BIOMETRICAL INVESTIGATIONS ON DIVERSIFIED USES IN SUGARCANE [*Saccharum* spp.]

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M. Sc. (Ag.)

DOCTOR OF PHILOSOPHY IN AGRICULTURE
(GENETICS & PLANT BREEDING)

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BIOMETRICAL INVESTIGATIONS ON DIVERSIFIED USES IN SUGARCANE [*Saccharum* spp.]

By

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M. Sc. (Ag.)

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2013

CERTIFICATE

Mrs. **M.SHANTHI PRIYA** has satisfactorily prosecuted the course of research and that thesis entitled **"BIOMETRICAL INVESTIGATIONS ON DIVERSIFIED USES IN SUGARCANE [*Saccharum* spp.]"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

Date :

(Dr. K. HARIPRASAD REDDY)
Chairperson

DECLARATION

I, **M.SHANTHI PRIYA**, hereby declare that the thesis entitled **"BIOMETRICAL INVESTIGATIONS ON DIVERSIFIED USES IN SUGARCANE [*Saccharum* spp.]"** submitted to the **Acharya N.G. Ranga Agricultural University** for the degree of **DOCTOR OF PHILOSOPHY IN AGRICULTURE** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place : Tirupati **(M. SHANTHI PRIYA)**

I. D. No. TAD/2009 -04

Date :

CERTIFICATE

This is to certify that the thesis entitled **"BIOMETRICAL INVESTIGATIONS ON DIVERSIFIED USES IN SUGARCANE [*Saccharum* spp.]"** submitted in partial fulfillment of the requirements for the degree of '**DOCTOR OF PHILOSOPHY IN AGRICULTURE'** of the Acharya N. G. Ranga Agricultural University, Hyderabad, is a record of the bonafide original research work carried out by Mrs. **M. SHANTHI PRIYA** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

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Place : Tirupati

Date : March, 2013 (*M. Shanthi Priya....*✍)

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	per cent
^	:	circumflex accent
∑	:	summation
≤	:	Less than or equal to
°	:	Degree
ANOVA	:	Analysis of variance
BM	:	Biomass
C_1	:	First clonal stage
C_2	:	Second clonal stage
CCS	:	Commercial Cane Sugar
CD	:	Critical Difference
cm	:	centimeter
cm^3	:	cubic centimeter
Co	:	Coimbatore
Cov	:	Covariance
CY	:	Cane yield
DAP	:	Days After Planting
DAR	:	Days After Ratooning
df	:	Degrees of freedom
et al.	:	And others
FC	:	Fibre content
FY	:	Fibre yield
g	:	gram
GA	:	Genetic Advance
GAM	:	Genetic Advance as per cent of Mean
GCV	:	Genotypic Coefficient of Variation

$h^2_{(b)}$	:	Heritability in broad sense
ha	:	Hectare
HRB	:	Hand Refractometer Brix
HRBY	:	HR Brix Yield
IN L	:	Internode length
IN No.	:	Internode number
JE	:	Juice extraction
JP	:	Juice purity
kg	:	kilogram
M ha	:	Million hectares
M t	:	Million tones
ml	:	milli litre
mm	:	milli meter
MW	:	Mega watt
NGL	:	No. of green leaves
NGL M	:	No. of green leaves at maturity
NMC	:	Number of millable canes
No.	:	Number
PCV	:	Phenotypic Coefficient of Variation
Per se	:	As such with mean
r	:	Correlation coefficient
RE	:	Relative Efficiency
SCW	:	Single cane weight
SD	:	Stalk diameter
SE	:	Standard Error
SL	:	Stalk length
SP 180 DAP	:	Shoot population at 180 days after planting
SP 240 DAP	:	Shoot population at 240 days after planting

SUC	:	Sucrose
SV	:	Stalk volume
T 120 DAP	:	Tillers at 120 days after planting
t ha^{-1}	:	Tonnes per hectare
T	:	Tirupati
TS	:	Total sugars
TYA	:	Theoretical yield of alcohol
V	:	Vuyyur
Var	:	Variance
viz.,	:	Namely
σ^2	:	variance
σ_g	:	genotypic standard deviation
σ_p	:	phenotypic standard deviation

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ABSTRACT

The present experiment entitled "Biometrical investigations on diversified uses in sugarcane (*Saccharum* spp.)" was carried out at Agricultural Research Station, Perumallapalle, Andhra Pradesh, from 2010 to 2012. Four hundred and twenty nine genotypes selected from seedling nursery based on phenotypic evaluation were planted in augmented block design. Seventy three genotypes selected from the first clonal stage were evaluated for diversified uses viz., biomass per cane, fibre yield, theoretical yield of alcohol, commercial cane sugar (CCS) yield and cane yield in second clonal stage.

Considering the genetic parameters in second clonal stage, the characters viz., shoot population at 240 DAP, stalk length, number of millable canes, fibre content, brix, sucrose, CCS per cent, pol per cent cane, total sugars per cent, biomass per cane, fibre yield, CCS yield, theoretical yield of alcohol and cane yield showed high heritability coupled with high genetic advance as per cent of mean indicating that these characters were under the influence of additive gene effects and selection would be effective for the improvement of these characters.

Association studies and path analysis for diversified uses in second clonal stage revealed that single cane weight, fibre yield and number of millable canes at harvest were the major contributing characters to cane yield; cane yield and fibre content are the major contributing characters to fibre yield; selection based on stalk volume and single cane weight would be helpful for the improvement of biomass; total sugars per cent, pol per cent

cane and CCS per cent were the major contributing characters to theoretical yield of alcohol; and the characters pol per cent cane, CCS per cent, cane yield, fibre yield, single cane weight and number of millable canes exhibited positive direct effects on CCS yield and the majority of the characters also exhibited high indirect positive effects on CCS yield via CCS per cent and pol per cent cane indicating that CCS percent and pol per cent cane are the major contributing characters to CCS yield in sugarcane.

The selection indices constructed with the inclusion of more than one character gave higher genetic advance and relative efficiency over straight selection for the five diversified uses viz., cane yield, biomass per cane, fibre yield, theoretical yield of alcohol and commercial cane sugar yield.

As sugar production scenario is changing, varietal needs have started changing. Based on the mean performance of the genotypes viz., 2010T-152 and 2010T-53 showing high performance for biomass, fibre yield, CCS yield, theoretical yield of alcohol and cane yield; the genotypes viz., 2010T-146 and 2010T-84 showing higher performance for biomass, fibre yield, CCS yield and cane yield; the genotypes viz., 2010T-4, 2010T-103, 2010T-72 showing higher performance for fibre yield, CCS yield, theoretical yield of alcohol and cane yield; the genotypes viz., 2010T-115, 2010T-387 and 2010T-285 showing higher performance for fibre yield, CCS yield and cane yield could be suggested for promotion as varieties for respective diversified uses.

The genotypes 2010T-16, 2010T-18, 2010T-82, 2010T-88, 2010T-103, 2010T-124, 2010T-153, 2010T-229, 2010T-239, 2010T-344, 2010T-347 and 2010T-416 selected by the index method could serve as potential genetic stocks in sugarcane breeding for diversified uses.

On the basis of genetic divergence and mean performance of genotypes, the most promising cross combinations suggested for the development of varieties for diversified uses are 2010T-124 x 2010T-4, 2010T-16 x 2010T-146, 2010T-88 x 2010T-146 and 2010T-18 x 2010T-146.

Chapter I

Introduction

Chapter I

INTRODUCTION

Sugarcane is an important cash crop and raw material for sugar industry which is the second largest agro based industry of India. It assumes an important position in the economy of the country. Its contribution to agricultural GDP is 10% which is significant as the crop is grown in only 2.57% of the gross cropped area in the country (SBI, 2011). Sugarcane crop serves as the major source for a variety of products such as sugar, jaggery, molasses, bagasse, filter cake, out of which sugar and jaggery are meant for daily use as consumable products while other byproducts have industrial significance. It is realized that sugar production alone will not be able to make the industry profitable and under such circumstances diversification is a necessary consequence for the successful growth of industry.

Sugarcane is grown in an area of 17.53 M ha worldwide producing 1286.67 M t of cane with a productivity of 73.40 t ha^{-1} (FAOSTAT, 2011). In India sugarcane is cultivated in an area of 5.03 M ha producing 342.19 M t of cane with an average productivity of 68.1 t ha^{-1} (Sugar India, 2012). In India sugarcane is grown in both tropical and sub tropical regions. Uttar Pradesh, Maharastra, Karnataka, Tamil Nadu, Gujarat and Andhra Pradesh are the major cane growing states. In Andhra Pradesh it is grown in an area of 1.8 lakh ha producing 140.4 lakh tonnes of sugarcane with an average productivity of 78.0 t ha^{-1} (Sugar India, 2012). In India 24.39 M t of sugar is produced, but the projected requirement of sugar by 2030 is 36 M t which has to be achieved from the existing cane area through improved varieties for cane yield and sugar recovery as further expansion in area is not possible.

Sugarcane, which is also considered as an important bio energy crop belongs to the category of C4 plants which converts the solar energy effectively into high quality and low cost raw materials for sugar and ethanol (Bruce *et al.* 2005). Molasses and bagasse are the byproducts of sugar industry which form the feedstock for ethanol production and cogeneration respectively. National policy on biofuels proposed to scale up the blending from 5% to 20% by 2017. The target is difficult to achieve due to limited availability of bioethanol which to a greater extent comes from sugarcane molasses apart from a smaller proportion from grains. This necessitates significant increase in domestic ethanol production by developing varieties which yield higher ethanol. More than 500 sugar industries in the country have a potential to generate electricity of 5000 MW. However, the current installed capacity is only 2200 MW which is due to under utilization of full capacity of the industry to generate required quantity of bagasse and lack of energy canes with high fiber. Sugar factories with co-generation facility demand for high fibre varieties up to 16% as it helps in increasing the baggase availability (Natarajan, 2000).

Generally the main objective of sugarcane breeding is to develop varieties capable of producing high cane yield and CCS yield per unit land area. The recent awareness on the advantages of using green fuel for generation of power and use of gasohol to reduce automobile emission have resulted in setting up of a number of cogeneration plants in various sugar mills. To achieve these goals of increased sugar, alcohol and cogeneration, sugar industries need special varieties to meet their specific requirement of raw materials. Sugarcane breeders traditionally breed varieties for high sucrose and high stalk yield. As sugar production scenario is changing, varietal needs have started changing. Hence, breeding programmes must integrate new traits such as high fiber, high biomass and high total sugars in addition to yield and juice quality.

Proper exploitation of variability in a crop like sugarcane with a complex ploidy and a high level of heterozygosity is a complicated process (Babu *et al.* 2009). Breeding for higher cane yield and quality traits requires basic information on the extent of genetic variation in a population and its response to selection.

Understanding various genetic parameters that govern a population under improvement is essential for proper planning and direction of plant breeding programme. The success of such program will depend upon largely on the extent of genetic variability available in the base population and heritability of the characters under improvement. Therefore, a clear understanding of genetic parameters is of paramount importance in the development of a breeding strategy (Singh *et al.* 2002).

Furthermore, the most important function of heritability in genetic studies of quantitative traits is its prediction value that could be used as a guide to breeding value and heritability estimates along with genetic advance expected by selection for cane yield, commercial cane sugar yield, biomass, fibre and ethanol and their contributing characters seem to help in designing an effective breeding program and selecting superior clones for diversified uses for the sustainability of sugar industry.

Statistical correlation coefficient is a measure that denotes the magnitude and direction of interrelationship between any two casually related variables (Singh and Narayanan, 1993). The association between two or more characters is due to pleiotropic gene action or linkage (Falconer, 1989). In plant breeding correlation coefficient analysis measures the mutual relationship between two plant characters and it determines characters association for genetic improvement of yield and other economic traits. The character associations will help in the selection of superior genotypes from divergent population based on more than one interrelated characters. The present study was conducted to obtain the information on the association of various characters with cane yield, fibre yield, sugar yield, biomass and ethanol. However, correlation coefficients, sometimes, may be misleading and thus, need to be partitioned into direct and indirect effects. It is important for a breeder to know how other characters influence a particular character. Hence, path coefficient analysis was carried out to partition correlation coefficient into direct and indirect effects.

The main objective of a selection programme is to shift the mean to a new peak by directional selection. Continuous selection in one character may result in a loss or gain in the other characters, which are also of equal importance. On the other hand, if selection is made for a number of characters, the efficiency of selection would be reduced. So the plant breeder will have to base his selection on a combination of a few important characters related to the main character under consideration in the form of a selection index by appropriate weightages assigned to the phenotypic values of each character so that the genetic gain in the character under consideration will be maximum without any loss in other important characters. Selection indices provide the means for making use of correlated characters for higher efficiency in selection for characters of low heritability. Selection index is a tool, which breeder can use successfully for selection on several characters simultaneously by discriminating the desirable ones on the basis of phenotypic performance.

Hybridization is one of the most essential steps in plant breeding since it is the source of all genetic variability available for selection of new plants. The correct planning of the crosses increases the probability of developing superior cultivars because it maximizes the use of favourable genes, besides reducing the costs of breeding programmes (Cruz *et al.* 2004a). Sugarcane is a species with asexual reproduction. The objective of hybridization in sugarcane is, therefore, to create genetic variability for the selection of superior and productive plants that are propagated to become the future cultivars. In this case, the genetic potential is fixed from the clonal selection onwards and is not altered through the generations (Calijia *et al.* 2001).

Depending on the objectives of a breeding programme different methods can be used to select the parents (Cruz *et al.* 2004b). In general breeders try to make crosses between divergent and high yielding plants (Carpentieri-Pipolo *et al.* 2003, Cruz *et al.* 2004b). Knowledge on genetic divergence is therefore fundamental to identify and organize the available genetic resources aiming at the production of promising cultivars (Palomino *et al.* 2005).

The identification of diverse genotypes or parents for hybridization is an important consideration in sugarcane improvement. Mahalanobis D^2 technique has been quite useful in determining the diversity in crop species (Punia *et al.* 1983). In vegetatively propagated crops like sugarcane, development of improved genotypes with high heterotic expression for yield and quality characters is desired. The heterotic genotypes can be developed by utilization of diverse parents in hybridization.

Keeping the above points in consideration, the present investigation was taken up with the following objectives.

- To estimate genetic parameters for different component characters related to diversified uses viz., fibre yield, ethanol yield, biomass, sugar yield and cane yield in sugarcane.

- To study the extent of association existing among different component characters with cane yield, sugar yield, fibre yield, biomass and ethanol yield and among themselves in different clonal stages.

- To identify characters which are directly and / or indirectly influencing fibre yield, ethanol yield, biomass, cane yield and sugar yield in different clonal stages.
- To formulate selection indices for diversified uses viz., fibre yield, ethanol yield, biomass, sugar yield and cane yield in sugarcane.
- To identify divergent genotypes in second clonal stage for improving fibre yield, ethanol yield, biomass, sugar yield and cane yield.
- To identify genotypes suitable for diversified uses viz., fibre yield, ethanol yield, biomass, sugar yield and cane yield in sugarcane.

Chapter II

Review of Literature

Chapter II

REVIEW OF LITERATURE

In view of the objectives mentioned in chapter one, a brief review of literature on sugarcane in respect of genetic parameters (coefficient of variation, heritability and genetic advance), character association, path analysis, selection indices, genetic divergence and diversified uses is presented in this chapter.

2.1 GENETIC PARAMETERS

In any plant breeding programme the information on genetic parameters like genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance has an immense value in identifying the superior genotypes. Presence of variability is the basic requirement for improving any crop. Heritability measures the amount of heritable portion of variability, while genetic advance helps to measure the amount of progress that could be expected with selection. Hence, heritability estimates in conjunction with the estimates of genetic advance were more valid for selection than heritability estimates alone (Johnson *et al*. 1955a).

The available literature on variability, heritability and genetic advance in sugarcane is reviewed briefly here under.

In a study of thirty five genotypes of sugarcane Verma *et al*. (1988) reported high heritability coupled with high genetic advance for stalk weight, brix per cent and commercial cane sugar.

Singh and Singh (1994) evaluated seedlings of five biparental crosses to assess genetic variability, narrowsense heritability, genetic advance and noticed that the phenotypic and genotypic coefficient of variance, heritability and genetic advance over mean were higher for number of green leaves, leaf area, leaf length, diameter of stalk, brix per cent and shoot per clump.

Seedlings of five biparental crosses were evaluated by Singh *et al.* (1995) to assess genetic variability, heritability (narrow sense) and genetic advance. The results showed that the phenotypic and genotypic coefficients of variance, heritability and genetic advance were high for number of green leaves, number of nodes, stalk diameter and stalk weight.

Das *et al.* (1996) examined the range of variability, heritability and expected genetic improvement in twenty four early maturing genotypes and reported high to medium genetic variability and heritability for stalk yield and its components, viz., individual stalk weight, number of internodes and number of millable canes per hectare indicating that these traits were highly amenable to selection procedures and hence offered better scope for improvement through selection. Quality characters like sucrose per cent and commercial cane sugar per cent showed less variability, intermediate heritability and low genetic gain suggesting difficulty in improvement of these characters.

Highest estimates of genotypic variance and coefficient of variation, heritability and genetic advance were recorded for cane yield, number of millable canes, plant height, germination at 45 days, number of shoots at 90 and 120 days, whereas juice quality characters showed lower values for these statistics (Ghosh and Singh, 1996).

In a study on fourteen genotypes of sugarcane, Singh *et al.* (1996) reported that genotypic and phenotypic coefficients of variation were high for commercial cane sugar and cane yield, moderate for cane height and number of millable canes and low for brix per cent, sucrose per cent and cane diameter. Heritability in broad sense was high for all the characters.

Genetic advance was high for cane yield and commercial cane sugar and moderate for cane diameter, cane height and number of millable canes.

High heritability was recorded for leaf width followed by length of internodes and high genetic advance was observed for single cane weight and cane yield in a study on thirty two genotypes of sugarcane (Kadian *et al.* 1997). Tyagi and Singh (1998) evaluated twenty two genotypes of sugarcane and reported high heritability with high genetic advance for stalk density and stalk weight and indicated that selection for these traits will be more effective.

Chaudhary (2001) estimated phenotypic and genotypic coefficients of variation, heritability and genetic advance for seven stalk characters in sugarcane and noticed that single cane weight, germination at 45 DAP and millable cane number had high genotypic and phenotypic coefficients of variation. High heritability estimates were recorded for millable cane number, stalk diameter and single cane weight. Maximum genetic gain as percent of mean was observed for single cane weight and millable cane number.

Jain *et al.* (2001) conducted a trial with eighty one sugarcane genotypes to assess the extent of variability at phenotypic and genotypic levels, heritability coefficients, genotypic coefficient of variability and genetic advance to estimate the relative contribution of various components towards final cane yield. They reported that number of millable canes per clump, single stalk weight and cane yield recorded higher estimates of coefficient of variation, heritability and genetic gain.

Variability, heritability and genetic advance were estimated for eleven morphological characters of sixty sugarcane genotypes and a good amount of variability was recorded for all the characters. Maximum heritability was recorded for germination percentage, leaf area, dry matter, leaf angle, number of internodes and cane yield per plot. Genetic advance as percentage of mean was high for germination percentage, leaf area, dry matter, leaf angle and cane formed shoots, and lowest for stem diameter and number of millable canes per plot (Tippeswamy *et al*. 2001).

High broad sense heritability was observed for cane yield, commercial cane sugar per plot, internode number, juice brix and commercial cane sugar per cent in studies involving sugarcane germplasm (Ravishankar *et al*. 2003). Highest genotypic coefficient of variation in plant and ratoon crop was recorded for single cane weight and number of millable canes respectively and highest genetic advance was recorded for cane yield in plant crop and for number of millable canes in ratoon crop by Bhatnagar *et al*. (2003) in an evaluation of eighteen sugarcane genotypes.

In a study involving fifty two genotypes of sugarcane Deep *et al*. (2004) found that selection based on juice quality traits viz., juice brix per cent, pol per cent, purity per cent, commercial cane sugar per cent and commercial cane sugar per clump was not of much use as these traits showed moderate to high heritability with low estimates of variability and genetic gain.

Kumar *et al*. (2004) observed high heritability and genetic advance expressed as per cent of mean for number of millable canes, number of tillers at 240 DAP, commercial cane sugar, cane yield, cane height, cane girth, single cane weight and number of internodes per stalk in a study of 27 subtropical sugarcane cultivars.

The extent of genetic variation in two hundred and twenty five sugarcane genotypes was studied by Ravishankar *et al*. (2004). Genotypic and phenotypic variances were high for cane yield per plot, and moderate for number of tillers per plot, number of millable canes per plot and number of internodes. High heritability in broad sense was recorded for cane yield per plot, single cane weight and internode length. The genetic advance was moderate for number of tillers per plot, number of millable canes per plot and number of internodes.

Chandrakanth *et al.* (2006) evaluated eighty four clones in augmented design and reported high range of variation along with high coefficient of variation for germination percent at 45 days, number of shoot per hectare at 120 days, number of millable canes per hectare, cane height, cane diameter, single cane weight and cane yield.

Evaluation of 781 (439 *S. officinarum* x *S. spontaneum* and 342 *S. robustum* x Commercials / *S. officinarum*) hybrid progenies for cane yield and quality traits by Nagarajan *et al.* (2006) revealed differences between the groups for number of millable canes, cane height, cane weight and juice quality characters. Heritability was moderate for sucrose in both the groups. The higher estimates of heritability coupled with higher genetic advance for number of millalbe canes indicated that the heritability of this trait was mainly due to additive effects and selection would be effective for this trait.

In variability studies among forty diverse sugarcane cultivars Patel *et al.* (2006) reported high heritability coupled with high genetic advance for cane weight and commercial cane sugar indicating the effectiveness of direct selection for these traits.

Doule and Balasundaram (2007) observed that fibre per cent, cane and rind hardness at 300 and 360 DAP exhibited high degree of genotypic coefficient of variability, genetic advance and moderate levels of heritability coefficient. Rahman *et al.* (2008) noticed that number of tillers, number of millable canes per clump, stalk height, number of green leaves and cane yield showed high heritability, high genetic advance and high genetic advance as percent of mean.

Berding and Pendrigh (2009) observed that the broad sense heritability values were high for brix, commercial cane sugar, dry matter and fibre indicating likely success for selection for these traits. In variability studies among twenty one phenotypically diverse genotypes of sugarcane Mali *et al*. (2009) observed high heritability coupled with high genetic advance for number of tillers and single cane weight indicating the presence of additive gene action and suggested that direct selection may be highly effective.

Rahman and Bhuiyan (2009) in a study on twenty five promising clones and two standard sugarcane cultivars noticed high genotypic coefficient of variation for mean number of tillers per hectare, cane yield per hectare and single cane weight. High heritability with high genetic advance as percentage of mean was observed for number of tillers per hectare and single stalk weight.

Krishna *et al.* (2011) evaluated nineteen sugarcane clones in second plant crop and ratoon crop and observed that the estimates of variability, heritability and genetic advance as percent of mean were high for cane length, internode length, single cane weight, number of millable canes, commercial cane sugar yield and cane yield in both plant and ratoon crops and for sucrose per cent and CCS per cent in plant crop suggesting the effectiveness of simple selection procedures for improving morphological characters in plant crop or ratoon crop and quality characters in plant crop.

Ahmed and Obeid (2012) tested twelve exotic sugarcane clones and reported wide range of variation for number of millable canes, stalk height and juice purity (%) in both plant crop and ratoon crop. Maximum genotypic and phenotypic coefficients of variation were exhibited by number of millable canes and single stalk weight in plant crop whereas in ratoon crop single stalk weight and sugar yield recorded highest value. The fiber per cent recorded lowest values for both coefficients in both crops. Maximum values for heritability (%) along with high genetic advance (%) was recorded for number of millable canes whereas fiber per cent showed the minimum values for both parameters across the two crops, indicating the possibility of improvement of millable canes by means of straight selection. Juice purity (%) showed pronounced heritability and genetic advance in ratoon crop than in the plant crop, demonstrating the improvement of this trait during the ratoon crop.

Mancini *et al*. (2012) evaluated the progeny clones derived from a biparental cross and revealed that broad sense heritability values were generally high for stalk diameter, stalk weight, stalk height, brix and pol per cent cane in plant and ratoon cane.

2.2 CHARACTER ASSOCIATION

The concept of correlation was given by Fisher (1918) and Wright (1921), which helps in determining the nature and degree of relationship between any two measurable characters. Generally, quantitative characters of economic importance are often associated with one another either positively or negatively. Hence, the selection for the major economic traits on the basis of *per se* performance alone may not be as effective as that based on the component characters associated with them, which is biometrically determined by correlation and path coefficient analysis.

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

A brief review of studies on the association of characters in sugarcane is presented here under.

In a study involving thirty five genotypes of sugarcane by Verma *et al.* (1988) reported significant positive association of internodes per cane, stalk weight, brix per cent and commercial cane sugar with each other. Further, they reported that stalk weight, brix per cent and commercial cane sugar exhibited significant positive association with stalk girth.

Gravios *et al.* (1992) in a study involving twenty two clones observed that fibre content was significantly and negatively correlated with stalk diameter indicating that indirect selection for larger stalk diameter would decrease fibre content. Direct selection for optimum fibre content by evaluating clones in a single crop would be effective.

Rakkiyappan and Pandiyan (1992) in a study of 23 varieties of *Saccharum officinarum* reported that total sugars content was positively associated with fermentable sugars content in the juice. Ethanol yield per unit volume of juice was also significantly and positively associated with total sugars and fermentable sugars in cane juice. Cane yield directly affected ethanol yield as evidenced from the highly significant positive correlation between them. Hence, a variety meant for ethanol production should contain high total and fermentable sugars in juice coupled with high cane yield and juice extraction per cent.

Patel *et al.* (1993) in a study of fourteen cultivars of sugarcane notied that cane yield was significantly and positively correlated with commercial cane sugar, cane height and internode number. They also reported significant positive correlation of juice sucrose per cent with commercial cane sugar.

In a study on early maturing clones of sugarcane Choudhary and Singh (1994) reported that germination percentage at 45 DAP, number of shoots at 90 and 120 DAP, height of cane, cane width and number of millable canes were positively correlated with cane yield and among themselves.

Significant and positive association of number of green leaves with early brix and cane yield was observed by Singh and Singh (1994) in a study comprising seedlings of five biparental crosses. Ramesh and Varghese (1995) reported that number of millable canes and single cane weight were significantly postitively correlated with cane yield, in a study on sugarcane crop which received twenty seven treatment combinations of N, P and K.

Singh *et al*. (1995) observed that brix quality was significantly correlated with number of green leaves and stalk diameter, whereas stalk yield was positively and significantly associated with number of stalks per clump and stalk weight in a study involving seedlings of five biparental crosses.

Das *et al*. (1997) determined the correlations between cane yield and its various component characters in a group of 24 early maturing sugarcane varieties. They found that cane yield was significantly positively associated with CCS (t ha^{-1}), stalk weight, stalk diameter and number of internodes per cane, whereas number of millable canes per hectare was negatively and significantly associated with stalk weight, height of millable cane, sucrose per cent in juice and CCS per cent. Stalk weight was significantly and positively correlated with CCS (t ha^{-1}), height of millable canes and stalk diameter. Sucrose per cent in juice was significantly and positively associated with CCS (t ha^{-1}) and cane height. They also noticed that

CCS (t ha^{-1}) was significantly correlated with cane height and both were significantly and positively associated with stalk diameter, while stalk diameter was significantly and positively correlated with number of internodes.

Ram and Hemaprabha (1997) studied correlation coefficients in thirty F_1 hybrids derived from crosses of *S.officinarum* with *S.barberi* (OB), *S.robustum* (OR), *S.spontaneum* (OS) and commercial hybrids (OH) and found a positive association between cane yield and number of millable canes in all crosses while significant association of cane length with cane yield was noticed in OB and OH groups. The sugar yield was associated with number of millable canes in the OB, OH and OR crosses; with brix per cent and sucrose per cent in the OB, OR and OS crosses; and with per cent juice extraction only in the OS cross.

Das *et al*. (1997) reported that sugar yield was positively and significantly associated with cane productivity, cane weight, juice purity, CCS per cent and cane height in a study including twenty seven mid late sugarcane cultivars. They also found that quality traits including sucrose and CCS per cent were positively correlated with each other and also with sugar productivity.

In a study of twelve sugarcane varieties, positive significant association of cane height, cane girth and cane weight with cane yield was noticed by Hapase and Repale (1999). However, sugar yield exhibited significant positive association with juice brix per cent, commercial cane sugar per cent and cane yield.

Nair *et al*. (1999) evaluated fourteen intraspecific hybrids of *S. officinarum* selected for better stalk thickness and soft rind for yield and quality attributes. They noticed that stalk thickness was not correlated with stalk and sugar yields but stalk height had a very high genotypic correlation with stalk and sugar yields and hence, it was considered as the most important yield component.

Verma *et al*. (1999) reported that millable canes, commercial cane sugar and cane yield were significantly and positively correlated with each other. Whereas significant positive association of stalk height with internodes per cane and cane yield; stalk girth with stalk weight and commercial cane sugar was noticed in a study involving sixteen sugarcane varieties.

Relationships between attributes were studied in seedling, seedling ratoon and settling stages in two open pollinated populations of sugarcane by Ram *et al*. (2000). Significant correlations were recorded between brix yield and its components such as number of millable stalks, stalk diameter, stalk length, single stalk weight and stalk yield. There was no difference in the nature of association between traits in the two populations at the clonal stage.

The correlation coefficients between various contributing characters on cane yield revealed that germination, number of tillers and millable canes were significantly and positively associated with cane yield in a study conducted by Setia *et al*. (2001) on twenty two genotypes of sugarcane.

The character association studies by Ishaq *et al*. (2002) in eight genotypes of sugarcane revealed that stalk weight, stalk height, number of stalks per stool, leaf area, juice and commercial cane sugar per cent were the major traits contributing to cane and sugar yield. Stalk diameter, an important component of cane yield, was positively correlated with stalk weight, stalk height and leaf area.

In a study involving ten sugarcane genotypes, Nahar *et al*. (2002) noticed strong positive correlation of cane yield with number of millable canes and cane height, but negative correlation was observed with brix per cent and sucrose per cent at both genotypic and phenotypic level, whereas cane diameter exhibited least correlation with cane yield.

Jain *et al*. (2002) in a study involving eighty one genotypes of sugarcane reported that there was no significant association between cane yield and yield components with the juice quality characters, but the interrelationship between the quality traits was high and positive.

In an investigation involving sixty sugarcane genotypes Thippeswamy *et al*. (2003) observed that single cane weight, number of millable canes per plot, leaf area and germination percentage were highly and positively correlated with cane yield as well as with commercial cane sugar yield.

Significant and positive correlation of cane yield with number of tillers at 120 and 240 DAP, number of millable canes, cane height, cane girth and single cane weight was reported by Krishna *et al*. (2004) in a study involving twenty seven subtropical sugarcane cultivars.

Correlation studies by Dagar *et al*. (2004) involving fifty sugarcane genotypes indicated a significant and positive association of cane yield with number of millable canes per clump, cane height, cane thickness, number of internodes per cane, internode length, leaf length, leaf breadth, leaf area and single cane weight. No significant relationship was observed between cane yield per clump and the four juice quality traits viz., brix, pol, purity and CCS per cent. The interrelationship among the juice quality attributes was significant and positive, which indicated that improvement in one attribute would certainly lead to the improvement in other three traits in desired direction.

In a study involving twenty two sugarcane clones, Singh and Khan (2004) noticed significant positive association of number of millable canes, stalk height and cane weight with cane yield and highly significant and positive association of CCS yield with cane yield, cane weight and stalk height indicating the importance of these traits in improving CCS yield. Thangavelu (2004) reported significant positive association of tillers with cane yield, sugar yield, juice weight, juice volume, dry matter and number of millable canes.

In a study involving sixty five clones of sugarcane Chaudhary and Joshi (2005) noticed positive and highly significant correlation of single cane weight, stalk length and millable cane number with cane yield. There was also positive and significant correlation of cane diameter and number of internodes with cane yield. Length of internode had positive non-significant association with cane yield.

Correlation coefficient studies by Chandrakanth *et al*. (2006) revealed significant positive association of number of shoots at 120 days, number of millable canes at harvest and single cane weight with cane yield. Kadian and Mehla (2006) in a study involving thirty two sugarcane genotypes reported significant positive correlation of cane yield with single cane weight and cane thickness. The four juice quality parameters viz., brix per cent, pol per cent, purity and CCS showed highly significant and positive association among themselves

In an association study involving forty diverse sugarcane genotypes significant and positive correlation of cane yield with single cane weight, stalk length, stalk diameter and number of internodes at both genotypic and phenotypic levels was observed by Patel *et al*. (2006).

Soomro *et al*. (2006) evaluated eleven sugarcane varieties for quantitative and qualitative characters and noticed that cane thickness, cane height, number of internodes and millable canes were positively and highly significantly correlated with cane yield and hence the increase in these traits resulted in simultaneous increase in cane yield. CCS per cent exhibited positive but non significant association with cane yield.

Tyagi and Praduman (2007) observed positive and significant correlation between plant volume and number of millable stalks; plant volume and weight per stalk; plant volume and weight of millable stalks; plant volume and stalk thickness; number of millable stalks and weight of millable stalks; pure obtainable cane sugar and pol; pure obtainable cane sugar and purity; pol and purity. Correlation studies indicated that for sugarcane yield plant volume, plant height, number of millable stalks per stool, stalk thickness and weight of millable stalks are the most important characters. However, for biochemical characters pure obtainable cane sugar, pol and purity are the most important characters.

In a study involving six early duration sugarcane commercial hybrids, Das *et al*. (2007) observed that cane length, single cane weight, cane diameter and purity per cent had highly positive significant genetic association with both cane and sugar yield. The genetic correlation coefficient among quality parameters of juice revealed that sucrose per cent is comparatively more reliable indicator of juice quality than brix per cent. The results of both genotypic and phenotypic correlation coefficient indicated that single cane weight is the main component character contributing to both cane and sugar yield.

Singh *et al*. (2008) reported that in sugarcane brix and juice purity were highly correlated with sucrose per cent and with each other. Rahman *et al*. (2008) studied the character association of different characters on cane yield in sugarcane using twenty eight promising clones and two standard cultivars and observed that in general, the genotypic correlation was higher than the corresponding phenotypic correlation. The correlation coefficients between the number of millable canes per hectare, stalk weight and stalk height were highly significant and positive. These characters also showed significant positive correlation with cane yield along with number of millable canes per clump.

Sahu *et al*. (2008) observed that number of tillers per clump, number of millable canes per clump, plant height and single cane weight showed high positive significant correlation with cane yield at both seedling and settling stages while cane diameter and number of leaves per plant were significantly correlated with cane yield at seedling stage only. They reported that number of tillers per clump, number of millable canes per clump, plant height and single cane weight were the most reliable characters for selection of genotypes at seedling and settling stages.

Shah *et al*. (2008) evaluated five sugarcane genotypes for ratooning ability and reported that cane yield was significantly and positively correlated with refractive brix, sucrose content and sugar yield. Berding and Pendrigh (2009) observed that the genetic correlations between brix and CCS, brix and dry matter and dry matter and fibre were strong whereas those between brix and fibre, CCS and dry matter and CCS and fibre were weak.

Mali *et al*. (2009) in a study on twenty one sugarcane genotypes noticed significant positive association of cane yield with number of internodes, cane diameter, single cane weight and CCS (kg/plot) at 360 DAP and number of millable canes per plot.

Character association studies revealed a positive correlation of cane yield with number of millable stalks, stalk height, internode number per stalk and single stalk weight indicating improvement in one of these characters may result in positive response of cane yield in sugarcane (Ahmed *et al*. 2010).

Singh *et al*. (2010) conducted an experiment to evaluate seventeen genotypes of sugarcane and the results revealed that number of shoots at 120 DAP, number of shoots at 240 DAP, number of millable canes at 12 months and cane yield were highly significant and positively correlated with sugar yield. Highly significant and positive association of sugar yield with number of internodes per stalk, number of millable canes per square meter, total soluble solids per cent and sucrose per cent was detected by Al-Sayed *et al.* (2012) in studies on sugarcane.

In a study involving the progeny clones derived from a biparental cross in sugarcane, Mancini *et al*. (2012) observed that tonnes of sugarcane per hectare was significantly correlated with stalk weight and stalk number in both plant and ratoon crop. They found that stalk number together with stalk weight were the most important components in the determination of tonnes of sugarcane per hectare, while fiber and pol per cent cane were negatively correlated showing that they are inversely correlated traits.

Tyagi *et al.* (2012) in a study on thirteen sugarcane cultivars observed a significant positive association between cane yield and number of canes per plot, cane weight, cane height and sugar yield per plot. They also observed non-significant negative correlation of sucrose with cane and sugar yields which implied that both yield and sucrose could be selected simultaneously.

2.3 PATH COEFFICIENT ANALYSIS

The concept of path analysis was originally developed by Wright (1921) in animal breeding, but the technique was first used for plant selection by Dewey and Lu (1959). Path analysis furnishes a means of measuring the direct and indirect effects of a variable through other variables on the end product. This technique partitions the correlation into direct and indirect effects. Hence, correlation in conjunction with path coefficient analysis will give a clear idea of the association and helps in determining the contributing characters useful in indirect selection of a dependent character.

The findings of earlier workers on the relative contribution of different characters to cane yield, commercial cane sugar yield, biomass, fibre yield and ethanol yield in sugarcane are furnished here under.

Path analysis in 34 genotypes of sugarcane revealed that millable canes per clump had a high direct effect on cane yield. Single cane weight emerged as the most important trait influencing cane yield as most of the characters were exhibiting positive indirect effects via single cane weight on cane yield (Hooda *et al*. 1988).

Path coefficient analysis in plant cane and first ratoon crops of 48 genotypes of sugarcane by Kang *et al*. (1989) indicated that the direct effects of rind puncture resistance and juice extraction and moisture percentages on cane fibre per cent were positive, negative and negative respectively. They reported that fibre per cent was the least important component of cane and sugar yields. The direct effects of stalk number and stalk weight on cane yield were both positive and hence, selection for these characters was recommended to increase cane yield.

Hooda *et al*. (1990) studied the influence of four quality traits viz., brix per cent, pol per cent, purity per cent and reducing sugars on commercial cane sugar in six environments and found that although correlations were generally high for all four traits, the direct effects were low or negative.

From path analysis, the negative direct effect of fibre content on recoverable sucrose indicates a weak inverse relationship between these two traits was reported by Gravios *et al.* (1992).

Commercial cane sugar yield exhibited highest direct positive effect on cane sugar productivity, while juice sucrose per cent, CCS per cent and internode number had maximum positive indirect effects through CCS yield on cane yield in a study of 14 sugarcane cultivars by Patel *et al*. (1993).

Path coefficient analysis in early maturing clones of sugarcane by Choudhary and Singh (1994) indicated that number of millable canes and individual cane weight made the greatest direct contribution to cane yield and germination percentage at 45 DAP, number of shoots at 90 and 120 DAP, cane height, cane width were indirect contributors via number of millable canes.

In a study involving seedlings of five biparental crosses Singh and Singh (1994) reported that number of green leaves and leaf area influenced directly the brix quality while stalk diameter, and shoot per clump directly influenced cane yield.

Singh *et al*. (1994) studied direct and indirect effects of characters affecting cane yield of five sugarcane crosses and revealed that number of millable stalks followed by stalk weight had the maximum direct effect on cane yield, while the direct effects of stalk height, stalk diameter, brix per cent and sucrose per cent on cane yield was generally very low.

In another study of 45 sugarcane genotypes, Singh and Khan (1995) observed highest positive direct effect of number of millable stalks followed by stalk weight on cane yield.

Path coefficient analysis by Das *et al*. (1996) in a group of 24 early maturing sugarcane varieties revealed that CCS (t ha^{-1}) had the highest direct positive effect on cane yield, followed by number of millable canes per ha, stalk weight and stalk diameter. Stalk weight, stalk diameter, CCS per cent and sucrose per cent in the juice were indirectly associated with cane yield via CCS (t ha^{-1}).

Path analysis in 30 F_1 hybrids from crosses of *S.officinarum* with *S.barberi* (OB), *S.robustum* (OR), *S.spontaneum* (OS) and commercial hybrids (OH) by Ram and Hemaprabha (1997) indicated the importance of different traits in different crosses. Number of millable canes and sucrose per cent were found to be important traits of sugar yield in the OB and OR crosses whereas number of millable canes alone was important in the OH cross. In the OS cross, sucrose per cent made the greatest contribution to sugar yield.

Das *et al.* (1996) in a field trial involving twenty four sugarcane cultivars noticed that CCS (t ha^{-1}) had the highest direct positive effect on cane yield, followed by number of millable canes per hectare, stalk weight and stalk diameter. Stalk weight, stalk diameter, CCS per cent and sucrose per cent in the juice were indirectly associated with cane yield via CCS (t ha^{-1}).

Hapase and Repale (1999) noticed positive direct effect of cane yield, cane height and cane weight on sugar yield in a study of 12 sugarcane varieties, while cane height, cane girth, sucrose content and CCS per cent were considered as important components of cane yield.

In a path analysis study involving 14 intraspecific hybrids of *S. officinarum* by Nair *et al*. (1999) showed that stalk height had positive indirect effects on stalk yield through number of millable canes per plot and stalk thickness.

Path analysis revealed that number of millable stalks was the most important trait of brix yield as it showed highest direct effect and correlation values (Ram *et al*. 2000).

Positive direct effect of internodes per stalk, plant height and millable canes per stool on cane yield was reported by Khan *et al*. (2001) in a study comprising 27 indigenously evolved sugarcane crosses. They also noticed negative direct effect of brix value on cane yield.

In a study involving 22 sugarcane genotypes Setia *et al*. (2001) revealed that the number of millable canes had the highest direct effect on cane yield. Germination and number of tillers had low direct effect on cane yield, but their indirect effect via the number of millable canes was quite high. Single cane weight also had a high direct effect on cane yield. It was concluded that the number of millable canes, single cane weight, number of tillers and germination count could be used as selection criteria for development of high yielding sugarcane genotypes.

Ishaq *et al*. (2002) reported high direct effect of stalk weight, stalk height and number of stalks per stool on cane yield in a study involving 8 genetically diverse sugarcane clones.

Path coefficient analysis revealed that sucrose per cent had the highest direct effect on commercial cane sugar per cent, whereas brix per cent and purity per cent had the greatest indirect effect (Jain *et al*. 2002).

Thippeswamy *et al*. (2003) found that commercial cane sugar per plot, commercial cane sugar per cent at harvest, dry matter and number of internodes were the major contributors to cane yield per plot, while sugar yield was found to be dependent on both cane yield and sucrose per cent in an investigation involving 60 sugarcane genotypes.

Kumar *et al*. (2004) in a study involving 27 subtropical sugarcane cultivars noticed that the maximum direct effects on the cane yield was exhibited by the number of millable canes followed by single cane weight.

Path coefficient analysis by Dagar *et al*. (2004) revealed that brix and purity per cent contributed directly and pol per cent contributed indirectly via brix per cent to the CCS per cent in a study comprising 50 sugarcane genotypes.

In a study of 22 sugarcane clones, Singh and Khan (2004) observed high positive direct effect of number of millable canes and cane weight on cane yield, while cane yield had high positive direct effect on CCS yield.

Chaudhary and Joshi (2005) conducted a study to determine the contribution of different traits to cane yield in sugarcane and found that single cane weight had the highest positive direct effect on cane yield followed by millable cane number. Further stalk diameter and stalk length exhibited significant and positive correlation with cane yield due to indirect effect of single cane weight. Hence, genotypes should be selected on the basis of single cane weight and millable cane number for getting higher sugarcane yield.

Path analysis by Sousa-Vieira and Milligan (2005) revealed that stalk diameter and number of stalks per plant had the largest direct positive effect on plant weight at both phenotypic and genotypic levels.

In path coefficient analysis for cane yield and its component traits using 32 sugarcane genotypes, Kadian and Mehla (2006) noticed very high direct effect of cane thickness and internode length on cane yield. In a study comprising 40 diverse sugarcane genotypes Patel *et al.* (2006) observed highest positive direct effect of CCS per cent on cane yield.

Path coefficient analysis in the case of agronomic characters revealed that the weight of millable stalks was the most important character with the highest direct effect on sugarcane yield followed by stalk height, number of millable stalks and stalk thickness. In bio-chemical characters pol per cent followed by purity per cent had highest direct effect on pure obtainable cane sugar (Tyagi and Praduman, 2007).

Doule and Balasundaram (2007) in a trial with 28 clones of sugarcane observed that number of millable canes and sucrose per cent were important for sugar yield at 300 DAP. At 360 DAP, in addition to number of millable canes and sucrose per cent, cane thickness also assumed greater importance. Brix percent juice had a negative direct effect on sugar yield. While number of millable canes, cane thickness and cane length contributed maximum to cane yield.

Seventeen hybrid families of sugarcane were evaluated by Ferreira *et al*. (2007) and they reported that mean stalk weight and stalk number could be used for indirect selection of high yielding families, due to positive and high direct effects on tonnes of stalks per hectare. However, although stalk height and stalk diameter showed high correlation with mean stalk weight, only stalk diameter showed high direct genotypic effect on mean stalk weight, demonstrating the importance of stalk diameter for indirect selection of families with higher mean stalk weight.

Singh *et al*. (2007) conducted an experiment with one plant and two successive ratoons, to explore the nature of correlations through path coefficient analysis. The results indicated that cane yield was the most important determining trait of sugar yield and is important for sugar yield in ratoon crops. Number of millable canes was the primary determinant of cane yield in ratoon crops. Hence, selection for sugar yield should be emphasized on cane yield with concentration on number of millable canes particularly in ratoon crops.

Das *et al*. (2007) in a study on six early duration sugarcane commercial hybrids indicated that number of millable canes had the maximum direct effect on cane yield while single cane weight had the maximum direct effect on sugar yield, whereas both cane and sugar yield are influenced directly mainly by single cane weight, number of millable canes and sucrose per cent.

Singh *et al*. (2008) in an attempt to investigate the effect of ratoon crop on the genetic relationships in sugarcane found that the cane yield was the most important determining trait of sugar yield in ratoon crops. The number of millable canes was the primary determinant of cane yield and was more important in determining yield in ratoon crops. The stalk diameter was more important than stalk height in affecting stalk weight. Hence, selection for sugar yield should be emphasized on cane yield with concentration on number of millable canes particularly in ratoon crops.

Rahman *et al*. (2008) in a study on relative contribution of different characters on cane yield in sugarcane reported that number of tillers per hectare, number of millable canes per hectare, number of millable canes per clump, stalk height, stalk girth, 10 stalk weight had direct effects on cane yield and hence, these could be chosen as the most important selection criteria for the improvement of cane yield in sugarcane.

In a study on 21 sugarcane genotypes Mali *et al*. (2009) revealed that sucrose per cent juice at 360 DAP had the highest positive direct effect on cane yield.

Number of millable canes at 12 months and single cane weight had high positive direct effect on sugar yield at phenotypic level as noticed by Singh *et al*. (2010).

Al-Sayed *et al*. (2012) from path analysis studies in sugarcane reported that the number of millable stalks per square meter was the most important trait with the highest direct effect on sugar yield followed by sucrose per cent and stalk weight.

2.4. SELECTION INDICES

The practical/economic value of a plant is almost always affected by several traits. Hence, in selection of plants to serve as parents for next generation, the breeder is forced to consider several different traits. In effecting varietal improvement for yield or other desirable combination of characters, selection of superior genotypes has to be made by the plant breeder on the basis of phenotypic values. Since, majority of the economic traits are polygenically inherited and their expression is subjected to varying degrees of fluctuations due to environmental factors the direct selection may not be useful for such characters. The discriminate function helps to find out as to what weightage should be attributed to each of the yield components so that the best indication of genetic value of an individual plant or line could be obtained through phenotypic values. Fisher (1936) developed the technique of "discriminant function" to know the extent of improvement that can be achieved in yield by combination of characters. This technique was adopted for plant selection by Smith (1936) suggesting a better way of exploiting genetic correlation with several traits having high heritability to construct "selection index" which combines information on all the independent variables and selection based on such index was found to be more efficient than straight selection for yield in yield improvement.

Indication of true genotype worth through discrimination of environmental portion from the total phenotype by the selection index was assessed by Panse and Khargonkar (1957). Importance of multiple trait selection criteria was stressed by Brim *et al.* (1959) who suggested that selection efficiency increases with the increase in the number of characters taken for constructing the selection index.

Miller *et al.* (1978) reported that when selection for cane yield was based on stalk length, stalk diameter and stalk number the expected genetic advance was 89.0% of that obtained by direct selection on cane yield. They also noticed that when the selection was for sugar yield the inclusion of brix in the index along with these traits gave 92.1% of the expected genetic advance compared to selection based on sugar yield itself.

Sundaresan *et al*. (1979) reported that seedling genotypes should be selected on the basis of the number of millable canes, coupled with diameter of cane as well as brix. Hooda *et al*. (1979) evaluated 944 clones of four intervarietal crosses of sugarcane in an augmented design at the settling stage and indicated that single cane weight, plant height and brix content could be the reliable indices for selecting clones at settling stage for higher yield.

Punia *et al*. (1982) in an experiment using forty one genotypes reported that out of various selection indices constructed for sucrose content in sugarcane, only the selection index including length of internode + brix per cent + purity per cent + CCS per cent + sucrose per cent was found to be the best as the expected genetic gain of 43.54 per cent over the straight selection was noticed. Hence, the selection for sucrose content in sugarcane would be more efficient when all these attributes are taken into consideration

Reddy and Reddi (1986) investigated the contribution of four yield components to cane yield which revealed that stalk number per plot and stalk weight independently which in combination were the most important characters. Kandasami and Thiraviam (1987) reported the importance of single cane weight in combination with number of millable stalks per plot as a best selection criterion in breeding programme involving *S. robustum*.

Singh *et al*. (1991) reported that a selection index combining plant height, number of green leaves and brix value is preferable in selection for stalk weight compared with an index for each trait individually. A combination of plant height, internode number per stalk and brix value also gave high selection efficiency.

Selection indices at different stages of selection were estimated for a biparental mating population of sugarcane by Pillai and Ethirajan (1993) and they noted that at the seedling stage indices constructed from primary characters were better than selection for yield alone and selection based on index can lead to better selection efficiency in succeeding clonal stages. They also reported that at the clonal stage the superiority of index selection was marginal over direct selection.

Sunil and Lawrence (1996) multiple regression analysis revealed that the most important predictors of cane yield were plant height followed by number of millable stalks and leaf width, for sugar content were field brix, leaf width and stem diameter and for sugar yield per hectare were plot weight, stem diameter, leaf width and field brix.

Das *et al*. (1997) reported that the multiple regression equation involving the number of millable stalks and stalk weight was as efficient as an equation involving all the yield components with a relative efficiency of 79.11 per cent.

Wijesuriya *et al*. (1997) constructed two indices for initial and intermediate stages of selection based on the data and information derived from an analysis of nine biparental families, their parents and two standard varieties. They proposed an index based on stalk length, hand refractometer brix and rind hardness for selection at initial stages and stalk length, purity, laboratory brix and fibre per cent (fresh weight) were selected to the index suggested for intermediate stages.

In a study on cane yield and its component characters in a population of 22 advanced sugarcane genotypes, the selection index formulated using number of millable canes, stalk height, stalk weight, juice extraction per cent and cane yield recorded the greatest genetic gain (18.5%), followed by selection index constructed using number of millable canes and cane yield which recorded 16.97 per cent genetic gain over direct selection for cane yield indicating the importance of above traits for maximum improvement in cane yield (Singh and Khan, 1998).

Doule and Balasundaram (1999) studied the efficiency of index selection and direct selection for high yield in twenty eight clones of sugarcane and reported that the expected genetic advance and relative efficiency were lower when the characters were studied individually over direct selection. Further they noted that the genetic advance and relative efficiency increased when the number of characters included in the discriminant function increased. Among the components of sugar yield, juice brix per cent, juice sucrose per cent and purity coefficient were found to be the most important selection criteria and any function involving one or more of these characters resulted in higher genetic gain and relative efficiency.

In an experiment on evaluation of 10 sugarcane genotypes, Nahar *et al.* (2002) observed higher expected genetic gain (148.24) for cane yield in four character combination index containing cane height, tillers per clump, number of millable canes and cane yield. While, three character combination containing cane diameter, leaf area and brix per cent gave maximum genetic gain of 459.36 for sugar yield.

Various selection indices were constructed for commercial cane sugar yield in a population of twenty two advanced sugarcane genotypes by Singh and Khan (2003). Selection index with juice extraction per cent, cane yield and CCS yield itself had maximum genetic gain (14.70%) over straight selection. Selection index with any character combination excluding cane yield had low genetic gain (-1.57 to 4.44%) for CCS yield. Exclusion of individual quality traits i.e., brix, sucrose and CCS per cent from selection index with any other characters did not result in appreciable decrease in genetic gain. It was, therefore, suggested that after primary selection for sugar content the selection can be based on juice extraction per cent, cane yield and CCS yield for maximum improvement in sugar yield.

Krishna and Singh (2005) evaluated twenty seven mid late sub tropical sugarcane clones and reported the importance of millable canes and single cane weight in cane yield contribution and used these two traits in the formulation of selection criteria.

Doule and Balasundaram (2006) developed selection indices for cane yield and estimated the gains through discriminant function over direct selection in an experiment using twenty eight genotypes of sugarcane. The expected genetic advance and relative efficiency of index selection at 300 days of plant growth varied from 0.23% to 18.14% and 2.10% to 166.01% respectively.

Sousa-Vieira and Milligan (2009) reported that an increase in efficiency was observed over direct selection for plant weight when all four plant weight contributing traits were included along with plant weight. The efficiency in selection tended to decrease when indices were based on fewer traits. A few indices that included two traits also had relative efficiencies comparable to the best indices and majority were as effective as direct selection for plant weight.

Sahu *et al*. (2010) conducted an experiment on index selection in intervarietal crosses of sugarcane and reported that, number of millable canes per clump and single cane weight were important for selection criteria.

Charumathi and Naidu (2012) in a study on thirty eight biparental crosses and eighteen general crosses revealed that selection based on selection indices was found more efficient in seedling and clonal stages than direct selection on cane yield alone. They noted a linear increase in genetic advance and relative efficiency with the inclusion of more number of characters viz., CCS yield, number of green leaves, leaf area index, shoot population at 120 DAP, number of millable canes, single cane weight, cane length, cane diameter, brix per cent, CCS per cent, purity per cent in sequential index along with cane yield.

2.5 GENETIC DIVERGENCE

Genetic improvement in any crop mainly depends on the amount of genetic variability present in the population. Mahalanobis's D^2 analysis is a powerful tool in quantifying the degree of divergence between biological populations at genetic level and provides a quantitative measure of association between geographic and genetic diversity based on generalized distance (Mahalanobis, 1936).

In plant breeding, genetic diversity plays an important role because, hybrids between genotypes of diverse origin, generally display a greater heterosis and throw more recombinants than those between closely related parents.

Punia *et al*. (1983) observed that number of tillers, millable canes, number of internodes, cane weight, cane yield per clump, brix per cent, sucrose and purity per cent were important characters for causing divergence in sugarcane.

Using Mahalanobis D^2 statistic Hooda *et al*. (1989) grouped 34 accessions into 8 clusters based on 15 economic characters under a normal planting regime and 9 clusters under a late planting regime. Rai and Singh (1990) on the basis of D^2 analysis of parents and 30 F_1 hybrids indicated that the genetic divergence was not associated with geographical origin and the clustering pattern of the crosses was not dependent on their parentage.

Singh and Khan (1990) studied divergence among 47 hybrid clones of sugarcane from 21 crosses in fourth clonal generation using D^2 statistic and observed that majority of the genotypes from a cross were included in the same cluster, but some were strikingly diverse to be included in different clusters. They reported that juice extraction per cent, cane thickness, maturity index, cane height and number of internodes were important contributors towards genotypic divergence in sugarcane.

Reddy and Somarajan (1992) evaluated forty six interspecific hybrids of sugarcane derived from crosses involving various species and grouped them into eleven clusters. Based on inter-cluster distances and cluster means for various characters, potential parents were identified from different clusters for hybridization programme.

Hemaprabha and Ram (1997) studied the pattern of genetic divergence using Mahalanobis D^2 statistics in fifty one flowering clones of *Saccharum robustum* and grouped them into eleven clusters. Cluster IV was the most divergent while cluster IX was the most distant from the other clusters. Cluster means indicated that cluster VI was the best for cane yield, but was poor for quality, while cluster IX was the best for quality and was poor for cane yield.

Thirty interspecific hybrid clones and their seven parents were grouped into sixteen clusters using multivariate D^2 analysis and the clustering pattern showed that grouping of progeny clones was independent of parental cross combinations i.e., progenies of crosses and their parents were grouped in different clusters (Ram and Hemaprabha, 1998).

Fourteen interspecific hybrids of sugarcane along with two commercial genotypes were evaluated by Srivastava *et al.* (1999) for yield and quality attributes. The interspecific hybrid lines were grouped into three clusters containing six, five and five genotypes each using D^2 statistics and they observed that cane yield, purity per cent, juice per cent and CCS per cent at 12 months contributed the most towards divergence.

Pathak *et al.* (2000) evaluated twenty interspecific sugarcane hybrids and two local controls and grouped them into five relatively homogeneous clusters. Clusters II and V had five genotypes while the other clusters had four each. The intracluster distances were lower than intercluster distances. Cluster IV included genotypes producing highest cane yield, CCS yield and juice sucrose whereas the cluster II recorded the highest NMC and the cluster V had the highest stalk diameter.

Fifty nine interspecific hybrids were grouped into eight clusters by Pathak *et al.* (2001) using cluster analysis and cluster III was characterized by better yield and quality of different hybrids. The genetic divergence was high between clusters VI and V, and low between clusters V and I indicating their close relationship.

Ram and Hemaprabha (2001) evaluated 30 sugarcane hybrid clones along with their 9 parents to study the nature and pattern of genetic divergence using multivariate D^2 analysis, and grouped the clones into 15 clusters. The clustering pattern showed that grouping of progeny clones was independent of parental cross combinations i.e. progenies of a cross and their parents were grouped in different clusters. They suggested that hybridization among clones from diverse clusters may help in isolating progenies with higher sugar yield.

Singh *et al.* (2001) conducted a study on 40 sugarcane accessions of Indian and exotic origin to explore the pattern of genetic diversity using multivariate D^2 statistical distance and the entries were grouped into eight non-overlapping clusters. The grouping of clones in different clusters was not related to their geographical origin. They suggested that the cultivars belonging to different clusters having maximum intercluster distance should be selected as a parental stock to be utilized in hybridization for generating the highest possible variability in cane and sugar yield contributing characters.

Singh and Singh (2002) grouped the 339 sugarcane commercial hybrids into fourteen clusters which consisted of hybrids with various geographical origin and indicated the non-significant correlation between genetic and geographical diversity. They suggested that hybrids belonging to clusters with greatest intercluster distance may be selected for hybridization for generating the greatest variability.

Genetic divergence among 63 commercial hybrids of sugarcane was assessed by Singh *et al*. (2004) using the Mahalanobis D^2 statistics, and grouped the genotypes into 9 clusters and the characters yield per plot, number of millable canes per plot, early vigour and cane girth contributed maximum towards genetic divergence.

Singh and Singh (2004) determined the genetic divergence among 51 *Saccharum* genotypes using Mahalanobis D^2 statistics. The genotypes were grouped into 8 clusters and single cane weight had the highest contribution towards the genetic divergence.

Fifty two sugarcane genotypes were grouped into ten clusters by Deep *et al*. (2005). Cluster I with 20 genotypes was the biggest followed by cluster II with 12 genotypes, cluster III with 10 genotypes, cluster IV with 4 genotypes and clusters V, VI, VII, VIII, IX and X with one genotype each. Cluster X was characterized by maximum mean values for number of millable canes per clump, internode length and lowest mean values for cane girth, number of internodes, single cane weight, cane yield per clump, pol per cent, purity per cent and CCS per cent. Cluster IX included one genotype with maximum values for brix, pol, purity and CCS per cent. Cluster VIII recorded maximum values for cane height, cane girth, number of internodes, single cane weight, cane yield per clump and CCS yield per clump.

Mishra *et al*. (2005) assessed the genetic divergence in 21 sugarcane genotypes based on 11 characters and grouped the genotypes into 7 clusters following D^2 analysis. They observed that cluster III exhibited maximum inter-cluster distance from all other clusters and indicated that hybridization of the genotypes in this cluster with other genotypes may result in transgressive recombinants and high heterosis and contribute substantially to varietal improvement. Among the characters considered, CCS had the highest contribution towards divergence.

Ram and Hemaprabha (2005) evaluated fifty three *S. officinarum* clones using D^2 statistics and grouped them into nine clusters and revealed that hybridization among the clones from clusters having the maximum inter-cluster distances, might yield better recombinants for various characters. Silva *et al*. (2005) evaluated the genetic similarity among 129 sugarcane clones using Mahalanobis D^2 statistics and reported that the number of stalks per plot and the brix production per kilograms per plot contributed maximum for the genetic variability.

Singh *et al*. (2006) grouped 34 widely-used interspecific hybrids of sugarcane into 5 clusters and the relative contribution of different characters towards the expression of genetic divergence revealed that stalk weight contributed maximum towards genetic divergence followed by tillers per plot and number of millable canes per plot.

Kashif and Khan (2007) investigated 14 genotypes of sugarcane for determining genetic diversity based on 12 quantitative traits using meteroglyph and divergence analysis based on pivotal elements and found that though cluster analyses grouped genotypes with greater similarity for agronomic traits, they did not necessarily include the genotypes from the same source of origin.

Lopes *et al*. (2008) estimated the genetic divergence of 140 sugarcane clones using the linear mixed model and grouping analysis by Tocher's procedure based on Mahalanobis' generalized distance. Based on the results, they recommended the combination of the most divergent clones with any one of the most productive clones.

Mali *et al*. (2009) performed D^2 analysis in 21 genotypes of sugarcane and noticed considerable diversity, and grouped them into eight clusters. They observed that germination percentage at 45 days, single cane weight at harvest, number of tillers at 120 DAP, number of millable canes per plot and CCS (kg/plot) contributed maximum to the total genetic divergence.

Sajjad and Khan (2009) grouped forty cultivars into sixteen clusters using Tocher's method based on Mahalanobis D^2 statistics and observed that the most contributing character for divergence was fibre per cent followed by cane weight, pol per cent, brix value, CCS per cent and juice per cent.

Twelve exotic sugarcane genotypes were grouped into six clusters by Ahmed and Obeid (2010), based on the genetic distance using Mahalanobis's statistics. Higher inter-cluster distance was noticed between cluster IV and V indicating high genetic diversity among two clusters and exploitation of genotypes within these two clusters as parents for crossing could produce good sugarcane segregants. High cluster mean value for juice quality was recorded by cluster I whereas for cane yield and sugar yield, cluster VI was the best.

Silva *et al.* (2011) evaluated the genetic divergence between seven standard varieties and eleven RB (Republica do Brasil) sugarcane clones using Mahalanobis distance as dissimilarity measure and revealed that sucrose per cent in juice, cane yield, brix per cent and stalk height were the major determinants in the quantification of genetic divergence.

2.6 DIVERSIFIED USES OF SUGARCANE

Sugarcane farmers are under constant pressure to reduce the cost of cultivation and to produce desirable biomass for supply to sugar and allied industries. Sugarcane represents one of the most efficient land based system for converting solar energy into biomass. This biomass cane provide both a solid fuel for combustion to process heat, steam or electricity and an easily fermentable juice which may be upgraded to ethanol which is of value as a liquid transport fuel and, in particular, as an octane booster for use in lead free petrol. Hence, future of the sugar industries depend upon the utilization of the sugarcane for the manufacture of sugarcane based byproducts such as alcohol, power etc. These two green power products also help in reducing the environmental pollution, a major concern in countries across the world. One of the major bottlenecks in the electrification of the rural areas for house hold and industrial purposes is the non availability or the heavy loss of energy during the power transmission from far away sources. Setting up of power generation units in rural areas based on bagasse will help in fulfilling the energy needs of the rural areas thus improving the standard of living and rural economy. In addition, sugarcane can be cultivated as an energy crop in marginal lands as well as in regions where the climate is not suitable for sugar extraction (Rao *et al*. 1979).

Biomass has gained prominence in the last few years as one of the most important renewable energy sources. In Brazil, sugarcane ethanol programme called Pro Alcohol was designed to supply the liquid gasoline substitution and has been running for the last 30 yrs. From the beginning of Pro Alcohol to the present time, ethanol yield has grown from 2,500 to around 7,000 litres per hecatare due to the improvement of industrial processes along with strong sugarcane breeding programmes. New technologies for energy production from crushed sugarcane stalk are currently supplying 15% of the electricity needs of the country. Projections show that sugarcane could supply over 30% of Brazil's energy needs by 2020 (Matsuoka *et al*. 2009).

Gillian *et al*. (2011) reported that with changing sugar markets in the U.S. and around the world, innovation and environmental protection through value-addition and diversification will be crucial for the sustainability of the sugarcane industry. The sugarcane industry is currently faced with the reality that sugar, molasses and bagasse can no longer be regarded as the final products of a factory. Instead, the sugar industry should be regarded as a biomass-based industry that is not only equipped to manufacture products for the food sector, but also value-added biofuels, energy and chemicals for the non-food sector.

In the genetic breeding programme of sugarcane the main goal is to obtain new cultivars with more productivity and best industrial characteristics (Bicudo, 1987).

Tai *et al*. (1992) reported that selection for improving juice quality reduced the fibre content. Inadvertently recent days commercial cultivars were selected for high sucrose content at the cost of fibre content. Normally 13-15% fibre content was considered as the best for better juice extraction per cent. With the modern equipments it is possible to use varieties with fibre content up to 18% without much compromise in the extraction percent.

Sugarcane converts solar energy into chemical energy at a very high efficiency rate. Traditionally, sugarcane is used primarily for sugar production. However, with the energy crisis that has struck the world, the sugarcane plant has emerged as a viable producer of bioenergy. Currently, in Brazil, alcohol is the main product derived from sugarcane and sugar is the principal by-product (Lee and Bressan, 2006).

Brumbley *et al.* (2007) indicated that sugarcane has great potential to be an inexpensive, abundant and renewable source of sugars for the new bio-refineries that are producing fuel ethanol.

Brazil, the fifth largest and fifth most populated country in the world, has been developing successful initiatives in renewable sources of energy for more than 75 yrs. The production and use of ethanol from sugarcane is a global model for ethanol production, distribution and use; therefore, the Brazilian ethanol industry has attracted interest from scientists, producers and governments of both developed and developing countries (Luciano *et al.* 2007).

Seventeen families comprising different generations (F_1, BC_1, BC_2) were evaluated to exploit sugarcane biomass for alternative commodities such as fuel ethanol and electricity to ensure sustainable sugarcane production. They reported that F_1 families could easily be identified that produced relatively high frequency of progenies with fibre exceeding 24% whereas BC_1 and BC_2 families could yield progenies suitable for ethanol and enhanced fibre for energy production (Ramdoyal and Badaloo, 2007).

Rao *et al.* (2007) reported that new multipurpose cane varieties with very high fibre content have been found to produce more biomass per hectare and a wide range of brix values when compared to the traditional sugarcane varieties. High fibre multipurpose cane varieties with acceptable levels of fermentable sugars would extend the supply of bagasse and contribute to fuel ethanol production.

Terajima *et al.* (2007) reported that sugarcane has been used only for sugar production in Japan, but for the sugarcane industry to survive, utilization of by-products is essential. To achieve the utilization of by products, high-biomass sugarcane clones were generated by inter-specific and inter-generic crossing involving *Saccharum spontaneum* and *Sorghum* *bicolor* and a programme was designed for the simultaneous production of sugar and biomass ethanol from high-biomass clones.

Amalraj *et al*. (2008) evaluated the wild cane species, *Erianthus arundinaceus* for biomass production, stalk yield, fibre content and juice quality and reported that this species has the potential to yield high biomass for the production of energy through cogeneration, alcohol through bio-fermentation of its juice and bagasse as raw material for paper manufacture. Kennedy (2008) based on studies involving ten biparental crosses of sugarcane reported that it is possible to combine both high fibre and high sugar content in the same genotype as there was no correlation between brix or pol and fibre.

Breeding varieties with high fibre content is gaining momentum as it is related to non lodging and increased biomass suitable for mechanical harvesting and feedstock for co-generation (Babu *et al*. 2009). In order to support cogeneration and ethanol production there is need for developing varieties capable of high biomass with high fibre content and higher total sugars (Govindaraj, 2009).

Rao and Pipat (2009), with a view to develop sugarcane cultivars for value addition through improved fiber content, evaluated a set of twenty one cultivars, selected based on fibre, brix and yield along with a standard commercial cultivar K 84-200. They observed that fibre content ranged from 13.5 to 19.3%. Cultivar MPT 99-582, which recorded cane yield of 102 t ha-1, commercial cane sugar 13.2% and fibre content 15.5% was found to be better performing than K 84-200 by 8%, 10%, 12%, 23% and 21% for fibre, commercial cane sugar, cane yield, sugar yield and fibre yield respectively. Their studies indicated that multipurpose cultivars could be selected with improved fibre content and sugar yield. Such cultivars would increase the amount of bagasse produced in sugar mills leading to a higher quantity of bagasse available either for co-generation or production of particle boards.

Deepack *et al*. (2012) evaluated sixty genotypes of different generations of crosses for eighteen inter-related traits. Cluster analysis defined six major groups in the population. Candidates from three of them were found suitable for commercial exploitation of either sugar or fibre or both as the main end products. They suggested that multivariate data analysis techniques were very effective in assessing the extent of genetic divergence between genotypes in the population and in the selection of different types of high biomass canes for multipurpose use.

Chapter III

Material and Methods

Chapter III

MATERIAL AND METHODS

The present investigation was carried out at Agricultural Research Station, Perumallapalle (Acharya N.G.Ranga Agricultural University), situated in the Southern Agro-climatic Zone of Andhra Pradesh, India located at an altitude of 182.90 m above the mean sea level, 13°N latitude and 79°E latitude from 2010 to 2012. The soil is red sandy loam with medium fertility. The materials used and methods followed pertaining to the present investigation are presented here under.

3.1 MATERIAL

The experimental material consisting 429 clones selected from the seedling nursery raised from the fluff obtained from 36 crosses comprising of 14 biparental crosses, 7 polycrosses and 15 general collections along with four checks viz., Co 6907, Co 7219, 2003 V46 and Co 86032 were used in this study for comparison of yield attributing characters and quality parameters. The details of the genotypes selected in seedling nursery are furnished in Table 3.1 and the salient features of the four checks are furnished in Table 3.2.

3.2 METHODS

3.2.1 First Clonal Generation (C_1) or Settling Nursery and Ratoon Crop

Four hundred and twenty nine genotypes selected from seedling nursery based on phenotypic evaluation were planted in July 2010. Each genotype was planted in two rows of 2.5 m length spaced at 80 cm apart with 4 three budded setts per meter in augmented design along with four checks viz., Co 6907, Co 7219, 2003 V46 and Co 86032. The material was planted in eleven blocks. Each block had 39 genotypes and four checks (Plate 1a).

The first plant crop of 2010-11 was allowed for ratooning to study the ratoonability of selected genotypes.

3.2.2 Data Recorded in First Clonal Generation (C_1) and Ratoon Crop

Observations were recorded on the following traits for each genotype before and at the time of harvest in the settling nursery (C_1) and ratoon crop.

3.2.2.1 Tiller Number per plot at 120 DAP

Total number of tillers were counted at 120 days after planting (DAP) for each genotype and expressed as tiller number per plot.

3.2.2.2 Shoot population at 180 and 240 DAP

Total number of shoots were counted at 180 and 240 DAP for each genotype and expressed as shoot population per plot at 180 and 240 DAP respectively.

3.2.2.3 Number of Millable Canes per Plot at Harvest (NMC)

Total number of millable canes in each genotype were counted at the time of harvest and expressed as NMC per plot.

3.2.2.4 Number of Green Leaves per plant

Number of green leaves on ten randomly selected plants in each genotype were counted at 90, 120, 240 DAP and at maturity and expressed as number of green leaves per plant.

3.2.2.5 Biomass per Cane (kg)

Weight of ten randomly selected canes along with trash, leaves and tops at harvest was recorded and mean data was expressed in kilograms as biomass per cane.

3.2.2.6 Number of Internodes per Cane

Mean number of internodes on ten randomly selected canes was recorded at harvest.

3.2.2.7 Internode Length (cm)

Length of internodes was taken at base, middle and top of the cane on ten canes and average internodal length was calculated at harvest.

3.2.2.8 Stalk Length (cm)

Mean length of ten canes from the base to the last transverse mark in the mature cane was recorded in centimeters at harvest.

3.2.2.9 Stalk Diameter (cm)

Internode diameter was recorded in centimeters at harvest with digital vernier calipers. The measurement was taken at the middle of the internode situated at the middle of cane from ten randomly selected canes and the mean was expressed in centimeters.

3.2.2.10 Stalk Volume (cm^3)

Stalk diameter (D) and average stalk length (L) of cane were used to determine the stalk volume using the formula (James, 1971)

$$V = \pi \times L \times (D/2)^2$$

3.2.2.11 Single Cane Weight (kg)

Ten randomly selected canes were cut from ground level at maturity and the total weight was recorded after the removal of trash, leaves and tops and the mean was expressed as single cane weight in kilogram.

3.2.2.12 HR Brix (%)

Juice was extracted with the help of pouch piercer from the middle of the internodes of the three randomly selected stalks and brix per cent was measured with the help of hand refractometer. Mean data was expressed as HR brix per cent.

3.2.2.13 Cane Yield (t ha^{-1})

Cane yield was computed for individual plots by multiplying single cane weight with NMC at harvest and expressed as tonnes per hectare.

$$\text{Cane yield (t ha}^{-1}) = \frac{\text{NMC per plot x Single cane weight (kg) x 10000}}{\text{0.8 m x 2.5 m x 2 x 1000}}$$

3.2.2.14 HR Brix Yield (t ha^{-1})

It was computed from cane yield and HR brix per cent as per the formula given below

$$\text{HR brix yield (t ha}^{-1}) = \frac{\text{Cane yield per hectare x HR brix (\%)}}{100}$$

3.2.2.15 Ratooning Ability for Cane Yield (RA)

Ratooning ability of each selected clone for cane yield was worked out by using the formula given by Shaw (1989).

$$\text{RA} = \frac{\text{Ratoon crop yield (t ha}^{-1})}{\text{Plant crop yield (t ha}^{-1})} \times 100$$

A sugarcane variety is considered to be a good ratooner when ratooning ability is nearer to 100 or above 100.

3.2.3 Second Clonal Generation (C_2) or Selection Nursery

Seventy three out of four hundred and twenty nine genotypes were selected in first clonal generation based on cane yield, single cane weight, number of millable canes, cane length, cane diameter, HR brix and other desired morphological characters. The seventy three genotypes along with four checks (Plate 1b) were planted in a randomized block design with two replications during April, 2011. Each entry was planted in 2 rows of 5 m length spaced at a distance of 80 cm between rows with 4 three budded setts per meter as seed rate.

3.2.4 Data Recorded in Second Clonal Generation (C_2) or Selection Nursery

Data was recorded for all the seventy three genotypes and four checks studied in the second clonal generation (Plate 2) for the characters viz., tiller number at 90 DAP, shoot population at 180 and 240 DAP, NMC per plot, number of green leaves at 90, 120, 240 DAP and at maturity, biomass per cane, internode number, internode length, stalk length, stalk diameter and stalk volume as detailed under 3.2.2. In addition, data on the following traits was also recorded for all the genotypes studied in the selection nursery.

3.2.4.1 Cane Yield (t ha^{-1})

Cane yield was computed for individual plots by multiplying single cane weight with NMC at harvest and expressed as tonnes per hectare.

$$\text{Cane yield (t ha}^{-1}\text{)} = \frac{\text{NMC per plot x Single cane weight (kg) x 10000}}{\text{0.8 m x 5 m x 2 x 1000}}$$

3.2.4.2 Fibre Content (%)

Fibre content was estimated from 3 randomly selected canes harvested at 360 DAP. These were further sub-sampled to include top, middle and bottom portion from each cane. This cane sample was split vertically and the split cane was cut into small bits of 1 cm length. All the bits of cane were pooled and by sub-sampling 250 g of fresh cut cane sample was obtained for analysis. 250 g of cut cane sample was transferred to the bowl of the “Rapipol extractor” and 2 litres of water was added to the bowl. The motor was run for 5 minutes so that the cane bits were sheared into fibre. The contents of the bowl were then transferred to a muslin cloth filter and the fibrous material was washed in running water under the tap till the material was free from juice and dissolved solids. Then the fibre from the filter was transferred to a previously weighed cloth bag and the water was squeezed out. The contents of the bag were dried in an oven at 100 °C and then the dry weight of the sample plus bag was obtained.

Fibre content was calculated as per the formula given by Thangavelu and Rao (1982).

$$\text{Fibre content (\%)} = \frac{A - B}{C} \times 100$$

Where:

A = Dry weight of bag + bagasse after drying (g)

B= Dry weight of bag alone (g)

C= Fresh weight of cane (g)

3.2.4.3 Fiber Yield (t ha^{-1})

Fibre yield was calculated by the following formula

$$\text{Fibre yield (t ha}^{-1}\text{)} = \frac{\text{Fibre per cent cane}}{100} \times \text{Cane yield (t ha}^{-1}\text{)}$$

3.2.4.4 Sucrose in Juice (%)

Pol per cent in juice was determined using polariscope. The pol reading and corrected brix were used in determining sucrose per cent in juice with the help of Schmitz's tables (Hawaiian Sug.Tech. Association, 1931).

3.2.4.5 Commercial Cane Sugar (%)

The commercial cane sugar (CCS) per cent was calculated using the formula

$$\text{CCS \%} = 1.022\ S - 0.292\ B$$

Where,

S = Sucrose per cent

B = Brix per cent

3.2.4.6 Juice Purity (%)

The purity per cent in juice was calculated using the following formula

$$\text{Juice purity \%} = \frac{\text{Sucrose \%}}{\text{Brix \%}} \times 100$$

3.2.4.7 Pol per cent Cane (%)

Pol per cent cane was calculated as suggested by Verma (1988).

$$\text{Pol per cent cane} = \frac{\text{Juice \% cane x Pol \% juice}}{100}$$

where

juice % cane = 100 – fibre % cane

3.2.4.8 Juice extraction %

Juice extracted by crushing a sample of three randomly selected canes at 360 DAP in a three roller power operated crusher was weighed in grams and the juice extraction per cent was worked out as per the formulae given below:

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

3.2.4.9 Brix (%)

Brix in juice was recorded using a brix hydrometer at 12th month. Correction for temperature was made to arrive at corrected brix per cent.

3.2.4.10 Commercial Cane Sugar Yield (t ha^{-1})

It was computed as per the formula given below

$$\text{CCS yield (t ha}^{-1}) = \frac{\text{CCS \% x Cane yield (t ha}^{-1})}{100}$$

3.2.4.11 Estimation of total sugars

Seventy five ml of fresh juice was taken in a 250 ml volumetric flask and after adding 12 ml of neutral lead acetate the volume was made up to 250 ml and the contents were filtered. From the filtrate, 200 ml was taken in a 250 ml volumetric flask and 10 ml of de-leading solution (prepared by dissolving 70 gm of disodium phosphate and 30 gm of potassium oxalate in distilled water and making up the volume to 1000 ml) was added and the volume was made up to 250 ml and filtered. In a 100 ml volumetric flask 10 ml of the filtrate was taken and to it 10 ml of 1:1 HCl and 20 ml of distilled water was added and kept in a water bath for 20 minutes at a temperature of 60^0C. Later the contents of the volumetric flask were cooled and neutralized with 40% sodium hydroxide and again cooled to room temperature. After cooling the volume was made up to 100 ml and then titrated against Fehling's solution (5 ml of Fehling's solution A + 5 ml of Fehling's solution B) taken in a volumetric flask. From the titre value the total sugars content of the juice was estimated and expressed in g/100ml.

$$\text{Total sugars (g/100ml)} = \frac{32.496 \times 10}{TV}$$

where, TV = Titre value

3.2.4.12 Estimation of unfermentable sugars

Filtered juice of 500 ml (diluted to 15% brix where the juice brix was more than 15%) was taken in a 1liter beer bottle and 250 mg of baker's yeast (*Saccharomyces cerevisiae*) was added to it, plugged with cotton and kept in dark. The juice was allowed to ferment till the brix of the fermented juice reached 0% as measured by brix hydrometer. The fermented juice as such was titrated against Fehling's solution to estimate the unfermentable sugars. From the titre value the unfermentable sugars content of the juice was calculated and expressed as g/100ml.

3.2.4.13 Theoretical Yield of Alcohol (g/100ml)

Theoretically 180.158 g of invert sugar yields 92.138 g of ethyl alcohol. Hence, the theoretical yield of alcohol was calculated using the following formula :

$$\text{Theoretical yield of alcohol (g/100ml)} = \frac{92.138 \times (A - B)}{180.158}$$

where, A = Total sugars, B = Unfermentable sugars

3.2.5 Crop Husbandry

Fertilizers were applied at recommended dose of 224:112:112 kg ha^{-1} N, P_2O_5 and K_2O respectively for plant crop and 336:112:112 kg ha^{-1} N, P_2O_5 and K_2O respectively for ratoon crop. The recommended dose of P_2O_5 and K_2O were applied as basal and nitrogen was applied in two equal split doses at 45 and 90 days after planting for plant crop. In ratoon crop, full dose of P_2O_5, K_2O and half dose of nitrogen were applied at the time of ratooning and remaining dose of nitrogen was applied at 45 days after ratooning. Cultural practices like weeding, irrigation, earthing up and propping were followed to maintain good crop growth.

3.3 STATISTICAL ANALYSIS

3.3.1 First Clonal Generation (C_1) and Ratoon Crop

3.3.1.1 Variability analysis

Analysis of variance for each character was carried out by using the method described by Federer (1956).

ANOVA for Augmented Design II

Source of variation	**Df**	**SS**	**MSS**	**F**
Blocks	b-1	BSS	BMS	BMS/EMS
Checks	c-1	CSS	CMS	CMS/EMS
Varieties	v-1	VSS	VMS	VMS/EMS
Error	(c-1) (b-1)	ESS	EMS	-
Total	N-1	TSS		

where

b = number of blocks

c = number of checks

v = number of genotypes

N = (v + bc)

3.3.1.2 Simple Correlation Coefficients

The simple correlation coefficients were calculated as per Panse and Sukhatme (1985). Significance was tested by referring to the correlation coefficient table at (n-2) df.

$$r = \frac{Cov(X,Y)}{\sqrt{Var(X).Var(Y)}}$$

where

r = Correlation coefficient

Cov(X,Y) = Covariance of (X,Y)

Var (X) = Variance of X

Var (Y) = Variance of Y

X, Y = Variables

3.3.1.3 Path Coefficient Analysis

The estimates of direct and indirect contribution of various characters were calculated through path analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

The following set of simultaneous equations were formed and solved for estimating various direct and indirect effects.

$r_{1y} = P_{1y} + r_{12}P_{2y} + r_{13}P_{3y} + \ldots\ldots\ldots + r_{1i}P_{iy}$

$r_{2y} = r_{21}P_{2y} + P_{2y} + r_{23}P_{3y} + \ldots\ldots\ldots + r_{2i}P_{iy}$

: : : : :

$r_{iy} = r_{21}P_{iy} + r_{i2}P_{2y} + r_{i3}P_{3y} + \ldots\ldots\ldots.. + P_{iy}$

where

r_{1y} to r_{iy} = correlation coefficients between causal factors 1 to i and dependent character Y

P_{1y} to P_{iy} = Direct effects of characters 1 to i on character Y

r_{12} to r_{iy} = Correlation coefficients among causal factors

The above equations were written in a matrix form as under:

$$\underset{A}{\begin{bmatrix} r_{1y} \\ r_{2y} \\ . \\ . \\ r_{3y} \end{bmatrix}} = \underset{B}{\begin{bmatrix} 1 & r_{12} & r_{13} & . & r_{1i} \\ r_{21} & 1 & r_{23} & . & r_{2i} \\ . & . & . & . & . \\ . & . & . & . & . \\ r_{i1} & r_{i2} & r_{i3} & . & 1 \end{bmatrix}} \underset{C}{\begin{bmatrix} P_{1y} \\ P_{2y} \\ . \\ . \\ P_{iy} \end{bmatrix}}$$

$$\text{Then } C = B^{-1} A$$

The path coefficients were calculated by solving the above matrices.

Residual effect was calculated by the following formula

$$\text{Residual effect} = \sqrt{1-(P_{1y}r_{1y} + P_{2y}r_{2y} + \ldots\ldots\ldots + P_{iy}r_{iy})}$$

The direct and indirect effects were rated as suggested by Lenka and Mishra (1973)

Negligible	-	0.00 – 0.09
Low	-	0.10 – 0.19
Moderate	-	0.20 – 0.29
High	-	0.30 – 1.00
Very high	-	More than 1.00

3.3.2 Second Clonal Generation (C_2)

3.3.2.1 Variability analysis

Analysis of variance for each character was carried out by using the method described by Panse and Sukhatme (1985).

ANOVA of RBD

Source of variation	Df	Sum of Squares	Mean squares	Expectations of MS	F ratio
Replications	(r - 1)	-			

Genotypes	(t - 1)	SS_1	MS_1	$\sigma_e^2 + r\,\sigma_g^2$	MS_1/MS_2
Error	(r - 1) (t - 1)	SS_2	MS_2	σ_e^2	
Total	(rt - 1)				

where

r = number of replications

t = number of genotypes

The significance test was carried out by referring to 'F' table value given by Fisher and Yates (1967).

From the above table, environmental, genotypic and phenotypic variances were estimated as suggested by Lush (1940).

Environmental variance = σ_e^2

Genotypic variance (σ_g^2) = $\dfrac{MS_1 - MS_2}{r}$

Phenotypic variance (σ_p^2) = $r\,\sigma_g^2 + \sigma_e^2$

3.3.2.2 Coefficient of Variation

Phenotypic and genotypic coefficients of variation were computed using the formulae given by Burton (1952).

Genotypic Coefficient of Variation (GCV) % = $\dfrac{\sigma_g}{Mean} x100$

Phenotypic Coefficient of Variation (PCV) % = $\dfrac{\sigma_p}{Mean} x100$

where

σ_g = genotypic standard deviation

σ_p = phenotypic standard deviation

The range of variation was categorized according to Sivasubramanian and Madhavamenon (1973) as detailed below:

Low	=	Less than 10%
Moderate	=	10 - 20%
High	=	More than 20%

3.3.2.3 Heritability ($h^2_{(b)}$)

Heritability in broad sense was estimated as suggested by Lush (1940)

$$h^2_{(b)}\ (\%) = \frac{\sigma^2_g}{\sigma^2_p} x100$$

where

σ^2_g and σ^2_p are genotypic and phenotypic variances respectively

The heritability values were categorized as suggested by Johnson *et al.* (1955a).

Low	=	Less than 30%
Moderate	=	30 – 60%
High	=	More than 30%

3.3.2.4 Genetic Advance as per cent of mean

Genetic advance as per cent of general mean was computed by using the formula (Johnson *et al*. 1955a)

$$\text{GA as percentage of mean} = \frac{h^2_{(b)} \text{ x K x } \sigma_p}{\text{Mean}} \text{x100}$$

where

$h^2_{(b)}$	=	heritability in broad sense
K	=	selection differential which is equal to 2.06 at 5 per cent intensity of selection
σ_p	=	phenotypic standard deviation

The range of genetic advance as per cent of mean was classified as suggested by Johnson *et al.* (1955a).

Low	=	Less than 10%
Moderate	=	10 - 20%
High	=	More than 20%

3.3.2.5 Character Association

Correlation coefficients were calculated at the phenotypic level (r_P) and genotypic level (r_g) using the following formulae as suggested by Johnson *et al.* (1955b).

$$r_p = \frac{Cov(X,Y)}{\sqrt{\sigma^2_{px}\ \sigma^2_{py}}}$$

$$r_g = \frac{Cov(X,Y)}{\sqrt{\sigma^2_{gx}\sigma^2_{gy}}}$$

where,

Cov(X,Y) = covariance between the variables x and y.

$\sigma^2{}_p$ and $\sigma^2{}_g$ are phenotypic and genotypic variances respectively.

Phenotypic correlation coefficients and genotypic correlation coefficients were tested against ‘r’ values given by Fisher and Yates (1967) table at (n-2) d.f at 5% and 1% probability levels to test their significance, where n = number of entries.

3.3.2.6 Construction of Selection Indices through Discriminant Function Technique

The technique of Discriminant function developed by Fisher (1936) was adopted to know the true genotypic worth of yield and its components and to have computational formulae for construction of selection indices which when applied to select plants can bring about effective improvement in yield compared to straight selection for yield. Smith (1936) has illustrated the use of discriminant function in plant selection.

The phenotypic and genotypic variances and covariance's used to compute the correlations provide the basis for constructing a selection index. The selection index of the form $b_1x_1 + b_2x_2 + \ldots\ldots\ldots + b_nx_n$ is so constructed as to have the estimated 'b' values give the best available weights to each of the various characters considered in selection. The symbols used in the general formulae for the selection index are $x_1, x_2, \ldots\ldots\ldots, x_n$, the phenotypic values of traits; and $b_1, b_2, \ldots\ldots\ldots, b_n$ the corresponding relative weights to be applied to each character. The 'b' values required in the selection index were obtained by solving the general formulae for the below mentioned set of simultaneous equations.

$$
\begin{array}{llll}
b_1p_{11} + b_2p_{12} + \ldots\ldots\ldots\ldots + b_np_{1n} & = & g_{1y} \\
b_1p_{12} + b_2p_{22} + \ldots\ldots\ldots\ldots + b_np_{2n} & = & g_{2y} \\
. \quad . \quad . & & . \\
. \quad . \quad . & & . \\
. \quad . \quad . & & . \\
b_1p_{1n} + b_2p_{2n} + \ldots\ldots\ldots\ldots + b_np_{nn} & = & g_{ny}
\end{array}
$$

Where,

p_{11} is the estimate of phenotypic variance of x_1

p_{12} is the estimate of the phenotypic covariance of x_1 and x_2

g_{1y} is an estimate of the genotypic covariance of x_1 and y.

The selection indices is now represented as

$$I = b_1x_1 + b_2x + b_3x_3 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots + b_nx_n$$

Where, 'I' is the score for the genotypic yield and b_1, b_2, b_3, …. ,b_n are the relative weights attached to each of the characters x_1 to x_n.

A number of different selection indices are constructed using 2, 3,……, n combination of characters and the genetic advance and relative efficiency of each of them is calculated as given below.

3.3.2.7 Expected Genetic Advance (GA)

The expected genetic advance based on the composition of characters that was included for formulation of the various selection indices was calculated as per the formula of Robinson *et al.* (1951).

$$\text{GA (D)} = \frac{Z}{P}\sqrt{(b_1 g_{1y} + b_2 g_{2y} + ...+ b_n g_{ny}}$$

Where,

$\frac{Z}{P}$ is the selection differential in standard units. The value of $\frac{Z}{P}$ was taken as 2.06 at 5 per cent selection intensity in the present study.

b_1, b_2, b_3, …., b_n are the discriminant coefficients attached to characters 1, 2, 3, ………., n.

g_{1y}, g_{2y}, g_{3y}, ………, g_{ny} are the genotypic covariance between the character under indirect selection (y) and those under direct selection (1, 2, 3 to n).

3.3.2.8 Relative Efficiency of the Discriminant Function

The relative efficiency of each selection index formulated was evaluated by comparing with yield alone which is considered as 100 per cent efficient. The formula for relative efficiency given by Brim *et al.* (1959) is as follows:

$$\text{Relative Efficiency (R.E.)} = \frac{\text{Genetic advance by selection index}}{\text{Genetic advance by straight selection}} \times 100$$

A number or different indices were constructed and the relative efficiency of each index was calculated and the best selection index having maximum relative efficiency was selected and applied to that particular population for selection of plants based on this selection index.

3.3.2.9 Genetic Divergence

D^2 statistic was used for assessing the genetic divergence. The concept of D^2 statistics was originally developed by Mahalanobis (1928). The application of this technique for the assessment of genetic diversity in plant breeding was suggested by Rao (1952).

Using ‘V’ statistics (which in turn utilizes Wilk’s criterion), a simultaneous test of differences between mean values of a number of correlated variables is done (Rao, 1948). This is usually done by pivotal condensation method.

$$V(stat) = -m \log \hat{e}$$

where

$$\hat{} = \frac{|w|}{|s|}$$

$|w|$	=	Determinant for error matrix
$|s|$	=	Determinant for error + genotype matrix
m	=	$n - \frac{(p+q+1)}{2}$
p	=	number of characters
q	=	degree of freedom for genotypes
n	=	degrees of freedom for error + genotype
e	=	2.7183

The V(stat) value was compared with chi-square table value for (pq) df. If V(stat) was found significant further analysis was made to estimate D^2 values.

The correlated variables are transformed to uncorrelated ones by pivotal condensation method to work out the D^2 values.

$$D^2 = \sum (Y_i^1 - Y_i^2)$$

where

i = 1, 2,…………,p number of characters

Y_i^1 = Transformed uncorrelated mean of i^{th} character for genotype 1

Y_i^2 = Transformed uncorrelated mean of i^{th} character for genotype 2

The grouping of the genotypes was done by using Tocher's method as described by Rao (1952).

Average intra-cluster distance was estimated using the formula

$$\frac{\sum D_i^2}{n}$$

where

$\sum D_i^2$ is the sum of distances between all possible combinations (n) of the genotypes included in a cluster.

Average inter cluster distance was estimated by the formula

$$\frac{\sum D_{ij}^2}{(n_i x n_j)}$$

where

$\sum D_{ij}^2$ is the sum of distance between the genotypes in cluster i and cluster j.

n_i = number of genotypes in cluster i

n_j = number of genotypes in cluster j

The square root of the average D^2 values obtained represent the distance (D) between and within clusters.

3.3.2.10 Criteria for Scoring Genotypes for Diversified Uses

The genotypes were scored based on mean performance for diversified uses viz., biomass, fibre yield, theoretical yield of alcohol, cane yield and commercial cane sugar yield in second clonal stage as follows:

Score	**Value**
0	≤ Mean
1	Mean + 1 CD
2	Mean + 2 CD
3	Mean + 3 CD
4	Mean + 4 CD
5	Mean + 5 CD

where

CD = Critical Difference

Chapter IV

Results and Discussion

Chapter IV

RESULTS AND DISCUSSION

Sugarcane is an important cash crop of India. In India it is grown in sub tropical and tropical climatic regions. Sugarcane crop serves as the major source for a variety of products such as sugar, jaggery, molasses, bagasse and filter cake out of which sugar and jaggery are meant for daily use as consumable products while other byproducts have industrial significance. It is realized that sugar production alone will not be able to make the industry profitable and under such circumstances diversification is a necessary consequence for the successful growth of industry.

Sugarcane, an important bio energy crop belongs to the category of C4 plants which converts the solar energy effectively into high quality and low cost raw materials for sugar and ethanol (Bruce *et al.* 2005). Molasses and bagasse are the byproducts of sugar industry which form the feedstock for ethanol production and cogeneration respectively. Generally the main objective of sugarcane breeding is to develop varieties capable of producing high sugar yields per unit land area. The recent awareness on the advantages of using green fuel for generation of power and use of gasohol to reduce automobile emission have resulted in setting up of a number of cogeneration plants and distilleries in various sugar mills. To achieve these goals of increased sugar, alcohol and cogeneration, sugar industries need special varieties to meet their specific requirement of raw materials. Hence, breeding programmes must integrate new traits such as high fiber, high biomass and high total sugars in addition to cane yield and juice quality.

Breeding for higher yield and quality traits requires basic information on the extent of genetic variation in a population and its response to selection. Understanding various genetic parameters that govern a population under improvement is essential for proper planning and direction of plant breeding program. The success of such program will depend upon largely on the extent of genetic variability available in the base population and heritability of the characters under improvement. Therefore, a clear understanding of genetic parameters is of paramount importance in the development of a breeding strategy (Singh *et al.* 2002).

In plant breeding correlation coefficient analysis measures the mutual relationship between two plant characters and it determines characters association for genetic improvement of yield and other economic traits. The character associations will help in the selection of superior genotypes from divergent population based on more than one interrelated characters. The present study was conducted to obtain the information on the association of various characters with cane yield, fibre yield, sugar yield, biomass and ethanol. The path coefficient analysis was also carried out to partition correlation coefficient into direct and indirect effects.

Hybridization is one of the most essential steps in plant breeding since it is the source of all genetic variability available for selection of new plants. In vegetatively propagated crops like sugarcane, development of improved genotypes with high heterotic expression for yield and quality characters is desired. The heterotic genotypes can be developed by utilization of diverse parents in hybridization. Thus the identification of diverse genotypes or parents for hybridization is an important consideration in sugarcane improvement. In order to breed for high yielding varieties, it is necessary to understand the genetic variability and inter-relationships of component characters on yield which helps to frame a suitable selection criterion for screening best genotypes.

Keeping the above points in consideration, the present investigation was taken up with the following objectives :

- To estimate genetic parameters for different component characters related to diversified uses viz., fibre yield, ethanol yield, biomass, sugar yield and cane yield in sugarcane.

- To study the extent of association existing among different component characters with cane yield, sugar yield, fibre yield, biomass and ethanol yield and among themselves in different clonal stages.

- To identify characters which are directly and / or indirectly influencing fibre yield, ethanol yield, biomass, cane yield and sugar yield in different clonal stages.

- To formulate selection indices for diversified uses viz., fibre yield, ethanol yield, biomass, sugar yield and cane yield in sugarcane.

- To identify divergent genotypes in second clonal stage for improving fibre yield, ethanol yield, biomass, sugar yield and cane yield.

- To identify genotypes suitable for diversified uses viz., fibre yield, ethanol yield, biomass, sugar yield and cane yield in sugarcane.

The results of present investigation are presented and discussed in the following heads.

4.1 FIRST CLONAL STAGE

4.1.1 Analysis of Variance

The analysis of variance was performed individually for each character and total variation was partitioned into different sources of variation. The results are presented in Table 4.1.

Analysis of variance revealed significant mean sum of squares due to blocks and entries for all the eighteen characters viz., tillers at 120 DAP, shoot population at 180, 240 DAP, NMC at harvest, number of green leaves at 90, 120, 240 DAP and at maturity, biomass per cane, number of internodes per cane, internode length, stalk length, stalk diameter, stalk volume, single cane weight, HR brix, HR brix yield and cane yield. Since the variance due to block effects was also significant for all the characters critical difference was calculated to draw conclusions. The mean sum of squares due to checks was significant for tillers at 120 DAP, shoot population at 180, 240 DAP, NMC at harvest, number of green leaves at 90 DAP, biomass per cane, internode length, stalk length, stalk diameter, single cane weight, HR brix, HR brix yield and cane yield.

The mean data recorded on eighteen characters for 429 genotypes along with the best check data corrected with block effect and critical difference in each block is presented in Appendix A. The range, mean and number of genotypes showing higher performance than the best check for eighteen characters in 429 genotypes are presented in Table 4.2.

4.1.2 Mean and Range for Different Characters in First Clonal Stage

4.1.2.1 Tillers at 120 DAP (No.)

Two hundred and thirty nine genotypes recorded significantly higher tiller number at 120 DAP than the best check Co 6907. The tiller number at 120 DAP ranged from 30.00 (2010T-398, 2010T-150, 2010T-309, 2010T-329 and 2010T-393) to 180.00 (2010T-296) with a general mean of 75.09.

4.1.2.2 Shoot Population at 180 and 240 DAP

One hundred and thirty nine genotypes recorded significantly higher shoot population at 180 DAP than the best check Co 6907. The shoot population at 180 DAP varied from 33.00 (2010T-375) to 195.00 (2010T-300) with a mean value of 67.02.

The shoot population at 240 DAP ranged from 30.00 (2010T-355) to 162.00 (2010T-296) with a general mean of 63.66. Two hundred and twenty eight genotypes showed significantly higher performance than the best check Co 6907.

4.1.2.3 Number of Millable Canes per Plot at Harvest

Number of millable canes per plant varied from 4.0 (2010T-63) to 75.00 (2010T-219) with a general mean of 34.37. One hundred and twenty nine genotypes recorded significantly higher number of millable canes per plant compared to the best check Co 6907.

4.1.2.4 Number of Green Leaves at 90, 120, 240 DAP and Maturity

Number of green leaves at 90 DAP ranged from 4.24 (2010T-24) to 18.00 (2010T-83, 239, 292) with a mean value of 7.44. The best check's (Co 6907) mean value was surpassed by one hundred and twenty three genotypes.

One hundred and fifty one genotypes recorded significantly more number of green leaves at 120 DAP than the best check Co 7219. Minimum number of green leaves at 120 DAP (3.63) was recorded in 2010T-393 while maximum number of green leaves was recorded in 2010T-155 (23.00) at 120 DAP. The mean value observed was 8.41.

Number of green leaves at 240 DAP ranged from 3.70 (2010T-296) to 26.15 (2010T-126, 314) with a general mean value of 13.57. One hundred and one genotypes recorded significantly more number of leaves at 240 DAP than the best check Co 86032.

At maturity one hundred and eighty four genotypes recorded significantly more number of green leaves than the best check Co 86032. The number of green leaves ranged from 5.00 (2010T-65, 165, 345 and 411) to 27.00 (2010T-205) with a general mean of 15.63.

4.1.2.5 Biomass per Cane (kg)

Biomass per cane was found to be significantly higher in one hundred and forty one genotypes compared to the best check Co 86032. The genotype 2010T-219 recorded minimum biomass value of 0.28 kg while 2010T-413 recorded maximum biomass of 2.6 kg. The general mean value observed was 0.99 kg.

4.1.2.6 Number of Internodes per Cane

One hundred and sixty three genotypes recorded significantly more number of internodes per cane than the best check Co 7219. The number of internodes per cane varied from 8.00 (2010T-65, 165, 345, 411) to 30.00 (2010T-205) with a general mean value of 18.62.

4.1.2.7 Internode Length (cm)

The length of the internodes ranged from 2.81cm (2010T-236, 213) to 19.17 cm (2010T-361) with a general mean of 9.59cm. Two hundred and fifty four genotypes showed significantly more internode length than the best check Co 7219.

4.1.2.8 Stalk Length (cm)

Stalk length varied from 45.00cm (2010T-236, 213) to 340.00 cm (2010T-413) with a general mean of 177.04cm. Two hundred and seven genotypes recorded significantly higher values for stalk length compared to the best check Co 7219.

4.1.2.9 Stalk Diameter (cm)

Stalk diameter ranged between 1.10cm (2010T-241) and 3.60 cm (2010T-395) with a general mean value of 2.26cm. Sixty four genotypes showed more stalk diameter than the best check Co 86032.

4.1.2.10 Stalk Volume (cm^3)

One hundred and sixty eight genotypes recorded significantly more stalk volume than the best check Co 86032. Minimum stalk volume was recorded in 2010T-420 (124.46 cm^3) and maximum stalk volume in 2010T-413 (2094.40 cm^3). The general mean value observed was 734.53 cm^3.

4.1.2.11 Single Cane Weight (kg)

Single cane weight ranged from 0.10 kg (2010T-247) to 1.84 kg (2010T-3) with a general mean value of 0.75 kg. One hundred and eleven genotypes recorded significantly higher cane weight than the best check Co 86032.

4.1.2.12 HR Brix (%)

Twenty one genotypes recorded significantly higher brix than the best check 2003 V-46. The HR brix values varied from 4.60 (2010T-60) to 22.60 (2010T-248) with a general mean of 14.33.

4.1.2.13 HR Brix Yield (t ha^{-1})

One hundred and nineteen genotypes recorded significantly more HR brix yield than the best check Co 7219. The HR brix yield ranged from 0.48 t ha^{-1} (2010T-383) to 33.75 t ha^{-1} (2010T-254) with a general mean value of 9.55 t ha^{-1}.

4.1.2.14 Cane Yield (t ha^{-1})

Cane yield ranged from 4.75 t ha^{-1} (2010T-383) to 253.75 t ha^{-1} (2010T-254) with a general mean of 65.58 t ha^{-1}. One hundred and sixty six genotypes showed significantly higher cane yield than the best check Co 7219.

Seventy three genotypes were selected in first clonal stage based on mean performance of the genotypes over the best respective check for most of the characters with due importance to cane yield, HR brix yield, single cane weight, biomass per cane and number of millable canes at harvest and desired morphological characters.

4.1.3 Character Association Studies in First Clonal Stage

Phenotypic correlation coefficients between cane yield and its component characters and inter correlations among different traits are presented in the Table 4.3.

4.1.3.1 Inter Correlations among Cane Yield Components

Number of tillers at 120 DAP expressed positive significant association with shoot population at 180 (0.508) and 240 DAP (0.389), number of green leaves at 90 DAP (0.098) and significant negative association with number of green leaves at 240 DAP (-0.274), biomass per cane (-0.110), stalk diameter (-1.04), stalk volume (-0.122) and single cane weight (-0.129).

Shoot population at 180 DAP exhibited positive significant association with shoot population at 240 DAP (0.362), whereas significant negative association was recorded with number of green leaves at 120 (-0.246), 240 DAP (-0.322), at maturity (-0.142), internode number (-0.134), stalk length (-0.106) and single cane weight (-0.099).

Shoot population at 240 DAP recorded significant negative association with number of green leaves at 240 DAP (-0.731), biomass per cane (-0.118), stalk volume (-0.110), single cane weight (-0.165) and HR brix (-0.123).

The results revealed that NMC at harvest was positively and significantly correlated with number of green leaves at 90 (0.294), 120 DAP (0.334), at maturity (0.182), biomass per cane (0.158), number of internodes (0.186), internode length (0.204), stalk length (0.307), stalk volume (0.117), single cane weight (0.124) and HR brix yield (0.677).

Number of green leaves at 90 DAP exhibited significant positive association with number of green leaves at 120 (0.546), 240 DAP (0.173), at maturity (0.175), biomass per cane (0.123), number of internodes (0.195), stalk length (0.213), stalk volume (0.122), single cane weight (0.145), HR brix (0.159) and HR brix yield (0.315).

Significant positive association was noticed between number of green leaves at 120 DAP and the traits viz., number of green leaves at 240 DAP (0.231), at maturity (0.174), biomass per cane (0.232), internode number (0.188), stalk length (0.219), stalk volume (0.179), single cane weight (0.228), HR brix (0.171) and HR brix yield (0.425).

Positive significant association of number of green leaves at 240 DAP was observed with number of green leaves at maturity (0.561), biomass per cane (0.442), internode number (0.553), stalk length (0.440), stalk diameter (0.169), stalk volume (0.398), single cane weight (0.461), HR brix (0.173) and HR brix yield (0.372).

The results revealed that number of green leaves at maturity was positively and significantly correlated with biomass per cane (0.596), internode number (0.989), stalk length (0.722), stalk diameter (0.131), stalk volume (0.545), single cane weight (0.562) and HR brix yield (0.418) while negative significant association was observed with internode length (-0.194).

Biomass per cane exhibited positive significant association with internode number (0.592), internode length (0.154), stalk length (0.630), stalk diameter (0.532), stalk volume (0.802), single cane weight (0.842) and HR brix yield (0.585).

The number of internodes per cane was found to be positively and significantly associated with stalk length (0.729), stalk diameter (0.134), stalk volume (0.551), single cane weight (0.560) and HR brix yield (0.418). This character showed significant negative association with internode length (-0.196).

Positive significant association of internode length was found with stalk length (0.504), stalk volume (0.233), single cane weight (0.171) and HR brix yield (0.244).

Stalk length exhibited positive significant association with stalk volume (0.647), single cane weight (0.611) and HR brix yield (0.552).

Positive significant association of stalk diameter was observed with stalk volume (0.778), single cane weight (0.488) and HR brix yield (0.235).

Stalk volume exhibited positive significant association with single cane weight (0.770) and HR brix yield (0.522).

Positive significant association of single cane weight was observed with HR brix yield (0.662).

HR brix exhibited positive significant association with HR brix yield (0.431).

4.1.3.2 Correlation between Cane Yield and its Components

The cane yield per hectare recorded positive and significant association with NMC at harvest (0.716), number of green leaves at 90 (0.291), 120 (0.383), 240 DAP (0.362), at maturity (0.428), biomass per cane (0.654), number of internodes (0.482), internode length (0.242), stalk length (0.601), stalk diameter (0.263), stalk volume (0.579), single cane weight (0.743), HR brix (0.118) and HR brix yield (0.925), except tillers at 120 DAP, shoot population at 180 and 240 DAP.

The results pertaining to the correlation studies in first clonal stage in the foregoing discussions revealed that NMC at harvest, number of green leaves at 90, 120, 240 DAP and at maturity, biomass per cane, internode number, internode length, stalk length, stalk diameter, stalk volume, single cane weight, HR brix and HR brix yield showed positive and significant association with cane yield and also among themselves indicating that simultaneous selection for these characters would result in the improvement of cane yield in sugarcane.

Positive and significant association of shoot population at 120 DAP (Singh *et al*., 2005, Sirisha *et al*., 2010 and Charumathi, 2011); number of millable canes (Dagar *et al*., 2004, Niraj and Singh, 2005, Kadian *et al*., 2006, Sabitha *et al*., 2008, Sahu *et al*., 2008 and Sirisha *et al*., 2010); stalk length (Rahman *et al*., 2008, Sirisha *et al*., 2010 and Charumathi, 2011); stalk diameter (Sabitha *et al*., 2008, Rahman *et al*., 2008, Sahu *et al*., 2008, Sirisha *et al*., 2010, Navneeth *et al*., 2010 and Charumathi, 2011); single cane weight (Kadian *et al*., 2006 and Charumathi 2011) with cane yield were reported in sugarcane.

4.1.4 Direct and Indirect Effects of Yield Components on Cane Yield in First Clonal Stage

The correlation coefficient of different component characters with cane yield was further partitioned into direct and indirect effects by path analysis and the results are presented in Table 4.4. Cane yield was considered as resultant variable and NMC at harvest, number of green leaves at 90, 120, 240 DAP and at maturity, biomass per cane, internode number, internode length, stalk length, stalk diameter, stalk volume, single cane weight, HR brix and HR brix yield were considered as causal variables which exhibited significant positive correlation with cane yield.

Number of millable canes at harvest expressed positive and significant correlation with cane yield (0.716). Its direct effect on cane yield was positive and moderate (0.297). The indirect effect of this trait on cane yield was positive and high through HR brix yield (0.394).

The direct contribution of number of green leaves at 90 DAP was negligible (0.008) but the positive and low indirect effects via HR brix yield (0.183) and positive negligible indirect effects through NMC at harvest (0.087), single cane weight (0.049) and stalk length (0.016) contributed to significant positive association of number of green leaves at 90 DAP with cane yield (0.291).

Number of green leaves at 120 DAP showed negative and negligible direct effect on cane yield (-0.015) but its association with cane yield was positive and significant (0.383). Positive and moderate indirect effect of this trait was noticed through HR brix yield (0.247).

The direct effect of number of green leaves at 240 DAP on cane yield (-0.010) was negative and negligible but its association with cane yield was positive and significant (0.362), which is due to moderate indirect effects of this trait through HR brix yield (0.217) and positive and low indirect effect through single cane weight (0.157).

Number of green leaves at maturity was positively and significantly related with cane yield (0.482). Positive and negligible direct effect on cane yield (0.008) was noticed by this trait. This trait expressed moderate indirect effect on cane yield through HR brix yield (0.243) and low positive indirect effect through single cane weight (0.191).

Biomass per cane exhibited negative and negligible direct effect on cane yield (-0.005) but its high and positive indirect effect through HR brix yield (0.341) and moderate indirect effect through single cane weight (0.286) contributed to significant positive association of biomass per cane with cane yield (0.654).

The association between number of internodes per cane and cane yield was positive and significant (0.482). This trait expressed negative and negligible direct effect on cane yield (-0.083). The number of internodes per cane exhibited positive and moderate indirect effect through HR brix yield (0.243) and positive and low indirect effect through single cane weight (0.190) on cane yield.

Internode length showed positive and significant correlation with cane yield (0.242) *in spite* of its negative negligible direct effect on cane yield (-0.071). It was due to its positive indirect effects via HR brix yield (0.142), NMC at harvest (0.061), single cane weight (0.058), stalk length (0.038) and internode number (0.016) on cane yield.

Stalk length exhibited significant and positive correlation with cane yield (0.601). Its direct effect on cane yield was positive but negligible (0.075) but it showed positive and high indirect effect on cane yield through HR brix yield (0.321) and moderate indirect effect through single cane weight (0.207).

Stalk diameter registered positive and significant association with cane yield (0.263). The direct effect of stalk diameter on cane yield was negative and negligible (-0.031). Positive and indirect effect of stalk diameter on cane yield was noticed through single cane weight (0.166) and HR brix yield (0.137).

Stalk volume was positively and significantly related with cane yield (0.579). Positive and negligible direct effect on cane yield was noticed by this trait. This trait displayed positive and high indirect effect through HR brix yield (0.304) and positive and moderate indirect effect through single cane weight (0.261).

Single cane weight had positive and significant relationship with cane yield (0.743). Positive and high direct effect was expressed by this trait on cane yield (0.339). This trait exhibited positive and high indirect effect on cane yield through HR brix yield (0.385).

The association between HR brix and cane yield was positive and significant (0.118). However, it expressed negative and low direct effect on cane yield. Its indirect effect on cane yield was positive and moderate through HR brix yield (0.251).

The relationship between HR brix yield and cane yield was positive and significant (0.925). This trait also exhibited the highest positive direct effect on cane yield (0.582). HR brix yield registered positive and moderate indirect effect on cane yield through single cane weight (0.225) and NMC at harvest (0.201).

Residual effect was found to be very low (0.154) which indicated that almost all the yield attributing characters were included.

Critical analysis of the results by path analysis revealed that the characters HR brix yield, single cane weight and number of millable canes exhibited high positive direct effects on cane yield and the other characters also exhibited their indirect positive effects on cane yield via these characters indicating that these are the major contributing characters to cane yield in sugarcane. Hence, direct selection for HR brix yield, single cane weight and number of millable canes would be helpful for the improvement of cane yield in first clonal stage. These three characters showed significant positive correlation among themselves and with number of green leaves at 90, 120 DAP and at maturity, biomass per cane, internode number, internode length, stalk length, stalk volume and HR brix indicating that indirect selection based on these characters may be given importance in first clonal stage.

Similar results of positive direct effect on cane yield were also reported by several workers for number of millable canes (Zhou, 2004; Niraj and Singh, 2005; Kadian and Mehla, 2006; Chandrakanth *et al.*, 2007; Sirisha *et al.*, 2010 and Charumathi, 2011); for single cane weight (Dagar *et al.*, 2004; Kumar *et al.*, 2004; Singh and Khan, 2004; Verma and Singh, 2004; Niraj and Singh, 2005; Kadian *et al.*, 2006; Patel *et al.*, 2006; Rahman *et al.*, 2008; Sirisha *et al.*, 2010 and Charumathi, 2011) and for HR brix yield (Ram *et al.*, 2000).

4.2 RATOON CROP

The mean data recorded on eighteen characters in the ratoon crop for the seventy seven genotypes including checks and ratoonability for cane yield are presented in the Table 4.5. The range, mean and number of genotypes showing higher performance than the best check for different characters in ratoon crop are presented in Table 4.6

4.2.1 Mean and Range for Different Characters in Ratoon Crop

4.2.1.1 Tillers at 120 DAR (No.)

Thirty three genotypes recorded significantly higher tiller number at 120 DAR than the best check Co 6907 (75). The tiller number at 120 DAR ranged from 2.00 (2010T-208) to 144.00 (2010T-282) with a general mean of 72.58.

4.2.1.2 Shoot Population at 180 and 240 DAR

Fourteen genotypes recorded significantly higher shoot population at 180 DAR than the best check Co 6907 (69.00). The shoot population at 180 DAR varied from 9.00 (2010T-208) to 99.00 (2010T-282) with a mean value of 51.71.

The shoot population at 240 DAR ranged from 9.00 (2010T-321) to 154.00 (2010T-282) with a general mean of 70.12. Thirty five genotypes showed significantly higher performance than the best check Co 7219 (71.00).

4.2.1.3 Number of Millable Canes per Plant at Harvest

Number of millable canes per plant varied from 6.0 (2010T-362) to 62.00 (2010T-282) with a general mean of 32.94. Twenty nine genotypes recorded significantly higher number of millable canes per plant compared to the best check Co 6907 (37.00).

4.2.1.4 Number of Green Leaves at 90, 120, 240 DAR and Maturity

Number of green leaves at 90 DAR ranged from 8.00 (2010T-429) to 59.00 (2010T-20) with a mean value of 18.81. The best check Co 7219 (17.00) value was surpassed by twenty nine genotypes.

Thirty five genotypes recorded significantly more number of leaves at 120 DAR than the best check Co 86032 (13.00). Minimum number of green leaves at 120 DAR (6.00) were recorded in 2010T-321 and 2010T-4 recorded maximum number of green leaves (38.00) at 120 DAR. The mean number of leaves observed was 15.73.

Number of green leaves at 240 DAR ranged from 7.00 (2010T-321) to 48.00 (2010T-15) with a mean value of 19.51. Thirty five genotypes recorded significantly more number of leaves at 240 DAR than the best check Co 7219 (18.00).

At maturity thirty one genotypes recorded significantly more number of green leaves than the best check Co 7219 and 2003V-46 (16.00). The number of green leaves ranged from 11.00 (2010T-82, 88, 158, 249) to 21.00 (2010T-18) with a general mean of 15.74.

4.2.1.5 Biomass per Cane (kg)

Biomass per cane was found to be significantly higher in thirty three genotypes compared to the best check 2003 V-46 (1.07). The genotype 2010T-208 recorded minimum biomass 0.20 kg while 2010T-153 recorded maximum biomass of 1.78 kg. The mean value observed was 1.03 kg.

4.2.1.6 Number of Internodes per Cane

Thirty genotypes recorded significantly more number of internodes per cane than the best check Co 7219 (21.90). The number of internodes per cane varied from 12.80 (2010T-88) to 28.00 (2010T-18) with a mean value of 20.51.

4.2.1.7 Internode Length (cm)

The length of the internodes ranged from 6.05cm (2010T-313) to 14.18cm (2010T-249) with a general mean of 9.47cm. Thirty one genotypes showed significantly higher internodal length than the best check Co 6907 (9.72cm).

4.2.1.8 Stalk Length (cm)

Stalk length varied from 92.00cm (2010T-313) to 273.00 cm (2010T-179) with a general mean of 193.76cm. Forty nine genotypes recorded significantly higher values for stalk length compared to the best check Co 7219 (177.00 cm).

4.2.1.9 Stalk Diameter (cm)

Stalk diameter ranged from 1.63cm (2010T-184) to 3.18 cm (2010T-153) with a mean value of 2.46cm. Twenty genotypes showed more stalk diameter than the best check Co 86032 (2.64cm).

4.2.1.10 Stalk Volume (cm^3)

Forty eight genotypes recorded significantly more stalk volume than the best check Co 86032 (839.75 cm^3). Minimum stalk volume was recorded in 2010T-208 (314.81cm^3) and 2010T-153 recorded maximum stalk volume of 1954.58 cm^3. The mean value observed was 939.83 cm^3.

4.2.1.11 Single Cane Weight (kg)

Single cane weight ranged from 0.17 kg (2010T-208) to 1.55 kg (2010T-153) with a mean value of 0.83 kg. Forty seven genotypes recorded significantly higher cane weight than the best check Co 86032 (0.74 kg).

4.2.1.12 HR Brix (%)

Twenty five genotypes recorded significantly higher brix value than the best check Co 86032 (20.17%). The HR brix values varied from 10.20% (2010T-209) to 22.90% (2010T-347) with a general mean of 18.61%.

4.2.1.13 HR Brix Yield (t ha^{-1})

Forty seven genotypes recorded significantly more HR brix yield than the best check Co 7219 (10.81 t ha^{-1}). The HR brix yield ranged from 1.00 t ha^{-1} (2010T-88) to 29.31 t ha^{-1} (2010T-282) with a mean value of 12.66 t ha^{-1}.

4.2.1.14 Cane Yield (t ha^{-1})

Cane yield ranged from 3.70 t ha^{-1} (2010T-321) to 153.45 t ha^{-1} (2010T-282) with a general mean of 68.99 t ha^{-1}. Forty four genotypes showed significantly higher performance than the best check 2003 V-46 (61.94 t ha^{-1}).

4.2.1.15 Ratoonability for Cane Yield (%)

The ratooning ability of the selected genotypes for cane yield ranged from 3.62% (2010T-321) to 96.78% (2010T-153). Six genotypes viz., 2010T-18 (95.45%), 2010T-124 (93.38%), 2010T-153 (96.78%), 2010T-161 (90.35%), 2010T-282 (94.49%) and 2010T-340 (91.43%) recorded more than ninety % of ratoonability for cane yield. The best check Co 7219 recorded 91.57% ratoonability for cane yield.

The yield of ratoon crop was found to be less than that of the plant crop and these results are in agreement with the findings of Yadav (1992), Sundara (1998), Solomon (2000) and Verma (2002).

4.2.2 Character Association Studies in the Ratoon Crop

Phenotypic correlation coefficients between cane yield and its component characters and inter correlations among different traits in ratoon crop are presented in the Table 4.7.

4.2.2.1 Inter Correlations Among Cane Yield Components

Number of tillers at 120 DAR showed positive significant association with shoot population at 180 (0.658) and 240 DAR (0.611), NMC at harvest (0.576), internode length (0.239), stalk length (0.301) and HR brix yield (0.526).

Shoot population at 180 DAR exhibited positive significant association with shoot population at 240 DAR (0.720), NMC at harvest (0.779), number of green leaves at maturity (0.329), biomass per cane (0.255), internode number per cane (0.330), internode length (0.323), stalk length (0.477) and HR brix yield (0.639).

Shoot population at 240 DAR recorded positive significant association with NMC at harvest (0.814), number of green leaves at maturity (0.250), internode length (0.348), stalk length (0.381) and HR brix yield (0.707).

The results revealed that NMC at harvest was positively and significantly correlated with number of green leaves at maturity (0.325), internode number per cane (0.293), internode length (0.441), stalk length (0.521) and HR brix yield (0.783). Negative significant association of stalk diameter (-0.231) was observed with this character.

Number of green leaves at 90 DAR exhibited significant positive association with number of green leaves at 120 (0.300) and 240 DAR (0.672).

Positive significant association of number of green leaves at 120 DAR was observed with number of green leaves at 240 DAR (0.282), biomass per cane (0.315) and single cane weight (0.313).

Positive significant association of number of green leaves at 240 DAR was observed with number of green leaves at maturity (0.423), internode number per cane (0.271) and stalk length (0.245).

The results revealed that number of green leaves at maturity was positively and significantly correlated with biomass per cane (0.529), internode number (0.834), stalk length (0.613), stalk volume (0.503), single cane weight (0.454) and HR brix yield (0.498).

Positive significant association of biomass per cane was observed with internode number (0.602), stalk length (0.607), stalk diameter (0.649), stalk volume (0.860), single cane weight (0.949) and HR brix yield (0.595).

The number of internodes per cane was found to be positively and significantly associated with stalk length (0.730), stalk volume (0.574), single cane weight (0.542) and HR brix yield (0.531).

Positive significant association of internode length was found with stalk length (0.619) and HR brix yield (0.408). This character exhibited negative significant association with stalk diameter (-0.229).

Stalk length exhibited positive significant association with stalk volume (0.594), single cane weight (0.561) and HR brix yield (0.700).

Positive significant association of stalk diameter was observed with stalk volume (0.781) and single cane weight (0.713).

Stalk volume exhibited positive significant association with single cane weight (0.899) and HR brix yield (0.540).

Positive significant association of single cane weight was observed with HR brix yield (0.559).

HR brix exhibited positive nonsignificant association with HR brix yield.

4.2.2.2 Correlation between Cane Yield and its components

The results revealed that number of tillers at 120 DAR (0.529), shoot population at 180 (0.638) and 240 DAR (0.707), NMC at harvest (0.806), number of green leaves at maturity (0.501), biomass per cane (0.641), internode number (0.499), internode length (0.434), stalk length (0.690), stalk volume (0.584), single cane weight (0.607), and HR brix yield (0.954) were positively and significantly correlated with cane yield, whereas HR brix (-0.233) recorded negative significant correlation with cane yield in the ratoon crop.

4.2.3 Direct and Indirect Effects of Yield Components on Cane Yield in Ratoon Crop

The phenotypic correlation coefficients of different component characters with cane yield was partitioned into direct and indirect effects by path analysis and the results are presented in Table 4.8. Cane yield was considered as resultant variable and number of tillers at 120 DAR, shoot population at 180, 240 DAR, NMC at harvest, number of green leaves at maturity, biomass per cane, internode number, internode length, stalk length, stalk volume, single cane weight, HR brix and HR brix yield were considered as causal variables which exhibited significant correlations with cane yield.

The high positive direct effect on cane yield was exerted by HR brix yield (0.905) followed by stalk length (0.142), biomass per cane (0.113), NMC at harvest (0.107). Negligible positive direct effects were exhibited by stalk volume (0.037) and number of tillers at 120 DAR (0.025).

HR brix recorded moderate negative direct effect on cane yield (-0.261), whereas low negative direct effect on cane yield was observed by internode number (-0.155) and internode length (-0.129).

The characters viz., number of tillers at 120 DAR, shoot population at 180, 240 DAR, NMC at harvest, number of green leaves at maturity, biomass per cane, internode number, internode length, stalk length, stalk volume, single cane weight irrespective of positive or negative direct effects exhibited high indirect effect on cane yield through HR brix yield resulting in significant positive association of these characters with cane yield. Indirect selection for cane yield could be accomplished through the characters number of tillers at 120 DAR, shoot population at 180, 240 DAR, NMC at harvest, number of green leaves at maturity, biomass per cane, internode number, internode length, stalk length, stalk volume, cane weight as these traits exhibited significant positive correlation with HR brix yield.

Residual effect was found to be very low (0.088) which indicated that almost all the yield attributing characters were included.

A perusal of the association studies in plant crop and ratoon crop revealed that number of tillers at 120 DAP, shoot population at 180 DAP and 240 DAP showed non significant negative association with cane yield in plant crop, whereas significant positive association of these traits with cane yield was observed in ratoon crop. However, the traits viz., number of green leaves at 90 DAP, 120 DAP and 240 DAP and stalk diameter which registered significant positive correlation with cane yield in plant crop exhibited positive but non significant association in ratoon crop. HR brix which showed significant positive association with cane yield in plant crop exhibited significant negative correlation with cane yield in ratoon crop.

In both plant and ratoon crops the HR brix yield showed high positive direct effect on cane yield and all the other characters exhibited significant positive correlation with cane yield due to their positive indirect effects through HR brix yield. Hence, in both plant and ratoon crop HR brix yield has to be given due importance when selecting for cane yield.

4.3 SECOND CLONAL STAGE

Data were recorded on seventy seven genotypes including four checks for twenty seven characters viz., tiller number at 120 DAP, shoot population at 180 and 240 DAP, number of green leaves at 90, 120, 240 DAP and at maturity, number of internodes, internode length, stalk length, stalk diameter, stalk volume, NMC per plot at harvest, single cane weight, fibre content, brix per cent, sucrose per cent, CCS per cent, juice purity per cent, pol per cent cane, juice extraction per cent, total sugars per cent, biomass per cane, fibre yield, CCS yield, theoretical yield of alcohol and cane yield. The data recorded on twenty seven characters were subjected to analysis of variance and the results are presented in Table 4.9. The treatment differences among the seventy seven genotypes were significant for twenty six characters except for number of green leaves at 120 DAP.

4.3.1 Mean, Range, Variability and Genetic Parameters

The information on the nature and magnitude of variability present in the genetic material is of prime importance for a breeder to initiate any effective selection programme. Genotypic and phenotypic coefficients of variation along with heritability as well as genetic advance are very essential to improve any trait of sugarcane because this would help in knowing whether the desired objective can be achieved from the material or not (Tyagi and Singh, 1998). Hence, in the present study the nature and extent of genetic variability, heritability and genetic advance for twenty seven characters were estimated in second clonal stage.

The mean performance (Table 4.10), GCV, PCV, heritability (broad sense) and genetic advance as percentage of mean (Table 4.11) are presented hereunder character wise.

4.3.1.1 Tiller Number at 120 DAP (No.)

The number of tillers at 120 DAP varied from 71.00 (2010T-153) to 175 (2010T-15) with a mean of 117.00. Moderate GCV (10.05) and high PCV (20.64) were observed for this character. Heritability (23.71) was low and GAM (10.08) was moderate for this trait.

4.3.1.2 Shoot Population at 180 and 240 DAP (No.)

This trait varied from 52.00 (2010T-153) to 130 (2010T-347) with a mean of 90.00. Moderate GCV (12.84) and PCV (19.96) were recorded. Heritability (41.16) and GAM (16.68) were moderate for this character.

Shoot population at 240 DAP ranged from 53.00 (2010T-183) to 155 (2010T-115) with a mean of 95.00. Moderate values of GCV (15.55) and

PCV (16.28) were observed. Heritability (91.13) and GAM (30.57) were high for this character.

4.3.1.3 Number of Green Leaves at 90, 120, 240 DAP and at Maturity

Number of green leaves at 90 DAP ranged between 10.00 (2010T-355) and 27.00 (2010T-126) and with a general mean of 16.00. Moderate GCV (17.28), high PCV (29.92), moderate heritability (33.36) and high GAM (20.56) were recorded for this character.

Number of green leaves at 120 DAP ranged from 10.00 (2010T-158) to 25.00 (2010T-225) with a mean of 17.00. Low GCV (9.12) and high PCV (24.76) were observed. Heritability (13.58) and GAM (6.93) were low for this character.

Number of green leaves at 240 DAP varied from 7.00 (2010T-4) to 15.00 (2010T-240) with a general mean of 10.00 Moderate GCV (10.34) and high PCV (22.54) were recorded for this character. Heritability (21.03) and GAM (9.77) estimates were low for number of green leaves at 240 DAP.

At maturity the number of green leaves ranged between 6.00 (2010T-362) and 19.00 (2010T-103) with a mean of 13.00. High estimates of GCV (21.39) and PCV (27.97) and moderate heritability (58.46) and high GAM (33.68) were recorded for this character.

4.3.1.4 Number of Internodes per cane (No.)

The number of internodes per cane varied from 14.00 (2010T-88) to 29.00 (2010T-124) with a mean of 22.00. This character registered moderate values for GCV (12.21), PCV (18.79), heritability (42.24) and GAM (16.35).

4.3.1.5 Internode Length (cm)

This character ranged from 8.87cm (2010T-340) to 17.71cm (2010T-208) with a general mean of 12.70cm. Internode length registered moderate values for GCV (11.94), PCV (19.15), heritability (38.84) and GAM (15.32).

4.3.1.6 Stalk Length (cm)

Stalk length varied from 185.00cm (2010T-18) to 368.00cm (2010T-208) with a mean of 268.00cm. Moderate GCV (12.77) and PCV (13.11) were observed for this character. High heritability (94.82) coupled with high GAM (25.61) was reported for stalk length.

4.3.1.7 Stalk Diameter (cm)

This trait ranged between 1.90 cm (2010T-179) and 3.40cm (2010T-84) with a mean of 2.53cm. Low GCV (8.40) and moderate PCV (13.54) were recorded. The heritability (38.50) and GAM (10.74) were moderate for this character.

4.3.1.8 Stalk Volume (cm^3)

Stalk volume ranged from 685.00cm^3 (2010T-267) to 2557.00cm^3 (2010T-84) with a mean of 1362.00cm^3. GCV (20.26) and PCV (29.36) values were high for this character. Moderate heritability (47.62) and high GAM (28.80) were registered for this trait.

4.3.1.9 NMC per Plot at Harvest (No.)

The number of millable canes per plot at harvest varied from 40.00 (2010T-321) to 118.00 (2010T-115) with a general mean of 83.00. Moderate GCV (17.28) and high PCV (20.35) were recorded for this character. NMC per plot at harvest registered high heritability (72.04) coupled with high GAM (30.21).

4.3.1.10 Single Cane Weight (kg)

Single cane weight ranged from 0.68 (2010T-351) to 1.59 (2010T-84) with a general mean of 1.07. Moderate GCV (15.45) and high PCV (21.81) were observed. This character registered moderate heritability (50.18) and high GAM (22.55).

4.3.1.11 Fibre Content (%)

Minimum fibre content (9.44) was observed in 2010T-184, whereas maximum fibre content (21.44) was recorded in 2010T-237. The general mean was 14.55 for this character. Moderate values for GCV (19.37) and PCV (19.48) and high values for heritability (98.81) and GAM (39.66) were recorded for fibre content.

4.3.1.12 Brix (%)

Brix per cent ranged from 9.59% (2010T-267) to 20.81% (2010T-175) with a mean value of 17.13%. Moderate values of GCV (13.51) and PCV (13.96) were recorded. High heritability (93.78) coupled with high GAM (26.96) was reported for this character.

4.3.1.13 Sucrose (%)

Sucrose per cent in juice ranged from 8.27% (2010T-267) to 19.92% (2010T-175) with a general mean of 15.61%. Moderate values for GCV (16.21) and PCV (16.33) and high values for heritability (98.57) and GAM (33.16) were recorded.

4.3.1.14 CCS Percentage (%)

Commercial cane sugar per cent ranged from 7.18% (2010T-249) to 14.29% (2010T-175) with a mean of 11.01%. GCV (16.26) and PCV (16.36) were moderate. High estimates of heritability (98.78) and GAM (33.30) were registered for this character.

4.3.1.15 Juice Purity (%)

Juice purity per cent varied from 80.63% (2010T-249) to 98.47% (2010T-331) with a mean value of 90.85%. Estimates of GCV (4.19) and PCV (4.66) were found to be low. High heritability (80.79) and low GAM (7.76) were observed for this character.

4.3.1.16 Pol per cent Cane (%)

Pol per cent cane ranged from 6.73% (2010T-267) to 16.98% (2010T-88) with a general mean of 13.33%. Estimates of GCV (16.02) and PCV (16.14) were moderate, whereas heritability (98.00) and GAM (32.74) were high for this character.

4.3.1.17 Juice Extraction (%)

Juice extraction per cent varied from 54.23% (2010T-240) to 73.61% (2010T-344) with a mean value of 63.47%. Low GCV (7.45) and PCV (7.53) values were noted for this character. High heritability (96.00) and moderate GAM (15.00) was observed for juice extraction per cent.

4.3.1.18 Total Sugars (%)

Total sugars per cent ranged from 11.46% (2010T-158) to 29.25% (2010T-72) with a mean value of 20.38%. This character registered high values for GCV (20.20), PCV (21.08), heritability (91.82) and GAM (39.88).

4.3.1.19 Biomass per Cane (kg)

Biomass per cane ranged between 1.00 kg (2010T-362) and 2.85 kg (2010T-124) with a mean value of 1.56 kg. This character recorded high values for GCV (20.31), PCV (21.27), heritability (91.18) and GAM (39.94).

4.3.1.20 Fibre Yield (t ha^{-1})

Fibre yield varied from 7.25 t ha^{-1} (2010T-321) to 30.06 t ha^{-1} (2010T-146) with a general mean value of 15.76 t ha^{-1}. High estimates of GCV (28.57), PCV (29.80), heritability (91.92) and GAM (56.43) were registered for this character.

4.3.1.21 CCS Yield (t ha^{-1})

Commercial cane sugar yield ranged from 5.76 t ha^{-1} (2010T-208) to 20.73 t ha^{-1} (2010T-4) with a mean value of 12.00 t ha^{-1}. This character registered high values for GCV (28.34), PCV (29.51), heritability (92.00) and GAM (56.09).

4.3.1.22 Theoretical Yield of Alcohol (g / 100ml)

Theoretical yield of alcohol varied from 1.79 g/100ml (2010T-416) to 14.67 g/100ml (2010T-72) with a general mean value of 9.29 g/100ml. High estimates of GCV (26.06), PCV (27.17), heritability (91.96) and GAM (51.47) were registered for this character.

4.3.1.23 Cane Yield (t ha^{-1})

Cane yield ranged from 54.06 t ha^{-1} (2010T-183) to 205.49 t ha^{-1} (2010T-146) with a general mean value of 109.84 t ha^{-1}. High estimates of GCV (26.76), PCV (28.00), heritability (91.32) and GAM (52.67) were registered for cane yield.

The top ten percent genotypes for diversified uses viz., biomass, fibre yield, CCS yield, theoretical yield of alcohol and cane yield are presented in Table 4.12.

An understanding of the various genetic parameters that govern a population under improvement is essential for the proper planning and effective execution of a plant breeding programme. Parameters like genetic variability and heritability are especially important in this context. In sugarcane, a clonally propagated crop, the effectiveness of selection in identifying superior genotypes as potential cultivars is a reflection of broad sense heritability. Broad sense heritability also referred to as degree of genetic determination refers to the control of the phenotype of an individual by its genotype (Falconer, 1989 and Allard, 1960). In vegetatively propagated crops such as sugarcane, the genotype of a plant is fixed after crossing because there is no opportunity for further segregation. Therefore, selection capitalizes on the variability inherent from initial crossing and hence heritability can be used to determine if the population has sufficient variability to identify superior genotypes. The magnitude of heritability determines the magnitude of gains from selection (Zhou and Joshi, 2012).

The GCV and PCV values were high for the traits viz., number of leaves at maturity, stalk volume, total sugars, biomass per cane, fibre yield, commercial cane sugar yield, theoretical yield of alcohol and cane yield indicating that the variability observed in the seventy seven genotypes was high. Moderate variability was observed for the traits viz., number of tillers at 120 DAP, shoot population at 180 and 240 DAP, number of leaves at 90 and 240 DAP, number of internodes per cane, internode length, stalk length, number of millable canes, single cane weight, fibre content, brix per cent, sucrose per cent, CCS per cent and pol per cent cane. The low GCV values for number of green leaves at 120 DAP, stalk diameter, juice purity per cent and juice extraction per cent indicated that the variability was low for these traits in the seventy seven genotypes.

High to moderate GCV and PCV values for stalk volume (Reddy, 1989 and Madhavi and Reddy, 1992), cane yield (Hapase and Repale, 2001; Gupta and Chatterjee, 2002; Agarwal, 2003; Kumar, 2004; Patel *et al*., 2006; Rahman *et al*., 2008; Sabitha *et al*., 2009 and Anbanandan and Sarvanan, 2010), CCS yield (Thippeswamy *et al*., 2000; Patel *et al*., 2006; Sabitha *et al*., 2009 and Anbanandan and Sarvanan, 2010), number of millable canes (Kamat and Singh, 2001; Bhatnagar *et al*., 2003; Ravishankar *et al*., 2004, Sabitha and Rao, 2008 and Navneeth *et al*.,2010), single cane weight (Jain *et al*., 2001; Bhatnagar *et al*., 2003; Ravishankar *et al*., 2004, Sabitha and Rao, 2008 and Navneeth *et al*.,2010), stalk length (Singh *et al*., 2001; Gupta and Chatterjee, 2002; Sousa-Viera and Milligan, 2005; Delvadia and Patel, 2006; Rahman and Bhuiyan, 2009 and Navneeth *et al*.,2010), HR brix (Singh *et al*., 2001 and Chandrakanth *et al*., 2006) and low GCV and PCV values for juice purity per cent (Thippeswamy *et al*., 2000; Singh and Singh, 2000 and Anbanandan and Sarvanan, 2010) recorded in the present study are in tune with the findings of previous researchers.

Critical analysis of the results pertaining to genetic parameters indicated that the characters viz., shoot population at 240 DAP, stalk length, number of millable canes, fibre content, brix, sucrose, CCS per cent, pol per cent cane, total sugars, biomass per cane, fibre yield, CCS yield, theoretical yield of alcohol and cane yield showed high heritability coupled with high genetic advance as per cent of mean indicating that these characters are controlled by additive gene effects and selection would be effective for these characters. These results are in agreement with the findings of Singh and Singh (1994) for brix per cent; Das *et al.* (1996), Ghosh and Singh (1996) for number of millable canes and cane yield ; Singh *et al.*(1996) for commercial cane sugar, and cane yield; Ravishankar *et al.* (2003) for cane yield, commercial cane sugar yield, CCS per cent and juice brix; Berding and Pendrigh (2009) for brix, commercial cane sugar, dry matter and fibre content; Krishna *et al.* (2011) for sucrose per cent and CCS per cent; Mancini *et al.* (2012) for pol per cent cane. The existence of sufficiently large genetic variability and less influence of environment on these traits facilitates effective phenotypic selection.

Number of green leaves at 90 DAP and at maturity, stalk volume and single cane weight exhibited low to moderate heritability coupled with high genetic advance as per cent of mean indicating that these traits are governed by additive gene effects, hence selection may be effective for these characters but low or moderate heritability might be due to high environmental effects.

Similar results of importance of additive gene action for number of millable canes, single cane weight, cane yield, stalk volume (Charumathi, 2011), sugar yield (Kumar, 2004, Sabitha and Rao, 2008), shoot population (Sabitha, 2007), stalk length (Sharma and Singh, 1993, Navneeth *et al.* 2010) were also reported in sugarcane. Whereas non additive gene action was reported for CCS per cent (Verma and Singh, 2004, Deep *et al.* 2004 and Sabitha, 2007), shoot population (Deep *et al.* 2004), number of millable canes (Kadian *et al.* 1997), single cane weight and stalk length (Tyagi and Singh, 2000).

Juice purity and juice extraction per cent showed high heritability coupled with low genetic advance as per cent of mean which indicated that these traits were governed by non additive gene action and hence selection for these characters may not be rewarding. These results are in conformity with the findings of Verma *et al* (1987), Tyagi and Singh (2000), Sabitha and Rao (2008), Charumathi (2011), Ahmed and Obeid (2012) for juice purity per cent.

The traits viz., shoot population at 180, number of green leaves at 120, 240 DAP, tiller number at 120 DAP, internode number, internode length and shoot diameter registered low to moderate heritability coupled with low to moderate genetic advance as per cent of mean indicating that these traits are highly influenced by environmental effects and selection for these characters would be ineffective.

4.3.2 Character Associations in Second Clonal Stage

The phenotypic correlation coefficients between cane yield, fibre yield, biomass, theoretical yield of alcohol, CCS yield and their component characters respectively and inter correlations among different traits were estimated in second clonal stage and the results are presented in Table 4.13 and Table 4.14 . The correlation coefficients between 27 characters were split into 2 Tables for convenience of presentation.

4.3.2.1 Intercorrelations among Cane Yield, Fibre Yield, Biomass, Theoretical Yield of Alcohol and CCS Yield Components

Number of tillers at 120 DAP exhibited positive significant association with shoot population at 180 DAP (0.383) and fibre content (0.252) while significant negative association of this character was observed with stalk diameter (-0.240). Similar results of positive correlation of tillering with fibre content and negative correlation of tillering with stalk diameter were reported by Badaloo and Ramdoyal, 2003; Hoarau *et al*., 2002 and Anusonpornpurm *et al*., 2008.

Shoot population at 180 DAP showed significant positive association with shoot population at 240 DAP (0.356), number of leaves at 120 DAP (0.275) and number of millable canes (0.273).

Significant positive association of shoot population at 240 DAP was noted with number of millable canes (0.609), whereas significant negative association of this character was observed with juice purity (-0.252). Significant positive association of shoot population at 240 DAP with number of millable canes was noticed by Kumar *et al*., 2003; Chandrakanth *et al*., 2007 and Sirisha *et al*., 2010.

Number of green leaves at maturity exhibited significant negative association with internode length (-0.376), whereas significant positive association of this character was noted with internode number (0.577), stalk length (0.284), stalk diameter (0.318) and stalk volume (0.392). The results were the same as reported by earlier workers for stalk diameter (Hapase and Repale, 1999; Singh *et al*., 2002 and Dagar *et al*., 2004).

Number of internodes per cane exhibited significant positive association with stalk length (0.369) and stalk volume (0.256). Internode number has registered significant negative association with intenode length (-0.754).

Significant positive association of internode length was observed with stalk length (0.301) and number of millable canes per plot (0.255).

Significant positive association of stalk length was noted with stalk volume (0.388). Stalk length exhibited significant negative association with brix (-0.237), sucrose per cent (-0.264), CCS per cent (-0.257) and pol per cent cane (-0.285). Non significant negative association of stalk length with brix, sucrose and CCS per cent was reported by Singh *et al*., 2002, Singh *et al*., 2007 and Sirisha, 2009.

Stalk diameter showed significant positive association stalk volume (0.884), whereas significant negative association of this character was observed with fibre content (-0.268). The positive and significant association of stalk diameter with stalk volume is in accordance with the findings of Reddy and Reddi (1986), Sharma and Katiyar (1986), Madhavi *et al.* (1990) and Charumathi (2011) in sugarcane. Similar results of negative association of stalk diameter with fibre content were noticed by Gravios and Milligan, 1992, Anusonpornpurm *et al*. 2008. This indicated that selection for larger stalk diameter would decrease the fibre content. Further they suggested that direct selection for optimum fibre content by evaluation of clones in a single crop would be effective.

Significant negative association of stalk volume was noted with total sugars per cent (-0.225).

Number of millable canes per plot at harvest showed significant positive association with juice extraction per cent (0.291).

Single cane weight exhibited significant negative association with juice extraction per cent (-0.238).

Fibre content exhibited significant negative association with juice extraction per cent (-0.388).

Significant positive association of brix per cent was observed with sucrose per cent (0.967), CCS per cent (0.903), juice purity per cent (0.444), pol per cent cane (0.948) and total sugars per cent (0.359). These results are in conformity with the findings of earlier workers for sucrose per cent (Thippeswamy *et al*., 2003; Patel *et al*., 2006, Sahu *et al*., 2008 and Sirisha, 2009) and purity per cent (Kadian and Mehla, 2006; Singh *et al*., 2007 and Sabitha, 2007).

Sucrose per cent showed significant positive association with CCS per cent (0.970), juice purity per cent (0.654), pol per cent cane (0.979) and total sugars (0.415). Similar results were noticed for CCS per cent (Hapase and Repale, 2001; Thangavelu 2004; Chandrakanth *et al*., 2007 and Sirisha, 2009) and purity per cent (Singh and Singh, 2002; Kadian *et al*., 2006; and Sabitha, 2007).

CCS per cent exhibited significant positive association with juice purity (0.723), pol per cent cane (0.943) and total sugars (0.412). These findings are in tune with that of Hapase and Repale, 2001; Jain *et al*., 2002 and Sirisha, 2009 for purity per cent.

Positive and significant association of juice purity per cent was observed with pol per cent cane (0.643) and total sugars (0.396).

Pol per cent cane showed significant positive association with total sugars (0.379).

Significant negative association of juice extraction per cent was observed with total sugars (-0.281).

4.3.2.1 Correlation between Cane Yield and its Components

Cane yield was positively and significantly associated with shoot population at 240 DAP (0.487), stalk volume (0.241), number of millable canes per plot (0.618), single cane weight (0.632), fibre yield (0.779) and CCS yield (0.846), while significant negative association of cane yield was observed with fibre content (-0.253).

Similar results of positive and significant association of cane yield with number of millable canes (Chandrakanth *et al.*, 2006 and Charumathi, 2011), stalk volume (Mariotti, 2002; Thangavelu, 2005 and Charumathi 2011), single cane weight (Dagar *et al*., 2004; Kadian *et al*., 2006; Chandrakanth *et al*., 2007; Rahman *et al*., 2008 and Sirisha *et al*., 2010) and CCS yield (Patel *et al*., 2006; Sabitha, 2007 and Sirisha *et al*., 2010).

4.3.2.2 Correlation between Fibre Yield and its Components

Fibre yield showed significant positive association with shoot population at 240 DAP (0.510), number of millable canes per plot (0.507), single cane weight (0.459), fibre content (0.389), CCS yield (0.686) and cane yield (0.779).

4.3.2.3 Correlation between Biomass per Cane and its Components

Biomass per cane was positively and significantly associated with number of green leaves at maturity (0.313), number of internodes per cane (0.370), stalk length (0.374), stalk diameter (0.385), stalk volume (0.540) and single cane weight (0.376). Significant positive or negative correlation was not observed between biomass per cane sucrose per cent. Moreover Inman-Bamber *et al*., 2011, reported that sucrose accumulation in sugarcane stalks does not limit photosynthesis and biomass production. Hence, breeding and selection for increased biomass could be practiced without reduction in sucrose content.

4.3.2.4 Correlation between Theoretical Yield of Alcohol and its Components

Significant negative association of theoretical yield of alcohol was observed with stalk volume (-0.242) and juice extraction per cent (-0.290) while the characters brix (0.389), sucrose (0.440), CCS per cent (0.447), juice purity (0.388), pol per cent cane (0.414), total sugars (0.919) and CCS yield (0.256) were significantly and positively associated with this character.

These results are in conformity with the findings of Rakkiyappan and Pandiyan (1992) with respect to the positive association of ethanol yield with total sugars. Hence a variety meant for ethanol production should contain high total sugars in juice coupled with high cane yield.

4.3.2.5 Correlation between CCS Yield and its Components

CCS yield exhibited significant positive association with shoot population at 240 DAP (0.351), number of millable canes per plot (0.526), single cane weight (0.533), brix (0.411), sucrose (0.397), CCS per cent (0.357), pol per cent cane (0.436), total sugars (0.272), fibre yield (0.686), theoretical yield of alcohol (0.256) and cane yield (0.846).

Significant and positive association of sugar yield was reported by Singh and Khan (2004) with cane yield, single cane weight, and Al-Sayed *et al.* (2012) with number of millable canes, sucrose per cent, total soluble solids per cent.

In all the three generations viz., first clonal stage, ratoon and second clonal stage the traits viz., number of millable canes, single cane and stalk volume exhibited positive and significant association with cane yield. The positive and significant association of number of leaves at maturity, number of internodes, stalk length, stalk diameter, stalk volume, and single cane weight were observed with biomass per cane in all the three generations.

A perusal of the association studies of the three generations it is evident that shoot population at 240 DAP exhibited non significant negative association with cane yield in first clonal stage but it showed significant positive association with cane yield in ratoon crop and second clonal stage. The brix per cent registered positive and significant association with cane yield in first clonal stage, while negative and significant association of this trait was observed in ratoon crop. However, in second clonal stage its association with cane yield was non significant and negative. Number of green leaves at 90, 120 and 240 DAP exhibited significant and positive association with cane yield only in first clonal generation, while the number of tillers at 120 DAP, shoot population at 180 and 240 DAP showed significant positive association with cane yield only in ratoon crop. Number of green leaves at maturity, number of internodes, internode length, stalk length, stalk diameter and biomass per cane recorded positive and significant association with cane yield in first clonal stage and ratoon but these traits exhibited non significant association with cane yield in second clonal stage.

The results further indicated that it is possible to combine both high fibre and high sugar content in the same genotype as there was no significant positive or negative correlation between brix or pol and fibre content. This suggested that they are independent of one another and so selection could be made for these traits in a new variety that would have both increased sugar and increased fibre, thus satisfying the future demands of the sugar industries. These results are in conformity with the findings of Kennedy (2008). The independence of these two characters viz., fibre and brix which compete for the same source material i.e., the product of photosynthesis; might be attributed to the fact that the two characters use the photosynthetic product at different times of growth phases. Fibre, a function of the structure of the stem is accumulated during growth phase, whereas sugar is accumulated during ripening phase. These results are encouraging for the prospect of developing multipurpose cultivars that have both high fibre and high sugar content. These cultivars would increase the amount of bagasse produced in sugar mills leading to a higher quantity of bagasse available for co-generation.

4.3.3 Path Coefficient Analysis

Path analysis was carried out separately for cane yield, fibre yield, biomass per cane, theoretical yield of alcohol and CCS yield considering them as dependent variables and the component traits showing significant associations with them as independent variables and the results are presented in Tables 4.15, 4.16, 4.17, 4.18 and 4.19.

4.3.3.1 Direct and Indirect Effects of Component Characters on Cane Yield in Second Clonal Stage

The direct and indirect effects of seven characters on cane yield are presented in Table 4.15.

The direct effect of shoot population at 240 DAP on cane yield was positive and negligible (0.014) but its indirect effects were moderate and positive through number of millable canes (0.256) and fibre yield (0.216), and negligible through cane weight (0.006) and CCS yield (0.015). These indirect positive effects resulted in significant positive correlation of shoot population at 240 DAP with cane yield (0.487) *in spite* of its negligible direct effect.

Stalk volume recorded negligible positive direct effect (0.022) on cane yield and its indirect effects through number of millable canes (0.050), cane weight (0.073), fibre content (0.056), fibre yield (0.035) and CCS yield (0.005) were also positive resulting in positive significant correlation with cane yield (0.241).

Number of millable canes exhibited high direct positive effect (0.421) on cane yield. Its indirect effects via fibre yield (0.215) was moderate and positive, whereas negligible and positive through fibre content (0.037), CCS yield (0.023), shoot population at 240 DAP (0.009), and stalk volume

(0.003). The correlation coefficient was higher (0.618) than the direct effect due to these positive indirect effects.

Cane weight showed high direct positive effect on cane yield (0.444) and its indirect effects via stalk volume (0.004), fibre content (0.051), fibre yield (0.195) and CCS yield (0.024) were positive which resulted in significant correlation coefficient (0.632).

Fibre content exerted moderate negative direct effect (-0.261) on cane yield and its indirect effects were negative and negligible via stalk volume (-0.005), number of millable canes (-0.059), cane weight (-0.086) and CCS yield (-0.008) and low positive via fibre yield (0.165). Negligible positive direct effect of fibre content on cane yield was noticed by Kang *et al.*, 1989.

Fibre yield showed high positive direct effect (0.424) on cane yield. The moderate indirect effects through number of millable canes (0.213), cane weight (0.204) and very low positive indirect effects through shoot population at 240 DAP (0.007), stalk volume (0.002) and CCS yield (0.030) resulted in significant correlation coefficient higher than its direct effect on cane yield (0.779).

CCS yield recorded a relatively negligible direct effect (0.044) on cane yield, but its indirect effects through number of millable canes (0.221), cane weight (0.237) and fibre yield (0.291) were positive and moderate. It also showed very low magnitude of positive indirect effects through fibre content (0.045), shoot population at 240 DAP (0.005) and stalk volume (0.002), consequently the total correlation of CCS yield with cane yield (0.846) was positive and highly significant.

The residual effect was very low (0.115) indicating that almost all the characters contributing to cane yield were included and that most of the variation in cane yield was accounted by these seven characters.

The results revealed that single cane weight, fibre yield and number of millable canes at harvest exhibited high positive direct effects on cane yield and the other characters also exhibited their indirect positive effects on cane yield through these characters indicating that these were the major contributing characters to cane yield in sugarcane. Hence, direct selection for single cane weight, fibre yield and number of millable canes would be helpful for the improvement of cane yield. Fibre yield showed significant positive correlation with number of millable canes at harvest, single cane weight and shoot population at 240 DAP indicating that indirect selection for cane yield based on these characters may be given importance in later generations.

Similar results of positive direct effect on cane yield were reported by Setia *et al*., (2001), Kumar (2004), Krishna *et al*., (2004), Kadian and Mehla (2006), Chandrakanth *et al*., (2007), Sabitha (2007), Rahman *et al*., (2008) and Sirisha *et al*., (2010) for number of millable canes: Verma and Singh (2004), Kadian *et al*., (2006), Patel *et al*., (2006), Sabitha (2007), Sirisha *et al*., (2010) and Charumathi (2011) for single cane weight.

Number of millable canes and stalk volume exhibited positive direct effect on cane yield in all the three generations viz., first clonal stage, ratoon and second clonal stage. While single cane weight registered positive direct effect on cane yield in first and second clonal stages but in ratoon crop the direct effect of single cane weight on cane yield was negative and the significant positive correlation of this trait with cane yield resulted due to its high positive indirect effects via HR brix yield.

4.3.3.2 Direct and Indirect Effects of Component Characters on Fibre Yield in Second Clonal Stage

The direct and indirect effects of six characters on fibre yield are presented in Table 4.16.

Shoot population at 240 DAP exerted negligible negative direct effect on fibre yield (-0.006). But its substantial indirect effects through cane yield (0.390), number of millable canes (0.074) and fibre content (0.049) resulted in significant positive correlation of this character with fibre yield (0.510).

Number of millable canes showed a relatively low positive direct effect on fibre yield (0.122). It also exhibited high indirect positive effect through cane yield (0.495) and negligible positive indirect effect through CCS yield (0.002). These positive indirect effects resulted in higher correlation coefficient of this character with fibre yield (0.507) compared to its direct effect.

Single cane weight exerted very low direct effect on fibre yield (0.098). But its substantial positive indirect effect through cane yield (0.506) resulted in significant correlation with fibre yield (0.459).

Fibre content recorded the high positive direct effect on fibre yield (0.629). But its indirect effects through number of millable canes (-0.017), cane weight (-0.019) and cane yield (-0.202) were negative which resulted in a reduction in the total correlation of fibre content with fibre yield to 0.389.

CCS yield recorded the lowest positive direct effect (0.004) on fibre yield. The total correlation coefficient of CCS yield with fibre yield was significant and was of higher magnitude (0.686) which was due to the positive indirect effects via cane yield (0.677), number of millable canes (0.064) and cane weight (0.052).

Among all the components, cane yield showed the highest positive direct effect (0.800) on fibre yield. Its negative indirect effects through fibre content (-0.159) and shoot population at 240 DAP (-0.003) reduced the total correlation to 0.779, despite a higher direct effect.

Residual effect was found to be very low (0.159) which suggested that most of the variation in fibre yield was due to these six characters.

Among all the component traits cane yield and fibre content exhibited highest positive direct effect on fibre yield and almost all the traits exerted their positive indirect effects via cane yield. Hence, cane yield and fibre content are the major contributing characters to fibre yield. A genotype selected for fibre yield should have moderate high fibre content coupled with high cane yield since these two traits are negatively correlated.

4.3.3.3 Direct and Indirect Effects of Component Characters on Biomass per Cane in Second Clonal Stage

The direct and indirect effects of six characters on biomass per cane are presented in Table 4.17.

Number of green leaves at maturity exhibited low positive direct effect (0.137) on biomass per cane. *In spite* of, its high positive indirect effect via stalk volume (0.445) and negligible positive indirect effect through internode number per cane (0.064), the total correlation was reduced to 0.322 due to negative indirect effects via stalk length (-0.058), stalk diameter (-0.233) and single cane weight (-0.033).

Internode number showed low positive direct effect (0.111) on biomass per cane. However, the total correlation of internode number with biomass per cane was positive and significant (0.370), which is due to its indirect positive effects through stalk volume (0.290), cane weight (0.043) and number of green leaves at maturity (0.079).

Stalk length exhibited moderate negative direct effect on biomass per cane (-0.205) but its total correlation with biomass per cane was positive and significant (0.374), which is due to the high indirect positive effects via stalk volume (0.440) and very low positive indirect effects through number of green leaves at maturity (0.039), internode number (0.041), stalk diameter (0.048) and cane weight (0.011).

Stalk diameter recorded high negative direct effect (-0.732) on biomass per cane. It showed very high positive indirect effect via stalk volume (1.003) and negligible positive indirect effects through other characters resulting in significant positive correlation of stalk diameter with biomass per cane (0.385).

Stalk volume exhibited the highest positive direct effect (1.134) on biomass per cane. But its high indirect negative effect through stalk diameter (-0.647) and very low indirect negative effect via stalk length (-0.080) resulted in the reduction of total correlation of this character to 0.540 with biomass per cane.

Single cane weight recorded high direct positive effect (0.304) on biomass per cane. This trait exhibited low positive indirect effects via stalk volume (0.187) and internode number (0.016) which resulted in a significant positive correlation of single cane weight (0.376) with biomass per cane.

Residual effect was found to be high (0.739) which indicated that some other characters not considered in this study might be contributing to biomass. The top weight and other characters not included in this study may be contributing to the biomass per cane.

The path analysis results indicated that direct selection based on stalk volume and single cane weight would be helpful for the improvement of biomass in sugarcane, as these two characters showed high positive direct effects on biomass per cane as well as all other characters exhibited their high indirect effects via stalk volume. Further stalk volume showed significant positive correlation with stalk length, stalk diameter and cane yield. Indirect selection for stalk length and stalk diameter would improve the biomass content in sugarcane.

4.3.3.4 Direct and Indirect Effects of Component Characters on Theoretical Yield of alcohol in Second Clonal Stage

The direct and indirect effects of nine characters on theoretical yield of alcohol are presented in Table 4.18.

Stalk volume showed negligible negative direct effect (-0.030) on theoretical yield of alcohol. Its indirect effects through total sugars, CCS per cent (-0.049), pol per cent cane (-0.048), juice extraction (-0.003) and CCS yield (-0.003) were negative resulting in significant negative correlation of this character with theoretical yield of alcohol (-0.242).

Brix recorded high negative direct effect (-0.330) on theoretical yield of alcohol and it also exhibited negative indirect effects via sucrose

(-0.154), juice purity (-0.076) and CCS yield (-0.011). But the high positive indirect effects through pol per cent cane (0.392), total sugars (0.319) and CCS per cent (0.242) resulted in significant positive correlation of brix with theoretical yield of alcohol (0.389).

Sucrose per cent exhibited negative direct effect (-0.159) on theoretical yield of alcohol. The correlation between sucrose per cent and theoretical yield of alcohol was significant and positive (0.440) which was due to high positive indirect effects of sucrose per cent through pol per cent cane (0.404), total sugars (0.368) and CCS per cent (0.260).

CCS per cent recorded moderate positive direct effect (0.268) on theoretical yield of alcohol. Its indirect effects via brix per cent (-0.298) and juice purity (-0.124) were negative while its indirect effects via pol per cent cane (0.390) and total sugars (0.366) were high and positive which resulted in significant correlation of CCS per cent with theoretical yield of alcohol (0.447).

Juice purity per cent showed low negative direct effect (-0.171) on theoretical yield of alcohol. Positive and high indirect effects of juice purity per cent on theoretical yield of alcohol was noticed through total sugars (0.351), pol per cent cane (0.266) and CCS per cent (0.193) resulting in significant positive correlation of this character with theoretical yield of alcohol (0.388).

Pol per cent cane registered high positive direct effect (0.413) on theoretical yield of alcohol. It also showed positive indirect effects via total sugars (0.336) and CCS per cent (0.252). But its correlation with theoretical yield of alcohol (0.414) was on par with the direct effect of pol per cent cane due to its negative indirect effects through brix (-0.313), sucrose per cent (-0.156), juice purity per cent (-0.110) and CCS yield (-0.011).

Juice extraction per cent recorded negligible negative direct effect (-0.062) on theoretical yield of alcohol and its indirect effects were negative through total sugars (-0.249), CCS per cent (-0.016) and stalk volume (-0.002), which resulted in significant negative correlation of this character with theoretical yield of alcohol (-0.290).

Total sugars showed the highest positive direct effect (0.887) on theoretical yield of alcohol. Its low positive indirect effects through pol per cent cane (0.157) and CCS per cent (0.110) resulted in total correlation of 0.919.

CCS yield direct effect on theoretical yield of alcohol was negligible and negative (-0.026). But its correlation with theoretical yield of alcohol was positive and significant (0.256) due to its positive indirect effects through total sugars (0.241), pol per cent cane (0.180) and CCS per cent (0.096).

Residual effect was found to be low (0.374) which indicated that most of the characters contributing to theoretical yield of alcohol were included in study.

Critical analysis of the results by path analysis revealed that the characters viz., total sugars per cent, pol per cent cane and CCS per cent exhibited positive direct effects on theoretical yield of alcohol and the other characters also exhibited their indirect positive effects on theoretical yield of alcohol via total sugars per cent, pol per cent cane and CCS per cent, indicating that these were the major contributing characters to theoretical yield of alcohol in sugarcane. Further, these three characters showed significant positive correlations among themselves indicating that selection for any one of these traits would improve the remaining two traits simultaneously. Hence, a variety meant for ethanol production should have high total sugars or pol per cent cane or CCS per cent coupled with high cane yield.

4.3.3.5 Direct and Indirect Effects of Component Characters on CCS Yield in Second Clonal Stage

The direct and indirect effects of eleven characters on CCS yield are presented in Table 4.19.

Shoot population at 240 DAP recorded negligible direct effect on CCS yield (-0.016). But its indirect effects through number of millable canes (0.124), sucrose per cent (0.211), fibre yield (0.161) and cane yield (0.190) were positive and resulted in significant positive correlation of this character with CCS yield (0.351).

Number of millable canes exhibited moderate positive direct effect on CCS yield (0.204) and its indirect effects through sucrose per cent (0.073), fibre yield (0.160) and cane yield (0.241) were positive and resulted in a significant correlation of this trait with CCS yield (0.526).

Single cane weight showed moderate positive direct effect on CCS yield (0.212). The total correlation of single cane weight with CCS yield was 0.533 which was due to moderate to low positive indirect effects through cane yield (0.246), fibre yield (0.145).

Brix per cent had a negligible positive direct effect on CCS yield (0.016). However, its association with CCS yield (0.411) was significant and high due to high positive indirect effects through pol per cent cane (0.971) and CCS per cent (0.591) *in spite* of very high negative indirect effect via sucrose per cent (-1.146).

Sucrose recorded very high negative direct effect on CCS yield (-1.185). But its high positive indirect effects through CCS per cent (0.635) and pol per cent cane (1.003) resulted in significant positive correlation of this character with CCS yield (0.397).

CCS per cent showed high positive direct effect on CCS yield (0.655). It also exhibited high positive indirect effect via pol per cent cane (0.966) but the correlation was brought down to 0.357 due to its very high indirect negative effect (-1.150) through sucrose.

Pol per cent cane had the highest positive direct effect (1.024) on CCS yield and its indirect effect via CCS per cent was also high and positive (0.617). But the correlation of pol per cent cane with CCS yield was reduced to 0.436 due to its very high indirect negative effect (-1.160) through sucrose.

Total sugars exhibited negligible negative direct effect (-0.012) on CCS yield and its indirect effect via sucrose was high and negative (-0.492). The indirect effects of total sugars through CCS per cent (0.270) and pol per cent cane (0.388) were positive to result in significant positive correlation of this character with CCS yield (0.272).

Fibre yield had high positive direct effect on CCS yield (0.316) and its indirect effects through cane yield (0.303) and number of millable canes (0.103) were positive resulting in significant positive correlation (0.686) of this character with CCS yield *in spite* of its negative indirect effect via pol per cent cane (-0.119).

Cane yield exhibited high positive direct effect on CCS yield (0.389) and its indirect effects through fibre yield (0.246), sucrose (0.123), single cane weight (0.134) and number of millable canes (0.126) were also positive resulting in high correlation of 0.846.

Theoretical yield of alcohol had negligible direct effect on CCS yield (0.026). But its association with CCS yield was significant and positive (0.256), which was due to its high positive indirect effects through pol per cent cane (0.424) and CCS per cent (0.293).

Residual effect was found to be very low (0.141) which suggested that the choice of the component characters was appropriate and that most of the variation in CCS yield could be accounted by these eleven components.

The results revealed that the characters pol per cent cane, CCS per cent, cane yield, fibre yield, single cane weight and number of millable canes exhibited positive direct effects on CCS yield and the other characters also exhibited high indirect positive effects on CCS yield via CCS per cent and pol per cent cane indicating that CCS per cent and pol per cent cane are the major contributing characters to CCS yield in sugarcane. CCS per cent and pol per cent cane showed significant correlation with one another and with brix, sucrose per cent, juice purity per cent and total sugars per cent indicating that indirect selection based on these characters may be given importance. Hence, a variety meant for high commercial cane sugar yield should have high brix, high sucrose, high juice purity per cent, high total sugars in juice coupled with high cane yield.

These results are in conformity with the findings of Thippeswamy *et al.* (2003), Kumar (2004), Singh and Khan (2004), Patel *et al.* (2006), Sirisha (2009) and Charumathi (2011) for cane yield, Thippeswamy *et al.* (2003), Kumar (2004), Singh *et al.* (2005) and Sirisha *et al.* (2010) for single cane weight; Hapase and Repale (2001), Thippeswamy *et al.* (2003) and Sirisha (2009) for number of millable canes.

4.4 SELECTION INDICES THROUGH DISCRIMINANT FUNCTION ANALYSIS

Efficiency of index selection over straight selection has been studied in various crops including sugarcane ever since the concept was proposed by Smith (1936) based on Fisher's discriminant function. Straight selection is often based on arbitrary considerations, while index selection has the advantage that (i) it is based on genotypic considerations, (ii) the different characters can be suitably weighed according to their relative importance and (iii) simultaneous improvement might be possible for the target character as well as the associated attributes. Discriminant function is useful in knowing the extent of improvement that can be achieved in a dependent character by selecting plants based on different combination of independent component characters. When a trait is associated with other characters, indirect selection through such traits is sometimes likely to be better than straight selection. But, when the number of characters associated with a trait is large, it becomes difficult to select simultaneously for all the characters. Under such circumstances, selection indices formulated involving different combinations of characters giving appropriate weightage to each character helps in making the selection procedure easy.

The technique of discriminant function developed by Fisher (1936) was adopted to know the genotypic worth of clones with respect to cane yield, fibre yield, biomass, CCS yield and theoretical yield of alcohol and their components so as to have computational formulae for construction of selection indices which when applied for selection can bring about effective improvement in these traits compared to straight selection.

4.4.1 Formulation of Selection Indices through Discriminant Function Analysis for Cane Yield

Selection indices were formulated considering cane yield and six of its component characters which showed high correlation with cane yield in second clonal generation. Among seven characters, cane yield (X_1) was considered as dependent character while, other characters viz., shoot population at 240 DAP (X_2), stalk volume (X_3), number of millable canes (X_4), single cane weight (X_5), fibre yield (X_6) and commercial cane sugar yield (X_7) were considered as independent variables. The expected genetic advance was computed for each of the indices at five per cent selection intensity. The relative efficiency of all the indices was computed considering the relative efficiency of cane yield as 100 per cent. The discriminant functions and the estimated values of genetic advance (GA) and relative efficiency (RE) for each combination of characters are presented in Table 4.20 and briefly discussed below.

One hundred and twenty seven different selection indices were formulated based on various combinations of seven characters considered for construction of selection indices. Among these, higher relative efficiency of 1092.49 coupled with high genetic advance (303.78) was exhibited by the combination involving all the seven traits viz., cane yield (X_1), shoot population at 240 DAP (X_2), stalk volume (X_3), number of millable canes (X_4), single cane weight (X_5), fibre yield (X_6) and commercial cane sugar yield (X_7) followed by the combination of six traits viz., cane yield (X_1), shoot population at 240 DAP (X_2), stalk volume (X_3), number of millable canes (X_4), fibre yield (X_6) and commercial cane sugar yield (X_7) which recorded relative efficiency of 1090.22 with genetic advance of 303.15.

Among single characters, stalk volume (X_3) was highly efficient with relative efficiency of 670.00 and high genetic advance of 186.30, compared to the direct selection based on cane yield (X_1), whereas among two character combinations, maximum relative efficiency of 993.66 was observed for the combination of stalk volume (X_3) and single cane weight (X_5) with high genetic advance of 276.30. However, in case of three character combinations, the combination involving cane yield (X_1), stalk volume (X_3) and single cane weight (X_5) exhibited higher relative efficiency of 1062.83 coupled with high genetic advance of 295.53.

Among four character combinations, cane yield (X_1), stalk volume (X_3), single cane weight (X_5) and commercial cane sugar yield (X_7) exhibited high relative efficiency of 1074.16 coupled with high genetic advance of 298.68, whereas among five character combinations, maximum relative efficiency of 1081.45 was observed for the combination of cane yield (X_1), shoot population at 240 DAP (X_2), stalk volume (X_3), number of millable canes (X_4) and fibre yield (X_6) with high genetic advance of 300.71.

Since fibre yield and commercial cane sugar yield are derived characters, more emphasis during selection could be given on the directly measurable characters to get the accurate results. Hence, the combinations without fibre yield and commercial cane sugar yield could be considered for selection for cane yield. Among them the combination involving the traits cane yield (X_1), shoot population at 240 DAP (X_2), stalk volume (X_3), number of millable canes (X_4) and single cane weight (X_5) recorded maximum relative efficiency of 1074.14 with genetic advance of 298.68. When indirect selection scheme excluding cane yield in formulating index is to be followed, the index involving the combination of three characters viz., stalk volume (X_3), number of millable canes (X_4) and single cane weight (X_5) which exhibited maximum relative efficiency of 1010.31 with genetic advance of 280.93 could be considered for selection schemes to improve cane yield.

Selection indices were formulated by several workers in sugarcane to suit different contexts. Ethirajan (1966) formulated selection indices for seedling and settling populations , Miller *et al.* (1978) studied four hybrid populations of sugarcane and evolved suitable selection indices for them and reported high genetic gain for cane yield when the index was based on stalk height, stalk diameter, millable stalk number per plot and stalk yield. Punia *et al.* (1982) reported that selection index involving internode number, brix, purity, sucrose and CCS per cent was efficient over straight selection for sucrose. Nair and Sreenivasan (1989) reported that highest relative efficiency was observed for cane yield with the index involving stalk yield, millable stalk number per cane, stalk diameter, stalk weight and stalk height. Charumathi (2011) suggested a combination involving four characters viz., length of millable cane, diameter of cane, single cane weight and number of canes per clump in seedling nursery and clonal stages which showed the highest genetic advance as well as relative efficiency over straight selection for cane yield.

Scoring of sugarcane genotypes for cane yield based on the best selection index is depicted in Figure 4.1.

4.4.2 Formulation of Selection Indices through Discriminant Function Analysis for Fibre Yield

Among seven characters that were used to formulate selection indices, fibre yield (X_1) was considered as dependent character while other characters viz., shoot population at 240 DAP (X_2), number of millable canes (X_3), single cane weight (X_4), fibre content (X_5), CCS yield (X_6) and cane yield (X_7) were considered as independent variables. The discriminant functions and the estimated values of genetic advance and relative efficiency for each combination of characters over straight selection for fibre yield are presented in Table 4.21 and briefly discussed below.

Out of one hundred and twenty seven different selection indices formulated, higher relative efficiency of 1328.62 coupled with high genetic advance (57.13) was exhibited by the combination involving six traits viz., fibre yield (X_1), shoot population at 240 DAP (X_2), number of millable canes (X_3), single cane weight (X_4), CCS yield (X_6) and cane yield (X_7) followed by the combination of five traits viz., fibre yield (X_1), shoot population at 240 DAP (X_2), number of millable canes (X_3), CCS yield (X_6) and cane yield (X_7) which recorded relative efficiency of 1324.94 with genetic advance of 56.97.

Among single characters, cane yield (X_7) was highly efficient with relative efficiency of 646.69 and high genetic advance of 27.81, compared to the direct selection based on fibre yield (X_1). Whereas among two character combinations, maximum relative efficiency of 925.88 was observed for the combination of number of millable canes (X_3) and cane yield (X_7) with high genetic advance of 39.81. However, in case of three character combinations, the combination involving shoot population at 240 DAP (X_2), number of millable canes (X_3) and cane yield (X_7) exhibited high relative efficiency of 1185.82 coupled with high genetic advance of 50.99.

Among four character combinations, fibre yield (X_1), shoot population at 240 DAP (X_2), number of millable canes (X_3) and cane yield (X_7) exhibited high relative efficiency of 1265.06 coupled with high genetic advance of 54.39.

When indirect selection scheme excluding fibre yield is to be followed, the index involving the combination of six characters viz., shoot population at 240 DAP (X_2), number of millable canes (X_3), single cane weight (X_4), fibre content (X_5), CCS yield (X_6) and cane yield (X_7) which exhibited maximum relative efficiency of 1241.00 with genetic advance of 53.36 could be considered for selection schemes to improve fibre yield.

Scoring of sugarcane genotypes for fibre yield based on the best selection index is depicted in Figure 4.2.

4.4.3 Formulation of Selection Indices through Discriminant Function Analysis for Biomass per Cane

Selection indices formulated in sugarcane considering biomass per cane and its six component characters which had high correlation with it were formulated and presented in Table 4.22.

Among the different selection indices formulated, higher relative efficiency of 103115.07 coupled with high genetic advance (319.96) was exhibited by the combination involving all the seven traits viz., biomass per cane (X_1), number of leaves at maturity (X_2), number of internodes per cane

(X_3), stalk length (X_4), stalk diameter (X_5), stalk volume (X_6) and single cane weight (X_7) followed by six character combination involving biomass per cane (X_1), number of leaves at maturity (X_2), number of internodes per cane (X_3), stalk length (X_4), stalk volume (X_6) and single cane weight (X_7) which recorded relative efficiency of 102620.59 with high genetic advance of 318.43 compared to other combinations.

When considered individually, stalk volume (X_6) recorded higher relative efficiency of 60040.21 coupled with high genetic advance of 186.30 over straight selection for biomass per cane. Among two character combinations, the function involving stalk volume (X_6) and single cane weight (X_7) showed higher relative efficiency of 89043.32 with a genetic advance of 276.30. When a combination of three attributes was considered, relative efficiency of 99083.69 coupled with genetic advance of 307.45 was recorded for the index involving stalk length (X_4), stalk volume (X_6) and single cane weight (X_7). The discriminant function involving four characters viz., number of leaves at maturity (X_2), stalk length (X_4), stalk volume (X_6) and single cane weight (X_7) exhibited higher relative efficiency of 100494.61 and genetic advance of 311.83.

The indirect selection for biomass per cane could be based on the index involving six characters viz., number of leaves at maturity (X_2), number of internodes per cane (X_3), stalk length (X_4), stalk diameter (X_5), stalk volume (X_6) and single cane weight (X_7) which recorded higher relative efficiency of 101704.03 and genetic advance of 315.58.

Scoring of sugarcane genotypes for biomass based on the best selection index is depicted in Figure 4.3.

4.4.4 Formulation of Selection Indices through Discriminant Function Analysis for Commercial Cane Sugar Yield

Selection indices were formulated for commercial cane sugar yield considering eleven of its component characters which showed high correlation with commercial cane sugar yield in second clonal generation. Among twelve characters, commercial cane sugar yield (X_1) was considered as dependent character while other characters viz., shoot population at 240 DAP (X_2), number of millable canes (X_3), single cane weight (X_4), brix per cent (X_5), sucrose per cent (X_6), commercial cane sugar per cent (X_7), pol per cent cane (X_8), total sugars per cent (X_9), fibre yield (X_{10}), theoretical yield of alcohol (X_{11}) and cane yield (X_{12}) were considered as independent variables. Selection indices showing higher relative efficiencies based on different character combinations along with their genetic advance and relative efficiency over straight selection for commercial cane sugar yield are presented in Table 4.23.

Higher relative efficiency of 1828.82 coupled with high genetic advance (59.00) was exhibited by the combination involving all the twelve traits viz., commercial cane sugar yield (X_1), shoot population at 240 DAP (X_2), number of millable canes (X_3), single cane weight (X_4), brix per cent (X_5), sucrose per cent (X_6), commercial cane sugar per cent (X_7), pol per cent cane (X_8), total sugars per cent (X_9), fibre yield (X_{10}), theoretical yield of alcohol (X_{11}) and cane yield (X_{12}) followed by eleven character combination excluding commercial cane sugar per cent (X_7); ten character combination excluding single cane weight (X_4) and commercial cane sugar per cent (X_7); nine character combination excluding sucrose per cent (X_6), commercial cane sugar per cent (X_7), pol per cent cane (X_8).

Among single characters, cane yield (X_{12}) was highly efficient with relative efficiency of 861.95 and high genetic advance of 27.81, compared to the direct selection based on commercial cane sugar yield (X_1). Whereas among two character combinations, maximum relative efficiency of 1234.09 was observed for the combination of number of millable canes (X_3) and cane yield (X_{12}) with high genetic advance of 39.81.

However, in case of three character combinations, the combination involving shoot population at 240 DAP (X_2), number of millable canes (X_3) and cane yield (X_{12}) exhibited high relative efficiency of 1580.55 coupled with high genetic advance of 50.99.

Among four character combinations, selection index based on shoot population at 240 DAP (X_2), number of millable canes (X_3), fibre yield (X_{10}) and cane yield (X_{12}) exhibited high relative efficiency of 1686.17 coupled with high genetic advance of 54.39. This selection index could be used for indirect selection of commercial cane sugar yield. All the other combinations which showed higher relative efficiency and genetic advance included commercial cane sugar yield.

Whereas among five character combinations, maximum relative efficiency of 1765.98 was observed for the index based on commercial cane sugar yield (X_1), shoot population at 240 DAP (X_2), number of millable canes (X_3), fibre yield (X_{10}) and cane yield (X_{12}) with high genetic advance of 56.97. When total sugars per cent (X_9) was included to this selection index the relative efficiency was 1789.24 with genetic advance of 57.72. To this selection index, inclusion of theoretical yield of alcohol (X_{11}) resulted in a relative efficiency of 1803.10 and genetic advance of 58.17. Among seven character combinations inclusion of brix per cent (X_5) further increased the relative efficiency to 1808.29 and genetic advance to 58.33 among eight character combination.

From the results it was evident that all the selection indices included cane yield which indicated that cane yield was the most important character for commercial cane sugar yield. Similar kind of results were reported by Miller *et al.* (1978) and Singh and Khan (2003).

Scoring of sugarcane genotypes for commercial cane sugar yield based on the best selection index is depicted in Figure 4.4.

4.4.5 Formulation of Selection Indices through Discriminant Function Analysis for Theoretical Yield of Alcohol

Among eight characters that were used to formulate selection indices, theoretical yield of alcohol (X_1) was considered as dependent character while other characters viz., brix per cent (X_2), sucrose per cent (X_3), commercial cane sugar per cent (X_4), juice purity per cent (X_5), pol per cent cane (X_6), total sugars per cent (X_7) and commercial cane sugar yield (X_8) were considered as independent variables. The discriminant functions and the estimated values of genetic advance and relative efficiency for each combination of characters over straight selection for theoretical yield of alcohol are presented in Table 4.24 and briefly discussed below.

Out of two hundred and fifty five different selection indices formulated higher relative efficiency of 744.59 coupled with high genetic advance (17.25) was observed in the combination involving all the eight traits followed by the index based on seven characters excluding commercial cane sugar per cent (X_4) with a relative efficiency of 687.77 and genetic advance of 15.72.

Among single characters, total sugars per cent (X_7) was highly efficient with relative efficiency of 170.65 and high genetic advance of 3.95, compared to the direct selection based on theoretical yield of alcohol (X_1). Whereas among two character combinations, maximum relative efficiency of 268.97 was observed for the combination of juice purity per cent (X_5) and total sugars per cent (X_7) with a genetic advance of 6.23. However, in case of three character combinations, the combination involving sucrose per cent (X_3), juice purity per cent (X_5) and total sugars per cent (X_7) exhibited higher relative efficiency of 360.64 coupled with a genetic advance of 8.35.

Among four character combinations, theoretical yield of alcohol (X_1), sucrose per cent (X_3), juice purity per cent (X_5) and total sugars per cent (X_7) exhibited high relative efficiency of 445.34 coupled with a genetic advance of 10.32.

When indirect selection scheme excluding theoretical yield of alcohol is to be followed, the index involving the combination of five characters viz., brix per cent (X_2), sucrose per cent (X_3), juice purity per cent (X_5), pol per cent cane (X_6) and total sugars per cent (X_7) which exhibited maximum relative efficiency of 523.98 with genetic advance of 12.14 could be considered for selection schemes to improve theoretical yield of alcohol. Inclusion of commercial cane sugar yield to this index increased the relative efficiency to 602.98 and genetic advance of 13.97.

From the results it is evident that to increase the alcohol yield selection should be mainly based on total sugars per cent as all the selection indices showing higher relative efficiency and genetic advance involved this trait.

Scoring of sugarcane genotypes for theoretical yield of alcohol based on the best selection index is depicted in Figure 4.5.

In the present investigation, the selection indices constructed with the inclusion of more than one character gave higher genetic advance and relative efficiency over straight selection for the five diversified uses viz., cane yield, biomass per cane, fibre yield, theoretical yield of alcohol and commercial cane sugar yield. Similar results were reported in the selection indices formulated for cane yield, CCS yield and yield components in sugarcane by Miller *et al.* (1978), Dosado *et al.* (1980), Punia *et al.* (1982), Singh *et al.* (1991), Pillai and Ethirajan (1993), Das *et al.* (1997), Singh and Khan (1998), Doule and Balasundaram (1999), Singh *et al.* (2003), Krishna and Singh (2005), Sabitha (2007), Sahu *et al.* (2008) and Charumathi (2011).

4.5 GENETIC DIVERGENCE

The genetic divergence can be determined by multivariate analysis, a procedure that is widely used in different crops for parent selection (Cruz *et al.* 2004b). The objective of this study was to evaluate sugarcane clones for the genetic divergence through the multivariate analysis procedure and grouping by Tocher's optimization method for parent selection. The selection in sugarcane improvement programmes is directed to traits of agronomic interest and in advanced stages, a great number of genotypes would be discarded due to previous selection in early stages that alter the genotypic mean in the desirable direction. Hence, the possibility of identifying divergent plants would be higher through the study of divergence in the initial stages of the breeding programme.

Analysis of variance carried out separately for each of the characters showed highly significant differences among the seventy seven genotypes for 26 characters studied except for number of green leaves at 120 DAP. Wilk's test also showed highly significant differences among the genotypes for the aggregate effect of 26 characters which suggested the existence of considerable divergence in the material, hence D^2 analysis was carried out.

4.5.1 Grouping of Genotypes into Various Clusters

The seventy seven genotypes were grouped into ten clusters (Table 4.25) based on the D^2 values such that the genotypes belonging to the same cluster had on an average smaller D^2 values than those belonging to different clusters. Cluster I was the largest with fifteen genotypes followed by cluster X with fourteen, cluster IV with twelve, cluster VII with nine, cluster VIII with eight, cluster II with seven and cluster V with six genotypes. The clusters III, VI and IX had two genotypes each.

The results revealed that the distribution of genotypes into different clusters was at random and independent of each other. The genotypes from same parentage had fallen in different clusters and the genotypes with different parentage had fallen in the same cluster. The three clones 2010T-374, 2010T-369 and 2010T-368 obtained from the cross 81V48 x Co 94005 had fallen in three different clusters viz., VII, IX and X clusters respectively. All the clusters included the genotypes from different parentage (Table 4.25).

4.5.2 Contribution of Individual Character towards Divergence

The percent contribution of each character is estimated based on the number of times ranked and presented in Table 4.26 and Figure 4.6. Among the total 2926 pair combinations, biomass per cane ranked first for 1022 times and contributed 34.93% towards total divergence. It was followed by cane yield (18.42%), sucrose (11.62%), total sugars (9.57%), fibre yield (8.37%), pol per cent cane (6.29%), CCS yield (5.78%) and fibre content (2.22%). The contribution of juice extraction per cent (1.67%), theoretical yield of alcohol (0.85), shoot population at 240 DAP (0.13), number of millable canes per plot (0.13) and cane weight (0.03) towards genetic divergence was minimum. The remaining characters viz., tillers at 120 DAP, shoot population at 180 DAP, number of leaves at 90, 240 DAP and at maturity, number of internodes, internode length, stalk length, stalk diameter, stalk volume, brix and juice purity per cent did not contribute towards genetic divergence.

The present results are in contrast with those of Sarvjit and Khan (1990), Punia *et al.* (1983), Singh *et al.* (2004) and Sajjad and Khan (2009). The difference in the material, characters studied and the stage of clonal generation could be the reason for differences in the results of these studies.

4.5.3 Intra and Inter Cluster Distances

The intra and inter cluster distances (Table 4.27) for twenty six characters showed that the genotypes were highly divergent. The maximum inter cluster distance was observed between cluster IV and IX (100.33), while the minimum inter cluster distance was observed between cluster III and VI (20.68). The intra cluster distance ranged from 14.43 (cluster III) to 90.30 (cluster X).

In relation to the distance between the clones, the most similar clones were 2010T-179 (C0 98009 x Co 89003) and 2010T-333 (Co 94012 poly cross) which originated from different crosses, with a distance of 9.34. The most divergent were 2010T-175 and 2010T-124, with a distance of 256.68, according to the Mahalanobis generalized distance.

4.5.4 Cluster Means

The estimated cluster mean values for 26 characters are presented in Table 4.28. Analysis of the data indicated considerable differences between the clusters for most of the characters studied. The most remarkable differences between the clusters were noticed for tillers at 120 DAP, shoot population at 180 and 240 DAP, number of green leaves at 90 DAP, number of green leaves at maturity, stalk length, stalk volume, number of millable canes, fibre content, brix, sucrose, juice purity, pol per cent cane, internode number, juice extraction per cent, total sugars, fibre yield, CCS yield, theoretical yield of alcohol and cane yield. The differences between cluster means for number of green leaves at 240, internode length, stalk diameter, single cane weight, CCS per cent and biomass per cane were narrow.

The cluster means for tillers at 120 DAP ranged from 104.50 (III) to 141.00 (VI). The clusters I, IV, VI, VII and X recorded more number of tillers at 120 DAP than the general mean (116.14).

Shoot population at 180 DAP was highest in cluster VI (104.00) and lowest in cluster V (81.67). Higher cluster means than the average (89.52) were recorded in the clusters I, VI, VII, VIII and X.

The shoot population at 240 DAP differed from 109.50 (VI) to 82.17 (V). The superior clusters for shoot population at 240 DAP over their general mean (96.26) were II, III, VI, VII and IX.

The values ranged from 13.25 (X) to 18.00 (VI) for number of green leaves at 90 DAP with an general mean of 15.59. The clusters that recorded higher values than general mean (15.59) were I, IV, VI, VII and VIII.

Number of green leaves at 240 DAP exhibited an overall mean value of 9.64 with cluster means ranging from 10.75 (VI) to 8.25 (IX). The superior values above the average were recorded by the clusters II, IV, V, VI, VII and VIII.

The cluster means for number of green leaves at maturity varied from 16.25 (VI) to 11.25 (III). The clusters II, IV, V and VI recorded higher values than the general mean (12.88).

The maximum and minimum values were observed for number of internodes in cluster VI (25.84) and cluster IX (18.84) respectively. The general mean of 21.73 was exceeded by the clusters I, II, IV and VI.

The cluster means for internode length ranged between 10.94 cm (VI) and 14.48 cm (VII). Higher values than the general mean of 12.68 cm were recorded in the clusters III, VII, IX and X.

The cluster mean value for stalk length varied from 241.67 cm (VIII) to 297.50 cm (III). The clusters I, II, III, IV, VI and VII exhibited superior values than the overall mean of 268.31 cm.

The cluster mean value for stalk diameter was low in the cluster VI (2.25 cm) and was high in the cluster IV (2.69 cm). Higher values than the general mean (2.49 cm) were observed in the clusters II, IV, VIII and X.

Shoot volume recorded the cluster means ranging from 1127.75 cm^3 (VI) to 1571.96 cm^3 (IV) with an average value of 1328.80 cm^3. The II, III, IV and VII clusters recorded higher means than the general mean.

The superior clusters for number of millable canes per plot over the general mean (84.11) were I, II, VI and IX. Their values were distributed between 71.00 (V) and 98.00 (VI).

Cluster means for single cane weight ranged from 0.89 kg (IX) to 1.19 kg (IV). The clusters I, II, IV, V, VIII and X were superior with higher values than the overall mean of 1.03 kg .

The cluster means for fibre content ranged from 11.24% (IX) to 17.04% (III). The clusters I, III, VI, VII and VIII recorded more fibre content than the general mean (14.63%).

Brix per cent was highest in cluster IX (19.19%) and lowest in cluster VIII (15.19%). Higher cluster means than the average (17.42%) were recorded in the clusters I, II, III, V, VI and IX.

Sucrose per cent varied from 13.53% (VIII) to 17.48% (IX). The superior clusters for sucrose per cent over their general mean (15.89%) were I, II, III, V, VI and IX.

The values ranged from 9.71% (VIII) to 12.36% (V) for commercial cane sugar per cent with an overall mean of 11.22%. The clusters that recorded higher values than general mean (11.22%) were I, II, III, V, VI and IX.

Juice purity per cent exhibited an overall mean value of 91.05% with cluster means ranging from 88.78% (VII) to 93.46% (V). The superior values above the average were recorded by the clusters I, II, III, V, VI and IX.

The cluster means for pol per cent cane varied from 11.43% (VIII) to 15.52% (IX). The clusters I, II, III, V, VI and IX recorded higher values than the general mean (13.57%).

The minimum and maximum values for juice extraction per cent were observed in cluster VII (60.27%) and cluster IX (69.80%) respectively. The general mean of 64.02% was exceeded by the clusters VIII, IX and X.

The cluster means for total sugars per cent ranged between 17.57% (VIII) and 24.37% (I). Higher values than the general mean of 20.28% were recorded in the clusters I, II and IV.

The cluster mean value for biomass per cane varied from 1.36 kg (IX) to 1.81 kg (IV). The clusters II, III, IV and X exhibited superior mean values than the overall mean of 1.53 kg.

The cluster mean value for fibre yield was low in the cluster IX (10.98 t ha^{-1}) and was high in the cluster VI (18.63 t ha^{-1}). Higher values than the overall mean (15.52 t ha^{-1}) were observed in the clusters I, II, III, IV, VII and VIII.

CCS yield for the cluster means ranged from 9.36 t ha^{-1} (VII) to 14.60 t ha^{-1} (II) with an average value of 11.94 t ha^{-1}. The clusters I, II, IV, VI and IX recorded higher means than the general mean.

The cluster means for the theoretical yield of alcohol in grams per 100 ml of juice varied from 7.05 g/100ml (III) and 11.59 g/100ml (I). The superior clusters for theoretical yield of alcohol over the general mean (9.12 g/100ml) were I, II and VI.

Cane yield for cluster means ranged from 90.95 t ha^{-1} (III) to 131.13 t ha^{-1} (II). The clusters I, II, IV, VI and X were superior with higher values than the overall mean of 107.23 t ha^{-1}.

From the foregoing results it was evident that genetic variability existed in the sugarcane clones tested, but this variability should be further increased by divergent crosses to raise the probability of finding superior clones. Crosses between divergent genotypes increase the heterotic effect (Silva *et al.,* 2005) and avoid future problems with inbreeding depression (Ferreira *et al.,* 2005), which improves the chances to select superior clones in the segregating populations derived from these divergent crosses. The crosses between the most divergent with the highest yielding clones would improve the variability.

Pratap and Singh (2002) suggested that varieties belonging to different clusters having maximum distance should be selected for hybridization for generating the highest possible variability in yield and quality traits.

4.6 IDENTIFICATION OF CLONES FOR DIVERSIFIED USES

Generally the main objective of sugarcane breeding is to develop varieties capable of producing high sugar yields per unit land area. The recent awareness on the advantages of using green fuel for generation of power and use of gasohol to reduce automobile emission have resulted in setting up of a number of cogeneration plants and distilleries in various sugar mills. To achieve these goals of increased sugar, alcohol and cogeneration, sugar industries need special varieties to meet their specific requirement of raw materials. Furthermore a prosperous blend of all these characters would be a reward to all the sugarcane stalkeholders. Sugarcane breeders traditionally breed varieties for high sucrose and high stalk yield. As sugar production scenario is changing, varietal needs have started changing. Hence, breeding programmes must integrate new traits such as high fiber, high biomass and high total sugars in addition to yield and juice quality.

With this objective a comprehensive evaluation of seventy three genotypes for diversified uses was carried out. A total of fifty one genotypes which showed higher *per se* performance than the general mean for atleast one of the diversified use viz., cane yield, fibre yield, biomass per cane, theoretical yield of alcohol or commercial cane sugar yield were considered and scored relatively based on the *per se* performance of these genotypes for the diversified uses and the results are presented in the Table 4.29 and the genotypes identified for diversified uses are presented in the Table 4.30.

The genotypes viz., 2010T-124, 2010T-344 and 2010T-84 performed significantly superior to general mean for biomass per cane. The genotypes viz., 2010T-146, 2010T-285 and 2010T-115 showed superior performance over general mean for fibre yield. The genotypes viz., 2010T-4, 2010T-53 and 2010T-146 recorded significantly superior performance over general mean for CCS yield. The genotypes viz., 2010T-72, 2010T-16 and 2010T-88 showed significantly higher performance than general mean for theoretical yield of alcohol. For cane yield, the genotypes viz., 2010T-146, 2010T-115 and 2010T-84 showed higher performance (Table 4.12).

The genotypes 2010T-152 and 2010T-53 showed higher *per se* performance for all the five diversified uses viz., cane yield, fibre yield, biomass per cane, theoretical yield of alcohol or commercial cane sugar yield.

The two genotypes 2010T-146 and 2010T-84 showed higher *per se* performance for the four characters viz., biomass per cane, fibre yield, commercial cane sugar yield and cane yield. Further, the genotype 2010T-146 showed highest performance for cane yield and fibre yield among all the genotypes evaluated.

The genotypes 2010T-4, 2010T-103, 2010T-72, 2010T-229 and 2010T-58 were identified as the best for four uses viz., fibre yield, commercial cane sugar yield, theoretical yield of alcohol and cane yield.

The genotype 2010T-109 showed higher *per se* performance for biomass per cane, commercial cane sugar yield, theoretical yield of alcohol and cane yield.

The genotypes 2010T-115, 2010T-387, 2010T-285 and 2010T-347 recorded higher *per se* performance for fibre yield, commercial cane sugar yield and cane yield.

The genotype 2010T-344 showed higher *per se* performance with respect to biomass per cane, commercial cane sugar yield and cane yield, while the genotype 2010T-184 recorded higher mean values for commercial cane sugar yield and cane yield. The genotype 2010T-258 was good for fibre yield and cane yield.

The genotypes 2010T-16, 2010T-88 and 2010T-18 were found to be best for ethanol but the cane yield was low, while 2010T-124 recorded the highest biomass per cane but it showed poor performance for other characters. These genotypes may be used in the crossing programmes to produce genotypes with high cane yield and other desirable characters as well.

Based on the mean performance of the genotypes for five diversified uses, the genotypes viz., 2010T-152 and 2010T-53 showing high performance for biomass, fibre yield, CCS yield, theoretical yield of alcohol and cane yield; the genotypes viz., 2010T-146 and 2010T-84 showing higher performance for biomass, fibre yield, CCS yield and cane yield; the genotypes viz., 2010T-4, 2010T-103, 2010T-72 showing higher performance for fibre yield, CCS yield, theoretical yield of alcohol and cane yield; the genotypes viz., 2010T-115, 2010T-387 and 2010T-285 showing higher performance for fibre yield, CCS yield and cane yield could be suggested for promotion as varieties for different diversified uses.

On the basis of genetic divergence studies and mean performance of genotypes, the most promising cross combinations suggested for the development of varieties for diversified uses are

1. 2010T-124 x 2010T-4

The genotype 2010T-124 (cluster IV) showing high mean performance for biomass and having higher ratoonability for cane yield can be crossed with 2010T-4 (cluster I) which showed high mean performance for fibre yield, CCS yield, theoretical yield of alcohol and cane yield.

2. 2010T-16 x 2010T-146

3. 2010T-18 x 2010T-146

4. 2010T-88 x 2010T-146.

The genotype 2010T-146 (cluster IV) which showed high mean performance for biomass, fibre yield, CCS yield and cane yield except for theoretical yield of alcohol can be crossed with 2010T-16 , 2010T-18 (cluster I) and 2010T-88 (cluster II) which showed high mean performance for theoretical yield of alcohol.

These crosses involving the genotypes from divergent clusters may throw useful segregants for diversified uses in sugarcane.

Using the best index, the top 10 per cent of the clones for five diversified uses viz., biomass, fibre yield, CCS yield, theoretical yield of alcohol and cane yield were selected (Table 4.31). Comparison of the means of selected population with that of the original population revealed that there was sizable improvement in the target characters. In addition to the genotypes viz., 2010T-4, 2010T-53, 2010T-72, 2020T-84, 2010T-115, 2010T-146, 2010T-152 and 2010T-285 suggested for promotion as varieties for diversified uses, the genotypes 2010T-16, 2010T-18, 2010T-82, 2010T-88, 2010T-103, 2010T-124, 2010T-153, 2010T-229, 2010T-239, 2010T-344, 2010T-347 and 2010T-416 selected by the index method could serve as potential genetic stocks in sugarcane breeding for diversified uses.

Chapter V

Summary and Conclusions

Chapter V

SUMMARY AND CONCLUSIONS

Diversification is on one way of sustenance in any crop. Apart from sugar production, the sugarcane plant is now viewed as a high value low cost feed stock for renewable energy and an ideal crop for ethanol production. To achieve these goals of increased sugar, alcohol and cogeneration, sugar industries need special varieties to meet their specific requirement of raw materials. With this in view, the present study was taken up to investigate the possibilities of developing multipurpose sugarcane cultivars.

The present study on "Biometrical investigations on diversified uses in sugarcane (*Saccharum* spp.)" was carried out at Agricultural Research Station, Perumallapalle, situated in the Southern Agro-climatic Zone of Andhra Pradesh, India from 2010 to 2012. Four hundred and twenty nine genotypes selected from seedling nursery based on phenotypic evaluation were planted along with four checks viz., Co 6907, Co 7219, 2003 V46 and Co 86032 in augmented block design in July, 2010. Seventy three genotypes were selected in first clonal stage based on mean performance of the genotypes over the best respective check for most of the characters with due importance to cane yield, HR brix yield, single cane weight, biomass per cane and number of millable canes at harvest and desired morphological characters. The seventy three genotypes along with four checks were planted in a randomized block design with two replications during April, 2011. The first plant crop of 2010-11 was allowed for ratooning to study the ratoonability of selected genotypes.

Analysis of variance revealed significant mean sum of squares due to blocks and entries for all the eighteen characters viz., tillers at 120 DAP, shoot population at 180, 240 DAP, NMC at harvest, number of green leaves at 90, 120, 240 DAP and at maturity, biomass per cane, number of internodes per cane, internode length, stalk length, stalk diameter, stalk volume, single cane weight, HR brix, HR brix yield and cane yield in the first clonal stage. Since the variance due to block effects was also significant for all the characters critical difference was calculated to draw conclusions.

The correlation studies in first clonal stage revealed that NMC at harvest, number of green leaves at 90, 120, 240 DAP and at maturity, biomass per cane, internode number, internode length, stalk length, stalk diameter, stalk volume, single cane weight, HR brix and HR brix yield showed positive and significant association with cane yield and also among themselves indicating that simultaneous selection for these characters would result in the improvement of cane yield in sugarcane.

Path analysis revealed that the characters viz., HR brix yield, single cane weight and number of millable canes exhibited high positive direct effects on cane yield and the other characters also exhibited their indirect positive effects on cane yield via, these characters indicating that these were the major contributing characters to cane yield in sugarcane. Hence, direct selection for HR brix yield, single cane weight and number of millable canes would be helpful for the improvement of cane yield in first clonal stage. These three characters also showed significant positive correlation among themselves and with number of green leaves at 90, 120 DAP and at maturity, biomass per cane, internode number, internode length, stalk length, stalk volume and HR brix indicating that indirect selection based on these characters may be given importance in first clonal stage.

In plant crop the number of tillers at 120 DAP, shoot population at 180 DAP and 240 DAP showed non significant negative association with cane yield, whereas significant positive association of these traits with cane yield was observed in ratoon crop. However, the traits viz., number of green leaves at 90 DAP, 120 DAP and 240 DAP and stalk diameter which registered significant positive correlation with cane yield in plant crop exhibited positive but non significant association in ratoon crop. HR brix which showed significant positive association with cane yield in plant crop exhibited significant negative correlation with cane yield in ratoon crop.

In both plant and ratoon crops the HR brix yield showed high positive direct effect on cane yield and all the other characters exhibited significant positive correlation with cane yield due to their high positive indirect effects through HR brix yield. Hence, in both plant and ratoon crops HR brix yield has to be given due importance when selecting for cane yield.

The data recorded in second clonal stage on twenty seven characters viz., tiller number at 120 DAP, shoot population at 180 and 240 DAP, number of green leaves at 90, 120, 240 DAP and at maturity, number of internodes, internode length, stalk length, stalk diameter, stalk volume, NMC per plot at harvest, single cane weight, fibre content, brix per cent, sucrose per cent, CCS per cent, juice purity, pol per cent cane, juice extraction, total sugars, biomass per cane, fibre yield, CCS yield, theoretical yield of alcohol and cane yield in second clonal stage.

Analysis of variance indicated that the treatment differences among the seventy seven genotypes were significant for twenty six characters except for number of green leaves at 120 DAP.

Critical analysis of the results pertaining to genetic parameters in second clonal stage indicated that the characters viz., shoot population at 240 DAP, stalk length, number of millable canes, fibre content, brix, sucrose, CCS per cent, pol per cent cane, total sugars, biomass per cane, fibre yield, CCS yield, theoretical yield of alcohol and cane yield showed high heritability coupled with high genetic advance as per cent of mean indicating that these characters are under the influence of additive gene effects and the simple selection would be effective for the improvement of these characters. The existence of sufficiently large genetic variability and less influence of environment on these traits facilitates effective phenotypic selection.

Number of green leaves at 90 DAP and at maturity, stalk volume and cane weight showed low or moderate heritability coupled with high genetic advance as per cent of mean indicating that these traits are also governed by additive gene effects but low or moderate heritability might be due to high environmental effects, hence selection may be effective for these characters.

Juice purity and juice extraction per cent showed low genetic advance as per cent of mean which indicated that these traits were governed by non additive gene action and hence selection for these characters may not be rewarding. Shoot population at 180, number of green leaves at 120, 240 DAP, tiller number at 120 DAP, internode number, internode length and stalk diameter registered low to moderate heritability coupled with low genetic advance as per cent of mean indicating that these traits are highly influenced by environmental effects and selection for these characters would be ineffective.

In all the three generations viz., first clonal stage, ratoon and second clonal stage number of millable canes, single cane and stalk volume exhibited positive and significant association with cane yield. Whereas positive and significant association of number of leaves at maturity, number of internodes, stalk length, stalk diameter, stalk volume, and single cane weight was observed with biomass per cane in three generations. Shoot population at 240 DAP exhibited non significant negative association with cane yield in first clonal stage but it showed significant positive association with cane yield in ratoon crop and second clonal stage. Whereas brix per cent registered significant association with cane yield in first clonal stage but negative and significant association of this trait was observed in ratoon crop and in second clonal stage its association with cane yield was non significant and negative.

Character associations and path analysis studies in second clonal stage revealed that single cane weight, fibre yield and number of millable canes at harvest exhibited positive direct effects on cane yield and the other characters viz., shoot population at 240 DAP, stalk volume and CCS yield also exhibited their indirect positive effects on cane yield via these characters indicating that these were the major contributing characters to cane yield in sugarcane. Hence, direct selection for single cane weight, fibre yield and number of millable canes would be helpful for the improvement of cane yield. Fibre yield showed significant positive correlation with number of millable canes at harvest, single cane weight and shoot population at 240 DAP indicating that indirect selection for cane yield based on these characters may be given importance in later generations.

Number of millable canes and stalk volume exhibited positive direct effect on cane yield in all the three generations viz., first clonal stage, ratoon and second clonal stage. While single cane weight registered positive direct effect on cane yield in first and second clonal stages but in ratoon crop the direct effect of single cane weight on cane yield was negative and the significant positive correlation of this trait with cane yield resulted due to its high positive indirect effects via HR brix yield.

Among all the component traits, cane yield and fibre content exhibited highest positive direct effect on fibre yield and other traits viz., shoot population at 240 DAP, number of millable canes, single cane weight and CCS yield exerted their positive indirect effects via cane yield. Hence, cane yield and fibre content are the major contributing characters to fibre yield. A genotype selected for fibre yield should have high fibre content coupled with high cane yield.

With reference to biomass improvement in sugarcane direct selection based on stalk volume and single cane weight would be helpful, as these two characters showed high positive direct effects on biomass per cane as well as all other characters viz., number of green leaves at maturity, number of internodes, stalk length and stalk diameter exhibited their high indirect effects via stalk volume. Further stalk volume showed significant positive correlation with stalk length, stalk diameter and cane yield. Hence, indirect selection for stalk length and stalk diameter would improve the biomass content in sugarcane.

Critical analysis of the results by path analysis revealed that the characters total sugars per cent, pol per cent cane and CCS per cent exhibited positive direct effects on theoretical yield of alcohol and other characters viz., stalk volume, brix per cent, sucrose per cent, juice purity per cent, juice extraction per cent and CCS yield also exhibited their indirect positive effects on theoretical yield of alcohol via these characters, indicating that total sugars per cent, pol per cent cane and CCS per cent were the major contributing characters to theoretical yield of alcohol in sugarcane. These three characters also showed significant positive correlation among themselves. Selection for any one of these traits would improve the other two traits correspondingly. Moreover, there was no significant positive or negative correlation between total sugars per cent or pol per cent cane or CCS per cent and cane yield. When selecting a variety for ethanol production, selection could be based on total sugars or pol per cent cane or CCS per cent and cane yield.

The results revealed that the characters pol per cent cane, CCS per cent, cane yield, fibre yield, single cane weight and number of millable canes exhibited positive direct effects on CCS yield and the other characters viz., brix per cent, sucrose per cent and total sugars per cent also exhibited indirect positive effects via CCS per cent and pol per cent cane on CCS yield indicating that CCS per cent and pol per cent cane are the major contributing characters to CCS yield in sugarcane. CCS per cent and pol per cent cane also exhibited significant correlation with brix, sucrose per cent, juice purity per cent and total sugars per cent indicating that indirect selection based on these characters may be given importance. Hence, a variety meant for high commercial cane sugar yield should have high brix, high sucrose, high juice purity per cent, high total sugars in juice coupled with high cane yield.

Selection indices were formulated considering cane yield and six of its component characters which showed high correlation with cane yield in second clonal generation. Higher relative efficiency of 1092.49 coupled with high genetic advance (303.78) was exhibited by the combination involving all the seven traits viz., cane yield (X_1), shoot population at 240 DAP (X_2), stalk volume (X_3), number of millable canes (X_4), single cane weight (X_5), fibre yield (X_6) and commercial cane sugar yield (X_7).

Since fibre yield and commercial cane sugar yield are derived characters, more emphasis during selection could be given on the directly measurable characters to get the accurate results. Hence, the combinations without fibre yield and commercial cane sugar yield could be considered for selection for cane yield. Among them the combination involving the traits cane yield (X_1), shoot population at 240 DAP (X_2), stalk volume (X_3), number of millable canes (X_4) and single cane weight (X_5) recorded maximum relative efficiency of 1074.14 with genetic advance of 298.68. When indirect selection scheme excluding cane yield in formulating index is to be followed, the index involving the combination of three characters viz., stalk volume (X_3), number of millable canes (X_4) and single cane weight (X_5) which exhibited maximum relative efficiency of 1010.31 with genetic advance of 280.93 could be considered for selection schemes to improve cane yield.

Among one hundred and twenty seven different selection indices formulated for fibre yield, higher relative efficiency of 1328.62 coupled with high genetic advance (57.13) was exhibited by the combination involving six traits viz., fibre yield (X_1), shoot population at 240 DAP (X_2), number of millable canes (X_3), single cane weight (X_4), CCS yield (X_6) and cane yield (X_7). When indirect selection scheme excluding fibre yield is to be followed, the index involving the combination of six characters viz., shoot population at 240 DAP (X_2), number of millable canes (X_3), single cane weight (X_4), fibre content (X_5), CCS yield (X_6) and cane yield (X_7) which exhibited maximum relative efficiency of 1241.00 with genetic advance of 53.36 could be considered for selection schemes to improve fibre yield.

Selection indices formulated for biomass per cane, higher relative efficiency of 103115.07 coupled with high genetic advance (319.96) was exhibited by the combination involving all the seven traits viz., biomass per cane (X_1), number of leaves at maturity (X_2), number of internodes per cane (X_3), stalk length (X_4), stalk diameter (X_5), stalk volume (X_6) and single cane weight (X_7)

The indirect selection for biomass per cane could be based on the index involving six characters viz., number of leaves at maturity (X_2), number of internodes per cane (X_3), stalk length (X_4), stalk diameter (X_5), stalk volume (X_6) and single cane weight (X_7) which recorded higher relative efficiency of 101704.03 and genetic advance of 315.58.

Among the selection indices formulated for commercial cane sugar yield in second clonal generation, higher relative efficiency of 1828.82

coupled with high genetic advance (59.00) was exhibited by the combination involving the twelve traits viz., commercial cane sugar yield (X_1), shoot population at 240 DAP (X_2), number of millable canes (X_3), single cane weight (X_4), brix per cent (X_5), sucrose per cent (X_6), commercial cane sugar per cent (X_7), pol per cent cane (X_8), total sugars per cent (X_9), fibre yield (X_{10}), theoretical yield of alcohol (X_{11}) and cane yield (X_{12}). Whereas, selection index based on shoot population at 240 DAP (X_2), number of millable canes (X_3), fibre yield (X_{10}) and cane yield (X_{12}) which exhibited high relative efficiency of 1686.17 coupled with high genetic advance of 54.39 could be used for indirect selection of commercial cane sugar yield.

Among eight characters that were used to formulate selection indices, theoretical yield of alcohol (X_1) was considered as dependent character while seven characters *viz.*, brix per cent (X_2), sucrose per cent (X_3), commercial cane sugar per cent (X_4), juice purity per cent (X_5), pol per cent cane (X_6), total sugars per cent (X_7) and commercial cane sugar yield (X_8) were considered as independent variables. Higher relative efficiency of 744.59 coupled with high genetic advance (17.25) was exhibited by the combination involving all the eight traits. When indirect selection scheme excluding theoretical yield of alcohol is to be followed, the index involving the combination of five characters viz., brix per cent (X_2), sucrose per cent (X_3), juice purity per cent (X_5), pol per cent cane (X_6) and total sugars per cent (X_7) which exhibited maximum relative efficiency of 523.98 with genetic advance of 12.14 could be considered for selection schemes to improve theoretical yield of alcohol. From the results it is evident that to increase the alcohol yield selection should be mainly based on total sugars per cent as all the selection indices involving this trait showed higher relative efficiency and genetic advance.

The magnitude of D^2 values suggested that there was considerable diversity in the material studied. This variation allowed for grouping of 77 genotypes into ten clusters. Cluster I was the largest with fifteen genotypes followed by cluster X with fourteen, cluster IV with twelve, cluster VII with nine, cluster VIII with eight, cluster II with seven and cluster V with six genotypes. The clusters III, VI and IX had two genotypes each. The results revealed that the distribution of genotypes into different clusters was at random and independent of each other. The genotypes selected from same parentage had fallen in different clusters and the genotypes with different parentage had fallen in the same cluster.

The maximum inter cluster distance was observed between cluster IV and IX (100.33), while the minimum inter cluster distance was observed between cluster III and VI (20.68). The intra cluster distance ranged from 14.43 (cluster III) to 90.30 (cluster X).

Maximum cluster means for tillers at 120 DAP, shoot population at 180, 240 DAP, number of leaves at 90, 240 DAP and at maturity, number of internodes, number of millable canes per plot and fibre yield were observed for cluster VI. Cluster IV recorded maximum mean values for stalk diameter, stalk volume, cane weight and biomass per cane. Higher mean values were exhibited by Cluster III for stalk length and fibre content; by cluster for pol per cent cane and juice extraction per cent; by cluster II for CCS yield and cane yield; by cluster I for total sugars per cent and theoretical yield of alcohol; by cluster IX for brix per cent and sucrose per cent and cluster V for CCS per cent and juice purity.

From the foregoing results it was evident that genetic variability existed in the sugarcane clones tested, but this variability should be further increased by divergent crosses to raise the probability of finding superior clones.

As sugar production scenario is changing, varietal needs have started changing. Hence, breeding programmes must integrate new traits such as high fiber, high biomass and high ethanol yield in addition to cane yield and CCS yield. With this objective a comprehensive evaluation of seventy three genotypes for diversified uses was carried out. Based on the mean performance of the genotypes for five diversified uses, the genotypes viz., 2010T-152 and 2010T-53 showing high performance for biomass, fibre yield, CCS yield, theoretical yield of alcohol and cane yield; the genotypes viz., 2010T-146 and 2010T-84 showing higher performance for biomass, fibre yield, CCS yield and cane yield; the genotypes viz., 2010T-4, 2010T-103, 2010T-72 showing higher performance for fibre yield, CCS yield, theoretical yield of alcohol and cane yield; the genotypes viz., 2010T-115, 2010T-387 and 2010T-285 showing higher performance for fibre yield, CCS yield and cane yield could be suggested for promotion as varieties for different diversified uses.

The genotypes 2010T-16, 2010T-18, 2010T-82, 2010T-88, 2010T-103, 2010T-124, 2010T-153, 2010T-229, 2010T-239, 2010T-344, 2010T-347 and 2010T-416 selected by the index method could serve as potential genetic stocks in sugarcane breeding for diversified uses.

The information generated by D^2 analysis along with mean values for the diversified uses could be utilized for selection of parents for hybridization. On the basis of genetic divergence studies and mean performance of genotypes, the most promising cross combinations suggested for the development of varieties for diversified uses are 2010T-124 x 2010T-4, 2010T-16 x 2010T-146, 2010T-88 x 2010T-146 and 2010T-18 x 2010T-146. The genotype 2010T-124 (cluster IV) showing high mean performance for biomass and having higher ratoonability for cane yield can be crossed with 2010T-4 (cluster I) which showed high mean performance for fibre yield, CCS yield, theoretical yield of alcohol and cane yield. The genotype 2010T-146 (cluster IV) which showed high mean performance for biomass, fibre yield, CCS yield and cane yield can be crossed with 2010T-16 , 2010T-18 (cluster I) and 2010T-88 (cluster II) which showed high mean performance for theoretical yield of alcohol. These crosses involving the parents from divergent clusters may throw useful segregants for diversified uses in sugarcane.

Highlights

- A comprehensive evaluation of the seventy three genotypes for diversified uses revealed that the genotypes viz., 2010T-146, 2010T-4, 2010T-84, 2010T-115, 2010T-152 could be promoted as varieties to meet the changing demands of sugar industry.

- Based on *per se* performance and genetic divergence studies the crosses viz., 2010T-124 x 2010T-4, 2010T-16 x 2010T-146, 2010T-88 x 2010T-146 and 2010T-18 x 2010T-146 identified may be persuaded to develop varieties to solve the problem envisaged in the present investigation which may in turn sustain the sugar industry.

- Inclusion of the genotypes 2010T-16, 2010T-18, 2010T-82, 2010T-88, 2010T-103, 2010T-124, 2010T-153, 2010T-229, 2010T-239, 2010T-344, 2010T-347 and 2010T-416 in the crossing programmes may throw some useful segregants for diversified uses.

- The study indicated the possibility of combining high fibre content and high sugar content in the same genotype as there was no significant positive or negative correlation between brix or pol and fibre content.

- Selection indices were formulated for the diversified uses viz., biomass, fibre yield, cane yield, theoretical yield of alcohol and CCS yield.

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Appendices

Appendix .A. Mean data on different characters for four hundred and twenty nine selected genotypes in first clonal stage in sugarcane

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-5	1	162.00 *	72.00 *	78.00 *	30.00	5.67	8.50 *	9.62	14.00	0.47	17.00	7.35	125.00	1.80	318.21	0.30	17.10	3.85	22.50
2010T-6	1	84.00 *	81.00 *	69.00 *	22.00	6.36	6.89	9.13	10.00	0.99	13.00	10.00 *	130.00	2.20	494.37	0.58	14.00	4.47	31.90
2010T-7	1	66.00	54.00	72.00 *	20.00	7.00 *	7.39	10.83	15.00	0.62	18.00	7.78	140.00	2.20	532.40	0.51	8.20	2.09	25.50
2010T-8	1	102.00 *	54.00	66.00	51.00 *	15.00 *	10.39 *	18.00 *	12.60	1.15 *	15.60	11.92 *	186.00 *	2.60 *	987.93 *	0.95 *	18.30	22.17 *	121.13 *
2010T-9	1	99.00 *	66.67	90.00 *	28.00	7.42 *	9.15 *	6.00	7.00	0.35	10.00	8.00	80.00	2.10	277.20	0.25	8.90	1.56	17.50
2010T-10	1	75.00	69.00 *	99.00 *	38.00	7.20 *	8.30	6.97	12.00	0.68	15.00	9.67 *	145.00	1.90	411.28	0.43	7.60	3.10	40.85
2010T-11	1	90.00 *	60.00	72.00 *	40.00 *	7.30 *	9.50 *	8.75	10.00	0.54	13.00	7.69	100.00	2.30	415.64	0.35	14.40	5.04	35.00
2010T-12	1	90.00 *	87.00 *	111.00 *	28.00	6.10	8.34	4.59	6.00	0.40	9.00	11.67 *	105.00	1.90	297.83	0.26	12.30	2.24	18.20
2010T-13	1	135.00 *	87.00 *	93.00 *	32.00	7.27 *	6.97	8.39	15.00	0.50	18.00	5.83	105.00	2.30	436.43	0.37	15.80	4.68	29.60
2010T-14	1	84.00 *	60.00	81.00 *	20.00	6.79 *	7.40	7.41	9.00	0.38	12.00	6.25	75.00	2.20	285.21	0.27	14.00	1.89	13.50
2010T-15	1	81.00	75.00 *	93.00 *	53.00 *	13.00 *	18.00 *	21.00 *	15.00	0.95	18.00	10.22 *	184.00 *	2.60 *	977.30 *	0.80	20.50 *	21.73 *	106.00 *
2010T-16	1	78.00	45.00	66.00	49.00 *	8.27 *	10.60 *	13.55	17.80 *	1.10 *	20.80 *	9.18	191.00 *	2.42	878.88 *	0.90	18.80	20.73 *	110.25 *
2010T-18	1	96.00 *	81.00 *	75.00 *	44.00 *	7.56 *	11.00 *	21.00 *	15.60	1.08 *	19.00	10.00 *	190.00 *	2.70 *	1088.29 *	0.90	19.60	19.40 *	99.00 *
2010T-19	1	114.00 *	110.00 *	102.00 *	40.00 *	7.89 *	7.79	6.76	12.00	0.59	15.00	7.00	105.00	2.40	475.20	0.41	7.10	2.91	41.00
2010T-20	1	105.00 *	63.00	105.00 *	59.00 *	16.00 *	14.00 *	18.00 *	17.40 *	1.06 *	20.40 *	8.97	183.00	2.40	828.21 *	0.79	19.00	22.14 *	116.53 *
2010T-21	1	84.00 *	54.00	63.00	36.00	7.57 *	8.33	11.90	14.00	0.60	17.00	5.59	95.00	2.10	329.18	0.36	7.90	2.56	32.40
2010T-22	1	97.50 *	112.50 *	72.00 *	20.00	8.42 *	7.20	8.75	10.00	0.69	13.00	6.92	90.00	2.50	441.96	0.43	10.80	2.32	21.50
2010T-23	1	87.00 *	60.00	66.00	28.00	7.72 *	8.45 *	10.91	13.00	0.44	16.00	5.00	80.00	1.90	226.91	0.27	18.00	3.40	18.90
2010T-24	1	126.00 *	78.00 *	90.00 *	10.00	4.24	7.46	6.33	8.00	1.08 *	11.00	9.55 *	105.00	2.70 *	601.43	0.59	7.30	1.08	14.75
2010T-25	1	72.00	57.00	54.00	36.00	7.58 *	10.32 *	13.33	13.00	0.85	16.00	9.38 *	150.00	2.50	736.61	0.66	12.50	7.43	59.40

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-26	1	111.00*	78.00*	87.00*	43.00*	8.33*	9.55*	14.38	18.20*	1.08*	21.20*	10.19*	216.00*	2.20	821.42*	0.92	16.60	16.42*	98.90*
2010T-27	1	111.00*	78.00*	87.00*	34.00	7.08*	9.19*	6.90	9.00	0.72	12.00	9.58*	115.00	2.30	477.99	0.50	11.40	4.85	42.50
2010T-28	1	75.00	60.00	60.00	24.00	7.88*	9.90*	9.00	7.00	0.48	10.00	8.00	80.00	2.60*	424.91	0.37	12.00	2.66	22.20
2010T-29	1	66.00	57.00	48.00	14.00	6.95*	9.16*	13.75	11.00	0.45	14.00	7.86	110.00	2.20	418.31	0.34	18.00	2.14	11.90
2010T-31	1	96.00*	60.00	60.00	16.00	6.06	6.75	15.00	19.00*	0.97	22.00*	6.82	150.00	2.30	623.46	0.68	9.20	2.50	27.20
2010T-32	1	37.50	37.50	57.00	16.00	8.60*	10.80*	12.11	12.00	0.70	15.00	8.67	130.00	2.30	540.34	0.51	19.10	3.90	20.40
2010T-44	1	105.00*	65.00	78.00*	38.00	7.43*	7.77	8.46	11.00	0.59	14.00	6.43	90.00	2.30	374.08	0.39	18.40	6.82	37.05
2010T-45	1	78.00	69.00*	63.00	32.00	7.62*	8.83*	9.52	9.00	0.51	12.00	8.75	105.00	2.30	436.43	0.47	8.80	3.31	37.60
2010T-48	1	93.00*	70.00*	63.00	30.00	6.19	7.38	10.95	12.00	0.36	15.00	6.00	90.00	1.80	229.11	0.22	20.00	3.30	16.50
2010T-51	1	60.00	50.00	51.00	36.00	6.85*	9.20*	12.94	11.00	0.58	14.00	8.21	115.00	2.10	398.48	0.44	9.90	3.92	39.60
2010T-54	1	102.00*	78.00*	69.00*	20.00	8.53*	9.50*	10.43	13.00	0.70	16.00	9.06	145.00	2.60*	770.16	0.60	13.00	3.90	30.00
2010T-56	1	90.00*	87.00*	60.00	16.00	6.67	5.52	11.00	11.00	0.50	14.00	6.43	90.00	2.40	407.31	0.38	11.00	1.67	15.20
2010T-57	1	75.00	69.00*	78.00*	28.00	7.64*	7.96	9.62	14.00	0.81	17.00	8.24	140.00	2.60*	743.60	0.60	14.70	6.17	42.00
2010T-61	1	99.00*	81.00*	105.00*	52.00*	7.73*	6.52	9.14	21.00*	0.77	24.00*	5.00	120.00	1.70	272.49	0.56	15.40	11.21	72.80*
2010T-62	1	78.00	48.00	63.00	14.00	6.35	7.63	11.90	14.00	0.82	17.00	6.47	110.00	2.70*	630.06	0.62	17.00	3.69	21.70
2010T-64	1	114.00*	72.00*	105.00*	20.00	6.89*	8.71*	7.71	16.00	0.81	19.00	7.89	150.00	2.10	519.75	0.53	13.20	3.50	26.50
2010T-65	1	129.00*	93.00*	93.00*	44.00*	6.84*	5.06	5.16	5.00	0.76	8.00	13.75*	110.00	1.70	249.78	0.33	13.00	4.72	36.30
2010T-67	1	113.33*	90.00*	99.00*	22.00	6.00	5.81	7.27	13.00	0.72	16.00	8.75	140.00	2.10	485.10	0.52	10.60	3.03	28.60
2010T-69	1	105.00*	57.00	72.00*	42.00*	7.77*	10.32*	10.42	14.00	0.59	17.00	11.18*	190.00*	1.80	483.69	0.45	7.40	3.50	47.25
Best check		81.32	68.61	67.59	39.00	6.75	8.36	17.00	16.09	1.05	19.57	9.37	183.02	2.60	779.09	0.94	20.31	12.28	69.94

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-1	2	54.00	39.00	36.00	18.00	6.11	8.38	20.83*	14.00*	1.00	17.00	9.41*	160.00	2.40	724.11*	0.74	14.10	4.70	33.30
2010T-2	2	84.00*	66.00	57.00	30.00	7.04	6.59	15.79*	19.00*	0.81	22.00*	7.73	170.00*	2.00	534.29	0.62	12.50	5.81	46.50
2010T-3	2	51.00	54.00	57.00	28.00	7.76	9.72*	15.79*	19.00*	2.26*	22.00*	9.77*	215.00*	3.00*	1520.36*	1.84*	12.90	16.62*	128.80*
2010T-4	2	105.00*	87.00*	75.00*	32.00	17.00*	15.00*	10.32	13.80*	1.40*	16.80	11.96*	201.00*	2.53	1010.88*	1.10*	17.80	15.66*	88.00*
2010T-17	2	81.00*	66.00	96.00*	50.00*	7.81	9.00*	9.69	20.00*	0.93	23.00*	9.13	210.00*	1.90	595.65	0.67	6.20	5.19	83.75*
2010T-30	2	69.00	39.00	54.00	28.00	7.74	8.92*	17.78*	21.00*	1.80*	24.00*	9.58*	230.00*	3.00*	1626.43*	1.50*	16.30	17.12*	105.00*
2010T-33	2	60.00	54.00	69.00*	20.00	7.65	9.17*	13.91	21.00*	1.20*	24.00*	8.33	200.00*	2.60*	1062.29*	0.97*	18.00	8.73	48.50
2010T-34	2	48.00	48.00	51.00	26.00	8.13*	7.19	18.24*	20.00*	1.50*	23.00*	9.35*	215.00*	2.80*	1324.40*	1.27*	18.00	14.86*	82.55*
2010T-35	2	60.00	63.00	57.00	13.00	7.55	8.38	14.74	17.00*	1.25*	20.00*	8.50	170.00*	2.20	646.49	0.97*	13.80	4.35	31.53
2010T-36	2	54.00	60.00	45.00	18.00	7.83	7.60	14.67	11.00	0.57	14.00	8.21	115.00	2.40	520.46	0.52	18.30	4.28	23.40
2010T-37	2	75.00	57.00	60.00	12.00	7.28	7.79	14.50	18.00*	1.04	21.00*	7.62	160.00	2.50	785.71*	0.84	16.90	4.26	25.20
2010T-38	2	69.00	72.00*	66.00	40.00	7.96	7.08	12.73	17.00*	1.10	20.00*	10.00*	200.00*	2.50	982.14*	0.90	13.40	12.06	90.00*
2010T-39	2	54.00	45.00	144.00*	6.00	5.61	6.73	5.21	14.00*	0.80	17.00	10.00*	170.00*	2.00	534.29	0.60	7.30	0.66	9.00
2010T-40	2	75.00	69.00	63.00	32.00	5.68	7.39	12.86	16.00*	1.04	19.00*	9.74*	185.00*	2.20	703.53*	0.74	14.70	8.70	59.20
2010T-41	2	93.00*	69.00	69.00*	16.00	6.23	8.26	9.13	10.00	0.46	13.00	6.15	80.00	2.70*	458.23	0.42	11.40	1.92	16.80
2010T-42	2	111.00*	75.00*	87.00*	30.00	6.76	7.96	9.66	17.00*	1.72*	20.00*	9.75*	195.00*	3.30*	1668.50*	1.54*	12.20	14.09*	115.50*
2010T-43	2	60.00	57.00	60.00	36.00	7.40	9.00*	13.00	15.00*	1.21*	18.00	10.00*	180.00*	3.10*	1359.13*	1.00*	19.10	17.19*	90.00*
2010T-46	2	105.00*	63.00	66.00	26.00	9.11*	8.00	16.36*	25.00*	0.98	28.00*	6.25	175.00*	2.10	606.38	0.80	10.80	5.62	52.00
2010T-47	2	72.00	51.00	69.00*	30.00	6.75	8.88*	10.43	13.00*	0.80	16.00	9.38*	150.00	2.40	678.86	0.59	14.20	6.28	44.25
2010T-49	2	66.00	63.00	72.00*	24.00	9.59*	7.14	11.67	17.00*	1.44*	20.00*	10.50*	210.00*	2.40	950.40*	1.15*	12.50	8.63	69.00

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-50	2	57.00	60.00	54.00	18.00	9.42*	10.65*	13.89	14.00*	0.87	17.00	7.06	120.00	2.30	498.77	0.60	16.90	4.56	27.00
2010T-52	2	72.00	63.00	69.00*	28.00	8.42*	8.00	10.87	14.00*	0.88	17.00	8.24	140.00	2.60*	743.60*	0.69	14.00	6.76	48.30
2010T-53	2	66.00	51.00	63.00	54.00*	8.09*	10.94*	13.33	16.00*	0.90	19.00*	8.84	168.00	2.05	554.73	0.68	18.70	17.17*	91.80*
2010T-55	2	66.00	57.00	84.00*	49.00*	10.82*	9.26*	10.57	17.60*	1.00	20.60*	11.50*	237.00*	2.31	993.66*	0.98*	16.90	20.29*	120.05*
2010T-58	2	93.00*	63.00	57.00	73.00*	7.77	18.00*	15.58*	14.00*	1.00	20.60*	10.78*	222.00*	2.15	806.30*	0.75	18.10	24.77*	136.88*
2010T-59	2	108.00*	60.00	78.00*	18.00	6.28	7.60	11.54	19.00*	0.99	22.00*	7.27	160.00	2.30	665.03	0.70	13.90	4.38	31.50
2010T-60	2	69.00	66.00	72.00*	20.00	7.87	6.50	13.33	21.00*	1.35*	24.00*	7.08	170.00*	2.50	834.82*	0.93*	4.60	2.14	46.50
2010T-63	2	132.00*	99.00*	63.00	4.00	6.93	4.76	12.38	15.00*	0.72	18.00	7.78	140.00	2.70*	801.90*	0.61	19.10	1.17	6.10
2010T-66	2	87.00*	63.00	66.00	38.00	6.66	6.43	10.45	12.00	0.98	15.00	12.00*	180.00*	2.60*	956.06*	0.77	5.40	3.95	73.15
2010T-68	2	45.00	36.00	48.00	20.00	8.20*	11.17*	13.75	11.00	0.97	14.00	11.43*	160.00	2.40	724.11*	0.59	7.90	2.33	29.50
2010T-70	2	129.00*	75.00*	78.00*	19.00	5.86	8.72*	10.38	16.00*	1.45*	19.00*	11.05*	210.00*	2.50	1031.25*	1.10*	8.50	4.44	52.25
2010T-74	2	72.00	69.00	54.00	24.00	7.21	7.65	11.67	10.00	0.58	13.00	9.23*	120.00	1.90	340.37	0.43	16.90	4.36	25.80
2010T-75	2	90.00*	69.00	72.00*	34.00	7.30	8.39	10.83	15.00*	0.80	18.00	7.78	140.00	2.50	687.50	0.60	9.60	4.90	51.00
2010T-76	2	108.00*	84.00*	78.00*	40.00	6.72	5.00	9.62	14.00*	0.71	17.00	9.12	155.00	2.00	487.14	0.54	7.90	4.27	54.00
2010T-78	2	78.00*	72.00*	96.00*	38.00	7.08	8.63*	8.13	15.00*	0.70	18.00	7.78	140.00	2.20	532.40	0.58	15.50	8.54	55.10
2010T-83	2	87.00*	54.00	36.00	26.00	18.00*	13.00*	25.17*	18.20*	1.37*	24.20*	8.22	199.00*	2.64*	1089.75*	1.11*	18.60	13.42*	72.15
2010T-96	2	99.00*	69.00	90.00*	40.00	8.00	7.87	8.00	13.00*	0.65	16.00	7.50	120.00	2.20	456.34	0.44	12.50	5.50	44.00
2010T-172	2	51.00	48.00	66.00	39.00	7.65	13.00*	14.82*	20.60*	1.33*	23.60*	10.13*	239.00*	2.64*	1308.79*	1.16*	16.00	18.10*	113.10*
2010T-173	2	105.00*	81.00*	75.00*	47.00*	17.00*	12.00*	11.20	16.00*	1.40*	19.00*	10.53*	200.00*	2.59*	1054.13*	1.05*	16.10	19.86*	123.38*
Best check		76.07	71.36	67.34	42.75	8.00	8.61	14.75	12.84	1.10	18.57	9.14	168.27	2.57	698.90	0.92	19.41	13.36	77.90

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-71	3	126.00 *	69.00	72.00 *	42.00 *	5.98	7.57	10.42	14.00	0.68	17.00 *	9.12 *	155.00 *	2.60	823.27 *	0.52	9.80	5.35	54.60
2010T-72	3	75.00	57.00	51.00	70.00 *	7.64	13.00 *	15.88 *	15.00	1.30 *	18.00 *	14.00 *	252.00 *	2.15	915.26 *	0.95 *	16.10	26.77 *	166.25 *
2010T-73	3	93.00 *	69.00	66.00 *	42.00 *	7.06	7.87	14.55 *	21.00 *	1.48 *	24.00 *	10.42 *	250.00 *	2.60	1327.86 *	1.35 *	9.60	13.61 *	141.75 *
2010T-77	3	90.00 *	75.00	54.00	10.00	5.63	6.24	12.78	12.00	0.94	15.00	13.00 *	195.00 *	2.20	741.56 *	0.71	15.60	2.77	17.75
2010T-79	3	105.00 *	93.00 *	81.00 *	24.00	5.94	4.68	6.67	7.00	0.60	10.00	12.00 *	120.00	2.20	456.34	0.46	13.30	3.67	27.60
2010T-80	3	66.00	57.00	69.00 *	32.00	9.27 *	10.16 *	13.48 *	20.00 *	1.40 *	23.00 *	10.43 *	240.00 *	2.60	1274.74 *	1.22 *	13.70	13.37 *	97.60 *
2010T-81	3	45.00	39.00	48.00	26.00	7.60	9.69	14.38 *	12.00	0.70	15.00	5.33	80.00	1.70	181.66	0.42	16.00	4.37	27.30
2010T-82	3	123.00 *	96.00 *	81.00 *	49.00 *	17.00 *	15.00 *	11.11	13.00	0.80	21.00 *	7.52	158.00 *	2.51	782.11 *	0.55	18.90	12.73 *	67.38 *
2010T-87	3	63.00	42.00	57.00 *	24.00	7.24	11.43 *	12.11	12.00	0.99	15.00	9.67 *	145.00	1.90	411.28	0.75	14.40	6.48	45.00
2010T-88	3	84.00 *	120.00 *	81.00 *	24.00	7.21	12.00 *	9.26	14.00	1.77 *	17.00 *	9.71 *	165.00 *	2.90 *	1090.30 *	1.16 *	18.00	12.53 *	69.60 *
2010T-89	3	51.00	45.00	72.00 *	46.00 *	7.41	9.73	7.50	7.00	0.74	10.00	10.00 *	100.00	2.20	380.29	0.39	12.20	5.47	44.85
2010T-90	3	99.00 *	129.00 *	66.00 *	28.00	7.00	5.35	11.82	15.00	0.66	18.00 *	7.50	135.00	2.00	424.29	0.43	15.00	4.52	30.10
2010T-91	3	72.00	60.00	66.00 *	20.00	7.25	8.45	11.82	15.00	0.96	18.00 *	8.06	145.00	2.60	770.16 *	0.70	13.40	4.69	35.00
2010T-92	3	105.00 *	87.00 *	69.00 *	18.00	7.49	8.59	11.30	15.00	1.09 *	18.00 *	10.56 *	190.00 *	2.20	722.54 *	0.74	14.60	4.86	33.30
2010T-93	3	105.00 *	72.00	75.00 *	36.00	6.54	6.92	10.00	14.00	0.70	17.00 *	10.88 *	185.00 *	1.70	420.08	0.52	11.00	5.15	46.80
2010T-94	3	57.00	57.00	78.00 *	46.00 *	8.63 *	9.11	11.15	18.00 *	0.91	21.00 *	9.05 *	190.00 *	2.40	859.89 *	0.75	10.50	9.06	86.25 *
2010T-95	3	96.00 *	87.00 *	78.00 *	30.00	6.69	7.10	9.62	14.00	0.32	17.00 *	6.47	110.00	1.60	221.26	0.22	15.00	2.48	16.50
2010T-97	3	81.00 *	81.00 *	78.00 *	40.00	6.96	5.96	9.62	14.00	0.81	17.00 *	8.53	145.00	2.10	502.43	0.48	13.00	6.24	48.00
2010T-98	3	84.00 *	120.00 *	81.00 *	24.00	7.21	6.08	9.26	14.00	1.77 *	17.00 *	9.71 *	165.00 *	2.90 *	1090.30 *	1.16 *	13.00	9.05	69.60 *
2010T-99	3	93.00 *	69.00	63.00 *	20.00	7.19	7.65	12.86	16.00	0.64	19.00 *	8.16	155.00 *	2.10	537.08	0.52	16.20	4.21	26.00

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-100	3	63.00	57.00	48.00	30.00	7.19	7.89	16.25 *	15.00	0.72	18.00 *	10.56 *	190.00 *	2.00	597.14	0.53	14.00	5.57	39.75
2010T-101	3	84.00 *	60.00	48.00	50.00 *	7.54	8.40	18.75 *	19.00 *	1.36 *	22.00 *	5.91	130.00	2.30	540.34	1.00 *	16.20	20.25 *	125.00 *
2010T-102	3	87.00 *	66.00	48.00	50.00 *	7.66	7.41	21.88 *	24.00 *	1.51 *	27.00 *	8.15	220.00 *	2.20	836.63 *	1.19 *	12.10	18.00 *	148.75 *
2010T-103	3	63.00	69.00	57.00 *	49.00 *	7.43	8.09	14.95 *	16.40 *	1.10 *	19.40 *	12.22 *	237.00 *	2.04	774.95 *	0.85 *	17.80	18.53 *	104.13 *
2010T-104	3	111.00 *	84.00 *	84.00 *	40.00	7.11	8.11	8.57	13.00	1.12 *	16.00	10.63 *	170.00 *	1.80	432.77	0.46	16.80	7.73	46.00
2010T-105	3	72.00	63.00	69.00 *	22.00	7.50	8.48	12.61	18.00 *	1.00 *	21.00 *	8.57	180.00 *	2.30	748.16 *	0.73	12.00	4.82	40.15
2010T-106	3	87.00 *	54.00	63.00 *	44.00 *	7.48	7.44	12.86	16.00	1.00 *	19.00 *	10.26 *	195.00 *	2.30	810.50 *	0.85 *	15.70	14.68 *	93.50 *
2010T-107	3	102.00 *	60.00	45.00	36.00	6.79	6.15	16.67 *	14.00	1.14 *	17.00 *	8.24	140.00	2.70	801.90 *	0.87 *	13.20	10.34	78.30 *
2010T-108	3	123.00 *	54.00	63.00 *	32.00	6.63	9.00	12.38	15.00	0.61	18.00 *	10.83 *	195.00 *	2.30	810.50 *	0.92 *	8.70	6.40	73.60 *
2010T-109	3	105.00 *	66.00	72.00 *	45.00 *	16.00 *	19.00 *	15.58 *	25.40 *	1.55 *	28.40 *	7.89	224.00 *	2.67	1254.69 *	1.36 *	17.10	26.16 *	153.00 *
2010T-110	3	84.00 *	63.00	60.00 *	30.00	8.25 *	7.86	16.00 *	21.00 *	2.09 *	24.00 *	10.42 *	250.00 *	2.60	1327.86 *	1.70 *	14.40	18.36 *	127.50 *
2010T-111	3	63.00	66.00	57.00 *	22.00	7.48	8.91	12.63	13.00	0.54	16.00	7.50	120.00	2.10	415.80	0.42	15.30	3.53	23.10
2010T-112	3	87.00 *	75.00	75.00 *	30.00	6.55	5.80	9.20	12.00	0.47	15.00	4.67	70.00	1.70	158.95	0.36	18.30	4.94	27.00
2010T-113	3	90.00 *	63.00	57.00 *	36.00	7.20	8.24	15.79 *	19.00 *	1.45 *	22.00 *	12.73 *	280.00 *	2.60	1487.20 *	1.23 *	14.60	16.16 *	110.70 *
2010T-114	3	90.00 *	51.00	66.00 *	56.00 *	7.57	9.12	14.09 *	20.00 *	1.53 *	23.00 *	10.22 *	235.00 *	2.80 *	1447.60 *	1.11 *	7.40	11.50 *	155.40 *
2010T-115	3	75.00	69.00	54.00	62.00 *	7.80	7.09	17.56 *	19.60 *	1.25 *	22.60 *	9.69 *	219.00 *	2.30	910.26 *	0.91 *	15.60	22.00 *	141.05 *
2010T-116	3	123.00 *	63.00	72.00 *	28.00	6.78	9.86	14.17 *	23.00 *	1.07 *	26.00 *	9.04 *	235.00 *	2.60	1248.19 *	0.74	12.20	6.32	51.80
2010T-131	3	90.00 *	66.00	84.00 *	38.00	5.83	6.05	10.00	17.00 *	1.48 *	20.00 *	9.00	180.00 *	2.50	883.93 *	1.05 *	11.50	11.47	99.75 *
2010T-133	3	108.00 *	72.00	90.00 *	36.00	6.92	7.88	7.33	11.00	0.51	14.00	7.86	110.00	2.30	457.21	0.41	14.00	5.17	36.90
Best check		79.82	75.11	54.84	41.25	8.00	10.11	13.00	16.09	0.99	16.32	9.41	152.02	2.72	720.63	0.79	20.73	11.49	62.65

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-84	4	81.00*	69.00	51.00*	38.00	13.00*	15.00*	18.94*	20.20*	1.50*	23.20*	8.45	196.00*	2.97*	1358.42*	1.20*	14.40	16.42*	114.00*
2010T-117	4	63.00	57.00	45.00	31.00	8.33*	9.68*	20.67*	20.00*	1.12*	23.00*	10.87*	250.00*	2.00	785.71*	0.87	13.80	9.30	67.43
2010T-130	4	69.00	72.00	57.00*	66.00*	8.57*	7.38	15.79*	19.00*	1.03	22.00*	8.18	180.00*	2.50	883.93*	0.80	10.50	13.86*	132.00*
2010T-132	4	99.00*	66.00	51.00*	30.00	5.94	8.73*	18.82*	21.00*	1.65*	24.00*	8.75	210.00*	2.50	1031.25*	1.17*	13.20	11.58	87.75*
2010T-134	4	75.00*	60.00	69.00*	50.00*	7.80*	9.35*	13.48	20.00*	1.70*	23.00*	10.00*	230.00*	2.60*	1221.63*	1.20*	9.80	14.70*	150.00*
2010T-135	4	84.00*	60.00	60.00*	30.00	6.00	9.00*	14.50*	18.00*	1.22*	21.00*	9.76*	205.00*	2.20	779.59*	0.86	12.10	7.80	64.50
2010T-136	4	108.00*	75.00	54.00*	36.00	5.78	8.16	14.44*	15.00	0.90	18.00	8.61	155.00	2.00	487.14	0.50	19.10	8.60	45.00
2010T-137	4	87.00*	78.00	108.00*	28.00	7.28	7.35	6.39	12.00	0.55	15.00	8.67	130.00	1.90	368.74	0.38	14.80	3.94	26.60
2010T-138	4	87.00*	63.00	63.00*	46.00*	7.83*	9.33*	16.19*	23.00*	1.00	26.00*	9.23*	240.00*	2.30	997.54*	0.70	14.00	11.27	80.50*
2010T-142	4	105.00*	42.00	102.00*	18.00	4.91	9.50*	9.71	22.00*	1.28*	25.00*	8.00	200.00*	2.70*	1145.57*	0.94*	11.60	4.91	42.30
2010T-143	4	72.00*	75.00	69.00*	24.00	6.79	7.72	10.87	14.00	0.85	17.00	8.82	150.00	2.00	471.43	0.56	9.20	3.09	33.60
2010T-152	4	57.00	48.00	51.00*	40.00	7.05	18.00*	15.88*	15.00	1.50*	18.00	11.33*	204.00*	2.46	969.99*	1.20*	17.00	20.40*	120.00*
2010T-153	4	51.00	60.00	48.00	41.00	7.06	17.00*	17.00*	15.20	1.50*	18.20	12.09*	220.00*	2.50	1080.36*	1.25*	18.20	23.32*	128.13*
2010T-154	4	45.00	69.00	42.00	30.00	7.33	8.52	23.57*	22.00*	1.71*	25.00*	9.60*	240.00*	2.70*	1374.69*	1.40*	12.00	12.60	105.00*
2010T-155	4	93.00*	84.00*	48.00	41.00	11.00*	23.00*	17.88*	16.60	1.60*	19.60*	9.80*	192.00*	2.38	854.52*	1.15*	16.10	18.98*	117.88*
2010T-156	4	90.00*	99.00*	66.00*	40.00	7.00	6.30	14.09	20.00*	1.10	23.00*	7.39	170.00*	2.40	769.37*	0.75	9.80	7.35	75.00*
2010T-157	4	108.00*	78.00	81.00*	40.00	6.42	8.19	8.15	11.00	1.30*	14.00	10.00*	140.00	2.70*	801.90*	0.91*	10.50	9.56	91.00*
2010T-158	4	63.00	51.00	60.00*	41.00	7.05	8.18	13.20	14.40	1.40*	17.40	9.31*	162.00	2.19	610.48	0.95*	16.90	16.46*	97.38*
2010T-159	4	93.00*	87.00*	84.00*	36.00	7.42	9.34*	8.57	13.00	0.91	16.00	12.50*	200.00*	2.00	628.57	0.65	13.20	7.72	58.50
2010T-160	4	66.00	39.00	54.00*	36.00	7.73	9.92*	12.78	12.00	0.51	15.00	10.33*	155.00	1.90	439.65	0.45	14.80	5.99	40.50

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	$t\ ha^{-1}$	$t\ ha^{-1}$
2010T-161	4	63.00	51.00	60.00 *	43.00 *	7.94 *	9.77 *	19.44 *	24.00 *	1.40 *	17.40	9.31 *	162.00	2.19	610.48	1.00 *	17.10	18.38 *	107.50 *
2010T-162	4	111.00 *	75.00	51.00 *	18.00	6.24	8.12	15.88 *	16.00	1.11 *	19.00	8.42	160.00	1.90	453.83	0.78	15.70	5.51	35.10
2010T-163	4	68.57	55.71	54.00 *	16.00	7.94 *	9.77 *	19.44 *	24.00 *	2.15 *	27.00 *	8.89	240.00 *	2.60 *	1274.74 *	1.57 *	12.50	7.85	62.80
2010T-164	4	63.00	63.00	57.00 *	48.00 *	7.76 *	9.10 *	12.11	12.00	1.17 *	15.00	10.67 *	160.00	2.40	724.11 *	0.92 *	9.10	10.05	110.40 *
2010T-165	4	132.00 *	117.00 *	75.00 *	36.00	5.77	5.90	6.40	5.00	0.57	8.00	16.25 *	130.00	2.30	540.34	0.50	12.20	5.49	45.00
2010T-166	4	96.00 *	87.00 *	66.00 *	30.00	7.00	8.52	10.91	13.00	0.57	16.00	9.38 *	150.00	2.10	519.75	0.37	15.60	4.33	27.75
2010T-168	4	87.00 *	84.00 *	57.00 *	28.00	7.10	7.64	16.84 *	21.00 *	0.94	24.00 *	7.92	190.00 *	1.80	483.69	0.64	16.20	7.26	44.80
2010T-169	4	72.00 *	63.00	69.00 *	40.00	8.54 *	8.14	10.00	12.00	0.54	15.00	9.33 *	140.00	1.80	356.40	0.42	11.00	4.62	42.00
2010T-170	4	45.00	48.00	39.00	32.00	6.87	8.13	19.23 *	14.00	0.74	17.00	9.41 *	160.00	2.00	502.86	0.53	19.40	8.23	42.40
2010T-171	4	75.00 *	57.00	66.00 *	59.00 *	8.04 *	19.00 *	12.82	16.20	1.00	19.20 *	9.27 *	178.00 *	2.02	570.67	0.75	18.90	20.91 *	110.63 *
2010T-174	4	84.00 *	72.00	63.00 *	48.00 *	9.21 *	9.21 *	13.33	17.00	0.74	20.00 *	8.50	170.00 *	1.90	482.19	0.50	13.00	7.80	60.00
2010T-218	4	87.00 *	60.00	54.00 *	28.00	6.41	6.70	14.44 *	15.00	0.76	18.00	9.44 *	170.00 *	2.00	534.29	0.52	10.50	3.82	36.40
2010T-220	4	129.00 *	75.00	72.00 *	60.00 *	6.44	7.80	11.25	16.00	0.74	19.00	8.42	160.00	2.00	502.86	0.49	14.90	10.95	73.50 *
2010T-229	4	81.00 *	75.00	51.00 *	47.00 *	10.63 *	9.48 *	15.88 *	16.00	0.82	19.00	9.47 *	180.00 *	2.40	814.63 *	0.70	19.40	15.96 *	82.25 *
2010T-230	4	81.00 *	75.00	51.00 *	47.00 *	10.63 *	9.48 *	15.88 *	16.00	0.62	19.00	9.47 *	180.00 *	1.90	510.56	0.51	15.10	9.05	59.93
2010T-232	4	75.00 *	60.00	57.00 *	25.00	8.96 *	6.80	14.21	16.00	0.65	19.00	8.68	165.00	2.00	518.57	0.58	17.90	6.49	36.25
2010T-233	4	96.00 *	60.00	60.00 *	37.00	4.91	7.45	15.00 *	19.00 *	1.40 *	22.00 *	8.18	180.00 *	2.60 *	956.06 *	1.07 *	9.80	9.70	98.98 *
2010T-236	4	96.00 *	72.00	66.00 *	30.00	6.22	7.92	10.91	13.00	0.51	16.00	2.81	45.00	1.90	127.64	0.40	15.00	4.50	30.00
2010T-256	4	60.00	45.00	57.00 *	37.00	8.70 *	9.87 *	14.74 *	17.00	0.45	20.00 *	8.25	165.00	1.50	291.70	0.38	16.90	5.94	35.15
Best check		71.57	81.11	49.59	41.75	7.75	8.61	14.25	17.84	1.11	19.07	9.06	169.77	2.55	709.44	0.90	20.16	13.03	73.44

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-118	5	114.00 *	114.00 *	87.00 *	27.00	7.63	6.66	12.41	25.00 *	1.00	28.00 *	8.21	230.00 *	2.00	722.86	0.78	13.00	6.84	52.65
2010T-119	5	57.00	39.00	39.00	45.00 *	7.32	9.00 *	20.00	15.00	0.46	18.00	8.33	150.00	1.70	340.61	0.35	11.30	4.45	39.38
2010T-120	5	63.00	45.00	57.00 *	19.00	7.86	9.40 *	17.37	22.00 *	1.21 *	25.00 *	8.40	210.00 *	2.30	872.85	0.83	11.60	4.57	39.43
2010T-121	5	96.00 *	96.00 *	102.00 *	59.00 *	9.09 *	7.22	7.94	16.00	0.90	19.00	3.42	65.00	2.00	204.29	0.68	12.50	12.54	100.30 *
2010T-122	5	54.00	66.00	42.00	29.00	10.22 *	9.09 *	13.57	8.00	0.46	11.00	12.27 *	135.00	1.90	382.92	0.43	18.20	5.67	31.18
2010T-129	5	72.00	66.00	54.00	38.00	9.04 *	9.18 *	17.22	20.00 *	1.28 *	23.00 *	10.65 *	245.00 *	2.20	931.70 *	1.10 *	9.20	9.61	104.50 *
2010T-212	5	105.00 *	60.00	69.00 *	15.00	7.57	8.00	12.17	17.00 *	0.90	20.00	9.75 *	195.00 *	1.90	553.10	0.67	16.40	4.12	25.13
2010T-223	5	84.00 *	63.00	75.00 *	33.00	9.21 *	6.52	13.60	23.00 *	2.10 *	26.00 *	10.77 *	280.00 *	2.30	1163.80 *	1.65 *	12.70	17.29 *	136.13 *
2010T-225	5	72.00	60.00	63.00 *	45.00 *	9.04 *	9.45 *	15.52	20.60 *	1.30 *	23.60 *	11.65 *	275.00 *	1.95	821.61	0.80	15.40	13.86 *	90.00 *
2010T-226	5	69.00	51.00	48.00	59.00 *	8.70	9.76 *	17.63	16.20	1.25 *	19.20	10.94 *	210.00 *	2.20	798.60	0.85	17.70	22.19 *	125.38 *
2010T-227	5	45.00	45.00	42.00	65.00 *	9.87 *	8.67 *	22.14 *	20.00 *	0.75	23.00 *	7.83	180.00	1.40	277.20	0.60	9.20	8.97	97.50 *
2010T-235	5	78.00 *	45.00	48.00	46.00 *	7.81	7.80	16.88	16.00	1.35 *	19.00	12.63 *	240.00 *	2.00	754.29	0.96 *	9.40	10.38	110.40 *
2010T-238	5	75.00 *	48.00	48.00	48.00 *	7.44	8.31	21.88 *	24.00 *	1.10 *	27.00 *	8.89 *	240.00 *	1.90	680.74	0.71	10.50	8.95	85.20 *
2010T-239	5	84.00 *	78.00 *	75.00 *	50.00 *	18.00 *	14.00 *	11.08	16.80	0.90	19.80	10.45 *	207.00 *	1.92	599.57	0.65	16.10	13.08 *	81.25 *
2010T-240	5	96.00 *	69.00	63.00 *	41.00 *	7.94	10.48 *	15.24	21.00 *	1.33 *	24.00 *	10.83 *	260.00 *	1.40	400.40	1.02 *	16.70	17.46 *	104.55 *
2010T-241	5	84.00 *	78.00 *	75.00 *	30.00	8.43	9.04 *	12.00	19.00 *	0.39	22.00 *	11.36 *	250.00 *	1.10	237.68	0.36	19.00	5.13	27.00
2010T-242	5	48.00	45.00	54.00	31.00	7.56	9.20 *	12.78	12.00	0.70	15.00	11.33 *	170.00	1.30	225.74	0.50	10.70	4.15	38.75
2010T-244	5	72.00	66.00	63.00 *	27.00	6.71	6.18	11.43	13.00	0.99	16.00	11.25 *	180.00	2.20	684.51	0.63	16.00	6.80	42.53
2010T-245	5	96.00 *	69.00	63.00 *	41.00 *	7.94	10.48 *	15.24	21.00 *	1.33 *	24.00 *	10.83 *	260.00 *	1.40	400.40	1.02 *	16.70	17.46 *	104.55 *
2010T-246	5	69.00	63.00	72.00 *	38.00	8.52	8.81 *	12.92	20.00 *	1.06	23.00 *	10.22 *	235.00 *	1.80	598.24	0.88	9.80	8.19	83.60 *

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-248	5	90.00 *	72.00	60.00 *	21.00	7.90	6.04	17.00	23.00 *	0.82	26.00 *	10.77 *	280.00 *	1.80	712.80	0.67	22.60 *	7.95	35.18
2010T-249	5	93.00 *	84.00 *	72.00 *	36.00	7.23	7.11	10.83	14.00	1.30 *	17.00	13.06 *	222.00 *	2.18	828.95	0.85	20.10 *	15.38 *	76.50 *
2010T-250	5	126.00 *	81.00 *	63.00 *	43.00 *	8.38	5.74	10.95	12.00	0.59	15.00	13.00 *	195.00 *	1.20	220.63	0.45	14.50	7.01	48.38
2010T-251	5	72.00	63.00	48.00	39.00	8.71	10.00 *	16.88	16.00	0.59	19.00	8.95 *	170.00	1.90	482.19	0.48	11.30	5.29	46.80
2010T-253	5	60.00	66.00	54.00	33.00	7.75	9.55 *	17.22	20.00 *	1.12 *	23.00 *	8.26	190.00 *	2.40	859.89	0.83	14.90	10.20	68.48
2010T-254	5	78.00 *	81.00 *	60.00 *	35.00	9.12 *	9.63 *	11.00	11.00	0.40	14.00	11.43 *	160.00	1.30	212.46	0.29	13.30	3.37 *	25.38
2010T-255	5	102.00 *	84.00 *	66.00 *	44.00 *	7.47	8.79 *	11.82	15.00	0.70	18.00	10.56 *	190.00 *	1.90	538.92	0.53	12.50	7.29	58.30
2010T-257	5	78.00 *	60.00	57.00 *	30.00	9.58 *	8.80 *	14.21	16.00	0.87	19.00	10.00 *	190.00 *	1.90	538.92	0.65	18.10	8.82	48.75
2010T-258	5	57.00	48.00	63.00 *	56.00 *	8.05	6.13	14.67	18.80 *	1.10 *	21.80 *	11.83 *	258.00 *	2.22	999.06 *	0.80	19.60 *	21.95 *	112.00 *
2010T-260	5	72.00	60.00	63.00 *	34.00	8.29	10.90 *	13.81	18.00 *	0.92	21.00	10.48 *	220.00 *	1.80	560.06	0.67	18.00	10.25	56.95
2010T-261	5	54.00	51.00	60.00 *	55.00 *	8.11	8.29	11.00	11.00	0.97	14.00	11.79 *	165.00	1.80	420.04	0.47	9.80	6.33	64.63
2010T-262	5	81.00 *	57.00	72.00 *	29.00	7.07	8.16	7.92	8.00	0.80	11.00	15.00 *	165.00	2.00	518.57	0.58	11.40	4.79	42.05
2010T-265	5	84.00 *	75.00 *	54.00	41.00 *	8.32	8.72 *	16.67	19.00 *	1.18 *	22.00 *	11.36 *	250.00 *	2.20	950.71 *	0.91	12.50	11.66	93.28 *
2010T-266	5	81.00 *	81.00 *	60.00 *	17.00	7.96	7.85	17.00	23.00 *	1.51 *	26.00 *	8.27	215.00 *	2.20	817.61	1.13 *	15.40	7.40	48.03
2010T-267	5	93.00 *	51.00	60.00 *	73.00 *	7.19	7.47	13.20	14.40	1.25 *	17.40	11.09 *	193.00 *	1.77	475.08	0.70	17.00	21.72 *	127.75 *
2010T-269	5	72.00	69.00	63.00 *	47.00 *	8.08	8.70 *	12.86	16.00	0.52	19.00	9.47 *	180.00	2.00	565.71	0.38	14.00	6.25	44.65
2010T-271	5	78.00 *	75.00 *	45.00	40.00	8.31	8.52	21.33 *	21.00 *	1.08	24.00 *	9.58 *	230.00 *	1.70	522.26	0.77	10.80	8.32	77.00 *
2010T-273	5	93.00 *	57.00	51.00	19.00	7.03	8.53	17.65	19.00 *	1.26 *	22.00 *	8.86	195.00 *	2.20	741.56	0.88	12.20	5.10	41.80
2010T-275	5	81.00 *	69.00	60.00 *	19.00	7.85	8.35	10.00	9.00	0.58	12.00	11.67 *	140.00	2.00	440.00	0.42	15.00	2.99	19.95
Best check		74.57	74.86	54.34	40.75	8.75	8.61	20.00	16.84	1.08	21.32	8.87	187.52	2.77	902.67	0.93	19.28	12.65	75.05

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-175	6	72.00 *	57.00	45.00	50.00 *	7.50	9.68 *	20.13 *	18.20 *	1.20	21.20	10.40 *	220.50 *	2.41	1006.25 *	1.00 *	17.50	21.88 *	125.00 *
2010T-176	6	96.00 *	72.00 *	57.00	32.00	6.91	5.88	13.16	14.00	0.73	17.00	12.35 *	210.00 *	2.00	660.00	0.68	18.00	9.79	54.40
2010T-177	6	84.00 *	63.00	57.00	40.00 *	7.93	9.19 *	15.79	18.00 *	1.20	21.00	10.62 *	223.00 *	2.36	975.87 *	1.00 *	17.60	17.60 *	100.00 *
2010T-178	6	63.00 *	57.00	66.00 *	41.00 *	9.81 *	10.42 *	14.55	21.00 *	1.06	24.00 *	10.63 *	255.00 *	2.10	883.58 *	0.78	14.90	11.91	79.95 *
2010T-179	6	72.00 *	60.00	48.00	51.00 *	9.13 *	7.80	20.00 *	20.00 *	1.15	23.00 *	11.30 *	260.00 *	2.33	1109.05 *	0.60	17.60	13.46 *	76.50 *
2010T-180	6	48.00	45.00	51.00	30.00	9.06 *	7.27	11.18	8.00	0.70	11.00	14.09 *	155.00	2.30	644.25	0.66	9.80	4.85	49.50
2010T-181	6	72.00 *	45.00	42.00	54.00 *	6.46	8.67 *	22.14 *	20.00 *	1.60 *	23.00 *	10.87 *	250.00 *	2.60 *	1327.86 *	1.30 *	19.00	33.35 *	175.50 *
2010T-182	6	63.00 *	54.00	54.00	27.00	8.10 *	5.28	16.11	18.00 *	0.86	21.00	10.71 *	225.00 *	1.90	638.20	0.78	16.00	8.42	52.65
2010T-183	6	69.00 *	45.00	66.00 *	49.00 *	7.35	11.00 *	13.36	17.40 *	1.60 *	20.40	10.46 *	213.40 *	2.28	871.62 *	1.20 *	19.00	27.93 *	147.00 *
2010T-184	6	54.00	57.00	57.00	41.00 *	10.50 *	10.32 *	16.63	19.60 *	1.30	22.60 *	8.85 *	200.00 *	2.63 *	1086.94 *	1.05 *	21.90 *	23.57 *	107.63 *
2010T-185	6	96.00 *	69.00 *	54.00	22.00	6.81	8.35	12.78	12.00	0.60	15.00	11.33 *	170.00	2.00	534.29	0.52	15.00	4.29	28.60
2010T-186	6	63.00 *	78.00 *	51.00	23.00	7.24	5.81	19.41 *	22.00 *	1.54 *	25.00 *	8.80 *	220.00 *	3.10 *	1661.16 *	1.39 *	18.00	14.39 *	79.93 *
2010T-187	6	63.00 *	72.00 *	63.00 *	25.00	8.43 *	7.96	11.90	14.00	0.99	17.00	11.18 *	190.00 *	2.00	597.14	0.70	10.50	4.59	43.75
2010T-188	6	81.00 *	69.00 *	57.00	35.00	7.93	8.39 *	15.26	18.00 *	1.22	21.00	10.00 *	210.00 *	1.90	595.65	0.87	13.20	10.05	76.13 *
2010T-195	6	48.00	39.00	66.00 *	44.00 *	8.81 *	10.85 *	14.09	20.00 *	0.94	23.00 *	10.00 *	230.00 *	2.30	955.98 *	0.86	8.90	8.42	94.60 *
2010T-198	6	90.00 *	63.00	51.00	45.00 *	7.53	9.86 *	17.65	19.00 *	0.52	22.00 *	8.64	190.00 *	1.60	382.17	0.41	11.60	5.35	46.13
2010T-203	6	87.00 *	51.00	63.00 *	37.00	7.24	9.47 *	14.29	19.00 *	0.75	22.00 *	9.77 *	215.00 *	2.00	675.71	0.59	14.00	7.64	54.58
2010T-211	6	45.00	48.00	81.00 *	53.00 *	7.73	8.50 *	11.11	19.00 *	0.84	22.00 *	10.00 *	220.00 *	1.90	624.01	0.64	8.80	7.46	84.80 *
2010T-219	6	84.00 *	87.00 *	60.00 *	75.00 *	7.50	8.76 *	11.00	11.00	0.28	14.00	10.71 *	150.00	1.50	265.18	0.27	10.50	5.32	50.63
2010T-221	6	111.00 *	93.00 *	93.00 *	27.00	6.95	6.58	10.97	23.00 *	1.12	26.00 *	9.23 *	240.00 *	2.10	831.60 *	0.86	13.50	7.84	58.05

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	$t\ ha^{-1}$	$t\ ha^{-1}$
2010T-222	6	78.00*	69.00*	87.00*	37.00	7.85	8.00	10.00	18.00*	0.72	21.00	10.00*	210.00*	1.90	595.65	0.56	16.30	8.44	51.80
2010T-224	6	75.00*	66.00*	57.00	17.00	7.40	8.41*	10.00	8.00	0.40	11.00	12.73*	140.00	1.80	356.40	0.33	16.20	2.27	14.03
2010T-231	6	66.00*	45.00	66.00*	22.00	7.41	9.13*	13.18	18.00*	0.96	21.00	12.38*	260.00*	1.60	522.97	0.67	9.80	3.61	36.85
2010T-234	6	45.00	54.00	51.00	31.00	9.00*	7.50	11.76	9.00	0.51	12.00	11.25*	135.00	2.00	424.29	0.46	14.40	5.13	35.65
2010T-237	6	108.00*	72.00*	42.00	59.00*	16.00*	13.00*	20.86*	17.20	1.50*	20.20	12.48*	252.00*	2.20	958.32*	1.00*	16.20	23.90*	147.50*
2010T-243	6	78.00*	66.00*	69.00*	40.00*	7.77	6.59	13.04	19.00*	1.21	22.00*	11.82*	260.00*	2.00	817.14*	0.92	12.10	11.13	92.00*
2010T-247	6	102.00*	63.00	69.00*	35.00	6.82	8.67*	13.48	20.00*	1.24	23.00*	9.57*	220.00*	2.30	914.41*	0.10	19.60	1.72	8.75
2010T-252	6	72.00*	87.00*	117.00*	53.00*	8.58*	7.59	7.49	17.20	1.50*	20.20	12.48*	252.00*	2.10	873.18*	1.00*	14.10	18.68*	132.50*
2010T-259	6	72.00*	54.00	81.00*	59.00*	10.00*	9.83*	10.74	18.00*	0.50	21.00	10.95*	230.00*	1.40	354.20	0.37	17.00	9.28	54.58
2010T-263	6	84.00*	84.00*	60.00*	54.00*	7.96	6.00	16.00	21.00*	1.17	24.00*	8.33	200.00*	2.20	760.57	0.77	12.40	12.89*	103.95*
2010T-268	6	96.00*	84.00*	63.00*	56.00*	6.66	7.32	12.86	16.00	0.44	19.00	11.58*	220.00*	1.60	442.51	0.40	13.50	7.56	56.00
2010T-270	6	54.00	51.00	42.00	20.00	7.67	7.29	17.86*	14.00	1.16	17.00	13.53*	230.00*	2.20	874.66*	0.86	11.60	4.99	43.00
2010T-272	6	87.00*	72.00*	75.00*	38.00	8.00	9.71*	11.60	18.00*	0.92	21.00	9.52*	200.00*	1.90	567.29	0.62	11.30	6.66	58.90
2010T-274	6	45.00	42.00	45.00	48.00*	7.53	9.50*	16.00	13.00	0.91	16.00	10.94*	175.00	2.50	859.38*	0.87	13.90	14.51*	104.40*
2010T-276	6	69.00*	60.00	69.00*	38.00	9.00*	8.05	9.57	11.00	0.56	14.00	11.43*	160.00	2.00	502.86	0.46	21.40*	9.35	43.70
2010T-277	6	66.00*	60.00	48.00	27.00	8.18*	7.65	19.38*	20.00*	0.97	23.00*	10.43*	240.00*	1.70	544.97	0.69	17.70	8.24	46.58
2010T-278	6	87.00*	60.00	87.00*	70.00*	12.00*	19.00*	9.93	16.80	1.35*	19.80	10.61*	210.00*	2.14	755.63	0.80	16.40	22.96*	140.00*
2010T-279	6	90.00*	57.00	63.00*	42.00*	6.60	8.00	12.86	16.00	1.00	19.00	12.11*	230.00*	2.20	874.66*	0.88	12.40	11.46	92.40*
2010T-280	6	75.00*	54.00	48.00	21.00	7.20	7.67	16.88	16.00	0.87	19.00	7.37	140.00	2.40	633.60	0.60	18.20	5.73	31.50
Best check		59.57	63.11	58.59	38.75	8.00	8.36	17.75	17.34	1.35	21.32	8.75	184.27	2.55	767.09	0.98	20.21	12.74	72.12

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-189	7	69.00 *	45.00	63.00 *	43.00	6.26	5.80	12.38	15.00	0.92	18.00	10.00 *	180.00	2.00	565.71	0.60	15.80	10.19	64.50
2010T-190	7	63.00	48.00	78.00 *	19.00	7.19	8.88 *	10.77	17.00	0.84	20.00	9.25 *	185.00 *	2.00	581.43	0.70	16.90	5.62	33.25
2010T-191	7	48.00	54.00	60.00 *	21.00	7.19	7.56	13.00	15.00	0.74	18.00	8.61	155.00	2.00	487.14	0.52	18.20	4.97	27.30
2010T-192	7	57.00	48.00	51.00	23.00	7.47	9.75 *	12.94	11.00	0.63	14.00	10.71 *	150.00	2.00	471.43	0.54	12.40	3.85	31.05
2010T-193	7	93.00 *	39.00	69.00 *	41.00	7.10	9.31 *	14.35	22.00 *	0.81	25.00 *	8.20	205.00 *	1.70	465.50	0.54	13.70	7.58	55.35
2010T-194	7	78.00 *	48.00	81.00 *	13.00	5.31	7.94	10.74	18.00 *	0.76	21.00	8.10	170.00	2.20	646.49	0.63	16.40	3.36	20.48
2010T-196	7	72.00 *	75.00	66.00 *	30.00	7.54	6.68	15.00	22.00 *	1.10	25.00 *	9.20 *	230.00 *	2.10	796.95 *	0.81	10.40	6.32	60.75
2010T-197	7	51.00	45.00	48.00	43.00	7.59	7.07	12.50	9.00	0.48	12.00	11.67 *	140.00	2.10	485.10	0.40	17.70	7.61	43.00
2010T-199	7	63.00	45.00	45.00	33.00	6.90	6.67	20.00 *	19.00 *	0.87	22.00 *	10.23 *	225.00 *	2.00	707.14	0.69	11.40	6.49	56.93
2010T-200	7	72.00 *	57.00	60.00 *	57.00 *	7.13	7.68	11.00	11.00	0.53	14.00	12.50 *	175.00	2.40	792.00 *	0.49	15.00	10.47	69.83
2010T-201	7	66.00	75.00	51.00	25.00	7.45	7.32	17.06	18.00 *	0.90	21.00	8.33	175.00	2.20	665.50	0.62	15.20	5.89	38.75
2010T-202	7	57.00	48.00	72.00 *	27.00	7.63	10.31 *	12.50	19.00 *	0.74	22.00 *	7.73	170.00	2.10	589.05	0.55	11.60	4.31	37.13
2010T-204	7	72.00 *	45.00	42.00	46.00	6.88	10.33 *	22.14 *	20.00 *	1.92 *	23.00 *	11.30 *	260.00 *	2.30	1080.67 *	1.28 *	10.70	15.75 *	147.20 *
2010T-205	7	72.00 *	48.00	69.00 *	27.00	8.17 *	9.31 *	16.52	27.00 *	1.13	30.00 *	9.00 *	270.00 *	2.10	935.55 *	0.90 *	9.20	5.59	60.75
2010T-206	7	75.00 *	39.00	45.00	24.00	6.28	6.85	22.00 *	22.00 *	0.96	25.00 *	7.60	190.00 *	2.00	597.14	0.71	16.20	6.90	42.60
2010T-207	7	51.00	39.00	63.00 *	26.00	7.76	9.54 *	17.14	25.00 *	1.30 *	28.00 *	10.36 *	290.00 *	2.20	1102.83 *	1.02 *	14.60	9.68	66.30
2010T-208	7	63.00	48.00	57.00	51.00 *	7.71	10.88 *	14.53	15.60	1.25 *	18.60	12.61 *	234.50 *	2.21	899.90 *	0.75	16.90	16.16 *	95.63 *
2010T-209	7	69.00 *	45.00	54.00	42.00	7.65	10.87 *	16.44	17.60	1.40 *	20.60	10.92 *	225.00 *	2.53	1131.59 *	0.80	16.80	14.11 *	84.00 *
2010T-210	7	105.00 *	60.00	45.00	54.00 *	6.46	8.90 *	20.00 *	19.00 *	0.68	22.00 *	9.55 *	210.00 *	1.60	422.40	0.57	14.60	11.23	76.95 *
2010T-213	7	57.00	42.00	45.00	44.00	8.47 *	10.50 *	16.00	13.00	0.51	16.00	2.81	45.00	1.90	127.64	0.38	12.40	5.18	41.80

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-283	7	54.00	78.00	45.00	31.00	8.22 *	5.54	18.67	17.00	1.00	20.00	10.00 *	200.00 *	2.50	982.14 *	0.80	12.70	7.87	62.00
2010T-284	7	66.00	54.00	72.00 *	17.00	8.14 *	6.50	7.50	7.00	0.53	10.00	11.50 *	115.00	2.20	437.33	0.49	16.40	3.42	20.83
2010T-285	7	93.00 *	69.00	69.00 *	57.00 *	6.23	8.57	11.22	13.80	1.00	16.80	11.67 *	196.00 *	2.48	947.16 *	0.70	18.10	18.05 *	99.75 *
2010T-286	7	48.00	54.00	45.00	36.00	6.31	7.89	16.00	13.00	0.97	16.00	9.38 *	150.00	2.60 *	796.71 *	0.65	15.90	9.30	58.50
2010T-287	7	48.00	54.00	54.00	24.00	9.00 *	9.72 *	17.78	21.00 *	1.06	24.00 *	6.67	160.00	2.60 *	849.83 *	0.68	13.20	5.39	40.80
2010T-288	7	75.00 *	66.00	48.00	29.00	6.60	5.55	14.38	12.00	0.61	15.00	9.00 *	135.00	2.20	513.39	0.55	13.70	5.46	39.88
2010T-289	7	102.00 *	78.00	111.00 *	51.00 *	7.47	9.08 *	8.11	19.00 *	1.24 *	22.00 *	9.55 *	210.00 *	2.30	872.85 *	0.91 *	11.40	13.23	116.03 *
2010T-290	7	99.00 *	75.00	63.00 *	31.00	7.76	9.84 *	17.62	26.00 *	1.31 *	29.00 *	7.93	230.00 *	2.60 *	1221.63 *	1.03 *	12.60	10.06	79.83 *
2010T-291	7	90.00 *	81.00 *	48.00	17.00	5.60	5.44	13.13	10.00	0.53	13.00	17.31 *	225.00 *	2.50	1104.91 *	0.46	20.20	3.95	19.55
2010T-292	7	99.00 *	75.00	63.00 *	72.00 *	18.00 *	9.84 *	17.62	26.00 *	1.31 *	29.00 *	7.93	230.00 *	2.60 *	1221.63 *	1.03 *	12.60	23.36 *	185.40 *
2010T-293	7	81.00 *	66.00	66.00 *	32.00	7.26	8.32	12.27	16.00	0.76	19.00	8.42	160.00	1.80	407.31	0.51	17.50	7.14	40.80
2010T-294	7	60.00	42.00	75.00 *	30.00	5.80	8.86	12.00	19.00 *	0.62	22.00 *	6.36	140.00	2.00	440.00	0.42	18.10	5.70	31.50
2010T-295	7	126.00 *	90.00 *	72.00 *	25.00	7.05	11.07 *	11.25	16.00	0.89	19.00	11.05 *	210.00 *	1.90	595.65	0.66	12.50	5.16	41.25
2010T-296	7	180.00 *	165.00 *	162.00 *	20.00	5.85	5.47	3.70	9.00	0.51	12.00	12.50 *	150.00	2.00	471.43	0.32	14.50	2.32	16.00
2010T-297	7	75.00 *	72.00	57.00	36.00	6.36	7.08	16.32	20.00 *	1.50 *	23.00 *	10.43 *	240.00 *	2.70 *	1374.69 *	1.15 *	16.50	17.08 *	103.50 *
2010T-298	7	66.00	48.00	51.00	44.00	6.95	9.63 *	15.29	15.00	1.14	18.00	8.33	150.00	2.50	736.61	0.69	13.20	10.02	75.90 *
2010T-299	7	51.00	57.00	66.00 *	53.00 *	6.41	8.53	15.91	24.00 *	1.56 *	27.00 *	7.41	200.00 *	2.30	831.29 *	0.81	13.60	14.60 *	107.33 *
2010T-300	7	129.00 *	195.00 *	75.00 *	17.00	5.44	4.34	9.20	12.00	0.65	15.00	10.67 *	160.00	2.00	502.86	0.49	14.40	3.00	20.83
2010T-301	7	105.00 *	162.00 *	81.00 *	23.00	6.83	4.46	7.04	8.00	0.66	11.00	12.73 *	140.00	2.60 *	743.60	0.62	13.70	4.88	35.65
Best check		67.82	79.61	57.09	46.50	8.00	8.86	18.75	17.64	1.21	21.32	8.71	181.77	2.52	750.71	0.86	21.11	14.02	75.70

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-148	8	87.00*	81.00*	72.00*	19.00	7.66	8.67	10.83	15.00	0.86	18.00	8.89	160.00	2.30	665.03	0.66	16.00	5.02	31.35
2010T-149	8	87.00*	84.00*	57.00	11.00	5.86	7.07	14.74	17.00	0.95	20.00	7.50	150.00	2.40	678.86	0.70	16.20	3.12	19.25
2010T-216	8	87.00*	114.00*	75.00*	41.00*	7.76	6.42	10.00	14.00	0.77	17.00	11.76*	200.00*	2.00	628.57	0.58	13.00	7.73	59.45
2010T-302	8	63.00	48.00	51.00	17.00	6.71	7.31	12.94	11.00	0.43	14.00	10.00*	140.00	1.60	281.60	0.36	17.90	2.74	15.30
2010T-303	8	63.00	63.00	45.00	19.00	7.14	8.67	17.33	15.00	1.20	18.00	10.00*	180.00	2.40	814.63*	0.94*	17.20	7.68	44.65
2010T-304	8	54.00	63.00	51.00	25.00	7.11	9.38	15.88	16.00	0.85	19.00	8.68	165.00	2.00	518.57	0.59	11.60	4.28	36.88
2010T-306	8	69.00*	93.00*	69.00*	23.00	6.39	6.65	9.57	11.00	0.38	14.00	8.57	120.00	2.00	377.14	0.34	17.30	3.38	19.55
2010T-307	8	39.00	36.00	39.00	25.00	9.00*	10.83*	23.85*	20.00*	1.37*	23.00*	9.57*	220.00*	2.40	995.66*	1.08*	11.80	7.97	67.50*
2010T-330	8	63.00	60.00	39.00	68.00*	8.19	8.95	22.00*	16.60	1.25*	19.60	10.79*	211.50*	2.13	753.94	0.90*	17.40	26.62*	153.00*
2010T-331	8	60.00	63.00	66.00*	48.00*	9.35*	9.81	13.82	18.40*	1.30*	21.40*	10.61*	227.00*	2.26	910.98*	0.95*	15.40	17.56*	114.00*
2010T-332	8	48.00	54.00	57.00	25.00	7.00	9.06	14.74	17.00	0.95	20.00	8.00	160.00	2.50	785.71	0.80	15.80	7.90	50.00
2010T-334	8	63.00	51.00	57.00	19.00	7.05	7.29	10.00	8.00	0.52	11.00	10.00*	110.00	2.30	457.21	0.48	16.00	3.65	22.80
2010T-335	8	78.00*	84.00*	63.00*	43.00*	7.04	6.29	14.29	18.00*	1.40*	21.00*	9.12	191.50*	2.43	888.48*	1.00*	18.90	20.32*	107.50*
2010T-336	8	93.00*	72.00*	51.00	23.00	6.26	8.21	12.35	10.00	0.42	13.00	6.92	90.00	2.10	311.85	0.38	14.10	3.08	21.85
2010T-337	8	66.00*	51.00	54.00	11.00	6.09	5.82	17.22	20.00*	1.96*	23.00*	9.13	210.00*	3.20*	1689.60*	1.52*	18.60	7.77	41.80
2010T-339	8	93.00*	60.00	42.00	15.00	6.45	6.25	20.00*	17.00	0.80	20.00	6.50	130.00	2.40	588.34	0.61	13.60	3.11	22.88
2010T-340	8	93.00*	72.00*	63.00*	42.00*	6.42	10.93*	14.94	13.40	1.20	16.40	9.51*	156.00	2.58	815.88*	0.75	16.90	13.31*	78.75*
2010T-341	8	105.00*	51.00	60.00*	21.00	5.26	8.82	12.00	13.00	0.68	16.00	8.13	130.00	2.00	408.57	0.52	13.90	3.79	27.30
2010T-344	8	120.00*	81.00*	78.00*	42.00*	17.00*	15.00*	19.00*	11.60	1.25*	14.60	10.79*	157.50	2.88*	1026.43*	0.80	19.90	16.72*	84.00*
2010T-345	8	72.00*	90.00*	63.00*	57.00*	6.58	8.50	7.62	5.00	0.50	8.00	11.25*	90.00	2.40	407.31	0.48	10.30	7.05	68.40*

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-346	8	99.00 *	81.00 *	48.00	19.00	6.18	7.81	14.38	12.00	0.66	15.00	10.00 *	150.00	2.20	570.43	0.52	13.00	3.21	24.70
2010T-350	8	60.00	69.00 *	93.00 *	15.00	7.65	8.26	7.10	11.00	0.50	14.00	10.36 *	145.00	1.90	411.28	0.38	11.50	1.64	14.25
2010T-354	8	63.00	69.00 *	45.00	23.00	6.00	6.78	18.00 *	16.00	0.96	19.00	8.95	170.00	2.50	834.82 *	0.75	13.40	5.78	43.13
2010T-356	8	81.00 *	63.00	48.00	27.00	5.93	7.90	16.25	15.00	0.82	18.00	10.00 *	180.00	2.20	684.51	0.63	13.50	5.74	42.53
2010T-360	8	84.00 *	66.00	57.00	23.00	6.32	6.09	14.21	16.00	1.27 *	19.00	10.00 *	190.00 *	2.50	933.04 *	0.97 *	12.70	7.08	55.78
2010T-363	8	99.00 *	87.00 *	66.00 *	25.00	7.27	10.93 *	9.55	10.00	0.38	13.00	8.85	115.00	3.20 *	925.26 *	0.35	14.80	3.24	21.88
2010T-368	8	69.00 *	57.00	48.00	39.00	9.00 *	10.83 *	23.85 *	20.00 *	1.05	18.00	9.28	167.00	2.56	859.93 *	0.80	16.30	12.71 *	78.00 *
2010T-369	8	72.00 *	90.00 *	66.00 *	46.00 *	6.53	6.28	16.67	13.00	1.20	16.00	9.47 *	151.50	2.26	607.99	0.70	19.70	15.86 *	80.50 *
2010T-379	8	66.00 *	45.00	54.00	45.00 *	6.95	8.93	13.33	13.00	0.98	16.00	9.38 *	150.00	2.00	471.43	0.69	17.60	13.66 *	77.63 *
2010T-380	8	81.00 *	75.00 *	57.00	11.00	5.96	4.64	13.16	14.00	1.03	17.00	4.41	75.00	2.00	235.71	0.60	15.60	2.57	16.50
2010T-383	8	69.00 *	66.00	48.00	5.00	6.87	4.73	13.75	11.00	0.50	14.00	9.29	130.00	1.90	368.74	0.38	10.20	0.48	4.75
2010T-384	8	96.00 *	105.00 *	45.00	9.00	5.59	4.77	13.33	9.00	0.55	12.00	10.00 *	120.00	2.20	456.34	0.48	10.80	1.17	10.80
2010T-386	8	72.00 *	60.00	45.00	29.00	6.71	9.00	22.67 *	23.00 *	2.12 *	26.00 *	9.42 *	245.00 *	3.00 *	1732.50 *	1.52 *	12.20	13.44 *	110.20 *
2010T-387	8	75.00 *	48.00	48.00	42.00 *	6.76	10.13	18.25 *	17.20	1.60 *	20.20 *	10.27 *	207.50 *	2.53	1043.58 *	1.15 *	16.40	19.80 *	120.75 *
2010T-405	8	78.00 *	75.00 *	42.00	31.00	5.31	7.60	12.14	6.00	0.56	9.00	16.67 *	150.00	2.20	570.43	0.53	15.20	6.24	41.08
2010T-406	8	93.00 *	87.00 *	60.00 *	33.00	5.97	8.52	13.00	15.00	0.91	18.00	8.33	150.00	2.30	623.46	0.62	13.40	6.85	51.15
2010T-409	8	78.00 *	75.00 *	72.00 *	19.00	7.00	6.52	11.67	17.00	1.34 *	20.00	11.00 *	220.00 *	2.20	836.63 *	0.84	11.50	4.59	39.90
2010T-410	8	102.00 *	87.00 *	72.00 *	19.00	6.53	4.90	9.17	11.00	0.35	14.00	6.07	85.00	2.00	267.14	0.25	15.60	1.85	11.88
2010T-411	8	66.00 *	90.00 *	54.00	53.00 *	7.64	7.10	8.89	5.00	0.38	8.00	13.13 *	105.00	2.20	399.30	0.32	10.60	4.49	42.40
Best check		65.57	67.61	58.59	39.75	8.25	10.36	17.50	17.34	1.20	20.07	9.36	186.27	2.60	792.32	0.86	20.08	11.96	67.13

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-145	9	87.00*	87.00*	63.00	27.00	6.76	6.14	11.90	14.00	1.21	17.00	11.18*	190.00	2.60	1009.17*	0.88	13.30	7.90	59.40
2010T-147	9	81.00*	90.00*	63.00	50.00*	6.48	6.97	13.33	16.00*	1.15	19.00	10.03*	190.50	2.23	744.34	0.75	16.00	15.00*	93.75*
2010T-215	9	69.00	78.00*	72.00*	54.00*	7.13	8.65*	12.25	17.40*	1.15	20.40*	9.51	194.00	2.27	785.45	0.90	15.70	19.08*	121.50*
2010T-305	9	84.00*	183.00*	48.00	17.00	5.57	4.46	15.63	14.00	0.64	17.00	11.18*	190.00	2.00	597.14	0.49	13.00	2.71	20.83
2010T-327	9	78.00*	84.00*	51.00	33.00	6.23	7.64	17.65	19.00*	0.97	22.00*	6.82	150.00	2.20	570.43	0.67	9.10	5.03	55.28
2010T-333	9	81.00*	90.00*	63.00	50.00*	6.48	6.97	13.33	16.00*	1.15	19.00	10.03*	190.50	2.23	744.34	0.75	16.00	15.00*	93.75*
2010T-342	9	75.00*	96.00*	72.00*	49.00*	6.32	6.84	13.33	21.00*	0.79	24.00*	8.75	210.00*	2.20	798.60	0.76	13.00	12.10	93.10*
2010T-349	9	57.00	54.00	45.00	11.00	7.05	8.44	15.33	12.00	0.54	15.00	8.33	125.00	2.40	565.71	0.52	19.10*	2.73	14.30
2010T-351	9	75.00*	72.00	75.00*	60.00*	6.76	9.00*	10.24	13.60	0.75	16.60	11.63*	193.00	2.15	700.97	0.65	18.30*	17.84*	97.50*
2010T-352	9	51.00	66.00	60.00	27.00	7.47	5.91	16.00	21.00*	1.16	24.00*	8.54	205.00*	2.50	1006.70*	0.87	16.90	9.92	58.73
2010T-355	9	66.00	84.00*	30.00	37.00	4.45	12.00*	25.00*	14.00	1.60*	17.00	9.41	160.00	1.80	407.31	1.33*	18.80*	23.13*	123.03*
2010T-358	9	66.00	99.00*	72.00*	52.00*	5.68	8.00	13.75	22.00*	1.63*	25.00*	8.40	210.00*	3.00*	1485.00*	1.30*	15.90	26.87*	169.00*
2010T-359	9	63.00	60.00	57.00	21.00	6.48	7.65	13.16	14.00	0.47	17.00	6.76	115.00	2.30	477.99	0.43	13.20	2.98	22.58
2010T-361	9	51.00	63.00	78.00*	31.00	6.35	7.33	7.69	9.00	0.47	12.00	19.17*	230.00*	1.90	652.38	0.35	13.00	3.53	27.13
2010T-362	9	90.00*	84.00*	81.00*	36.00	7.53*	8.86*	11.33	18.60*	1.75*	21.60*	11.53*	249.00*	2.64	1363.55*	1.20*	18.00	19.44*	108.00*
2010T-364	9	42.00	63.00	51.00	45.00*	7.64*	10.67*	17.65	19.00*	1.76*	22.00*	10.00*	220.00*	2.50	1080.36*	1.29*	14.70	21.33*	145.13*
2010T-367	9	60.00	63.00	66.00	23.00	6.50	7.71	10.45	12.00	0.46	15.00	7.00	105.00	2.00	330.00	0.36	18.40*	3.81	20.70
2010T-370	9	39.00	39.00	39.00	27.00	7.00	9.62*	19.23*	14.00	1.08	17.00	7.65	130.00	3.00*	919.29*	0.72	20.00*	9.72	48.60
2010T-371	9	48.00	42.00	45.00	37.00	7.25	6.21	16.67	14.00	0.51	17.00	8.53	145.00	2.20	551.41	0.46	8.80	3.74	42.55
2010T-372	9	72.00	66.00	75.00*	43.00	6.58	7.77	11.60	18.00*	0.91	21.00*	9.29	195.00*	2.20	741.56	0.66	11.00	7.80	70.95

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-374	9	78.00 *	78.00 *	60.00	48.00 *	6.38	8.12	11.50	11.00	1.40 *	14.00	14.57 *	204.00 *	2.06	680.19	0.80	16.80	16.13 *	96.00 *
2010T-375	9	54.00	33.00	51.00	71.00 *	8.67 *	10.55 *	11.18	8.00	0.47	11.00	10.45 *	115.00	2.00	361.43	0.32	11.50	6.53	56.80
2010T-376	9	69.00	51.00	54.00	45.00 *	6.78	6.65	12.22	11.00	0.45	14.00	8.57	120.00	1.80	305.49	0.29	11.60	3.78	32.63
2010T-377	9	66.00	75.00 *	63.00	17.00	7.45	7.40	12.38	15.00 *	0.95	18.00	9.44	170.00	2.10	589.05	0.64	17.60	4.79	27.20
2010T-378	9	78.00 *	78.00 *	60.00	44.00	6.38	8.12	11.50	11.00	1.40 *	14.00	14.57 *	204.00 *	2.06	680.19	0.80	16.80	14.78 *	88.00 *
2010T-381	9	57.00	54.00	39.00	5.00	5.84	6.83	20.77 *	16.00 *	0.96	19.00	8.95	170.00	2.00	534.29	0.75	20.20 *	1.89	9.38
2010T-382	9	90.00 *	84.00 *	81.00 *	36.00	7.53 *	8.86 *	11.33	18.60 *	1.75 *	21.60 *	11.53 *	249.00 *	2.64	1363.55 *	1.20 *	15.00	16.20 *	108.00 *
2010T-385	9	72.00	78.00 *	78.00 *	13.00	7.00	7.19	8.85	12.00	0.41	15.00	5.67	85.00	2.40	384.69	0.35	18.00	2.05	11.38
2010T-388	9	75.00 *	72.00	75.00 *	60.00 *	6.76	5.29	10.24	13.60	0.75	16.60	11.63 *	193.00	2.15	700.97	0.65	18.30 *	17.84 *	97.50 *
2010T-389	9	39.00	90.00 *	69.00 *	39.00	8.00 *	6.13	9.57	11.00	1.41 *	14.00	11.43 *	160.00	2.30	665.03	0.80	13.60	10.61	78.00
2010T-390	9	66.00	99.00 *	72.00 *	7.00	5.68	6.30	13.75	22.00 *	1.63 *	25.00 *	8.40	210.00 *	3.00 *	1485.00 *	1.30 *	15.90	3.62	22.75
2010T-391	9	54.00	72.00	57.00	33.00	6.83	5.46	16.00	18.40 *	1.40 *	21.40 *	9.02	193.00	2.62	1040.94 *	1.00 *	19.50 *	16.09 *	82.50 *
2010T-407	9	39.00	60.00	36.00	25.00	7.31	8.55	17.50	10.00	0.78	13.00	11.15 *	145.00	2.20	551.41	0.58	11.80	4.28	36.25
2010T-408	9	84.00 *	81.00 *	42.00	34.00	6.89	13.00 *	21.14 *	17.60 *	1.40 *	20.60 *	10.29 *	212.00 *	2.36	927.74 *	0.90	18.60 *	14.23 *	76.50
2010T-412	9	48.00	57.00	54.00	43.00	8.69 *	10.58 *	15.78	16.40 *	0.90	19.40	9.69 *	188.00	2.16	689.18	0.75	16.30	13.14 *	80.63 *
2010T-413	9	60.00	45.00	60.00	45.00 *	8.05 *	10.47 *	18.00	25.00 *	2.60 *	28.00 *	12.14 *	340.00 *	2.80 *	2094.40 *	1.80 *	11.00	22.28 *	202.50 *
2010T-414	9	75.00 *	60.00	69.00 *	49.00 *	8.12 *	7.45	10.00	12.00	0.91	15.00	12.67 *	190.00	2.20	722.54	0.67	14.00	11.49	82.08 *
2010T-415	9	81.00 *	87.00 *	90.00 *	46.00 *	7.41	8.59	10.33	20.00 *	1.41 *	23.00 *	9.57	220.00 *	2.40	995.66 *	1.00 *	13.60	15.64 *	115.00 *
2010T-416	9	81.00 *	87.00 *	90.00 *	48.00 *	7.41	8.59	10.33	20.00 *	1.41 *	23.00 *	9.57	220.00 *	2.40	995.66 *	1.00 *	14.60	17.52 *	120.00 *
Best check		72.57	73.61	68.09	44.00	7.50	8.61	18.75	14.34	1.26	20.32	9.57	194.27	2.75	917.78	0.90	18.13	12.40	78.03

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-86	10	69.00	63.00	51.00	51.00 *	7.70	8.38	17.06 *	18.00	1.10	21.00	11.90 *	250.00 *	2.10	866.25	0.84	21.70 *	23.24 *	107.10 *
2010T-125	10	48.00	42.00	39.00	27.00	6.81	6.36	21.54 *	17.00	1.22	20.00	9.25	185.00	2.70	1059.65 *	1.04 *	13.00	9.13	70.20
2010T-127	10	105.00 *	63.00	45.00	25.00	5.66	6.95	18.00 *	16.00	0.97	19.00	7.89	150.00	2.50	736.61	0.67	15.30	6.41	41.88
2010T-128	10	72.00	72.00	57.00	39.00	7.04	9.71 *	15.79	19.00 *	1.35	22.00 *	6.59	145.00	2.60	770.16	0.93	12.50	11.33	90.68 *
2010T-139	10	72.00	69.00	51.00	23.00	7.46	8.78	17.65 *	19.00 *	1.52 *	22.00 *	9.55	210.00 *	3.20 *	1689.60 *	1.44 *	14.50	12.01	82.80 *
2010T-141	10	66.00	84.00 *	48.00	60.00 *	7.05	5.07	20.00 *	20.00 *	1.05	23.00 *	8.57	197.00	2.38	876.77	0.90	17.10	23.09 *	135.00 *
2010T-144	10	42.00	48.00	48.00	37.00	6.43	13.00 *	18.13 *	18.00	1.84 *	21.00	9.76 *	205.00 *	3.00 *	1449.64 *	1.33 **	15.00	18.45 *	123.03 *
2010T-146	10	78.00 *	69.00	48.00	28.00	7.38	8.57	16.88 *	18.60 *	1.55 *	21.60 *	9.26	200.00	2.69	1137.10 *	1.15 *	14.20	11.43	80.50
2010T-167	10	78.00 *	69.00	57.00	27.00	6.58	7.74	10.53	9.00	0.61	12.00	8.75	105.00	2.20	399.30	0.34	12.30	2.82	22.95
2010T-214	10	84.00 *	129.00 *	45.00	21.00	4.82	5.44	15.33	12.00	0.59	15.00	7.00	105.00	2.90 *	693.83	0.50	13.70	3.60	26.25
2010T-217	10	66.00	54.00	60.00	38.00	5.82	6.56	15.10	18.20 *	1.15	21.20	9.39	199.00	2.54	1008.75 *	0.85	16.80	13.57	80.75 *
2010T-282	10	63.00	75.00	93.00 *	56.00 *	6.52	9.56 *	10.65	22.00 *	1.43 *	25.00 *	10.80 *	270.00 *	2.40	1221.94 *	1.16 *	18.30	29.72 *	162.40 *
2010T-308	10	87.00 *	63.00	66.00	50.00 *	5.97	7.48	11.82	15.00	0.24	18.00	11.11 *	200.00	2.10	693.00	1.00 *	17.80	22.25 *	125.00 *
2010T-310	10	63.00	63.00	66.00	35.00	4.90	5.00	10.00	11.00	0.46	14.00	8.57	120.00	2.10	415.80	0.35	8.60	2.63	30.63
2010T-311	10	54.00	75.00	66.00	29.00	4.61	6.20	12.27	16.00	0.64	19.00	7.63	145.00	2.00	455.71	0.46	7.60	2.53	33.35
2010T-318	10	42.00	57.00	66.00	25.00	5.43	7.84	13.64	19.00 *	0.65	22.00 *	10.00 *	220.00 *	2.10	762.30	0.49	10.70	3.28	30.63
2010T-326	10	60.00	51.00	51.00	27.00	6.40	9.24 *	13.53	12.00	0.45	15.00	7.33	110.00	2.00	345.71	0.35	14.90	3.52	23.63
2010T-328	10	48.00	72.00	87.00 *	35.00	5.38	6.54	8.97	15.00	1.10	18.00	11.39 *	205.00 *	2.10	710.33	0.78	8.10	5.53	68.25
2010T-338	10	45.00	69.00	45.00	23.00	5.07	6.83	15.33	12.00	0.34	15.00	5.67	85.00	1.60	170.97	0.20	11.60	1.33	11.50
2010T-343	10	57.00	108.00 *	81.00 *	11.00	5.63	5.50	8.52	12.00	0.53	15.00	5.67	85.00	2.00	267.14	0.32	7.80	0.69	8.80

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	$t\ ha^{-1}$	$t\ ha^{-1}$
2010T-347	10	69.00	63.00	51.00	51.00 *	7.70	12.00 *	17.06 *	18.00	1.10	21.00	11.90 *	250.00 *	2.10	866.25	0.84	21.70 *	23.24 *	107.10 *
2010T-348	10	33.00	39.00	51.00	45.00 *	7.36	7.77	10.59	7.00	0.85	10.00	10.50 *	105.00	2.80 *	646.80	0.55	10.90	6.74	61.88
2010T-353	10	57.00	66.00	69.00 *	11.00	6.11	5.45	10.87	14.00	1.10	17.00	9.71 *	165.00	2.10	571.73	0.67	19.80 *	3.65	18.43
2010T-357	10	36.00	54.00	60.00	21.00	6.50	6.39	11.50	12.00	0.71	15.00	8.33	125.00	2.10	433.13	0.47	17.10	4.22	24.68
2010T-365	10	84.00 *	90.00 *	69.00 *	64.00 *	6.29	9.03 *	11.30	14.00	1.00	17.00	10.97 *	186.50	2.32	788.71	0.75	16.40	19.68 *	120.00 *
2010T-366	10	87.00 *	63.00	72.00 *	50.00 *	5.97	7.48	11.82	15.00	1.24	18.00	11.11 *	200.00	2.10	693.00	1.00 *	17.80	22.25 *	125.00 *
2010T-373	10	57.00	75.00	63.00	45.00 *	7.21	7.00	15.71	22.00 *	0.86	25.00 *	8.20	205.00 *	2.20	779.59	0.73	6.80	5.58	82.13 *
2010T-392	10	57.00	69.00	78.00 *	70.00 *	7.68	11.00 *	11.77	18.60 *	1.20	21.60 *	11.37 *	245.50 *	2.42	1129.66 *	0.90	18.70	29.45 *	157.50 *
2010T-394	10	57.00	60.00	63.00	20.00	5.05	6.90	13.81	18.00	1.58 *	21.00	8.57	180.00	2.90 *	1189.41 *	1.11 *	10.70	5.94	55.50
2010T-397	10	42.00	48.00	48.00	37.00	6.43	7.31	18.13 *	18.00	1.84 *	21.00	9.76 *	205.00 *	3.00 *	1449.64 *	1.33 *	13.00	15.99 *	123.03 *
2010T-398	10	30.00	43.33	33.00	11.00	5.78	7.69	21.82 *	13.00	1.07	16.00	10.63 *	170.00	2.20	646.49	0.72	9.10	1.80	19.80
2010T-399	10	39.00	51.00	57.00	30.00	7.69	10.18 *	13.68	15.00	1.23	18.00	9.17	165.00	3.00 *	1166.79 *	1.02 *	11.60	8.87	76.50
2010T-400	10	42.00	87.00 *	87.00 *	32.00	5.29	5.62	9.66	17.00	1.08	20.00	9.00	180.00	2.00	565.71	0.72	15.80	9.10	57.60
2010T-402	10	84.00 *	78.00	57.00	33.00	6.04	5.42	13.68	15.00	0.70	18.00	9.44	170.00	2.10	589.05	0.55	14.60	6.62	45.38
2010T-403	10	57.00	48.00	72.00 *	39.00	5.89	9.38 *	10.83	15.00	0.82	18.00	6.11	110.00	2.10	381.15	0.75	9.00	6.58	73.13
2010T-404	10	42.00	66.00	90.00 *	20.00	7.93	9.27 *	8.67	15.00	0.88	18.00	11.94 *	215.00 *	2.00	675.71	0.64	6.80	2.18	32.00
2010T-419	10	54.00	51.00	42.00	31.00	6.06	7.76	19.29 *	16.00	1.14	19.00	7.89	150.00	2.30	623.46	0.75	11.70	6.80	58.13
2010T-425	10	36.00	45.00	39.00	24.00	6.83	8.47	19.23 *	14.00	1.26	17.00	11.47 *	195.00	2.30	810.50	0.89	8.60	4.59	53.40
2010T-428	10	78.00 *	69.00	48.00	28.00	7.38	8.57	16.88 *	18.60 *	1.55 *	21.60 *	9.26	200.00	2.69	1137.10 *	1.15 *	14.20	11.43	80.50
Best check		76.32	81.11	66.84	41.50	8.00	8.86	16.50	18.09	1.39	21.32	9.58	200.02	2.75	953.07	0.97	19.58	14.06	80.57

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-85	11	66.00 *	90.00 *	51.00	40.00	6.36 *	7.63	15.18 *	13.80	1.20 *	16.80	11.49 *	193.00 *	2.36	844.59	0.85	16.80	14.28 *	85.00 *
2010T-123	11	81.00 *	72.00 *	69.00	42.00 *	5.00	7.83	12.17	17.00 *	1.19 *	20.00	8.00	160.00	2.90 *	1057.26 *	0.86	11.90	10.75	90.30 *
2010T-124	11	81.00 *	72.00 *	69.00	52.00 *	5.00	7.83	12.17	17.00 *	1.19 *	20.00	8.00	160.00	2.90 *	1057.26 *	0.86	13.90	15.54 *	111.80 *
2010T-126	11	51.00	66.00 *	39.00	49.00 *	5.94	7.68	26.15 *	23.00 *	1.49 *	26.00 *	9.62 *	250.00 *	2.30	1039.11 *	1.18 *	14.80	21.39 *	144.55 *
2010T-140	11	36.00	36.00	39.00	25.00	7.17 *	9.92 *	21.54 *	17.00 *	1.55 *	20.00	9.75 *	195.00 *	2.60	1035.73 *	1.24 *	9.40	7.29	77.50 *
2010T-150	11	30.00	42.00	45.00	21.00	6.90 *	6.36	21.33 *	21.00 *	1.54 *	24.00 *	10.42 *	250.00 *	2.20	950.71 *	1.18 *	15.20	9.42	61.95
2010T-151	11	42.00	69.00 *	66.00	25.00	6.50 *	8.00	13.18	18.00 *	1.61 *	21.00 *	10.00 *	210.00 *	2.50	1031.25 *	1.15 *	13.90	9.99	71.88
2010T-228	11	63.00 *	81.00 *	69.00	35.00	5.05	6.63	9.57	10.00	0.90	13.00	9.42 *	122.50	2.65	675.92	0.55	18.40	8.86	48.13
2010T-281	11	33.00	54.00	66.00	21.00	6.82 *	8.39	11.36	14.00	0.98	17.00	8.53	145.00	2.20	551.41	0.64	17.80	5.98	33.60
2010T-309	11	30.00	63.00	75.00 *	25.00	6.90 *	5.76	6.80	6.00	0.34	9.00	8.33	75.00	2.10	259.88	0.25	15.30	2.39	15.63
2010T-312	11	36.00	63.00	51.00	13.00	6.33 *	6.76	11.76	9.00	1.10 *	12.00	9.58 *	115.00	2.90 *	759.90	0.87	17.70	5.00	28.28
2010T-313	11	45.00	84.00 *	66.00	49.00 *	7.27 *	13.00 *	14.27 *	19.40 *	1.15 *	22.40 *	9.13 *	204.50 *	2.56	1053.02 *	0.70	16.40	14.06 *	85.75 *
2010T-314	11	51.00	66.00 *	39.00	30.00	5.94	7.68	26.15 *	23.00 *	1.00	26.00 *	9.62 *	250.00 *	2.30	1039.11 *	1.65 *	19.80 *	24.50 *	123.75 *
2010T-315	11	45.00	84.00 *	66.00	49.00 *	7.27 *	6.39	14.27 *	19.40 *	1.15 *	22.40 *	9.13 *	204.50 *	2.56	1053.02 *	0.70	16.40	14.06 *	85.75 *
2010T-316	11	39.00	36.00	54.00	45.00 *	5.92	7.42	13.89 *	14.00	1.12 *	17.00	9.24 *	157.00	2.50	770.98	0.79	13.80	12.26	88.88 *
2010T-317	11	33.00	57.00	96.00 *	17.00	6.00	7.42	8.44	16.00 *	0.76	19.00	8.16	155.00	1.90	439.65	0.54	11.70	2.69	22.95
2010T-319	11	48.00	54.00	63.00	39.00	6.69 *	8.94	12.86	16.00 *	1.18 *	19.00	10.53 *	200.00 *	2.40	905.14 *	0.90	11.11	9.75	87.75 *
2010T-320	11	33.00	48.00	48.00	21.00	6.64 *	5.50	16.88 *	16.00 *	0.96	19.00	7.89	150.00	2.60	796.71	0.75	17.30	6.81	39.38
2010T-321	11	48.00	48.00	51.00	43.00 *	5.63	9.50	15.88 *	16.00 *	1.05	19.00	8.16	155.00	2.80 *	954.80 *	0.95 *	16.30	16.65 *	102.13 *
2010T-322	11	48.00	54.00	72.00 *	37.00	6.31 *	9.28	10.42	14.00	0.77	17.00	8.82	150.00	2.10	519.75	0.55	14.10	7.17	50.88

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
2010T-323	11	57.00 *	63.00	84.00 *	29.00	5.21	5.10	7.86	11.00	1.24 *	14.00	11.79 *	165.00	2.60	876.39	0.83	15.00	9.03	60.18
2010T-324	11	42.00	69.00 *	48.00	20.00	6.71 *	7.13	19.38 *	20.00 *	1.96 *	23.00 *	9.13 *	210.00 *	3.20 *	1689.60 *	1.52 *	15.00	11.40	76.00 *
2010T-325	11	60.00 *	69.00 *	87.00 *	29.00	5.15	8.22	8.97	15.00	0.99	18.00	9.72 *	175.00	2.70	1002.38 *	0.84	12.10	7.37	60.90
2010T-329	11	30.00	45.00	72.00 *	12.00	10.00 *	10.13 *	10.83	15.00	0.53	18.00	12.22 *	220.00 *	1.60	442.51	0.40	10.20	1.22	12.00
2010T-393	11	30.00	57.00	72.00 *	25.00	5.80	3.63	8.75	10.00	0.81	13.00	11.15 *	145.00	2.20	551.41	0.58	14.50	5.26	36.25
2010T-395	11	54.00	60.00	48.00	23.00	5.00	7.50	11.88	8.00	0.80	11.00	10.91 *	120.00	3.60 *	1221.94 *	0.62	10.60	3.78	35.65
2010T-396	11	39.00	45.00	57.00	32.00	7.38 *	6.20	13.16	13.00	1.20 *	16.00	10.84 *	173.50	2.62	935.76 *	0.90	17.00	12.24	72.00
2010T-401	11	57.00 *	75.00 *	60.00	39.00	5.53	6.92	9.50	8.00	0.48	11.00	10.45 *	115.00	2.50	564.73	0.36	15.80	5.55	35.10
2010T-417	11	45.00	78.00 *	84.00 *	49.00 *	5.73	6.85	10.36	18.00 *	1.12 *	21.00 *	10.00 *	210.00 *	2.30	872.85	0.81	20.00 *	19.85 *	99.23 *
2010T-418	11	39.00	57.00	51.00	19.00	5.77	7.47	12.94	11.00	0.75	14.00	9.64 *	135.00	2.40	610.97	0.58	17.90	4.93	27.55
2010T-420	11	69.00 *	45.00	54.00	23.00	5.57	6.60	10.00	7.00	0.40	10.00	11.00 *	110.00	1.20	124.46	0.32	20.40 *	3.75	18.40
2010T-421	11	51.00	48.00	54.00	41.00	7.29 *	10.50 *	15.44 *	15.80 *	1.40 *	18.80	8.51	160.00	2.35	694.26	1.00 *	15.90	16.30 *	102.50 *
2010T-422	11	108.00 *	75.00 *	75.00 *	34.00	5.47	7.64	11.44	16.60 *	1.50 *	19.60	9.57 *	187.50 *	2.69	1066.03 *	1.00 *	14.80	12.58	85.00 *
2010T-423	11	87.00 *	84.00 *	48.00	42.00 *	5.52	7.21	14.38 *	12.00	1.70 *	15.00	12.33 *	185.00 *	3.00 *	1308.21 *	1.17 *	9.40	11.55	122.85 *
2010T-424	11	48.00	73.33 *	51.00	13.00	6.69 *	4.27	12.94	11.00	1.41 *	14.00	10.00 *	140.00	3.30 *	1197.90 *	1.00 *	11.60	3.77	32.50
2010T-426	11	54.00	51.00	57.00	30.00	4.83	6.41	12.11	12.00	0.79	15.00	8.00	120.00	3.00 *	848.57	0.68	11.20	5.71	51.00
2010T-427	11	36.00	72.00 *	75.00 *	38.00	7.42 *	7.38	12.40	20.00 *	0.80	23.00 *	11.52 *	265.00 *	2.60	1407.53 *	0.70	10.30	6.85	66.50
2010T-429	11	51.00	72.00 *	75.00 *	41.00	7.42 *	7.38	12.40	20.00 *	1.20 *	23.00 *	11.52 *	265.00 *	2.60	1407.53 *	0.95 *	18.30	17.82 *	97.38 *
2010T-430	11	39.00	63.00	90.00 *	48.00 *	7.08 *	7.62	13.00	18.80 *	1.25 *	21.80 *	8.12	177.00	2.61	947.37 *	1.05 *	18.70	23.56 *	126.00 *
Best check		54.82	64.86	69.09	41.00	6.00	9.61	13.75	15.59	1.08	20.82	8.83	182.77	2.75	891.57	0.93	19.51	12.61	73.80

Appendix .A. contd.....

Genotype	Block	T 120	SP 180	SP 240	NMC	NGL90	NGL120	NGL240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm^3	kg	%	t ha^{-1}	t ha^{-1}
Best check		Co 6907	Co 6907	Co 6907	Co 6907	Co 6907	Co 7219	Co86032	Co86032	Co86032	Co 7219	Co 7219	Co 7219	Co86032	Co86032	Co86032	2003V46	Co 7219	Co 7219
SEm		12.79	13.17	8.32	3.63	1.14	1.74	3.48	3.54	0.22	3.01	1.10	21.73	0.23	170.54	0.15	1.98	2.43	11.23
CD		25.06	25.81	16.32	7.12	2.24	3.40	6.83	6.94	0.43	5.90	2.15	42.59	0.45	334.25	0.30	3.88	4.76	22.02
CV		17.45	17.59	13.18	8.96	13.79	18.60	19.52	20.87	18.60	13.48	11.31	11.58	8.24	20.11	17.20	10.04	18.75	14.84

T 120 - Tiller number per plot at 120 DAP

SP 180 - Shoot population per plot at 180 DAP

SP 240 - Shoot population per plot at 240 DAP

NMC - Number of millable canes per plot at harvest

NGL 90 - Number of green leaves per plant at 90 DAP

NGL 120 - Number of green leaves per plant at 120 DAP

NGL 240 - Number of green leaves per plant at 240 DAP

NGL M - Number of green leaves per plant at maturity

BM - Biomass per cane at harvest

IN No. - Number of internodes per cane

IN L - Internode length

SL - Stalk length

SD - Stalk diameter

SV - Stalk volume

SCW - Single cane weight

HRB - HR Brix

HRBY - HR Brix yield

CY - Cane yield

* Genotypes showing higher performance than the best respective check

Plate 1a. Field view of sugarcane crop in first clonal stage

Plate 1b. Field view of sugarcane crop in second clonal stage

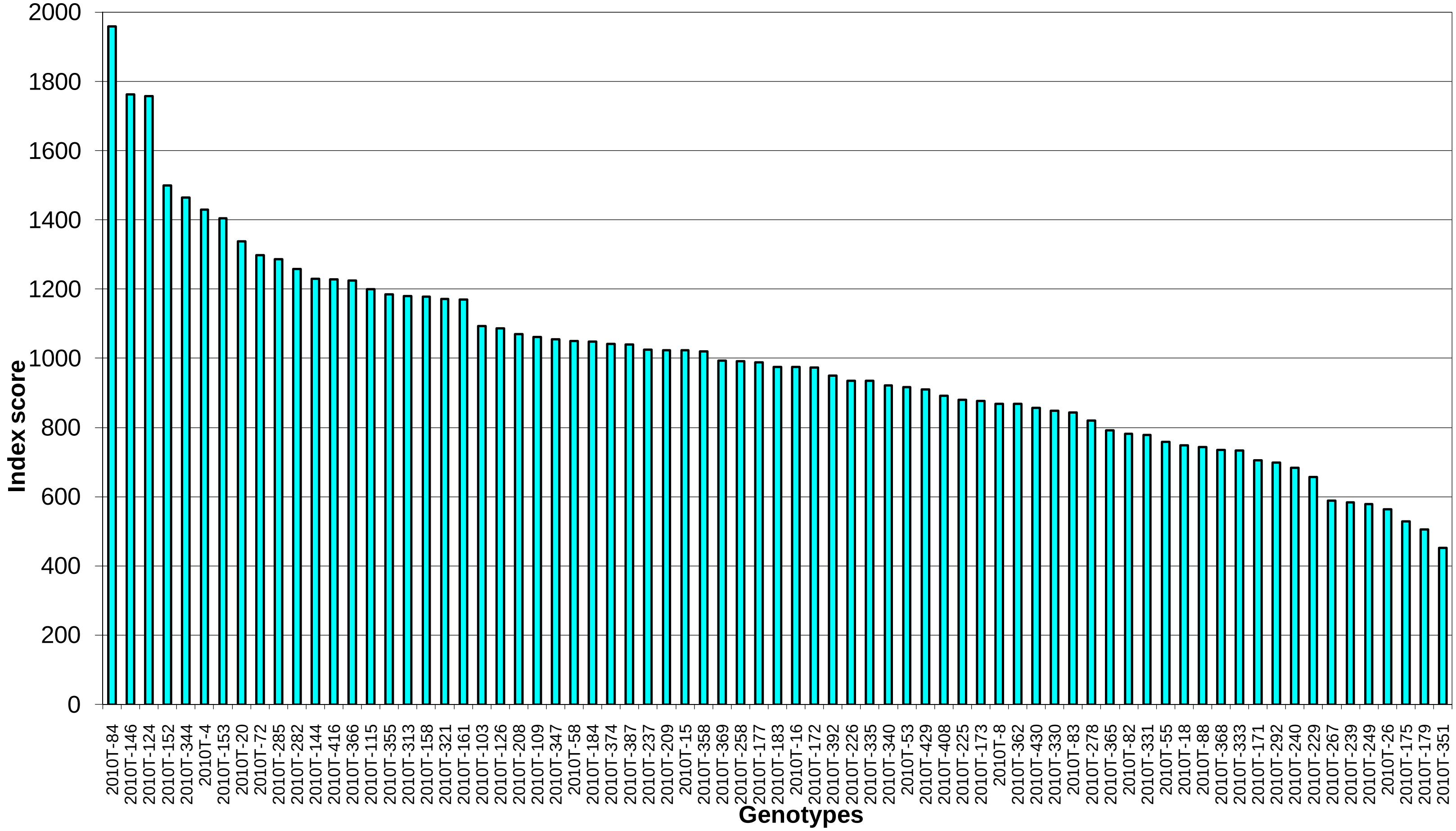

Figure 4.1. Selection index score of sugarcane genotypes for cane yield

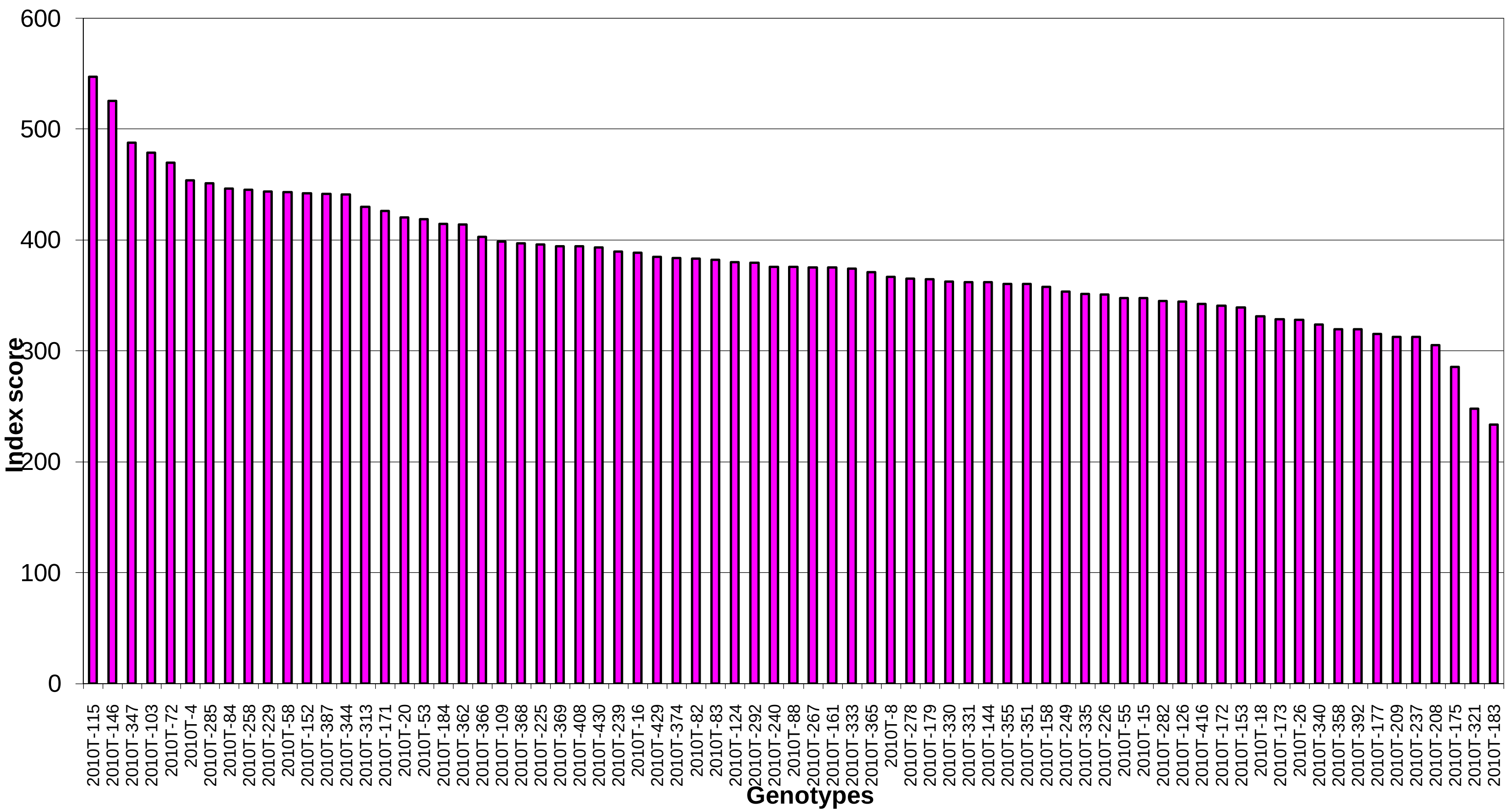

Figure 4.2. Selection index score of sugarcane genotypes for fibre yield

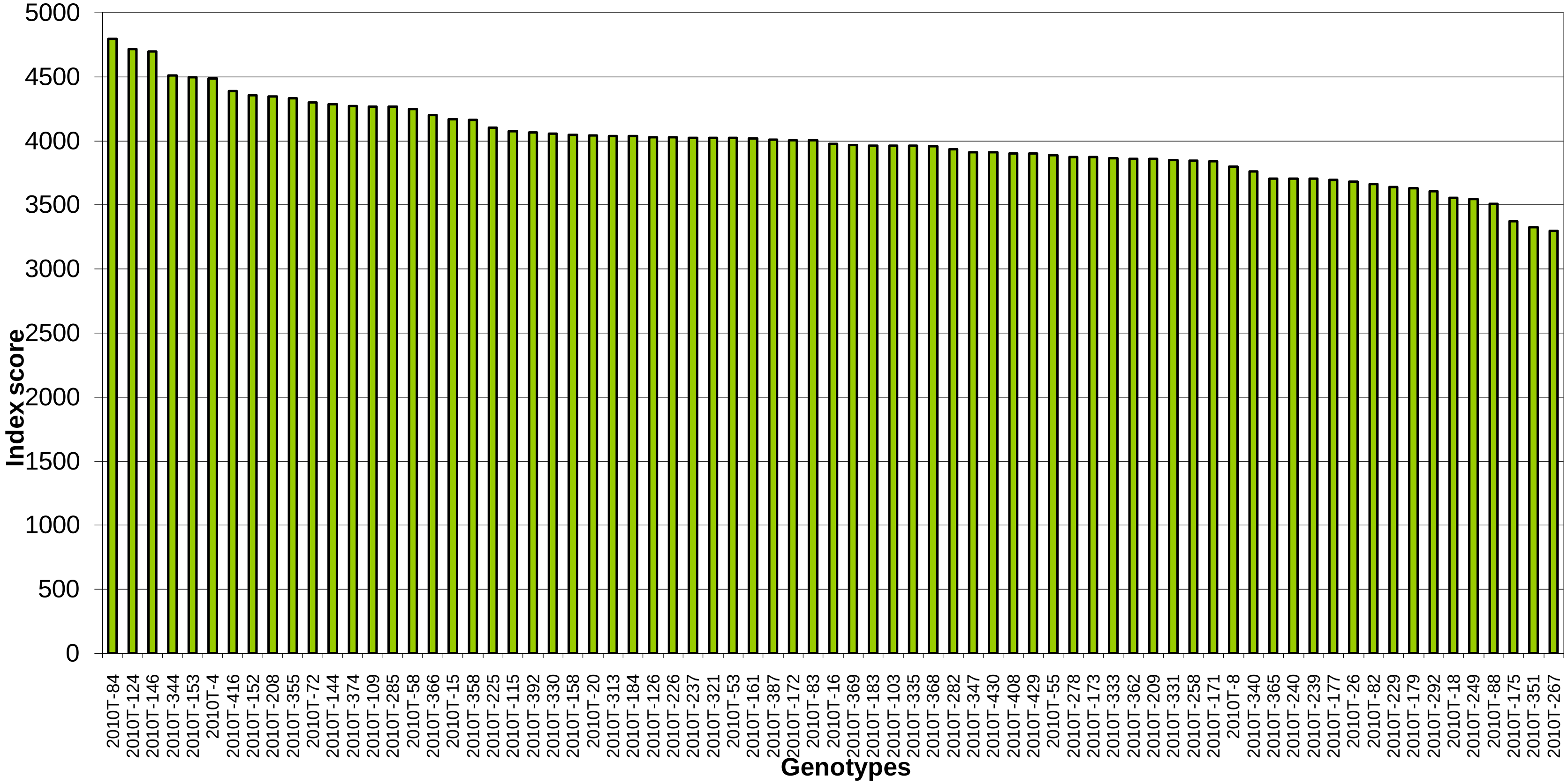

Figure 4.3. Selection index score of sugarcane genotypes for biomass

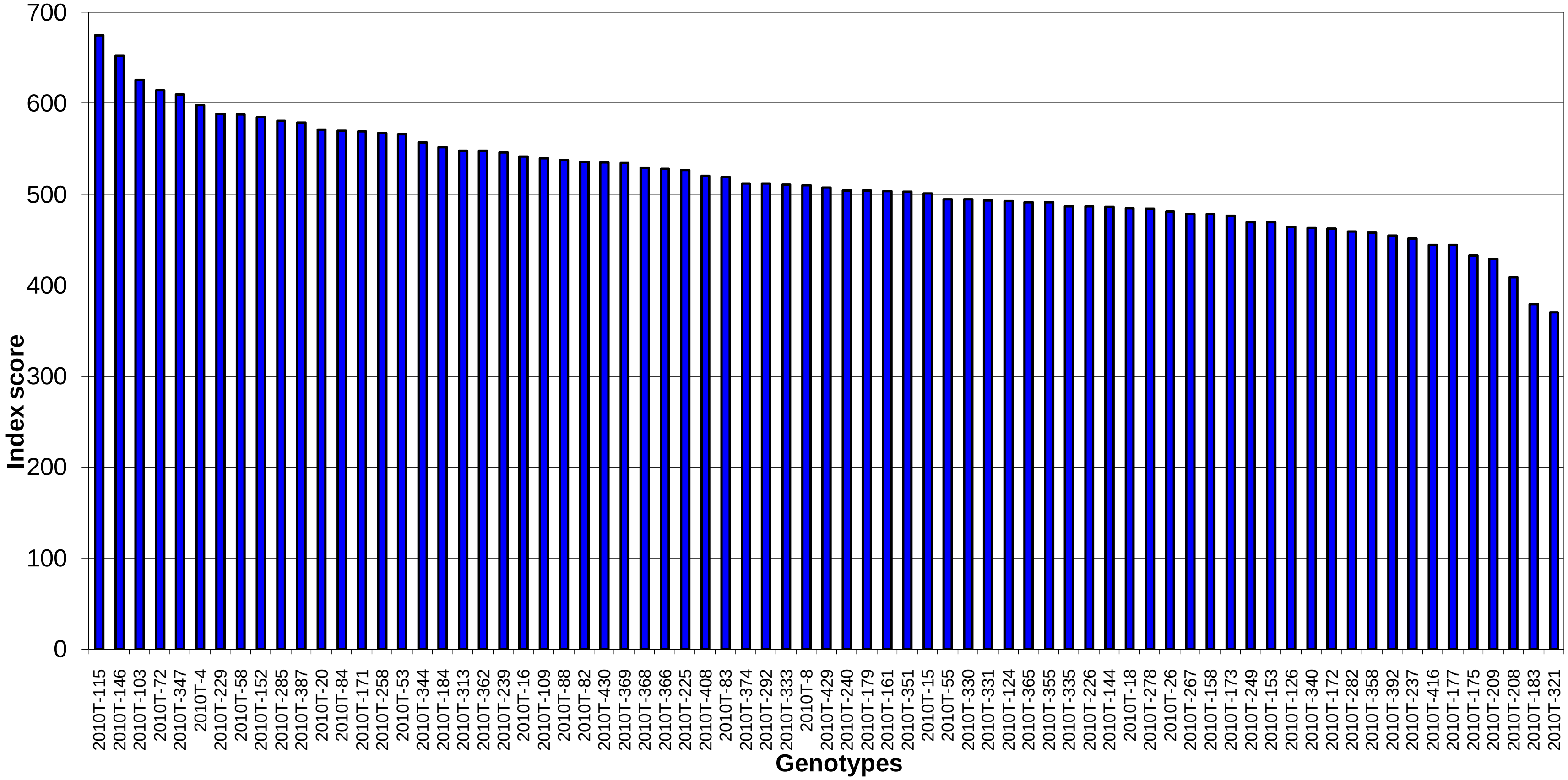

Figure 4.4. Selection index score of sugarcane genotypes for commercial cane sugar yield

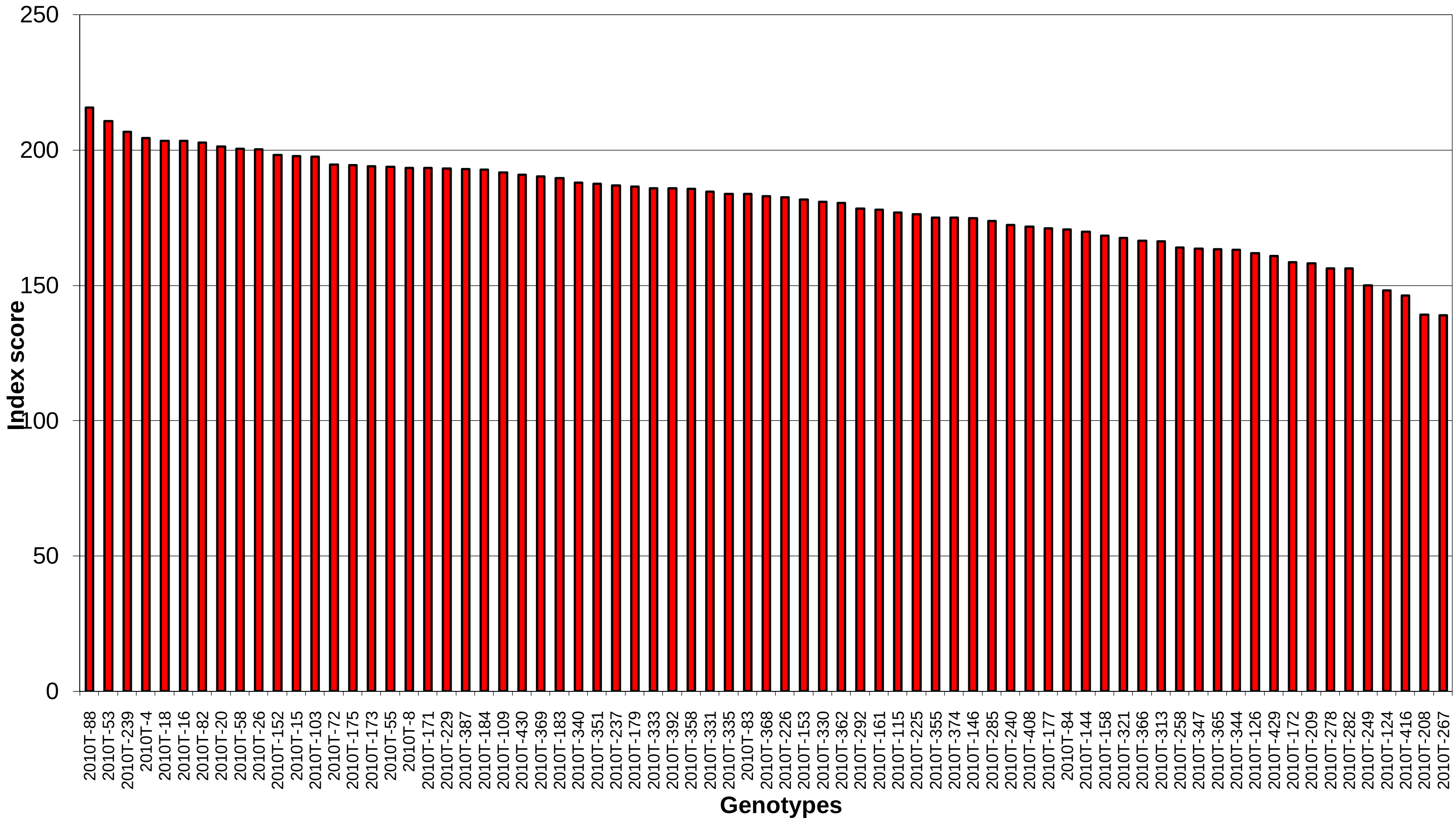

Figure 4.5. Selection index score of sugarcane genotypes for theoretical yield of alcohol.

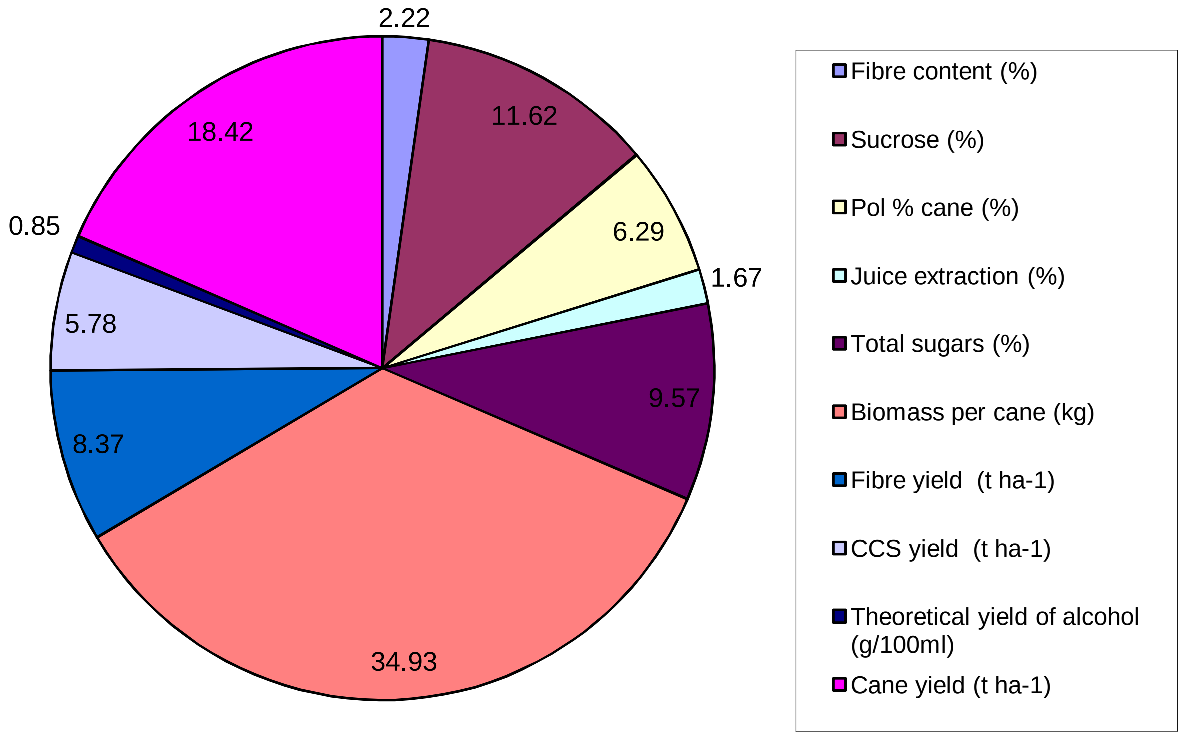

Figure 4.6. Contribution of different characters to divergence

Table 3.1. Pedigree of the genotypes selected in seedling nursery of sugarcane

S.No	Pedigree	Selections		No. of
Station crosses		**From**	**To**	**Selections**
1	Co 8371 x CoV 92102	2010T-152	2010T-160	9
2	Co 98008 x Co 89003	2010T-175	2010T-188	14
3	81 V 48 x Co 94005	2010T-364	2010T-378	15
4	93 A 145 x Co A 7602	2010T-407	2010T-411	5
5	Co 94008 x 79 R 207	2010T-412	2010T-420	9
6	KMS 2095 x Co V 92102	2010T-421	2010T-427	7
7	Co 85002 x Co V 92102	2010T-428	2010T-430	3
Zonal crosses				
1	Co 8371 x Co T 8201	2010T-28	2010T-36	9
2	Co 86032 x Co 86250	2010T-68	2010T-69	2
3	Co 86002 x ISH 69	2010T-87	2010T-91	5
4	Co 8213 x Co T 8201	2010T-173	2010T-174	2
5	CoC 671 x Co T 8201	2010T-342	2010T-343	2
6	Co 95021 x Co 97015	2010T-355	2010T-360	6
7	Co Snk 03-044 x Co 775	2010T-379	2010T-406	28
Poly crosses				
1	Co M 0265	2010T-1	2010T-4	4
2	Co N Snk03-044	2010T-5	2010T-27	23
3	Co 8371	2010T-37	2010T-43	7
4	Co 85002	2010T-302	2010T-326	25
5	ISH 100	2010T-327	2010T-329	3
6	Co 94012	2010T-330	2010T-335	6
7	Co 7201	2010T-336	2010T-341	6
General collections				
1	Co N 85134	2010T-44	2010T-67	24
2	Co 89003	2010T-70	2010T-86	17
3	Co M 6806	2010T-92	2010T-128	37
4	Co(Si)6	2010T-129		1
5	Co N 98133	2010T-130	2010T-141	12
6	Co Sn 86572	2010T-142	2010T-151	10
7	81 V 78	2010T-161	2010T-167	7
8	HR 83-65	2010T-168	2010T-172	5
9	B 096	2010T-189	2010T-217	29
10	Co 88039	2010T-218	2010T-282	64
11	Co 92008	2010T-283	2010T-301	19
12	Co 92020	2010T-344	2010T-345	2
13	Co 8338	2010T-346	2010T-350	5
14	Co 8347	2010T-351	2010T-354	4
15	Co 0239	2010T-361	2010T-363	3
			TOTAL	429

Table 3.2. Salient features of the four check varieties of sugarcane

S.No	Variety	Parentage	Year of release and station	Characteristic features
1	Co 6907	Co 740 x Co 1287	1979, Regional Sugarcane & Rice Research Station, Rudrur	Semi-erect, yellow, medium thick cane, medium bud, pithiness present, medium NMC, tall plant, early, suitable for all situations, susceptible to smut in ratoon.
2	Co 7219 (Sanjeevani)	Co 449 x Co 758	1981, Regional Sugarcane & Rice Research Station, Rudrur	Semi-erect, yellowish green, medium cane, medium bud, pithiness absent, medium NMC and medium height, mid late, tolerant to red rot in field conditions, rich in sucrose, susceptible to smut.
3	Co 86032 (Nayana)	Co 62198 x CoC 671	2000, Sugarcane Breeding Institute, Coimbatore	Semi-erect, light purple thick cane, medium bud, pithiness absent, high NMC and tae, plant, mid late, smut resistant, susceptible to red rot
4	2003 V 46 (Bharani)	86 A 146 x Co V 92102	2010, Agricultural Research Station, Vuyyuru	Erect, dark purple thick cane, medium bud, pithiness absent, medium NMC and medium height, early, non lodging, synchronous in tillering, suitable to delayed harvesting, resistant to red rot and smut.

Table 4.1. Analysis of variance for eighteen characters in first clonal stage of sugarcane

S.No	Character	Mean squares			
		Block	Entries	Checks	Error
		df = 10	df = 432	df = 3	df = 30
1	Tillers at 120 DAP	5960.81**	402.14**	378.45*	124.06
2	Shoot population at 180 DAP	619.93**	371.63**	628.87**	131.52
3	Shoot population at 240 DAP	1160.34**	247.45**	275.94**	52.57
4	NMC at harvest	495.52**	180.11**	392.93**	10.00
5	No. of green leaves at 90 DAP	21.74**	3.39**	3.06*	0.99
6	No. of green leaves at 120 DAP	11.94**	5.36**	4.94	2.29
7	No. of green leaves at 240 DAP	55.19**	15.24*	5.39	9.21
8	No. of green leaves at maturity	74.41**	16.69*	16.76	9.51
9	Biomass per cane (kg)	0.45**	0.15**	0.25**	0.04
10	No. of internodes per cane	76.06**	16.42**	7.78	6.86
11	Internode length (cm)	14.58**	3.72**	6.45**	0.92
12	Stalk length (cm)	17976.22**	1925.72**	3432.99**	358.24
13	Stalk diameter (cm)	1.06**	0.12**	0.65**	0.04
14	Stalk volume (cm^3)	406059.80**	95657.06**	48147.72	22062.86
15	Single cane weight (kg)	0.32**	0.09**	0.12**	0.02
16	HR brix (%)	11.48**	12.17**	60.73**	2.97
17	HR brix yield ($t\ ha^{-1}$)	83.15**	41.62**	34.24**	4.48
18	Cane yield ($t\ ha^{-1}$)	4159.39**	1463.11**	487.11**	95.74

** Significant at 1% level

* Significant at 5% level

Table 4.2. Range, mean and number of genotypes showing higher performance than the best check for different characters in first clonal stage in sugarcane

S.No.	Charater	Range		General Mean	Best check	No. of genotypes
		Min	Max			
1	Tillers at 120 DAP	30.00	180.00	75.09	Co 6907 (54.82)	239
2	Shoot population at 180 DAP	33.00	195.00	67.02	Co 6907 (64.86)	139
3	Shoot population at 240 DAP	30.00	162.00	63.66	Co 6907 (69.09)	228
4	NMC at harvest	4.00	75.00	34.37	Co 6907 (41.00)	129
5	No. of green leaves at 90 DAP	4.24	18.00	7.44	Co 6907 (6.00)	123
6	No. of green leaves at 120 DAP	3.63	23.00	8.41	Co 7219 (9.61)	151
7	No. of green leaves at 240 DAP	3.70	26.15	13.57	Co 86032 (13.75)	101
8	No. of green leaves at maturity	5.00	27.00	15.63	Co 86032 (15.59)	184
9	Biomass per cane (kg)	0.28	2.60	0.99	Co 86032 (1.08)	141
10	No. of internodes per cane	8.00	30.00	18.62	Co 7219 (20.82)	163
11	Internode length (cm)	2.81	19.17	9.59	Co 7219 (8.83)	254
12	Stalk length (cm)	45.00	340.00	177.04	Co 7219 (182.77)	207
13	Stalk diameter (cm)	1.10	3.60	2.26	Co 86032 (2.75)	64
14	Stalk volume (cm^3)	124.46	2094.40	734.53	Co 86032 (891.57)	168
15	Single cane weight (kg)	0.10	1.84	0.75	Co 86032 (0.93)	111
16	HR brix (%)	4.60	22.60	14.33	2003 V46 (19.51)	21
17	HR brix yield (t ha^{-1})	0.48	33.75	9.55	Co 7219 (12.61)	119
18	Cane yield (t ha^{-1})	4.75	253.75	65.58	Co 7219 (73.8)	166

Table 4.3. Phenotypic correlation coefficients between different traits among four hundred and thirty three genotypes in first clonal stage of sugarcane

	Shoot population		Number of milla ble canes	Number of green leaves at				Biomass per cane	Inter node number	Inter node length	Stalk length	Stalk diameter	Stalk volume	Single cane weight	HR Brix	HR Brix yield	Cane yield
	180 DAP	240 DAP		90 DAP	120 DAP	240 DAP	maturity										
	SP 180	SP 240	NMC	NGL 90	NGL 120	NGL 240	NGLM	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
T 120	0.508**	0.389**	0.052	0.098*	0.008	-0.274**	-0.038	-0.110*	-0.027	-0.031	-0.064	-0.104*	-0.122*	-0.129**	-0.016	-0.050	-0.046
SP 180		0.362**	-0.049	-0.058	-0.246**	-0.322**	-0.142**	-0.086	-0.134**	0.046	-0.106*	0.014	-0.063	-0.099*	0.002	-0.063	-0.083
SP240			0.053	0.030	-0.055	-0.731**	-0.062	-0.118*	-0.059	-0.020	-0.070	-0.089	-0.110*	-0.165**	-0.123*	-0.074	-0.062
NMC				0.294**	0.334**	0.096	0.182**	0.158**	0.186**	0.204**	0.307**	-0.089	0.117*	0.124*	0.081	0.677**	0.716**
NGL90					0.546**	0.173**	0.175**	0.123*	0.195**	0.064	0.213**	-0.006	0.122*	0.145**	0.159**	0.315**	0.291**
NGL120						0.231**	0.174**	0.232**	0.188**	0.053	0.219**	0.066	0.179**	0.228**	0.171**	0.425**	0.383**
NGL240							0.561**	0.442**	0.553**	-0.063	0.440**	0.169**	0.398**	0.461**	0.173**	0.372**	0.362**
NGLM								0.596**	0.989**	-0.194**	0.722**	0.131**	0.545**	0.562**	0.032	0.418**	0.482**
BM									0.592**	0.154**	0.630**	0.532**	0.802**	0.842**	0.063	0.585**	0.654**
IN No.										-0.196**	0.729**	0.134**	0.551**	0.560**	0.034	0.418**	0.482**
IN L											0.504**	-0.059	0.233**	0.171**	0.052	0.244**	0.242**
SL												0.073	0.647**	0.611**	0.083	0.552**	0.601**
SD													0.778**	0.488**	0.019	0.235**	0.263**
SV														0.770**	0.072	0.522**	0.579**
SCW															0.064	0.662**	0.743**
HRB																0.431**	0.118*
HRBY																	0.925**

** Significant at 1% level * Significant at 5% level T 120 = Tillers number per plot at 120 DAP

Table 4.4. Phenotypic path coefficients of fourteen characters on cane yield in first clonal stage in sugarcane

	NMC at harvest	Number of green leaves at				Biomass per cane	Internode number	Internode length	Stalk length	Stalk diameter	Stalk volume	Singlecane weight	HR Brix	HR brix yield	Cane yield "r"
		90 DAP	120 DAP	240 DAP	Maturity										
	NMC	NGL 90	NGL 120	NGL 240	NGLM	BM	IN No	IN L	SL	SD	SV	SCW	HRB	HRBY	CY
NMC	**0.297**	0.002	-0.005	-0.001	0.001	-0.001	-0.015	-0.015	0.023	0.003	0.004	0.042	-0.014	0.394	0.716**
NGL 90	0.087	**0.008**	-0.008	-0.002	0.001	-0.001	-0.016	-0.005	0.016	0.000	0.004	0.049	-0.028	0.183	0.291**
NGL 120	0.099	0.005	**-0.015**	-0.002	0.001	-0.001	-0.016	-0.004	0.016	-0.002	0.006	0.077	-0.030	0.247	0.383**
NGL 240	0.029	0.001	-0.003	**-0.010**	0.004	-0.002	-0.046	0.005	0.033	-0.005	0.014	0.157	-0.031	0.217	0.362**
NGLM	0.054	0.001	-0.003	-0.005	**0.008**	-0.003	-0.082	0.014	0.054	-0.004	0.019	0.191	-0.006	0.243	0.482**
BM	0.047	0.001	-0.003	-0.004	0.005	**-0.005**	-0.049	-0.011	0.047	-0.016	0.027	0.286	-0.011	0.341	0.654**
IN No	0.055	0.002	-0.003	-0.005	0.008	-0.003	**-0.083**	0.014	0.055	-0.004	0.019	0.190	-0.006	0.243	0.482**
IN L	0.061	0.001	-0.001	0.001	-0.002	-0.001	0.016	**-0.071**	0.038	0.002	0.008	0.058	-0.009	0.142	0.242**
SL	0.091	0.002	-0.003	-0.004	0.006	-0.003	-0.060	-0.036	**0.075**	-0.002	0.022	0.207	-0.015	0.321	0.601**
SD	-0.026	0.000	-0.001	-0.002	0.001	-0.002	-0.011	0.004	0.005	**-0.031**	0.027	0.166	-0.003	0.137	0.263**
SV	0.035	0.001	-0.003	-0.004	0.004	-0.004	-0.046	-0.017	0.048	-0.024	**0.034**	0.261	-0.013	0.304	0.579**
SCW	0.037	0.001	-0.003	-0.004	0.004	-0.004	-0.046	-0.012	0.046	-0.015	0.026	**0.339**	-0.011	0.385	0.743**
HRB	0.024	0.001	-0.002	-0.002	0.000	0.000	-0.003	-0.004	0.006	-0.001	0.002	0.022	**-0.177**	0.251	0.118*
HRBY	0.201	0.003	-0.006	-0.004	0.003	-0.003	-0.035	-0.017	0.041	-0.007	0.018	0.225	-0.077	**0.582**	0.925**

Residual effect = 0.154

Bold diagonal values indicate direct effects

** Significant at 1% level

* Significant at 5% level

Table 4.5. Mean performance of seventy seven genotypes for different characters in ratoon crop of first clonal stage of sugarcane

S No	Genotype	T 120	SP 180	SP 240	NMC	NGL 90	NGL 120	NGL 240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY	Ratoona-bility
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm3	kg	%	t ha^{-1}	t ha^{-1}	for CY (%)
1	2010T- 4	53	40	32	14	31	38	18	15	1.34	19.2	9.22	177	2.76	1059.39	1.15	18.4	7.41	40.25	45.74
2	2010T- 8	65	81	87	45	52	13	31	17	1.09	21.0	10.81	227	2.56	1168.88	0.94	20.3	21.47	105.75	87.31
3	2010T- 15	75	63	59	42	49	30	48	19	1.05	24.6	9.59	236	2.22	913.87	0.90	20.7	19.56	94.50	89.15
4	2010T- 16	95	42	92	43	20	11	19	18	0.88	23.2	8.58	199	2.58	1040.78	0.81	20.7	18.02	87.08	78.98
5	2010T- 18	48	44	53	35	27	18	38	21	1.16	28.0	9.43	264	2.64	1445.69	1.08	20.5	19.37	94.50	95.45
6	2010T- 20	103	58	102	43	59	14	41	18	0.84	24.0	9.38	225	2.14	809.61	0.65	21.6	15.09	69.88	59.97
7	2010T- 26	70	54	72	39	19	15	18	18	1.10	24.2	9.38	227	2.36	993.38	0.60	21.2	12.40	58.50	59.15
8	2010T- 53	90	95	138	49	17	28	20	18	1.01	22.0	10.14	223	2.24	879.16	0.65	21.2	16.88	79.63	86.74
9	2010T- 55	74	77	83	47	17	14	20	19	1.10	25.8	9.46	244	2.26	979.20	0.70	18.6	15.30	82.25	68.51
10	2010T- 58	83	51	120	43	11	25	18	13	0.90	22.8	9.69	221	2.08	751.25	0.74	21.4	17.02	79.55	58.12
11	2010T- 72	95	78	130	45	17	16	19	17	1.33	21.4	12.24	262	2.48	1266.10	1.10	20.9	25.86	123.75	74.44
12	2010T- 82	77	40	35	17	28	23	16	11	1.08	20.6	8.45	174	2.54	882.03	0.93	20.3	8.02	39.53	58.66
13	2010T- 83	43	36	36	24	49	24	18	18	1.15	21.2	7.36	156	2.43	723.77	0.80	20.5	11.55	56.33	78.08
14	2010T- 84	47	25	38	18	15	14	17	15	1.53	19.4	9.18	178	3.04	1292.50	1.31	15.1	8.90	58.95	51.71
15	2010T- 88	46	22	15	7	24	12	17	11	0.29	12.8	8.28	106	2.14	381.42	0.26	21.9	1.00	4.55	6.54
16	2010T- 103	116	73	58	32	21	18	16	16	1.25	23.6	10.47	247	2.22	956.46	1.03	17.5	14.42	82.40	79.14
17	2010T- 109	87	53	108	33	29	24	20	18	1.30	22.8	9.87	225	2.62	1213.53	0.95	21.0	16.46	78.38	51.23

Table 4.5. (cont.)

S No	Genotype	T 120	SP 180	SP 240	NMC	NGL 90	NGL 120	NGL 240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY	Ratoona-bility
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm3	kg	%	t ha^{-1}	t ha^{-1}	for CY(%)
18	2010T- 115	99	83	78	53	11	11	18	18	1.10	25.4	10.08	256	2.04	837.08	0.80	18.5	19.61	106.00	75.15
19	2010T- 124	79	47	64	36	22	16	20	18	1.40	23.6	9.32	220	2.98	1535.04	1.16	15.2	15.87	104.40	93.38
20	2010T- 126	78	54	72	30	12	11	17	18	1.21	25.2	8.41	212	2.96	1459.43	1.03	14.5	11.20	77.25	53.44
21	2010T- 144	25	24	22	12	11	12	20	20	0.95	26.6	6.43	171	2.70	979.46	0.79	18.5	4.38	23.70	19.26
22	2010T- 146	38	37	31	10	11	11	20	16	1.33	19.8	7.47	148	3.12	1131.97	1.05	22.0	5.78	26.25	32.61
23	2010T- 152	56	35	46	26	17	21	17	16	1.58	22.2	11.04	245	2.98	1709.48	1.54	18.6	18.62	100.10	83.42
24	2010T- 153	65	31	58	32	14	31	18	16	1.78	21.6	11.39	246	3.18	1954.58	1.55	17.5	21.70	124.00	96.78
25	2010T- 158	56	47	103	43	17	16	13	11	0.63	13.0	11.52	149	2.39	671.63	0.56	17.2	10.40	60.39	62.01
26	2010T- 161	80	59	98	37	13	12	20	18	1.30	22.4	8.66	194	2.28	792.38	1.05	18.8	18.26	97.13	90.35
27	2010T- 171	70	30	32	17	11	26	19	14	0.44	15.8	9.75	154	1.90	436.81	0.43	19.6	3.58	18.28	16.52
28	2010T- 172	55	47	72	34	9	16	18	17	1.20	23.4	9.32	218	2.60	1157.89	0.95	18.0	14.54	80.75	71.40
29	2010T- 173	85	53	107	43	38	17	20	16	1.01	18.6	9.78	182	2.44	851.36	0.86	17.7	16.36	92.45	74.93
30	2010T- 175	83	74	68	32	10	10	19	16	0.95	19.4	10.67	207	2.76	1238.95	0.86	20.9	14.38	68.80	55.04
31	2010T- 177	81	54	45	30	12	11	16	15	0.91	21.8	10.18	222	2.24	875.21	0.76	19.1	10.89	57.00	57.00
32	2010T- 179	74	37	30	12	12	16	17	17	1.32	23.6	11.57	273	2.38	1215.01	1.05	21.6	6.80	31.50	41.18
33	2010T- 183	87	49	70	41	13	15	18	17	1.40	23.0	9.30	214	3.02	1533.53	1.21	15.8	19.60	124.03	84.37
34	2010T- 184	65	48	42	26	15	11	16	16	1.40	22.8	8.29	189	2.96	1301.10	1.20	16.1	12.56	78.00	72.47

Table 4.5. (cont.)

S No	Genotype	T 120	SP 180	SP 240	NMC	NGL 90	NGL 120	NGL 240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY	Ratoona-bility
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm3	kg	%	t ha^{-1}	t ha^{-1}	for CY(%)
35	2010T- 208	2	9	11	15	26	11	27	13	0.20	14.0	10.76	151	1.63	314.81	0.17	20.6	1.29	4.20	4.39
36	2010T- 209	78	72	98	36	11	9	20	18	1.02	22.0	8.59	189	2.42	869.68	0.78	10.2	7.16	70.20	83.57
37	2010T- 225	44	52	61	39	10	12	22	19	0.72	23.4	10.26	240	1.94	709.71	0.61	13.6	8.09	59.48	66.08
38	2010T- 226	50	33	27	17	8	8	16	12	0.45	15.4	9.22	142	2.28	579.99	0.41	16.9	2.94	17.43	13.90
39	2010T- 229	69	71	69	42	10	22	16	15	0.87	20.4	7.75	158	2.12	557.95	0.50	22.7	11.92	52.50	63.83
40	2010T- 237	88	53	54	43	28	16	18	16	0.72	20.2	9.95	201	2.02	644.41	0.57	19.7	12.07	61.28	41.54
41	2010T- 239	61	60	79	38	19	20	20	16	0.86	18.8	11.12	209	1.98	643.79	0.65	13.8	8.52	61.75	76.00
42	2010T- 240	57	55	54	29	8	10	15	15	1.18	21.2	11.37	241	2.12	851.05	0.93	17.8	12.00	67.43	64.49
43	2010T- 249	63	42	55	32	19	7	15	11	0.80	13.4	14.18	190	2.30	789.72	0.64	18.9	9.68	51.20	66.93
44	2010T- 258	79	59	80	44	19	11	15	14	0.96	20.4	10.83	221	2.16	810.15	0.82	20.3	18.31	90.20	80.54
45	2010T- 267	81	73	123	52	16	10	20	16	0.85	19.0	11.11	211	1.82	549.15	0.63	20.2	16.54	81.90	64.11
46	2010T- 278	80	65	82	52	17	22	18	16	1.08	20.0	10.20	204	1.98	628.38	0.77	15.8	15.82	100.10	71.50
47	2010T- 282	144	99	154	62	19	18	20	17	1.19	20.8	10.58	220	2.50	1080.36	0.99	19.1	29.31	153.45	94.49
48	2010T- 285	135	62	90	37	13	12	16	13	1.20	16.8	10.65	179	2.56	921.72	0.95	13.0	11.42	87.88	88.10
49	2010T- 292	80	75	132	51	30	13	20	15	0.94	16.6	10.60	176	2.68	993.22	0.78	15.0	14.92	99.45	53.64
50	2010T- 313	35	28	48	16	8	16	20	14	0.73	15.2	6.05	92	2.76	550.64	0.68	19.0	5.17	27.20	31.72
51	2010T- 321	57	13	9	13	9	6	7	13	0.27	14.3	6.96	100	2.07	334.01	0.21	19.8	1.32	3.70	3.62

Table 4.5. (cont.)

S No	Genotype	T 120	SP 180	SP 240	NMC	NGL 90	NGL 120	NGL 240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY	Ratoona-bility
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm3	kg	%	t ha^{-1}	t ha^{-1}	for CY(%)
52	2010T- 330	63	54	109	51	19	19	20	18	1.26	22.8	9.96	227	2.42	1044.53	1.00	16.7	21.29	127.50	83.33
53	2010T- 331	83	62	130	43	25	13	20	17	1.07	21.2	10.24	217	2.28	886.33	0.85	18.3	16.72	91.38	80.15
54	2010T- 333	95	62	82	58	15	11	15	14	0.69	19.8	9.65	191	2.08	649.27	0.55	15.7	12.52	79.75	85.07
55	2010T- 335	57	54	32	14	21	11	16	16	0.90	22.6	8.01	181	2.66	1006.25	0.73	16.8	4.29	25.55	23.77
56	2010T- 340	75	44	98	36	9	11	20	16	0.96	18.2	9.34	170	2.66	945.10	0.80	18.5	13.32	72.00	91.43
57	2010T- 344	72	41	39	18	46	26	42	16	0.98	18.0	8.11	146	2.80	899.36	0.84	18.2	6.88	37.80	45.00
58	2010T- 347	110	42	72	22	14	10	18	13	0.63	15.8	7.91	125	2.24	492.80	0.45	22.9	5.67	24.75	23.11
59	2010T- 351	73	57	58	24	11	29	19	15	0.80	18.0	8.56	154	2.58	805.42	0.71	15.6	6.65	42.60	43.69
60	2010T- 355	61	51	40	25	19	35	18	17	1.49	23.4	9.62	225	2.60	1195.07	1.17	20.1	14.70	73.13	59.44
61	2010T- 358	60	48	104	34	35	11	20	18	1.51	23.2	9.09	211	3.10	1593.20	1.22	17.2	17.84	103.70	61.36
62	2010T- 362	79	26	45	6	19	7	15	12	0.49	15.2	6.71	102	2.36	446.36	0.38	20.9	1.19	5.70	5.28
63	2010T- 365	100	64	72	28	15	9	18	17	1.49	22.2	9.23	205	2.80	1262.80	1.21	19.5	16.52	84.70	70.58
64	2010T- 366	86	70	76	41	11	12	13	14	0.87	21.4	7.71	165	2.80	1016.40	0.74	19.9	15.09	75.85	60.68
65	2010T- 368	71	45	68	32	10	11	20	15	1.07	17.0	10.18	173	2.58	904.79	0.85	15.4	10.47	68.00	87.18
66	2010T- 369	44	23	48	22	9	10	16	13	0.68	16.6	7.47	124	2.34	533.48	0.64	22.0	7.74	35.20	43.73
67	2010T- 374	81	75	92	44	16	13	16	13	1.00	16.0	11.00	176	2.50	864.29	0.63	18.3	12.68	69.30	72.19
68	2010T- 387	54	50	57	18	11	11	20	17	1.00	20.2	6.83	138	2.84	874.54	0.78	19.0	6.67	35.10	29.07

Table 4.5. (cont.)

S No	Genotype	T 120	SP 180	SP 240	NMC	NGL 90	NGL 120	NGL 240	NGL M	BM	IN No.	IN L	SL	SD	SV	SCW	HRB	HRBY	CY	Ratoona-bility
		No.	No.	No.	No.	No.	No.	No.	No.	kg	No.	cm	cm	cm	cm3	kg	%	t ha^{-1}	t ha^{-1}	for CY(%)
69	2010T- 392	125	69	103	53	15	17	21	17	1.06	19.6	9.49	186	2.46	884.40	0.77	19.0	19.38	102.03	64.78
70	2010T- 408	52	21	42	18	9	26	18	15	1.10	18.4	10.82	199	2.60	1056.97	0.90	16.1	6.52	40.50	52.94
71	2010T- 416	65	55	72	46	19	13	20	18	1.32	23.0	9.65	222	2.56	1143.14	0.93	16.4	17.54	106.95	89.13
72	2010T- 429	78	56	68	35	8	12	15	17	1.08	25.2	7.18	181	2.46	860.62	0.88	22.1	17.02	77.00	79.08
73	2010T- 430	68	44	90	29	14	7	20	15	1.05	22.6	9.38	212	2.42	975.51	0.86	22.2	13.84	62.35	49.48
74	Co 6907	75	69	56	37	8	8	14	15	0.85	17.9	9.72	172	2.22	675.03	0.65	16.55	9.50	58.01	78.04
75	Co 7219	70	51	71	34	17	11	18	16	0.83	21.9	8.08	177	2.23	698.08	0.67	18.89	10.81	57.08	91.57
76	Co 86032	43	38	48	19	12	13	17	15	0.97	19.4	7.76	150	2.64	839.75	0.74	20.17	7.33	36.72	53.59
77	2003V46	60	55	62	34	8	8	14	16	1.07	18.6	7.98	148	2.56	771.79	0.72	19.85	10.54	61.94	81.84

T 120 - Tiller number per plot at 120 DAR
SP 180 - Shoot population per plot at 180 DAR
SP 240 - Shoot population per plot at 240 DAR
NMC - Number of millable canes per plot at harvest
NGL 90 - Number of green leaves per plant at 90 DAR
NGL 120 - Number of green leaves per plant at 120 DAR
NGL 240 - Number of green leaves per plant at 240 DAR
NGL M - Number of green leaves per plant at maturity
BM - Biomass per cane at harvest (kg)

IN No. - Number of internodes per cane
IN L - Internode length
SL - Stalk length (cm)
SD - Stalk diameter (cm)
SV - Stalk volume cm^3)
SCW - Single cane weight (kg)
HRB - HR Brix (%)
HRBY - HR Brix yield (t ha^{-1})
CY - Cane yield (t ha^{-1})

Table 4.6 Range, mean and number of genotypes showing higher performance than the best check for different characters in ratoon crop of first clonal stage of sugarcane

S.No.	Charater	Range		General Mean	Best check	No. of genotypes
		Min	Max			
1	Tillers at 120 DAR	2.00	144.00	72.58	Co 6907 (75)	33
2	Shoot population at 180 DAR	9.00	99.00	51.71	Co 6907 (69)	14
3	Shoot population at 240 DAR	9.00	154.00	70.12	Co 7219 (71)	35
4	NMC at harvest	6.00	62.00	32.94	Co 6907 (37)	29
5	No. of green leaves at 90 DAR	8.00	59.00	18.81	Co 7219 (17)	29
6	No. of green leaves at 120 DAR	6.00	38.00	15.73	Co 86032 (13)	35
7	No. of green leaves at 240 DAR	7.00	48.00	19.51	Co 7219 (18)	35
8	No. of green leaves at maturity	11.00	21.00	15.74	Co 7219 2003V-46 (16)	31
9	Biomass per cane (kg)	0.20	1.78	1.03	2003V-46 (1.07)	33
10	No. of internodes per cane	12.80	28.00	20.51	Co 7219 (21.9)	30
11	Internode length (cm)	6.05	14.18	9.47	Co 6907 (9.72)	31
12	Stalk length (cm)	92.00	273.00	193.76	Co 7219 (177)	49
13	Stalk diameter (cm)	1.63	3.18	2.46	Co 86032 (2.64)	20
14	Stalk volume (cm^3)	314.81	1954.58	939.83	Co 86032 (839.75)	48
15	Single cane weight (kg)	0.17	1.55	0.83	Co 86032 (0.74)	47
16	HR brix (%)	10.20	22.90	18.61	Co 86032 (20.17)	25
17	HR brix yield (t ha^{-1})	1.00	29.31	12.66	Co 7219 (10.81)	47
18	Cane yield (t ha^{-1})	3.70	153.45	68.99	2003V-46 (61.94)	44
19	Ratoonability for cane yield (%)	3.62	96.78	61.33	Co 7219 (91.57)	4

Table 4.7. Correlation coefficients between different traits among seventy seven genotypes in ratoon crop of first clonal stage in sugarcane

	Shoot population at		No. of millable canes	Number of green leaves at				Biomass per cane	Inter node number	Inter node length	Stalk length	Stalk diameter	Stalk volume	Single cane weight	HR Brix	HR Brix yield	Cane yield
	180 DAR	240 DAR		90 DAR	120 DAR	240 DAR	Maturity										
	SP 180	**SP 240**	**NMC**	**NGL 90**	**NGL 120**	**NGL 240**	**NGL M**	**BM**	**IN No.**	**IN L**	**SL**	**SD**	**SV**	**SCW**	**HRB**	**HRBY**	**CY 'r'**
T 120	0.658**	0.611**	0.576**	0.055	-0.004	-0.016	0.077	0.182	0.149	0.239*	0.301**	-0.071	0.096	0.126	-0.036	0.526**	0.529**
SP 180		0.720**	0.779**	0.079	0.011	0.088	0.329**	0.255*	0.330**	0.323**	0.477**	-0.124	0.127	0.121	-0.112	0.639**	0.638**
SP 240			0.814**	0.105	-0.021	0.083	0.250*	0.219	0.183	0.348**	0.381**	-0.069	0.135	0.129	-0.079	0.707**	0.707**
NMC				0.116	-0.003	0.117	0.325**	0.189	0.293**	0.441**	0.521**	-0.231*	0.106	0.086	-0.166	0.783**	0.806**
NGL 90					0.300**	0.672**	0.198	0.071	0.121	0.085	0.152	-0.011	0.082	0.076	0.156	0.214	0.157
NGL 120						0.282*	0.160	0.315**	0.157	0.117	0.221	0.100	0.220	0.313**	0.043	0.175	0.141
NGL 240							0.423**	0.066	0.271*	0.042	0.245*	-0.008	0.119	0.096	0.112	0.213	0.157
NGL M								0.529**	0.834**	-0.060	0.613**	0.205	0.503**	0.454**	-0.101	0.498**	0.501**
BM									0.602**	0.200	0.607**	0.649**	0.860**	0.949**	-0.189	0.595**	0.641**
IN No.										-0.065	0.730**	0.212	0.574**	0.542**	0.008	0.531**	0.499**
IN L											0.619**	-0.229*	0.219	0.195	-0.187	0.408**	0.434**
SL												-0.003	0.594**	0.561**	-0.102	0.700**	0.690**
SD													0.781**	0.713**	-0.177	0.156	0.215
SV														0.899**	-0.197	0.540**	0.584**
SCW															-0.212	0.559**	0.607**
HRB																0.049	-0.233**
HRBY																	0.954**

** Significant at 1% level

* Significant at 5% level

T 120 - Tillers at 120 DAR (Days after ratooning)

Table 4.8. Phenotypic path coefficients of thirteen characters on cane yield in ratoon crop of first clonal stage in sugarcane

	Tillers at 120 DAP	Shoot population at 180 DAP	Shoot population at 240 DAP	No. of millable canes	No. of green leaves at maturity	Biomass per cane	Internode number	Internode length	Stalk length	Stalk volume	Single cane weight	HR Brix	HR Brix yield	Cane yield
	T 120	**SP 180**	**SP 240**	**NMC**	**NGLM**	**BM**	**IN No**	**IN L**	**SL**	**SV**	**SCW**	**HRB**	**HRBY**	**CY**
T 120	**0.025**	-0.037	-0.010	0.061	0.000	0.021	-0.023	-0.031	0.043	0.004	-0.008	0.009	0.476	0.529**
SP 180	0.016	**-0.057**	-0.011	0.083	-0.001	0.029	-0.051	-0.042	0.068	0.005	-0.008	0.029	0.578	0.638**
SP 240	0.015	-0.041	**-0.016**	0.087	-0.001	0.025	-0.028	-0.045	0.054	0.005	-0.009	0.021	0.640	0.707**
NMC	0.014	-0.044	-0.013	**0.107**	-0.001	0.021	-0.045	-0.057	0.074	0.004	-0.006	0.043	0.709	0.806**
NGLM	0.002	-0.019	-0.004	0.035	**-0.004**	0.060	-0.129	0.008	0.087	0.019	-0.030	0.026	0.451	0.501**
BM	0.005	-0.014	-0.003	0.020	-0.002	**0.113**	-0.093	-0.026	0.086	0.032	-0.063	0.049	0.538	0.641**
IN No	0.004	-0.019	-0.003	0.031	-0.003	0.068	**-0.155**	0.008	0.104	0.021	-0.036	-0.002	0.481	0.499**
IN L	0.006	-0.018	-0.005	0.047	0.000	0.023	0.010	**-0.129**	0.088	0.008	-0.013	0.049	0.369	0.434**
SL	0.007	-0.027	-0.006	0.056	-0.002	0.068	-0.113	-0.080	**0.142**	0.022	-0.037	0.027	0.633	0.690**
SV	0.002	-0.007	-0.002	0.011	-0.002	0.097	-0.089	-0.028	0.084	**0.037**	-0.060	0.051	0.489	0.584**
SCW	0.003	-0.007	-0.002	0.009	-0.002	0.107	-0.084	-0.025	0.080	0.033	**-0.067**	0.055	0.506	0.607**
HRB	-0.001	0.006	0.001	-0.018	0.000	-0.021	-0.001	0.024	-0.014	-0.007	0.014	**-0.261**	0.044	-0.233**
HRBY	0.013	-0.036	-0.011	0.084	-0.002	0.067	-0.082	-0.053	0.099	0.020	-0.037	-0.013	**0.905**	0.954**

Residual effect = 0.088

** Significant at 1% level

* Significant at 5% level

Bold diagonal values indicate direct effects

Table 4.9. Analysis of variance for twenty seven characters for seventy seven genotypes of sugarcane in second clonal stage

S.No	Character	Mean sum of squares		
		Replication	Treatment	Error
		df = 1	df = 76	df = 76
1	Tillers at 120 DAP	67.57	724.78*	446.92
2	Shoot population at 180 DAP	280.94	450.45**	187.77
3	Shoot population at 240 DAP	72.96	456.55**	21.18
4	No. of green leaves at 90 DAP	12.01	29.5065**	14.74
5	No. of green leaves at 120 DAP	1.46	20.11	15.30
6	No. of green leaves at 240 DAP	5.46	5.81*	3.79
7	No. of green leaves at maturity	8.89	19.73**	5.17
8	No. of internodes per cane	0.05	23.52**	9.55
9	Internode length (cm)	0.42	8.21**	3.62
10	Stalk length (cm)	61.95	2402.38**	63.88
11	Stalk diameter (cm)	0.08	0.16**	0.07
12	Stalk volume(cm^3)	83471	236149.00**	83788
13	NMC at harvest	21.03	490.46**	79.72
14	Single cane weight (kg)	0.00	0.08**	0.03
15	Fibre content (%)	0.65	15.97**	0.10
16	Brix (%)	0.04	11.07**	0.36
17	Sucrose (%)	1.78	12.89**	0.09
18	CCS percentage (%)	1.57	6.46**	0.04
19	Juice purity (%)	79.30	32.46**	3.45
20	Pol % cane (%)	0.99	9.19**	0.07
21	Juice extraction (%)	1.09	44.93**	0.75
22	Total sugars (%)	13.01	35.40**	1.51
23	Biomass per cane (kg)	0.02	0.21**	0.01
24	Fibre yield (t ha^{-1})	1.46	42.31**	1.78
25	CCS yield (t ha^{-1})	0.06	24.11**	0.96
26	Theoretical yield of alcohol (g/100ml)	0.33	12.22**	0.51
27	Cane yield (t ha^{-1})	229.12	1809.30**	82.05

** Significant at 1% level

* Significant at 5% level

Table 4.10. Mean performance of seventy seven genotypes of sugarcane for different characters in second clonal stage

S. No	Genotype	T 120	SP 180	SP 240	NGL 90	NGL 120	NGL 240	NGL M	IN No	IN L cm	SL cm	SD cm	SV cm^3	NMC No.	SCW kg	FC %	BRIX %	SUC %	CCS %	JP %	P%C %	JE %	TS% %	BM kg	FY t ha^{-1}	CCSY t ha^{-1}	TYA g/100ml	CY t ha^{-1}
1	2010T- 4	106	72	95	16	17	7	12	18	16.48	298	2.75	1771	92	1.45	14.00	18.77	17.62	12.53	93.91	15.16	65.29	24.03	1.70	23.12	20.73	10.83	165.41
2	2010T- 8	133	99	92	20	19	8	13	25	10.25	252	2.54	1273	81	1.01	15.74	18.69	17.43	12.36	93.32	14.69	62.05	22.13	1.13	15.98	12.56	10.53	101.59
3	2010T- 15	175	100	79	18	18	12	17	25	12.73	313	2.60	1669	76	1.07	16.94	20.01	17.61	12.15	87.98	14.62	56.39	26.83	1.62	17.07	12.26	13.13	100.91
4	2010T- 16	144	75	99	11	16	9	13	24	10.96	258	2.60	1374	84	1.07	15.44	18.19	17.13	12.19	94.19	14.48	57.82	28.65	1.60	17.12	13.52	14.01	110.93
5	2010T- 18	123	86	85	24	14	11	6	15	12.30	185	2.30	770	66	1.06	17.84	18.67	17.87	12.81	95.73	14.68	57.92	27.74	1.36	15.62	11.22	13.65	87.60
6	2010T- 20	133	85	122	23	12	11	18	25	10.55	263	2.70	1511	76	1.28	14.64	20.67	18.62	12.99	90.10	15.89	56.03	23.08	1.36	17.69	15.71	11.27	120.96
7	2010T- 26	109	109	79	12	20	11	12	24	10.52	261	2.32	1104	80	0.82	19.04	19.91	18.39	12.98	92.34	14.89	62.25	26.18	1.35	15.39	10.49	12.70	80.85
8	2010T- 53	123	110	89	12	18	13	10	17	14.86	251	2.19	948	88	1.28	14.64	19.89	19.39	14.02	97.53	16.55	60.91	22.66	1.77	20.60	19.75	10.23	140.88
9	2010T- 55	111	92	90	13	17	10	10	21	13.14	275	2.67	1546	88	0.78	12.24	17.63	16.59	11.81	94.10	14.56	64.75	25.75	1.53	10.43	10.07	11.82	85.22
10	2010T- 58	129	108	110	13	19	11	17	26	13.58	343	2.63	1875	106	0.99	13.74	18.17	17.33	12.40	95.40	14.95	69.26	23.93	1.56	17.97	16.26	11.35	131.05
11	2010T- 72	116	105	114	15	15	8	16	23	14.02	315	2.57	1646	103	1.23	13.04	15.51	14.33	10.12	92.38	12.46	60.89	29.25	1.62	20.63	16.00	14.67	158.41
12	2010T- 82	106	84	92	23	15	7	8	20	9.94	202	2.44	941	88	1.04	9.84	20.31	18.57	13.05	91.49	16.74	64.48	23.47	1.37	11.12	14.73	11.47	112.90
13	2010T- 83	109	85	94	22	24	9	17	25	11.40	278	2.37	1227	86	1.02	17.44	17.90	16.09	11.21	89.85	13.28	61.02	21.33	2.13	18.93	12.17	9.76	108.55
14	2010T- 84	94	74	94	12	19	8	12	23	12.13	282	3.40	2557	86	1.59	11.84	15.59	13.73	9.48	88.13	12.11	61.44	17.03	2.20	20.06	16.06	7.15	169.48
15	2010T- 88	80	92	90	11	20	8	14	14	13.35	190	2.83	1198	88	0.96	13.84	20.51	19.71	14.15	96.09	16.98	63.16	27.99	1.32	14.55	14.87	13.93	105.11
16	2010T- 103	106	104	114	17	21	10	19	26	10.41	270	2.53	1360	108	1.19	13.84	18.07	16.03	11.11	88.74	13.81	60.85	26.98	1.50	22.13	17.75	13.37	159.82
17	2010T- 109	139	72	90	22	14	12	15	27	11.12	298	2.43	1405	88	1.17	13.44	16.81	15.67	11.11	93.23	13.57	61.32	24.21	2.07	17.10	14.12	12.20	127.20
18	2010T- 115	138	100	155	17	17	10	14	22	13.09	292	2.42	1346	118	1.17	15.84	16.67	14.72	10.18	88.35	12.39	58.96	17.39	1.36	27.09	17.41	8.51	171.13

Table. 4.10. contd….

S.	Genotype	T	SP	SP	NGL	NGL	NGL	NGL	IN	IN L	SL	SD	SV	NMC	SCW	FC	BRIX	SUC	CCS	JP	P%C	JE	TS%	BM	FY	CCSY	TYA	CY
No		120	180	240	90	120	240	M	No	cm	cm	cm	cm^3	No.	kg	%	%	%	%	%	%	%	%	kg	t ha^{-1}	t ha^{-1}	g/100ml	t ha^{-1}
19	2010T- 124	118	98	98	21	23	10	18	29	10.19	293	3.00	2087	66	1.47	11.04	14.18	11.59	7.71	81.77	10.31	59.04	13.94	2.85	13.28	9.28	6.59	120.35
20	2010T- 126	117	84	90	27	19	11	12	21	13.18	275	2.40	1250	68	1.14	14.24	14.72	12.92	8.91	87.80	11.09	63.64	18.01	1.43	13.82	8.64	8.11	97.06
21	2010T- 144	112	79	80	15	19	9	15	22	13.82	298	2.63	1628	76	1.23	13.44	13.91	12.84	9.06	92.33	11.12	61.83	20.92	1.77	15.43	10.40	8.99	114.84
22	2010T- 146	119	85	116	17	16	9	9	20	15.04	288	2.97	1995	106	1.56	14.64	15.31	13.38	9.21	87.50	11.42	63.13	19.96	1.80	30.06	18.91	8.19	205.49
23	2010T- 152	87	68	92	14	23	8	14	20	13.12	255	2.73	1503	86	1.55	11.04	16.59	15.63	11.13	94.19	13.91	62.40	25.97	1.75	18.41	18.52	12.18	166.63
24	2010T- 153	71	52	69	12	17	10	10	21	12.65	265	3.23	2181	68	1.28	14.24	16.89	16.13	11.55	95.50	13.83	66.06	17.43	2.17	15.35	12.46	7.10	107.86
25	2010T- 158	115	101	82	26	10	9	13	22	10.82	235	2.90	1550	76	1.18	9.84	17.29	15.49	10.78	89.56	13.97	67.90	11.46	1.60	10.98	12.07	5.17	111.77
26	2010T- 161	117	92	86	14	18	9	17	25	9.91	250	2.70	1447	78	1.24	10.64	18.69	16.78	11.69	89.83	15.00	59.90	13.33	1.60	12.56	13.80	5.82	118.08
27	2010T- 171	122	97	115	19	17	10	9	19	14.28	275	2.30	1162	102	0.89	16.24	19.69	17.97	12.62	91.24	15.05	67.38	20.68	1.42	18.35	14.25	9.32	112.97
28	2010T- 172	139	73	94	13	17	13	19	27	11.54	303	2.70	1751	80	0.84	15.84	14.43	12.05	8.10	83.53	10.14	64.29	21.04	1.93	13.16	6.74	10.17	83.21
29	2010T- 173	131	67	86	15	16	9	12	23	11.05	248	2.40	1130	70	1.00	11.84	17.67	16.41	11.61	92.90	14.47	65.21	26.17	1.80	10.25	10.05	13.05	86.55
30	2010T- 175	111	58	80	16	13	9	13	16	14.95	238	2.33	1022	68	0.69	16.24	20.81	19.92	14.29	95.78	16.69	70.31	17.48	1.26	9.53	8.39	8.36	58.73
31	2010T- 177	103	92	98	16	24	11	15	22	12.21	265	2.43	1240	62	0.94	11.04	16.28	14.43	9.99	88.64	12.83	70.38	19.80	1.08	7.98	7.20	9.39	72.23
32	2010T- 179	95	99	93	12	18	11	12	22	12.99	288	1.90	826	90	0.83	15.84	18.48	16.89	11.87	91.50	14.22	67.46	20.51	1.13	14.56	10.91	9.85	91.88
33	2010T- 183	82	64	53	12	16	8	16	24	11.02	260	2.80	1605	46	0.97	13.84	19.37	18.23	12.97	94.11	15.71	56.33	19.89	1.83	7.47	7.03	9.59	54.06
34	2010T- 184	97	122	95	21	22	11	11	22	12.42	272	2.37	1198	92	1.20	9.44	18.05	17.00	12.10	94.25	15.39	64.05	19.25	1.33	12.92	16.55	8.95	136.86
35	2010T- 208	125	113	94	21	20	10	12	21	17.71	368	2.47	1763	64	0.84	14.64	10.69	9.00	8.58	84.26	7.69	62.40	14.18	1.78	9.82	5.76	6.77	67.08
36	2010T- 209	119	68	81	15	16	10	13	20	12.28	245	3.00	1752	72	0.90	11.04	15.09	13.32	9.21	88.37	11.85	58.74	14.48	1.47	8.68	7.26	6.36	78.80

Table. 4.10. contd….

S.	Genotype	T	SP	SP	NGL	NGL	NGL	NGL	IN	IN L	SL	SD	SV	NMC	SCW	FC	BRIX	SUC	CCS	JP	P%C	JE	TS%	BM	FY	CCSY	TYA	CY
No		120	180	240	90	120	240	M	No	cm	cm	cm	cm^3	No.	kg	%	%	%	%	%	%	%	%	kg	t ha^{-1}	t ha^{-1}	g/100ml	t ha^{-1}
37	2010T- 225	115	91	109	18	25	9	15	27	11.94	323	2.27	1330	89	0.94	18.64	15.49	14.11	9.89	91.04	11.48	64.26	23.00	1.77	19.57	10.40	9.80	104.94
38	2010T- 226	100	77	97	14	16	7	12	20	15.20	297	2.57	1551	78	0.91	15.44	17.99	16.56	11.67	92.10	14.01	62.43	20.08	1.56	13.44	10.13	7.74	86.88
39	2010T- 229	130	99	114	19	13	10	17	28	9.60	265	2.07	897	106	0.96	16.64	17.89	16.21	11.34	90.58	13.51	63.86	25.36	1.38	21.02	14.32	12.34	126.39
40	2010T- 237	144	96	105	20	18	10	18	27	11.75	317	2.27	1282	52	0.99	21.44	20.48	19.11	13.55	93.39	15.02	55.07	16.13	1.63	13.81	8.74	7.77	64.45
41	2010T- 239	126	108	103	19	21	10	12	19	14.74	272	2.30	1146	96	0.81	17.44	19.37	18.35	13.10	94.75	15.15	57.35	28.73	1.40	16.74	12.58	13.19	95.96
42	2010T- 240	111	80	93	14	18	15	10	17	16.13	273	2.10	960	88	0.95	18.64	15.59	13.88	9.64	89.11	11.30	54.23	22.76	1.06	19.25	9.96	8.29	103.37
43	2010T- 249	131	75	96	12	13	10	12	16	17.10	265	2.10	924	88	0.78	17.44	13.49	10.88	7.18	80.63	8.98	61.59	20.95	1.45	14.95	6.13	9.00	85.84
44	2010T- 258	123	102	109	17	20	9	13	18	14.68	267	2.37	1174	104	1.10	13.04	14.61	12.53	8.54	85.85	10.90	65.75	21.18	1.24	18.53	12.15	6.15	142.20
45	2010T- 267	129	98	114	11	20	11	10	15	15.31	233	1.93	685	86	0.81	18.64	9.59	8.27	8.15	86.15	6.73	62.82	15.15	1.07	16.27	7.12	6.50	87.31
46	2010T- 278	153	110	88	21	16	11	13	20	14.19	279	2.30	1182	88	0.96	13.44	14.68	12.19	8.17	83.21	10.55	62.38	17.97	1.60	13.92	8.45	8.40	103.47
47	2010T- 282	113	90	106	19	20	9	11	19	11.03	203	2.77	1235	54	1.28	20.24	13.11	11.89	8.33	90.69	9.48	54.72	17.09	1.52	17.19	7.08	8.20	84.91
48	2010T- 285	127	110	107	16	17	7	12	20	14.12	282	2.77	1704	94	1.28	18.24	17.48	14.85	10.07	85.04	12.14	65.32	18.42	1.47	27.16	15.00	8.06	148.92
49	2010T- 292	110	89	94	18	23	9	8	18	12.63	223	2.37	990	92	0.93	12.64	16.79	15.16	10.59	90.30	13.24	67.27	19.65	1.17	13.32	11.16	9.56	105.43
50	2010T- 313	79	79	108	18	15	10	11	20	12.50	248	2.90	1647	100	1.08	9.44	15.39	13.82	9.63	89.85	12.51	71.46	14.45	1.50	12.68	12.95	6.19	134.46
51	2010T- 321	93	81	58	15	12	12	18	25	10.03	250	2.70	1442	40	1.24	12.24	14.21	13.59	9.74	95.64	11.92	64.23	18.04	1.72	7.25	5.76	8.38	59.34
52	2010T- 330	109	94	96	15	17	10	11	23	13.03	298	2.27	1216	78	0.99	18.64	17.79	16.41	11.57	92.22	13.35	65.77	20.00	1.63	17.70	11.00	6.37	95.03
53	2010T- 331	91	96	98	14	15	11	13	21	13.63	283	2.20	1085	82	0.92	13.04	16.57	16.32	11.84	98.47	14.19	69.57	18.21	1.63	12.26	11.13	7.50	94.08
54	2010T- 333	110	84	90	18	13	10	9	20	13.97	283	2.27	1149	90	0.94	13.84	17.79	16.53	11.70	92.94	14.24	65.96	20.08	1.16	14.53	12.29	8.66	105.00

Table. 4.10. contd….

S. No	Genotype	T 120	SP 180	SP 240	NGL 90	NGL 120	NGL 240	NGL M	IN No	IN L cm	SL cm	SD cm	SV cm^3	NMC No.	SCW kg	FC %	BRIX %	SUC %	CCS %	JP %	P%C %	JE %	TS% %	BM kg	FY t ha^{-1}	CCSY t ha^{-1}	TYA g/100ml	CY t ha^{-1}
55	2010T- 335	97	79	91	13	14	15	14	23	11.74	267	2.83	1680	82	0.89	13.84	18.22	16.89	11.94	92.68	14.55	70.29	17.94	1.75	12.60	10.87	8.59	91.10
56	2010T- 340	128	89	73	14	18	10	17	24	8.87	215	2.80	1351	68	1.09	18.24	17.69	16.66	11.85	94.16	13.62	68.21	21.75	1.57	16.39	10.65	10.28	89.87
57	2010T- 344	108	96	101	13	16	9	12	24	11.87	280	2.90	1871	96	1.30	11.04	14.05	12.71	8.88	90.41	11.31	73.61	15.51	2.33	17.04	13.71	5.81	154.50
58	2010T- 347	155	130	122	17	13	13	8	16	15.63	235	2.53	1196	112	1.14	14.64	15.03	12.78	8.67	85.08	10.91	68.50	17.48	1.33	23.40	13.89	7.79	160.05
59	2010T- 351	112	96	98	13	22	7	10	16	13.99	220	2.43	1029	96	0.68	12.24	18.29	16.91	11.94	92.43	14.84	72.72	21.36	1.05	9.78	9.55	9.93	80.03
60	2010T- 355	136	73	79	10	14	10	17	26	12.49	320	2.30	1333	72	1.30	12.64	16.43	14.56	10.09	88.67	12.72	61.86	19.29	1.73	14.77	11.80	9.59	116.88
61	2010T- 358	100	86	69	13	13	8	15	22	13.22	287	2.57	1492	68	1.12	13.84	17.83	16.50	11.66	92.54	14.21	66.77	21.76	1.97	12.83	10.81	8.14	92.70
62	2010T- 362	116	102	108	12	17	8	6	18	14.57	255	2.57	1325	100	0.94	10.64	18.09	16.05	11.12	88.73	14.34	66.44	18.37	1.00	12.32	12.90	7.99	116.00
63	2010T- 365	116	107	96	14	15	10	12	20	10.95	222	2.53	1120	90	0.91	10.24	15.03	13.27	9.17	88.28	11.91	71.41	16.57	1.85	10.37	9.29	7.89	101.33
64	2010T- 366	127	100	89	15	19	9	9	20	14.01	273	2.70	1568	88	1.24	12.24	17.53	14.47	9.67	82.59	12.70	65.77	15.90	1.27	16.55	13.08	6.62	135.30
65	2010T- 368	110	83	104	12	15	10	11	20	15.09	293	2.27	1186	98	0.87	11.84	16.09	15.39	11.03	95.66	13.57	71.72	19.07	1.73	12.59	11.73	10.05	106.45
66	2010T- 369	100	73	96	15	12	10	15	22	12.18	263	2.52	1313	88	1.10	10.24	20.09	18.06	12.59	89.91	16.21	66.88	17.78	1.67	12.18	14.96	7.23	118.87
67	2010T- 374	109	81	92	15	15	9	9	21	14.03	290	2.70	1686	86	1.05	18.64	15.63	14.32	10.07	91.62	11.65	63.06	20.04	1.92	20.81	11.24	9.71	111.74
68	2010T- 387	132	82	104	11	17	13	16	24	10.73	260	2.70	1505	98	1.15	16.24	18.85	17.54	12.43	93.08	14.70	58.07	18.85	1.60	22.66	17.33	8.80	139.40
69	2010T- 392	119	72	63	13	13	9	9	20	12.59	255	2.20	978	60	1.32	17.04	18.32	17.39	12.42	94.88	14.43	57.15	16.89	1.57	16.72	12.19	8.05	98.13
70	2010T- 408	91	74	92	13	16	10	7	16	16.25	250	2.53	1264	90	1.06	16.24	17.93	15.57	10.67	86.87	13.04	68.68	15.12	1.13	19.34	12.72	6.84	119.13
71	2010T- 416	120	88	95	13	17	9	16	23	15.35	345	2.53	1762	68	1.08	16.24	13.53	12.11	8.43	89.52	10.14	63.05	11.64	1.98	14.51	7.54	1.79	89.30
72	2010T- 429	131	105	94	21	21	11	15	27	10.46	278	2.40	1273	88	1.03	15.84	17.27	14.05	9.32	81.39	11.83	67.21	16.05	1.30	17.75	10.45	6.45	112.17

Table. 4.10. contd....

S. No	Genotype	T 120	SP 180	SP 240	NGL 90	NGL 120	NGL 240	NGL M	IN No	IN L cm	SL cm	SD cm	SV cm^3	NMC No.	SCW kg	FC %	BRIX %	SUC %	CCS %	JP %	P%C %	JE %	TS% %	BM kg	FY t ha^{-1}	CCSY t ha^{-1}	TYA g/100ml	CY t ha^{-1}
73	2010T-430	152	109	105	17	19	12	16	24	12.29	292	2.43	1359	90	0.94	15.44	18.89	17.32	12.19	91.72	14.65	63.61	20.79	1.53	16.25	12.82	10.44	105.35
CD (5%)		31	20.2	6.8	5.6	5.75	2.9	3.3	4.6	2.80	12	0.39	425.7	13.1	0.24	0.45	0.88	0.45	0.29	2.73	0.40	1.26	1.81	0.15	1.96	1.44	1.05	13.32
Checks	Co 86032	107	69	90	16	16	14	13	24	9.56	232	2.50	1137	82	1.33	17.04	20.69	19.45	13.84	94.10	16.14	56.21	22.44	1.40	23.04	18.73	10.99	135.27
	2003V46	147	82	98	15	20	10	15	24	8.62	203	2.90	1342	44	1.27	15.44	20.05	19.41	13.99	96.83	16.42	60.42	25.56	1.65	10.76	9.75	12.59	69.73
	Co 6907	140	99	86	11	16	11	18	25	9.49	233	2.57	1212	72	0.73	19.04	20.75	20.22	14.61	97.47	16.37	64.36	22.34	1.37	11.99	9.19	10.28	62.90
	Co7219	130	94	94	16	18	7	8	20	12.18	245	1.93	733	76	1.08	13.84	14.19	12.70	8.84	89.52	10.94	51.87	26.17	1.39	13.98	8.93	12.80	101.10

T 120 - Tiller number per plot at 120 DAP
SP 180 - Shoot population per plot at 180 DAP
SP 240 - Shoot population per plot at 240 DAP
NGL 90 - Number of green leaves per plant at 90 DAP
NGL 120 - Number of green leaves per plant at 120 DAP
NGL 240 - Number of green leaves per plant at 240 DAP
NGL M - Number of green leaves per plant at maturity
IN No. - Number of internodes per cane
IN L - Internode length (cm)
SL - Stalk length (cm)
SD - Stalk diameter (cm)
SV - Stalk volume (cm^3)
NMC - Number of millable canes per plot at harvest
SCW - Single cane weight (kg)
FC - Fibre content (%)
Brix - Brix per cent (%)
SUC - Sucrose per cent (%)
CCS - Commercial cane sugar per cent (%)
JP - Juice purity per cent (%)
P%C - Pol % cane (%)
JE - Juice extraction per cent (%)
TS - Total sugars per cent (%)
BM - Biomass per cane at harvest (kg)
FY - Fibre yield (t ha^{-1})
CCSY - Commercial cane sugar yield (t ha^{-1})
TYA - Theoretical yield of alcohol (g/100 ml)
CY - Cane yield (t ha^{-1})

Table 4.11. Range, mean, GCV, PCV, heritability and genetic advance as percent of mean for twenty seven characters in second clonal stage of sugarcane

S.No.	Character	Range		Mean	GCV	PCV	h^2	GA(%) of mean
		Min	Max					
1	Tillers at 120 DAP	71.00	175.00	117.00	10.05	20.64	23.71	10.08
2	Shoot population at 180 DAP	52.00	130.00	90.00	12.84	19.96	41.16	16.68
3	Shoot population at 240 DAP	53.00	155.00	95.00	15.55	16.28	91.13	30.57
4	No. of green leaves at 90 DAP	9.50	27.00	15.72	17.28	29.92	33.36	20.56
5	No. of green leaves at 120 DAP	9.50	24.50	16.99	9.12	24.76	13.58	6.93
6	No. of green leaves at 240 DAP	7.00	15.00	9.72	10.34	22.54	21.03	9.77
7	No. of green leaves at maturity	5.67	18.83	12.62	21.66	28.10	59.13	34.22
8	No. of internodes per cane	14.33	29.00	21.65	12.21	18.79	42.24	16.35
9	Internode length (cm)	8.62	17.71	12.70	11.94	19.15	38.84	15.32
10	Stalk length (cm)	185.00	368.00	267.81	12.77	13.11	94.82	25.61
11	Stalk diameter (cm)	1.90	3.40	2.53	8.40	13.54	38.50	10.74
12	Stalk volume(cm^3)	685.27	2556.91	1362.45	20.26	29.36	47.62	28.80
13	NMC at harvest	40.00	118.00	82.96	17.28	20.35	72.04	30.21
14	Single cane weight (kg)	0.68	1.59	1.07	15.45	21.81	50.18	22.55
15	Fibre content (%)	9.44	21.44	14.55	19.37	19.48	98.81	39.66
16	Brix (%)	9.59	20.81	17.13	13.51	13.96	93.78	26.96
17	Sucrose (%)	8.27	20.22	15.61	16.21	16.33	98.57	33.16
18	CCS percentage (%)	7.18	14.61	11.01	16.26	16.36	98.78	33.30
19	Juice purity (%)	80.63	98.47	90.85	4.19	4.66	80.79	7.76
20	Pol % cane (%)	6.73	16.98	13.33	16.02	16.14	98.00	32.74
21	Juice extraction (%)	54.23	73.61	63.47	7.45	7.53	96.00	15.00
22	Total sugars (%)	11.46	29.25	20.38	20.20	21.08	91.82	39.88
23	Biomass per cane (kg)	1.00	2.85	1.56	20.31	21.27	91.18	39.94
24	Fibre yield ($t\ ha^{-1}$)	7.25	30.06	15.76	28.57	29.80	91.92	56.43
25	CCS yield ($t\ ha^{-1}$)	5.76	20.73	12.00	28.34	29.51	92.00	56.09
26	Theoretical yield of alcohol (g/100ml)	1.79	14.67	9.29	26.06	27.17	91.96	51.47
27	Cane yield ($t\ ha^{-1}$)	54.06	205.49	109.84	26.76	28.00	91.32	52.67

Table 4.12. Top ranking sugarcane genotypes based on mean performance for diversified uses

	Biomass per cane (kg)		Fibre yield (t ha^{-1})		CCS yield (t ha^{-1})		Theoretical yield of alcohol (g/100ml)		Cane yield (t ha^{-1})	
Rank	Genotype	Mean	Genotype	Mean	Genotype	Mean	Genotype	Mean	Genotype	Mean
1	2010T-124	2.85	2010T-146	30.06	2010T-4	20.73	2010T-72	14.67	2010T-146	205.49
2	2010T-344	2.33	2010T-285	27.16	2010T-53	19.75	2010T-16	14.01	2010T-115	171.13
3	2010T-84	2.2	2010T-115	27.09	2010T-146	18.91	2010T-88	13.93	2010T-84	169.48
4	2010T-153	2.17	2010T-347	23.4	2010T-152	18.52	2010T-18	13.65	2010T-152	166.63
5	2010T-83	2.13	2010T-4	23.12	2010T-103	17.75	2010T-103	13.37	2010T-4	165.41
6	2010T-109	2.07	2010T-387	22.66	2010T-115	17.41	2010T-239	13.19	2010T-347	160.05
7	2010T-416	1.98	2010T-103	22.13	2010T-387	17.33	2010T-15	13.13	2010T-103	159.82

Table 4.13. Phenotypic correlation coefficients between cane yield, fibre yield, biomass, theoretical yield of alcohol, CCS yield and their component characters in second clonal stage of sugarcane

	Shoot population		No. of green leaves at				No. of Inter-nodes	Inter-node Length	Stalk Length	Stalk diameter	Stalk volume	No. of millable canes	Single cane weight	Fibre content	Biomass per cane	Fibre yield	Theoretical yield of alcohol	Commercial cane sugar yield	Cane yield
	at 180 DAP	at 240 DAP	at 90 DAP	at 120 DAP	at 240 DAP	Maturity													
	SP180	SP240	NGL90	NGL120	NGL240	NGLM	IN No	INL	SL	SD	SV	NMC	SCW	FC	BM	FY	TYA	CCSY	CY
T 120	0.383**	0.209	0.178	0.041	0.177	0.135	0.155	-0.075	0.122	-0.240*	-0.168	0.014	-0.008	0.252*	-0.075	0.163	0.166	-0.037	0.002
SP180		0.356**	0.153	0.275*	0.115	-0.021	-0.016	0.088	0.108	-0.220	-0.166	0.273*	-0.083	0.035	-0.194	0.149	0.015	0.077	0.142
SP240			0.108	0.129	0.018	-0.033	-0.028	0.147	0.147	-0.112	-0.034	0.609**	0.013	0.078	-0.198	0.510**	0.028	0.351**	0.487**
NGL90				0.055	-0.017	-0.054	0.144	-0.143	0.005	-0.128	-0.120	-0.069	0.131	-0.023	-0.004	0.042	0.010	0.019	0.058
NGL120					-0.005	0.048	0.025	0.030	0.067	-0.044	-0.009	0.024	0.024	0.075	-0.021	0.069	0.088	-0.004	0.034
NGL240						0.087	0.050	-0.015	0.030	-0.114	-0.105	-0.033	-0.060	0.167	-0.049	0.041	0.000	-0.042	-0.086
NGLM							0.577**	-0.376**	0.284*	0.318**	0.392**	-0.050	-0.107	0.063	0.322**	-0.085	0.085	-0.077	-0.121
IN No								-0.754**	0.369**	0.107	0.256*	-0.158	0.143	0.031	0.370**	-0.001	0.070	0.016	-0.009
INL									0.301**	-0.155	-0.001	0.255*	-0.126	0.050	-0.124	0.151	-0.218	-0.011	0.113
SL										-0.066	0.388**	0.114	0.035	0.076	0.374**	0.177	-0.211	0.008	0.138
SD											0.884**	0.060	0.149	-0.268*	0.385**	-0.015	-0.148	0.115	0.172
SV												0.119	0.165	-0.215	0.540**	0.083	-0.242*	0.113	0.241*
NMC													-0.201	-0.141	-0.215	0.507**	0.079	0.526**	0.618**
SCW														-0.194	0.376**	0.459**	-0.064	0.533**	0.632**
FC															-0.147	0.389**	0.135	-0.174	-0.253*
BM																0.008	-0.165	0.015	0.129
FY																	0.107	0.686**	0.779**
TYA																		0.256*	0.011
CCSY																			0.846**

* Significant at 5% level

** Significant at 1% level

T 120 - Tiller number per plot at 120 DAP

Table 4.14. Phenotypic correlation coefficients between cane yield, fibre yield, biomass, theoretical yield of alcohol, CCS yield and their component characters in second clonal stage of sugarcane

	Stalk length	Stalk diameter	Stalk volume	No. of millable canes	Single cane weight	Fibre content	Brix %	Sucrose %	Commercial cane sugar %	Juice puritiy %	Pol % cane	Juice extraction %	Total sugars %	Biomass per cane	Fibre yield	Theoretical yield of alcohol	Commercial cane sugar yield	Cane yield
	SL	**SD**	**SV**	**NMC**	**SCW**	**FC**	**BRIX**	**SUC**	**CCS**	**JP**	**P%C**	**JE**	**TS%**	**BM**	**FY**	**TYA**	**CCSY**	**CY**
SP240	0.147	-0.112	-0.034	0.609**	0.013	0.078	-0.127	-0.178	-0.189	-0.252*	-0.191	0.039	0.041	-0.198	0.510**	0.028	0.351**	0.487**
SL		-0.066	0.388**	0.114	0.035	0.076	-0.237*	-0.264*	-0.257*	-0.215	-0.285*	-0.012	-0.148	0.374**	0.177	-0.211	0.008	0.138
SD			0.884**	0.060	0.149	-0.268*	0.005	-0.003	-0.040	-0.011	0.047	0.074	-0.166	0.385**	-0.015	-0.148	0.115	0.172
SV				0.119	0.165	-0.215	-0.134	-0.154	-0.182	-0.126	-0.116	0.053	-0.225*	0.540**	0.083	-0.242*	0.113	0.241*
NMC					-0.201	-0.141	-0.002	-0.062	-0.107	-0.195	-0.029	0.291*	0.138	-0.215	0.507**	0.079	0.526**	0.618**
SCW						-0.194	-0.063	-0.072	-0.117	-0.038	-0.035	-0.238*	-0.068	0.376**	0.459**	-0.064	0.533**	0.632**
FC							0.095	0.106	0.144	0.060	-0.099	-0.388**	0.188	-0.147	0.389**	0.135	-0.174	-0.253*
BRIX								0.967**	0.903**	0.444**	0.948**	-0.054	0.359**	-0.196	0.011	0.389**	0.411**	-0.048
SUC									0.970**	0.654**	0.979**	-0.052	0.415**	-0.170	-0.038	0.440**	0.397**	-0.104
CCS										0.723**	0.943**	-0.061	0.412**	-0.187	-0.080	0.447**	0.357**	-0.170
JP											0.643**	-0.006	0.396**	-0.017	-0.153	0.388**	0.202	-0.189
P%C												0.027	0.379**	-0.148	-0.116	0.414**	0.436**	-0.051
JE													-0.281*	-0.052	-0.207	-0.290*	-0.021	0.035
TS%														-0.187	0.176	0.919**	0.272*	0.052
BM															0.008	-0.165	0.015	0.129
FY																0.107	0.686**	0.779**
TYA																	0.256*	0.011
CCSY																		0.846**

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

Table 4.15. Direct and indirect effects of component characters on cane yield at phenotypic level in second clonal stage of sugarcane

	Shoot population at 240 DAP	Stalk volume	No. of millable canes	Single cane weight	Fibre content	Fibre yield	Commercial cane sugar yield	Cane yield
	SP240	**SV**	**NMC**	**SCW**	**FC**	**FY**	**CCSY**	**CY 'r'**
SP240	**0.014**	-0.001	0.256	0.006	-0.020	0.216	0.015	0.487**
SV	0.000	**0.022**	0.050	0.073	0.056	0.035	0.005	0.241*
NMC	0.009	0.003	**0.421**	-0.089	0.037	0.215	0.023	0.618**
SCW	0.000	0.004	-0.085	**0.444**	0.051	0.195	0.024	0.632**
FC	0.001	-0.005	-0.059	-0.086	**-0.261**	0.165	-0.008	-0.253*
FY	0.007	0.002	0.213	0.204	-0.102	**0.424**	0.030	0.779**
CCSY	0.005	0.002	0.221	0.237	0.045	0.291	**0.044**	0.846**

Residual effect = 0.115

Table 4.16. Direct and indirect effects of component characters on fibre yield at phenotypic level in second clonal stage of sugarcane

	Shoot population at 240 DAP	No. of millable canes	Single cane weight	Fibre content	Commercial cane sugar yield	Cane yield	Fibre yield
	SP240	**NMC**	**SCW**	**FC**	**CCSY**	**CY**	**FY 'r'**
SP240	**-0.006**	0.074	0.001	0.049	0.001	0.390	0.510**
NMC	-0.004	**0.122**	-0.020	-0.089	0.002	0.495	0.507**
SCW	0.000	-0.025	**0.098**	-0.122	0.002	0.506	0.459**
FC	0.000	-0.017	-0.019	**0.629**	-0.001	-0.202	0.389**
CCSY	-0.002	0.064	0.052	-0.109	**0.004**	0.677	0.686**
CY	-0.003	0.075	0.062	-0.159	0.004	**0.800**	0.779**

Residual effect = 0.159

Table 4.17. Direct and indirect effects of component characters on biomass per cane at phenotypic level in second clonal stage of sugarcane

	No. of green leaves at maturity	No. of internodes	Stalk length	Stalk diameter	Stalk volume	Single cane weight	Biomass per cane
	NGLM	IN No	SL	SD	SV	SCW	BM 'r'
NGLM	**0.137**	0.064	-0.058	-0.233	0.445	-0.033	0.322**
IN No	0.079	**0.111**	-0.076	-0.078	0.290	0.043	0.370**
SL	0.039	0.041	**-0.205**	0.048	0.440	0.011	0.374**
SD	0.043	0.012	0.014	**-0.732**	1.003	0.045	0.385**
SV	0.054	0.029	-0.080	-0.647	**1.134**	0.050	0.540**
SCW	-0.015	0.016	-0.007	-0.109	0.187	**0.304**	0.376**

Residual effect = 0.739

Table 4.18. Direct and indirect effects of component characters on theoretical yield of alcohol at phenotypic level in second clonal stage of sugarcane

	Stalk volume	Brix per cent	Sucrose per cent	Commercial cane sugar per cent	Juice purity per cent	Pol % cane	Juice extraction per cent	Total sugars per cent	Commercial cane sugar yield	Theoretical yield of alcohol
	SV	**BRIX %**	**SUC %**	**CCS %**	**JP %**	**P%C**	**JE %**	**TS %**	**CCSY**	**TYA 'r'**
SV	**-0.030**	0.044	0.024	-0.049	0.022	-0.048	-0.003	-0.200	-0.003	-0.242*
BRIX %	0.004	**-0.330**	-0.154	0.242	-0.076	0.392	0.003	0.319	-0.011	0.389**
SUC %	0.005	-0.319	**-0.159**	0.260	-0.112	0.404	0.003	0.368	-0.010	0.440**
CCS %	0.005	-0.298	-0.154	**0.268**	-0.124	0.390	0.004	0.366	-0.009	0.447**
JP %	0.004	-0.147	-0.104	0.193	**-0.171**	0.266	0.000	0.351	-0.005	0.388**
P%C	0.003	-0.313	-0.156	0.252	-0.110	**0.413**	-0.002	0.336	-0.011	0.414**
JE %	-0.002	0.018	0.008	-0.016	0.001	0.011	**-0.062**	-0.249	0.001	-0.290*
TS %	0.007	-0.118	-0.066	0.110	-0.068	0.157	0.017	**0.887**	-0.007	0.919**
CCSY	-0.003	-0.136	-0.063	0.096	-0.035	0.180	0.001	0.241	**-0.026**	0.256*

Residual effect = 0.374

Table 4.19. Direct and indirect effects of component characters on CCS yield at phenotypic level in second clonal stage of sugarcane

	Shoot population at 240 DAP	No. of millable canes	Single cane weight	Brix per cent	Sucrose per cent	Commercial cane sugar per cent	Pol % cane	Total sugars per cent	Fibre yield	Cane yield	Theoretical yield of alcohol	Commercial cane sugar yield
	SP240	**NMC**	**SCW**	**BRIX %**	**SUC %**	**CCS %**	**P%C**	**TS %**	**FY**	**CY**	**TYA**	**CCSY 'r'**
SP240	**-0.016**	0.124	0.003	-0.002	0.211	-0.124	-0.196	-0.001	0.161	0.190	0.001	0.351**
NMC	-0.010	**0.204**	-0.043	0.000	0.073	-0.070	-0.030	-0.002	0.160	0.241	0.002	0.526**
SCW	0.000	-0.041	**0.212**	-0.001	0.085	-0.077	-0.036	0.001	0.145	0.246	-0.002	0.533**
BRIX %	0.002	0.000	-0.013	**0.016**	-1.146	0.591	0.971	-0.004	0.003	-0.019	0.010	0.411**
SUC %	0.003	-0.013	-0.015	0.016	**-1.185**	0.635	1.003	-0.005	-0.012	-0.040	0.011	0.397**
CCS %	0.003	-0.022	-0.025	0.015	-1.150	**0.655**	0.966	-0.005	-0.025	-0.066	0.012	0.357**
P%C	0.003	-0.006	-0.007	0.015	-1.160	0.617	**1.024**	-0.005	-0.037	-0.020	0.011	0.436**
TS %	-0.001	0.028	-0.014	0.006	-0.492	0.270	0.388	**-0.012**	0.056	0.020	0.024	0.272*
FY	-0.008	0.103	0.097	0.000	0.045	-0.052	-0.119	-0.002	**0.316**	0.303	0.003	0.686**
CY	-0.008	0.126	0.134	-0.001	0.123	-0.111	-0.052	-0.001	0.246	**0.389**	0.000	0.846**
TYA	0.000	0.016	-0.014	0.006	-0.522	0.293	0.424	-0.011	0.034	0.004	**0.026**	0.256*

Residual effect = 0.141

Table 4.20. Discriminant functions, their Genetic Advance (GA) and Relative Efficiency (RE) over straight selection for cane yield

S.No	Discriminant function	GA	RE
1	Y= 0.91 X_1	27.81	100.00
2	Y= 0.92 X_2	14.49	52.13
3	Y= 0.46 X_3	186.30	670.00
4	Y= 0.71 X_4	11.79	42.42
5	Y= 0.50 X_5	0.12	0.42
6	Y= 0.92 X_6	4.30	15.46
7	Y= 0.92 X_7	3.23	11.60
8	Y= 0.91 X_1 + 0.99 X_2	38.12	137.11
9	Y= 3.66 X_1 + 0.42 X_3	223.82	804.92
10	Y= 1.01 X_1 + 0.77 X_4	39.81	143.17
11	Y= 1.00 X_1 - 16.88 X_5	28.08	100.99
12	Y= 0.93 X_1 + 0.77 X_6	31.13	111.96
13	Y= 0.92 X_1 + 0.81 X_7	30.55	109.86
14	Y= 0.28 X_2 + 0.46 X_3	185.64	667.63
15	Y= 1.19 X_2 + 0.60 X_4	26.20	94.23
16	Y= 0.92 X_2 + 0.14 X_5	14.49	52.13
17	Y= 0.90 X_2 + 1.09 X_6	17.51	62.99
18	Y= 0.91 X_2 + 1.04 X_7	16.14	58.04
19	Y= 0.48 X_3 - 5.76 X_4	205.84	740.27
20	Y= 0.37 X_3 + 899.25 X_5	276.30	993.66
21	Y= 0.46 X_3 + 10.36 X_6	193.14	694.60
22	Y= 0.45 X_3 + 14.47 X_7	193.56	696.12
23	Y= 0.77 X_4 + 20.69 X_5	12.72	45.75
24	Y= 0.62 X_4 + 1.71 X_6	15.88	57.12
25	Y= 0.59 X_4 + 2.15 X_7	15.21	54.69
26	Y= -1.69 X_5 + 0.97 X_6	4.39	15.79
27	Y= -1.40 X_5 + 1.00 X_7	3.33	11.98
28	Y= 0.91 X_6 + 0.90 X_7	6.81	24.48
29	Y= 4.98 X_1 - 3.68 X_2 + 0.39 X_3	232.59	836.48
30	Y= 0.99 X_1 + 1.09 X_2 + 0.73 X_4	50.99	183.37
31	Y= 1.06 X_1 + 0.85 X_2 - 22.82 X_5	38.37	138.00
32	Y= 0.92 X_1 + 1.02 X_2 + 0.78 X_6	41.57	149.48
33	Y= 0.91 X_1 + 1.00 X_2 + 0.83 X_7	40.66	146.23
34	Y= 8.96 X_1 + 0.37 X_3 - 14.42 X_4	294.75	1060.04
35	Y= -1.62 X_1 + 0.40 X_3 + 1094.84 X_5	295.53	1062.83
36	Y= 4.97 X_1 + 0.41 X_3 - 9.83 X_6	227.80	819.24
37	Y= 6.15 X_1 + 0.40 X_3 - 23.85 X_7	229.64	825.87
38	Y= 0.46 X_1 + 1.54 X_4 + 59.37 X_5	39.99	143.83
39	Y= 1.00 X_1 + 0.81 X_4 + 0.86 X_6	43.19	155.33
40	Y= 0.98 X_1 + 0.80 X_4 + 1.02 X_7	42.59	153.16
41	Y= 1.04 X_1 - 19.73 X_5 + 0.67 X_6	31.44	113.07
42	Y= 1.03 X_1 - 18.97 X_5 + 0.72 X_7	30.85	110.93

Table 4.20. contd……

S.No	Discriminant function	GA	RE
43	Y= 0.94 X_1 + 0.76 X_6 + 0.81 X_7	33.86	121.77
44	Y= 7.61 X_2 + 0.51 X_3 - 9.87 X_4	220.58	793.28
45	Y= 0.10 X_2 + 0.37 X_3 + 899.76 X_5	275.92	992.31
46	Y= -2.11 X_2 + 0.44 X_3 + 16.03 X_6	196.76	707.61
47	Y= -1.15 X_2 + 0.44 X_3 + 18.15 X_7	195.23	702.11
48	Y= 1.12 X_2 + 0.69 X_4 + 19.16 X_5	26.56	95.52
49	Y= 1.11 X_2 + 0.57 X_4 + 1.60 X_6	29.57	106.34
50	Y= 1.17 X_2 + 0.49 X_4 + 2.10 X_7	28.58	102.80
51	Y= 0.88 X_2 - 4.66 X_5 + 1.26 X_6	17.56	63.15
52	Y= 0.90 X_2 - 3.55 X_5 + 1.22 X_7	16.17	58.17
53	Y= 0.91 X_2 + 1.07 X_6 + 0.88 X_7	19.35	69.58
54	Y= 0.38 X_3 - 3.22 X_4 + 862.47 X_5	280.93	1010.31
55	Y= 0.47 X_3 - 9.86 X_4 + 29.87 X_6	238.01	855.95
56	Y= 0.46 X_3 - 10.69 X_4 + 44.55 X_7	243.56	875.92
57	Y= 0.37 X_3 + 1016.84 X_5 - 11.97 X_6	282.28	1015.18
58	Y= 0.37 X_3 + 1086.40 X_5 - 22.56 X_7	285.63	1027.20
59	Y= 0.45 X_3 + 5.78 X_6 + 10.11 X_7	196.00	704.89
60	Y= 0.75 X_4 + 17.20 X_5 + 1.09 X_6	16.21	58.30
61	Y= 0.75 X_4 + 17.11 X_5 + 1.17 X_7	15.47	55.65
62	Y= 0.60 X_4 + 1.32 X_6 + 1.75 X_7	18.75	67.43
63	Y= -3.58 X_5 + 0.95 X_6 + 1.02 X_7	6.93	24.94
64	Y= 8.58 X_1 + 4.24 X_2 + 0.39 X_3 - 16.02 X_4	297.84	1071.12
65	Y= -3.02 X_1 + 4.02 X_2 + 0.42 X_3 + 1206.02 X_5	297.75	1070.82
66	Y= 5.62 X_1 - 3.34 X_2 + 0.38 X_3 - 5.09 X_6	235.02	845.22
67	Y= 8.37 X_1 - 4.40 X_2 + 0.35 X_3 - 30.74 X_7	240.66	865.49
68	Y= 0.40 X_1 + 1.10 X_2 + 1.56 X_4 + 64.80 X_5	51.14	183.92
69	Y= 0.99 X_1 + 1.11 X_2 + 0.76 X_4 + 0.78 X_6	54.39	195.62
70	Y= 0.96 X_1 + 1.09 X_2 + 0.75 X_4 + 1.14 X_7	53.56	192.62
71	Y= 1.08 X_1 + 0.86 X_2 - 25.02 X_5 + 0.85 X_6	41.83	150.43
72	Y= 1.11 X_1 + 0.83 X_2 - 25.51 X_5 + 0.55 X_7	40.94	147.22
73	Y= 0.92 X_1 + 1.03 X_2 + 0.75 X_6 + 0.85 X_7	44.10	158.61
74	Y= 5.19 X_1 + 0.38 X_3 - 9.09 X_4 + 407.08 X_5	295.41	1062.40
75	Y= 9.78 X_1 + 0.36 X_3 - 14.29 X_4 - 6.21 X_6	296.65	1066.85
76	Y= 11.04 X_1 + 0.35 X_3 - 14.28 X_4 - 20.25 X_7	298.15	1072.25
77	Y= -0.90 X_1 + 0.39 X_3 + 1084.93 X_5 - 4.65 X_6	297.05	1068.29
78	Y= 0.48 X_1 + 0.38 X_3 + 1084.32 X_5 - 19.51 X_7	298.68	1074.16
79	Y= 7.48 X_1 + 0.38 X_3 - 9.92 X_6 - 23.92 X_7	233.59	840.07
80	Y= 0.42 X_1 + 1.62 X_4 + 62.64 X_5 + 0.93 X_6	43.37	155.98
81	Y= 0.42 X_1 + 1.61 X_4 + 62.28 X_5 + 1.02 X_7	42.77	153.82
82	Y= 0.98 X_1 + 0.84 X_4 + 0.84 X_6 + 1.00 X_7	45.96	165.28
83	Y= 1.07 X_1 - 21.85 X_5 + 0.64 X_6 + 0.71 X_7	34.19	122.97
84	Y= 4.50 X_2 + 0.40 X_3 - 5.51 X_4 + 823.07 X_5	283.81	1020.66
85	Y= 4.89 X_2 + 0.49 X_3 - 11.74 X_4 + 26.12 X_6	242.16	870.88

Table 4.20. contd……

S.No	Discriminant function	GA	RE
86	Y= 7.11 X_2 + 0.49 X_3 - 14.35 X_4 + 43.32 X_7	254.33	914.67
87	Y= 2.76 X_2 + 0.37 X_3 + 1051.77 X_5 - 15.96 X_6	282.58	1016.24
88	Y= 2.27 X_2 + 0.37 X_3 + 1108.59 X_5 - 25.52 X_7	285.56	1026.97
89	Y= -2.16 X_2 + 0.44 X_3 + 11.29 X_6 + 10.61 X_7	199.79	718.53
90	Y= 1.12 X_2 + 0.70 X_4 + 17.01 X_5 + 0.98 X_6	29.74	106.96
91	Y= 1.13 X_2 + 0.65 X_4 + 14.51 X_5 + 1.28 X_7	28.69	103.18
92	Y= 1.14 X_2 + 0.53 X_4 + 1.15 X_6 + 1.82 X_7	31.85	114.53
93	Y= 0.88 X_2 - 6.88 X_5 + 1.21 X_6 + 1.09 X_7	19.42	69.85
94	Y= 0.37 X_3 + 2.46 X_4 + 911.43 X_5 - 3.30 X_6	282.14	1014.68
95	Y= 0.36 X_3 - 0.81 X_4 + 1032.47 X_5 - 15.77 X_7	283.40	1019.18
96	Y= 0.46 X_3 - 11.62 X_4 + 17.50 X_6 + 32.11 X_7	251.16	903.24
97	Y= 0.37 X_3 + 1098.80 X_5 - 4.13 X_6 - 18.52 X_7	286.97	1032.05
98	Y= 0.75 X_4 + 14.78 X_5 + 1.05 X_6 + 1.10 X_7	18.92	68.04
99	Y= 4.11 X_1 + 4.37 X_2 + 0.40 X_3 - 9.79 X_4 + 481.11 X_5	298.68	1074.14
100	Y= 9.77 X_1 + 4.89 X_2 + 0.38 X_3 - 16.16 X_4 - 9.91 X_6	300.71	1081.45
101	Y= 10.36 X_1 + 3.66 X_2 + 0.37 X_3 - 15.61 X_4 - 16.48 X_7	300.41	1080.37
102	Y= -2.11 X_1 + 4.53 X_2 + 0.41 X_3 + 1210.73 X_5 - 7.85 X_6	300.00	1078.91
103	Y= -1.01 X_1 + 3.45 X_2 + 0.40 X_3 + 1176.03 X_5 - 15.99 X_7	300.17	1079.51
104	Y= 8.89 X_1 - 4.08 X_2 + 0.35 X_3 - 4.40 X_6 - 30.37 X_7	242.89	873.51
105	Y= 0.36 X_1 + 1.11 X_2 + 1.64 X_4 + 67.74 X_5 + 0.84 X_6	54.55	196.18
106	Y= 0.34 X_1 + 1.10 X_2 + 1.63 X_4 + 67.74 X_5 + 1.15 X_7	53.72	193.18
107	Y= 0.96 X_1 + 1.11 X_2 + 0.79 X_4 + 0.75 X_6 + 1.14 X_7	56.97	204.88
108	Y= 1.13 X_1 + 0.84 X_2 - 27.71 X_5 + 0.84 X_6 + 0.54 X_7	44.39	159.66
109	Y= 6.32 X_1 + 0.37 X_3 - 9.50 X_4 + 366.66 X_5 - 5.69 X_6	297.21	1068.85
110	Y= 7.40 X_1 + 0.36 X_3 - 9.16 X_4 + 391.44 X_5 - 20.05 X_7	298.76	1074.45
111	Y= 11.89 X_1 + 0.35 X_3 - 14.15 X_4 - 6.32 X_6 - 20.33 X_7	300.08	1079.17
112	Y= 1.23 X_1 + 0.38 X_3 + 1074.22 X_5 - 4.78 X_6 - 19.58 X_7	300.23	1079.73
113	Y= 0.38 X_1 + 1.69 X_4 + 65.42 X_5 + 0.91 X_6 + 0.99 X_7	46.14	165.94
114	Y= 5.05 X_2 + 0.39 X_3 - 4.39 X_4 + 914.22 X_5 - 7.31 X_6	285.89	1028.15
115	Y= 4.13 X_2 + 0.38 X_3 - 3.36 X_4 + 960.87 X_5 - 12.23 X_7	285.64	1027.27
116	Y= 6.10 X_2 + 0.48 X_3 - 14.30 X_4 + 11.11 X_6 + 35.83 X_7	257.72	926.84
117	Y= 3.39 X_2 + 0.38 X_3 + 1154.38 X_5 - 8.78 X_6 - 20.40 X_7	288.03	1035.86
118	Y= 1.13 X_2 + 0.67 X_4 + 13.45 X_5 + 0.93 X_6 + 1.23 X_7	31.93	114.85
119	Y= 0.36 X_3 - 0.20 X_4 + 1070.90 X_5 - 2.71 X_6 - 15.43 X_7	284.56	1023.38
120	Y= 5.73 X_1 + 4.98 X_2 + 0.39 X_3 - 10.61 X_4 + 428.48 X_5 -9.39 X_6	301.40	1083.93
121	Y= 6.06 X_1 + 3.80 X_2 + 0.38 X_3 - 9.70 X_4 + 457.25 X_5 -16.05 X_7	301.18	1083.13
122	Y= 11.41 X_1 + 4.32 X_2 + 0.37 X_3 - 15.77 X_4 - 9.45 X_6 -15.67 X_7	303.15	1090.22
123	Y= -0.22 X_1 + 3.96 X_2 + 0.40 X_3 + 1181.43 X_5 - 7.43 X_6 -15.37 X_7	302.33	1087.27

Table 4.20. contd……

S.No	Discriminant function	GA	RE
124	Y= 0.31 X_1 + 1.11 X_2 + 1.70 X_4 + 70.55 X_5 + 0.82 X_6 +1.14 X_7	57.13	205.45
125	Y= 8.57 X_1 + 0.35 X_3 - 9.58 X_4 + 350.04 X_5 - 5.82 X_6 - 20.14 X_7	300.59	1081.02
126	Y= 4.66 X_2 + 0.38 X_3 - 2.57 X_4 + 1028.99 X_5 - 6.50 X_6 - 10.91 X_7	287.55	1034.12
127	Y= 7.53 X_1 + 4.41 X_2 + 0.37 X_3 - 10.48 X_4 + 408.18 X_5 - 8.95 X_6 - 15.32 X_7	303.78	1092.49

X_1 = Cane yield

X_2 = Shoot population at 240 DAP

X_3 = Stalk volume

X_4 = Number of millable canes

X_5 = Single cane weight

X_6 = Fibre yield

X_7 = Commercial cane sugar yield

Table 4.21. Discriminant functions, their Genetic Advance (GA) and Relative Efficiency (RE) over straight selection for fibre yield

S.No	Discriminant function	GA	RE
1	Y= 0.92 X_1	4.30	100.00
2	Y= 0.92 X_2	14.49	337.10
3	Y= 0.71 X_3	11.79	274.31
4	Y= 0.50 X_4	0.12	2.69
5	Y= 0.99 X_5	2.81	65.31
6	Y= 0.92 X_6	3.23	75.03
7	Y= 0.91 X_7	27.81	646.69
8	Y= 1.09 X_1 + 0.90 X_2	17.51	407.33
9	Y= 1.71 X_1 + 0.62 X_3	15.88	369.38
10	Y= 0.97 X_1 - 1.69 X_4	4.39	102.13
11	Y= 0.91 X_1 + 1.05 X_5	6.10	141.76
12	Y= 0.91 X_1 + 0.90 X_6	6.81	158.31
13	Y= 0.77 X_1 + 0.93 X_7	31.13	724.02
14	Y= 1.19 X_2 + 0.60 X_3	26.20	609.37
15	Y= 0.92 X_2 + 0.14 X_4	14.49	337.10
16	Y= 0.92 X_2 + 1.06 X_5	15.09	350.89
17	Y= 0.91 X_2 + 1.04 X_6	16.14	375.36
18	Y= 0.99 X_2 + 0.91 X_7	38.12	886.66
19	Y= 0.77 X_3 + 20.69 X_4	12.72	295.89
20	Y= 0.71 X_3 + 0.76 X_5	11.63	270.39
21	Y= 0.59 X_3 + 2.15 X_6	15.21	353.69
22	Y= 0.77 X_3 + 1.01 X_7	39.81	925.88
23	Y= 0.56 X_4 + 0.98 X_5	2.77	64.39
24	Y= -1.40 X_4 + 1.00 X_6	3.33	77.46
25	Y= -16.88 X_4 + 1.00 X_7	28.08	653.11
26	Y= 0.98 X_5 + 0.92 X_6	3.84	89.19
27	Y= 0.80 X_5 + 0.91 X_7	27.23	633.32
28	Y= 0.81 X_6 + 0.92 X_7	30.55	710.42
29	Y= 1.60 X_1 + 1.11 X_2 + 0.57 X_3	29.57	687.68
30	Y= 1.26 X_1 + 0.88 X_2 - 4.66 X_4	17.56	408.41
31	Y= 1.08 X_1 + 0.91 X_2 + 1.01 X_5	18.30	425.68
32	Y= 1.07 X_1 + 0.91 X_2 + 0.88 X_6	19.35	449.95
33	Y= 0.78 X_1 + 1.02 X_2 + 0.92 X_7	41.57	966.68
34	Y= 1.09 X_1 + 0.75 X_3 + 17.20 X_4	16.21	377.04
35	Y= 2.16 X_1 + 0.53 X_3 - 0.17 X_5	16.31	379.36
36	Y= 1.32 X_1 + 0.60 X_3 + 1.75 X_6	18.75	436.07
37	Y= 0.86 X_1 + 0.81 X_3 + 1.00 X_7	43.19	1004.49
38	Y= 0.99 X_1 - 1.85 X_4 + 0.94 X_5	6.14	142.78
39	Y= 0.95 X_1 - 3.58 X_4 + 1.02 X_6	6.93	161.26
40	Y= 0.67 X_1 - 19.73 X_4 + 1.04 X_7	31.44	731.18
41	Y= 0.86 X_1 + 1.07 X_5 + 0.96 X_6	7.84	182.26
42	Y= 0.59 X_1 + 1.19 X_5 + 0.95 X_7	30.79	716.09

Table 4.21. contd……

S.No	Discriminant function	GA	RE
43	Y= 0.76 X_1 + 0.81 X_6 + 0.94 X_7	33.86	787.49
44	Y= 1.12 X_2 + 0.69 X_3 + 19.16 X_4	26.56	617.73
45	Y= 1.21 X_2 + 0.57 X_3 + 0.58 X_5	26.33	612.34
46	Y= 1.17 X_2 + 0.49 X_3 + 2.10 X_6	28.58	664.77
47	Y= 1.09 X_2 + 0.73 X_3 + 0.99 X_7	50.99	1185.82
48	Y= 0.92 X_2 + 0.38 X_4 + 1.06 X_5	15.08	350.70
49	Y= 0.90 X_2 - 3.55 X_4 + 1.22 X_6	16.17	376.18
50	Y= 0.85 X_2 - 22.82 X_4 + 1.06 X_7	38.37	892.44
51	Y= 0.91 X_2 + 1.09 X_5 + 1.07 X_6	16.57	385.30
52	Y= 1.00 X_2 + 0.82 X_5 + 0.90 X_7	37.83	879.91
53	Y= 1.00 X_2 + 0.83 X_6 + 0.91 X_7	40.66	945.68
54	Y= 0.77 X_3 + 21.12 X_4 + 1.12 X_5	12.55	291.89
55	Y= 0.75 X_3 + 17.11 X_4 + 1.17 X_6	15.47	359.88
56	Y= 1.54 X_3 + 59.37 X_4 + 0.46 X_7	39.99	930.10
57	Y= 0.59 X_3 + 0.95 X_5 + 2.15 X_6	14.95	347.65
58	Y= 0.77 X_3 + 0.87 X_5 + 1.00 X_7	39.25	912.93
59	Y= 0.80 X_3 + 1.02 X_6 + 0.98 X_7	42.59	990.47
60	Y= -1.37 X_4 + 0.96 X_5 + 0.99 X_6	3.89	90.54
61	Y= -16.98 X_4 + 0.74 X_5 + 0.99 X_7	27.51	639.82
62	Y= -18.97 X_4 + 0.72 X_6 + 1.03 X_7	30.85	717.36
63	Y= 0.79 X_5 + 0.83 X_6 + 0.91 X_7	29.97	696.90
64	Y= 0.98 X_1 + 1.12 X_2 + 0.70 X_3 + 17.01 X_4	29.74	691.69
65	Y= 2.03 X_1 + 1.13 X_2 + 0.47 X_3 - 0.17 X_5	29.96	696.84
66	Y= 1.15 X_1 + 1.14 X_2 + 0.53 X_3 + 1.82 X_6	31.85	740.65
67	Y= 0.78 X_1 + 1.11 X_2 + 0.76 X_3 + 0.99 X_7	54.39	1265.06
68	Y= 1.41 X_1 + 0.86 X_2 - 6.68 X_4 + 0.69 X_5	18.35	426.77
69	Y= 1.21 X_1 + 0.88 X_2 - 6.88 X_4 + 1.09 X_6	19.42	451.70
70	Y= 0.85 X_1 + 0.86 X_2 - 25.02 X_4 + 1.08 X_7	41.83	972.83
71	Y= 1.07 X_1 + 0.92 X_2 + 0.99 X_5 + 0.89 X_6	19.97	464.54
72	Y= 0.70 X_1 + 1.02 X_2 + 1.07 X_5 + 0.93 X_7	41.43	963.46
73	Y= 0.75 X_1 + 1.03 X_2 + 0.85 X_6 + 0.92 X_7	44.10	1025.72
74	Y= 1.23 X_1 + 0.73 X_3 + 15.27 X_4 + 0.83 X_5	16.40	381.52
75	Y= 1.05 X_1 + 0.75 X_3 + 14.78 X_4 + 1.10 X_6	18.92	440.04
76	Y= 0.93 X_1 + 1.62 X_3 + 62.64 X_4 + 0.42 X_7	43.37	1008.73
77	Y= 1.89 X_1 + 0.56 X_3 + 0.09 X_5 + 1.21 X_6	18.90	439.45
78	Y= 1.23 X_1 + 0.80 X_3 + 0.58 X_5 + 0.95 X_7	42.80	995.48
79	Y= 0.84 X_1 + 0.84 X_3 + 1.00 X_6 + 0.98 X_7	45.96	1068.84
80	Y= 1.00 X_1 - 3.77 X_4 + 0.91 X_5 + 0.97 X_6	7.93	184.45
81	Y= -0.16 X_1 - 20.09 X_4 + 1.90 X_5 + 1.16 X_7	31.10	723.33
82	Y= 0.64 X_1 - 21.85 X_4 + 0.71 X_6 + 1.07 X_7	34.19	795.20
83	Y= 0.58 X_1 + 1.18 X_5 + 0.81 X_6 + 0.96 X_7	33.49	778.96
84	Y= 1.13 X_2 + 0.69 X_3 + 19.21 X_4 + 0.99 X_5	26.66	620.04
85	Y= 1.13 X_2 + 0.65 X_3 + 14.51 X_4 + 1.28 X_6	28.69	667.24

Table 4.21. contd......

S.No	Discriminant function	GA	RE
86	Y= 1.10 X_2 + 1.56 X_3 + 64.80 X_4 + 0.40 X_7	51.14	1189.36
87	Y= 1.18 X_2 + 0.48 X_3 + 0.79 X_5 + 2.07 X_6	28.62	665.68
88	Y= 1.11 X_2 + 0.72 X_3 + 0.75 X_5 + 0.99 X_7	50.65	1178.03
89	Y= 1.09 X_2 + 0.75 X_3 + 1.14 X_6 + 0.96 X_7	53.56	1245.63
90	Y= 0.90 X_2 - 3.36 X_4 + 1.07 X_5 + 1.23 X_6	16.59	385.90
91	Y= 0.85 X_2 - 22.55 X_4 + 0.94 X_5 + 1.06 X_7	38.08	885.54
92	Y= 0.83 X_2 - 25.51 X_4 + 0.55 X_6 + 1.11 X_7	40.94	952.07
93	Y= 1.01 X_2 + 0.80 X_5 + 0.85 X_6 + 0.91 X_7	40.35	938.34
94	Y= 0.75 X_3 + 17.47 X_4 + 1.09 X_5 + 1.17 X_6	15.21	353.83
95	Y= 1.53 X_3 + 58.95 X_4 + 0.95 X_5 + 0.47 X_7	39.43	917.10
96	Y= 1.61 X_3 + 62.28 X_4 + 1.02 X_6 + 0.42 X_7	42.77	994.74
97	Y= 0.80 X_3 + 0.84 X_5 + 1.03 X_6 + 0.98 X_7	42.03	977.39
98	Y= -19.07 X_4 + 0.72 X_5 + 0.73 X_6 + 1.02 X_7	30.27	703.93
99	Y= 1.12 X_1 + 1.13 X_2 + 0.66 X_3 + 14.89 X_4 + 0.82 X_5	30.01	697.94
100	Y= 0.93 X_1 + 1.13 X_2 + 0.67 X_3 + 13.45 X_4 + 1.23 X_6	31.93	742.70
101	Y= 0.84 X_1 + 1.11 X_2 + 1.64 X_3 + 67.74 X_4 + 0.36 X_7	54.55	1268.65
102	Y= 1.66 X_1 + 1.14 X_2 + 0.49 X_3 + 0.18 X_5 + 1.34 X_6	32.08	746.01
103	Y= 1.41 X_1 + 1.11 X_2 + 0.75 X_3 + 0.28 X_5 + 0.90 X_7	54.18	1260.04
104	Y= 0.75 X_1 + 1.11 X_2 + 0.79 X_3 + 1.14 X_6 + 0.96 X_7	56.97	1324.94
105	Y= 1.50 X_1 + 0.86 X_2 - 8.63 X_4 + 0.57 X_5 + 0.86 X_6	20.05	466.33
106	Y= -0.07 X_1 + 0.85 X_2 - 25.50 X_4 + 2.00 X_5 + 1.21 X_7	41.69	969.64
107	Y= 0.84 X_1 + 0.84 X_2 - 27.71 X_4 + 0.54 X_6 + 1.13 X_7	44.39	1032.48
108	Y= 0.68 X_1 + 1.03 X_2 + 1.07 X_5 + 0.86 X_6 + 0.93 X_7	43.93	1021.75
109	Y= 0.98 X_1 + 0.76 X_3 + 15.74 X_4 + 1.07 X_5 + 1.11 X_6	18.99	441.68
110	Y= 0.93 X_1 + 1.62 X_3 + 62.45 X_4 + 0.99 X_5 + 0.42 X_7	42.98	999.66
111	Y= 0.91 X_1 + 1.69 X_3 + 65.42 X_4 + 0.99 X_6 + 0.38 X_7	46.14	1073.12
112	Y= 1.12 X_1 + 0.83 X_3 + 0.67 X_5 + 1.00 X_6 + 0.94 X_7	45.55	1059.45
113	Y= -0.24 X_1 - 22.24 X_4 + 1.97 X_5 + 0.71 X_6 + 1.20 X_7	33.83	786.77
114	Y= 1.13 X_2 + 0.65 X_3 + 14.33 X_4 + 0.96 X_5 + 1.29 X_6	28.72	667.93
115	Y= 1.12 X_2 + 1.54 X_3 + 63.87 X_4 + 0.85 X_5 + 0.40 X_7	50.80	1181.48
116	Y= 1.10 X_2 + 1.63 X_3 + 67.74 X_4 + 1.15 X_6 + 0.34 X_7	53.72	1249.27
117	Y= 1.12 X_2 + 0.74 X_3 + 0.73 X_5 + 1.18 X_6 + 0.95 X_7	53.21	1237.46
118	Y= 0.84 X_2 - 25.21 X_4 + 0.94 X_5 + 0.56 X_6 + 1.11 X_7	40.61	944.57
119	Y= 1.60 X_3 + 61.75 X_4 + 0.93 X_5 + 1.03 X_6 + 0.42 X_7	42.21	981.60
120	Y= 0.84 X_1 + 1.13 X_2 + 0.69 X_3 + 14.60 X_4 + 1.08 X_5 +1.24 X_6	32.13	747.22
121	Y= 1.08 X_1 + 1.12 X_2 + 1.62 X_3 + 67.18 X_4 + 0.72 X_5 +0.34 X_7	54.33	1263.54
122	Y= 0.82 X_1 + 1.11 X_2 + 1.70 X_3 + 70.55 X_4 + 1.14 X_6 +0.31 X_7	57.13	1328.62
123	Y= 1.30 X_1 + 1.12 X_2 + 0.78 X_3 + 0.36 X_5 + 1.15 X_6 +0.88 X_7	56.73	1319.40

Table 4.21. contd……

S.No	Discriminant function	GA	RE
124	Y= -0.16 X_1 + 0.84 X_2 - 28.26 X_4 + 2.09 X_5 + 0.54 X_6 +1.28 X_7	44.23	1028.54
125	Y= 0.81 X_1 + 1.68 X_3 + 65.40 X_4 + 1.09 X_5 + 1.00 X_6 +0.39 X_7	45.74	1063.69
126	Y= 1.12 X_2 + 1.61 X_3 + 66.69 X_4 + 0.82 X_5 + 1.17 X_6 +0.34 X_7	53.36	1241.00
127	Y= 0.97 X_1 + 1.12 X_2 + 1.69 X_3 + 70.14 X_4 + 0.81 X_5 +1.15 X_6 + 0.29 X_7	56.89	1323.01

X_1 = Fibre yield

X_2 = Shoot population at 240 DAP

X_3 = Number of millable canes

X_4 = Single cane weight

X_5 = Fibre content

X_6 = Commercial cane sugar yield

X_7 = Cane yield

Table 4.22. Discriminant functions, their Genetic Advance (GA) and Relative Efficiency (RE) over straight selection for biomass per cane

S.No	Discriminant function	GA	RE
1	Y= 0.92 X_1	0.31	100.00
2	Y= 0.58 X_2	2.05	661.99
3	Y= 0.43 X_3	1.77	571.30
4	Y= 0.95 X_4	32.75	10554.78
5	Y= 0.37 X_5	0.12	40.25
6	Y= 0.46 X_6	186.30	60040.21
7	Y= 0.50 X_7	0.12	37.25
8	Y= 2.48 X_1 + 0.54 X_2	2.31	743.30
9	Y= 3.98 X_1 + 0.34 X_3	2.27	732.60
10	Y= -3.16 X_1 + 0.96 X_4	32.88	10594.92
11	Y= 1.19 X_1 + 0.30 X_5	0.45	146.28
12	Y= 450.88 X_1 + 0.26 X_6	226.75	73076.94
13	Y= 1.05 X_1 + 0.46 X_7	0.41	132.49
14	Y= 0.94 X_2 + 0.44 X_3	4.61	1487.12
15	Y= 0.74 X_2 + 0.96 X_4	33.95	10941.02
16	Y= 0.64 X_2 - 2.49 X_5	2.18	702.24
17	Y= -18.68 X_2 + 0.53 X_6	196.07	63186.96
18	Y= 0.63 X_2 + 5.23 X_7	2.43	784.34
19	Y= 0.07 X_3 + 0.99 X_4	34.30	11052.90
20	Y= 0.43 X_3 + 1.13 X_5	1.85	595.89
21	Y= 13.08 X_3 + 0.43 X_6	194.30	62616.92
22	Y= 0.42 X_3 + 2.28 X_7	1.88	606.78
23	Y= 0.95 X_4 + 1.36 X_5	32.74	10550.89
24	Y= 3.54 X_4 + 0.38 X_6	228.91	73772.89
25	Y= 0.95 X_4 + 0.43 X_7	32.76	10558.90
26	Y= -526.99 X_5 + 0.86 X_6	203.21	65488.39
27	Y= 0.64 X_5 + 1.22 X_7	0.38	123.14
28	Y= 0.37 X_6 + 899.25 X_7	276.30	89043.32
29	Y= 4.23 X_1 + 0.90 X_2 + 0.36 X_3	4.92	1586.49
30	Y= -2.74 X_1 + 0.83 X_2 + 0.97 X_4	34.07	10981.47
31	Y= 4.09 X_1 + 0.57 X_2 - 3.47 X_5	2.57	827.04
32	Y= 501.32 X_1 - 25.62 X_2 + 0.32 X_6	242.00	77991.20
33	Y= 1.07 X_1 + 0.63 X_2 + 5.18 X_7	2.62	843.78
34	Y= -0.06 X_1 + 0.09 X_3 + 0.99 X_4	34.41	11088.47
35	Y= 4.41 X_1 + 0.33 X_3 - 0.05 X_5	2.38	765.92
36	Y= 440.15 X_1 + 3.69 X_3 + 0.26 X_6	228.71	73707.26
37	Y= 4.04 X_1 + 0.34 X_3 + 0.74 X_7	2.35	758.59
38	Y= -4.38 X_1 + 0.97 X_4 + 3.57 X_5	32.87	10594.39
39	Y= 401.18 X_1 + 2.75 X_4 + 0.22 X_6	254.99	82175.36
40	Y= -3.75 X_1 + 0.96 X_4 + 2.99 X_7	32.89	10600.11
41	Y= 406.27 X_1 - 341.78 X_5 + 0.54 X_6	232.53	74937.10
42	Y= 1.00 X_1 + 0.65 X_5 + 1.21 X_7	0.63	201.99

Table 4.22. contd.....

S.No	Discriminant function	GA	RE
43	$Y = 230.86\ X_1 + 0.27\ X_6 + 798.36\ X_7$	283.34	91313.02
44	$Y = 1.43\ X_2 - 0.17\ X_3 + 0.99\ X_4$	35.68	11499.60
45	$Y = 1.01\ X_2 + 0.44\ X_3 - 2.84\ X_5$	4.70	1513.91
46	$Y = -38.84\ X_2 + 31.22\ X_3 + 0.51\ X_6$	221.69	71445.57
47	$Y = 1.09\ X_2 + 0.31\ X_3 + 7.82\ X_7$	4.99	1608.18
48	$Y = 0.80\ X_2 + 0.95\ X_4 - 1.93\ X_5$	33.94	10937.26
49	$Y = -24.50\ X_2 + 4.06\ X_4 + 0.44\ X_6$	242.52	78156.99
50	$Y = 0.80\ X_2 + 0.95\ X_4 + 5.32\ X_7$	33.99	10953.56
51	$Y = -22.17\ X_2 - 591.46\ X_5 + 0.98\ X_6$	215.89	69575.40
52	$Y = 0.71\ X_2 - 3.07\ X_5 + 6.95\ X_7$	2.70	868.86
53	$Y = -8.60\ X_2 + 0.40\ X_6 + 883.10\ X_7$	278.42	89727.24
54	$Y = 0.04\ X_3 + 0.99\ X_4 + 2.89\ X_5$	34.30	11052.48
55	$Y = 5.97\ X_3 + 3.31\ X_4 + 0.37\ X_6$	231.47	74595.11
56	$Y = 0.06\ X_3 + 0.99\ X_4 + 2.73\ X_7$	34.32	11058.90
57	$Y = 7.12\ X_3 - 474.63\ X_5 + 0.80\ X_6$	206.27	66476.37
58	$Y = 0.42\ X_3 + 1.23\ X_5 + 2.87\ X_7$	2.02	652.05
59	$Y = 8.59\ X_3 + 0.35\ X_6 + 888.15\ X_7$	279.37	90034.31
60	$Y = 3.01\ X_4 - 114.27\ X_5 + 0.48\ X_6$	229.04	73812.68
61	$Y = 0.95\ X_4 + 1.67\ X_5 + 0.89\ X_7$	32.75	10555.89
62	$Y = 3.63\ X_4 + 0.28\ X_6 + 904.74\ X_7$	307.45	99083.69
63	$Y = -516.49\ X_5 + 0.76\ X_6 + 897.36\ X_7$	287.65	92701.54
64	$Y = -0.42\ X_1 + 1.44\ X_2 - 0.14\ X_3 + 0.99\ X_4$	35.80	11537.68
65	$Y = 6.41\ X_1 + 1.00\ X_2 + 0.29\ X_3 - 4.67\ X_5$	5.15	1660.53
66	$Y = 440.65\ X_1 - 38.59\ X_2 + 21.70\ X_3 + 0.33\ X_6$	252.46	81361.66
67	$Y = 2.42\ X_1 + 1.05\ X_2 + 0.29\ X_3 + 7.02\ X_7$	5.20	1676.32
68	$Y = -1.86\ X_1 + 0.83\ X_2 + 0.96\ X_4 - 0.85\ X_5$	34.05	10975.02
69	$Y = 444.82\ X_1 - 29.14\ X_2 + 3.28\ X_4 + 0.28\ X_6$	272.18	87715.53
70	$Y = -5.45\ X_1 + 0.97\ X_2 + 0.97\ X_4 + 9.06\ X_7$	34.14	11002.90
71	$Y = 452.22\ X_1 - 27.30\ X_2 - 398.77\ X_5 + 0.65\ X_6$	249.28	80335.18
72	$Y = 2.32\ X_1 + 0.68\ X_2 - 3.38\ X_5 + 6.21\ X_7$	2.90	935.02
73	$Y = 273.26\ X_1 - 13.88\ X_2 + 0.31\ X_6 + 751.20\ X_7$	287.58	92680.60
74	$Y = -1.35\ X_1 + 0.09\ X_3 + 1.00\ X_4 + 3.78\ X_5$	34.41	11089.94
75	$Y = 408.89\ X_1 - 1.36\ X_3 + 2.83\ X_4 + 0.22\ X_6$	256.81	82762.94
76	$Y = -0.83\ X_1 + 0.09\ X_3 + 0.99\ X_4 + 3.65\ X_7$	34.43	11095.46
77	$Y = 409.93\ X_1 - 0.02\ X_3 - 346.98\ X_5 + 0.54\ X_6$	234.19	75472.29
78	$Y = 4.13\ X_1 + 0.33\ X_3 + 0.29\ X_5 + 1.50\ X_7$	2.48	797.97
79	$Y = 216.75\ X_1 + 4.42\ X_3 + 0.27\ X_6 + 799.83\ X_7$	285.08	91873.96
80	$Y = 405.09\ X_1 + 3.57\ X_4 + 181.40\ X_5 + 0.06\ X_6$	255.22	82251.30
81	$Y = -5.37\ X_1 + 0.97\ X_4 + 3.95\ X_5 + 3.78\ X_7$	32.90	10602.09
82	$Y = 156.81\ X_1 + 3.32\ X_4 + 0.23\ X_6 + 835.68\ X_7$	310.35	100016.62
83	$Y = 165.58\ X_1 - 442.03\ X_5 + 0.63\ X_6 + 825.51\ X_7$	291.03	93790.54
84	$Y = 1.48\ X_2 - 0.15\ X_3 + 0.98\ X_4 - 2.25\ X_5$	35.67	11495.61
85	$Y = -38.31\ X_2 + 23.83\ X_3 + 3.33\ X_4 + 0.45\ X_6$	254.56	82039.21

Table 4.22. contd.....

S.No	Discriminant function	GA	RE
86	Y= 1.60 X_2 - 0.31 X_3 + 0.98 X_4 + 9.52 X_7	35.77	11526.56
87	Y= -37.33 X_2 + 25.14 X_3 - 429.66 X_5 + 0.84 X_6	230.41	74255.47
88	Y= 1.23 X_2 + 0.27 X_3 - 3.95 X_5 + 9.91 X_7	5.20	1677.28
89	Y= -21.34 X_2 + 19.10 X_3 + 0.39 X_6 + 826.00 X_7	285.91	92141.52
90	Y= -25.41 X_2 + 5.39 X_4 + 285.94 X_5 + 0.19 X_6	242.93	78290.58
91	Y= 0.89 X_2 + 0.95 X_4 - 2.60 X_5 + 6.97 X_7	33.99	10953.63
92	Y= -14.29 X_2 + 3.95 X_4 + 0.32 X_6 + 875.91 X_7	311.83	100494.61
93	Y= -11.99 X_2 - 554.41 X_5 + 0.83 X_6 + 873.04 X_7	291.14	93826.15
94	Y= 6.09 X_3 + 2.68 X_4 - 136.11 X_5 + 0.50 X_6	231.61	74643.20
95	Y= 0.03 X_3 + 0.99 X_4 + 2.98 X_5 + 2.93 X_7	34.32	11060.02
96	Y= 0.39 X_3 + 3.66 X_4 + 0.28 X_6 + 906.24 X_7	308.90	99550.01
97	Y= 2.20 X_3 - 504.90 X_5 + 0.74 X_6 + 896.09 X_7	289.04	93149.54
98	Y= 4.66 X_4 + 224.94 X_5 + 0.07 X_6 + 908.94 X_7	307.79	99193.16
99	Y= 1.07 X_1 + 1.48 X_2 - 0.15 X_3 + 0.98 X_4 - 2.27 X_5	35.79	11533.30
100	Y= 409.25 X_1 - 38.08 X_2 + 16.39 X_3 + 2.84 X_4 + 0.30 X_6	277.85	89542.63
101	Y= -3.95 X_1 + 1.70 X_2 - 0.27 X_3 + 1.00 X_4 + 12.26 X_7	35.91	11572.21
102	Y= 414.60 X_1 - 37.57 X_2 + 18.02 X_3 - 300.26 X_5 + 0.58 X_6	256.25	82582.31
103	Y= 4.26 X_1 + 1.18 X_2 + 0.21 X_3 - 4.82 X_5 + 8.35 X_7	5.47	1763.39
104	Y= 239.88 X_1 - 23.41 X_2 + 15.45 X_4 + 0.31 X_6 + 721.87 X_7	292.63	94307.79
105	Y= 462.47 X_1 - 31.57 X_2 + 6.58 X_4 + 717.50 X_5 - 0.37 X_6	274.12	88341.26
106	Y= -4.82 X_1 + 0.98 X_2 + 0.96 X_4 - 0.84 X_5 + 9.82 X_7	34.13	10999.22
107	Y= 200.84 X_1 - 17.49 X_2 + 3.61 X_4 + 0.26 X_6 + 779.94 X_7	316.21	101904.85
108	Y= 208.33 X_1 - 15.50 X_2 - 469.97 X_5 + 0.69 X_6 + 774.25 X_7	296.08	95417.20
109	Y= 414.18 X_1 - 1.63 X_3 + 3.79 X_4 + 209.62 X_5 + 0.03 X_6	257.09	82852.01
110	Y= -2.52 X_1 + 0.08 X_3 + 1.00 X_4 + 4.17 X_5 + 4.43 X_7	34.44	11099.62
111	Y= 166.66 X_1 - 2.16 X_3 + 3.43 X_4 + 0.23 X_6 + 836.95 X_7	311.99	100544.94
112	Y= 170.16 X_1 - 0.37 X_3 - 449.63 X_5 + 0.64 X_6 + 826.06 X_7	292.42	94240.27
113	Y= 162.45 X_1 + 4.76 X_4 + 316.92 X_5 - 0.06 X_6 + 838.76 X_7	310.85	100179.03
114	Y= -39.70 X_2 + 24.14 X_3 + 5.08 X_4 + 380.43 X_5 + 0.11 X_6	255.22	82251.67
115	Y= 1.73 X_2 - 0.33 X_3 + 0.98 X_4 - 3.67 X_5 + 11.54 X_7	35.78	11529.94
116	Y= -20.36 X_2 + 10.46 X_3 + 3.65 X_4 + 0.32 X_6 + 847.03 X_7	314.61	101391.09
117	Y= -19.36 X_2 + 12.09 X_3 - 480.60 X_5 + 0.77 X_6 + 839.67 X_7	294.47	94900.03
118	Y= -15.70 X_2 + 6.12 X_4 + 466.65 X_5 - 0.10 X_6 + 880.48 X_7	312.69	100771.86
119	Y= 0.16 X_3 + 4.75 X_4 + 237.22 X_5 + 0.06 X_6 + 910.98 X_7	309.26	99664.84
120	Y= 427.07 X_1 - 40.78 X_2 + 16.66 X_3 + 6.29 X_4 + 750.71 X_5 -0.38 X_6	279.93	90212.69
121	Y= -2.63 X_1 + 1.77 X_2 - 0.29 X_3 + 0.99 X_4 - 2.54 X_5 +13.19 X_7	35.91	11571.63
122	Y= 189.27 X_1 - 22.03 X_2 + 8.36 X_3 + 3.39 X_4 + 0.27 X_6 +763.15 X_7	318.43	102620.59
123	Y= 195.04 X_1 - 21.31 X_2 + 10.10 X_3 - 414.56 X_5 + 0.65 X_6 +753.30 X_7	298.72	96269.17

Table 4.22. contd.....

S.No	Discriminant function	GA	RE
124	Y= 217.42 X_1 - 19.72 X_2 + 6.59 X_4 + 648.01 X_5 - 0.33 X_6 +778.01 X_7	317.66	102374.14
125	Y= 174.31 X_1 - 2.62 X_3 + 5.06 X_4 + 353.35 X_5 - 0.10 X_6 +840.42 X_7	312.56	100730.92
126	Y= -22.11 X_2 + 10.81 X_3 + 5.98 X_4 + 504.83 X_5 - 0.13 X_6 +850.83 X_7	315.58	101704.03
127	Y= 205.97 X_1 - 24.49 X_2 + 8.63 X_3 + 6.47 X_4 + 669.76 X_5 -0.34 X_6 + 760.51 X_7	319.96	103115.07

X_1 = Biomass per cane

X_2 = Number of leaves at maturity

X_3 = Number of Internodes per cane

X_4 = Stalk length

X_5 = Stalk diameter

X_6 = Stalk volume

X_7 = Single cane weight

Table 4.23. Discriminant functions, their Genetic Advance (GA) and Relative Efficiency (RE) over straight selection for commercial cane sugar yield

S.No	Discriminant function	GA	RE
1	Y= $0.92 X_1$	3.23	100.00
2	Y= $0.92 X_2$	14.49	449.32
3	Y= $0.91 X_{12}$	27.81	861.95
4	Y= $0.81 X_1 + 0.92 X_{12}$	30.55	946.90
5	Y= $0.99 X_2 + 0.91 X_{12}$	38.12	1181.81
6	Y= $0.77 X_3 + 1.01 X_{12}$	39.81	1234.09
7	Y= $0.83 X_1 + 1.00 X_2 + 0.91 X_{12}$	40.66	1260.47
8	Y= $1.02 X_1 + 0.80 X_3 + 0.98 X_{12}$	42.59	1320.17
9	Y= $1.09 X_2 + 0.73 X_3 + 0.99 X_{12}$	50.99	1580.55
10	Y= $1.14 X_1 + 1.09 X_2 + 0.75 X_3 + 0.96 X_{12}$	53.56	1660.27
11	Y= $1.11 X_2 + 0.76 X_3 + 0.78 X_{10} + 0.99 X_{12}$	54.39	1686.17
12	Y= $1.14 X_1 + 1.11 X_2 + 0.79 X_3 + 0.75 X_{10} + 0.96 X_{12}$	56.97	1765.98
13	Y= $1.14 X_1 + 1.11 X_2 + 1.70 X_3 + 70.55 X_4 + 0.82 X_{10}$ $+0.31 X_{12}$	57.13	1770.89
14	Y= $1.15 X_1 + 1.11 X_2 + 0.78 X_3 + 1.05 X_9 + 0.72 X_{10}$ $+0.97 X_{12}$	57.72	1789.24
15	Y= $1.15 X_1 + 1.12 X_2 + 1.70 X_3 + 71.11 X_4 + 1.05 X_9$ $+0.79 X_{10} + 0.31 X_{12}$	57.88	1794.07
16	Y= $1.22 X_1 + 1.11 X_2 + 0.79 X_3 + 0.95 X_9 + 0.74 X_{10}$ $+1.09 X_{11} + 0.96 X_{12}$	58.17	1803.10
17	Y= $1.20 X_1 + 1.11 X_2 + 1.73 X_3 + 72.91 X_4 + 0.88 X_9$ $+0.82 X_{10} + 1.23 X_{11} + 0.28 X_{12}$	58.32	1807.98
18	Y= $0.79 X_1 + 1.11 X_2 + 0.78 X_3 + 1.36 X_5 + 1.01 X_9$ $+0.72 X_{10} + 1.04 X_{11} + 1.00 X_{12}$	58.33	1808.29
19	Y= $0.57 X_1 + 1.12 X_2 + 1.75 X_3 + 74.40 X_4 + 1.54 X_5$ $+0.95 X_9 + 0.79 X_{10} + 1.18 X_{11} + 0.33 X_{12}$	58.49	1813.22
20	Y= $0.65 X_1 + 1.12 X_2 + 1.74 X_3 + 74.14 X_4 + 1.54 X_5$ $+0.91 X_6 + 0.98 X_9 + 0.79 X_{10} + 1.17 X_{11} + 0.33 X_{12}$	58.63	1817.53
21	Y= $0.52 X_1 + 1.12 X_2 + 1.74 X_3 + 74.19 X_4 + 1.37 X_5$ $+1.19 X_8 + 0.96 X_9 + 0.82 X_{10} + 1.18 X_{11} + 0.34 X_{12}$	58.65	1818.06
22	Y= $0.65 X_1 + 1.12 X_2 + 0.77 X_3 + 1.26 X_5 - 3.56 X_6$ $+6.54 X_8 + 1.09 X_9 + 1.47 X_{10} + 0.99 X_{11} + 0.91 X_{12}$	58.72	1820.23

Table 4.23. contd……

S.No	Discriminant function	GA	RE
23	Y= 0.46 X_1 + 1.12 X_2 + 1.72 X_3 + 73.16 X_4 + 1.29 X_5 -0.87 X_6 + 3.50 X_8 + 1.00 X_9 + 1.13 X_{10} + 1.16 X_{11} +0.31 X_{12}	58.87	1824.96
24	Y= -1.13 X_1 + 1.11 X_2 + 1.83 X_3 + 81.76 X_4 + 2.21 X_5 -4.78 X_6 + 5.21 X_7 + 5.02 X_8 + 1.11 X_9 + 1.30 X_{10} +1.05 X_{11} + 0.38 X_{12}	59.00	1828.82

X_1 = Commercial cane sugar yield

X_2 = Shoot population at 240 DAP

X_3 = Number of millable canes

X_4 = Single cane weight

X_5 = Brix percent

X_6 = Sucrose percent

X_7 = Commercial cane sugar percent

X_8 = Pol % cane

X_9 = Total sugars percent

X_{10} = Fibre yield

X_{11} = Theoretical yield of alcohol

X_{12} = Cane yield

Table 4.24. Discriminant functions, their Genetic Advance (GA) and Relative Efficiency (RE) over straight selection for Theoretical yield of alcohol

S.No	Discriminant function	GA	RE
1	Y= 0.92 X_1	2.32	100.00
2	Y= 0.93 X_2	2.17	93.85
3	Y= 0.98 X_3	2.41	104.24
4	Y= 0.99 X_4	1.69	72.99
5	Y= 0.81 X_5	3.37	145.52
6	Y= 0.98 X_6	2.07	89.32
7	Y= 0.92 X_7	3.95	170.65
8	Y= 0.92 X_8	3.23	139.28
9	Y= 0.96 X_1 + 0.99 X_2	3.93	169.75
10	Y= 0.93 X_1 + 1.04 X_3	4.16	179.51
11	Y= 0.91 X_1 + 1.07 X_4	3.54	152.72
12	Y= 1.03 X_1 + 0.79 X_5	4.90	211.54
13	Y= 0.93 X_1 + 1.05 X_6	3.82	164.95
14	Y= 1.03 X_1 + 0.87 X_7	6.21	268.15
15	Y= 0.96 X_1 + 0.93 X_8	4.59	197.96
16	Y= 0.24 X_2 + 1.66 X_3	4.60	198.51
17	Y= 0.73 X_2 + 1.30 X_4	3.82	164.81
18	Y= 1.25 X_2 + 0.80 X_5	5.27	227.42
19	Y= 0.54 X_2 + 1.43 X_6	4.22	182.22
20	Y= 1.06 X_2 + 0.93 X_7	5.42	234.08
21	Y= 0.98 X_2 + 0.92 X_8	4.68	201.97
22	Y= 0.95 X_3 + 1.05 X_4	4.08	176.10
23	Y= 1.37 X_3 + 0.68 X_5	5.62	242.77
24	Y= 1.00 X_3 + 0.96 X_6	4.46	192.48
25	Y= 1.10 X_3 + 0.91 X_7	5.63	242.87
26	Y= 1.03 X_3 + 0.91 X_8	4.83	208.60
27	Y= 1.65 X_4 + 0.62 X_5	5.00	216.08
28	Y= 1.02 X_4 + 0.96 X_6	3.71	160.13
29	Y= 1.15 X_4 + 0.91 X_7	5.05	217.94
30	Y= 1.05 X_4 + 0.91 X_8	4.21	181.89
31	Y= 0.69 X_5 + 1.42 X_6	5.28	228.03
32	Y= 0.78 X_5 + 0.97 X_7	6.23	268.97
33	Y= 0.81 X_5 + 0.98 X_8	5.34	230.71
34	Y= 1.11 X_6 + 0.91 X_7	5.29	228.29
35	Y= 1.05 X_6 + 0.91 X_8	4.62	199.28
36	Y= 0.94 X_7 + 0.96 X_8	6.00	259.00
37	Y= 0.95 X_1 + 0.38 X_2 + 1.57 X_3	6.16	265.81
38	Y= 0.95 X_1 + 0.81 X_2 + 1.26 X_4	5.44	234.77
39	Y= 0.94 X_1 + 1.33 X_2 + 0.79 X_5	6.78	292.61
40	Y= 0.98 X_1 + 0.63 X_2 + 1.38 X_6	5.78	249.75
41	Y= 0.94 X_1 + 1.13 X_2 + 0.92 X_7	7.60	328.23

Table 4.24. contd....

S.No	Discriminant function	GA	RE
42	$Y= 0.99 X_1 + 1.02 X_2 + 0.92 X_8$	6.16	265.81
43	$Y= 0.95 X_1 + 1.02 X_3 + 1.01 X_4$	5.69	245.63
44	$Y= 0.93 X_1 + 1.45 X_3 + 0.66 X_5$	7.11	306.96
45	$Y= 0.96 X_1 + 1.02 X_3 + 1.00 X_6$	6.02	260.02
46	$Y= 0.95 X_1 + 1.16 X_3 + 0.90 X_7$	7.79	336.53
47	$Y= 0.95 X_1 + 1.08 X_3 + 0.91 X_8$	6.33	273.32
48	$Y= 0.92 X_1 + 1.79 X_4 + 0.59 X_5$	6.50	280.47
49	$Y= 0.94 X_1 + 1.02 X_4 + 1.02 X_6$	5.32	229.86
50	$Y= 0.95 X_1 + 1.23 X_4 + 0.89 X_7$	7.27	313.66
51	$Y= 0.94 X_1 + 1.11 X_4 + 0.91 X_8$	5.72	246.77
52	$Y= 0.95 X_1 + 0.66 X_5 + 1.51 X_6$	6.76	291.80
53	$Y= 1.20 X_1 + 0.78 X_5 + 0.83 X_7$	8.31	358.81
54	$Y= 1.04 X_1 + 0.79 X_5 + 0.98 X_8$	6.82	294.37
55	$Y= 0.95 X_1 + 1.18 X_6 + 0.90 X_7$	7.48	322.87
56	$Y= 0.95 X_1 + 1.10 X_6 + 0.90 X_8$	6.07	262.25
57	$Y= 0.98 X_1 + 0.92 X_7 + 0.98 X_8$	8.01	345.94
58	$Y= 0.04 X_2 + 2.12 X_3 + 0.58 X_4$	6.24	269.34
59	$Y= 0.80 X_2 + 1.46 X_3 + 0.75 X_5$	7.60	328.30
60	$Y= 0.07 X_2 + 1.84 X_3 + 0.95 X_6$	6.63	286.35
61	$Y= 0.59 X_2 + 1.43 X_3 + 0.94 X_7$	7.47	322.58
62	$Y= 0.23 X_2 + 1.70 X_3 + 0.93 X_8$	6.74	290.95
63	$Y= 1.08 X_2 + 1.30 X_4 + 0.76 X_5$	6.91	298.27
64	$Y= 0.51 X_2 + 1.22 X_4 + 1.29 X_6$	5.85	252.65
65	$Y= 0.92 X_2 + 1.19 X_4 + 0.94 X_7$	6.79	293.31
66	$Y= 0.77 X_2 + 1.30 X_4 + 0.93 X_8$	6.02	259.78
67	$Y= 1.20 X_2 + 0.82 X_5 + 1.01 X_6$	7.24	312.62
68	$Y= 1.42 X_2 + 0.76 X_5 + 0.92 X_7$	8.04	347.23
69	$Y= 1.31 X_2 + 0.81 X_5 + 0.89 X_8$	7.20	310.77
70	$Y= 0.80 X_2 + 1.26 X_6 + 0.95 X_7$	7.10	306.55
71	$Y= 0.52 X_2 + 1.51 X_6 + 0.91 X_8$	6.45	278.48
72	$Y= 1.08 X_2 + 0.96 X_7 + 0.93 X_8$	7.52	324.71
73	$Y= 1.12 X_3 + 1.39 X_4 + 0.67 X_5$	7.25	313.16
74	$Y= 0.91 X_3 + 1.13 X_4 + 0.97 X_6$	6.11	263.69
75	$Y= 1.12 X_3 + 0.95 X_4 + 0.93 X_7$	7.03	303.41
76	$Y= 1.07 X_3 + 0.94 X_4 + 0.91 X_8$	6.21	268.32
77	$Y= 1.30 X_3 + 0.71 X_5 + 1.02 X_6$	7.57	326.88
78	$Y= 1.55 X_3 + 0.62 X_5 + 0.92 X_7$	8.35	360.64
79	$Y= 1.43 X_3 + 0.69 X_5 + 0.88 X_8$	7.48	323.11
80	$Y= 1.12 X_3 + 0.94 X_6 + 0.93 X_7$	7.33	316.33
81	$Y= 0.96 X_3 + 1.08 X_6 + 0.91 X_8$	6.63	286.36
82	$Y= 1.12 X_3 + 0.94 X_7 + 0.92 X_8$	7.69	332.03
83	$Y= 1.44 X_4 + 0.66 X_5 + 1.11 X_6$	6.90	297.84
84	$Y= 1.95 X_4 + 0.53 X_5 + 0.92 X_7$	7.75	334.67
85	$Y= 1.72 X_4 + 0.62 X_5 + 0.89 X_8$	6.84	295.26

Table 4.24. contd....

S.No	Discriminant function	GA	RE
86	Y= 1.04 X_4 + 1.06 X_6 + 0.93 X_7	6.66	287.60
87	Y= 0.94 X_4 + 1.09 X_6 + 0.90 X_8	5.94	256.35
88	Y= 1.17 X_4 + 0.93 X_7 + 0.93 X_8	7.10	306.33
89	Y= 0.62 X_5 + 1.62 X_6 + 0.93 X_7	7.99	345.09
90	Y= 0.69 X_5 + 1.52 X_6 + 0.87 X_8	7.20	310.79
91	Y= 0.78 X_5 + 0.98 X_7 + 1.01 X_8	8.13	350.83
92	Y= 1.15 X_6 + 0.94 X_7 + 0.92 X_8	7.41	320.10
93	Y= 0.97 X_1 + 0.23 X_2 + 1.91 X_3 + 0.67 X_4	7.74	334.29
94	Y= 0.96 X_1 + 0.56 X_2 + 1.80 X_3 + 0.68 X_5	9.06	391.14
95	Y= 0.98 X_1 + 0.23 X_2 + 1.69 X_3 + 0.99 X_6	8.10	349.90
96	Y= 0.92 X_1 + 0.71 X_2 + 1.38 X_3 + 0.94 X_7	9.50	410.19
97	Y= 0.98 X_1 + 0.39 X_2 + 1.59 X_3 + 0.92 X_8	8.21	354.61
98	Y= 0.95 X_1 + 1.10 X_2 + 1.38 X_4 + 0.73 X_5	8.38	361.73
99	Y= 0.99 X_1 + 0.61 X_2 + 1.17 X_4 + 1.26 X_6	7.36	317.77
100	Y= 0.92 X_1 + 1.00 X_2 + 1.18 X_4 + 0.94 X_7	8.88	383.30
101	Y= 0.98 X_1 + 0.85 X_2 + 1.24 X_4 + 0.92 X_8	7.52	324.49
102	Y= 0.96 X_1 + 1.22 X_2 + 0.80 X_5 + 1.07 X_6	8.69	375.24
103	Y= 0.99 X_1 + 1.49 X_2 + 0.75 X_5 + 0.88 X_7	10.03	432.95
104	Y= 0.97 X_1 + 1.37 X_2 + 0.80 X_5 + 0.88 X_8	8.68	374.59
105	Y= 0.92 X_1 + 0.89 X_2 + 1.23 X_6 + 0.95 X_7	9.15	395.05
106	Y= 1.00 X_1 + 0.62 X_2 + 1.45 X_6 + 0.90 X_8	7.91	341.44
107	Y= 0.88 X_1 + 1.16 X_2 + 0.97 X_7 + 0.93 X_8	9.50	410.12
108	Y= 0.95 X_1 + 1.15 X_3 + 1.47 X_4 + 0.63 X_5	8.71	375.95
109	Y= 0.98 X_1 + 0.94 X_3 + 1.08 X_4 + 1.01 X_6	7.61	328.74
110	Y= 0.94 X_1 + 1.19 X_3 + 0.92 X_4 + 0.91 X_7	9.10	392.79
111	Y= 0.98 X_1 + 1.14 X_3 + 0.88 X_4 + 0.91 X_8	7.72	333.42
112	Y= 0.96 X_1 + 1.34 X_3 + 0.69 X_5 + 1.07 X_6	9.01	388.99
113	Y= 0.99 X_1 + 1.63 X_3 + 0.59 X_5 + 0.88 X_7	10.32	445.34
114	Y= 0.96 X_1 + 1.50 X_3 + 0.66 X_5 + 0.88 X_8	8.96	386.68
115	Y= 0.94 X_1 + 1.17 X_3 + 0.95 X_6 + 0.92 X_7	9.37	404.37
116	Y= 0.99 X_1 + 0.94 X_3 + 1.14 X_6 + 0.90 X_8	8.10	349.88
117	Y= 0.89 X_1 + 1.19 X_3 + 0.95 X_7 + 0.93 X_8	9.67	417.52
118	Y= 0.95 X_1 + 1.52 X_4 + 0.62 X_5 + 1.15 X_6	8.35	360.36
119	Y= 0.93 X_1 + 2.08 X_4 + 0.50 X_5 + 0.91 X_7	9.74	420.67
120	Y= 0.95 X_1 + 1.83 X_4 + 0.59 X_5 + 0.89 X_8	8.32	359.12
121	Y= 0.94 X_1 + 1.06 X_4 + 1.12 X_6 + 0.91 X_7	8.75	377.89
122	Y= 0.98 X_1 + 0.90 X_4 + 1.16 X_6 + 0.90 X_8	7.42	320.56
123	Y= 0.89 X_1 + 1.25 X_4 + 0.94 X_7 + 0.94 X_8	9.11	393.11
124	Y= 0.98 X_1 + 0.60 X_5 + 1.71 X_6 + 0.90 X_7	9.97	430.34
125	Y= 0.98 X_1 + 0.66 X_5 + 1.60 X_6 + 0.86 X_8	8.65	373.62
126	Y= 1.15 X_1 + 0.78 X_5 + 0.86 X_7 + 1.03 X_8	10.08	435.08
127	Y= 0.89 X_1 + 1.22 X_6 + 0.95 X_7 + 0.92 X_8	9.39	405.48
128	Y= 1.93 X_2 + -0.07 X_3 + 1.42 X_4 + 0.94 X_5	9.26	399.81
129	Y= -0.16 X_2 + 2.44 X_3 + 0.49 X_4 + 0.89 X_6	8.27	357.06

Table 4.24. contd....

S.No	Discriminant function	GA	RE
130	$Y= 0.51\ X_2 + 1.60\ X_3 + 0.83\ X_4 + 0.95\ X_7$	8.97	387.42
131	$Y= -0.03\ X_2 + 2.32\ X_3 + 0.43\ X_4 + 0.92\ X_8$	8.23	355.20
132	$Y= 0.65\ X_2 + 1.57\ X_3 + 0.76\ X_5 + 1.00\ X_6$	9.61	414.78
133	$Y= -0.17\ X_2 + 2.71\ X_3 + 0.50\ X_5 + 0.94\ X_7$	10.24	442.11
134	$Y= 1.98\ X_2 + 0.20\ X_3 + 0.98\ X_5 + 0.89\ X_8$	9.43	407.28
135	$Y= 0.44\ X_2 + 1.57\ X_3 + 0.96\ X_6 + 0.95\ X_7$	9.31	401.86
136	$Y= 0.07\ X_2 + 1.81\ X_3 + 1.02\ X_6 + 0.93\ X_8$	8.65	373.57
137	$Y= 0.61\ X_2 + 1.44\ X_3 + 0.96\ X_7 + 0.93\ X_8$	9.49	409.82
138	$Y= 1.06\ X_2 + 1.26\ X_4 + 0.78\ X_5 + 1.00\ X_6$	8.89	383.81
139	$Y= 1.12\ X_2 + 1.52\ X_4 + 0.68\ X_5 + 0.93\ X_7$	9.57	413.27
140	$Y= 1.24\ X_2 + 1.11\ X_4 + 0.80\ X_5 + 0.89\ X_8$	8.73	377.02
141	$Y= 0.77\ X_2 + 1.17\ X_4 + 1.14\ X_6 + 0.96\ X_7$	8.59	370.86
142	$Y= 0.50\ X_2 + 1.14\ X_4 + 1.42\ X_6 + 0.91\ X_8$	7.91	341.32
143	$Y= 0.96\ X_2 + 1.16\ X_4 + 0.96\ X_7 + 0.92\ X_8$	8.82	380.81
144	$Y= 1.32\ X_2 + 0.77\ X_5 + 1.06\ X_6 + 0.94\ X_7$	9.87	425.91
145	$Y= 1.18\ X_2 + 0.82\ X_5 + 1.12\ X_6 + 0.89\ X_8$	9.12	393.58
146	$Y= 1.45\ X_2 + 0.77\ X_5 + 0.95\ X_7 + 0.89\ X_8$	9.94	428.99
147	$Y= 0.78\ X_2 + 1.32\ X_6 + 0.97\ X_7 + 0.91\ X_8$	9.18	396.20
148	$Y= 1.04\ X_3 + 1.37\ X_4 + 0.70\ X_5 + 1.06\ X_6$	9.22	397.89
149	$Y= 1.17\ X_3 + 1.59\ X_4 + 0.58\ X_5 + 0.93\ X_7$	9.89	426.81
150	$Y= 1.29\ X_3 + 1.21\ X_4 + 0.68\ X_5 + 0.89\ X_8$	9.03	389.67
151	$Y= 1.08\ X_3 + 1.02\ X_4 + 0.95\ X_6 + 0.95\ X_7$	8.83	381.43
152	$Y= 0.94\ X_3 + 1.03\ X_4 + 1.07\ X_6 + 0.91\ X_8$	8.12	350.46
153	$Y= 1.22\ X_3 + 0.83\ X_4 + 0.95\ X_7 + 0.92\ X_8$	9.02	389.47
154	$Y= 1.48\ X_3 + 0.64\ X_5 + 1.02\ X_6 + 0.93\ X_7$	10.17	439.08
155	$Y= 1.23\ X_3 + 0.72\ X_5 + 1.19\ X_6 + 0.88\ X_8$	9.40	405.75
156	$Y= 1.60\ X_3 + 0.62\ X_5 + 0.94\ X_7 + 0.89\ X_8$	10.20	440.59
157	$Y= 1.03\ X_3 + 1.08\ X_6 + 0.96\ X_7 + 0.92\ X_8$	9.37	404.55
158	$Y= 1.67\ X_4 + 0.57\ X_5 + 1.16\ X_6 + 0.93\ X_7$	9.52	410.91
159	$Y= 1.30\ X_4 + 0.67\ X_5 + 1.29\ X_6 + 0.88\ X_8$	8.72	376.27
160	$Y= 1.98\ X_4 + 0.54\ X_5 + 0.94\ X_7 + 0.90\ X_8$	9.58	413.59
161	$Y= 0.92\ X_4 + 1.19\ X_6 + 0.95\ X_7 + 0.91\ X_8$	8.71	376.06
162	$Y= 0.61\ X_5 + 1.70\ X_6 + 0.96\ X_7 + 0.87\ X_8$	9.89	426.97
163	$Y= 0.98\ X_1 + 1.85\ X_2 + 0.05\ X_3 + 1.47\ X_4 + 0.89\ X_5$	10.69	461.56
164	$Y= 1.00\ X_1 + 0.05\ X_2 + 2.15\ X_3 + 0.60\ X_4 + 0.95\ X_6$	9.71	419.39
165	$Y= 0.92\ X_1 + 0.67\ X_2 + 1.44\ X_3 + 0.94\ X_4 + 0.95\ X_7$	10.92	471.43
166	$Y= 1.00\ X_1 + 0.18\ X_2 + 2.10\ X_3 + 0.52\ X_4 + 0.92\ X_8$	9.70	418.59
167	$Y= 0.99\ X_1 + 0.41\ X_2 + 1.84\ X_3 + 0.68\ X_5 + 1.07\ X_6$	11.02	475.86
168	$Y= 0.96\ X_1 + -0.45\ X_2 + 3.10\ X_3 + 0.43\ X_5 + 0.91\ X_7$	12.12	523.10
169	$Y= 1.00\ X_1 + 1.83\ X_2 + 0.42\ X_3 + 0.92\ X_5 + 0.88\ X_8$	10.89	470.02
170	$Y= 0.92\ X_1 + 0.56\ X_2 + 1.51\ X_3 + 0.97\ X_6 + 0.95\ X_7$	11.22	484.62
171	$Y= 1.01\ X_1 + 0.24\ X_2 + 1.62\ X_3 + 1.10\ X_6 + 0.92\ X_8$	10.09	435.71
172	$Y= 0.86\ X_1 + 0.73\ X_2 + 1.39\ X_3 + 0.99\ X_7 + 0.93\ X_8$	11.39	491.91
173	$Y= 0.98\ X_1 + 1.02\ X_2 + 1.34\ X_4 + 0.74\ X_5 + 1.07\ X_6$	10.32	445.39

Table 4.24. contd....

S.No	Discriminant function	GA	RE
174	Y= 0.94 X_1 + 1.15 X_2 + 1.61 X_4 + 0.65 X_5 + 0.92 X_7	11.48	495.64
175	Y= 0.98 X_1 + 1.26 X_2 + 1.18 X_4 + 0.77 X_5 + 0.89 X_8	10.20	440.29
176	Y= 0.91 X_1 + 0.87 X_2 + 1.18 X_4 + 1.11 X_6 + 0.96 X_7	10.55	455.62
177	Y= 1.02 X_1 + 0.59 X_2 + 1.06 X_4 + 1.40 X_6 + 0.91 X_8	9.37	404.37
178	Y= 0.86 X_1 + 1.04 X_2 + 1.16 X_4 + 0.99 X_7 + 0.93 X_8	10.76	464.48
179	Y= 0.99 X_1 + 1.38 X_2 + 0.76 X_5 + 1.08 X_6 + 0.90 X_7	11.75	507.38
180	Y= 1.00 X_1 + 1.17 X_2 + 0.79 X_5 + 1.21 X_6 + 0.88 X_8	10.56	455.89
181	Y= 0.93 X_1 + 1.53 X_2 + 0.76 X_5 + 0.94 X_7 + 0.90 X_8	11.83	510.61
182	Y= 0.86 X_1 + 0.87 X_2 + 1.30 X_6 + 1.00 X_7 + 0.92 X_8	11.08	478.43
183	Y= 0.98 X_1 + 1.00 X_3 + 1.45 X_4 + 0.66 X_5 + 1.12 X_6	10.63	459.10
184	Y= 0.94 X_1 + 1.21 X_3 + 1.67 X_4 + 0.55 X_5 + 0.92 X_7	11.77	508.34
185	Y= 0.98 X_1 + 1.31 X_3 + 1.28 X_4 + 0.65 X_5 + 0.88 X_8	10.49	452.71
186	Y= 0.94 X_1 + 1.15 X_3 + 0.99 X_4 + 0.96 X_6 + 0.94 X_7	10.79	465.72
187	Y= 1.01 X_1 + 0.95 X_3 + 0.96 X_4 + 1.14 X_6 + 0.90 X_8	9.58	413.80
188	Y= 0.89 X_1 + 1.29 X_3 + 0.82 X_4 + 0.96 X_7 + 0.92 X_8	10.96	473.00
189	Y= 0.99 X_1 + 1.56 X_3 + 0.62 X_5 + 1.03 X_6 + 0.90 X_7	12.04	519.83
190	Y= 1.00 X_1 + 1.23 X_3 + 0.69 X_5 + 1.27 X_6 + 0.87 X_8	10.84	467.93
191	Y= 0.93 X_1 + 1.68 X_3 + 0.59 X_5 + 0.94 X_7 + 0.89 X_8	12.08	521.72
192	Y= 0.88 X_1 + 1.08 X_3 + 1.10 X_6 + 0.98 X_7 + 0.92 X_8	11.27	486.76
193	Y= 0.93 X_1 + 1.76 X_4 + 0.54 X_5 + 1.19 X_6 + 0.93 X_7	11.42	492.93
194	Y= 0.99 X_1 + 1.35 X_4 + 0.63 X_5 + 1.34 X_6 + 0.87 X_8	10.16	438.83
195	Y= 0.87 X_1 + 2.12 X_4 + 0.50 X_5 + 0.97 X_7 + 0.91 X_8	11.48	495.80
196	Y= 0.88 X_1 + 0.95 X_4 + 1.24 X_6 + 0.97 X_7 + 0.91 X_8	10.65	459.71
197	Y= 0.90 X_1 + 0.59 X_5 + 1.80 X_6 + 0.97 X_7 + 0.87 X_8	11.77	508.16
198	Y= 1.60 X_2 + 0.31 X_3 + 1.33 X_4 + 0.92 X_5 + 0.99 X_6	11.26	486.25
199	Y= 1.18 X_2 + 0.87 X_3 + 1.51 X_4 + 0.72 X_5 + 0.95 X_7	11.82	510.36
200	Y= 3.14 X_2 + -1.36 X_3 + 1.43 X_4 + 1.17 X_5 + 0.89 X_8	11.02	475.71
201	Y= 0.33 X_2 + 1.83 X_3 + 0.77 X_4 + 0.94 X_6 + 0.97 X_7	10.86	468.92
202	Y= -0.22 X_2 + 2.57 X_3 + 0.36 X_4 + 0.95 X_6 + 0.93 X_8	10.19	439.80
203	Y= 0.47 X_2 + 1.75 X_3 + 0.70 X_4 + 0.97 X_7 + 0.92 X_8	10.92	471.55
204	Y= -0.33 X_2 + 2.77 X_3 + 0.50 X_5 + 1.07 X_6 + 0.96 X_7	12.14	523.98
205	Y= 1.75 X_2 + 0.32 X_3 + 0.96 X_5 + 1.10 X_6 + 0.89 X_8	11.40	492.38
206	Y= 1.03 X_2 + 1.41 X_3 + 0.72 X_5 + 0.97 X_7 + 0.90 X_8	12.08	521.66
207	Y= 0.47 X_2 + 1.47 X_3 + 1.08 X_6 + 0.98 X_7 + 0.93 X_8	11.29	487.56
208	Y= 1.03 X_2 + 1.49 X_4 + 0.69 X_5 + 1.07 X_6 + 0.95 X_7	11.44	493.94
209	Y= 1.13 X_2 + 1.09 X_4 + 0.81 X_5 + 1.10 X_6 + 0.89 X_8	10.68	461.30
210	Y= 1.25 X_2 + 1.34 X_4 + 0.71 X_5 + 0.96 X_7 + 0.90 X_8	11.41	492.51
211	Y= 0.76 X_2 + 1.06 X_4 + 1.28 X_6 + 0.98 X_7 + 0.91 X_8	10.59	457.04
212	Y= 1.25 X_2 + 0.76 X_5 + 1.21 X_6 + 0.97 X_7 + 0.89 X_8	11.75	507.16
213	Y= 1.04 X_3 + 1.58 X_4 + 0.61 X_5 + 1.10 X_6 + 0.95 X_7	11.75	507.19
214	Y= 1.08 X_3 + 1.20 X_4 + 0.71 X_5 + 1.20 X_6 + 0.88 X_8	10.97	473.73
215	Y= 1.32 X_3 + 1.42 X_4 + 0.59 X_5 + 0.96 X_7 + 0.89 X_8	11.69	504.51
216	Y= 1.06 X_3 + 0.91 X_4 + 1.09 X_6 + 0.98 X_7 + 0.91 X_8	10.80	466.31
217	Y= 1.35 X_3 + 0.64 X_5 + 1.23 X_6 + 0.97 X_7 + 0.88 X_8	12.02	518.85

Table 4.24. contd....

S.No	Discriminant function	GA	RE
218	$Y = 1.50 X_4 + 0.58 X_5 + 1.34 X_6 + 0.97 X_7 + 0.88 X_8$	11.35	490.23
219	$Y = 1.01 X_1 + 1.53 X_2 + 0.34 X_3 + 1.39 X_4 + 0.86 X_5 + 1.07 X_6$	12.66	546.65
220	$Y = 0.93 X_1 + 0.98 X_2 + 1.15 X_3 + 1.56 X_4 + 0.66 X_5 + 0.95 X_7$	13.64	588.73
221	$Y = 1.02 X_1 + 3.17 X_2 + -1.38 X_3 + 1.49 X_4 + 1.13 X_5 + 0.88 X_8$	12.46	537.90
222	$Y = 0.92 X_1 + 0.50 X_2 + 1.64 X_3 + 0.88 X_4 + 0.97 X_6 + 0.97 X_7$	12.71	548.82
223	$Y = 1.03 X_1 + 0.00 X_2 + 2.23 X_3 + 0.45 X_4 + 1.06 X_6 + 0.92 X_8$	11.62	501.68
224	$Y = 0.87 X_1 + 0.65 X_2 + 1.56 X_3 + 0.83 X_4 + 1.00 X_7 + 0.93 X_8$	12.78	551.66
225	$Y = 0.95 X_1 + -0.64 X_2 + 3.18 X_3 + 0.42 X_5 + 1.10 X_6 + 0.94 X_7$	13.93	601.58
226	$Y = 1.03 X_1 + 1.62 X_2 + 0.44 X_3 + 0.90 X_5 + 1.21 X_6 + 0.88 X_8$	12.83	553.81
227	$Y = 0.91 X_1 + 0.68 X_2 + 1.88 X_3 + 0.63 X_5 + 0.97 X_7 + 0.90 X_8$	13.90	600.09
228	$Y = 0.85 X_1 + 0.59 X_2 + 1.40 X_3 + 1.11 X_6 + 1.02 X_7 + 0.93 X_8$	13.12	566.49
229	$Y = 0.93 X_1 + 1.02 X_2 + 1.59 X_4 + 0.66 X_5 + 1.11 X_6 + 0.95 X_7$	13.27	572.71
230	$Y = 1.01 X_1 + 1.08 X_2 + 1.15 X_4 + 0.76 X_5 + 1.20 X_6 + 0.88 X_8$	12.12	523.19
231	$Y = 0.89 X_1 + 1.27 X_2 + 1.46 X_4 + 0.68 X_5 + 0.98 X_7 + 0.90 X_8$	13.25	572.05
232	$Y = 0.85 X_1 + 0.85 X_2 + 1.08 X_4 + 1.24 X_6 + 1.02 X_7 + 0.92 X_8$	12.45	537.37
233	$Y = 0.91 X_1 + 1.30 X_2 + 0.74 X_5 + 1.25 X_6 + 0.97 X_7 + 0.89 X_8$	13.57	585.72
234	$Y = 0.93 X_1 + 1.04 X_3 + 1.67 X_4 + 0.58 X_5 + 1.14 X_6 + 0.95 X_7$	13.56	585.36
235	$Y = 1.02 X_1 + 1.02 X_3 + 1.27 X_4 + 0.67 X_5 + 1.30 X_6 + 0.87 X_8$	12.40	535.47
236	$Y = 0.89 X_1 + 1.34 X_3 + 1.52 X_4 + 0.56 X_5 + 0.98 X_7 + 0.89 X_8$	13.52	583.60
237	$Y = 0.87 X_1 + 1.12 X_3 + 0.91 X_4 + 1.11 X_6 + 1.00 X_7 + 0.91 X_8$	12.66	546.52
238	$Y = 0.91 X_1 + 1.42 X_3 + 0.62 X_5 + 1.26 X_6 + 0.97 X_7 + 0.88 X_8$	13.83	597.03
239	$Y = 0.87 X_1 + 1.61 X_4 + 0.55 X_5 + 1.37 X_6 + 0.99 X_7 + 0.88 X_8$	13.19	569.44
240	$Y = 0.87 X_2 + 1.14 X_3 + 1.44 X_4 + 0.69 X_5 + 1.09 X_6 + 0.97 X_7$	13.74	593.22
241	$Y = 2.74 X_2 - -0.99 X_3 + 1.35 X_4 + 1.13 X_5 + 1.09 X_6 + 0.89 X_8$	13.00	561.42
242	$Y = 2.48 X_2 - -0.56 X_3 + 1.54 X_4 + 0.96 X_5 + 0.98 X_7 + 0.89 X_8$	13.61	587.81
243	$Y = 0.31 X_2 + 1.85 X_3 + 0.65 X_4 + 1.06 X_6 + 0.99 X_7 + 0.92 X_8$	12.78	551.80
244	$Y = 0.80 X_2 + 1.43 X_3 + 0.70 X_5 + 1.22 X_6 + 0.99 X_7 + 0.89 X_8$	13.97	602.98
245	$Y = 1.05 X_2 + 1.32 X_4 + 0.70 X_5 + 1.22 X_6 + 0.98 X_7 + 0.89 X_8$	13.27	572.80
246	$Y = 1.01 X_3 + 1.43 X_4 + 0.61 X_5 + 1.30 X_6 + 0.98 X_7 + 0.88 X_8$	13.54	584.79
247	$Y = 0.92 X_1 + 0.64 X_2 + 1.41 X_3 + 1.50 X_4 + 0.62 X_5 + 1.12 X_6 + 0.97 X_7$	15.49	668.74
248	$Y = 1.05 X_1 + 2.79 X_2 + -1.14 X_3 + 1.41 X_4 + 1.09 X_5 + 1.21 X_6 + 0.88 X_8$	14.42	622.46
249	$Y = 0.88 X_1 + 2.26 X_2 + -0.27 X_3 + 1.61 X_4 + 0.89 X_5 + 1.00 X_7 + 0.90 X_8$	15.39	664.42
250	$Y = 0.86 X_1 + 0.49 X_2 + 1.62 X_3 + 0.79 X_4 + 1.10 X_6 + 1.03 X_7 + 0.92 X_8$	14.57	628.99
251	$Y = 0.89 X_1 + 0.41 X_2 + 1.92 X_3 + 0.61 X_5 + 1.26 X_6 + 1.00 X_7 + 0.89 X_8$	15.72	678.77
252	$Y = 0.87 X_1 + 1.03 X_2 + 1.44 X_4 + 0.66 X_5 + 1.27 X_6 + 1.01 X_7 + 0.89 X_8$	15.05	649.56
253	$Y = 0.86 X_1 + 0.99 X_3 + 1.55 X_4 + 0.58 X_5 + 1.35 X_6 + 1.01 X_7 + 0.88 X_8$	15.31	661.21

Table 4.24. contd….

S.No	Discriminant function	GA	RE
254	Y= 2.12 X_2 - -0.38 X_3 + 1.49 X_4 + 0.92 X_5 + 1.25 X_6 + 1.01 X_7 + 0.88 X_8	15.53	670.30
255	Y= 0.86 X_1 + 1.88 X_2 + -0.11 X_3 + 1.57 X_4 + 0.84 X_5 + 1.30 X_6 + 1.04 X_7 + 0.88 X_8	17.25	744.59

X_1 = Theoretical yield of alcohol

X_2 = Brix percent

X_3 = Sucrose percent

X_4 = Commercial cane sugar percent

X_5 = Juice purity percent

X_6 = Pol % cane

X_7 = Total sugars percent

X_8 = Commercial cane sugar yield

Table 4.25. Grouping of seventy seven genotypes of sugarcane into ten clusters

Cluster No.	Name of the genotype	No. of genotypes	Parentage of the genotypes falling in the cluster
I	2010T 4, 2010T 8, 2010T 15, 2010T 16,2010T 18, 2010T 20, 2010T 26, 2010T 53, 2010T 55, 2010T 58, 2010T 72, 2010T 82, 2010T 83, 2010T 179, 2010T 333	15	Co M 0265 (PC), Co N Snk03-044 (PC), Co N 85134 (GC), Co 89003 (GC), Co 98008 x Co89003 (SC), ISH 100 (PC)
II	2010T 84, 2010T 88, 2010T 103, 2010T 109, 2010T 115, 2010T 331 , 2010T 335	7	Co 89003 (PC), Co 86002 x ISH 69 (ZC), Co M6806 (GC), Co 94012 (PC)
III	2010T 226, 2010T 330	2	Co 88039 (GC), Co 94012 (PC)
IV	2010T 124, 2010T 126, 2010T 144, 2010T 146, 2010T 152, 2010T 153, 2010T 158, 2010T 161, 2010T 171, 2010T 172, 2010T 173, 2010T 278	12	Co M 6806 (GC), Co Sn 86572 (GC), 81 V 78 (GC), Co 8371 x CoV 92102 (SC), HR 83-65 (GC), Co 8213 x Co T 8201 (ZC), Co 88039 (GC)
V	2010T 175, 2010T 177, 2010T 183, 2010T 184, 2010T 387, 2010T 392	6	Co 98008 x Co 89003 (SC), Co Snk 03-044 x Co 775 (ZC)
VI	2010T 229, 2010T 430	2	Co 88039 (GC), Co 85002 x Co V 92102 (SC)
VII	2010T 208, 2010T 209, 2010T 225, 2010T 237, 2010T 239, 2010T 240, 2010T 249, 2010T 258, 2010T 374	9	B 096 (GC), Co 88039 (GC), 81 V 48 x Co 94005 (SC)
VIII	2010T 267,2010T 282, 2010T 285, 2010T 292, 2010T 313, 2010T 321, 2010T 340, 2010T 429	8	Co 88039 (GC), Co 92008 (GC), Co 85002 (PC), Co 7201 (PC), Co 85002 x Co V 921 02 (SC)
IX	2010T 351, 2010T 369	2	Co 8347 (GC), 81 V 48 x Co 94005 (SC)
X	2010T 344, 2010T 347, 2010T 355, 2010T 358, 2010T 362, 2010T 365, 2010T 366, 2010T 368, 2010T 408, 2010T 416, Co 86032, 2003 V 46, Co 6907, Co 7219	14	Co 92020 (GC), Co 8338 (GC), Co 95021 x Co 97015 (SC), Co 0239 (GC), 81 V 48 x Co 94005 (SC), 93 A 145 x Co A 7602 (SC), Co 94008 X 79 R 207 (SC)

Table 4.26. Contribution of each character to divergence

S.No.	Character	No. of times ranked first	% Contribution
1	Tillers at 120 DAP	0	0.00
2	Shoot population at 180 DAP	0	0.00
3	Shoot population at 240 DAP	3	0.13
4	No. of green leaves at 90 DAP	0	0.00
5	No. of green leaves at 240 DAP	0	0.00
6	No. of green leaves at maturity	0	0.00
7	No. of internodes per cane	0	0.00
8	Internode length (cm)	0	0.00
9	Stalk length (cm)	0	0.00
10	Stalk diameter (cm)	0	0.00
11	Stalk volume(cm^3)	0	0.00
12	NMC at harvest	3	0.13
13	Single cane weight (kg)	1	0.03
14	Fibre content (%)	65	2.22
15	Brix (%)	0	0.00
16	Sucrose (%)	340	11.62
17	CCS percentage (%)	1	0.03
18	Juice purity (%)	0	0.00
19	Pol % cane (%)	184	6.29
20	Juice extraction (%)	49	1.67
21	Total sugars (%)	280	9.57
22	Biomass per cane (kg)	1022	34.93
23	Fibre yield (t ha^{-1})	245	8.37
24	CCS yield (t ha^{-1})	169	5.78
25	Theoretical yield of alcohol (g/100ml)	25	0.85
26	Cane yield (t ha^{-1})	539	18.42
	TOTAL	2926	100

Table 4.27. Inter-cluster and intra-cluster (diagonal) D^2 values of seventy seven sugarcane genotypes

	I	II	III	IV	V	VI	VII	VIII	IX	X
I	**2809.36** **(53.00)**	4615.67 (67.94)	2019.24 (44.94)	8342.09 (91.33)	3072.91 (55.43)	1549.82 (39.37)	7770.53 (88.15)	7500.36 (86.60)	2416.81 (49.16)	6586.28 (81.16)
II		**6028.36** **(77.64)**	3505.33 (59.21)	7082.60 (84.16)	5575.17 (74.67)	3317.80 (57.60)	7407.96 (86.07)	7556.20 (86.93)	5212.81 (72.20)	6632.90 (81.44)
III			**208.16** **(14.43)**	6433.46 (80.21)	2208.95 (47.00)	427.63 (20.68)	5044.41 (71.02)	4626.25 (68.02)	1756.54 (41.91)	5036.38 (70.97)
IV				**7069.55** **(84.08)**	9897.22 (99.49)	6761.65 (82.23)	7866.12 (88.69)	8685.16 (93.19)	10065.95 (100.33)	7729.40 (87.92)
V					**3101.08** **(55.69)**	1942.19 (44.07)	8796.81 (93.79)	7807.59 (88.36)	1759.33 (41.94)	7414.42 (86.11)
VI						**313.77** **(17.71)**	5770.63 (75.96)	5442.45 (73.77)	1324.03 (36.39)	5156.06 (71.81)
VII							**8103.42** **(90.02)**	7586.40 (87.10)	8886.21 (94.27)	8316.42 (91.19)
VIII								**7946.70** **(89.14)**	7433.40 (86.22)	8567.97 (92.56)
IX									**472.65** **(21.74)**	7279.42 (85.32)
X										**8154.13** **(90.30)**

(D values are in paranthesis)

Table 4.28. Means of ten clusters for twenty six characters in second clonal stage in sugarcane

Cluster	Tillers at 120 DAP	Shoot population at 180 DAP	Shoot population at 240 DAP	No. of green leaves at 90 DAP	No. of green leaves at 240 DAP	No. of green leaves at maturity	No. of inter nodes per cane	Internode length	Stalk length	Stalk diameter	Stalk volume	No. of millable canes	Single cane weight
	No.	No.	No.	No.	No.	No.	No.	cm	cm	cm	cm^3	No.	kg
I	121.47	92.87	94.80	16.67	9.60	12.40	21.98	12.51	271.10	2.46	1308.47	86.20	1.06
II	106.43	88.14	104.57	14.93	10.29	14.07	22.47	12.21	268.81	2.66	1518.50	93.14	1.13
III	104.50	85.50	96.50	14.25	8.50	11.25	21.50	14.11	297.50	2.42	1383.25	78.00	0.95
IV	116.75	83.83	91.33	17.63	9.67	13.08	22.33	12.48	272.15	2.69	1571.96	80.29	1.19
V	107.33	81.67	82.17	14.50	10.08	13.00	21.44	12.32	258.33	2.47	1257.67	71.00	1.04
VI	141.00	104.00	109.50	18.00	10.75	16.25	25.84	10.94	278.34	2.25	1127.75	98.00	0.95
VII	122.56	90.44	98.00	16.61	10.00	12.39	20.70	14.48	291.11	2.40	1335.06	82.11	0.93
VIII	113.75	92.63	94.25	16.31	9.69	12.50	20.96	11.87	241.67	2.58	1290.63	77.75	1.09
IX	106.00	84.50	97.00	13.75	8.25	12.25	18.84	13.08	241.67	2.47	1170.50	92.00	0.89
X	121.64	91.64	94.50	13.25	9.54	11.61	21.19	12.80	262.38	2.52	1324.18	82.57	1.10
General mean	116.14	89.52	96.26	15.59	9.64	12.88	21.73	12.68	268.31	2.49	1328.80	84.11	1.03

Table. 4.28. contd.

Cluster	Fibre content (%)	Brix (%)	Sucrose (%)	CCS per cent (%)	Juice purity (%)	Pol % cane (%)	Juice extraction (%)	Total sugars (%)	Biomass per cane (kg)	Fibre yield (t ha^{-1})	CCS yield (t ha^{-1})	Theoretical yield of alcohol (g/100ml)	Cane yield (t ha^{-1})
I	14.95	18.71	17.36	12.28	92.85	14.76	62.16	24.37	1.49	16.72	13.91	11.59	113.48
II	13.66	17.49	16.15	11.40	92.24	13.94	63.66	21.39	1.69	17.97	14.60	10.18	131.13
III	17.04	17.89	16.48	11.62	92.16	13.68	64.10	20.04	1.59	15.57	10.56	7.05	90.95
IV	13.04	16.17	14.45	10.04	89.11	12.57	63.59	18.90	1.81	15.46	11.96	8.59	119.02
V	13.97	18.61	17.42	12.36	93.46	14.96	62.71	18.69	1.44	12.88	11.45	8.85	93.23
VI	16.04	18.39	16.76	11.76	91.15	14.08	63.73	23.07	1.46	18.63	13.57	11.39	115.87
VII	16.77	15.60	13.94	9.97	88.78	11.56	60.27	20.16	1.52	15.79	9.36	8.56	94.93
VIII	15.69	15.19	13.53	9.71	89.15	11.43	65.15	17.57	1.41	16.00	10.02	7.95	102.80
IX	11.24	19.19	17.48	12.26	91.17	15.52	69.80	19.57	1.36	10.98	12.25	8.58	99.45
X	13.92	16.94	15.37	10.76	90.45	13.19	65.05	19.09	1.58	15.25	11.72	8.51	111.47
General mean	14.63	17.42	15.89	11.22	91.05	13.57	64.02	20.28	1.53	15.52	11.94	9.12	107.23

Table 4.29. Scoring of genotypes based on mean performance for diversified uses in Second clonal stage in sugarcane

S.No	Genotype	Biomass	Fibre yield	CCS yield	Theoretical yield of alcohol	Cane yield	Total Score
1	2010T-146	1	5	4	0	5	15
2	2010T-4	0	3	5	1	4	13
3	2010T-103	0	3	3	4	3	13
4	2010T-152	1	1	4	2	4	12
5	2010T-72	0	2	2	5	3	12
6	2010T-84	4	2	2	0	4	12
7	2010T-115	0	5	3	0	4	12
8	2010T-53	1	2	5	1	2	11
9	2010T-285	0	5	2	0	2	9
10	2010T-344	5	0	1	0	3	9
11	2010T-387	0	3	3	0	2	8
12	2010T-109	3	0	1	2	1	7
13	2010T-229	0	2	1	3	1	7
14	2010T-347	0	3	1	0	3	7
15	2010T-58	0	1	2	2	1	6
16	2010T-16	0	0	1	4	0	5
17	2010T-88	0	0	1	4	0	5
18	2010T-124	5	0	0	0	0	5
19	2010T-20	0	0	2	2	0	4
20	2010T-83	3	1	0	0	0	4
21	2010T-374	2	2	0	0	0	4
22	2010T-184	0	0	3	0	1	4
23	2010T-18	0	0	0	4	0	4
24	2010T-173	1	0	0	3	0	4
25	2010T-15	0	0	0	3	0	3
26	2010T-82	0	0	1	2	0	3
27	2010T-153	3	0	0	0	0	3
28	2010T-239	0	0	0	3	0	3
29	2010T-26	0	0	0	3	0	3
30	2010T-258	0	1	0	0	2	3

Table 4.29. contd…..

S.No	Genotype	Biomass	Fibre yield	CCS yield	Theoretical yield of alcohol	Cane yield	Total Score
31	2010T-171	0	1	1	0	0	2
32	2010T-369	0	0	2	0	0	2
33	2010T-358	2	0	0	0	0	2
34	2010T-172	2	0	0	0	0	2
35	2010T-55	0	0	0	2	0	2
36	2010T-416	2	0	0	0	0	2
37	2010T-355	1	0	0	0	0	1
38	2010T-368	1	0	0	0	0	1
39	2010T-430	0	0	0	1	0	1
40	2010T-144	1	0	0	0	0	1
41	2010T-340	0	0	0	1	0	1
42	2010T-366	0	0	0	0	1	1
43	2010T-8	0	0	0	1	0	1
44	2010T-161	0	0	1	0	0	1
45	2010T-313	0	0	0	0	1	1
46	2010T-335	1	0	0	0	0	1
47	2010T-408	0	1	0	0	0	1
48	2010T-240	0	1	0	0	0	1
49	2010T-365	1	0	0	0	0	1
50	2010T-183	1	0	0	0	0	1
51	2010T-208	1	0	0	0	0	1
	Mean	1.65	16.86	13.06	9.63	119.23	
	CD	0.15	1.96	1.44	1.05	13.32	

Score		Biomass	Fibre yield	CCS yield	Theoretical yield of alcohol	Cane yield
1	Mean+1CD	1.80	18.82	14.50	10.68	132.55
2	Mean+2CD	1.95	20.78	15.94	11.73	145.87
3	Mean+3CD	2.10	22.74	17.38	12.78	159.19
4	Mean+4CD	2.25	24.70	18.82	13.83	172.51
5	Mean+5CD	2.40	26.66	20.26	14.88	185.83
0	≤ Mean	1.65	16.86	13.06	9.63	119.23

Table 4.30. Genotypes identified for diversified uses

S.No	Diversified uses	No. of uses	Genotypes
1	Biomass + Fibre yield + Commercial cane sugar yield + Theoretical yield of alcohol + Cane yield	5	2010T-152, 2010T-53
2	Biomass + Fibre yield + Commercial cane sugar yield + Cane yield	4	2010T-146, 2010T-84
3	Fibre yield + Commercial cane sugar yield + Theoretical yield of alcohol + Cane yield	4	2010T-4, 2010T-103, 2010T-72, 2010T-229, 2010T-58
4	Biomass + Commercial cane sugar yield + Theoretical yield of alcohol + Cane yield	4	2010T-109
5	Fibre yield + Commercial cane sugar yield + Cane yield	3	2010T-115, 2010T-387, 2010T-285, 2010T-347
6	Biomass + Commercial cane sugar yield + Cane yield	3	2010T-344
7	Commercial cane sugar yield + Cane yield	2	2010T-184
8	Fibre yield + Cane yield	2	2010T-258

Table 4.31. Top ranking genotypes based on the best selection index for diversified uses in sugarcane

	Biomass per cane (kg)			Fibre yield (t ha^{-1})			Commercial cane sugar yield (t ha^{-1})			Theoretical yield of alcohol (g/100 ml)			Cane yield (t ha^{-1})		
Rank	Genotype	Mean	Index score	Genotype	Mean	Index score	Genotype	Mean	Index score	Genotype	Mean	Index score	Genotype	Mean	Index score
1	2010T-84	2.20	4794	2010T-115	27.09	547	2010T-115	17.41	675	2010T-88	13.93	216	2010T-84	169.48	1959
2	2010T-124	2.85	4713	2010T-146	30.06	526	2010T-146	18.91	652	2010T-53	10.23	211	2010T-146	205.49	1763
3	2010T-146	1.80	4696	2010T-347	23.40	488	2010T-103	17.75	626	2010T-239	13.19	207	2010T-124	120.35	1758
4	2010T-344	2.33	4510	2010T-103	22.13	479	2010T-72	16.00	614	2010T-4	10.83	204	2010T-152	166.63	1500
5	2010T-153	2.17	4494	2010T-72	20.63	470	2010T-347	13.89	610	2010T-18	13.65	203	2010T-344	154.50	1464
6	2010T-4	1.70	4486	2010T-4	23.12	454	2010T-4	20.73	598	2010T-16	14.01	203	2010T-4	165.41	1429
7	2010T-416	1.98	4385	2010T-285	27.16	451	2010T-229	14.32	589	2010T-82	11.47	203	2010T-153	107.86	1405
Mean of the above seven genotypes		2.15			24.80			17.00			12.47			155.67	
Population mean		1.57			15.80			12.02			9.16			110.80	
%gain over Population mean		136.59			156.92			141.40			136.19			140.50	