EVALUATION OF MAIZE (*Zea mays* L.) INBRED LINES BY THEIR THREE-WAY CROSS HYBRID PERFORMANCE

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Thesis Submitted to the
University of Agricultural Sciences, Dharwad
in the partial fulfillment of the requirements for the

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IN

GENETICS AND PLANT BREEDING

By

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C E R T I F I C A T E

This is to certify that the thesis entitled **"EVALUATION OF MAIZE (*Zea mays* L.) INBRED LINES BY THEIR THREE-WAY CROSS HYBRID PERFORMANCE"** submitted by **Mr. M. G. GANGASHETTI** for the degree of **MASTER OF SCIENCE (AGRICULTURE) IN GENETICS AND PLANT BREEDING**, of the University of Agricultural Sciences, Dharwad, is a record of research work carried out by him during the period of his study in this University, under my guidance and supervision and the thesis has not previously formed the basis of the award of any Degree, Diploma, Associateship, Fellowship or other similar titles.

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MY LATE

GRANDFATHER

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(M.G. GANGASHETTI)

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INTRODUCTION

I INTRODUCTION

Maize (*zea mays* L.) is an important cereal crop belonging to the subtribe *maydeae*, of the grass family, Poaceae. The plant is native of South America. *Zea mays* is the only species in the genus Zea with 2n=20 chromosomes. It has two close relatives, among the American *maydeae* viz., genus Tripsacum (Gamagrass) and teosinte (Euchlena) which is generally regarded as its closest relative, and five among Asiatic *maydeae* viz, *Chionachne, Sclerachne, Coix, Trilobachne* and *Polytoca.*

The present day maize has wide adaptability. It is cultivated both in tropics and subtropics between 58° N to 40° S latitude and it can be grown successfully in areas having mean day temperature of more than 19° C during crop growth period. Though it can be grown in soils ranging from 5.5 to 8.0 pH, it is sensitive to salinity.

Maize is mainly grown for its grain and the whole plant or stover is fed to animals. The starchy grain itself is used as food and as the main constituent of feed to domestic animals besides its use as a source of starch in a number of chemical industries.Third in importance, after wheat and rice as food crops, it occupies an area of 135 mha with 450 mt of grain production and 3040 kg per hectare productivity on a global basis.

Maize is the fourth most important cereal crop in India next to rice, wheat and sorghum. It is mainly grown in Uttar Pradesh, Bihar, Rajasthan,

Madhyapradesh, Punjab and Karnataka, on area of 0.353 mha, with a total production of 1.042 mt. (Anonymous, 1995). Area under maize is fast increasing because of high yield, ease with which the crop can be cultivated and stability of prices.

The development of hybrid breeding methodology in maize and its successful application to exploit heterosis is considered to be a significant achievement and land mark in Biological sciences and plant breeding in the present century. A number of maize genotypes e.g., single crosses, top crosses, Three-way crosses, double top crosses, double crosses, varietal hybrids, multiple hybrids, composites, synthetics, pools, populations etc., are available to maize farmers by virtue of the crop being a highly cross pollinated one. In India since long time among hybrids double crosses, double top crosses and three way hybrids are in vogue since they are cheap in seed production. They are genetically diverse and there by withstand the environmental fluctuations, the seed coverage could be faster and cheaper in seed production.

Shull's (1908, 1909, 1910) original concept was the production and growing of single cross hybrids, but the costs of seed production seemed to limit its usefulness. This limitation was overcome with Jones (1918) suggestion that double cross hybrids can be produced from two single cross hybrids to reduce the cost of seed production. But with the improvements in vigour and yield potential of inbred lines and development of better cultural practices single crosses were adopted for commercial cultivation. But Jones (1958) reported that double cross hybrids are genetically more variable, stable and consistent in performance than single crosses.

He also described that the present trend in the commercial seed corn industry of replacing double crosses with single crosses is a step in the wrong direction because of two reasons; 1. It may loose some of the advantage of genetic homeostasis, 2. it invites disastrous epidemics of new strains of disease to which all plants of a single cross, being genetically identical, might be susceptible.

According to Allard and Bradshaw (1964), single crosses being uniform, they lack population buffering and possess only individual buffering, whereas three-way crosses have both population as well as individual buffering. It was therefore apprehended that single crosses may not perform as stable as double and three-way cross hybrids. Three way crosses are intermediate between single and double cross hybrids with respect to uniformity yield, stability and the relative simplicity of selecting and testing (Weatherspoon, 1970 and Sehnell, 1975). Compared to double cross hybrids three-way cross requires less number of isolations and seed production is cheap and economic, since three lines are involved instead of four. Presently in India, over twenty hybrids (including double cross, double topcross and three-way cross) besides many composites and synthetics are released to the farmers for their commercial exploitation.

Collection of germplasm and assessment of genetic variability is a basic step in any crop improvement programme. Yield being a complex character is influenced by a number of yield contributing characters controlled by polygenes and also influenced by environment. So, the observed variability in the collections for these characters is the sum total of heredity effects of concerned genes plus the influence of the environment. Hence, it becomes necessary to partition the observed

variability in to heritable and non-heritable components as genotypic and phenotypic co-efficient of variation (GCV and PCV), heritability and genetic advance.

In order to develop a suitable hybrid, the corn breeder must breed and evaluate large number of crosses among his outstanding inbred lines. When a desirable combination is found, however, it can be expected to perform in the same way each time, it is grown under the same environmental condition. Thus the final evaluation of inbred lines can be determined best by hybrid performance. Keeping this in view, an attempt was made to study the performance of three-way cross hybrids, using single cross (CI-5 x CI-9) as male parent (a tester).

The investigation was carried out utilizing 99 three-way cross hybrids to study the variability, genetic parameters and heterosis with respect to eight yield and yield components. This direct method of evaluating new lines with an established specific single cross in three way hybrid combination is a short cut method, economical and time saving as compared to conventional method of assessing first the GCA and next the SCA and then the hybrid combination. The objectives for the present investigations were as follows.

1. To know the extent of heterosis in respect of yield and other quantitative characters.
2. Evaluation of three way cross hybrids for commercial exploitation.
3. To know the best specific combiner line with CI-5 x CI-9 tester.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

The review of literature to the present investigation is presented under the following headings.

2.1 Hybrid maize research

2.1.1 Types of hybrids and performance

2.2 Inbred-Hybrid approach

2.3 Evaluation of lines by hybrid performance

2.3.1 Top cross testing

2.3.2 Line x Tester analysis

2.3.3 Method of diallel cross analysis

2.4 Heritability and Genetic Advance

2.5 Heterosis

2.6 Character wise review

2.1 Hybrid maize research

The future of world agriculture belongs to hybrids. In fact, hybrid cultivars will replace homozygous plants in many self pollinated crops and heterogenous populations in most cross-pollinated crops in the next few years. The development of hybrid breeding methodology in maize and its successful application to exploit heterosis is considered as significant achievement of plant breeding in the present century. Beal (1880) reported higher yield of hybrids between open pollinated varieties and advocated the commercial cultivation of intervarietial

hybrids even in the absence of knowledge of heterosis concept. The real break through, however, came with the studies of Shull (1908, 1909), who gave the pure line method of maize breeding, production of inbred lines through selfing, crossing inbred lines in pairs to develop single cross and their commercial cultivation. But the non availability of good inbred lines with acceptable yield levels greatly limited the production of reasonably priced, good quality inbred seeds. To over come seed production Jones (1918) suggested the commercial use of double crosses. Thus began the success story of hybrid maize.

2.1.1 TYPES OF HYBRIDS AND THEIR PERFORMANCE

Inbred as well as non inbred (NI) progenitors can be used to form hybrids. Though, inbred hybrid approach has been dominating conventional maize breeding yet in many case non inbred parents have been used to develop commercial hybrids. In view of the higher yield potential non inbred parents, and that they are easier to develop than inbred parents, CIMMYT decided to lay more emphasis initially on the use of NI parents in hybrid breeding for the countries having less developed breeding programmes and seed industry, and it introduced the terminology of convention and non-conventional hybrids (Vasal, 1986 and 1987).

Conventional hybrids are produced by crossing inbred lines which may be in advanced generation (fixed), early generation or even reconstituted lines. These include top, double top, single, modified single, sister line, three way, modified three way, double, double back, single back, multiple crosses and synthetics or composites. The pedigree of these can be explained as follows.

	Type of Hybrids	Pedigree
a.	Top crosses	(A) x Open-pollinated variety
b.	Double top crosses	(A x B) x Open-pollinated variety
c.	Single crosses	(A x B)
d.	Modified single crosses	(A x A') x (B)
e.	Sister line crosses	(A x A') x (B x B')
f.	Three way crosses	(A x B) x (C)
g.	Modified three way crosses	(A x B) x (C x C')
h.	Double crosses	(A x B) x (C x D)
i.	Double back crosses	[(A x B) x A]x [(C x D) x C]
j.	Single back crosses	[A x B] x [(C x D) x C]
k.	Multiple crosses	[(A x B) x (C x D)] [(E x F) x (GxH)]
l.	Synthetics (composites)	Composite of many lines.

Where A, B, C, D, E, F, G and H are the inbred lines and prime is used to indicate sister lines. Sister-line crosses are used to improve the yield and vigour of inbred parents with least adverse effect on performance and uniformity of commercial hybrids.

Shull's original concept was the production and growing of single-cross hybrids, but the cost of seed production seemed to limit its usefulness. This limitation was overcome with Jone's (1918) suggestion of double cross hybrids. In addition three-way hybrids and other hybrids have been used because of problems of

seed production that are alleviated by use of the single cross as a seed parent. These different types of maize hybrids have advantages and disadvantages with respect to uniformity, yield, stability and relative simplicity of selecting and testing the three types of hybrids (Schnell, 1973).

Single crosses are very uniform genotypically and phenotypically. A field of single cross hybrid is very attractive to the producer because of its uniformity of appearance, maturity and harvesting characteristics. By the use of single cross hybrids greater yields are possible. But the seed production is costly because single crossed seed, is produced on inbred plants which are relatively poor producers of seed and pollen. These single crosses are heterozygous, but they are homogeneous with respect to the genotype. So it lacks the genetic variability which will have a poor adaptability to the external environmental factors viz., weather, soil and pests (Jones, 1958).

Double crosses are slightly more variable in plant and ear characters than single crosses and three way crosses, which may be one advantage when crop is grown under adverse conditions and are also more stable and consistent in performance but slightly less yielding than single and three-way crosses (Jones, 1958).

Jones (1958) states that the present trend in commercial seed corn industry of replacing double crosses with single cross is a step in the wrong direction on two counts- (1) It may loose some of the advantage of genetic homeostasis (2) It invites disastrous epidemics of new strains of disease to which all plants of a single cross being genetically identical might be susceptible. This situation for a particular

maturity zone, existed when the 1970 *Helminthosporium maydis* out break occurred in the United States.

Allard and Bradshaw (1964) reported that single crosses may not perform as stable as double and three way crosses because single crosses being uniform they lack population buffering and possess only individual buffering, whereas three-way and double crosses have both population as well as individual buffering.

Three way crosses are intermediate between single and double crosses. Seed of three way crosses is less expensive to produce than that of single crosses. Genotype-environment component of variance was less for three way hybrids thus they are widely adapted (Federer and Sprague 1947 : Sprague and Federer, 1951). The data of three way crosses provides information on specific hybrids and often may eliminate the time and expense required for testing inbred line in top crosses and single crosses.The performance of these hybrids reviewed in the following paragraphs.

Arnold and Jenkins (1932) reported that single crosses were most uniform and the double crosses and the top crosses were approximately mid way in variability.

Jugenheimer (1936) studied the yields in per cent of open-pollinated varieties, the yields of hybrids averaged : top crosses, 114.6: double crosses 125.9 and three way crosses 128.1.

Jugenheimer (1948, 1958, 1964) reported that the average yields of single crosses (7113 q/ha), three way crosses (6830 q/ha), and double crosses (6711 q/ha) which were ranked I, II and III respectively.

He also reported (1948, 1957, 1958) that maximum ear weight, ear length, ear circumference, ear height and yield in single crosses followed in descending order by the three way and double crosses.

Sprague and Thomas (1967) reported that yields of the single crosses ranged from 4836 to 9308 kg/ha with a mean of 7526 kg. The range in yields of the three way crosses was only slightly less: 6147 to 8975 kg/ha with a mean of 7382 kg.

Eberhart and Hallauer (1968) pointed out that the single crosses were high yielding than the three way crosses in 1957-1958 experiment, but there were no differences in 1963-64. It is because of greater genetic variance among single crosses, as pointed out by Cockerham (1961).

Weatherspoon (1970) studied the comparative yields of single, three way and double cross of maize. The average yield of the 36 singles was 3.1 q/ha greater than that for the three ways and the average for the three ways was 1.7 q/ha in excess of that for doubles. The best single was 8.69 q/ha above the best three way and best three way, 5.2 q/ha above the best double. However, the poorest single was 4.1 q/ha below the poorest three way and the poorest three way was 6.3 q/ha below the poorest double. The range for singles was 12.7 q/ha greater than that for three way and 24.2 q/ha greater than that for doubles.

Wright *et al.*,(1971) reported that the average values of the single and three way crosses were very similar for traits viz., yield (g), plant height, ear height, ear length, ear diameter, kernel row number, 300 kernel weight. The small differences are so small that they have no biological or statistical significance. He also reported that averages for the 150 single crosses and 600 three way crosses for the four environments were nearly identical for all traits.

Otsuka *et al.*,(1972) reported that average yield per plant was less for single crosses (145 gm) than that of three way crosses (147 g).

Ivakhnenko and Zubko (1986) reported that the mean yield of 54.56 early three way hybrids was not appreciably higher than that of single hybrids.

2.2 INBRED-HYBRID APPROACH

The ultimate use of inbred lines of commercial maize growing is in the production of hybrids. The better hybrid combinations of selected lines gave substantial, increase in yield over the better open pollinated varieties. Not all hybrids are worthwhile: some are much less desirable than average open pollinated varieties. In order to develop satisfactory hybrid, the maize breeder must make and test a large number of crosses among his outstanding inbred line. The value of inbred lines for breeding is characterized by the traits like high uniformity, drop out of the lethal combinations and good combining ability. Maize breeders have diverse opinion on assessing the genetical constitution of inbred lines. It was Shull (1910) who first pointed out the relationship between the properties of certain inbred lines and of their single crosses, and its usefulness in breeding. Jones (1918) held the view that

the morphologically uniform lines are constant and as for variability, they behave like self pollinating variety. This view point is in accordance with the Mendelian laws and with the genotype concept of Johannsen. Similar conclusions were also drawn by Kiesselbach (1922), Richey (1924), Richey and Mayer (1925) who established relationships between yielding ability of inbred lines and their hybrid offsprings. The common understanding then was that the standard inbred lines were homogeneous for their traits, biologically pure and genetically stable.

Hays (1926) found that yield was very strongly correlated with those characters of inbred lines that are the expressions of vigour. Nilsson-Leissner (1927) reported positive correlations between certain characters of inbred lines and the same characters in their single cross progeny. Jorgenson and Brewbaker (1927) reported positive correlations between certain characters of inbred lines and the same characters in their single cross progeny. They concluded that selection of the most vigorous inbred lines was desirable procedure from a practical stand point. Jenkins (1929) found significant positive correlations between yield of the single cross and the following characters in the parents: date of tasselling, date of silking, plant height, number of nodes below the ear, number of ears per plant, ear length, ear diameter and yield.

Hays and Johnson (1939) reported the positive correlations between vigour characters of inbred lines and their hybrid yield performance.

Jugenheimer (1948, 1949a, 1949b, 1949c and 1958a) found that grain yield standability and maturity of three way crosses were correlated positively and significantly with the same characters of S_1 inbred lines.

Gilmore (1969) reported on the effect of inbreeding of parental lines on predicted yields of synthetics. He pointed out that parental lines which yield high because of low inbreeding will produce a synthetic equal in yield to a synthetic produced from low yielding inbred lines equals the gene frequency of the less inbred lines.

Hoegemeyer (1974) evaluated 144 intra population and 122 inter population single crosses involving S_7 lines from BS10 and BS11. Although the average superiority of inter population crosses were only 3.0 and 12.2 per cent greater than that of BS11 and BS10 inter population crosses, respectively. 28 of 30 best crosses were inter population crosses. It has been common experience that the best hybrids involve inbred lines derived from different varietal sources. Fleming (1971) reported the performance of stocks within long time inbred lines of corn by test crosses. Performance with seed stocks of six long time inbred lines mentioned by different breeders in several states, he found significant differences in the hybrids.He concluded that genetic changes and shifts in gene frequency may be constantly occurring within inbred lines. These changes affect the performance of the inbred and also of the hybrid in which it is used.

Grogan and Francis (1972) determined the variability within lines maintained at different locations with special emphasis on, within lines crosses. They reported significant heterosis of the 13 characteristics studied. Gilmore (1969) reported on the effect of inbreeding of parental lines on predicted yields of synthetics. He pointed out that parental lines which yield high because of low

inbreeding will produce a synthetic equal in yield to a synthetic produced from low yielding, highly inbred lines, of the gene frequency of the highly inbred lines equals the gene frequency of the less inbred lines. But presently the proper interpretation relying on factual data, it has been proved that inbred lines have no absolute stability but are variable in different scale, depending on the lines and features tested. It is convenient to evaluate the inbred lines in terms of their instability and their breeding value rather than their genetic stability.

2.3 EVALUATION OF LINES BY HYBRID PERFORMANCE

The present inbred lines of maize are utilized in hybrids or composites. Hence, they need to be evaluated for their utilization. Correlation studies between the various traits, within and among the inbred lines and their hybrid progeny are helpful measures of evaluation. However, the final evaluation of inbred lines can be determined best by hybrid performance. This is a time consuming and expansive process where decisions must be made on type and number of testers, time and stage of testing etc.

2.3.1 Top cross testing

The use of top crosses provides an efficient method for the preliminary evaluation of inbred lines. Jones (1922) reported on the relative performance of top crosses. Davis (1927) used top crosses to estimate the combining ability of S_2 lines. Lindstrom (1931) suggested the commercial use of top crosses. The use of top crosses provides an efficient method for the preliminary evaluation of inbred lines. They are especially useful for determining general combining ability, of a large number of lines.

Jenkins and Brunson (1932) reported significant correlation between yields of inbred lines crossed *inter se* and the same lines as top crosses, they concluded that crosses with standard open pollinated varieties provide an efficient means for the preliminary testing of inbred lines for later use in other types of hybrid combinations.

The method of early testing was suggested by Jenkins (1935). Under this scheme inbreeding and test cross evaluation proceed concurrently. The results presented by Sprague (1942), Lonnquist (1950) and Welhausen (1952) indicated that early testing aided in the detection of lines having high combining ability. The objections raised by several workers against early testing, from economic point of view rather than genetic considerations.

The top cross test with a heterogeneous tester gives valuable information for characters that are not complex in inheritance. Also this test will identity those lines that contribute low yield to hybrid combinations. According to Genter (1963) genes from the tester parent were found to mask and interact with the genes of the inbreeds in crosses so that the performance of the top cross may not accurately represent the genotype of the inbred being evaluated. Different tester will produce different responses in top crosses with the same inbred in the same environment and in different environments. Such interactions will decrease the accuracy with which the genetic constitutions of the inbreeds being tested can be evaluated in top crosses.

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Testing inbred lines in three way crosses is an efficient method where a desirable single cross seed parent is available. The procedure permits the testing of a large number of inbred lines at one time, and estimates the need for preliminary evaluation of inbred lines in top crosses.

Jugenheimer (1949a) designed performance test to evaluate the inbreds through their three way hybrids. Each three way cross was planted in replicated, single-hill plots. Its performance was compared to that of the single cross tester grown adjacent to it. The better lines obtained by the preliminary tests might be grown in larger populations for additional selection within families if deemed desirable. The remaining material also might be compared in standard yield tests to determine the superior inbred lines and hybrids.

Russel (1969) believes that the older methods of evaluation need to be changed because the current yield levels are much higher. The source materials are different, lot of genetic information is available. So testing procedures having maximum efficiency require greater emphasis on non-additive effects.

Russel (1968) pointed out that visual selection among and within inbred progeny permits the breeder to evaluate many more progenies than is possible in replicated yield trails, and at much lower cost. He suggested that visual selection may be carried out for about three generations of progeny line evaluation. Next immediately test for GCA with the help of an established line or single cross.

2.3.2 Line x tester analysis

The testing procedures were designed to evaluate for general combining ability or additive effects. Because of the change to single-cross and three way cross hybrids, testing procedures having maximum efficiency require greater emphasis on non-additive effects. The relative importance of additive and non-additive types of gene action is changing in our breeding programme.

Sprague (1942) suggested using a tester that was heterozygous and that in general carried recessive factors for the character(s) of particular interest. Federer and Sprague (1947) found that the Line x tester interaction was nearly 40 per cent as great as the line effect when both were measured by means of variance components. For maximum efficiency the tester should be tailored for specific information required.

Gresn (1948) compared US 35 a high yielding double cross and an open pollinated variety, Black Yellow Dent for comparing 83 S_2 plants, for each of the three single crosses, which were the crosses between high x high, high x low and low x low lines in combining ability. With US 35 as tester, he could not establish the difference between plants of high x high and high x low crosses. Whereas with Black, Yellow, Dent could establish a highly significant differences between two testers. Thus the detected segregation for combining ability was a function of genotype of the lines and the genetic characteristic of the tester parents.

Sprague and Federer (1951) reported that an increase in the number of testers would be of greater value than increased replications using a single tester.

The literature pertaining to tester studies reviewed by several workers has shown that interactions with environment decreased as the haterozygenity of the material tested increased (Rojas and Sprague 1952).

However, it is generally recognized that as the genetic base of a tester broadens, better estimates of general combining ability are obtained since the term implies exactly that. There are several alternatives in selection of a tester, broad genetic base versus narrow genetic base, high gene frequency versus low gene frequency, general combining ability versus specific combining ability: high yield versus low yield: several versus are one genotype etc.

According to Mantzinger (1953) desirable tester is one that combined simplicity in use with maximum information on performance.

Kemptnorne (1957) proposed a method (Line x tester analysis) to study combining ability. A sample of males taken at random was mated to each of the females, also selected at random. He expressed the relationship between covariance (H.S.) and (F.S.) and variance components due to general combining ability (σg) and specific combining ability ($\sigma^2 s$).

Cov. (H.S.) $= \sigma^2 g$

Cov. (F.S.) $= 2$ Cov (H.S.) $= S\ \sigma^2 S$

The method has frequently been used in the evaluation of inbred lines. A heterozygoas tester is used for estimating gca and homozygous one for SCA.

Again Rawlings and Thompson (1962) defined a good tester as one that classified correctly the relative performance of lines and discriminates efficiency among the lines under test.

Allison and Curnow (1966) defined a best tester as one that maximize the expected mean yield of the population produced from random mating the selected genotypes.

Hallauer (1975), a suitable tester should include simplicity in use, provide information that currently classifies relative merit of lines and maximizes genetic gain.

2.3.3 Method of diallel cross analysis

Schmidt (1919) introduced the method of diallel crossing and the considered the test crossing also as diallel crossing.

Jenkins (1934) gave the methods to predict the performance of three way and double cross hybrids which are generally used in maize breeding.

Sprague and Tatum (1942), gave the concept of general and specific combining ability which opened a new chapter in the usage of quantitative genetic principles in plant breeding. Diallel crossing is one of the most important maiting design, permitting the estimation of combining ability effects as well as partitioning the total genetic variance into additive and dominance components. The diallel maiting system can fit into two models, one such model developed for a single diallel gene but extended to many genes with certain restrictions (Jinks and Hayman,

1953). This method is often referred to as component analysis. The genetic basis of analysis is described by many biometricians (Jinks and Hayman, 1953; Jinks, 1954 and Hayman, 1954, 1958 and 1960.

Arunachalam (1976) commented that Hayman's approach invites criticisms because of stringent, unrealistic and impracticable assumptions to be fulfilled.

The more generalized model of combining ability analysis of diallel cross was given by Griffing (1956a and 1956b).

It consists of:

Method I - Parents, one set of F_1S and reciprocal F_1's with n^2 combinations are included.

Method II - parents and one set of F_1S (reciprocals excluded) with n (n+1)/2 combinations.

Method III - one set F_1's and reciprocals (No parents) with n (n-1) combinations.

Method IV - one set of direct F_1's only with n (n-1)/2 combinations.

He used the term, modified diallel for the last two methods where parents are not included. He provided two models for each of the four methods.

Model I (fixed effect model) - Wherein parental materials are selected and results obtained are applicable to the materials investigated. It estimates combining ability effects.

Model II (Random effect model), Wherein the parental materials are sampled at random from the population about which the inferences are to be drawn. It estimates different genetic components of the population variance.

2.4 HERITABILITY AND GENETIC ADVANCE

The data in quantitative genetics are composed of measurements on phenotypes. In a routine way yield is recorded, the genetic parameters are estimated and the conclusions are drawn on the magnitude of genotypic variance.

Comstock (1955) reported that phenotype associated with a given genotype varies with the environment, this leads to complete inconsistency of genotypic value, a different value of a given genotype relative to every variant of environment major or minor.

Lonquist (1964) reported that phenotype of a quantitative character was mainly due to the joint action of genotype and environment.

Fisher (1918) partitioned the total genetic variance into:

i) Additive genetic variance (σ^2A) which is the sum of additive genetic variances contributed by individual loci.

ii) Dominance variance (σ^2D)component which results from intra allelic interaction of genes at segregating loci.

iii) Epistatic variance (σ^2I) results from inter allelic interaction of genes at segregating loci.

Further Hayman and Mather (1955) partitioned epistaic variance into additive x additive (σ^2AA) additive x dominance (σ^2AD) and dominance x dominance (σ^2DD) components for two loci, three loci in (σ^2AAA, σ^2AAD, σ^2ADD..etc.) or more.

Heritability is the proportion of the total variance that is attributable to the average effects of genes and this is what determines the degree of resemblance between relatives. It helps for the prediction of metric characters, expressing the reliability of the phenotypic values as a guide to the breeding values.

Lush (1945) defined heritability in both broad sense and narrow sense. In broad sense, heritability refers to the functioning of the whole genotype as a unit and is used in contrast with the environmental effects. In the narrow sense, heritability largely includes only the average effect of genes transmitted additively from parent to off spring.

Warner (1952) has suggested different technique for estimating the degree of heritability in crop plant which is based on parent-offspring regression, variance component from an analysis of variance, and approximation of non heritable variance from genetically uniform population to estimate the total genetic variance.

The genetic gain that can be obtained for a particular trait through selection is the product of its heritability, phenotypic standard deviation and selection differential (Burton and Devane 1953).

2.5 HETEROSIS

Heterosis breeding has received more attention than other branches of plant breeding in several crop plants and maize is one such cross fertilized crop which has paid rich dividend since an array of hybrids have been realized over decades.

Shull (1908) coined the term heterosis t0 provide a term to describe the phenomenon but it did not include a description of genetic mechanism involved in its expression.

Bruce (1910) and Keeble and Pellew (1910) put forth the dominance hypothesis which suggested that increase in vigour after crossing resulted from the combination of various dominant alleles by each parent.

Shull (1911) and East and Hays (1912) objected the dominance theory and proposed over dominance hypothesis indicating heterosis as the result of heterozygosis.

Jones (1917) stated that heterosis was due to complementary action of linked dominant growth favorable genes brought from both parents.

Ashby (1930 & 1932) suggested that heterosis results from the maintenance of the initial advantage in the embryo size and not from an acceleration of metabolic process.

East (1936) concluded that seed size or the size of any part of the seed cannot be the causes of heterosis.

Hull (1945, 1946 & 1948) reported the evidence of over dominance in the expression of heterosis.

The degree of geographical separation and the degree of ancestral relationship can be used as an indication of genetic diversity. The greater genetic diversity of the parents is associated with greater heterosis in the F_1. (Moll *et al.*, 1962, Paternani and Lonnquist, 1963; Wellhausen, 1965; Heidrich sobrinho and Cordeiro, 1975 and Gervish, 1983).

Moll *et al.*,(1965) reported that heterosis increased with increased divergence within certain limits and extremely divergent crosses in maize resulted in decrease in heterosis.

Griffing and Zsiros (1971) viewed heterosis as not entirely the result of genetic stimuli but rather as result of the interaction between genetic and environmental stimuli and implicated that the environment was a significant factor in the manifestation of heterosis.

According to Konarev (1976), heterosis in yielding capacity is realized to the fullest extent under favorable conditions. Nettovich (1968) and Burton (1968) reported that unfavorable conditions cause negative heterosis.

Tarutina *et al.*,(1980) reported that heterosis was observed for many characters under different environmental conditions. As a rule, hybrids with the highest percentage of heterosis had a line with high gca as one of its parents.

Dornescu (1982) reported that in all the characters heterosis expression varied according to character, year and site. In general, its strongest expression occurred under least favorable environmental conditions.

2.6 CHARACTERWISE REVIEW

The review of literature pertaining to heritability and heterosis in respect of eight quantitative characters viz., (1) days to 50 per cent tasselling (2) days to 50 per cent silking (3) plant height (4) ear height (5) ear length (6) ear diameter (7) 100 grain weight (8) yield per plot have been presented here under character wise.

2.6.1 Days to 50 per cent tasselling

Days to 50 per cent tasselling is one of the components of maturity. Days from seeding to pollen shedding was used as a measure of maturity (Giesbrecht 1960).

Daniel and Bajtay (1976) and Rood and major 1980) observed high heritability for this trait. However, Klein (1975) and Hansen *et al.*,(1977) reported moderate to high range of heritability. Similarly low to moderate broad sense

heritability was reported by Debnath (1988) and Alika (1994) observed the moderate broad sense for this trait.

Glosen *et al.*, (1962) observed significant heterosis for early flowering. Shetty (1974) found significant heterosis ranging from -7.53 to 1.33 per cent over mid parent. Daniel and Bajtay (1976) reported highly significant negative heterosis for days to anthesis, while Ramamurthy (1978) quoted significant heterosis ranging from -8.86 to 15.57 per cent over better parent. Hassaballa *et al.*,(1980) observed the highly significant heterotic effect for early tasselling Satyanarayan (1994) reported the heterobeltosis for maturity components (for earliness). Significant average heterosis was noticed by Gomesh *et al.*, (1995). Considerable heterotic effect was noticed for this trait by Turgut *et al.*,(1995) and Perez *et al.*,(1995).

2.6.2 Days to 50 per cent silking

Days to silking is the most important attribute of maturity. Those genotypes which silk early will also show early maturity in most cases, since the period for silking to maturing remains almost constant. Shaw and Thom (1951) reported that adding 50 days to the known average days to silking of a cross will give the approximate period of its maturity. Daniel and Bajtay (1976), Bonaparte (1977) and Hassaballa *et al.*, (1980) reported the high heritability of days to silking. Low to moderate heritability was observed by Debnath (1988). Saadalls *et al.*, (1988) reported the heritability estimates of 37 per cent for date of silking, in three way cross hybrids of maize, high heritability for this trait was also noticed by Reddy and Agrawal (1992).

Significant heterosis for early silking was reported by Glosen *et. al.*,(1962), Mukherjee *et. al.*,(1971), Daniel (1973) and Daniel and Bajtay (1976). However, Sharma *et. al.*, (1972) did not observe significant heterosis for early silking.

Shetty (1974) found significant heterosis ranging from -08.40 to 7.56 per cent over mid parent in a diallel cross of maize inbred lines, while Dhillon and Singh (1977) reported it to be ranging from 94 to 98 per cent. Similarly, high heterosis over better parent in the range of -11.70 to 18.62 per cent was apparent in the report of Ramamurthy (1978). In another study, Akhtar and Singh (1981) observed mid parent heterosis ranging from -3.55 to 11.42 Vasal (1992), Satyanarayana (1994) and Altinbos (1995) observed the heterobeltosis for days to silking (for earliness), heterotic effect for this trait was also noticed by Prez *et al.*, (1995).

2.6.3 Plant height

Swamy Rao *et al.*,(1970) reported low heritability (23.42%) for plant height, and he also observed the high heritability estimates of 80.40 and 88.62 per cent. Similarly moderate to high broad sense heritability was noticed by El- Hosary (1987). In another study high heritability estimates 70 per cent for plant in 3 way cross hybrids of maize was noticed by Saadalls *et. al.*,(1988).

Debnath (1988) and Mahmoud *et al.*, (1990) noticed high heritability for the trait.

Goncherenko (1972) in a study of hybrids obtained by crossing

varieties, lines and simple hybrids of sweet corn with self pollinated lines and simple dent and flint hybrid reported heterosis for height. Vasal *et al.*, (1992) and Reddy and Agrawal (1992) observed high heterosis for this trait. Alvarez *et al.*, (1993) reported low heterosis value of per cent for plant height. Average heterosis for this trait was not significant (Gomesh-e- Gama, 1995).

2.6.4. Ear Height

El-Hosary (1987) reported moderate to high heritability values noticed for ear height Saadalls *et al.* (1988) pointed out the heritability estimates of 55 per cant. High heritability estimates for this trait was noticed by Debnath (1988), Reddy and Agrawal(1992) and Debnath and Azad (1993).

For ear height, Giesbrecht (1961) reported heterosis in the F_1. According to Dhillon and Singh (1977b) the heterosis percentage with regard to mid-parent ranged from 95 to 43. Alverez *et al.*, (1993) noticed the heterosis value 15 per cent for ear height. Altinbos (1995) observed the high parent heterosis.

2.6.5 Ear Length

Swamy Rao *et al.* (1970) noticed the low (17.23%) and high (87.36%) heritability for this trait, Patil *et al.*, (1972) reported the heritability value of 27.45 per cant for ear length. El-Hosary (1987) pointed out the moderate to high heritability. Saadalls *et al.*, (1988) reported the heritability value of a per cent for this trait. Mahmoud (1990) was also noticed the high broad sense heritability for this trait.

According to Leng(1954), if over dominance were present, the highest degree of heterosis should be in high x low crosses. Quite opposite situation was found in his study. Where the degree of heterosis was found in the low x low

and high x high crosses.

Dhillon and Singh (1977b) reported that the heterosis percentage over mid parent varied from 96 to 107. In another study, Varma and Singh (1980) reported it to be ranging from -5.9 to 19.9 per cent over better parent. Heterotic effect was considerable for this trait (Targut *et al* ., 1995).

2.6.6 Ear Diameter

Swamy Rao *et al.*, (1970)reported moderate to high heritability estimates of 55.55 and 86.04 per cent for ear diameter.

Patil *et al.*, (1972)noticed the moderate heritability of 68.88 per cent for this trait. Similarly El-Hosary (1987) noticed the moderate to high heritability for this trait.

Mukherjee *et al.* (1974) in a study of 5 diverse and heterozygous varieties, their S_1's the F_1 and the F_2 of half diallel based on them and some random crosses made among F_1's reported that heterosis effects were most significant in respect of ear diameter.

Turgut *et al.*, (1995) reported that heterotic effect were considerable for ear diameter.

2.6.7: 100 Grain Weight.

Raddovic (1979) and Johnson (1981) reported moderate to high range of heritability of 100-grain weight. However Wessel - Beaver *et al.*, (1985) observed moderate heritability. Low to moderate heritability was also noticed in three-way cross hybrids of maize, by Saadalls *et al.*, (1988). In another study, Debnath (1988) reported the low to moderate heritability for 1000 kernel weight. Mahmoud *et al.*, (1990) observed high broad sense heritability. While 52 per cent

broad sense heritability for this trait was reported by Alika (1994).

Shetty, (1974) observed heterosis percentage ranging from 16.4 to 30.95 over mid parent for 100 grain weight. Fairly high range of heterosis percentage over mid parent (-0.85 to 59.37) and over better parent (-30.48 to 37.35) was apparent in the report of Ramamurthy (1978). Similar results were observed by Radovic (1979) and Shakoor and Ataullah (1979), with maximum heterosis of 56.4 and 23.26 per cent respectively. Concurrently, Verma and Singh (1980) reported a heterosis range of 16.9 to 25.9 per cent over better parent. However, Mukherjee and Shaw (1984) obtained highly significant heterosis over mid parent (4.37 to 30.69 per cent) in inter varietal crosses of maize. Considerable heterotic effect for this trait was noticed by Alvarez *et al.*,(1993) and Turgut *et al.*,(1995).

2.6.8 Grain yield per plot

Grain yield is a complex metric trait, influenced by several component characters. It is highly influenced by the environmental factors thus causing low heritability.

Robinson *et al.*,(1949) obtained a very low heritability of 0.29, Klein (1975) and Ivanovic (1979) also observed low heritability for grain yield. Dhillon and Singh (1977a) quoted broadsense heritability estimates of 48 per cent. Similarly Bohm and Schuster (1985) reported low heritability estimate (18.00 per cent) for grain yield.

Debnath (1988) reported low to moderate broad sense heritability for

this trait. Mahmoud *et al.*, (1990) Odiemach (1992) noticed the high heritability for grain yield.

Richey (1922) showed that 82.4 per cent of the crosses exceeded the parental average with 55.7 per cent exceeding the higher yielding parent. High heterosis in inter varietal crosses of maize has been reported in the past by Robinson *et al.*,(1956), Lonquist and Gardner (1961), Dhawan and Singh (1961), Moll *et al.*, (1962) Paterniani and Lonnquist (1963), Appaduari and Nagarajan (1975) and Sayed Galal *et al.*, (1977). In the individual variety cross relative to the mid parent ranged from 4.5 per cent for 'BSK(S) s' x 'BSTE (FR) (I' to 60.2 per cent for 'BSSS(R) 6' x 'BS12(HI)CS' (Hallaur and Malithanao, 1976). Mukherjee *et al.*,(1974) and Paterniani (1963) obtained a maximum heterosis of 48.4 and 18.3 per cent respectively.

Varma and Singh (1980) reported a heterosis of 1.3 to 98.6 per cent over better parent. Jha and Khehara (1992) reported that 16 crosses significantly out yielding the best hybrid control. Similarly Mejaya and Lambert (1992) observed the heterosis for grain yield over control. Highest heterosis value (34 per cent) was noticed for grain yield by Alvarez *et al.*, (1993).

Gomes-e-Gama (1993) observed the average heterosis was 643 kg/ha. (8.4 per cent) for top crosses. Considerable heterotic effect was noticed for grain yield by Turgut *et al.*,(1995) Prez *et al.*,(1995).

MATERIAL AND METHODS

III MATERIAL AND METHODS

The present investigation was carried out during kharif, 1995 at the Agricultural Research Station, Arabhavi, University of Agricultural Sciences, Dharwad. This station is located in the northern dry zone (Zone III) of Karnataka which geographically lies at 16° 12'N latitude, 74°54'E longitude with an altitude of 640 meters above mean sea level and receives an average rainfall of 546 mm. The soils are medium black, sandy loam type with a pH of 7.2. Source of water is from Ghataprabha irrigation project which flows from July to February.

3.1 EXPERIMENTAL MATERIAL

The material for experimentation included the 99 three-way hybrids and a commercial check (Deccan 103) and two elite single crosses as checks (CI-4 x CI-5, CI-5 x CI-9) selected from a diallel crossing programme.

The base material was the eight elite germplasm sources. In this material inbreeding work was started from kharif 1991. Initially a large number of S_1 lines were generated. The number was restricted to 427 at S_2 stage and 312 at S_3 stage, at the time of harvest based on turcicum leaf blight disease reaction, uniformity and cob characters. From 312 S_3 lines crossing programme with elite single cross CI-5 x CI-9 as male parent was taken up during rabi 1994-95. At the time of harvest only 99 three way hybrids were selected and evaluated in Kharif 1995. The detailed pedigree regarding the experimental material used in this study is given in Table 1.a,b and c.

Table 1. a. Pedigree and Code of inbred lines and single crosses (Set-I)

Sl.No.	Pedigree	Code
1	1101-22-2-3	55
2	1101-23-2-1	56
3	1102-6-3-1	58
4	1102-6-3-3	60
5	1102-9-1-1	63
6	1102-12-2-1	66
7	1103-6-1-1	70
8	1103-6-1-3	71
9	1103-8-1-1	73
10	1103-8-2-3	74
11	1103-13-1-1	76
12	1101-1-1-1	77
13	1101-1-3-1	78
14	1101-5-3-1	80
15	1104-5-3-2	81
16	1105-1-1-1	83
17	1105-3-2-2	88
18	1105-3-4-1	89
19	1105-3-5-1	90
20	1101-13-4-1	91
21	1106-2-2-1	95
22	1106-2-2-3	96
23	1106-4-3-1	98
24	1106-5-3-1	99
25	1106-5-4-2	101
26	1106-5-5-1	102
27	1106-6-1-1	103
28	1106-7-1-2	105
29	1106-8-1-2	110
30	1106-8-2-1	111
31	1106-8-2-3	112
32	1106-15-1-2	117
33	1106-15-2-1	118
34	Deccan-103	Deccan-103
35	POP-27 C5-HS-29-1-1## x POP 28 - C6 HS-6####	CI-4 x CI-5
36	POP-28 C6-HS-6-#-#-#-# x Q 604 -	CI-5 x CI-9

Table 1 b. Pedigree and code of inbred lines and single crosses

Sl.No.	Pedigree	Code
1	1106-15-4-1	121
2	1106-15-5-1	123
3	1106-18-5-1	125
4	1106-18-5-2	126
5	1106-18-2-1	127
6	1106-18-8-1	128
7	1106-18-9-1	129
8	1106-19-1-2	130
9	1106-19-2-4	131
10	1107-2-1-1	132
11	1107-7-3-1	133
12	1107-7-3-2	134
13	1107-7-4-1	135
14	1107-14-3-2	136
15	1107-15-1-2	137
16	1107-16-2-2	138
17	1107-16-2-3	139
18	1107-16-3-1	140
19	1108-4-2-1	144
20	1108-10-1-2	148
21	1108-10-1-3	150
22	1108-10-3-2	152
23	1108-12-2-1	153
24	1108-12-5-1	154
25	1108-15-1-2	164
26	1108-16-1-4	166
27	1108-16-3-2	167
28	1108-16-4-1	168
29	1108-16-4-2	169
30	1108-18-1-3	170
31	1108-18-3-1	171
32	1108-18-5-3	173
33	1108-18-7-3	174
34	Deccan-103	Deccan-103
35	POP27-C5-HS-29-1-1-H## x POP28-C6 HS-6-#-#-#-#-	CI-5 x CI-4
36	POP28-C6-HS-6-# # # # x Q604-	CI-5 x CI-9

Table 1.c Pedigree code of inbred lines and single crosses (Set III)

Sl.No.	Pedigree	Code
1	1101-1-2-1	2
2	1101-14-1	6
3	1101-2-1-4	10
4	1101-3-4-1	12
5	1101-6-4-2	20
6	1101-7-6-1	28
7	1101-13-3-1	34
8	1101-13-5-1	38
9	1101-14-3-2	40
10	1101-17-1-1	41
11	1101-18-2-2	45
12	1101-20-8-2	51
13	1101-21-2-1	43
14	1102-8-3-1	61
15	1102-11-2-2	65
16	1102-12-2-2	67
17	1103-5-1-1	69
18	1103-7-4-3	72
19	1103-11-4-2	75
20	1104-10-2-4	82
21	1106-15-1-1	116
22	1106-15-3-1	119
23	1106-15-3-2	120
24	1106-15-4-2	122
25	1106-2-2-1	141
26	1108-7-1-1	164
27	1108-9-2-1	147
28	1108-10-1-1	149
29	1108-10-3-1	151
30	1108-13-2-2	158
31	1108-15-1-1	163
32	1108-16-1-2	165
33	1108-18-5-1	172
34	Deccan-103	Deccan 103
35	POP27-C5-HS-29-1-1 # # x POP28-C6-HS-6 # # # # -	CI-4 x CI-5
36	POP28-C6-HS-6-# # # # x Q604-	CI-5 x CI-9

3.2 FIELD PLOT TECHNIQUE

The experiment consisting of 99 three way hybrids and the three checks were divided into three different independent sets (SET-I, SET-II, SET- III). Each set consisting 33 three way hybrids and the three checks, were laid out in a randomized complete block design with four replications in Agricultural Research Station, Arabhavi, UAS, Dharwad, during kharif 1995. The summary of experimental layout is given below:

a.	Experimental design	Randomized complete block design
b.	Number of replication	4
c.	Number of total entries in each set per replications	36
d.	Row length	5 meters
e.	Number of rows per plot	1
f.	Spacing between rows	0.75 meters
g.	Spacing between plants within the row	0.20 meters

After a thorough land preparation hand dibbling of seeds was done with two seeds per hill and thinned out to maintain single plant per hill, ten days after germination.

The crop was applied with recommended doses of fertilizers (150 N; 75 P_2O5; 50 K_2O kg per hectare). The entire P_2O_5, K_{2O} and 1/3 of nitrogen was applied as basal dose and rest of the 2/3 nitrogen was top dressed in two equal splits at 4 weeks and 7 weeks after planting, weeding, irrigation, other cultural practices and after care were undertaken as per the recommended package of practices to raise the healthy crop.

3.3 RECORDING OF OBSERVATIONS

Observations were recorded on ten competitive randomly selected plants for six different quantitative characters. The average of ten plant observations was taken as the mean of the treatment. The 100 grain weight and yield per plot were recoreded on plot basis. The observations were recorded in the following manner.

3.3.1 Days to 50 per cent tasselling

The number of days taken from the date of planting to the day on which 50 per cent of plants in a treatment showed full tassel emergence, was recorded as days to 50 per cent tasselling.

3.3.2 Days to 50 per cent silking

The number of days taken from the date of planting to the day on which 50 per cent of the plants in a treatment showed silk emergence, was recorded as days to 50 per cent silking.

3.3.3 Plant height

Plant height expressed in centimeters was measured from the soil level at the base of the plant to the base of the last leaf sheath of the matured plant.

3.3.4 Ear height

Ear height was recorded at the same time as plant height and measured in centimeters as the length of the plant from the ground level to the upper most ear bearing node.

3.3.5 Ear length

Length of the upper most ear in centimeters was collected at the time of harvest as its total length i.e., from the base to the tip of the ear.

3.3.6 Ear diameter

Ear diameter was recorded at the same time that of ear length and measured in centimeters as the diameter of the ear i.e., at the middle of the ear.

3.3.7, 100 grain weight

Weight of 100 grains drawn from a random, sun dried sample from each plot was recorded in grams.

3.3.8 Grain yield per plot

At harvest fresh ear weight was recorded in kgs per plot. Moisture sample determinations were taken from shelled samples of two kernel rows from five random ears of each plot and moisture percentage was recorded using the moisture meter. These data were used to transform the fresh weight to dry weight basis at 15 per cent moisture grain yield in kg per plot was recorded.

3.4 STATISTICAL ANALYSIS

3.4.1 Analysis of variance

The data were subjected to RBD analysis as described by Panse and Sukhatme (1962). The mean values of the genotype in each replication were used for analysis of variance. The significant difference among genotypes was tested by 'F' test at one per cent and five per cent levels of probability.

The structure of analysis of variance (ANOVA) table is presented below.

Source of Variation	df	SS	M.S.S	F value	
				Calculate	Table
Replication	(r-1)	R	R/(r-1)		
Treatment	(t-1)	Tr	Tr/(t-1)	Tr.M.S.S / E.M.S.S.	
Error	(r-1)	E	E/(r-1)		
Total	(rt-1)	T	T/(rt-1)		

where, r = Number of replications

t = Number of treatments or genotypes

$$SEM = \sqrt{E.M.S.S./r.}$$

The significance was tested by referring to table given by Snedecor (1946).

3.4.2 Components of variance

Phenotypic and genotypic components of variance were computed according to the formula given by Lush (1940) and Choudhary and Prasad (1968).

$$\text{Genotypic variance (Vg)} = \frac{\text{Tr. M.S.S. - E.M.S.S.}}{r}$$

Error variance (Ve) = E.M.S.S.

Phenotypic variance (Vp) = V_g + Ve

3.4.3 Coefficient of variability

Genotypic and phenotypic coefficient of variability were computed according to Burton and De Vane (1953).

$$\text{Genotypic coefficient of variability (GCV)} = \frac{\sqrt{Vg}}{\bar{X}} \times 100$$

$$\text{Phenotypic coefficient of variability (PCV)} = \frac{\sqrt{Vp}}{\bar{X}} \times 100$$

where,

Vg = Genotypic variance

Vp = Phenotypic variance

and $\bar{X}$ = General mean of the character.

3.4.4 Heritability (h^2)

Broad sense heritability was estimated as the ratio of genotypic variance to the phenotypic variance and was expressed in percentage (Hanson *et. al.*, 1956).

$$\text{Heritability } (h^2) = \frac{Vg}{Vp} \times 100$$

Where,

Vg = Genotypic variance

Vp = Phenotypic variance

3.4.5 Genetic advance (GA)

Genetic advance (GA) was computed according to the formula given by Johnson *et. al.*, (1955a).

$$\text{Genetic advance (GA)} = ih^2 \sqrt{Vp}$$

Where,

i	=	Selection differential (2.06) at 5 per cent selection intensity.
h^2	=	Broadsense heritability.
$\sqrt{Vp}$	=	Phenotypic standard deviation.

Genetic advance over mean (GAM) was computed by the formula,

$$GAM = \frac{GA}{\overline{X}} \times 100$$

Where $\overline{X}$ = Mean of the population.

3.4.6 Heterosis

Estimates of percentage heterosis over three Checks (Deccan - 103, CI- 4 x CI-5, CI-5 x CI-9), were made as follows.

$$\text{Percentage heterosis} = \frac{\bar{F}_1 - \text{check}}{\text{check}} \times 100$$

Where,

$\bar{F}_1$ = Mean of F_1

The significance of F_1 heterosis values was tested by comparing the mean deviations with CD values, obtained for check, employing the formula given below.

$$\text{CD for heterosis} = \frac{\sqrt{2\ EMSS}}{r} \times \text{t value}$$

Where,

E.M.S.S. = Error mean square of RBD

r = Number of replications

t = table t value at error degrees of freedom.

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The present experiment was carried out during Kharif-1995 at the Agricultural Research Station, Arabhavi, University of Agricultural Sciences, Dharwad, to study the genetic nature of the newly developed inbred lines through three-way cross hybrid performance. The data on the experimental material comprising of 99 three-way cross hybrids involving newly developed inbred lines along with three checks viz., Deccan-103 (double cross hybrid, commercial check), CI-4 x CI-5 (high yielding single cross) and CI-5 x CI-9 (also a high yielding single cross and the tester for all the 99 lines) were tested in 3 sets of experiment. Yield and yield components have been used to estimate the variability parameters and heterosis. The experimental results of the three sets are presented under the following headings.

4.1 Analysis of variance

4.2 Genetic variability studies

4.3 Heterosis

4.1 ANALYSIS OF VARIANCE

The observations recorded in respect of eight quantitative characters viz., days to 50 per cent tasselling, days to 50 per cent silking, plant height, ear height, ear length, ear diameter, 100-grain weight and grain yield per plot on individual ten random competitive plants from each plot were averaged out. These replication wise means were subjected to analysis of variance to know the significant difference among the treatments. The mean sum of squares due to treatments of 3 sets of the experiment are presented in the Table 2.

Table 2 Analysis of variance of three sets in respect of eight quantitative characters in maize.

Set I

Source	df	Days to 50 % tasselling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	100 grain weight (gm)	Yield/ Plot (kg)
		1	2	3	4	5	6	7	8
Replication	3	5.56**	22.86**	3975.17**	1662.29**	13.70**	1.31**	16.98*	2.69**
Treatment	35	2.85**	4.72**	320.82**	276.57**	2.32**	0.47NS	20.93**	0.57**
Error	105	0.80	1.52	267.60	134.04	1.17	0.31	6.12	0.18
SEm ±		0.63	0.87	11.57	8.19	0.76	0.39	1.75	0.30
CD at 5%		1.25	1.73	22.93	16.23	1.51	0.78	3.47	0.60
CD at 1%		1.66	2.29	30.37	21.50	2.00	1.03	4.59	0.80
CV (%)		1.65	2.18	8.87	11.79	8.61	4.02	10.48	13.87

Set II

Source	df	Days to 50 % tasselling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	100 grain weight (gm)	Yield/ Plot (kg)
		1	2	3	4	5	6	7	8
Replication	3	2.49*	4.90*	3230.83**	2336.54**	12.81**	6.42**	17.47NS	2.88**
Treatment	35	1.89**	3.49**	600.54**	262.86**	2.00NS	1.71**	17.56**	0.43**
Error	105	0.79	1.26	290.41	93.58	1.56	0.87	9.52	0.22
SEm ±		0.63	0.79	12.05	6.84	0.89	0.66	2.18	0.33
CD at 5%		1.25	1.57	23.88	13.56	1.76	1.31	4.32	0.65
CD at 1%		1.65	2.07	31.63	17.96	2.34	1.73	5.72	0.87
CV (%)		1.62	1.97	9.05	9.68	9.65	6.94	11.28	15.12

Set III

Source	df	Days to 50 % tasselling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	100 grain weight (gm)	Yield/ Plot (kg)
		1	2	3	4	5	6	7	8
	3	26.36**	45.09**	7313.83**	3521.50**	26.62NS	4.08**	20.05NS	8.86**
	35	2.18**	2.79**	465.58**	263.84**	3.09**	0.95**	32.13**	0.53**
	105	0.88	1.00	215.84	126.30	1.04	0.29	18.99	0.24
		0.66	0.71	10.39	7.95	0.72	0.38	3.08	0.35
		1.31	1.41	20.59	15.76	1.43	0.75	6.10	0.69
		1.73	1.86	27.27	20.87	1.89	1.00	8.09	0.92
		1.72	1.77	8.33	12.48	8.07	3.91	14.70	16.32

*, ** - Significant at 5% and 1% levels of probability
NS - Non significant

The variance due to replications were highly significant for days to 50 per cent tasselling, days to 50 per cent silking, plant height, ear height, ear diameter, and grain yield per plot in all the three sets, except days to 50 per cent tasselling and days to 50 per cent silking in set II significant at 5 per cent level of probability. But with respect to ear length it was not significant in Set III, whereas highly significant in set I and set II. Variance due to replication with respect to 100 grain weight, was not significant in set II and set III. Whereas in set I, it was significant at 5 per cent level of probability.

The mean sum of squares due to treatments in all the three sets were significant for all the characters under study at five per cent and one per cent probability levels except for ear length and ear diameter in set II and set I respectively.

4.2 GENETIC VARIABILITY STUDIES

The values of mean, range, genotypic variance, phenotypic variance, environmental variance, heritability genetic advance, genetic advance as per cent mean (GAM) phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) of three sets of the experiment for all eight characters studied are presented in Table-3 and Figure-1.

4.2.1 Days to 50 per cent tasselling

In all the three sets the genotypes differed significantly with respect to days to 50 per cent tasselling which ranged from :

52.25 days (CI-5 x CI-9) to 55.75 days [83 (CI-5 x CI-9) : 71 (CI-5 x CI-9)], 53.5

Table 3. Estimates of variability and genetic parameters in respect of eight quantitative characters in maize

Parameters	Sets	Days to 50% tasselling 1	Days to 50% silking 2	Plant height (cm) 3	Ear height (cm) 4
Range	I	52.25 - 55.75	53.50 - 58.25	166.00 - 198.62	82.25 - 128.25
	II	53.50 - 56.00	55.25 - 58.25	155.65 - 209.40	84.54 - 118.50
	III	52.75 - 56.25	54.50 - 58.50	150.32 - 194.62	72.97 - 115.50
Mean	I	54.240	56.440	184.430	98.190
	II	54.850	57.020	188.410	99.910
	III	54.490	56.610	176.290	90.020
Phenotypic	I	1.313	2.321	280.911	169.674
variance	II	1.065	1.816	367.950	135.905
	III	1.206	1.450	278.085	160.686
Genotypic	I	0.512	0.800	13.306	35.632
variance	II	0.275	0.560	77.530	42.318
	III	0.324	0.448	62.500	34.386
Environmental	I	0.801	1.521	267.605	134.042
variance	II	0.790	1.260	290.420	93.587
	III	0.882	1.002	215.585	126.300
Phenotypic	I	2.110	2.700	9.090	13.270
co-efficient of	II	1.880	2.360	10.180	11.670
variance	III	2.020	2.130	9.460	14.080
Genotypic	I	1.320	1.580	1.980	6.080
co-efficient of	II	0.960	1.310	4.670	6.510
variance	III	1.040	1.180	4.480	6.510
Broad	I	39.000	34.500	4.700	21.000
sense	II	25.800	30.700	21.100	31.100
heritability	III	26.900	30.900	22.400	21.400
Genetic	I	0.920	1.080	1.640	5.640
Advance	II	0.550	0.850	8.330	7.480
(GA)	III	0.610	0.770	7.710	5.590
Genetic	I	1.706	1.914	0.889	5.740
advance over	II	1.000	1.491	4.421	7.487
mean (GAM)	III	1.120	1.360	4.373	6.400

Table 3. Cont'd....

Parameters	Sets	Ear length (cm) 5	Ear diameter (cm) 6	100-grain weight (gm) 7	Yield/Plot (kg) 8
Range	I	11.30 - 14.27	13.02 - 14.62	18.00 - 29.00	2.12 - 3.80
	II	12.02 - 14.57	10.57 - 14.60	19.98 - 32.75	2.40 - 3.97
	III	10.62 - 15.30	12.40 - 14.67	25.00 - 37.25	2.18 - 3.88
Mean	I	12.550	13.780	23.610	3.100
	II	12.980	13.440	27.350	3.070
	III	12.650	13.790	29.640	3.030
Phenotypic	I	1.457	0.347	9.723	0.281
variance	II	1.677	1.081	11.525	0.269
	III	1.556	0.455	22.278	0.316
Genotypic	I	0.289	0.039	3.604	0.097
variance	II	0.109	0.210	2.013	0.053
	III	0.514	0.164	3.286	0.071
Environmental	I	1.168	0.308	6.119	0.184
variance	II	1.568	0.871	9.512	0.216
	III	1.042	0.291	18.992	0.245
Phenotypic	I	9.620	4.270	13.210	17.110
co-efficient of	II	9.980	7.730	12.410	16.890
variance	III	9.850	4.890	15.920	18.540
Genotypic	I	4.280	1.440	8.040	10.030
co-efficient of	II	2.540	3.410	5.190	7.520
variance	III	5.660	2.930	6.110	8.800
Broad	I	19.800	11.300	37.100	34.300
sense	II	6.500	19.400	17.500	19.800
heritability	III	33.000	35.900	14.700	22.500
Genetic	I	0.490	0.140	2.380	0.370
Advance	II	0.170	0.420	1.220	0.210
(GA)	III	0.850	0.500	1.430	0.260
Genetic	I	3.904	1.016	10.080	11.935
advance over	II	1.309	3.125	4.461	6.840
mean (GAM)	III	6.719	3.626	4.825	8.581

Fig 1. PCV, GCV, Heritability and Genetic advance in respect of 8 characters in Maize

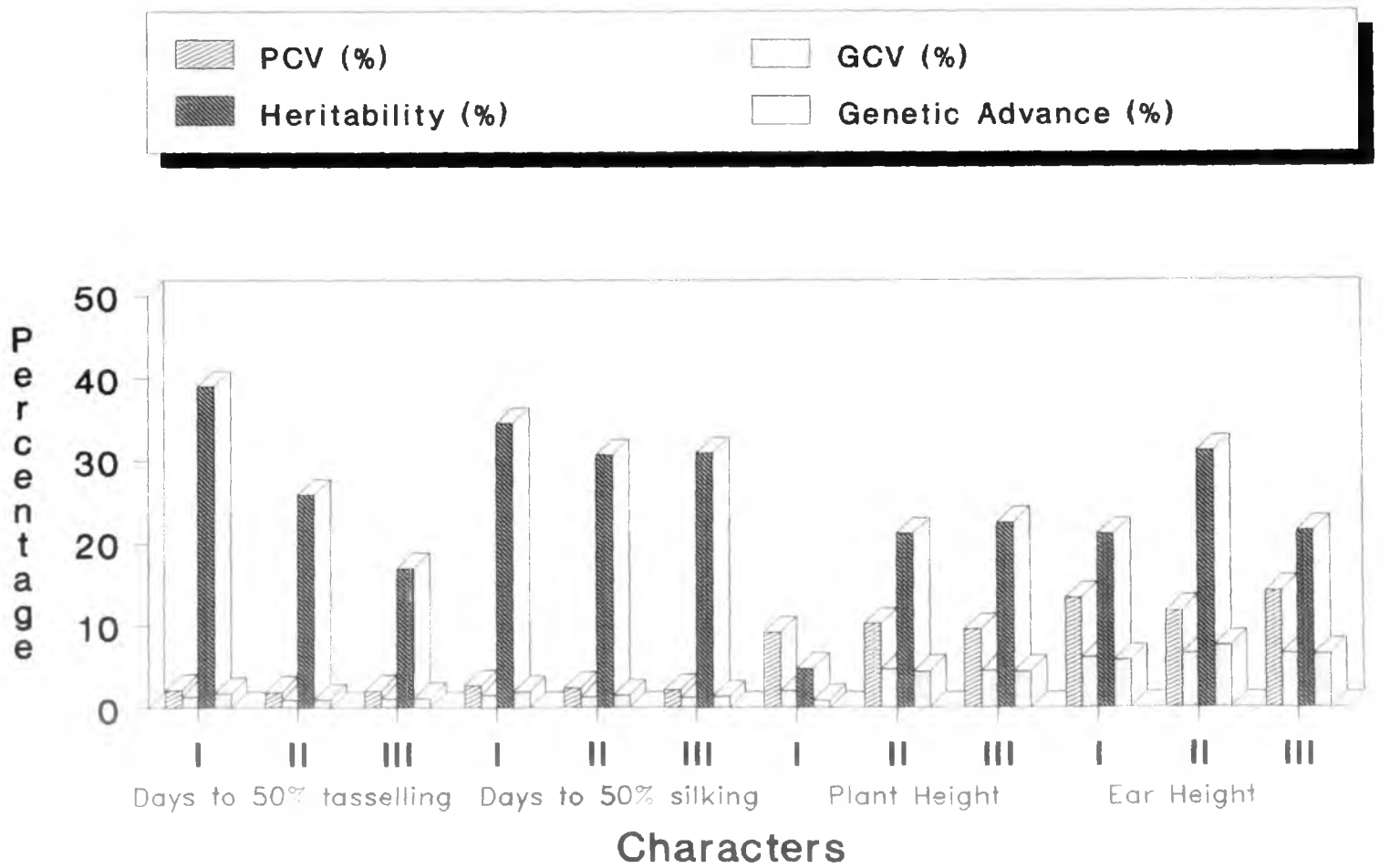
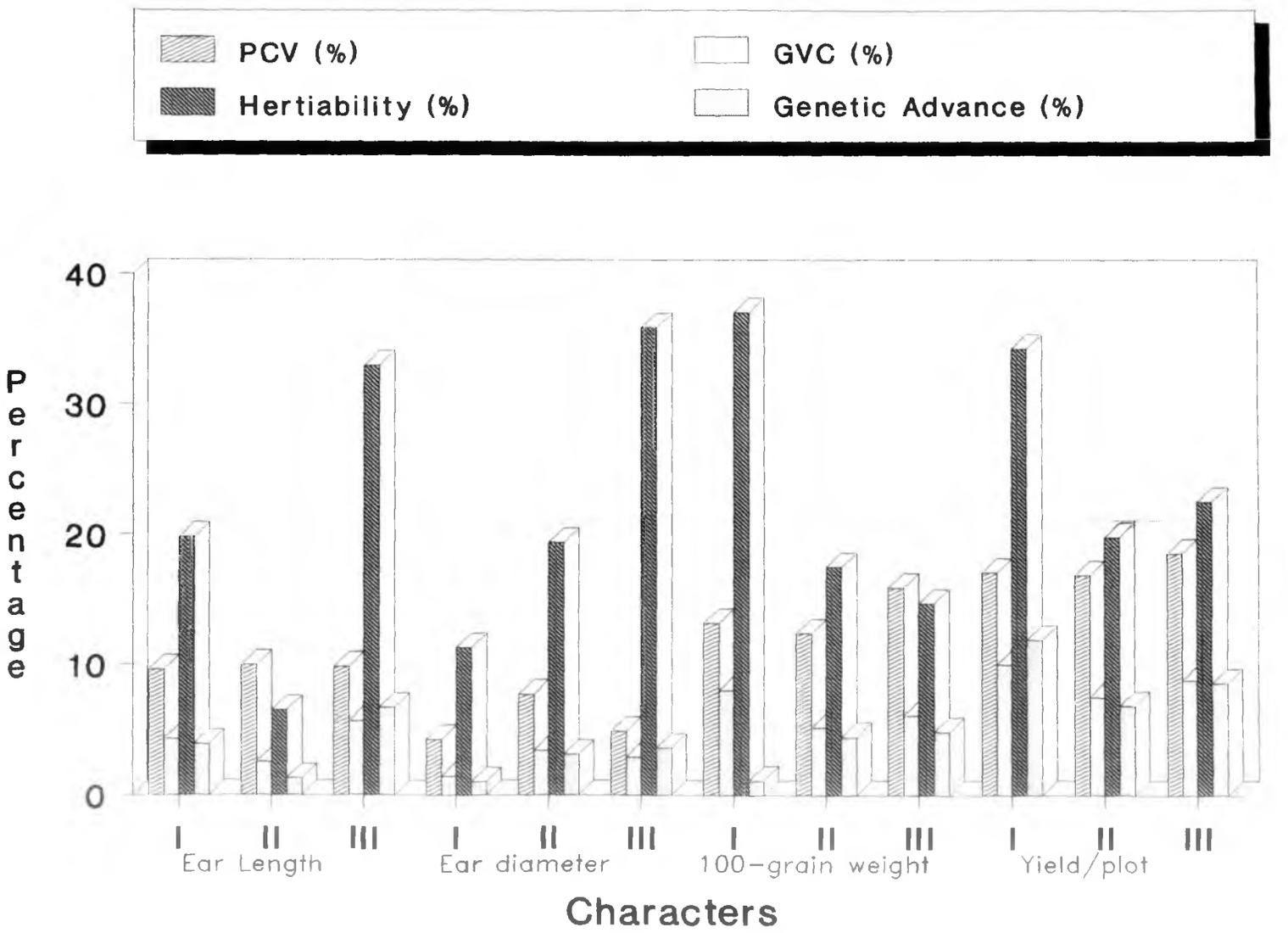


Fig 1. Cont'd.....


PCV (%)
GVC (%)
Hertiability (%)
Genetic Advance (%)
Percentage
40
30
20
10
0
I II III I II III I II III I II III
Ear Length
Ear diameter
100-grain weight
Yield/plot
Characters

days [121 (CI-5 x CI-9) : 123 (CI-5 x CI-9) : 138 (CI-5 x CI-9)] to 56.00 days [144 (CI-5 x CI-9)] and 52.75 days [12 (CI-5 x CI-9)] to 56.25 days [141 (CI-5 x CI-9)] with a mean value of 54.24, 54.85 and 54.49 days, respectively.

Out of three checks, CI-5 x CI-9 which matured early in all the three sets took 52.25 days in set I, 54.00 days in set II and 53.25 days in set III. Deccan-103 also took the same days as that of CI-5 x CI-9 only in set II.

The estimates of phenotypic and genotypic co-efficient of variation in all the three sets were 2.11, 1.88, 2.02 and 1.32, 0.96, 1.04, respectively.

Moderate broad sense heritability 39.00, 25.80, 26.90 per cent and low genetic advance 0.92, 0.55, 0.61 and genetic advance as per cent of mean 1.70, 1.00, 1.12 respectively in all the three sets were observed for this character.

4.2.2 Days to 50 per cent silking

In all the three sets hybrids deferred significantly with respect to days to 50 per cent silking which ranged from :

53.5 days (CI-5 x CI-9) to 58.25 days [71 (CI-5 x CI-9) : 76 (CI-5 x CI-9)], 55.25 days [121 (CI-5 x CI-9)] to 58.25 days [129 (CI-5 x CI-9) : 130 (CI-5 x CI-9) : 131 (CI-5 x CI-9) : 152 (CI-5 x CI-9)] and 54.5 days [12 (CI-5 x CI-9)] to 58.5 days [165 (CI-5 x CI-9)] with a mean value of 56.44, 57.02 and 56.61 days respectively.

Out of three checks the early matured CI-5 x CI-9 took 53.50 and 55.50 days in set I and set III respectively. Whereas in set II, CI-5 x CI-9 and Deccan-103 which matured at the time, took 55.75 days.

The estimates of phenotypic and genotypic coefficient of variation in respective three sets were 2.70, 2.36, 2.13 and 1.58, 1.31, 1.18 respectively.

Moderate broad sense heritability 34.50, 30.70, 30.90 per cent and low genetic advance 1.08, 0.85, 0.77 and genetic advance as per cent of mean 1.91, 1.49, 1.36 in respective three sets were observed for this character.

4.2.3 Plant height

The range of variation for plant height in set I was from : 166.00 cm [96 (CI-5 x CI-9)] to 198.62 cm [117 (CI-5 x CI-9)] with a mean value of 184.43 cm and in set II, 155.65 cm [171 (CI-5 x CI-9)] to 209.40 cm [166 (CI-5 x CI-9)] with a mean value of 188.41 and in set III, 150.32 cm [149 (CI-5 x CI-9)] to 194.62 [165 (CI-5 x CI-9)] with a mean value of 176.29 cm.

Among checks CI-4 x CI-5, Deccan 103 and CI-5 x CI-9 recorded highest mean plant height of 196.34 cm, 203.50 cm and 180.62 cm in all the three sets, respectively.

In the three sets the estimates of PCV and GCV were 9.09, 10.18, 9.46 and 1.98, 4.67, 4.48 respectively. The heritability value in all the three sets were 4.70, 21.10 and 22.40 per cent with genetic advance of 1.64, 8.33 and 7.71 respectively. The genetic advance recorded as per cent of mean was 0.89 (set I), 4.42 (set II) and 4.37 (set III).

4.2.4 Ear height

Ear height ranged from 82.25 cm [112 (CI-5 x CI-9)] to 128.25 cm [117 (CI-5 x CI-9)] with a mean value of 98.19 cm in set I, 84.54 cm [171 (CI-5 x CI-9)] to 118.50 cm [166 (CI-5 XCI-9)] with a mean value of 99.91 cm in set II and 72.97 cm [149 (CI-5 x CI-9)] to 115.50 cm [67 (CI-5 x CI-9)] with a mean value of 90.02 cm in set III.

Among checks Deccan 103 recorded highest mean ear height of 100.70 cm and 93.00 cm in set I and set III respectively. Whereas in set II CI-5 x CI-9 recorded highest mean ear height of 102.88. The estimates of PCV and GCV in all the three sets were 13.27, 11.67, 14.08 and 6.08, 6.51, 6.51 respectively.

The heritability value in three sets were 21.00, 31.10 and 21.40 per cent with genetic advance of 5.64, 7.48 and 5.59 respectively. The genetic advance recorded as per cent of mean was 5.74 (set I), 7.49 (set II) and 6.21 (set III).

4.2.5 Ear length

Ear length ranged from 11.30 cm [78 (CI-5 x CI-9)] to 14.27 cm [102 (CI-5 x CI-9)], 12.02 cm [CI-5 x CI-9)] to 14.57 cm [130 (CI-5 x CI-9)] and 10.62 cm [51 (CI-5 x CI-9)] to 15.30 cm [158 (CI-5 x CI-9)] with a mean value of 12.55 , 12.98 and 12.65 cm, respectively in the three sets.

Among the checks, Deccan-103 recorded longest ear length of 13.88 cm in set I and set III and 13.70 cm in set II.

Phenotypic coefficient of variation value of 9.62, 9.98, 9.85 and genotypic coefficient of variation value of 4.28, 2.54, 5.66 were recorded in the three sets respectively.

The heritability value in all the three sets were 19.80, 6.50 and 33.00 per cent with low genetic advance of 0.49, 0.17 and 0.85 respectively. The genetic advance recorded as per cent of mean was 3.90, 1.31 and 6.72 in the three sets respectively.

4.2.6 Ear diameter

Ear diameter ranged from 13.02 cm [112 (CI-5 x CI-9)] to 14.62 cm [99 (CI-5 x CI-9)], 10.57 cm [128 (CI-5 x CI-9)] to 14.60 cm [164 (CI-5 x CI-9)] and 12.40 cm [34 (CI-5 x CI-9)] to 14.67 cm [116 (CI-5 x CI-9)] with a mean value of 13.78, 13.44 and 13.79 cm respectively in the three sets.

The checks, CI-4 x CI-5 (14.05 cm), Deccan 103 (13.88 cm) and CI-5 x CI-9 (13.85 cm) recorded the highest ear diameter in the three sets respectively.

PCV value of 4.27, 7.73, 4.89 and GCV value of 1.44, 3.41, 2.93 were recorded in the three sets respectively.

The heritability value in the three sets were 11.30, 19.40 and 35.90 per cent respectively with low genetic advance of 0.14, 0.42 and 0.50 as well as genetic advance recorded as per cent of mean was 1.02, 3.13 and 3.63 respectively.

4.2.7 100 Grain weight

The mean 100 - grain weight was 23.61 gm, 27.35 gm and 29.64 gm in the three sets, respectively, with a range of 18.00 gm [81 (CI-5 x CI-9)] to 29.00 gm [118 (CI-5 x CI-9)], 19.98 gm [139 (CI-5 x CI-9)] to 32.75 gm [166 (CI-5 x CI-9)] and 25.00 gm [41 (CI-5 x CI-9) : 61 (CI-5 x CI-9)] to 37.75 gm [116 (CI-5 x CI-9)] in the three sets respectively.

Highest 100 grain weight was found to be 26.00 gm (set I) and 32.25 gm set III for the check Deccan-103. Whereas 28.50 gm (set II) for the check CI-5 x CI-9.

The estimates of phenotypic and genotypic coefficient of variation were 13.21, 12.41, 15.92 and 8.04, 5.19, 6.11 in the three sets respectively.

Moderate to low heritability values of 37.10, 17.50 and 14.70 per cent coupled with low genetic advance 2.38, 1.22 and 1.43 were observed, respectively in the three sets. The genetic advance as per cent of mean was 10.08, 4.46 and 4.83 in the three sets respectively.

4.2.8 Grain yield per plot

The mean grain yield per plot in all the three sets were 3.10, 3.07 and 3.03 kg with a range of 2.12 kg [81 (CI-5 x CI-9)] to 3.80 kg [118 (CI-5 x CI-9)], 2.40 kg [171 (CI-5 x CI-9)] to 3.97 kg [166 (CI-5 x CI-9)] and 2.18 kg [149 (CI-5 x CI-9)] to 3.88 kg [116 (CI-5 x CI-9)] respectively.

Highest grain yield per plot was found to be 3.32 kg (set I) : 3.35 kg (set II) and 3.40 kg (set III) in the checks Deccan-103, CI-5 x CI-9 and CI-4 x CI-5 respectively.

Phenotypic coefficient of variation values of 17.11, 16.89, 18.54 and genotypic coefficient of variation values of 10.03, 7.52, 8.80 were observed in the three sets respectively.

In all the three sets, heritability values of 34.30, 19.80 and 22.50 per cent coupled with low genetic advance 0.37, 0.21 and 0.26 were observed respectively. The genetic advance as per cent of mean was 11.94, 6.84 and 8.58 in the three sets respectively.

4.3 Heterosis

The percentage heterosis over commercial check and also over the two single crosses, as checks, in respect of eight characters studied in 3 sets of the experiment is presented in Table-4a, 4b. 4c. The commercial check choosen for this experiment was Deccan-103, and the check, which performed better as described among the three checks, considered as the best check. The results of percentage heterosis over commercial check and best check presented character wise in the following paragraphs.

4.3.1 Days to 50 per cent tasselling

The percentage of heterosis in the three sets over commercial check value ranged from -0.47 [80 (CI-5 x CI-9); 101 (CI-5 x CI-9)] to 3.74 [76 (CI-5 x CI-9)], -0.93 [121 (CI-5 x CI-9); 123 (CI-5 x CI-9) to 3.70

Table 4.a Heterosis over Deccan 103, CI-4 x CI-5 and CI-5 x CI-9 (SET I)

Sl.No.	Entries	Days to 50 per cent tasselling			Days to 50 per cent silking		
		Deccan-103	CI-4 x CI-5	CI-5 x CI-9	Deccan-103	CI-4 x CI-5	CI-5 x CI-9
		1	2	3	1	2	3
		1			2		
1	55(CI-5xCI-9)	2.34**	3.79**	4.78**	1.36	0.00	4.21**
2	56(CI-5xCI-9)	2.34**	1.90**	2.87**	4.09**	2.69**	7.01**
3	58(CI-5xCI-9)	0.93	2.37**	3.35**	3.63**	2.24**	6.54**
4	60(CI-5xCI-9)	2.34**	1.90**	2.87**	4.09**	2.69**	7.01**
5	63(CI-5xCI-9)	1.87**	3.32**	4.31**	3.18**	1.79**	6.07**
6	66(CI-5xCI-9)	1.40*	2.34**	3.83**	1.82**	0.45	4.67**
7	70(CI-5xCI-9)	3.27**	4.74**	5.74**	5.45**	4.04**	8.41**
8	71(CI-5xCI-9)	4.21**	5.69**	6.70**	5.91**	4.49**	8.88**
9	73(CI-5xCI-9)	3.27**	4.74**	5.74**	5.00**	3.58**	7.94**
10	74(CI-5xCI-9)	2.34**	3.79**	4.78**	4.09**	2.69**	1.48
11	76(CI-5xCI-9)	3.74**	5.21**	6.22**	5.91**	4.49**	8.88**
12	77(CI-5xCI-9)	1.40*	2.84**	3.83**	1.36	0.00	4.21**
13	78(CI-5xCI-9)	0.00	1.42**	2.39**	0.45	-0.90	3.27**
14	80(CI-5xCI-9)	-0.47	0.95	1.91**	0.45	-0.90	3.27**
15	81(CI-5xCI-9)	3.27**	4.74**	5.74**	1.36	3.58**	7.94**
16	83(CI-5xCI-9)	4.21**	5.69**	6.70**	5.43**	4.04**	8.41**
17	88(CI-5xCI-9)	3.27**	4.74**	5.74**	0.91	-0.45	3.74**
18	89(CI-5xCI-9)	2.34**	1.90**	2.87**	1.36	0.00	4.21**
19	90(CI-5xCI-9)	0.93	2.37**	3.35**	4.09**	2.69**	7.01**
20	91(CI-5xCI-9)	1.40*	2.84**	3.83**	2.73**	1.35	5.61**
21	95(CI-5xCI-9)	1.40*	2.84**	3.83**	2.27**	0.90	5.14**
22	96(CI-5xCI-9)	0.93*	2.37**	3.35**	2.27**	0.90	5.14**
23	98(CI-5xCI-9)	1.87**	3.32**	4.31**	2.73**	1.35	5.61**
24	99(CI-5xCI-9)	1.87**	3.32**	4.31**	3.18**	1.79*	6.07**
25	101(CI-5xCI-9)	-0.47	0.95	1.91**	-0.45	-1.79*	2.34**
26	102(CI-5xCI-9)	1.87**	3.32**	4.31**	1.36**	0.00	4.21**
27	103(CI-5xCI-9)	1.87**	3.32**	4.31**	1.82**	0.45	4.67**
28	105(CI-5xCI-9)	1.87**	3.32**	4.31**	0.45	-0.90	3.27**
29	110(CI-5xCI-9)	1.87**	3.32**	4.31**	4.09**	2.69**	7.01**
30	111(CI-5xCI-9)	2.34**	3.79**	4.78**	3.64**	2.24**	6.54**
31	112(CI-5xCI-9)	0.93	2.37**	3.85**	1.36	0.00	4.21
32	117(CI-5xCI-9)	1.87	3.32**	4.31**	2.73**	1.35	5.61
33	118(CI-5xCI-9)	2.34	3.79**	4.78**	3.64**	2.24**	6.54
	CD at 5 per cent		1.25			1.73	
	CD at 1 per cent		1.66			2.29	

*, ** Significant at 5 per cent and 1 per cent levels of probability respectively

Table 4.b Heterosis over Deccan 103, CI-4 x CI-5 and CI-5 x CI-9 (SET II)

Sl.No.	Entries	Days to 50 per cent tasselling			Days to 50 per cent silking		
		Deccan-103	CI-4 x CI-5	CI-5 x CI-9	Deccan-103	CI-4 x CI-5	CI-5 x CI-9
		1	2	3	1	2	3
			1			2	
1	121(CI-5xCI-9)	-0.93	-3.17**	-0.93	-0.89	-1.77*	-0.89
2	123(CI-5xCI-9)	-0.93	-3.17**	-0.93	0.00	-0.88	0.00
3	125(CI-5xCI-9)	3.24**	0.90	3.24**	4.03**	3.11**	4.04**
4	126(CI-5xCI-9)	3.24**	0.90	3.24**	1.34	0.44	1.35
5	127(CI-5xCI-9)	2.31**	0.00	2.31**	3.58**	2.66**	3.59**
6	128(CI-5xCI-9)	1.85**	-0.45	1.85**	3.58**	2.66**	3.59**
7	129(CI-5xCI-9)	1.85**	-0.45	1.85**	4.48**	3.55**	4.48**
8	130(CI-5xCI-9)	3.24**	0.90	3.24**	4.48**	3.55**	4.48**
9	131(CI-5xCI-9)	2.80**	0.45	2.80**	4.48**	3.55**	4.48**
10	132(CI-5xCI-9)	0.00	-2.26**	0.00	0.44	-0.44	0.45
11	133(CI-5xCI-9)	1.38*	-0.90	1.39*	0.90	0.00	0.90
12	134(CI-5xCI-9)	2.31**	0.00	2.31**	2.69**	1.77*	2.69**
13	135(CI-5xCI-9)	1.85**	-0.45	1.85**	0.44	-0.44	0.45
14	136(CI-5xCI-9)	0.00	-2.26**	0.00	0.89	0.00	0.90
15	137(CI-5xCI-9)	2.31**	0.00	2.31**	3.58**	2.66**	3.59**
16	138(CI-5xCI-9)	-0.93	-3.17**	-0.93	0.00	0.80	0.00
17	139(CI-5xCI-9)	2.80**	0.45	2.78**	4.03**	3.11**	4.04**
18	140(CI-5xCI-9)	1.85**	-0.45	1.85**	3.58**	2.66**	3.59**
19	144(CI-5xCI-9)	3.70**	1.36*	3.70**	3.58**	2.66**	3.59**
20	148(CI-5xCI-9)	0.92	-1.36*	0.93	2.24**	1.33	2.24**
21	150(CI-5xCI-9)	3.24**	0.90	3.24**	4.03**	3.11**	4.04**
22	152(CI-5xCI-9)	2.31**	0.00	2.31**	4.48**	3.55**	4.48**
23	153(CI-5xCI-9)	1.85**	-0.45	1.85**	1.34	0.44	1.35
24	154(CI-5xCI-9)	1.85**	-0.45	1.85**	4.03**	3.11**	4.04**
25	164(CI-5xCI-9)	0.92	-1.36*	0.93	1.34	0.44	1.35
26	166(CI-5xCI-9)	1.85**	-0.45	1.85**	1.34	0.44	1.35
27	167(CI-5xCI-9)	3.24**	0.90	3.24**	4.03**	3.11**	4.04**
28	168(CI-5xCI-9)	1.38*	-0.90	1.39*	4.03**	3.11**	4.04**
29	169(CI-5xCI-9)	1.38*	-0.90	1.39*	2.69**	1.77*	2.69**
30	170(CI-5xCI-9)	0.92	-1.36*	0.93	0.44	-0.44	0.45
31	171(CI-5xCI-9)	0.92	-1.36*	0.93	1.79*	0.88	1.79*
32	173(CI-5xCI-9)	0.46	-1.81**	0.46	2.69**	1.77*	2.69**
33	174(CI-5xCI-9)	0.92	-1.36*	0.93	1.34	0.44	1.35
	CD at 5 per cent		1.25			1.57	
	CD at 1 per cent		1.65			2.07	

*, ** Significant at 5 and 1 per cent levels of probability respectively

Table 4.c Heterosis over Deccan 103, CI-4 x CI-5 and CI-5 x CI-9 (SET III)

Sl.No.	Entries	Days to 50 per cent tasselling			Days to 50 per cent silking		
		Deccan-103	CI-4 x CI-5	CI-5 x CI-9	Deccan-103	CI-4 x CI-5	CI-5 x CI-9
		1	2	3	1	2	3
			1			2	
1	2(CI-5xCI-9)	0.00	-0.90	2.34**	0.63	0.00	2.25**
2	6(CI-5xCI-9)	1.38*	0.45	3.76**	0.89	0.00	2.25**
3	10(CI-5xCI-9)	0.00	-0.90	2.34**	0.00	-0.88	1.32
4	12(CI-5xCI-9)	-3.21**	-4.55*	-0.93	-3.12**	-3.96**	-1.80*
5	20(CI-5xCI-9)	-0.46	-1.36*	1.87**	-0.89	-1.76*	0.45
6	28(CI-5xCI-9)	0.00	-0.90	2.34**	0.00	-0.80	1.35
7	34(CI-5xCI-9)	1.38*	-0.45	3.76**	0.89	0.00	2.25**
8	38(CI-5xCI-9)	0.00	-0.90	2.34**	-0.45	-1.32	0.90
9	40(CI-5xCI-9)	-1.38*	-2.27**	0.93	-0.45	-1.32	0.90
10	41(CI-5xCI-9)	-2.29**	-3.18**	0.00	0.45	-0.44	1.80*
11	45(CI-5xCI-9)	0.00	-0.90	2.34**	-1.33	-2.20**	0.00
12	51(CI-5xCI-9)	0.46	-0.45	2.81**	2.23**	1.32	3.60**
13	53(CI-5xCI-9)	1.38*	0.45	3.75**	1.34	0.44	2.70**
14	61(CI-5xCI-9)	0.46	-0.45	2.34**	1.34	0.44	2.70**
15	65(CI-5xCI-9)	1.38*	0.45	3.75**	1.78*	0.88	3.15**
16	67(CI-5xCI-9)	-0.46	-1.36*	1.88**	2.67**	0.00	2.25**
17	69(CI-5xCI-9)	-1.84**	-2.72**	0.46	0.00	-0.88	1.35
18	72(CI-5xCI-9)	-0.92	-1.81**	1.40*	-0.45	-0.44	0.90
19	75(CI-5xCI-9)	1.38*	0.45	3.75**	3.56**	2.64**	4.95**
20	82(CI-5xCI-9)	0.46	-0.45	2.81**	2.23**	0.44	2.70**
21	116(CI-5xCI-9)	-0.46	-1.36*	1.87**	0.00	-0.88	1.35
22	119(CI-5xCI-9)	-0.92	-1.81*	1.40*	-1.33	-2.20**	0.00
23	120(CI-5xCI-9)	0.46	-0.45	2.81**	-0.45	-0.04	0.90
24	122(CI-5xCI-9)	-1.84**	-2.72**	0.46	1.78*	-2.64**	-0.45
25	141(CI-5xCI-9)	3.22**	-2.27**	5.63**	2.67**	1.76*	4.05**
26	146(CI-5xCI-9)	0.46	-0.45	2.81**	2.23**	1.32	3.60**
27	147(CI-5xCI-9)	-1.84**	-2.72**	0.46	-0.45	-1.32	0.90
28	149(CI-5xCI-9)	2.29**	1.36**	4.69**	2.23**	1.32	3.60**
29	151(CI-5xCI-9)	0.46	-0.45	2.81**	0.89	0.00	2.25**
30	158(CI-5xCI-9)	1.38*	-0.45	3.75**	1.78*	0.88	3.15**
31	163(CI-5xCI-9)	0.00	-0.90	2.34**	1.78*	0.88	3.15**
32	165(CI-5xCI-9)	0.00	-0.90	2.34**	4.00**	3.08**	5.40**
33	172(CI-5xCI-9)	0.00	-0.90	2.34**	1.34	0.44	2.70**
	CD at 5 per cent		1.31			1.41	
	CD at 1 per cent		1.73			1.86	

*, ** Significant at 5 and 1 per cent levels of probability respectively

[144 (CI-5 x CI-9) and -3.21 [12 (CI-5 x CI-9)] to 3.22 [14 (CI-5 x CI-9)], respectively.

Out of 33 crosses in each set, only in set III, 6 crosses showed significantly negative heterosis over commercial check. 27 crosses in set I, 22 crosses in set II and 8 crosses in set III showed significant positive heterosis over commercial check.

The percentage heterosis in 3 sets over best check [CI-5 x CI-9)] value ranged from 1.91 [80 (CI-5 x CI-9); 101 (CI-5 x CI-9)] to 6.70 [71 (CI-5 x CI-9), 83 (CI-5 x CI-9)], -0.93 [121 (CI-5 x CI-9); 123 (CI-5 x CI-9)] to 3.70 [144 (CI-5 x CI-9)] and -0.93 [12 (CI-5 x CI-9)] to 5.63 [141 (CI-5 x CI-9)], respectively. None of the crosses showed significant negative heterosis over best check. All the 33 crosses of set I, 22 crosses of set II and 27 crosses of set III showed significant and positive heterosis over best check.

4.3.2 Days to 50 per cent silking

The extent of per cent heterosis over commercial check (Deccan-103) and the best check [CI-5 x CI-9)] in set I and set III varied from;

-0.45 [101 (CI-5 x CI-9)] to 5.91 [71 (CI-5 x CI-9); 76 (CI-5 x CI-9)], -3.12 [12 C(CI-5 x CI-9)] to 4.0 [165 (CI-5 x CI-9)] and 1.48 [74 (CI-5 x CI-9)] to 8.88 [71 (CI-5 x CI-9); 76 (CI-5 x CI-9)], -1.80 [12 (CI-5 x CI-9)] to 5.40 [165 (CI-5 x CI-9)] respectively. In case of set II, where commercial check and best check were equal, the per cent heterosis varied from -0.89 [121 (CI-5 x CI-9)] to 4.48 [129 (CI-5 x CI-9); 130 (CI-5 x CI-9); 131 (CI-5 x CI-9); 152 (CI-5 x CI-9)].

In set III, out of 33 crosses, two crosses and one cross showed significant heterosis in negative direction over commercial check and best check respectively. However, in set I and set III, 22 and 11 crosses; 32 and 19 crosses showed significant heterosis in positive direction over commercial check and over best check, respectively. In case of set II, 20 crosses showed significant positive heterosis over the commercial and best checks which were equal.

4.3.3 Plant height

The extent of per cent heterosis over commercial check in the three sets varied from

-1.34 [96 (CI-5 x CI-9)] to 18.05 [117 (CI-5 x CI-9)], -47.9 [169 (CI-5 x CI-9)] to 2.89 [166 (CI-5 x CI-9)] and -15.74 [149 (CI-5 x CI-9)] to 9.10 [165 (CI-5 x CI-9)] respectively. The best check CI-4 x CI-5 in set I, Deccan-103 in set II, and CI-5 x CI-9 in set III were observed for this trait. The extent of per cent heterosis over best check in the three sets varied from:

-15.45 [96 (CI-5 x CI-9)] to 1.16 [117 (CI-5 x CI-9)], -47.9 [169 (CI-5 x CI-9) to 2.89 [166 (CI-5 x CI-9)] and -16.70 [149 (CI-5 x CI-9)] to 7.75 [165 (CI-5 x CI-9)] respectively.

Out of the 33 crosses in set I and set III, none of the crosses showed significant heterosis over commercial and best check, either in negative or positive direction. In case of set II, one cross out of 33 crosses showed significant negative heterosis over Deccan-103 (commercial and best check).

Table 4a. Cont'd...

Sl.No.	Entries	Plant height (cm)			Ear height (cm)		
		Deccan-103	CI-4 x CI-5	CI-5 x CI-9	Deccan-103	CI-4 x CI-5	CI-5 x CI-9
		1	2	3	1	2	3
			3			4	
1	55(CI-5xCI-9)	9.36	-6.30	-6.24	-4.17	-2.63	0.92
2	56(CI-5xCI-9)	6.62	-8.64	-8.60	-3.79	-2.25	1.32
3	58(CI-5xCI-9)	12.18	-3.87	-3.82	-4.42	-2.89	0.66
4	60(CI-5xCI-9)	6.95	-8.35	-8.31	-10.86	-9.43	-6.13
5	63(CI-5xCI-9)	15.01	-1.45	-1.40	4.77	6.45	10.33
6	66(CI-5xCI-9)	5.76	-9.37	-9.33	-0.20	1.40	5.10
7	70(CI-5xCI-9)	11.14	-4.78	-4.71	2.53	4.18	8.00
8	71(CI-5xCI-9)	10.85	-5.01	-5.00	3.16	4.81	8.64
9	73(CI-5xCI-9)	8.20	-7.28	-7.24	-9.51	-8.06	-4.71
10	74(CI-5xCI-9)	14.94	-1.51	-1.46	-3.92	-2.38	1.18
11	76(CI-5xCI-9)	5.65	-9.47	-9.43	-5.54	-4.03	-0.52
12	77(CI-5xCI-9)	7.64	-7.76	-7.71	-3.03	-1.47	2.12
13	78(CI-5xCI-9)	9.06	-6.54	-6.50	0.55	-2.19	5.88
14	80(CI-5xCI-9)	9.74	-5.96	-5.92	-4.27	-2.73	0.82
15	81(CI-5xCI-9)	6.48	-8.76	-8.71	-13.49	-12.10	-8.84
16	83(CI-5xCI-9)	7.80	-7.62	-7.57	-6.16	-4.65	-1.17
17	88(CI-5xCI-9)	6.54	-8.70	-8.66	-8.89	-7.43	-4.04
18	89(CI-5xCI-9)	2.26	-12.37	-12.33	-7.62	-6.13	-2.71
19	90(CI-5xCI-9)	10.03	-5.71	-5.67	-4.29	-2.75	0.79
20	91(CI-5xCI-9)	8.05	-7.41	-7.36	-3.79	-2.25	1.32
21	95(CI-5xCI-9)	-0.12	-14.41	-14.37	-6.16	-4.65	-1.17
22	96(CI-5xCI-9)	-1.34	-15.45	-15.41	-10.74	-9.31	-6.00
23	98(CI-5xCI-9)	15.60	-0.94	-0.89	0.05	1.65	5.36
24	99(CI-5xCI-9)	16.34	-0.30	-0.25	7.13	8.85	12.82
25	101(CI-5xCI-9)	13.52	-2.72	-2.68	-3.03	-1.47	2.12
26	102(CI-5xCI-9)	15.30	-1.19	-1.15	3.89	-5.56	9.41
27	103(CI-5xCI-9)	11.29	-4.63	-4.59	1.17	-2.79	6.55
28	105(CI-5xCI-9)	15.60	-0.94	-0.89	-1.57	0.01	3.66
29	110(CI-5xCI-9)	0.67	-13.73	-13.69	6.14	7.84	11.78
30	111(CI-5xCI-9)	5.99	-9.18	-9.14	-17.95*	-16.63*	-13.60
31	112(CI-5xCI-9)	10.85	-5.01	-5.00	-17.95*	-17.01*	-13.98
32	117(CI-5xCI-9)	18.05	1.16	-1.21	27.36**	29.40**	34.12**
33	118(CI-5xCI-9)	16.79	-0.08	0.13	11.97	13.76	17.91*
	CD at 5 per cent		22.93			16.23	
	CD at 1 per cent		30.37			21.50	

*, ** Significant at 5 per cent and 1 per cent levels of probability respectively

Table 4b. Cont'd...

Sl.No.	Entries	Plant height (cm)			Ear height (cm)		
		Deccan-103	CI-4 x CI-5	CI-5 x CI-9	Deccan-103	CI-4 x CI-5	CI-5 x CI-9
		1	2	3	1	2	3
			3			4	
1	121(CI-5xCI-9)	-9.20	-0.61	4.09	5.05	12.46	2.75
2	123(CI-5xCI-9)	-17.12	-9.27	-12.44	-5.09	2.66	-6.20
3	125(CI-5xCI-9)	-7.86	0.87	-2.66	2.61	9.84	0.36
4	126(CI-5xCI-9)	-13.92	-5.76	-9.06	-9.66	-3.30	-11.64
5	127(CI-5xCI-9)	-16.09	-5.60	-8.90	-6.72	-0.15	-8.77
6	128(CI-5xCI-9)	-12.53	-8.14	-11.35	-0.99	5.98	-3.17
7	129(CI-5xCI-9)	-1.28	-4.24	-7.59	-2.48	4.38	-4.63
8	130(CI-5xCI-9)	-1.47	8.07	4.29	17.52*	25.80**	14.94*
9	131(CI-5xCI-9)	-5.71	7.87	4.09	4.10	11.44	1.82
10	132(CI-5xCI-9)	-4.60	3.23	0.38	-9.68	-3.32	-11.66
11	133(CI-5xCI-9)	-1.92	4.43	0.78	4.13	11.47	1.85
12	134(CI-5xCI-9)	-2.88	7.38	3.61	-10.86	-4.59	-12.82
13	135(CI-5xCI-9)	-11.68	6.32	2.60	4.60	11.97	2.30
14	136(CI-5xCI-9)	-6.56	-3.31	-6.69	4.21	2.53	-6.31
15	137(CI-5xCI-9)	-8.94	2.30	1.28	3.05	10.31	0.79
16	138(CI-5xCI-9)	-7.67	-0.32	-3.81	-7.32	-0.80	-9.36
17	139(CI-5xCI-9)	-7.67	-1.08	-2.46	-4.83	1.86	-6.93
18	140(CI-5xCI-9)	-9.64	-1.08	-4.54	-6.54	0.03	-8.60
19	144(CI-5xCI-9)	1.77	-11.43	7.53	7.20	14.76*	4.85
20	148(CI-5xCI-9)	-11.48	-3.10	-6.49	-13.65*	-7.57	-15.55*
21	150(CI-5xCI-9)	-12.17	-3.85	-7.22	-8.08	-1.62	-10.11
22	152(CI-5xCI-9)	-15.29	-7.26	-10.51	-10.91	-4.64	-12.87
23	153(CI-5xCI-9)	-0.43	9.01	5.19	7.83	15.43*	5.46
24	154(CI-5xCI-9)	-9.10	-0.54	-4.02	-5.96	0.66	-8.03
25	164(CI-5xCI-9)	-0.43	9.01	5.19	12.28	20.19**	9.82
26	166(CI-5xCI-9)	2.89	12.65	8.71	17.76*	26.06**	15.18*
27	167(CI-5xCI-9)	-1.58	7.75	3.98	-0.31	6.70	-2.51
28	168(CI-5xCI-9)	-3.00	6.19	2.47	5.24	12.65	2.93
29	169(CI-5xCI-9)	-47.90**	-43.04**	-45.30**	2.64	9.87	0.39
30	170(CI-5xCI-9)	-3.88	5.23	1.55	6.16	13.64	3.83
31	171(CI-5xCI-9)	-23.51	-16.26	-1.92	-15.98*	-10.06	-17.83*
32	173(CI-5xCI-9)	-12.35	-4.05	-7.40	8.37	-1.93	-10.39
33	174(CI-5xCI-9)	-2.76	6.46	2.73	-0.49	6.51	-2.68
	CD at 5 per cent		23.88			13.56	
	CD at 1 per cent		31.63			17.96	

*, ** Significant at 5 and 1 per cent levels of probability respectively

Table 4c. Cont'd...

Sl.No.	Entries	Plant height (cm)			Ear height (cm)		
		Deccan-103 I	CI-4 x CI-5 2	CI-5 x CI-9 3	Deccan-103 1	CI-4 x CI-5 2	CI-5 x CI-9 3
		3			4		
1	2(CI-5xCI-9)	0.63	0.77	-0.62	-6.59	-5.44	-0.42
2	6(CI-5xCI-9)	-3.90	-3.75	-5.00	-7.84	-6.71	-1.53
3	10(CI-5xCI-9)	0.53	0.67	-0.71	-4.70	-3.54	1.57
4	12(CI-5xCI-9)	-9.60	-9.51	-10.70	-10.00	-8.94	-4.11
5	20(CI-5xCI-9)	-8.62	8.49	-9.75	-9.80	-8.70	-3.85
6	28(CI-5xCI-9)	3.78	-3.92	2.48	0.60	1.82	7.23
7	34(CI-5xCI-9)	5.29	5.44	3.99	1.55	2.79	8.24
8	38(CI-5xCI-9)	-1.10	-1.04	-2.41	-6.18	-5.03	0.00
9	40(CI-5xCI-9)	0.56	0.91	-0.48	-1.75	0.54	4.73
10	41(CI-5xCI-9)	-4.10	-4.78	-6.09	-6.98	-5.86	-0.85
11	45(CI-5xCI-9)	-0.85	-0.69	-2.00	-12.20	-11.10	-6.45
12	51(CI-5xCI-9)	-6.34	-6.24	-7.55	-5.90	-4.76	0.28
13	53(CI-5xCI-9)	-1.62	-1.48	-2.83	-8.34	-7.21	-2.29
14	61(CI-5xCI-9)	-0.07	0.07	-1.31	-5.91	-4.76	0.28
15	65(CI-5xCI-9)	5.18	5.33	3.88	2.02	3.26	8.79
16	67(CI-5xCI-9)	-3.37	-3.22	-4.57	24.20**	25.70**	32.37**
17	69(CI-5xCI-9)	-7.65	-7.50	-8.79	-7.26	-6.12	-1.14
18	72(CI-5xCI-9)	0.72	0.85	-0.53	-2.28	-1.08	4.16
19	75(CI-5xCI-9)	5.33	5.48	4.01	9.80	11.10	7.00
20	82(CI-5xCI-9)	-11.00	-10.80	-12.10	1.35	2.57	8.02
21	116(CI-5xCI-9)	5.60	5.77	4.29	10.00	11.42	17.30
22	119(CI-5xCI-9)	3.49	3.64	2.21	2.81	4.07	9.60
23	120(CI-5xCI-9)	1.70	1.84	0.43	-0.64	0.56	5.90
24	122(CI-5xCI-9)	-1.82	1.97	0.55	2.28	3.52	9.02
25	141(CI-5xCI-9)	-1.82	-1.69	-3.04	-9.40	8.30	-3.43
26	146(CI-5xCI-9)	-6.24	6.40	4.92	4.97	6.24	11.80
27	147(CI-5xCI-9)	-11.56	-11.40	-12.60	-20.20*	-19.20*	-14.90
28	149(CI-5xCI-9)	-15.74	-15.60	-16.70	-21.53**	-20.50*	-16.30
29	151(CI-5xCI-9)	-12.73	-12.50	-13.80	-20.54*	19.50*	-15.30
30	158(CI-5xCI-9)	7.42	7.57	6.09	0.13	20.40*	6.72
31	163(CI-5xCI-9)	2.59	2.73	1.31	0.56	1.79	7.19
32	165(CI-5xCI-9)	9.10	9.27	7.75	3.77	5.02	10.60
33	172(CI-5xCI-9)	-2.49	-2.34	-3.70	-4.18	-3.00	2.14
	CD at 5 per cent		20.59			15.76	
	CD at I per cent		27.27			20.87	

*, ** Significant at 5 and 1 per cent levels of probability respectively

4.3.4 Ear height

The extent of per cent heterosis in case of set I and set III, where the commercial check and best check were one and same (Deccan-103) varied from: -17.95 [111 (CI-5 x CI-9):112 (CI-5 x CI-9)] to 27.36 [117 (CI-5 x CI-9)] and -21.53 [149 (CI-5 x CI-9)] to 24.20 [67 (CI-5 x CI-9) respectively. In set II, the range of per cent heterosis over commercial check (Deccan-103) and the best check (CI-5 x CI-9) was -15.98 [171 (CI-5 x CI-9) to 17.76[166 (CI-5 x CI-9)] and -17.83 [171 (CI-5 x CI-9)] to 15.18 [166 (CI-5 x CI-9)] respectively.

Out of 33 crosses, 2 crosses in set I and 3 crosses in set III showed significant heterosis over Deccan-103 (commercial as well as best check) in negative direction, and one cross in each set showed significantly positive heterosis over Deccan-103.

In case of set II, out of 33 crosses two crosses showed significant negative as well as positive heterosis over commercial check (Deccan-103) and best check (CI-5 x CI-9) respectively.

4.3.5 Ear length

In all the 3 sets Deccan-103 was both commercial and best check. Thus the extent of per cent heterosis varied from
-15.55 [78 (CI-5 x CI-9)] to 6.20 [118 (CI-5 x CI-9)], -11.89 [127 (CI-5 x CI-9)] to 6.35 [130 (CI-5 x CI-9)] and -20.60 [51 (CI-5 x CI-9)] to 14.35 [158 (CI-5 x CI-9)] respectively.

Table 4a. Cont'd...

Sl.No.	Entries	Ear length (cm)			Ear diameter (cm)		
		Deccan-103	CI-4 x CI-5	CI-5 x CI-9	Deccan-103	CI-4 x CI-5	CI-5 x CI-9
		1	2	3	1	2	3
		5			6		
1	55(CI-5xCI-9)	-4.04**	-1.61**	2.88**	-0.59	-3.42**	1.50**
2	56(CI-5xCI-9)	-14.28**	-12.11**	-8.09**	3.15**	0.21	5.31**
3	58(CI-5xCI-9)	-9.64**	-7.36**	-3.13**	1.68**	-1.21**	3.81**
4	60(CI-5xCI-9)	-12.48**	-10.27**	-6.17**	0.15	-2.70**	2.24**
5	63(CI-5xCI-9)	-2.98**	-0.54	4.01**	1.46**	-1.42**	3.59**
6	66(CI-5xCI-9)	-1.12	1.38	6.01**	2.20**	-0.71	4.34**
7	70(CI-5xCI-9)	-12.41**	-10.19**	6.09**	3.16**	-1.78**	3.22**
8	71(CI-5xCI-9)	-3.59**	-1.15	3.37**	2.20**	-0.71	4.34**
9	73(CI-5xCI-9)	-12.03**	-9.81**	6.90**	0.37	-2.49**	2.47**
10	74(CI-5xCI-9)	-3.44**	-1.00	3.53**	2.34**	-0.57	4.49**
11	76(CI-5xCI-9)	-14.42**	-12.26**	-8.25**	-0.22	-3.06**	1.87**
12	77(CI-5xCI-9)	-7.92**	-5.59**	-1.28	-0.88*	-3.70**	1.20**
13	78(CI-5xCI-9)	-15.55**	-13.41**	-9.55**	-1.10**	-3.91**	0.97
14	80(CI-5xCI-9)	-8.82**	-6.51**	-2.24**	-3.15**	-5.91**	-1.12**
15	81(CI-5xCI-9)	-14.05**	-11.88**	-7.85**	-4.03**	-6.76**	-2.02**
16	83(CI-5xCI-9)	-14.05**	11.88**	-7.85**	0.73	-2.14**	2.84**
17	88(CI-5xCI-9)	-8.30**	-5.98**	-1.68*	3.08**	0.14	5.24**
18	89(CI-5xCI-9)	-10.31**	-8.05**	-3.85**	-1.98**	-4.77**	0.07
19	90(CI-5xCI-9)	-0.82	1.69*	6.33**	-1.83**	-4.63**	0.22
20	91(CI-5xCI-9)	-5.68**	-3.30**	1.12	1.77**	-1.71**	3.29
21	95(CI-5xCI-9)	-6.20**	-3.83**	0.56	-0.59	-3.42**	1.50**
22	96(CI-5xCI-9)	-13.68**	-11.49**	-7.45**	3.00**	0.07	5.16**
23	98(CI-5xCI-9)	1.27	-3.83**	8.57**	3.44**	0.50	5.61**
24	99(CI-5xCI-9)	0.30	2.84**	7.53**	7.11**	4.06**	9.35**
25	101(CI-5xCI-9)	-3.21**	-0.77	3.77**	2.93**	0.00	5.09**
26	102(CI-5xCI-9)	1.49	4.06**	8.81**	3.66**	0.71	5.81**
27	103(CI-5xCI-9)	-4.86**	-2.45**	2.00*	1.10**	-1.78**	3.22**
28	105(CI-5xCI-9)	2.24**	0.23	4.81**	1.25**	-1.64**	3.37**
29	110(CI-5xCI-9)	-10.16**	-7.89**	-3.69**	2.20**	-0.71	4.34**
30	111(CI-5xCI-9)	-6.05**	3.68**	0.72	0.00	-2.85**	2.09**
31	112(CI-5xCI-9)	-3.74**	-1.30	3.21**	-4.62**	-7.33**	-2.62**
32	117(CI-5xCI-9)	2.39**	4.98**	9.78**	4.18**	1.21**	6.36**
33	118(CI-5xCI-9)	6.20**	9.35**	14.34**	4.54**	1.57**	6.73**
	CD at 5 per cent		1.51			0.78	
	CD at 1 per cent		2.00			1.03	

*, ** Significant at 5 per cent and 1 per cent levels of probability respectively

Table 4b. Cont'd...

Sl.No.	Entries	Ear length (cm)			Ear diameter (cm)		
		Deccan-103	CI-4 x CI-5	CI-5 x CI-9	Deccan-103	CI-4 x CI-5	CI-5 x CI-9
		1	2	3	1	2	3
			5			6	
1	121(CI-5xCI-9)	-2.77**	10.82**	3.26**	0.14	3.89**	1.09
2	123(CI-5xCI-9)	-5.83**	7.32**	0.00	-0.93	2.77**	0.00
3	125(CI-5xCI-9)	-4.52**	8.82**	1.40	0.57	3.14**	0.36
4	126(CI-5xCI-9)	-8.17**	4.66**	2.48**	0.79	2.91**	0.15
5	127(CI-5xCI-9)	-11.89**	0.42	-6.43**	-3.09**	0.52	-2.18**
6	128(CI-5xCI-9)	-16.42**	-4.74**	-11.24**	-23.80**	-21.00**	-23.13**
7	129(CI-5xCI-9)	-8.54**	4.24**	-2.87**	0.29	4.04**	1.24
8	130(CI-5xCI-9)	6.35**	21.21**	12.95**	-4.53**	-0.92	-3.64**
9	131(CI-5xCI-9)	-6.20**	6.91**	-0.39	-3.81**	-0.22	-2.91**
10	132(CI-5xCI-9)	-1.45	12.31**	4.65**	-0.93	2.77**	0.00
11	133(CI-5xCI-9)	-9.48**	3.16**	-3.88**	-6.84**	3.36**	-5.96**
12	134(CI-5xCI-9)	-2.91**	10.65**	3.40**	-6.34**	-2.84**	-5.45**
13	135(CI-5xCI-9)	-10.07**	2.50**	-4.50**	-1.08	2.62**	-0.15
14	136(CI-5xCI-9)	-10.43**	2.08*	-4.88**	-4.53**	-0.97	-3.64**
15	137(CI-5xCI-9)	-1.24	12.56**	4.88**	-2.95**	0.67	-2.04**
16	138(CI-5xCI-9)	-10.72**	1.75	-5.19**	-6.91**	-3.44**	-6.04**
17	139(CI-5xCI-9)	-1.24	12.56**	4.88**	-7.99**	-4.56**	-7.13**
18	140(CI-5xCI-9)	-2.77**	10.82**	3.26**	-2.73**	0.96	-1.82**
19	144(CI-5xCI-9)	-8.39**	4.41**	-2.71**	3.17**	7.03**	4.15**
20	148(CI-5xCI-9)	-5.10**	8.18**	0.78	-2.23**	1.42*	-1.31
21	150(CI-5xCI-9)	-9.63**	3.00**	-4.03**	-5.25**	-1.72*	-4.36**
22	152(CI-5xCI-9)	-10.58**	1.91*	-5.04**	-5.47**	-1.94**	-4.58**
23	153(CI-5xCI-9)	-9.12**	3.58**	-3.49**	0.28	4.04**	1.24
24	154(CI-5xCI-9)	-10.94**	1.50	-5.43**	-4.75**	-1.20	-3.85**
25	164(CI-5xCI-9)	0.72	14.81**	6.98**	5.18**	9.12**	6.18**
26	166(CI-5xCI-9)	1.45	15.64**	7.75**	2.52**	6.35**	3.49**
27	167(CI-5xCI-9)	3.64**	18.14**	10.08**	0.54	4.26**	1.45*
28	168(CI-5xCI-9)	-3.43**	10.07**	2.56**	-4.03**	-0.45	-3.13**
29	169(CI-5xCI-9)	-1.00	13.14**	5.43**	-6.34**	-2.84**	-5.45**
30	170(CI-5xCI-9)	0.00	13.98**	6.20**	-7.63**	-4.19**	-6.76**
31	171(CI-5xCI-9)	-1.09	12.73**	5.04**	-2.73**	0.90	-1.82**
32	173(CI-5xCI-9)	-8.54**	4.16**	-2.95**	-4.89**	-1.35*	-4.00**
33	174(CI-5xCI-9)	-0.14	13.81**	6.05**	0.00	3.74**	0.95
	CD at 5 per cent		1.76			1.31	
	CD at 1 per cent		2.34			1.73	

*, ** Significant at 5 and 1 per cent levels of probability respectively

Table 4c. Cont'd...

Sl.No.	Entries	Ear length (cm)			Ear diameter (cm)		
		Deccan-103	CI-4 x CI-5	CI-5 x CI-9	Deccan-103	CI-4 x CI-5	CI-5 x CI-9
		1	2	3	1	2	3
		5			6		
1	2(CI-5xCI-9)	-10.84**	-3.63**	-7.15**	3.49**	1.82**	0.72
2	6(CI-5xCI-9)	0.81	5.41**	1.55**	3.86**	2.18**	1.08**
3	10(CI-5xCI-9)	0.81	9.04**	5.05**	-0.59	-2.18**	-3.24**
4	12(CI-5xCI-9)	-15.39**	-8.57**	-11.90**	2.30**	0.94*	-0.14
5	20(CI-5xCI-9)	6.96**	0.56	-3.11**	-0.38	-1.98**	-3.00**
6	28(CI-5xCI-9)	3.74**	12.11**	8.00**	-0.75	-2.33**	-3.39**
7	34(CI-5xCI-9)	-3.37**	4.44**	0.62	-8.01**	-9.40**	-10.40**
8	38(CI-5xCI-9)	-0.22	7.83**	3.90**	1.27**	-0.36	-1.44**
9	40(CI-5xCI-9)	0.15	8.24**	4.20**	-1.70**	-3.28**	-4.33**
10	41(CI-5xCI-9)	-6.57**	0.96	-2.72**	-0.59	-2.18**	-3.24**
11	45(CI-5xCI-9)	-10.88**	-2.82**	-6.38**	4.75**	3.06**	1.04**
12	51(CI-5xCI-9)	-20.60**	-14.20**	-17.30**	-0.60	-2.18**	-3.24**
13	53(CI-5xCI-9)	-8.29**	-0.88	-4.66**	1.27**	-0.36	-1.44**
14	61(CI-5xCI-9)	-11.60**	4.52**	-8.00**	4.00**	2.33**	1.22**
15	65(CI-5xCI-9)	-4.34**	3.39**	-0.39	3.49**	1.82**	0.72
16	67(CI-5xCI-9)	-3.97**	3.79**	0.00	5.35**	3.64**	2.52**
17	69(CI-5xCI-9)	-11.44**	-4.29**	-7.78**	-0.59	-2.18**	-3.24**
18	72(CI-5xCI-9)	-7.33**	0.96	-3.50**	1.79**	0.14	-0.91*
19	75(CI-5xCI-9)	-4.19**	3.55**	-0.23	7.52**	5.83**	4.70**
20	82(CI-5xCI-9)	-12.18**	-5.00**	-0.77	2.53**	0.87*	-0.21
21	116(CI-5xCI-9)	2.25**	10.50**	6.50**	8.83*	7.08**	5.92**
22	119(CI-5xCI-9)	-2.09**	5.81**	1.95**	4.23**	2.55**	1.44**
23	120(CI-5xCI-9)	-9.95**	-2.66**	-6.22**	6.08**	4.37**	3.24**
24	122(CI-5xCI-9)	-4.86**	2.82**	-0.93	1.49**	-0.14	-1.22**
25	141(CI-5xCI-9)	-6.58**	0.96	-2.72**	5.86**	4.16**	3.00**
26	146(CI-5xCI-9)	5.75**	14.29**	10.11**	3.27**	1.60**	0.50
27	147(CI-5xCI-9)	-10.30**	-3.06**	-6.60**	6.45**	4.74**	3.61**
28	149(CI-5xCI-9)	8.22**	-8.07**	-11.40**	-1.70**	-3.28**	-4.33**
29	151(CI-5xCI-9)	-0.37	7.67**	-3.73**	-3.79**	-5.32**	-6.35**
30	158(CI-5xCI-9)	14.35**	23.50**	19.00**	8.46**	6.71**	5.55**
31	163(CI-5xCI-9)	-8.45**	-1.00	-4.66**	4.22**	2.55**	1.44**
32	165(CI-5xCI-9)	-7.70**	0.24	-3.90**	7.19**	5.48**	4.33**
33	172(CI-5xCI-9)	-4.85**	2.82**	-0.93	-0.97*	2.55**	-3.60**
	CD at 5 per cent		1.43			0.75	
	CD at 1 per cent		1.89			1.00	

*, ** Significant at 5 and 1 per cent levels of probability respectively

There were 26, 22 and 25 crosses showing significant negative heterosis over Deccan-103 respectively in all three sets, out of 33 crosses, two crosses in set I and set II and five crosses in set III showed significant heterosis in positive direction over the check (Deccan-103 both commercial and best check).

4.3.6 Ear diameter

The extent of per cent heterosis over commercial check in all the 3 sets, varied from;

-4.62 [112 (CI-5 x CI-9)] to 7.11 [99 (CI-5 x CI-9)] -23.8 [128 (CI-5 x CI-9)] to 5.18 [164 (CI-5 x CI-9)] and -8.01 [34 (CI-5 x CI-9)] to 8.83 [116 (CI-5 x CI-9)] respectively.

The best check in all the three sets were CI-4 x CI-5, Deccan-103 and CI-5 x CI-9 respectively. The percentage heterosis over the best check in the three sets were-

-7.33 [112 (CI-5 x CI-9)] to 4.06 [99 (CI-5 x CI-9)], -23.8 [128 (CI-5 x CI-9)] to 5.18 [164 (CI-5 x CI-9)] and -10.4 [34 (CI-5 x CI-9)] to 5.92 [116 (CI-5 x CI-9)] respectively. The number of crosses, in set II, which showed significant negative and positive heterosis over the check (Deccan-103, both commercial as well as best check) were 21 crosses and three crosses respectively. In set I and set III, the number of crosses which showed significantly negative heterosis over commercial check and best check were 7 crosses; 5 crosses and 20 crosses, 15 crosses respectively. There were 19 and 2 crosses (set I), 22 and 13 crosses (set III) showed significantly positive heterosis over commercial and best check respectively.

4.3.7 100 Grain weight

Deccan 103 was the commercial and best check in set I and set III. In this case the per cent heterosis varied from:

-30.77 [81 (CI-5 x CI-9)] to 11.54 [118 (CI-5 x CI-9)] and -22.40 [61 (CI-5 x CI-9)], 41 [(CI-5 x CI-9)] to 17.00 [116 (CI-5 x CI-9)] respectively.

In set II, the extent of per cent heterosis over commercial check (Deccan-103) and best check (CI-5 x CI-9) varied from-

-26.68 [139 (CI-5 x CI-9)] to 20.18 [166 (CI-5 x CI-9)] and -29.89 [139 (CI-5 x CI-9)] to 14.91 [166 (CI-5 x CI-9)], respectively.

Out of 33 crosses in set I and set III 25 crosses and 22 crosses showed significant heterosis over check (Deccan-103, both commercial as well as best check) in negative direction respectively. Whereas, in set II, 6 crosses and 17 crosses showed significant negative heterosis respectively over commercial and best check. In case of set I and set III 4 and 2 crosses showed significant positive heterosis over Deccan-103 respectively. And in case of set II, 11 crosses and three crosses showed significant heterosis in positive direction over commercial and best check respectively.

4.3.8 Grain yield per plot

In the three sets, extent of per cent heterosis over commercial and the best check (Deccan-103 in set I: CI-5 x CI-9 in set II; CI-4 x CI-5 in set III) varied from-36.14 [81 (CI-5 x CI-9) to 14.46 [118 (CI-5 x CI-9)] in set I where commercial and best check were one and same, -11.22 [150 (CI-5 x CI-9)] to 39.30

Table 4a. Cont'd...

Sl.No.	Entries	100 grain weight (gm)			Yield per plot (kg)		
		Deccan-103	CI-4 x CI-5	CI-5 x CI-9	Deccan-103	CI-4 x CI-5	CI-5 x CI-9
		1	2	3	1	2	3
		7			8		
1	55(CI-5xCI-9)	-9.67**	-8.74**	-6.00**	-2.11**	0.00	-0.91**
2	56(CI-5xCI-9)	-11.54**	-10.68**	-8.00**	1.81**	4.00**	3.05**
3	58(CI-5xCI-9)	-15.38**	-14.56**	-12.00**	-8.13**	-6.15**	-7.01**
4	60(CI-5xCI-9)	-5.77**	-4.85**	-2.00	-17.17**	-15.38**	-16.16
5	63(CI-5xCI-9)	-5.77**	-4.85**	-2.00	-0.60	1.54**	0.61*
6	66(CI-5xCI-9)	-21.15**	-20.39**	-18.00**	5.42**	7.69**	6.71**
7	70(CI-5xCI-9)	-4.81**	-3.88*	-1.00	5.42**	7.69**	6.70**
8	71(CI-5xCI-9)	-1.92	-0.97	-2.00	-7.53**	-5.54**	-6.40**
9	73(CI-5xCI-9)	-12.50**	-11.65**	-9.00**	-17.17**	-15.38**	-16.16**
10	74(CI-5xCI-9)	-9.62**	-8.73**	-6.00**	-17.17**	-15.38**	-16.16**
11	76(CI-5xCI-9)	-19.63**	-18.45**	-16.00**	-21.08**	-19.38**	-20.12**
12	77(CI-5xCI-9)	-13.46**	-12.67**	-10.00**	0.30	2.46**	1.52**
13	78(CI-5xCI-9)	-5.77**	-4.85**	-2.00	-7.23**	-5.23**	-6.10**
14	80(CI-5xCI-9)	-50.19**	-19.42**	-7.00**	-17.77**	-16.00**	-16.77**
15	81(CI-5xCI-9)	-30.77**	-13.07**	-28.00**	-36.14**	-34.77**	-35.37**
16	83(CI-5xCI-9)	-12.50**	-11.65**	-9.00**	-8.73**	-6.77**	-7.62**
17	88(CI-5xCI-9)	-8.65**	-7.77**	-5.00**	-21.69**	-20.00**	-20.73**
18	89(CI-5xCI-9)	-17.00**	-16.19**	-13.68**	-16.27**	-14.46**	-15.24**
19	90(CI-5xCI-9)	-9.62**	-8.74**	-6.00**	-15.66**	-13.85**	-14.63**
20	91(CI-5xCI-9)	-18.27**	-17.48**	-15.00**	2.41**	4.62**	3.66**
21	95(CI-5xCI-9)	-18.27**	-17.48**	15.00**	-15.66**	-13.85**	-14.63**
22	96(CI-5xCI-9)	-6.73**	-3.88*	-1.00	-17.17**	15.38**	-16.16**
23	98(CI-5xCI-9)	0.00	0.97	4.00*	4.82**	7.08**	6.10**
24	99(CI-5xCI-9)	8.65**	9.71**	13.00**	10.54**	12.92**	11.87**
25	101(CI-5xCI-9)	-5.77**	-4.85**	-2.00	3.01**	5.23**	4.27**
26	102(CI-5xCI-9)	1.92	2.91	6.00**	5.42**	7.69**	6.71**
27	103(CI-5xCI-9)	-10.58**	-9.71**	-7.00**	-6.63**	-4.62**	-5.49**
28	105(CI-5xCI-9)	-6.73**	-5.23**	-3.00	0.30	2.46**	1.52**
29	110(CI-5xCI-9)	-7.69**	-6.79**	-4.00*	-11.14**	-9.23**	-10.06**
30	111(CI-5xCI-9)	-16.35**	-15.53**	-13.00**	-21.08**	-19.38**	-20.12**
31	112(CI-5xCI-9)	-20.19**	-19.42**	-17.00**	-18.67**	-16.92**	-17.68**
32	117(CI-5xCI-9)	-1.92	-0.97	2.00	9.94**	12.31**	11.28**
33	118(CI-5xCI-9)	11.54**	12.62**	16.00**	14.46**	16.92**	15.85**
	CD at 5 per cent		3.47			0.60	
	CD at 1 per cent		4.59			0.80	

*, ** Significant at 5 per cent and 1 per cent levels of probability respectively

Table 4b. Cont'd...

Sl.No.	Entries	100 grain weight (gm)			Yield per plot (kg)		
		Deccan-103	CI-4 x CI-5	CI-5 x CI-9	Deccan-103	CI-4 x CI-5	CI-5 x CI-9
		1	2	3	1	2	3
		7			8		
1	121(CI-5xCI-9)	4.58*	16.33**	0.00	10.52**	7.88**	-5.97**
2	123(CI-5xCI-9)	-1.83	9.18**	6.14**	0.00	2.40**	-14.93**
3	125(CI-5xCI-9)	0.91	12.24**	-3.51	14.03**	11.30**	-2.99**
4	126(CI-5xCI-9)	0.00	11.22**	-4.39*	7.01**	4.45**	-8.96**
5	127(CI-5xCI-9)	0.00	11.22**	-4.38*	-3.50**	-5.82**	-17.91**
6	128(CI-5xCI-9)	2.75	14.29**	-1.75	-3.50**	-5.82**	-17.91**
7	129(CI-5xCI-9)	-1.83	9.18**	-6.14**	1.05**	-1.37**	-14.02**
8	130(CI-5xCI-9)	9.17*	21.43**	4.39*	28.07**	25.00**	8.95**
9	131(CI-5xCI-9)	-12.84**	-3.06	-16.67**	15.08**	12.33**	-2.09**
10	132(CI-5xCI-9)	0.00	11.22**	-4.39*	7.01**	4.45**	-8.96**
11	133(CI-5xCI-9)	0.91	10.20**	-5.26*	3.50**	1.03**	-11.94**
12	134(CI-5xCI-9)	3.66	15.30**	-0.89	-7.01**	-9.25**	-20.90**
13	135(CI-5xCI-9)	-9.17**	1.02	-13.16**	16.49**	13.70**	-0.90**
14	136(CI-5xCI-9)	0.91	12.24**	-3.51	11.20**	8.56**	-5.37**
15	137(CI-5xCI-9)	0.00	11.22**	-4.39*	3.50**	1.03**	-11.94**
16	138(CI-5xCI-9)	2.75	14.29**	-1.75	4.56**	2.05**	-18.04**
17	139(CI-5xCI-9)	-26.68**	-18.45**	-29.89**	5.26**	2.74**	-10.45**
18	140(CI-5xCI-9)	-5.50*	5.10*	-9.65**	0.00	-2.40**	-14.93**
19	144(CI-5xCI-9)	9.17**	21.43**	4.39*	17.54**	14.73**	0.00**
20	148(CI-5xCI-9)	-4.58*	6.12**	-8.77**	1.05**	-1.37**	-14.03**
21	150(CI-5xCI-9)	0.91	10.20**	-5.26*	-11.22**	-13.36**	-24.48**
22	152(CI-5xCI-9)	6.42**	18.37**	1.75	-8.07**	-10.27**	-21.79**
23	153(CI-5xCI-9)	8.25**	20.40**	3.51	17.54**	14.73**	0.00
24	154(CI-5xCI-9)	4.58*	16.33**	0.00	3.50**	1.03**	-11.94**
25	164(CI-5xCI-9)	7.33**	19.39**	2.63	22.80**	19.86**	4.48**
26	166(CI-5xCI-9)	20.18**	33.67**	14.91**	39.30**	35.96**	18.51**
27	167(CI-5xCI-9)	6.42**	18.37**	1.75	24.56**	21.58**	5.97**
28	168(CI-5xCI-9)	-6.42**	4.08	-10.93**	13.33**	10.67**	-3.58**
29	169(CI-5xCI-9)	-0.91	10.90**	-5.26*	12.28**	9.59**	-4.48**
30	170(CI-5xCI-9)	3.66	15.31**	-0.88	10.52**	7.88**	-5.97**
31	171(CI-5xCI-9)	-2.75	8.16**	-7.02**	-15.79**	-17.81**	-28.36**
32	173(CI-5xCI-9)	-0.91	10.20**	-5.26*	1.05**	-1.37**	-14.03**
33	174(CI-5xCI-9)	3.66	15.31**	-0.88	17.54**	14.73**	0.00
	CD at 5 per cent		4.32			0.65	
	CD at 1 per cent		5.72			0.87	

*, ** Significant at 5 and 1 per cent levels of probability respectively

Table 4c. Cont'd...

Sl.No.	Entries	100 grain weight (gm)			Yield per plot (kg)		
		Deccan-103	CI-4 x CI-5	CI-5 x CI-9	Deccan-103	CI-4 x CI-5	CI-5 x CI-9
		1	2	3	1	2	3
			7			8	
1	2(CI-5xCI-9)	-15.50**	-9.17**	-6.83*	-6.83**	-11.76**	-6.25**
2	6(CI-5xCI-9)	-10.00**	-3.33	-0.85	-16.14**	-20.50**	-15.60**
3	10(CI-5xCI-9)	-10.00**	-3.33	-0.85	-5.90**	-10.80**	-5.03**
4	12(CI-5xCI-9)	-12.40**	-5.83	-0.25	-3.73**	-8.8**	-3.12**
5	20(CI-5xCI-9)	-5.42	-1.67	21.30**	-13.67**	-18.20**	-13.12**
6	28(CI-5xCI-9)	-6.20**	0.83	3.41	-8.39**	-3.20**	-7.95**
7	34(CI-5xCI-9)	-13.95**	-7.50*	-5.12	-20.80**	-25.00**	-20.30**
8	38(CI-5xCI-9)	-9.30**	-2.50	0.00	-8.39**	-13.20**	-7.80**
9	40(CI-5xCI-9)	-21.70**	-15.83**	-13.60**	-8.39**	-13.23**	-7.80**
10	41(CI-5xCI-9)	-22.40**	16.66**	-14.50**	-21.40**	-25.50**	-20.90**
11	45(CI-5xCI-9)	-10.86**	-4.77	-1.70	-2.18**	-7.35**	-1.56**
12	51(CI-5xCI-9)	-3.10	4.17	6.83*	-2.18**	-7.35**	-1.56**
13	53(CI-5xCI-9)	-10.00**	-3.33	-0.85	-13.67**	- 1.30**	-13.10**
14	61(CI-5xCI-9)	-22.40**	16.67**	-14.50**	-13.04**	-17.60**	-12.50**
15	65(CI-5xCI-9)	-10.00**	-13.33**	-0.85	-3.72**	-8.82**	-3.17**
16	67(CI-5xCI-9)	2.32	5.00	7.60*	-3.10**	-8.23**	-2.50**
17	69(CI-5xCI-9)	-19.30**	-13.33**	-11.10**	-23.9**	-27.90**	-23.40**
18	72(CI-5xCI-9)	-9.30**	-2.50	0.00	-1.5**	-6.76**	-0.93**
19	75(CI-5xCI-9)	2.32	10.00**	12.80**	8.69**	2.94**	9.37**
20	82(CI-5xCI-9)	-16.20**	-10.00**	- 7.69*	13.66**	-18.20**	-13.10**
21	116(CI-5xCI-9)	17.00**	25.83**	29.00**	20.49**	-14.10**	21.20**
22	119(CI-5xCI-9)	-6.20*	0.83	-3.41	-1.55**	-6.76**	-0.93**
23	120(CI-5xCI-9)	-0.77	6.66*	9.40**	0.00	-5.29**	0.62
24	122(CI-5xCI-9)	-2.32	5.00	7.69*	-1.25**	-6.47**	-0.62
25	141(CI-5xCI-9)	-7.76*	0.83	1.70	5.59**	-8.82**	-3.12**
26	146(CI-5xCI-9)	8.52**	16.67**	19.60**	5.59**	0.00	6.25**
27	147(CI-5xCI-9)	-4.66	2.50	5.12	-16.14*	-20.50**	-15.60**
28	149(CI-5xCI-9)	-11.60**	-5.00	-2.60	-32.30**	-35.80**	-31.80**
29	151(CI-5xCI-9)	-10.80**	-4.17	-1.70	-19.88**	-24.10**	-19.30**
30	158(CI-5xCI-9)	-4.66	12.50**	15.30**	18.00**	11.80**	18.75**
31	163(CI-5xCI-9)	-13.17**	-6.67*	-4.27	4.97**	-0.58	2.50**
32	165(CI-5xCI-9)	3.10	10.80**	13.60**	7.76**	-2.05	11.50**
33	172(CI-5xCI-9)	-21.70**	-15.83**	-13.60**	-13.05**	-17.60	-12.50**
	CD at 5 per cent		6.10			0.69	
	CD at 1 per cent		8.09			0.92	

*, ** Significant at 5 and 1 per cent levels of probability respectively

[116 (CI-5 x CI-9)] in set II, -32.3 [149 (CI-5 x CI-9)] to 20.49 [116 (CI-5 x CI-9)] and -28.36 [171 (CI-5 x CI-9)] to 18.51 [166 (CI-5 x CI-9)] in set II, -35.80 [149 (CI-5 x CI-9)] to 14.10 [116 (CI-5 x CI-9)] in set III respectively.

There were 20 crosses in set I (Deccan-103, commercial as well as best check), 5 crosses in set II and 25 crosses in set III showed significantly negative heterosis over commercial check. There were 26 crosses in set II and 27 crosses in set III showed significantly negative heterosis over best check. The number of crosses which showed significant and positive heterosis over commercial check and best check were 10 crosses in set I (Deccan-103 commercial as well as best check), 26 crosses, 4 crosses in set II and 7 crosses, 4 crosses in set III respectively.

DISCUSSION

V DISCUSSION

The plant breeders aim in evolving genotypes that are more efficient and show substantial increase over the existing types in respect of yield and other economic characters. The success achieved in these efforts mainly depend upon the nature, magnitude and interrelationship of heritable variation. The degree of improvement depends on the beneficial and utilizable genetic variability. The determination of genetic variability and its partitioning into various components is essential to gain an insight into the genetic nature of yield and its components. This helps in formulating the strategy to be adopted to breed the superior genotypes. In this context several single, double and three-way cross hybrids, synthetics, composite varieties and varietal hybrids have been reported periodically as and when the hybrids have been released, their parental inbred lines have accumulated in the list. It is worth while to go back and see, what has happened to these parental inbred lines with regard to their genetic potentialities, since the yielding potential directly dependent on the true to type or genetic purity in maintenance of these inbred lines.

The development of inbred lines poses no problem and is quite a simple process. But, the evaluation of inbred lines is more complicated and poses more problems and the final worth of these lines can be judged only through their performance in hybrid combination. Correlation between quantitative characters of inbreds and hybrids is one of the approaches of evaluating inbred lines. The evaluation of lines by hybrid performance particularly for their combining ability is another important approach widely used by the maize breeders all over the world for screening inbred lines in the initial phase of hybrid programmes.

Shull's (1910) original concept was the production and growing of single cross hybrids. The single cross hybrids are very uniform genotypically and phenotypically and are also high yielding. The cost of seed production seemed to limit its usefulness. Thus these single crosses were replaced by double cross hybrids. Slightly more variable in plant and ear characters than single and three way crosses.

Jones (1958) states that the present trend in commercial seed corn industry of replacing double crosses with single cross is a step in the wrong direction on two counts. (1) It may loose some of the advantage of genetic homeostasis (2) it invites disastrous epidemic of new strains of disease to which all plants of a single cross being genetically identical might be susceptible. Three-way crosses are intermediate between single and double crosses. Seed of three-way crosses less expensive to produce than that of single crosses. But yield will be slightly less. According to Eberhart and Hallauer (1968), favorable epistatic combinations of genes in the inbred lines may be important in contributing to heterosis in the F_1 hybrids. If favourable epistatic combinations of genes became fixed in the inbred lines during the selection process, the opportunity for recombination would not be present in the production of single cross hybrids. On the other hand, because of recombination in the single crosses that would be used as parents in the production of three-way and double cross hybrids, the yields of the three way and double cross hybrids might be expected to be less than the single crosses. There are a number of short cut methods deviced in conventional plant breeding to evaluate the newly developed inbred lines. These are time consuming and expensive. One of the short cut method is the evaluation of lines through three way cross hybrid performance.

Large number of newly developed lines are crossed with an established single cross tester and then evaluate the three way hybrids. Based on the performance the superior three way hybrids, lines can be selected and used in further breeding programme. These superior three way hybrids can also be exploited for commercial cultivation.

Keeping this view, the present investigation was carried out to evaluate the 99 newly developed maize inbred lines through three way cross hybrid performance with CI-5 x CI-9 single cross as male parent (tester).This single cross was found to be quite high yielding which was studied in a diallel crossing programme at Arabhavi. The three checks for the experiment were CI-5 x CI-9 (tester) CI-4 x CI-5 (another high yielding single cross) and Deccan-103 (commercial check, a double cross hybrid).

5.1 Genetic variability and per se performance of hybrids

A knowledge of genetic variability is basic to improve any crop by adopting selection based on variation present in the population. The analysis of variance for the eight characters in all the three sets of the study revealed presence of highly significant variation among the genotypes except for cob diameter in set I and cob length in set II which is depicted in Table 2. The variation in cob length and cob diameter is less and they are more stable characters. Similar observations were made by Wright *et al.*, (1971) and Jha and Khehra (1992).

The range, mean, phenotypic, genotypic and environmental variance, phenotypic and genotypic coefficient of variation, broad sense heritability genetic advance over mean for eight character were studied (Table-3). The range values

reflect the extent of phenotypic variability for different characters. It also include genotypic, environmental and genotypic x environmental interaction components. Therefore, the estimation of genotypic, phenotypic and environmental components of variance is of primary importance. In order to get an idea of relative extent of heritable and non-heritable variations, components of variation and *per se* performance of hybrids have been discussed in following paragraphs.

From Table-3, for all three sets the maximum range of variation was exhibited for plant height which was followed by ear height and 100 grain weight. The variation for grain yield per plot was also noticed. The range of variation for days to 50 per cent tasselling and silking remained almost same. Very less variation was noticed for ear diameter and ear length.

The genotypic variance was least for grain yield per plot in all the three sets. Plant height exhibited high genotypic variance in set II and set III, low in set I, which was followed by the ear height and 100 grain weight. Environmental variance was also high for plant height 267.605, 290.42, 215.585 followed by ear height 134.042, 93.587, 126.30 and 100 grain weight 6.119, 9.512, 18.992 in all the three sets respectively. Days to silking was less affected by environment.

High values of phenotypic and genotypic coefficient of variation were obtained for grain yield per plot which followed by 100 grain weight, ear height, ear length and plant height. It indicated the presence of high variability for their characters. Low values of PCV and GCV were observed for days to 50 per cent silking and tasselling.

The heritability of days to 50 per cent tasselling and silking under all the 3 sets were comparatively higher and showed a range from 25.80 and 39.00 per cent and 30.70 to 34.50 per cent respectively. Grain yield per plot with a range of 19.80 to 34.30 per cent had moderate heritability values than other characters. High heritability value of 37.1 per cent for 100 grain weight in set I was observed as compared to 17.50 per cent in set II and 14.70 per cent in set III for this trait. Low to moderate values of heritability was observed for plant height, ear height, ear length and ear diameter. Moderate to high heritability indicated the greater role of additive genetic variance in the inheritance of these traits

These results are in conformity with Robinson *et al.*,(1949), Swamy Rao *et al.*,(1970), Patil *et al.*,(1972), Kelein (1975), Danaiel and Bajtay (1976), Bonaparte (1977), Hansel *et al.*,(1977), Dhillon and Singh (1977a), Radovic (1979), Ivanovic (1979), Rood and major (1980), Hassaballa *et al.*,(1980), Wessel - Beaver *et al.*,(1985), Johnson (1981), Bohm and Schuster (1985), El-Hosary (1987), Debnath (1988), Saadalls *et al.*,(1988), Mahmoud *et al.*,(1990), Reddy and Agrawal (1992), Odiemach (1992), Debnath and Azad (1993) and Alika (1994) Robin and Subramanian (1994).

Per se performance of 99 hybrids in all the three sets of the study discussed in the following paragraphs. The top five hybrids performance presented in the Table 5a, 5b and 5c.

Out of 33 hybrids studied in set I, the three-way hybrid 118 (CI-5 x CI-9) numerically produced the highest grain yield of 3.80 kg per plot, followed by

Table 5a. Hybrids with better performance in respect of yield and yield components in maize (Set I)

Characters		Top five performing hybrids	Mean performance of top five hybrids	
1	I	101 (CI-5xCI-9); 80 (CI-5xCI-9)	I	53.25
Days to	II	78 (CI-5xCI-9)	II	53.50
50 % ta-	III	56 (CI-5xCI-9); 60 (CI-5xCI-9); 89 (CI-5xCI-9)	III	53.75
asselling	IV	58 (CI-5xCI-9); 90 (CI-5xCI-9); 96 (CI-5xCI-9);112	IV	54.00
	V	66 (CI-5xCI-9); 77 (CI-5xCI-9); 91 (CI-5xCI-9); 95 (CI-5xCI-9)	V	54.25
2	I	101 (CI-5xCI-9)	I	54.50
Days to	II	105 (CI-5x CI-9)	II	55.25
50 %	III	88 (CI-5xCI-9)	III	55.50
silking	IV	55, 77, 89, 102, 112 (CI-5xCI-9)	IV	55.75
	V	66 (CI-5xCI-9)	V	56.00
3	I	117 (CI-5xCI-9)	I	198.62
Plant	II	118 (CI-5xCI-9)	II	196.50
height	III	99 (CI-5xCI-9)	III	195.75
(cm)	IV	98 (CI-5x CI-9); 105 (CI-5x CI-9)	IV	194.50
	V	102 (CI-5x CI-9)	V	194.00
4	I	117 (CI-5xCI-9)	I	128.25
Ear	II	118 (CI-5xCI-9)	II	112.75
height	III	99 (CI-5xCI-9)	III	107.88
(cm)	IV	110 (CI-5xCI-9)	IV	106.88
	V	63 (CI-5xCI-9)	V	105.50
5	I	118 (CI-5xCI-9)	I	**14.27**
Ear	II	117 (CI-5xCI-9)	II	**13.70**
length	III	102 (CI-5xCI-9)	III	**13.58**
(cm)	IV	98 (CI-5xCI-9)	IV	**13.55**
	V	99 (CI-5xCI-9)	V	13.42
6	I	99 (CI-5xCI-9)	I	14.62
Ear	II	118 (CI-5xCI-9)	II	14.27
diameter	III	117 (CI-5xCI-9)	III	14.22
(cm)	IV	102 (CI-5xCI-9)	IV	14.15
	V	98 (CI-5xCI-9)	V	14.22
7	I	118 (CI-5xCI-9)	I	29.00
100-grain	II	99 (CI-5xCI-9	II	28.25
weight	III	102 (CI-5xCI-9)	III	26.50
(gm)	IV	98 (CI-5xCI-9)	IV	26.00
	V	117 (CI-5xCI-9); 71 (CI-5xCI-9)	V	25.50
8	I	118 (CI-5xCI-9)	I	3.80
Grain	II	99 (CI-5xCI-9)	II	3.67
yield	III	117 (CI-5xCI-9)	III	3.65
kg/plot	IV	102 (CI-5xCI-9); 66 (CI-5xCI-9); 70 (CI-5xCI-9)	IV	3.55
	V	98 (CI-5xCI-9)	V	3.48

Table 5b. Hybrids with better performance in respect of yield and yield components in maize (Set II)

Characters		Top five performing hybrids	Mean performance of top five hybrids	
1	I	121 (CI-5xCI-9); 123 (CI-5xCI-9); 138 (CI-5xCI-9)	I	53.50
Days to	II	132 (CI-5xCI-9); 136 (CI-5xCI-9)	II	54.00
50 % ta-	III	173 (CI-5xCI-9)	III	54.25
asselling	IV	148, 164, 170, 171, 174 (CI-5xCI-9)	IV	54.50
	V	133 (CI-5xCI-9); 168 (CI-5xCI-9)	V	54.75
2	I	121 (CI-5xCI-9)	I	55.25
Days to	II	123 (CI-5xCI-9); 138 (CI-5xCI-9)	II	55.75
50 %	III	132 (CI-5xCI-9); 135 (CI-5xCI-9); 170 (CI-5xCI-9)	III	56.00
silking	IV	133 (CI-5xCI-9); 136 (CI-5xCI-9)	IV	56.25
	V	126 (CI-5xCI-9); 153, 164, 166, 174, (CI-5xCI-9)	V	56.50
3	I	166 (CI-5xCI-9)	I	209.40
Plant	II	144 (CI-5xCI-9)	II	207.12
height	III	153 (CI-5xCI-9); 164 (CI-5xCI-9)	III	202.62
(cm)	IV	130 (CI-5xCI-9)	IV	200.88
	V	131 (CI-5xCI-9)	V	200.50
4	I	166 (CI-5xCI-9)	I	118.50
Ear	II	130 (CI-5xCI-9)	II	118.25
height	III	164 (CI-5xCI-9)	III	112.98
(cm)	IV	153 (CI-5xCI-9)	IV	108.50
	V	144 (CI-5xCI-9)	V	107.87
5	I	130 (CI-5xCI-9)	I	14.57
Ear	II	167 (CI-5xCI-9)	II	14.20
length	III	166 (CI-5xCI-9)	III	13.90
(cm)	IV	164 (CI-5xCI-9)	IV	13.80
	V	170 (CI-5xCI-9)	V	13.70
6	I	164 (CI-5xCI-9)	I	14.60
Ear	II	144 (CI-5xCI-9)	II	14.32
diameter	III	166 (CI-5xCI-9)	III	14.23
(cm)	IV	153 (CI-5xCI-9)	IV	13.92
	V	167 (CI-5xCI-9)	V	13.95
7	I	166 (CI-5xCI-9)	I	32.75
100-grain	II	144 (CI-5xCI-9); 130 (CI-5xCI-9)	II	29.75
weight	III	153 (CI-5xCI-9)	III	29.50
(gm)	IV	164 (CI-5xCI-9)	IV	29.25
	V	152 (CI-5xCI-9); 167 (CI-5xCI-9)	V	29.00
8	I	166 (CI-5xCI-9)	I	3.97
Grain	II	130 (CI-5xCI-9)	II	3.65
yield	III	167 (CI-5xCI-9)	III	3.55
kg/plot	IV	164 (CI-5xCI-9)	IV	3.50
	V	144 (CI-5xCI-9); 153 (CI-5xCI-9); 174 (CI-5xCI-9)	V	3.35

Table 5c. Hybrids with better performance in respect of yield and yield components in maize (Set III)

Characters		Top five performing hybrids	Mean performance of top five hybrids	
1	I	12 (CI-5xCI-9)	I	52.75
Days to	II	41 (CI-5xCI-9)	II	53.25
50 % ta-	III	69, 122,147 (CI-5xCI-9)	III	53.50
asselling	IV	40 (CI-5xCI-9)	IV	53.75
	V	72 (CI-5xCI-9); 119 (CI-5xCI-9)	V	54.00
2	I	12 (CI-5xCI-9)	I	54.50
Days to	II	122 (CI-5xCI-9)	II	55.25
50 %	III	45 (CI-5xCI-9); 119 (CI-5xCI-9)	III	55.50
silking	IV	20 (CI-5xCI-9)	IV	55.75
	V	38, 40, 147 (CI-5xCI-9)	V	56.00
3	I	165 (CI-5xCI-9)	I	194.62
Plant	II	158 (CI-5xCI-9)	II	191.62
height	III	146 (CI-5xCI-9)	III	189.52
(cm)	IV	116 (CI-5xCI-9)	IV	188.38
	V	75 (CI-5xCI-9)	V	187.88
4	I	67 (CI-5xCI9)	I	115.50
Ear	II	116 (CI-5xCI-9)	II	102.38
height	III	75 (CI-5xCI-9)	III	102.12
(cm)	IV	146 (CI-5xCI-9)	IV	97.62
	V	165 (CI-5xCI-9)	V	96.50
5	I	158 (CI-5xCI-9)	I	15.30
Ear	II	146 (CI-5xCI-9)	II	14.05
length	III	28 (CI-5xCI-9)	III	13.88
(cm)	IV	116 (CI-5xCI-9)	IV	13.68
	V	10 (CI-5xCI-9)	V	13.50
6	I	116 (CI-5xCI-9)	I	14.67
Ear	II	158 (CI-5xCI-9)	II	14.62
diameter	III	75 (CI-5xCI-9)	III	14.50
(cm)	IV	165 (CI-5xCI-9)	IV	14.45
	V	147 (CI-5xCI-9)	V	14.35
7	I	116 (CI-5xCI-9)	I	37.75
100-grain	II	146 (CI-5xCI-9)	II	35.00
weight	III	158 (CI-5xCI-9)	III	33.75
(gm)	IV	165 (CI-5xCI-9)	IV	33.25
	V	75 (CI-5xCI-9)	V	33.00
8	I	116 (CI-5xCI-9)	I	3.88
Grain	II	158 (CI-5xCI-9)	II	3.80
yield	III	75 (CI-5xCI-9)	III	3.50
kg/plot	IV	165 (CI-5xCI-9)	IV	3.47
	V	146 (CI-5xCI-9)	V	3.40

99 (CI-5 x CI-9), 117 (CI-5 x CI-9), [102 (CI-5 x CI-9), 66 (CI-5 x CI-9), 70 (CI-5 x CI-9)] and 98 (CI-5 x CI-9). There was a least variation in days to 50 per cent silking in all the se hybrids which varied from 55.575 to 57.00 days. The high yielding ability of three way cross hybrid 118 (CI-5 x CI-9) appeared to be deriving contribution from high 100 grain weight (29.00 gm), high ear length (14.27 cm), second highest in plant height (196.50 cm), ear height (112.27 cm), and highest in ear diameter (14.57cm), among the 33 hybrids. The high yielding ability of the remaining 4 hybrids appeared to be deriving contribution from yield components which come in top five ranks.

Similarly in set II, out of 33 hybrids studied the three way cross hybrid 166 (CI-5 x CI-9) produced the highest grain yield of 3.97 kg per plot, followed by 130 (CI-5 x CI-9), 167 (CI-5 x CI-9), 164 (CI-5 x CI-9), [144 (CI-5 x CI-9), 153 (CI-5 x CI-9)] and 174 (CI-5 x CI-9). In most of three way cross hybrids the days to 50 per cent silking remained same. The least range of 56.50 to 58.25 days for days to 50 per cent silking was observed among these top five hybrids. The high yielding ability of 166 (CI-5 x CI-9), three way hybrid was due to contribution from high 100 grain weight (32.75 gm), high plant height (209.40 cm), high ear height (118.50 cm), third highest in ear length (13.90 cm) and ear diameter (14.23 cm) among the 33 hybrids.

Among the 33 hybrids of the set III, the three way cross 116 (CI-5 x CI-9) numerically produced the highest grain yield of 3.88 kg per plot, which was followed by the 158 (CI-5 x CI-9), 75 (CI-5 x CI-9) 165 (CI-5 x CI-9) and 146 (CI-5 x CI-9). The range of variation for days to 50 per cant silking among these top

five hybrids was 56.25 to 58.50 days. As earlier mentioned the high yielding ability of 116 (CI-5 x CI-9)appeared to be deriving contribution from high ear diameter (14.67cm), high100 grain weight (37.75gm), second highest in ear height (102.38), fourth highest in plant height (188.38cm) and ear length (13.68cm), among the 33 hybrids. The results were in accordance with Hutchinson and wolfe (1924), Jenkins (1929), Johnson (1939), Swamy Rao *et al.*,(1970), patil *et al.*,(1972), Hansel *et al.*, (1977), Rood and Major (1980), Mahmoud *et al.*,(1990), Reddy and Agrawal (1992), Odiemach (1992), Debnath and Azad (1993), Alika(1994), Robin and Subramanian (1994), Vasal *et al.*,(1994) and Turgut, *et al.*,(1995).

5.2 Character wise interpretation of heterosis

The word heterosis was coined by Shull (1908) to provide a term to describe the phenomenon but it did not include a description of the genetic mechanism involved in its expression. Heterosis is usually expressed in percentage over mid parent or better parent or standard check. The results obtained in the studies on heterosis for all 3 sets are comprehended and discussed below. Per cent heterosis of best three way hybrids over the checks presented in Table-6 and figure 2.

5.2.1 Days to 50 per cent tasselling

Days to 50 per cent tasselling is often used as an attribute of maturity. It is known that anthesis is less affected by environmental fluctuations as compared to silking, so to say the days to anthesis is a more stable trait. Days to anthesis will be the better indication of maturity. The negative heterosis is desirable as we are interested in early tasselling.

Table 6. Per cent heterosis of the best performing hybrids over commercial and the best check in all three sets.

Characters		Mean of the commercial check	Mean of the best check	Mean of the top hybrid	Percent heterosis over Commercial check	Percent heterosis over Best check
1	Set					
Days to	I	53.50	52.25	53.25	−0.47	1.91
50 % ta−	II	54.00	54.00	53.50	−0.93	−0.93
asselling	III	54.50	53.25	52.75	−3.21	−0.93
2						
Days to	I	55.00	53.50	54.75	−0.45	2.34
50 %	II	55.75	55.75	55.25	−0.89	−0.89
silking	III	56.25	55.50	54.50	−3.11	−1.80
3						
Plant	I	168.25	196.34	198.62	18.05	1.16
height	II	203.50	203.50	209.40	2.89	2.89
(cm)	III	178.38	180.62	194.62	9.10	7.75
4						
Ear	I	100.70	100.70	128.25	27.36	27.36
height	II	100.62	102.88	118.50	17.77	15.18
(cm)	III	93.00	93.00	115.50	24.20	24.20
5						
Ear	I	13.38	13.38	14.27	6.20	6.20
length	II	13.70	13.70	14.57	6.35	6.35
(cm)	III	13.38	13.38	15.30	14.35	14.35
6						
Ear	I	13.65	14.05	14.62	7.11	4.06
diameter	II	13.88	13.88	14.60	5.18	5.18
(cm)	III	13.48	13.85	14.67	8.83	5.92
7						
100−grain	I	26.00	26.00	29.00	11.54	11.54
weight	II	27.25	28.50	32.75	20.18	14.91
(gm)	III	32.25	32.25	37.75	17.00	17.00
8						
Grain	I	3.32	3.32	3.80	14.46	14.46
yield	II	2.85	3.35	3.97	39.30	18.51
kg/plot	III	3.22	3.40	3.88	20.50	14.10

Fig 2. Per cent heterosis of best performing hybrid over commerical and best check in all three sets

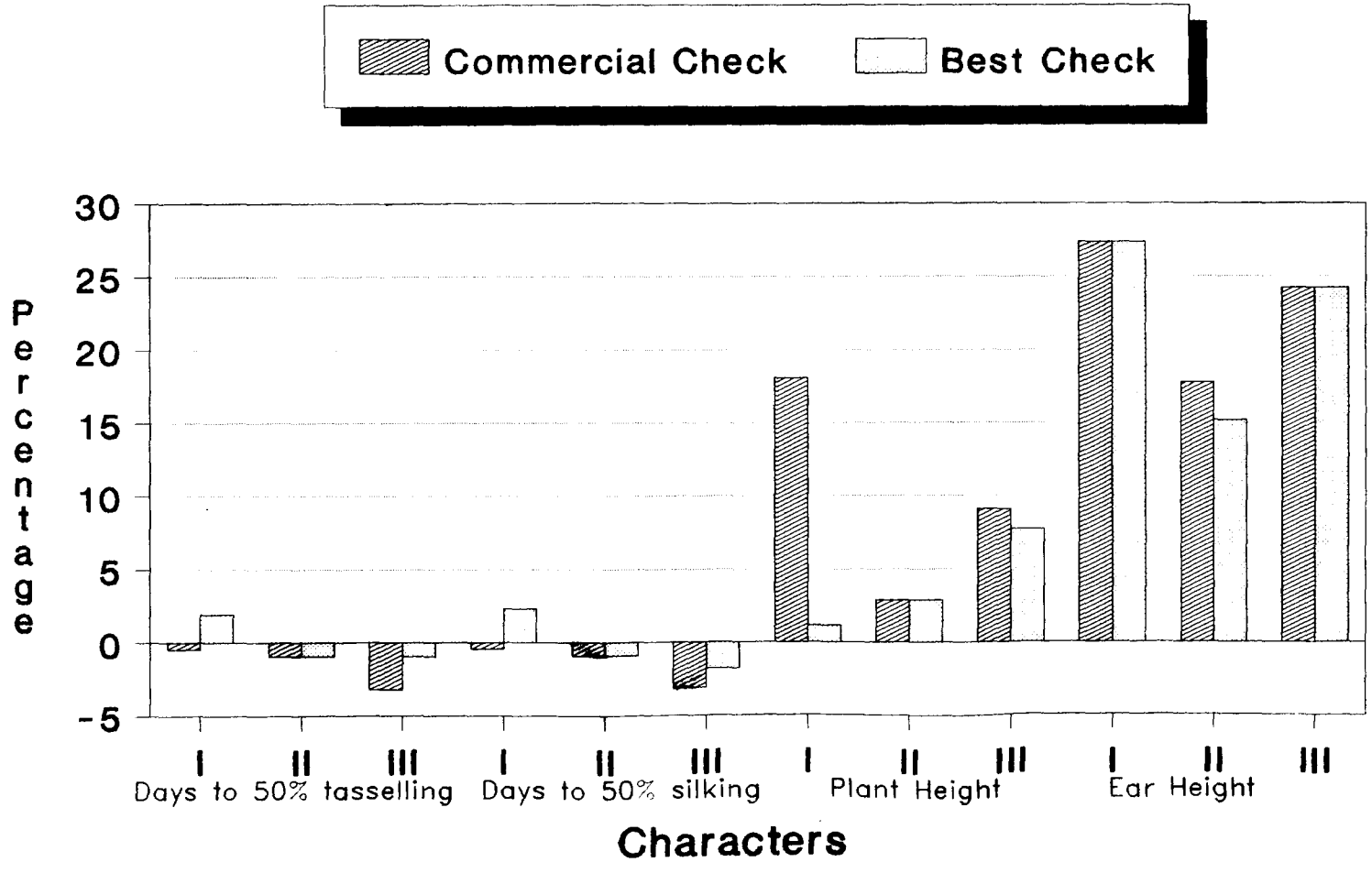
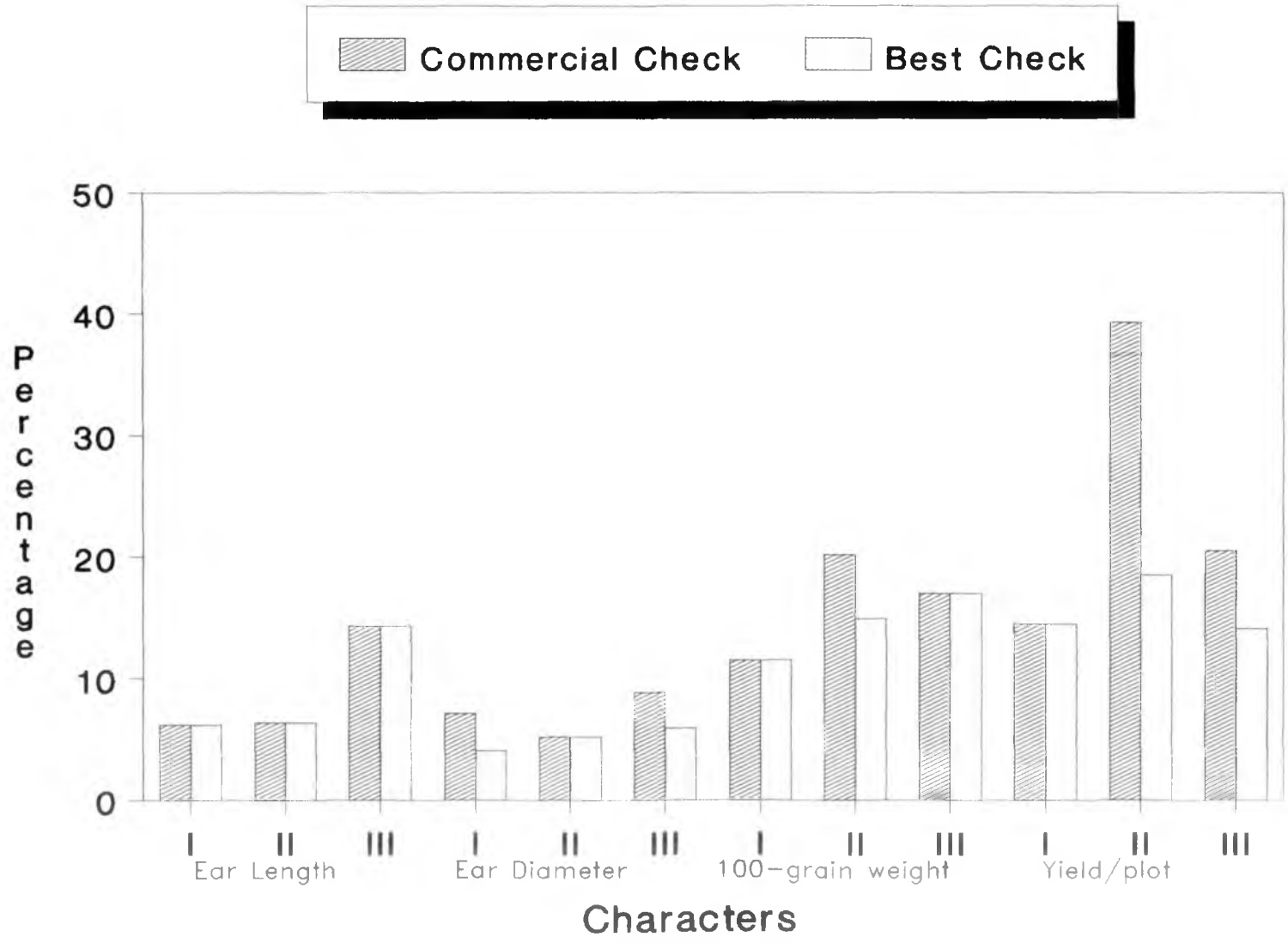


Fig 2. Cont'd....


Commercial Check
Best Check
50
40
30
20
10
0
Percentage
I
II
III
Ear Length
Ear Diameter
100-grain weight
Yield/plot
Characters

None of the hybrids out of 33 hybrids in all the three sets studied showed significant and negative heterosis over best check. Whereas, 6 out of 33 hybrids in only set III showed significant and negative heterosis over commercial check. The cross 12 (CI-5 x CI-9) which tasselled in 52.75 days showed highest significant negative heterosis (-3.21) over the commercial check in set III. This cross followed by 41 (CI-5 x CI-9) (-2.29) : [69 (CI-5 x CI-9) : 122 (CI-5 x CI-9) : 147 (CI-5 x CI-9) (-1.84)] and 40 (CI-5 x CI-9) (1.38) etc., for early tasselling in set III.

The results were in accordance with Glosen *et al.*,(1962), Kalsy and Sharma (1970), Shetty (1974), Hassaballa *et al.*,(1980) and Ramamurthy (1978) in their study of mid parent heterosis, Satyanarayana (1994), Gomesh *et al.*,(1995), Turgut *et al.*,(1995) and Perez *et al.*,(1995) also observed heterosis for this trait. Absence of heterosis in majority of the crosses may be taken as an indirect evidence to the major role of additive gene action in the inheritance of this trait.

5.2.2 Days to 50 per cent silking

The negative heterosis is desirable since we are interested in early silking. Appadurai and Nagarajan (1975). Dhillon and Singh (1976), Ramamurthy *et al.*,(1980) and Akhtar and Singh (1981), Vasal (1992), Satyanarayana (1994), Altinbos (1995) and Prez *et al.*, (1995) also observed heterosis for this character (for earliness).

The study of heterosis in all the three sets over commercial check indicated that only two crosses out of 33 crosses in set-III showed significant and

negative heterosis. However one cross out of 33 crosses in set III showed significant negative heterosis over the best check. None out of 33 crosses in set I and II showed negative significant heterosis over commercial and best check. Absence of heterosis in majority of the crosses may be taken as an indirect evidence to the major role of additive gene action in the inheritance of this trait. The cross 12 (CI-5 x CI-9) which silked in 54.50 days showed highest significant negative heterosis (-3.12) and (-1.80) over commercial and best check respectively in set III. This cross was followed by 122 (CI-5 x CI-9) (-1.78) for early silking compared to the commercial check only.

As per Mukherjee *et al.*,(1971) and Bonaparte (1977) both additive as well as non additive components were of the same order. According to Lonnquist and Gardner (1961), Lindsey *et al.*,(1962), Tripathi (1968), Wright *et al.*, (1971), Singh *et al.*,(1971), Dhillon and Singh (1977a), Singh *et al.*,(1971), Hassaballa *et al.*, (1980), Ramamurthy *et al.*, (1980) and Sanghi *et al.*, (1983) reported a higher proportion of additive component.

5.2.3 Plant height

None of the crosses studied in all the three sets exhibited significant positive heterosis over commercial as well as best check. This confirms the predominant role of additive genetic variance in the inheritance of this trait. The results are in accordance with Gomes-e-Gama (1995).

However the crosses 117 (CI-5 x CI-9) in set I 166 (CI-5 x CI-9) in set II and 165 (CI-5 x CI-9) in set III which had highest mean plant height of 198.62 cm, 209.40 cm and 194.62 cm respectively and were found to be superior in their

mean performance over commercial check by 18.05, 2.89, 9.10 per cent and over best check by 1.16, 2.89, 7.75 per cent respectively. Alvarez *et al.*, (1993), Vasal *et al.*,(1992) and Reddy and Agrawal (1992) reported low to high heterosis for this trait.

5.2.4 Ear height

The study of heterosis in set I and set III indicated that only one cross out of 33 crosses in each set showed significant and positive heterosis over commercial and the best check which were one and same (Deccan-103). However, in case of set II, two out of 33 crosses showed significant positive heterosis over commercial check (Deccan-103) and best check (CI-5 x CI-9) presence of heterosis indicates the importance of non-additive genetic variance. As per Thompson and his associates (1971) both additive and non-additive genetic variance were equally important.

The crosses 117 (CI-5 x CI-9) in set I, 166 (CI-5 x CI-9) in set II and 67 (CI-5 x CI-9) in set III where the ear placement was at maximum height of 128.25 cm, 118.50 cm, 115.50 cm respectively showed highest significant positive heterosis over commercial check 27.36, 17.76, 24.20 per cent and over best check 27.36, 15.18, 24.20 respectively in all the three sets. Similar results were also noticed by Giesbrecht (1960), Dhillon and Singh (1977b), Alvarez *et al.*, (1993) and Altinbos (1995).

5.2.5 Ear length

For this trait, Deccan-103 was both commercial and best check, in all the three sets. Heterosis study indicated that out of 33 crosses in all the sets two

crosses each in set I and set II and five crosses in set III deviated significantly from Deccan-103. Absence of heterosis in majority of the crosses indicates the greater role of additive components but however it need not necessarily indicate the absence of non-additive components. It may be because of mutual collection of internal components (Falconer 1960). Dhillon and Singh *et al.*,(1977b), Singh *et al.*,(1979) and Turgut *et al.*,(1995) also reported heterosis for this trait and results were also in accordance with these workers.

The crosses 118(CI-5xCI-9), 130(CI-5xCI-9) and 158 (CI-5 x CI-9) which was highest value of 14.27 cm, 14.57 cm and 15.30 cm respectively in all the three sets exhibited the highest significant heterosis. Value 6.20, 6.35 and 14.35 over the commercial and the best check in all the three sets respectively. These crosses were followed by 105 (CI-5 x CI-9) in set I, 167 (CI-5 x CI-9) in set II and 149 (CI-5 x CI-9) : 146 (CI-5 x CI-9) : 28 (CI-5 x CI-9) and 116 (CI-5 x CI-9) for higher significant heterosis over both the checks.

5.2.6 Ear diameter

Heterosis study in all the three sets indicated that out of 33 crosses in each set, 19 crosses in set I, three crosses in set II and 22 crosses in set III deviated significantly from their commercial check value. Similarly 2 crosses in set I, three crosses in set II, and 13 crosses in set III, showed significantly positive heterosis over best check. As stated earlier absence of heterosis in majority of the crosses need not indicate absence of non additive component. The association of genes in parents may lead to such observations (Mather and Jinks, 1971). The results were in accordance with Mukherjee *et al.*,(1974) and Turgut *et al.*,(1995).

The crosses 99 (CI-5 x CI-9), 164 (CI-5 x CI-9) and 116 (CI-5 x CI-9) which had the highest values of 14.62, 14.60cm and 14.67 cm respectively in all the three sets exhibited the highest significant heterosis value of 7.11, 5.18, 8.83 per cent and 4.06, 5.18, 5.92 per cent over the commercial and best check respectively in all the three sets. These crosses were followed by 118(CI-5xCI-9), 117 (CI-5 x CI-9), 102 (CI-5 x CI-9) in set II, 158 (CI-5 x CI-9), 75 (CI-5 x CI-9), 147 (CI-5 x CI-9) etc., in set III for higher significant heterosis over commercial and best check.

5.2.7 100 Grain weight

In case of set I and set III Deccan-103 was the commercial as well as best check. Out of 33 crosses, in each set, 4 crosses in set I and 2 crosses in set III showed positive heterosis over Deccan-103. Out of 33 crosses in set II, 9 crosses and 5 crosses showed significant heterosis in positive direction over commercial and best check respectively. This considerable heterosis among the hybrids confirms the role of non-additive genetic variance in the inheritance of grain weight. The results are in contradiction with Varma and Singh (1980) who reported that additive genetic variance was important. As per Kalsy and Sharma (1970), Sharma *et al.*,(1972) and Singh *et al.*,(1973) both additive and non additive genetic variances were equally important. Shetty (1974), Ramamurthy (1978), Radovic (1979), Shakoor and Ataullah (1979), Varma and Singh (1980), Alvarez *et al.*,(1993) and Turgut *et al.*, (1995) were also observed considerable heterosis for this trait.

The crosses, 118 (CI-5 x CI-9), 166 (CI-5 x CI-9), 116 (CI-5 x CI-9) which had the highest values of 29.00 gm, 32.75 gm, 37.75 gm respectively in all the three sets exhibited the highest significant heterosis value of 11.154, 20.18 and

17.00 per cent and 11.54, 14.91 and 17.00 per cent over the commercial check and best check respectively. In case of set I and III, these best crosses followed by 99 (CI-5 x CI-9) and 102 (CI-5 x CI-9) for higher significant heterosis over commercial and best check. Whereas in case of set II the best cross followed by 130 (CI-5 x CI-9) 144 (CI-5 x CI-9), 153 (CI-5 x CI-9), 164 (CI-5 x CI-9) for higher significant heterosis over commercial and best check.

5.2.8 Grain yield per plot

Grain yield in a complex quantitative character having many fold influence by other ancillary and component characters. On the changes the characters may tend to counter balance each other giving in effect, homoeostasis for yield. Hence all the change in components would not be expressed as changes in yield, but all changes in yield would be accompanied by changes in one or more components. Johnson (1973) reported that genetic variability for grain yield in single ear plant is attributable to the additive and non-additive genetic variance expressed through yield components. Because of influence from various ancillary characters and environmental functions comprehensive study becomes very difficult and it is the focal point about which plant breeding experiments are centered around.

Heterosis study in respect of grain yield per plot in all the three sets indicated the presence of considerable heterosis. The number of crosses which deviated significantly in positive direction from the commercial check value were 10 crosses in set I, 26 crosses in set II and 7 crosses in set III and from the best check value were 10 crosses, in set I and 4 crosses each in set II and set III. The results were in accordance with Matzinger *et al.*,(1959), Hallauer and Sears (1968), Kalsy

and Sharma (1970), Dhillon and Singh (1977a), Ramamurthy *et al.*,(1981), Jha and Khehara (1992), Mejaya and Lamabert (1992), Alvarez *et al.*,(1993), Gomesh-e-Gama (1993), Turgut *et al.*, (1995) and Prez *et al.*, (1995), Robinson *et al.*,(1955), Penny *et al.*, (1962), Lindsey *et al.*, (1962), Lonnquist and Gardner(1961), Wright *et al.*,(1971), Stubber *et al.*,(1973), Varma and Singh (1980) and Singh *et al.*, (1983) reported the importance additive genetic variance for this trait. As per Mukherjee *et al.*,(1971) and Singh *et al.*, (1979), both additive and non-additive genetic variances were equally important.

The crosses 118 (CI-5 x CI-9), 166 (CI-5 x CI-9) and 116 (CI-5 x CI-9) which expressed the highest grain yield of 3.80 kg, 3.97 kg and 3.88 kg per plot respectively in all the three sets, exhibited the highest significant heterosis value of 14.46, 39.30, 20.50 per cent and 14.46, 18.51, 14.10 per cent over the commercial check and best check respectively. These crosses in all the three sets were followed by 99 (CI-5 x CI-9), 117 (CI-5 x CI-9), 102 (CI-5 x CI-9), 66 (CI-5 x CI-9), 70 (CI-5 x CI-9) in set I, 130 (CI-5 x CI-9), 167 (CI-5 x CI-9), 164 (CI-5 x CI-9), in set II and 158 (CI-5 x CI-9), 75 (CI-5 x CI-9), 165 (CI-5 x CI-9) in set III for higher significant positive heterosis over commercial and best checks.

5.3 Selection of desirable lines and hybrids for future use

Per se performance of hybrids revealed the three way hybrids 118 (CI-5 x CI-9), 99 (CI-5 x CI-9), 117 (CI-5 x CI-9), 102 (CI-5 x CI-9), 98 (CI-5 x CI-9), 164 (CI-5 x CI-9), 144 (CI-5 x CI-9), 116 (CI-5 x CI-9), 158 (CI-5 x CI-9), 75 (CI-5 x CI-9), 165 (CI-5 x CI-9) and 146 (CI-5 x CI-9) were the best performers among the 99 crosses, when all the characters were taken into consideration.

However, pooling the scores for yield and yield components plant height, ear height, ear length and 100 grain weight) the hybrids 166 (CI-5 x CI-9), 130 (CI-5 x CI-9), 118 (CI-5 x CI-9) were found to be the top and 158 (CI-5 x CI-9) and 164 (CI-5 x CI-9) five performers among 99 hybrids, in descending order. These hybrids out yielded the best single crosses CI-5 x CI-9, CI-5 x CI-4 and commercial check (Deccan-103). Among these top three way hybrids, it was observed that the cross 166 (CI-5 x CI-9) exhibited highest heterosis of 39.30 and 18.51 per cent over the commercial and best check with respect to grain yield per plot. In addition, it showed the highest grain yield per plot (3.97 kg), the highest plant height (209.40 cm), second highest 100 grain weight (32.75 gm) and second highest ear length (14.57 cm). It also silked earlier (55.25 days) which was not significant compared to check. Therefore, from all consideration 166 (CI-5 x CI-9) hybrid appears to be excellent for commercial cultivation. It is worth while to take up trials on farmers field to study the performance of this potential cross so as to make commercial exploitation of hybrid vigour a reality. It is also suggested that five crosses 130 (CI-5 x CI-9), 118 (CI-5 x CI-9), 158 (CI-5 x CI-9), 164 (CI-5 x CI-9) could be tried on large scale to explore the possibility of finding a superior segregates also. The inbreds 166, 130, 118, 158 and 164 were found to be the most promising and need to be further exploited in different hybrid combinations.

SUMMARY

VI SUMMARY

The present experiment was conducted during Kharif - 1995 at the Agricultural Research Station, Arabhavi, University of Agricultural Sciences, Dharwad, with the objectives to study the genetic nature of the newly developed inbred lines through three-way cross hybrid performance and assess the performance of three way hybrids for commercial exploitation.

Three sets of the experiment comprising of 99 three-way cross hybrids involving newly developed inbred lines along with three checks viz., Deccan-103 (double-cross hybrid, commercial check), CI-4 x CI-5 (a high yielding single cross) and CI-5 x CI-9 (high yielding tester single cross) were planted in randomized complete block design with four replications. Eight quantitative characters were recorded on individual ten random competitive plants from each plot, viz., days to 50 per tasselling, days to 50 per cent silking, plant height, ear height, ear diameter, 100-grain weight and yield per plot. The important finding of the study were as follows.

The analysis of variance due to treatments in all the three sets revealed significant differences for all the characters under study, except for ear length and ear diameter in set II and set I respectively.

Based on mean yield performance, three-way hybrids 166 (CI-5 x CI-9), 116 (CI-5 x CI-9), 118 (CI-5 x CI-9), 158 (CI-5 x CI-9) and 164 (CI-5 x CI-9) were identified as potentially high yielding genotypes. These

genotypes need to be evaluated over locations and years to confirm their superiority before considering them for possible identification for release as commercial cultivars.

In all 3 sets the phenotypic and genotypic coefficient of variation (PCV and GCV) were high for grain yield per plot, ear height and 100-grain weight. High variability present in these characters can be exploited. Low values of PCV and GCV were observed for days to 50 per cent tasselling, days to 50 per cent silking, ear diameter, indicating that they are less amenable for improvement. Moderate values of PCV and GCV were observed for plant height and ear length.

Heritability in broad-sense was moderate for grain yield, ear height, days to 50 per cent silking and tasselling and 100-grain weight. Low to moderate heritability was exhibited by remaining characters, in all the 3 sets. Genetic advance over mean was high for grain yield and 100-grain weight in set I as compared to the other two sets. Moderate to low genetic advance over mean was observed for remaining characters.

Heterosis study in respect of grain yield per plot in all the three sets indicated the presence of considerable heterosis over commercial as well as best check. High heterosis was also observed for 100-grain weight. Six out of 33 crosses in only set III showed significant and negative heterosis for days to 50 per cent silking over commercial check. These were quite early but low yielding. None of the 99 crosses studied in all the 3 sets exhibited significantly positive heterosis for plant height, over commercial and best check. This confirms the indirect evidence to the major role of additive genetic variance in the inheritance of this trait.

However, some crosses exceeded in the mean performance of the check, for this trait. The per cent heterosis value over commercial and best check ranged from -36.14 [81(CI-5 x CI-9)] to 14.46 [118 (CI-5 x CI-9)] in set I. However in set II and set III the commercial check and best check were different. In this case the per cent heterosis value over commercial and best check ranged from -15.79 and -28.36 [171 (CI-5 x CI-9)] to 39.30 and 18.51 [166 (CI-5 x CI-9) in set II and from -32.30 and -35.80 [149 (CI-5 x CI-9)] to 20.50 and 14.10 [116 (CI-5 x CI-9)] in set III respectively.

On an over all basis the following three way hybrids need to be further evaluated over locations and years for their commercial exploitation; 166 (CI-5 x CI-9), 130 (CI-5 x CI-9), 118 (CI-5 x CI-9), 158 (CI-5 x CI-9) and 164 (CI-5 x CI-9).

The inbreds 166, 130, 118, 158 and 164 were found to be the most promosing and need to be further exploited in different hybrid combinations.

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* Originals not seen

APPENDICES

Appendix 1. Mean performance of three-way hybrids and checks in respect of eight quantitative characters (Set I)

Sl. No.	Entries	Days to 50% tasselling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	100 grain weight (gm)	Yield/ Plot (kg)
		1	2	3	4	5	6	7	8
1	55(CI-5xCI-9)	54.75	55.75	184.00	96.50	12.84	13.57	23.50	3.25
2	56(CI-5xCI-9)	53.75	57.25	179.38	96.88	11.47	14.08	23.00	3.38
3	58(CI-5xCI-9)	54.00	57.00	188.75	96.25	12.07	13.88	22.00	3.05
4	60(CI-5xCI-9)	53.75	57.25	179.94	89.76	11.71	13.67	24.50	2.75
5	63(CI-5xCI-9)	54.50	56.75	193.50	105.50	12.98	13.85	24.50	3.30
6	66(CI-5xCI-9)	54.25	56.00	177.94	100.50	13.23	13.95	20.50	3.50
7	70(CI-5xCI-9)	55.25	58.00	187.00	103.25	11.72	13.80	24.75	3.50
8	71(CI-5xCI-9)	55.75	58.25	186.50	103.88	12.90	13.95	25.50	3.07
9	73(CI-5xCI-9)	55.25	57.75	182.05	91.12	11.77	13.70	22.75	2.75
10	74(CI-5xCI-9)	54.75	57.25	193.38	96.75	12.92	13.97	23.50	2.75
11	76(CI-5xCI-9)	55.50	58.25	177.75	95.12	11.45	13.62	21.00	2.62
12	77(CI-5xCI-9)	54.25	55.75	181.11	97.65	12.32	13.53	22.50	3.33
13	78(CI-5xCI-9)	53.50	55.25	183.50	101.25	11.30	13.50	24.50	3.08
14	80(CI-5xCI-9)	53.25	55.25	184.63	96.40	12.20	13.22	20.75	2.73
15	81(CI-5xCI-9)	55.25	57.75	179.15	87.12	11.50	13.10	18.00	2.12
16	83(CI-5xCI-9)	55.75	58.00	181.38	94.50	11.50	13.75	22.75	3.03
17	88(CI-5xCI-9)	55.25	55.50	179.25	91.75	12.27	14.07	23.75	2.60
18	89(CI-5xCI-9)	53.75	55.75	172.05	93.03	12.00	13.38	21.58	2.78
19	90(CI-5xCI-9)	54.00	57.25	185.12	96.38	13.27	13.40	23.50	2.80
20	91(CI-5xCI-9)	54.25	56.50	181.80	96.88	12.62	13.81	21.25	3.40
21	95(CI-5xCI-9)	54.25	56.25	168.05	94.50	12.55	13.57	21.25	2.80
22	96(CI-5xCI-9)	54.00	56.25	166.00	89.88	11.55	14.06	24.75	2.75
23	98(CI-5xCI-9)	54.50	56.50	194.50	100.75	13.55	14.12	26.00	3.48
24	99(CI-5xCI-9)	54.50	56.75	195.75	107.88	13.42	14.62	28.25	3.67
25	101(CI-5xCI-9)	53.25	54.50	191.00	97.65	12.95	14.05	24.50	3.48
26	102(CI-5xCI-9)	54.50	55.75	194.00	104.62	13.58	14.15	26.50	3.50
27	103(CI-5xCI-9)	54.50	56.00	187.25	101.88	12.73	13.80	28.25	3.10
28	105(CI-5xCI-9)	54.50	55.25	194.50	99.12	13.08	13.82	24.50	3.33
29	110(CI-5xCI-9)	54.50	57.25	169.58	106.88	12.02	13.95	26.50	2.95
30	111(CI-5xCI-9)	54.75	57.00	178.32	82.62	12.57	13.65	23.25	2.62
31	112(CI-5xCI-9)	54.00	55.75	186.50	82.25	12.88	13.02	24.25	2.70
32	117(CI-5xCI-9)	54.50	56.50	198.62	128.25	13.70	14.22	24.00	3.65
33	118(CI-5xCI-9)	54.75	57.00	196.50	112.75	14.27	14.27	21.75	3.80
CHECKS									
34	Deccan-103	53.50	55.00	168.25	100.70	13.38	13.65	20.75	3.32
35	CI-4xCI-5	52.75	55.75	196.34	99.11	13.05	14.05	25.50	3.25
36	CI-5xCI-9	52.25	53.50	196.25	95.62	12.48	13.37	29.00	3.28

Appendix 2. Mean performance of three-way hybrids and checks in respect of eight quantitative characters (Set II)

Sl. No.	Entries	Days to 50% tasselling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	100 grain weight (gm)	Yield/ Plot (kg)
		1	2	3	4	5	6	7	8
1	121(CI-5xCI-9)	53.50	55.25	184.74	105.70	13.32	13.90	28.50	3.15
2	123(CI-5xCI-9)	53.50	55.75	168.65	96.50	12.90	13.75	26.75	2.85
3	125(CI-5xCI-9)	55.75	58.00	187.50	103.25	13.08	13.80	27.50	3.25
4	126(CI-5xCI-9)	55.75	56.50	175.17	90.90	12.58	13.77	27.25	3.05
5	127(CI-5xCI-9)	55.25	57.75	175.47	93.86	12.07	13.45	27.25	2.75
6	128(CI-5xCI-9)	55.00	57.75	170.75	99.62	11.45	10.57	28.00	2.75
7	129(CI-5xCI-9)	55.00	58.25	178.00	98.12	12.53	13.85	26.75	2.88
8	130(CI-5xCI-9)	55.75	58.25	200.88	118.25	14.57	13.25	29.75	3.65
9	131(CI-5xCI-9)	55.50	58.25	200.50	104.75	12.85	13.35	23.75	3.28
10	132(CI-5xCI-9)	54.00	56.00	191.88	90.88	13.50	13.75	27.25	3.05
11	133(CI-5xCI-9)	54.75	56.25	194.12	104.78	12.40	12.93	27.00	2.95
12	134(CI-5xCI-9)	55.25	57.25	199.59	189.69	13.30	13.00	28.25	2.65
13	135(CI-5xCI-9)	55.00	56.00	197.62	105.25	12.32	13.73	24.75	3.32
14	136(CI-5xCI-9)	54.00	56.25	179.73	96.38	12.27	13.25	27.50	3.17
15	137(CI-5xCI-9)	55.25	57.75	190.15	103.69	13.53	13.47	27.25	2.95
16	138(CI-5xCI-9)	53.50	55.75	185.29	93.25	12.23	12.92	28.00	2.98
17	139(CI-5xCI-9)	55.50	58.00	187.88	95.75	13.53	12.77	19.98	3.00
18	140(CI-5xCI-9)	55.00	57.75	183.88	94.03	13.32	13.50	25.75	2.85
19	144(CI-5xCI-9)	56.00	57.75	207.12	107.87	12.55	14.32	29.75	3.35
20	148(CI-5xCI-9)	54.50	57.00	180.12	86.88	13.00	13.57	26.00	2.88
21	150(CI-5xCI-9)	55.75	58.00	178.72	92.48	12.38	13.15	27.00	2.53
22	152(CI-5xCI-9)	55.25	58.25	172.38	89.64	12.25	13.12	29.00	2.62
23	153(CI-5xCI-9)	55.00	56.50	202.62	108.50	12.45	13.92	29.50	3.35
24	154(CI-5xCI-9)	55.00	58.00	184.88	94.62	12.20	13.22	28.50	2.95
25	164(CI-5xCI-9)	54.50	56.50	206.62	112.98	13.80	14.60	29.25	3.50
26	166(CI-5xCI-9)	55.00	56.50	209.40	118.50	13.90	14.23	32.75	3.97
27	167(CI-5xCI-9)	55.75	58.00	200.28	100.30	14.20	13.95	29.00	3.55
28	168(CI-5xCI-9)	54.75	58.00	197.38	105.89	13.23	13.32	25.50	3.23
29	169(CI-5xCI-9)	54.75	57.25	105.88	103.28	13.60	13.00	27.00	3.20
30	170(CI-5xCI-9)	54.50	56.00	195.60	106.82	13.70	12.82	28.25	3.15
31	171(CI-5xCI-9)	54.50	56.75	155.65	84.54	13.55	13.50	26.50	2.40
32	173(CI-5xCI-9)	54.25	57.25	178.36	92.19	12.52	13.20	27.00	2.88
33	174(CI-5xCI-9)	54.50	56.20	197.88	100.12	13.68	13.88	28.25	3.35
CHECKS									
34	Deccan-103	54.00	55.75	203.50	100.62	13.70	13.88	27.25	2.85
35	CI-4xCI-5	56.25	56.25	185.88	94.00	12.02	13.38	24.50	2.92
36	CI-5xCI-9	54.00	55.75	192.62	102.88	12.90	13.75	28.50	3.35

Appendix 3. Mean performance of three-way hybrids and checks in respect of eight quantitative characters (Set III)

Sl. No.	Entries	Days to 50% tasselling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	100 grain weight (gm)	Yield/ Plot (kg)
		1	2	3	4	5	6	7	8
1	2(CI-5xCI-9)	54.50	56.75	179.50	86.88	11.93	13.95	27.25	3.00
2	6(CI-5xCI-9)	55.25	56.75	171.43	85.91	13.05	14.00	29.00	2.70
3	10(CI-5xCI-9)	54.50	56.25	179.32	88.62	13.50	13.40	29.00	3.03
4	12(CI-5xCI-9)	52.75	54.50	161.18	83.66	11.32	13.83	28.25	3.10
5	20(CI-5xCI-9)	54.25	55.75	163.00	83.89	12.45	13.43	30.50	2.78
6	28(CI-5xCI-9)	54.50	56.25	185.11	93.56	13.88	13.38	30.25	2.95
7	34(CI-5xCI-9)	55.25	56.75	187.81	94.44	12.93	12.40	27.75	2.55
8	38(CI-5xCI-9)	54.50	56.00	176.25	87.25	13.35	13.65	29.25	2.95
9	40(CI-5xCI-9)	53.75	56.00	179.75	91.38	13.40	13.25	25.25	2.95
10	41(CI-5xCI-9)	53.25	56.50	169.62	86.50	12.50	13.40	25.00	2.53
11	45(CI-5xCI-9)	54.50	55.50	176.88	81.62	12.03	12.14	28.75	3.15
12	51(CI-5xCI-9)	54.75	57.50	167.00	87.50	10.62	13.40	31.25	3.15
13	53(CI-5xCI-9)	55.25	57.00	175.50	85.25	12.27	13.65	29.00	2.78
14	61(CI-5xCI-9)	54.75	57.00	178.25	87.50	11.82	14.02	25.00	2.80
15	65(CI-5xCI-9)	55.25	57.25	187.62	94.88	12.80	13.95	29.00	3.10
16	67(CI-5xCI-9)	54.25	56.75	172.38	115.50	12.85	14.20	31.50	3.12
17	69(CI-5xCI-9)	53.50	56.25	164.75	86.25	11.85	13.40	26.00	2.45
18	72(CI-5xCI-9)	54.00	56.50	179.65	90.88	12.40	13.72	29.25	3.17
19	75(CI-5xCI-9)	55.25	58.25	187.88	102.12	12.82	14.50	33.00	3.50
20	82(CI-5xCI-9)	54.75	57.00	158.75	94.25	11.75	13.82	27.00	2.78
21	116(CI-5xCI-9)	54.25	56.25	188.38	102.38	13.68	14.67	37.75	3.88
22	119(CI-5xCI-9)	54.00	55.50	184.62	95.62	13.10	14.05	30.25	3.17
23	120(CI-5xCI-9)	54.75	56.50	181.40	92.40	12.05	14.30	32.00	3.22
24	122(CI-5xCI-9)	53.50	55.25	181.62	95.12	12.73	13.68	31.50	3.18
25	141(CI-5xCI-9)	56.25	57.75	172.12	84.25	15.50	14.27	29.75	3.10
26	146(CI-5xCI-9)	54.75	57.50	189.52	97.62	14.05	13.92	35.00	3.40
27	147(CI-5xCI-9)	53.50	56.00	157.75	74.20	12.00	14.35	30.75	2.70
28	149(CI-5xCI-9)	55.75	57.50	150.32	72.97	11.38	13.25	28.50	2.18
29	151(CI-5xCI-9)	54.75	56.75	155.68	73.90	13.33	12.97	28.75	2.58
30	158(CI-5xCI-9)	55.25	57.25	191.62	93.12	15.30	14.62	33.75	3.80
31	163(CI-5xCI-9)	54.50	57.25	182.99	93.53	12.25	14.05	28.00	3.38
32	165(CI-5xCI-9)	54.50	58.50	194.62	96.50	12.35	14.45	33.25	3.47
33	172(CI-5xCI-9)	54.50	57.00	173.94	89.12	12.73	13.35	25.25	2.80
CHECKS									
34	Deccan-103	54.50	56.25	178.38	93.00	13.38	13.48	32.25	3.22
35	CI-4xCI-5	55.00	56.75	178.12	91.88	12.38	13.70	30.00	3.40
36	CI-5xCI-9	53.25	55.50	180.62	87.25	12.85	13.55	29.25	3.20

EVALUATION OF MAIZE (*Zea mays* L.) INBRED LINES BY THEIR THREE-WAY CROSS HYBRID PERFORMANCE

M.G. Gangashetti 1996 S. J. PATIL
Major Advisor

ABSTRACT

The experiment was conducted to study the genetic nature of the newly developed inbred lines of maize and also to assess the performance of three-way hybrids for commercial exploitation. Three trials of the experiment comprising of 99 three-way cross hybrids involving newly developed inbred lines along with three checks were evaluated in RCBD with four replications during *kharif*-1995. Observation on eight quantitative characters were recorded on individual ten random competitive plants from each plot.

Anova in all the 3 trials revealed significant differences for all the traits under study except for ear length and ear diameter in trial II and trial I respectively. Based on mean yield performance three-way hybrids viz., 166 (CI-5 x CI-9), 116 (CI-5 x CI-9), 118 (CI-5 x CI-9), 158 (CI-5 x CI-9), and 164 (CI-5 x CI-9) were identified as potentially high yielding over the best check.

In all the 3 trials highest PCV and GCV were observed for grain yield per plot ear height and 100-grain weight indicating high variability in these character which can be exploited. Low values of PCV and GCV were observed for days to 50 per cent tasselling, days to 50 per cent silking, ear diameter, indicates that they are less amenable for improvement. Grain yield, ear height, days to 50 per cent silking, 50 per cent tasselling and 100-grain weight showed moderate heritability. Low to moderate heritability was exhibited by remaining characters.

Considerable heterosis over commercial check and best check was observed i.e., 14.46, 39.30, 20.50 and 14.46, 18.51, 14.10 for grain yield per plot and 11.54, 20.18, 17.00 and 11.54, 14.91, 17.00 for 100-grain weight in all the 3 trials respectively. Only six out of 99 crosses showed significant and negative heterosis for days to 50 per cent silking over commercial check and they were quite early by -0.47, -0.93 and -3.21 per cent, however, they were low yielders. None of the crosses showed significant positive heterosis over checks for plant height which indicates compact and desirable plant height.

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