K.V. (1978b). Path analysis in sugarcane. *Indian J. Agric. Res.*, *12*(4): 215-218.

Barber, C.A. (1916). Studies in Indian sugarcane No.2. Sugarcane seedlings including some correlations between morphological characters and sucrose in juice. *Mem. Dept. Agric. India Bot. Ser.*, *8* (3): 103-149.

Batcha, M.B.G.R. (1975). A study on the association of yield and yield contributing characters in sugarcane under north Bihar conditions. Ph.D. Thesis, *Univ. of Bihar*.

Batcha, M.B.G.R. and Sahi, B.K. (1972). Studies on the association of certain agronomic traits under subtropical conditions - Motihari. *Diamond Jub. Symp. Sugarcane, Breed. Inst.*, Coimbatore, India. In *Abstr. of Pub.* S.B.I., India. pp.33.

Bathila, H.V.L. (1978). Study of correlations between cane yield and different attributing characters. *Indian Sug. Crops J.*, *5*(3): 45-46.

Bathila, H.V.L. (1981). Effect of different yield attributing characters on cane yield. *Indian Sug. Crops J.*, *8*(1): 19-20.

Behl, K.L., Sangwan, R.S., Chhabra, K.L. and Sharma, G.R. (1979). Comparative performance of early genotypes of sugarcane. *Indian Sug. Crops. J.*, *6*(4): 87-88.

Bhat, N.R., Batcha, M.B.G.R. and Sankaranarayanan, P.(1960). Disparity between seedling and settling performance in sugarcane. *Proc. All India Conf. Sugarcane Res. Dev.Wkrs.*, *Waltair 4*: 308-318.

Bhide, V.S. (1969). Biometrical study in the aspects of quality and yield and its components in Saccharum officinarum L. Ph.D. Thesis, Fac. Agric., Agra Univ.

*
Bond, R.S. (1979). Evaluating a new variety (n11) in seedcane increase plots by means of a sample harvest method. S. Afr. Sug. J., 63: 481-483.

Breese, E.L. (1969). The measurement and significance of genotype - environment interaction in grasses. Heredity, 24: 27-44.

Brown, A.H.D. (1965). Correlation between brix in juice and fibre in commercial hybrid sugarcane populations. Proc. Int. Soc. Sugarcane Technol., 12: 754-759.

Brown, A.H.D., Daniels, J. and Latter, B.D.H. (1969). Quantitative genetics in sugarcane II. Correlation analysis of continuous characters in relation to hybrid sugarcane breeding. Theor. Appl. Genet., 39(1): 1-10.

*
Burton, G.W. (1952). Quantitative inheritance in grasses. Proc. 6th Int. Grassland Congr., 1: 277-283.

Cesnik, R. and Voncovsky, R. (1974). Heritability, genetic correlation and response to selection of some characters in sugarcane. Proc. Int. Soc. Sugarcane Technol., 15: 96-101.

Comstock, R.E. and Moll, R.H. (1963). Genotype-environment interactions. Stat. Genet. and Pl. Breed., NAS-NRC, Publ., 982: 164-196.

*
Comstock, R.E. and Robinson, H.F. (1952). Genetic parameters, their estimation and significance. Proc. 6th Int. Grassland Congr., 284-291.

*
Craig, N. (1944). A note on the quantitative and qualitative characters of first year sugarcane seedlings. Trop. Agric., XI (a): 244-245.

Cuenya, M.I., Mariotti, J.A. and Ahmed, M.A. (1983). Analysis of the selection quality of hybrid progenies of sugarcane-I. Micro-plots. Plant Breed. Abstr., 53(5):4148.

Dillewijn, C. Van. (1950). Tillering of cane.Sug. J., 13: 33-48.

Deswal, D.P. and Sangwan, R.S.(1985). Phenotypic stability for cane yield in sugarcane. Madras Agric. J., 72(2): 95-97.

*
Dewey, D.R. and Lu, K.H. (1959). A path coefficient analysis of components of crested wheat grass seed production. Agron. J., 51: 515-518.

*
Losado, V.G., Geolingo, D. and Geolingo, R. (1976). Factors affecting yield of sugarcane-I. Plant characters associated in the yield among high yielding varieties. Proc. Philipp. Sug. Technol. Assn., 24: 64-75.

Dosado, V., Tapay, R.E. and Miayo, H.M. (1980). Selection indices for high yield in sugarcane. Proc. Int. Soc. Sugarcane Technol., 17: 7.

Eberhart, S.A. and Russell, W.A. (1966). Stability parameters for comparing varieties. Crop Sci., 6(1): 36-40.

Ekambaram, C. (1967). Ideal breeding and selection of sugarcane. Madras Agric. J., 54: 524-530.

Ekosugiatro, Soemartono., Woerjono and Mangoendidjojo. (1986). Yield stability analysis in sugarcane cultivar trial. *Plant Breed. Abstr.*, *56*(4):3019.

Epinosa, R. and Galvez, G. (1980). Study of genotype-environment interaction in sugarcane-I. The interaction of the genotypes with planting dates and harvest cycles. *Proc. Int. Soc. Sugarcane Technol.*, *17*: 1161-1167.

Ethirajan, A.S. (1963). Evaluation of plant attributes concerned with yield in sugarcane and assessing their behaviour in succeeding clonal population. Ph.D. Thesis, *Univ. of Madras*.

Evans, L.T. (1978). *Crop Physiology*. Cambridge University press, Cambridge, London. pp.355.

Falconer, D.S. (1981). *Introduction to quantitative genetics*. Longman, Inc., New York. pp.340.

Finlay, K.W. and Wilkinson, G.M. (1963). The analysis of adaptation in a plant breeding programme. *Aust J. Agric. Res.*, *14*: 742-754.

*
Fisher, R.A. (1918). The correlation between relatives in the supposition of Mendelian inheritance. *Trans. Roy. Soc. Edinb.*, *52*: 399-433.

Francis, T.R. and Kannenberg, L.W. (1978). Yield stability studies in short-season maize-I. A descriptive method for grouping genotypes. *Can. J. Plant Sci.*, *58*: 1029-1034.

Freeman, G.H. (1973). Statistical methods for the analysis of genotype-environment interactions. *Heredity*, *31*: 339-354.

Freeman, G.H. and Perkins, J.M.(1971). Environmental and genotype environmental component of variability-VIII. Relation between genotypes grown in different environments and measures of these environmentS. *Heredity*, *27*: 15-23.

*
Fuchs, A. and Ponce, J.P (1979). Methods for estimating the yield stability. Variety trials with sugarcane *Beir*, *Trop*. *Landwirtsch* *Veterinacrmed*. *17*: 351-359.

Galvez, G.(1980). The genotype-environment interaction in experiments of sugarcane variety trials (*Saccharum* spp.) Comparison of three stability methods. *Proc*. *Int*. *Soc*. *Sugarcane* *Technol*., *17*: 1152-1160.

Galvez, G. (1982). Estimation of genotype x environment interaction in sugarcane variety trials-2. Study of stability. *Plant* *Breed*. *Abstr*., *52*(11): 9512.

*
Galvez, G. and Amador. (1978). Study of yield and some of its components in 22 cane varieties. *ATAC*, *37*(6): 24-29 (Spanish).

George, E.F. (1959). Effect of the environment on components of yield in seedlings from five *Saccharum* crosses. *Proc*. *Int*. *Soc*. *Sugarcane* *Technol*. *10*: 755-765.

George, E.F. (1962). A further study of *Saccharum* progenies in contrasting environments. *Proc*. *Int*. *Soc*. *Sugarcane* *Technol*., *11*: 488-497.

Gill, P.S. (1949). Effect of manures and irrigation on the yield and quality of sugarcane. M.Sc. Thesis, *Univ*. *of* *Punjab*.

Gill, S.D., Tripathi, B.K., Mishra, G.P. and Lal, S.(1983). Character association analysis in some foreign varieties of sugarcane. *Indian* *J*. *agric*. *Sci*., *53* (12):985-987.

Hanson, C.H., Robinson, H.F. and Comstock, R.E.(1956). Biometric studies of yield in segregating population of Korean lespodeza. *Agron. J.*, *48*: 268-272.

Hebert, L.P. (1965). Association between yield components and yield of sugarcane varieties in Louisiana. *Proc. Int. Soc. Sugarcane Technol.*, *12*:760-763.

*
Hebert, L.P. and Henderson, M.T. (1959). Breeding behaviour of certain agronomic characters in progenies of sugarcane crosses. *USDA Tech. Bull.*, No.1194, pp.54.

Hogarth, D.M. (1971). Quantitative inheritance studies in sugarcane-II. Correlations and predicted responses to selection.*Aust. J. Agric. Res.*, *22*(1):103-109.

Hogarth, D.M., Wu, K.K. and Heinz, D.J. (1981). Estimating genetic variance in sugarcane using factorial cross design. *Crop Sci.*, *21*(1): 21-25.

Hooda, R.S., Babu, C.N. and Khairwal, I.S. (1979). Association and path analysis of nine characters in progenies of four sugarcane crosses at settling stage. *Indian J. agric. Sci.*, *49*(12): 931-933.

Hunsigi, G. and Srivastava, S.C. (1975). An approach towards plant type concept in sugarcane. *Curr. Sci.*, *44*(24): 897-899.

Jagathesan, D., Venkataraman, M.R. and Shah, S.S. (1967). Introgression in *Saccharum*. *Curr. Sci.*, *36*: 217-218.

Jain, J.P. (1982). *Statistical techniques in quantitative genetics*. Tata Mc Graw-Hill, Co., New Delhi, pp.281.

James, N.I. (1971). Yield components in random and selected sugarcane populations. *Crop Sci.*, *11*: 906-908.

James, N.I. and Falgout, R.N. (1969). Association of five characters in progenies of four sugarcane crosses. Crop Sci., 9: 88-91.

Johnson, H.W., Robinson, H.F. and Comstock, R.E.(1955a). Estimates of genetic and environmental variability in soybean. Agron. J. 47: 314-318.

Johnson, H.W., Robinson, H.F. and Comstock, R.E.(1955b). Genotypic and phenotypic correlations in soybean and their implications in selection. Agron. J., 47: 477-482.

*Juang, P.V. (1971). Relationship between cane yield and the main characters of sugarcane. Annu. Rep. Taiwan Sug. Expt. Stan., 3: 41-43.

Kang, M.S. and Miller, J.D.(1984). Genotype x environment interactions for cane and sugar yield and their implications in sugarcane breeding. Crop Sci., 24: 435-440.

Kang, M.S., Miller, J.D. and Tai, P.Y.P. (1983). Genetic and phenotypic path analysis and heritability in sugarcane. Crop Sci., 23: 643-647.

Kempthorne, O. (1957). An Introduction to Genetic statistics. New York. John Wiley and Sons, Inc., London Chapman & Hall Ltd., pp.514.

Kennedy, A.J. (1978). Analysis of sugarcane variety trials-I. Components of variance and genotype-environment interaction. Euphytica, 27(3): 767-775.

Khan, A.Q. (1981). Varietal buffering in sugarcane. Indian Sug., 31(6): 409-411.

Khairwal, I.S. and Babu, C.N. (1975). Path coefficient analysis of cane yield in sugarcane. Int.Soc. Sugarcane Technol., Sugarcane Breed.Newsl., 36: 58-61.

Khairwal, I.S. and Babu, C.N. (1976). Estimates of heritability and its implications in selection of sugarcane varieties. Int. Soc. Sugarcane Technol. Sugarcane Breed. Newsl., 37: 32-36.

Khairwal, I.S., Singh, S. and Paroda, R.S.(1985). Genetic variability created by physical and chemical mutagens for some quantitative characters in sugarcane. Indian J. agric. Sci., 55(5): 362-364.

*
Khapaga, E.E., Eladawi, M.K., Elsmei, M.A., Nour, A.H. and Fayed, T.M. (1966). Correlation studies in sugarcane. Agric. Res. Rev., Cairo. 44: 57-62.

Langer, S., Frey, K.J. and Bailey, T. (1979). Association among productivity, production responses and stability index in oat varieties. Euphytica, 28: 17-24.

Lapastra, E.P., Empig, L.T., Solivas, E.S. and Magejes, B.E.(1975). Population parameters of some agronomic characters of clones in the germplasm collection of La. Granja experiment station Philippines Sugar Institute. Int. Soc. Sugarcane Technol., Sugarcane Breed Newsl., 35: 27-35.

Lewis, D. (1954). Gene-environment interaction. A relationship between dominance, heterosis, phenotypic stability and variability. Heredity, 8: 333-356.

Lu, Y.Q.(1984). Studies on the correlation of yield components in sugarcane. Plant Breed. Abstr., 54 (4-5): 3379.

Luna, L.A. (1965). Study of some characters of the progeny in four crosses of sugarcane. Proc. Int.Soc. Sugarcane Technol., 12: 764-772.

*
Lush, J.L. (1937). Animal Breeding Plans. Iowa State College Press, Ames, Iowa. pp.473.

Lyrene, P.M. (1977). Single stool variety selection in sugarcane. Proc. Int. Soc. Sugarcane Technol., 16: 93-100.

Lyrene, P.M. (1981). Heritability of lodging in sugarcane. Int. Sug. J., 83 (996): 371.

Mangelsdorf, A.J. (1935). Sugarcane breeding in Hawaii. Proc. Int. Soc. Sugarcane Technol., 5: 348-357.

Mangelsdorf, A.J. (1956). Sugarcane breeding in retrospect and in prospect. Proc. Int.Soc.Sugarcane Technol., 9: 560-595.

Mangelsdorf, A.J. (1959). Sugarcane breeding methods. Proc. Int. Soc. Sugarcane Technol., 10: 694-701.

Mariotti, J.A. (1971a). Association among yield and quality components in sugarcane hybrid progenies. Proc. Int. Soc. Sugarcane Technol., 14: 297-302.

*
Mariotti, J.A. (1971b). Phenotypic association among characters at the first stage of selection in sugarcane. Rev. Agron. Noroeste. Argent. 8(3/4): 327-340.

*
Mariotti, J.A. (1972). Experiments on clonal selection of sugarcane in Jujuy province-I. Study of association between characters. Rev. Agron. Noroeste. Argent., 9(3/4): 573-583.

*
Mariotti, J.A.(1973a) Clonal selection experiments in sugarcane-I. Realised heritability and sectorial heritability. Rev. Agron. Noroeste. Argent., 10(1/2): 75-88.

Mariotti, J.A. (1973b). A Path analysis of yield components in sugarcane. *Int. Soc. Sugarcane Technol., Sugarcane Breed. Newsl.*, **32**: 14-18.

Mariotti, J.A.(1973c). The influence of environment on the relationships between yield and its components in sugarcane. *Int. Soc. Sugarcane Technol., Sugarcane Breed Newsl.*, **32**: 19-22.

Mariotti, J.A. (1975). Heritability estimates of five hybrid populations of sugarcane in clonal plots. *Plant Breed. Abstr.* **45**(4): 2900.

Mariotti, J.A. (1977). Sugarcane clonal selection research in Argentino. A review of experimental results. *Proc. Int. Soc. Sugarcane Technol.*, **16**: 121-136.

Mariotti, J.A. (1980). Clonal selection across environments. *Proc. Int. Soc. Sugarcane Technol.*, **17**: 1142-1151.

Mariotti, J.A. (1985). The problem of behaviour stability, its implication in genetic improvement of sugarcane *Plant Breed. Abstr.*, **55**(7): 5502.

*Mariotti, J.A., Oyarzabal, E.S., Osa, J.M., Bulacio, A.N.R. and Almada, G.H. (1976a). Analysis of stability and adaptability in sugarcane genotypes-I. Interaction with in an experimental site. *Rev. Agron. Noroeste. Argent.*, **13**(1/4): 105-118.

Mariotti, J.A., Ploper, D.L., Oyarzabal, E.S., Bulacio, A.N.R., Turowski, I.A., Osa, J.M., Divizia, M.T and Avellaneda R.A.(1976b). Response of sugarcane genotypes to natural and controlled environmental stimulii *Plant Breed. Abstr.*, **46**(9):8208.

Mathur, R.B.L.(1978). *Handbook of cane sugar Technology*. Oxford and I.B.H. Co., New Delhi. pp.484.

McIntosh, A.E.S.(1935). Methods of selecting seedlings at the sugarcane breeding station in Barbados. *Proc. Int. Soc. Sugarcane Technol.*, *5*: 324-326.

Miller, J.D. (1977). Combining ability and yield components analysis in a five parent diallel cross in sugarcane. *Crop Sci.* *17*(4): 545-547.

Miller, J.D. and James, N.I. (1974). The influence of stalk density on cane yield. *Proc. Int. Soc. Sugarcane Technol.*, *15*: 177-184.

Miller, J.D. and James, N.I. (1975). Selection in six crops of sugarcane-I. Repeatability of three characters. *Crop Sci.*, *15*(1): 23-25.

*
Nagatomi, S. and Kodama, S. (1971). Studies on selection methods in sugarcane breeding-III. On correlations between yield components, stalk morphology, juice quality and morphological leaf characters. *Jap. J. Trop. Agric.*, *15*(1): 6-10.

*
Nagatomi, S., Maeda, H. and Lo, C.C.(1982). Studies on selection methods for sugarcane breeding-XVI. Analysis of yield components. *Jap. J. Trop. Agric.* *26*(4): 229-238.

Nair, N.V. and Somarajan, K.G. (1984). Genetic correlations and selection responses in a hybrid sugarcane population selected for adaptation to waterlogging. *Indian J. agric. Sci.*, *54*(3): 180-182.

Nair, N.V., Somarajan, K.G. and Balasundram, N. (1979). Population characteristics of eight quantitative characters in the *Saccharum officinarum* L. germplasm. *Indian Sug.*, *29*(9): 1-5.

Nair, N.V., Somarajan, K.G. and Balasundaram, N. (1980). Genetic variability, heritability and genetic advance in *Saccharum officinarum* L. *Int. Sug. J.*, *82*: 275-276.

Nair, V.G. (1978). Agricultural research in Kerala-status paper on sugarcane. Kerala Agric. Univ. pp.72-73.

Narain, P., Bhatia, V.K. and Malhotra, P.K. (1979). Handbook of statistical genetics I.A.S.R.I., I.C.A.R., New Delhi. pp.360.

Oraon, P., Prakash, R. and Alague, M.F. (1977). Correlation studies in chickpea (Cicer arietinum L.) Trop. Grain Leg. Bull., 7: 18-19.

Orliz, R. (1982). Components of variance in studies of precommercial varieties of sugarcane (Saccharum spp). Int. Sug. J., 84 (1003): 211.

Panje, R.R. and Ethirajan, A.S. (1960). Studies in Saccharum spontaneum - preliminary studies in inbreeding. Proc. Int. Soc. Sugarcane Technol., 10: 751-754.

Panse, V.G.(1957). Genetics of quantitative characters in relation to plant breeding. Indian J. Genet., 17: 318-328.

Parashar, K.S., Patil, R.R., Mahavir prasad, and Dhaka, B.S. (1980). Studies on interrelationship between cane yield and juice quality and plant characters of sugarcane. Indian Sug., 30(3): 149-151.

Paroda, R.S. and Hays, J.D. (1971). An investigation of genotype-environment interaction for rate of ear emergence in spring barley. Heredity, 26(2):157-175

Paroda, R.S., Panwar, D.V.S. and Sharma, G.D.(1973). Genotype x environment interaction for fodder yield in sorghum. Indian J. agric. Sci., 43: 336-385.

Perkins, J.M. and Jinks, J.L. (1968). Environmental and genotype-environmental components of variability-III. Multiple lines and crosses. Heredity, 23: 339-356.

Pires, C.E.L.S. and da Costa, E.F.S.(1980). Association between some characters of sugarcane (Saccharum spp.) grown in four localities in the north east of Brazil. Proc. Int. Soc. Sugarcane Technol., 17: 1365-1372.

*Plaisted, R.L. and Peterson, L.C.(1959). A technique for evaluating the ability of selection to yield consistently in different locations or seasons. Am. Potato J., 36: 381-385.

Pollock, J.S.(1975). Selection consequences of differential performance of standard clones across environments. Int. Soc. Sugarcane Technol., Sugarcane Breed. Newsl., 35: 36-38.

*Pollock, J.S. (1978). Variety x environment interaction and selection of sugarcane. Proc. Soc. Sugarcane Technol.,Queensl., 45: 275-277.

Punia, M.S. (1981). Path analysis for yield and quality attributes in sugarcane. Thesis Abstr., 7(4): 338. Haryana Agric. Univ.

Punia, M.S., Paroda, R.S. and Hooda, R.S. (1983). Correlation and path analysis of cane yield in sugarcane. Indian J. Genet., 43(1): 109-112.

Raghavan, T.S. and Govindaswami, S. (1956). Sugarcane as a material for genetical studies. Proc. Int. Soc. Sugarcane Technol., 9: 677-694.

Ramanujam, S. and Thirumalachar, D.K. (1967). Genetic variability of certain characters in red pepper (Capsicum annuum L.) Mysore J. Agric. Sci., 1(1): 30-36.

Rao, C.P. and Rahman, M.A. (1985). Stability analysis in sugarcane. Indian J. agric. Sci., 55(5): 318-320.

Rao, J.T. (1968). Breeding to develop improved varieties. Proc. Int. Soc. Sugarcane Technol., 13: 26-30.

Rao, J.T., Krishnamurthy, T.N. and Natarajan, B.V.(1967). Heritability of economic characters in sugarcane and its implications in selection. Indian Sug., 17(2): 1-6.

Rao, J.T. and Narasimhan, R. (1963). Recent currents in sugarcane breeding. Indian Sug., 13: 135-137.

Rao, J.T., Natarajan, B.V. and Krishnamurthy, T.N.(1966). The genetic approach to selection of promising sugarcane varieties. Indian Sug., 16: 167-171.

Rao, J.T., Ethirajan, A.S., Sankaranarayanan, P., Natarajan, B.V., Nagarajan, R. and Bhagyalakshmi, K.V. (1979). Sugarcane as an energy crop. Indian Sug., 29(2): 77-80.

Rao, M.S. and Negi, N.S.(1956). Growth correlations in sugarcane. Proc. Int. Soc. Sugarcane Technol.,9: 13-20.

Rao, P.N. and Ethirajan, A.S.(1984). Correlation and path coefficient analysis in crosses of high and low sugar cultivars of sugarcane(Saccharum) Part-I. high x high and low x low sugar cultivars. Indian Sug., 33(11): 721-728.

Rao, P.N., Rahman, M.A. and Rao., P.C. (1983). Genetic variability and character associations in sugarcane progenies. Indian J. agric. Sci., 53: 621-623.

Rattan, P. (1951). Studies on the effect of some agronomic characters on the ratoon crop of sugarcane in Punjab. Msc. Thesis, Univ. of Punjab.

Reddy, C.R.(1980). Studies on heritability and genetic advance in sugarcane. Maharashtra Sug., 5(6):15-18.

Reddy, K.R. and Khan, A.Q.(1984). Association among yield and quality characters in sugarcane. Indian J. agric. Sci., 54(8): 645-650.

*Richard, G.A.(1975). Genetic behaviour of sucrose content in sugarcane. Diss. Abstr. Int., 36(4):1535-1536.

Robinson, H.F.(1966). Quantitative genetics in relation to breeding on the centennial of Mendelism. Indian J. Genet., 26 A: 171-187.

Ruschel, R. (1977). Phenotypic stability of some sugarcane varieties in Brazil. Proc. Int. Soc. Sugarcane Technol., 16: 275-281.

Sahi, B.K. (1981). Further studies on the heritability of some of the economic characters in sugarcane. Ph.D Thesis, Univ. of Bombay.

Sahi, B.K. and Patel, K.A.(1975). Correlation study of quality and yield contributing characters in early maturing sugarcane cultivars. Indian Sug., 25(7): 621-624.

Sahi, B.K., Shah, S.S. and Patel, K.A. (1977). Variability in plant and ratoon crops of early varieties of sugarcane. Indian J. Genet., 37(3): 496-500.

Sangwan, R.S. (1981). Studies on stalk characters of selected sugarcane. Indian Sug. Crops J., 8(2): 4-6.

Sankaranarayanan, P. and Shanmughasundaram, S. (1981). Progeny studies in leaf width and breadth in sugarcane. Indian J. agric. Sci., 51(1): 5-6.

Shah, S.S., Rajasekharan, S. and Venkataraman, M.R. (1966). Heritability of some characters in sugarcane. Indian J. Genet., 26(1): 107-111.

Sharma, H.L. and Bharaj, T.S. (1983). Adaptability studies for quality traits in sugarcane. (Saccharum spp). Int. Soc. Sugarcane Technol. Sugarcane Breed. Newsl., 45: 186-192.

Sharma, H.L., Kanwar, R.S. and Aulakh, M.S. (1979). Association of phenotypic traits in the progeny of some sugarcane crosses. J. Res. Punjab Agric. Univ. 16(3): 261-266.

Shukla, G.K. (1972). Some statistical aspects of partitioning genotype-environmental components of variability. Heredity, 29: 237-245.

Sidwell, R.J., Smith, E.L. and McNew, R.W.(1976). Inheritance and interrelationships of grain yield and selected yield - related traits in hard red winter wheat cross. Crop Sci., 16: 650-654.

Simmonds, N.W. (1981). Genotype (G), environment (E) and G.E. components of crop yields. Exp. Agric., 17: 355-362.

Singh, B.V. and Jain, R.P. (1968). Correlation studies in sugarcane. *Madras Agric. J.*, *55*: 287-289.

Singh, B.V. and Sangha, A.S. (1970). Correlation studies in sugarcane. *Madras Agric. J.*, *57*: 474-477.

Singh, H. and Sharma, H.L. (1982). Interrelationship between yield and yield components in sugarcane. *J. Res.*, *19*(3): 185-187. *Punjab Agric. Univ.*

Singh, H. and Sharma, H.L. (1983). Path coefficient analysis of cane yield in sugarcane. *Indian Sug. Crops J.*, *9*(2): 7-9.

Singh, H.N., Singh, S.B. and Singh, T.K. (1981a). Selection parameters in sugarcane. *Indian J. agric. Sci.*, *51*(8): 562-566.

Singh, H.N., Singh, S.B., Châuhan, R.V.S. and Vishwakarma, R.S. (1983). Variability for yield and quality in sugarcane. *Indian J. agric. Sci.*, *53*(9): 760-789.

Singh, I.N., Singh, S.B., Verma, P.S. and Singh, R.V. (1981c). Correlation and path analysis in sugarcane. *Indian J. Agric. Res.*, *15*(2): 126-130.

Singh, K., Sangwan, R.S., Sharma, G.R., Taneja, A.D. and Hooda, M.S. (1978). Correlation and path coefficient analysis in early maturing genotypes in sugarcane. *Proc. 42nd Ann. Conv. Sugarcane Technol. Assn.*, India: 81-83.

Singh, M. and Singh, H. (1954). Certain correlation studies in sugarcane. *Proc. 2nd Bienn Conf. Sugarcane Res. Dev. Workers*. pp. 70-81.

Singh, R. and Sangwan, R.S. (1980). Studies on genetic variability for stalk characters in sugarcane. *Indian Sug.*, *30*(8): 409-412.

Singh, R and Sangwan, R.S. (1981). Correlation and path coefficient analysis of stalk yield and its components in sugarcane. *Maharashtra Sug.*, 6(12): 33-36.

Singh, R.K. and Chaudhary, B.D.(1977). *Biometrical methods in quantitative genetic analysis.* Kalyani publishers, Ludhiana, pp.296.

Singh, R.K., Tehlan, R.S. and Taneja, A.D. (1985). Investigations on some morphological and quality traits in relation to cane and sugar yield. *Indian Sug.*, 35(4):267-271.

Singh, R.R., Tripathi, B.K and Lal, S.S. (1981b). Variability and correlation studies in sugarcane. *Indian Sug.*, 31(7): 457-459.

Singh, U.S., Saxena, M.M.S. and Singh, L.(1970). Studies on crop estimates and forecasting yield and quality of sugarcane-I. Correlation between leaf nitrogen and cane weight, sucrose content and purity coefficient of juice. *Indian Sug.*, 19(11): 761-764.

Skinner, J.C. (1956). The inheritance of hairiness in sugarcane. *Proc. Int. Soc. Sugarcane Technol.*, 9: 668-677.

Smith, G.A. and James, N.I. (1969). Association of characters within and repeatability between years in progenies of four sugarcane crosses. *Crop Sci.*, 9: 819-821.

Snedecor, G.W. and Cochran, W.G.(1968). *Statistical methods.* Oxford & I.B.H. Co., New Delhi. pp.575.

*
Soopramanien, G.C. and Julien, M.H.R.(1980). Physiological basis of yield variation between and within sugarcane varieties grown under contrasting environments-I. Components of sucrose yield at harvest. *Sug. News*, 56(4): 131-136.

Spencer, G.L. and Meade, G.P. (1945). Cane sugar hand book. John Wiley and Sons, Inc.,London. pp.815.

*
Sprague, G.F. and Federer, W.T.(1951). A comparison of variance components in corn yield trials-II. Error. Year x variety, location x variety and variety components. Agron J., 43:535-541.

*
Stevenson, G.C. (1954). Reflection on the evolution of Hawaii's philosophy of sugarcane breeding. Sug., 49(6): 51-65.

Stokes, I.E. (1934). A biometrical analysis of certain characters of Saccharum officinarum. M.Sc. Diss. A and M Coll. Texas, USA.

Sundaresan, K., Balasundram, N. and Shanmugasundaram,S. (1979). Correlation between seedlings and their settlings in intervarietal crosses of sugarcane for major economic characters. Indian J. agric. Sci., 49(12): 934-937.

*
Tai, P.Y.P., Miller, J.D., Gill, B.S. and Chew, V.(1978). Relations among characters of sugarcane in two intermediate selection stages. Agron.Abst., 64.

Tai, P.Y.P., Rice, E.R., Chew, V. and Miller, J.D.(1982). Phenotype stability analysis of sugarcane cultivar performance tests. Crop Sci., 22: 1179-1184.

Tripathi, B.K., Ethirajan, A.S. and Shukla, R.K. (1978). Phenotypic stability of some exotic and Indian sugarcane(Saccharum sp. hybrids) varieties. Indian J. Sugarcane Technol.,1(2): 119-125.

Varma, H.P. (1963). A study of certain correlations between yield and growth factors in sugarcane. _Proc. 31st Ann. Conv. Sugarcane Technol. Assn., India_. _1_: 33-41.

*Wricke, G. (1962). Ubereine methode zur erfassung der akologischen streubreite in feldversuchen. Z. _flanzenzucht_, _47_: 92-96.

*Wright, S. (1921). Correlation and causation. _J. Agric. Res._, _20_: 557-585.

*Wright, S. (1923). Theory of path coefficients. _Genetics._ _8_: 239-255.

*Wright, S. (1934). The method of path coefficients. _Ann. Math.Statist._, 5: 161-215.

*Wright, S. (1956). Modes of selection. _Am. Nat._, _90_: 5-24.

Yadav, R.L. and Sharma, R.K. (1978).Correlation and regression studies between yield and its attributes in sugarcane varieties. _Indian J. Sugarcane Technol._, _1_: 17-22.

*Yang, T.C. and Chu, C.C. (1962). Studies on combining ability in sugarcane hybrids. _Rep. Taiwan Sug. Exp. Stn._, _26_: 1-10.

*Yates, F. and Cochran, W.G. (1938). The analysis of group of experiments _J. Agric. Sci. Camb._, _28_: 556-580.

* Originals not seen

GENETIC VARIABILITY, PATH ANALYSIS AND STABILITY PARAMETERS IN SUGARCANE

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ABSTRACT OF A THESIS

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ABSTRACT

Investigations on genetic variability, path analysis and stability parameters were conducted at the Sugarcane Research Station, Thiruvalla, Sugarcane Research Centre, Chittoor and Horticultural Research Station, Ambalavayal. The analysis of data collected from 48 clones evaluated at Thiruvalla revealed that the clones showed significant differences for all the 21 characters except juiciness at 10th month in the first ratoon crop. The germination count on the 45th day, shoot count on the 180th day, number of late shoots at harvest, number of millable canes per plot, cane yield per plot and sugar yield per plot recorded moderate to high heritability in the broad sense coupled with high genetic advance both in the plant and in the first ratoon crops indicating that selection based on these characters will be effective in improving cane and sugar yields.

Correlation studies revealed that cane yield per plot had significant positive genotypic correlations with germination count on the 45th day, shoot count on the 180th day, number of millable canes per plot, cane weight and length of cane both in the plant and the first ratoon crops. Therefore, improvement in any one or more of these

characters will result in a simultaneous improvement in the yield of cane. The quality characters such as juiciness, brix, pol and C.C.S. percentages at 12th month had positive but non-significant correlations with cane yield in the plant crop and the first ratoon crop, suggesting difficulty in the simultaneous improvement of cane yield and quality characters through direct selection.

The number of late shoots at harvest had highly significant positive genotypic and phenotypic correlations with the yield of cane in the first ratoon crop indicating that the number of late shoots at the time of harvest can be considered as a reliable criterion for the selection of clones with good yielding ability in the ratoon crop. Sugar yield recorded significant positive genotypic correlations with cane yield and the components of cane yield such as germination count on the 45th day, number of millable canes per plot, cane weight and length of cane. Sugar yield also had significant positive genotypic correlations with brix, pol and C.C.S.percentages at 12th month. The significant positive genotypic correlations of sugar yield with cane yield and its important components suggests that by increasing the cane yield, sugar yield per plot can be increased.

Among the six components considered as causal factors of cane yield, the girth of cane and the number of millable canes per plot had maximum positive direct effects in the plant crop, whereas the number of millable canes per plot and cane weight had maximum positive direct effect in the first ratoon crop. Therefore, for the improvement of cane yield in the plant crop, the girth of cane and the number of millable canes per plot have to be considered, whereas due weightage must be given for the number of millable canes per plot and cane weight in the first ratoon crop. For the improvement of C.C.S.percentage in the plant crop, the pol percentage which had maximum positive direct effect has to be considered while the brix percentage which had maximum positive direct effect on C.C.S.percentage has to be considered in the first ratoon crop in selection programmes aimed at the improvement of C.C.S.percentage. Among the two components of sugar yield, the cane yield had maximum positive direct effect in both plant and the first ratoon crops suggesting that by increasing the cane yield per plot rather than C.C.S.percentage, the sugar yield per plot can be increased

The evaluations of 15 selected clones at three locations and estimation of genetic parameters indicated that cane yield per plot, sugar yield per plot, number of millable canes per plot and cane weight had high genotypic coefficient of variation, broad sense heritability and genetic advance, suggesting the reliability of the above characters in selection programmes aimed at the improvement of cane and sugar yields.

The pooled analysis of the data collected on eight characters from the location trials revealed that genotype x environment interaction was significant for length of cane, cane weight, brix, pol and sugar yield per plot. The non-significant interaction for number of millable canes per plot, girth of cane and cane yield per plot indicate the stability of the above characters across environments. The estimation of stability parameters such as mean, regressions coefficient and deviations from regression revealed that none of the clones had stability for all the component characters. The clones CoC.771. Co.7219 and S-87 with higher cane and sugar yield satisfying the conflicting interests of the cane grower and the miller along with stability in performance across environments can be recommended to the sugar industry as stable genotypes. The grouping of genotypes based on mean and coefficient of variation indicated that none of the clones had consistency in performance across environments for all the components.

The varietal stability is achieved by 'buffering' and compensation mechanism among yield components such as stalk number and stalk diameter. The more number of millable canes in CoC.771 and increased girth in Co.7219 and S-87 had resulted in the stability of these clones across environments. The number of millable canes and girth are the two components having maximum direct contribution for cane yield. Therefore, breeding clones with more number of millable canes and girth will result in the development of high yielding clones with stability of performance across environments.