

**ISOLATION AND EARLY GENERATION EVALUATION
OF INBRED LINES DERIVED FROM YELLOW POOL
POPULATION OF MAIZE (*Zea mays* L.)**

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I. INTRODUCTION

Maize (*Zea mays* L.; $2n = 20$) is an important cereal crop with high yield potential. The total production at world level has surpassed both sorghum and pearl millet gaining a third place after wheat and rice. The demand for maize grain is increasing every year due to its diversified use in poultry, piggery and industry.

During the year 2005-06, the total area in the country under maize cultivation was 7.58 m.ha. and the total production was 14.70 m.t. as compared to 14.17 m.t. during 2004-05. The increased production from Andhra Pradesh, Gujarat, Karnataka, Maharastra, Orissa and Tamil Nadu was due to the availability and adaptation of recently released hybrids (Anon., 2005).

Karnataka state ranked first in yield realization till 1996-97, but now (2004-05) it is lagging behind compared to Andhra Pradesh. The average productivity of maize in Karnataka state (3110 kg/ha) is much higher than the national productivity (1938 kg/ha). During 2004-05, a total of 8.5 lakh ha in the state was under maize with a production of 25.12 lakh tonnes and productivity of 3110 kg per ha. Area under maize is increasing rapidly in the state because of better environment, high yield and ease with which the crop is cultivated. Hence, there is an enormous scope to increase the productivity in Karnataka to a global level.

Maize is physiologically more efficient crop with high grain yield and wide adaptation. It is grown from 58° N to 40° S, from below sea level to altitudes higher than 3000 m and in areas of lower rainfall (250 mm) to high rainfall (5000 mm) (Shaw, 1988 and Dowswell *et al.*, 1996). However, it is mainly grown in the warmer parts of temperate regions and in humid-subtropical climate. The highest production is in areas with the warmest month isotherms from 21° to 27° C and a frost-free season of 120 to 180 days duration. Today, maize has become an all season crop in India.

Maize has more than 1000 industrial uses and mainly used for production of starch due to its high starch content (66.2 to 77%). Maize seed oil contains highest polyunsaturated fatty acid (PUFA), linoleic acid (61.9%) and it remains as liquid at fairly low temperatures which is helpful in combating heart diseases. Maize seed oil is also low in linolenic acid (0.7%) and contains a high level of natural flavour. Maize is used primarily as food for humans in Africa and Asian sub-continent.

Principal types of maize are dent, flint, pod, pop, soft or flour, sweet and waxy corn. The flinty and opaque are nutritional quality types with high tryptophan and lysine content, respectively. Maize is the only cereal, which can be used as food at various stages of its plant development. It is used as baby corn as soon as the plant flowers. Green ears of maize are used on large scale for roasting and boiling and consumed as food at dough stage.

In India, about 50-55 per cent of maize production is consumed directly as food, 30-35 per cent for poultry, piggery and fishmeal and 10 to 12 per cent in wet milling industry *viz.*, in starch and oil and about 3 per cent in dry milling for traditional requirement like *Dalia* and *Sattu*.

A number of genotypes *viz.*, single cross, three way cross, double top cross, double cross hybrids, composites, synthetic population are being cultivated by farmers.

Shull (1908 and 1911) gave the original concept for production and growing of single cross hybrids, but the cost of seed production has limited its utility. Jones (1918) suggested that double cross hybrids can be produced from two single cross hybrids to reduce the cost of seed production. Subsequently, with the improvement in vigour and yield potential of inbred lines and development of better cultural practices, single crosses were adapted for commercial cultivation in the advanced countries. The recent trend even in the developing and underdeveloped countries single cross hybrid are more popular due to their higher yield levels under favorable environments and uniformity in expression and low cost of hybrid seed

production. Hence, there is a greater scope for the exploitation of heterosis through single cross hybrids.

Beal (1880) was the first to conduct experiment on various hybridizations in maize. The inbreeding experiments were first reported by Darwin (1877) which continued for only one generation with limited impact on the future of maize breeding. East (1908) and Shull (1908, 1909) were first to report the results of their experiments on inbreeding and restoration of vigour upon crossing. Shull (1909) published "A pure line method of corn breeding", which outlined the three essential steps a) large scale inbreeding to obtain many homozygous or near homozygous lines, (b) testing the selected pure lines in all possible crosses and (c) utilizing the best cross for practical corn production. In early days when relatively few lines were available, it was common to evaluate inbreds in all possible cross combinations. However, as the number of inbred parents increased, the number of possible single crosses also increased rapidly involving much labour and resource for evaluation. Hence, a simple procedure was required for the preliminary evaluation of inbred lines. Davis (1927) suggested the use of inbred $\times$ variety or top cross test to evaluate the large number of inbred lines.

The efficiency and success of hybrid maize breeding depends on the contribution of heterotic effects from the superior inbred lines. The superior cross combination may be exploited as commercial single cross. Usually, the hybrid development programme in maize involves development of inbred lines, evaluation of inbred lines, crossing of selected inbreds and production of hybrids. In this context, a programme on development of inbred lines was initiated by using inbreeding system utilizing yellow pool as the base population. Yellow pool is a blend of 50 elite lines received from Directorate of Maize Research (DMR), New Delhi and inter mated for four cycles at Agricultural Research Station, Arabhavi. The S_2 lines derived from this population were evaluated by line $\times$ tester analysis involving four diverse testers in *kharif* season (2005) to know their performance, combining ability and nature of inheritance of different quantitative traits. The line $\times$ tester ($L \times T$) design is basically an extension of top cross analysis involving more than one tester (Kempthorne, 1957). Thus, keeping these views in background, the proposed work was undertaken to develop hybrids suitable for *kharif* season.

Objectives :

1. To study the magnitudes of variability in early inbreeding generations (S_1 and S_2) for plant morphological traits, grain yield and its components.
2. To study the nature of association between grain yield and yield components during inbreeding system.
3. To study the *per se* performance of single cross hybrids for grain yield and its components.
4. To evaluate the combining abilities of parents for various yield component traits.
5. To study the level of heterosis for grain yield and its components.

II. REVIEW OF LITERATURE

The available research findings related to the present investigation on maize have been reviewed and presented under following headings:

- 2.1 Base population
- 2.2 Inbreeding generation
 - 2.2.1 Variability, heritability and genetic advance.
 - 2.2.2 Association studies
- 2.3 Top cross testing
- 2.4 Line $\times$ Tester analysis
- 2.5 Heterosis

2.1 BASE POPULATION

In maize breeding programmes, base population is a prerequisite to develop inbred lines. This fact has been very much realized in the present scenario wherein most of the inbred lines have been developed from one or two base populations, such as Tuxpeno sequio and B-73, BS-1, BS-11, CML-85, CML-79, FS8A and FS8B in case of maize in USA. In this regard the development of indigenous base population is very essential in order to generate new high yielding and pest and disease resistant inbred lines.

Role of base population

1. The superiority of inbreds directly depends on the presence of desirable genes and gene complexes in the base population.
2. Efficiency of the selection during inbreeding in various cycles also determines the superiority of inbreds.

Development of inbred lines for commercial use in hybrid combinations is one of the most important objectives of maize breeding programme. For improving the yield potential of varieties and hybrids, the decision should be made about the choice of the right type of parents for hybridisation. Combining ability analysis is frequently employed to identify the desirable parents and the nature of genetic variation. The general combining ability and specific combining ability effects are important indications of the potential value of inbreds in hybrid combinations. Differences in GCA have been attributed to additive and additive $\times$ additive and higher order interaction of additive genetic effects in base population, while differences in sca effects have been attributed to non-additive variance (Falconer, 1964).

Carlone and Russell (1988) used S_2 as base population derived from 247 random lines from Iowa Stiff Stalk Synthetic (BSSS) by single seed descent.

Hoard and Crosbic (1986) studied the correlated changes in agronomic traits of maize developed as the base population after five cycles of recurrent selection in BS13 (SLT) and BSSS2 (SLT) populations.

Horner *et al.* (1989) developed S_2 base population by taking up four cycles of full sib selection of all lines resistant to southern corn leaf blight resistance.

Eathington *et al.* (1997) developed S_1 , S_4 and S_5 population by selfing the F_2 progeny of BS11 (FRUIT) C7 and FRM017 in order to study the early generation testing for combining ability using molecular markers.

Roger *et al.* (1998) used S_2 as the base population developed from BS11 population in order to study the selection response and reported that S_2 progeny selection had a greatest response for grain yield of 4.5 per cent per cycle when compared to others.

Venkatesh *et al.* (2001) selfed to improve populations of CMIP 2-7 for two generations and later one generation of plant to plant sibbing to generate S_3 , which formed the base for their study.

A purview of the cross combinations with high heterosis shows that the testers drawn from diverse sources have given heterotic crosses in combination with the sister line crosses (SLCs) developed. The results on the *per se* performance of line crosses vis-a-vis experimental hybrids revealed that a majority of the high yielding SLCs recorded high values for various yield related traits.

2.2 INBREEDING GENERATION

Inbreds are the basis for developments of specific hybrids in maize. Hence, inbreeding methodology has been used to develop new inbreds since the period of Shull (1909). The consequence is that it increases homozygosity by bringing together identical alleles at a locus. This serves the purpose of maintaining genotypes through multiple generation of seed production though there is reduction in the mean phenotypic value due to inbreeding as a result of inbreeding depression (Fehr, 1987). However, in maize, it is dependent on number of segregating loci, the level of directional dominance and allelic frequency (Benson and Hallauer, 1994).

In case of maize, Genter (1971) reported that inbreeding depression rate for grain yield was unchanged after four cycles of S_1 progeny selection in VCBS maize population. But Rodriguez and Hallauer (1988) worked on inbreeding in S_0 , S_1 and S_2 bulked populations of maize and reported that one or two generations of inbreeding is not sufficient to cause the change in allelic frequency.

2.2.1 Variability, heritability and genetic advance

The studies on partitioning the total variability into heritable and environmental components had their beginning from the work of Johannsen (1909) and East (1916). The classical experiment of Johannsen (1909) demonstrated that both heritable and non-heritable agencies contributed to somatic variation in segregating populations and that variation in pureline was entirely environmental. East (1916) further confirmed the work of Johannsen (1909) and demonstrated how such results were obtained.

Based on non-segregating populations, Charles and Smith (1939), Powers (1942) and Powers *et al.* (1950) separated the genetic variance from total variance by the use of estimates of environmental variance.

Yield is the product of action and interaction of the vital activities of the plants throughout the life cycle. Therefore, for rational improvement of crop yields, an understanding of the heritable portion of the total variation for the desirable character becomes essential. This has induced the biometricians to study the variability and heritability of yield and other yield contributing components (Grafius, 1959 and Dewey and Lu, 1959).

The extent of genetic variability present in the breeding materials is a pre-requisite for deciding the appropriate breeding methodology for the improvement of specific characters, where the phenotypic variability is less utilised in breeding programme because it arises due to interaction of genotype with the environments.

Adaptability of genotypes varies greatly due to their genetic differences. Some strains can perform well under wide range of environments, while others require specific conditions for the expression of their genetic potential. The environmental conditions have a significant effect on the expression of yield and other quantitative characters. The evaluation of genotypes under several environmental conditions provide information on the relative magnitude of phenotypic and genotypic variability and the extent of genetic advance that can be made by studying the material under more than one environment has been emphasised by Comstock and Robinson (1952), Johnson *et al.* (1955), Nei and Syakudd (1957), Athwal and Singh (1966) and Mital *et al.* (1969).

Moll *et al.* (1960) reported that the amount of genetic variability of a parental cross is influenced by the amount of genetic variability present in the parent and by the degree of genetic variance of the varieties.

Welhansen (1965) reported that the local maize varieties in India were genetically more uniform and lacked adequate variability. Singh and Nigam (1977) also had expressed that the variability in indigenous germplasm of maize was not extensive. He further pointed

out that the variability in plant characters in maize germplasm of North-Eastern Himalayan region is more in comparison to Indo-Gangetic plane.

Sanghi *et al.* (1983) observed a sizeable portion of additive genetic variance for grain yield and its characters. They also suggested that the full sib selection is more effective as compared to mass selection. Higher amount of phenotypic coefficient of variation for grain yield, ear height, number of kernels per ear and 100 grain weight was observed by Ganguli (1986) indicating the scope of improvement of these characters.

Heritability

Different methods were developed for estimating heritability. Lush (1940) used parent progeny regression method for estimating heritability. A slight modification of this version was proposed by Frey and Horner (1957), *i.e.*, standard unit method. Kempthorne and Curnow (1961) and Gardner (1963) proposed a method for estimating heritability from combining ability analysis, wherein variance components were used for estimating additive and non-additive genetic variances. This method was used by several scientists like Dhillon and Singh (1977a) and Bohm and Schuster (1985) for estimating heritability in maize.

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 per cent. Klein (1975) and Ivanovic (1979) also observed low heritability for grain yield. Dhillon and Singh (1977a) quoted broad sense heritability estimates of 48 per cent. Similarly, Bohm and Schuster (1985) reported low heritability estimate (18 %) for grain yield.

The estimation of broad sense heritability (V_G/V_P) is useful to predict the response even though it has got some limitations. Estimating heritability along with genetic gain is usually more useful in predicting the resultant effect from selecting the best individual (Johnson *et al.*, 1955).

Heritability estimate in maize was reported by several workers. Leng (1963) analysed the yield components and related metric traits indicated that heritability of grain yield was higher than that of corresponding metric traits on the basis of constant parent regression analysis of data. Strube (1967) in an analysis of complete diallel set of 14 flint and six dent inbreds observed that heritability for yield was low and high estimates for days to flowering.

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

Swamy Rao *et al.* (1970) reported moderate to high heritability estimates of 55.55 and 86.04 per cent for ear diameter, whereas Patil *et al.* (1972) noticed moderate heritability of 68.88 per cent for this trait. Similarly, El-Hosary (1987) noticed moderate to high heritability for this trait.

Swamy Rao *et al.* (1970) reported low heritability (23.42%) for plant height. Similarly, moderate to high broad sense heritability was noticed by EL-Hosary (1987). In another study, high heritability estimates of 70 per cent for plant height in 3-way cross hybrid maize was noticed by Saadalls and Kadam (1988), Debnath *et al.* (1988) and Mahamoud *et al.* (1990) noticed high heritability for these traits.

Swamy Rao *et al.* (1970) reported that the simple grain yield, ear length, number of rows per ear and ear diameter showed high genetic advance and high heritability. Daniel (1974) observed that broad sense heritability was 42 per cent for days of flowering in maize. Daniel and Bajtay (1975) estimated high broad sense heritability for number of grain rows per ear (0.892), length of upper ear (0.829), height of insertion of top ear (0.831) and plant height (0.813). Dhillon and Singh (1976) noted that narrow sense heritability was low for grain yield, high for plant and ear height, number of kernel rows and moderate for ear diameter and ear length. Konarev *et al.* (1976) observed the high heritability for height of ear insertion, number of grain rows per ear, 1000 grain weight and earliness.

Dhillon and Singh (1977a) studied the inheritance of grain yield and other quantitative traits in maize and observed that broad sense heritability estimates were high for all traits except grain yield and grain moisture, while narrow sense heritability estimate were high for all traits except grain yield and ear length.

Ivanovic (1979) reported high narrow sense heritability for the ear length and grain yield per plant. Saxsena *et al.* (1996) noted high heritability for plant height, ear height, ear girth and kernel rows per ear and low for grain yield, ear length and number of kernels per row. Maximum genetic gain was reported for ear height.

Radovic (1979) and Johnson (1981) reported moderate to high range of heritability for 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, Mahmoud *et al.* (1990) observed high broad sense heritability, while 52 per cent broad sense heritability for this trait was reported by Alika (1994).

Bhalla *et al.* (1986) in their study reported high heritability estimates associated with high genetic advance for grain yield per plant, ear placement height, number of kernel rows per cob and plant height. Shahi and Singh (1986) reported high heritability for days to flowering, plant height and ear height. The expected genetic gain was about 17 per cent for plant height and 12 per cent for ear height in one of the locations. Liao *et al.* (1987) observed that ear position showed the highest broad sense heritability followed by earliness and 100 grain weight.

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

Stem thickness showed the highest narrow sense heritability followed by ear position, thousand grain weight and ear girth. Debnath (1987) found that heritability was high for plant height and ear height, but low for the remaining characters. Expected genetic advance was high for grain yield, plant height and ear height. Dawod and Mohamad (1989) reported high heritability for ear diameter and number of kernel rows per ear in maize.

Odiemah (1992) stated that broad sense heritability estimates were high, while narrow sense heritability estimates ranged from 0.26 to 0.76 per cent including grain yield.

Altinbos (1995) reported low heritability estimates and suggested that selection for ear length and ear diameter in early generations.

De (1996) studied diallel analysis for 11 quantitative characters and reported that heritability in broad sense for all the characters under study.

Mani and Bisht (1996) in their study on variability in local germplasm of maize reported high heritability estimates (broad sense) and high genetic advance for grain yield, ear height and moderate for plant height. Singh (1996) in his study of 8 × 8 diallel (excluding reciprocal) reported moderate heritability (narrow sense) for ear length and ear diameter. Whereas, high genetic advance for yield per plant, ear length, moderate for kernel rows per ear and plant height and low for other traits were also recorded.

Satyanarayana and Saikumar (1997) studied genetic variability of 45 F₁ diallele crosses for grain yield and reported high phenotypic, genotypic variance and heritability estimates for grain yield.

El-Hosary *et al.* (1990) reported information on genetic advance and heritability estimation for six grain yield related characters in three crosses.

Muhammad Rafique *et al.* (2004) studied the estimates of heritability which were higher than 80 per cent for all parameters indicating heritable variation among genotypes. Heritability values for number of kernels per row, plant height and grain yield per plant were higher than the other characters.

In a study by Muhammad Rafique *et al.* (2004) noticed the differences between genotypic coefficients of variance (GCV) and phenotypic coefficients of variance (PCV) for all

characters studied, indicating that the role of environmental factors in the development of these parameters.

2.2.2 Association studies

Grain yield is influenced by several quantitative characters and is more influenced by environmental factors in which the plant is grown. Selection based on simple correlation may be useful in some cases, but considering the inter-correlation (interaction effects) between various components with grain yield. Therefore selection based on grain yield performance only may create confusion and give a biased result. Grain yield in maize as in other crops is associated with a number of yield components. A study of the nature and degree of association of these components with yield assumes greater importance for fixing up characters that play a decisive role in influencing yield. Selection would therefore be more effective if it is based on component characters rather than directly on grain yield.

Hayes and Johnson (1939) reported that grain yield of top crosses were correlated positively with leaf area and stalk diameter. Jugenheimer (1948, 1949a, 1949b, 1949c, 1958) reported that grain yield was correlated positively and significantly with the leaf area and stover characters among S_1 inbred lines.

According to Appadurai and Nagarajan (1975), grain weight per ear and grain numbers per row had little effect on yield, while ear length and ear circumference had positive correlation with yield.

Kim (1975) and Hallauer (1989) reported correlation coefficients among the traits were generally positive and significant for plant height and ear height.

Probecky (1976) reported that grain yield primarily depends on the number of grains per plant; which in turn depend mainly on the number of grains in the rows. Utkhede and Shukla (1976) revealed highly significant positive genotypic and phenotypic correlation between yield and number of grain rows per ear, weight of ear, ear height and ear length. Ear height and dry ear weight contributed substantially to yield. Singh and Nigam (1977) found that grain yield was positively and significantly correlated with five yield components *i.e.*, 100 grain weight, number of kernel rows per cob, ear weight, ear diameter and number of grain per rows.

Mohammad Saleem and Mohammad Yousaf (1979) reported high significant correlations between yield and ear number per plant, kernel number per row and kernel number per ear. Zozulya (1979) reported a close positive correlation between number of grains per ear and number of grain rows per ear. Leptev and Yu (1980) concluded that yield was correlated positively with plant height, height of ear attachment and substantial negative correlation was recorded between number of ears per plant and hundred grain weight.

Karavaev (1982) observed close correlation between grain yield and the following characters. Weight of single ear ($r=0.92$), 1000 grain weight ($r=0.87$), number of grains per ear ($r=0.75$) and leaf area ($r=0.89$). Sharma *et al.* (1982) reported that grain yield was positively correlated with grains per ear, hundred grain weight, plant height and ear height. El-Nagouly *et al.* (1983) concluded that phenotypic and genotypic correlation between yield and ear height was positive and highly significant.

Saha and Mukherjee (1985) observed that grain yield per plant was significantly correlated with ovules per ear, grains per ear and 100 grain weight. Malhotra and Khehra (1986) recorded positive correlation between grain yield and yield components like ear length, ear circumference, number of rows per ear, 1000 grain weight, shelling percentage, ear height and plant height.

Tyagi *et al.* (1988) opined that grain yield was influenced more by ear weight, ear length, plant height, kernels per row and 100 grain weight. Mahajan *et al.* (1990) concluded that grain yield was positively correlated with ear length, number of kernels per row and plant height.

Singh *et al.* (1991) noted that grain yield per plant had significant positive correlations with plant height and ear height in F_1 and F_2 generations under alkaline soil and with leaf area in both the generations under normal soil. Debnath and Khan (1991) revealed that plant height, number of kernels per row and 1000 grain weight had strong positive contributions to

grain yield. Boraneog and Duara (1993) observed that plant height and ear height exhibited significant positive correlation with grain yield.

Saha and Mukherjee (1993) reported positive significant correlation between grain yield per plant with 100 grain weight, ear length, ear circumference, number of kernel rows per ear and number of kernels per row, the ear circumference and number of grains per row. Krishnan and Natarajan (1995) obtained high positive association between grain yield and plant height, ear length, ear weight and number of kernels per row. Rahman *et al.* (1995) reported that grain yield was significantly and positively correlated with plant height, ear height, number of grains per ear and 1000 grain weight.

According to Satyanarayana (1996), grain yield was positively correlated with number of kernel rows per ear, ear length, ear circumference and 100 grain weight. According to Kumar and Kumar (1997), values of genotypic correlation were slightly higher than the corresponding phenotypic values. Significant positive correlation was recorded for plant height, ear length and ear height with yield per plant.

Zhang-Luxiao and Yan-Wel (1997) studied the coefficient of variation for 100 grain weight in hybrids which was 14.6 per cent.

Annapurna *et al.* (1998) reported that seed yield was positively and significantly correlated with plant height, ear circumference, number of seeds per row, number of seed rows per ear. Dutu (1998) reported correlations using the date of flowering, plant height and the number of leaves which were used as indirect selection criteria and resulted in positive correlated response in earliness and yielding potential.

Khakim *et al.* (1998) noticed that grain yield was positively correlated with plant and ear insertion height, leaf area, ear number, ear length, number of kernel rows per cob, number of grains per row and grain weight per cob, ear weight and 1000 grain weight. Manivannan (1998) reported that ear circumference; number of kernels per row, 1000 grain weight, kernels per row and ear length had significant positive correlation with grain yield.

Alok Kumar *et al.* (1999) revealed that the number of grains per row, number of rows per ear, ear circumference and ear length had direct effect on grain yield. Dutu (1999) indicated that at phenotypic and genotypic levels, growth period was strongly correlated with plant height and leaf numbers.

Firoza Khatun *et al.* (1999) reported that grain yield per plant was positively and significantly correlated with 1000 grain weight, number of kernels per ear, ear circumference and ear insertion height.

Gautam *et al.* (1999) reported maximum correlation between grain yield and number of kernels per row, leaf area, plant height and cob length.

Mani *et al.* (1999) reported that grain yield per plant indicated that highly significant positive correlation with all the attributes and was highest with ear weight per plant. Mohammad Basheruddin *et al.* (1999) reported that correlation coefficients had highly positive significant influence on plant height, number of leaves, leaf area per plant and stem girth.

Nawar *et al.* (1999) observed that additive components were significant for number of kernel rows per cob. Highly significant positive correlation coefficients were detected among yield per plant, components of ear and plant height.

Netaji *et al.* (2000) reported that yield per plot was significantly and positively correlated with all the characters except dry husk. Umakanth *et al.* (2000) observed that yield per plot was positively correlated with plant height, 1000 grain weight and number of kernels per ear. Vaezi *et al.* (2000) noticed that grain yield was significantly and positively correlated to ear weight, ear circumference, number of kernel rows per cob and number of kernels per row.

Geetha and Jayaraman (2000a) studied the effects of different quantitative traits on grain yield in 90 hybrids. Kumar and Kumar (2000) suggested that selection based on plant height with greater ear weight, number of seeds rows per ear and number of seeds per ear was desirable for grain yield.

Pradeep Kumar and Satyanarayana (2001) concluded that grain yield was positively associated with plant height, ear height, ear length, ear circumference, number of seed rows per ear and test weight.

Swarnalatha Devi and Shaik Mohammed (2001) indicated that plant height, ear length, number of seeds per row and 100 grain weight positively influenced the yield directly and also indirectly through several yield components.

Umakanth and Khan (2001) observed that grain yield per plot showed significant positive correlation with ear circumference, ear length, plant height and 100 seed weight. Guang-Cheng *et al.* (2002) noticed that grain yield per plot had significant positive correlation with 100 kernel weight.

Venugopal *et al.* (2003) indicated that plant height, ear height, ear length, ear girth, 100 seed weight and number of seeds per row were positively associated with grain yield.

Although the character number of seed rows per ear had a direct positive contribution towards grain yield, but it had indirect negative influence through ear length, 100 seed weight and number of seeds per row.

Arun Kumar and Singh (2004) reported that cob length had maximum positive direct effect on grain yield at genotypic and phenotypic levels, respectively. Path analysis revealed that six characters had positive contribution to grain yield via number of other characters both at genotypic and phenotypic levels.

Bao Heping *et al.* (2004) revealed that grain yield was mainly influenced by ear length followed by number of kernels per row, ear width, number of kernel rows per ear, growth period and 1000 seed weight.

Muhammad Rafique *et al.* (2004) reported that the grain yield was positively and significantly associated with all parameters studied. Number of Kernels per row was positively correlated with grain yield followed by plant height, ear height, ear length and its diameter.

El-Shouny *et al.* (2005) evaluated under two planting dates to estimate phenotypic correlation and results showed that grain yield per plant correlated positively and significantly with ear diameter, ear length, number of kernels per row, 100 kernel weight, number of rows per ear, ear height, plant height under normal planting and with number of kernels per row, ear diameter, 100 kernel weight, ear length, number of rows per ear, ear height under late planting.

Reddy *et al.* (2005) reported that no association was found between mean *per se* and all other estimates. They noticed that general combining ability failed to exhibit closer association in grain yield per plant and ear length.

2.3 TOP CROSS TESTING

The use of top cross testing is an efficient method for 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. Lindstorm (1931) suggested the commercial use of top crosses. The use of top crosses is one of the methods for early evaluation of inbred lines and specially useful for determining general combining ability of a large number of inbred lines.

Jenkins and Brunson (1932) reported significant correlation between yields of inbred lines crossed *per 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.

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 some lines if deemed desirable. The remaining material also might be compared in standard yield tests to determine the superior inbred lines and hybrids.

The top cross test with a heterogenous tester gives valuable information for characters that are not complex in inheritance. Also, this test will identify those lines that contribute low yield to hybrid combinations. According to Genter (1963), genes from the tester parents were found to mask and interact with the genes of the inbreds 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 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 inbreds being tested can be evaluated in top crosses.

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.

Russell (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 trials and at much lower cost. He suggested that visual selection may be carried out for about three generations of progeny line evaluation.

Russell (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 procedure having maximum efficiency require greater emphasis on non-additive effects.

Pilar Soengas *et al.* (2006) reported that test crosses showed variation due to GCA of varieties and was significant for early vigour, whereas GCA of testers was not significant for early vigour.

2.4 COMBINING ABILITY

Line $\times$ tester mating design is a modified form of the top cross scheme proposed by Davis in 1927 for inbred evaluation.

The concept of combining ability was originally evolved through the work of Davis (1927) who suggested that use of inbred $\times$ variety cross to test the combining ability of inbreds in maize. It may be defined as the ability of a strain to produce superior progeny upon hybridisation with other strains. Combining ability provides information about the nature and magnitude of gene action controlling various quantitative characters.

The concept of combining ability was put forward by Sprague and Tatum (1942). According to them, general combining ability is the average performance of a strain in series of cross combinations estimated from the performance of F_1 s from the crosses, whereas specific combining ability is used to designate those cases in which certain combinations do relatively better or worse than would be expected as the basis of average performance of lines involved.

Henderson (1952) defined general combining ability as the average merit with respect to traits or weighted combination of traits of an infinitely large number of progeny of an individual or line when mated with random sample from some specific population under a specified environmental circumstances. He defined specific combining ability as deviation, an average of infinitely large number of progeny of two individuals or lines, as the value of which would be expected on the basis of known general combining ability of their two lines or individual and the maternal ability of the female parents.

The general combining ability is associated with genes which are additive in effects and specific combining ability is attributed primarily to deviation from the additive scheme caused by dominance and epistasis (Rojas and Sprague, 1952).

Griffing (1956) has shown relationship between various heritable variance components and GCA and SCA variances. Thus GCA variance is due to additive variation

and additive $\times$ additive interaction variance, while SCA variance is due to dominance variance, additive $\times$ additive variance, additive $\times$ dominance variance and dominance $\times$ dominance variance components.

Estimates of the variances due to GCA and SCA provide an appropriate diagnosis of the predominant role of additive or non-additive variance.

The line $\times$ tester technique was developed by Kempthorne (1957). Among the different biometrical methods employed to study combining ability, line $\times$ tester is the most widely used method.

Allard (1960) reported that the combining ability analysis is highly useful technique for the plant breeder which provides indication of the genetic behaviour of the parental material and is therefore desirable to select the parents for hybridization on the basis of their combining ability.

Ratio of additive and non-additive gene action is to be considered in order to decide the predominance of the kind of genetic variation for a given character. If the ratio of additive to non-additive gene action is more than unity, indicates the major role of additive variance in controlling the expression of a character, whereas less than unity indicates the importance of non-additive variance (Gardner, 1963).

Strube (1967) reported that sca effects were greater than gca effects for yield, while the reverse was true for the other characters.

Piovarci (1973a) analysed a diallel cross and noted that GCA was more important than SCA for yield and additive genetic effects were of greater importance than non-additive.

Cross (1986) noted high general combining ability effects for high grain yield. Muthiah (1989) reported that the proportion of GCA variance was higher than the SCA variance showing preponderance of additive genetic effects for all the characters studied.

Satyanarayana (1995) recorded low genotypic coefficient of variance combined with low to medium heritability and low genetic advances for grain yield. In case of other agronomic characters, genotypic coefficient of variance estimates were high combined with high heritability and genetic advance indicating the inheritance of additive gene action controlling these traits.

Dass *et al.* (1997) reported that non-additive gene action played major role in the inheritance of grain yield and majority of ear traits. But According to Altinbas and Tosum (1998), GCA and SCA variances for grain yield per plant and other yield components indicated that screening parental lines and crosses based on combining ability effects for 100 grain weight and ear length should be effective.

Dutu (1998) observed that plant height was controlled by additive and non-additive gene actions and cytoplasmic inheritance, whereas number of leaves per plant was controlled by additive gene effects only. Lou-Xiang Yang (1998) concluded that most plant and ear characters were improved with additive and dominance effects of the female parents. Mikhailov and Chernov (1999) reported that partial dominance of the positive allele is the main type of allelic interaction in the loci controlling kernel row number. Yu Zhongliang *et al.* (1999) concluded that endosperm genetic effects controlled most of the traits although maternal effects were predominant and utilization of maternal heterosis was an effective way of improving traits.

Kadlubiec *et al.* (2000) obtained higher GCA values than those of SCA for majority of traits which suggests the importance of additive gene action. Non-additive gene effects were responsible for the inheritance of lodging resistance. Ramesh *et al.* (2000) observed greater ratios of GCA to SCA mean squares for all traits except for number of seed rows per ear, indicating the importance of non-additive gene effects in their genetic control. Rosa *et al.* (2000) obtained highest SCA values in 13 $\times$ 13 diallel crosses, viz., AS-910 $\times$ AS-4450 and PP-9538 $\times$ AS-948.

Desai and Singh (2001) reported significant difference in gca and sca effects for the traits, viz., plant height, ear height, number of leaves per plant. Kara (2001) observed significant gca effects for all the traits and significant sca effects for ear circumference, ear height and grain yield per unit area. Konak *et al.* (2001) obtained non-additive gene effects for

ear length and number of kernel rows per ear and additive gene effect for yield, 1000 kernel weight, plant height, ear height and days to silking. Mandal *et al.* (2001) noticed significant GCA and SCA variances for most of the traits studied. Ganguli (1986) observed that both additive and non-additive genetic components for 100 grain weight and shelling percentage in CML 85 and CML 79. The crosses showed positive and highly significant specific combining ability effect for grain yield.

Fan-Xing Ming *et al.* (2001) studied that variance analysis of seed yield showed that highly significant differences existed between genotypes and between ecological environments while no significant difference was observed between replications.

Vidal Martinez *et al.* (2001) obtained better *per se* combining ability for pollen yield of Corn Belt genotypes and good combining ability for grain yield and their components for exotic genotypes. Dominance gene effects were the most important contributors to the inheritance of pollen yield, grain yield and their components.

Ashish-Srivastava and Singh (2002) reported that the specific combining ability variance was greater than general combining ability variance indicating the importance of non-additive gene effects for all characters.

Katna *et al.* (2002) observed preponderance of additive gene effects for all traits.

Vacaro *et al.* (2002) reported that mean square for gca effects was greater than that for sca effects for the traits like plant height, point of insertion of the first ear, number of ears per plant, number of grains per ear, root and stalk lodging and grain yield, indicating the predominance of additive effects.

Anees-Ahmad and Muhammad-Saleem (2003) observed that both additive and non-additive gene effects played an important role in the genetic control of all the traits. The estimates of mean of squares due to general combining ability were significant for all the traits except growing degree days in both F_1 and F_2 generations. Mean squares due to specific combining ability were significant for all the traits in both the generations.

Abdel-Sattar (2004) observed that value of GCA and SCA were increased from 53 to 55 self generations. The ratios of GCA/SCA through all self generations showed greater role of dominance variance than that of additive variance. Lines contributed much more than the testers to the total genetic variation.

Fan Xing Ming *et al.* (2004) revealed that the inbreds had high combining ability for grain yield of ten quality protein maize (QPM) lines and showed high general combining ability (GCA) and it is possible to get high yielding crosses by using them as parents. The results from the yields of F_1 crosses suggest that lines with high GCA and specific combining ability (SCA) should be selected as parents.

Koinuma *et al.* (2004) noticed that new inbred line H049 shows high combining ability with dent inbred lines.

Malik *et al.* (2004) observed highly significant gca effects for all the traits under study, but sca effects were less significant in certain cases suggesting predominance of additive genes. High gca effects for grain yield were observed in the temperate material, *i.e.*, QPM-1 (0.168), QPM-3 (0.169) and QPM-5 (0.485), while sca effects were remarkable for hybrids QPM-3 $\times$ NCML-1078 (0.890), NCML-NCML-1084 (0.878) and NCML-1082 $\times$ NCML-1083 (0.831).

Vafias and Ipsilandis (2005) observed that rapid lines developed from combining half sib/ S_1 evaluation may ensure high and stable crossing performances, based on additive gene action, stability and uniformity of performance of three way crosses was due to proper breeding in single cross hybrid and high stable inbred line performance.

Sheena Lukose and Godawah (2007) reported the crop geometry under four different environmental conditions, the data were recorded on yield and its related different morpho-physiological traits. These results revealed significant contribution of line $\times$ testers towards GCA variance and of line $\times$ testers towards SCA variance. The preponderance of non-additive gene effects for grain yield in maize was also reported earlier in addition to significant positive gca effects for grain yield per plant, ear per plant.

2.4.1 Character-wise review

The review of literature pertaining to combining ability in respect of 16 quantitative characters, viz., plant height at 30 days after sowing (DAS), stem girth/thickness at 30 DAS, leaf area at 30 DAS, plant height at 60 DAS, ear height at 60 DAS, cob weight, cob length, cob girth, number of kernel rows, number of kernels per row, number of kernels per cob, pith weight, 100 kernel weight, shelling percentage, grain weight per plot have been reviewed and presented as under.

2.4.1.1 Plant height at 30 DAS

Revilla *et al.* (1999) reported significant GCA and SCA variance for early vigour and plant height.

2.4.1.2 Plant girth at 30 DAS

Revilla *et al.* (1999) reported significant GCA and SCA variance for early vigour.

2.4.1.3 Leaf area at 30 DAS

There are no reports available in the literature on leaf area at 30 DAS.

2.4.1.4 Leaf area at 60 DAS

Pavilikova and Rood (1987) indicated that dominant and over-dominant effects was responsible for increased leaf area in maize. The ratio of GCA / SCA mean squares showed that gca effects were more important than sca effects. Malik *et al.* (2004) reported that temperate material gave high gca effects for striking characters contributing towards high grain yield, i.e., leaf area.

2.4.1.5 Plant height at 60 DAS

According to Dhillon and Sing (1976), general combining ability was more important than specific combining ability for the inheritance of plant height. Bhalla and Khehra (1977) reported on general and specific combining ability for plant height. They further indicated the importance of additive genetic variance in the inheritance of this trait. Narain (1978) reported that gca effects were highly significant for characters plant height and sca effects were also significant for this trait.

Ramamurthy (1980) reported the predominance of additive gene effects for plant height. Equal importance of both additive and non-additive components in the inheritance of plant height was opined by Sharma *et al.* (1982). Singh *et al.* (1983) reported predominant role of GCA variance for this trait, while predominant role of SCA variance was reported by Gue *et al.* (1986), Herbert and Gallis (1986) and Pal *et al.* (1986).

Predominant role of additive genetic variance in the inheritance of plant height was reported by Shahi and Singh (1986) and Crossa *et al.* (1987). Ali and Topera (1986) noticed that the additive gene action was more important than non-additive gene action for plant height. Significant maternal effects were reported by Melchinger *et al.* (1986) for plant height. Diallel analysis revealed that epistatic variance for yield was significant and negative in 11 out of 15 crosses studied. As per Debnath and Sarkar (1987), both additive and non-additive components were important. Prasad *et al.* (1988) studied combining ability of maize for plant height and reported that the mean square due to GCA, SCA were significant for this character. Zargar and Singh (1990) suggested that additive components of variance with dominance played a major role in the inheritance of plant height.

Predominant role of additive genetic variance in the inheritance of plant height was reported again by Crossa *et al.* (1990) and Vasal *et al.* (1992) higher estimates of GCA variance for plant height was recorded by Jha and Khehra (1992), whereas predominance of non-additive variance was observed by Anuradha *et al.* (1993). The importance of SCA variance was reported by El-Hosary *et al.* (1994a) and Zheng-Zuping *et al.* (1995) reported predominant role of GCA variance. According to Packiraj (1995), GCA variance was greater in magnitude than SCA for plant height.

Dehghanapour *et al.* (1997) reported that non-additive component was important for this trait, Geetha (1997) added that proportion of GCA variance was higher than the SCA

variance having preponderance of additive genetic effects for characters such as plant height and Petrovie (1998) reported that non-additive component was important for plant height, while equal importance of both additive and non-additive components in the inheritance of plant height was opined by Choudhary and Singh (1997) and Kumar *et al.* (1998). According to Singh and Singh (1998), SCA variance was important for the character like plant height. Paul and Debnath (1999) obtained significant gca and sca effects for the character studied, *like.*, plant height. Talleei and Kocha Ksarai (1999) observed significant gca effects for plant height.

Geetha and Jayaraman (2000b) reported that additive and dominance components were significant for plant height. Suneetha *et al.* (2000) noticed significant variances for GCA and SCA for plant height. Zelleke (2000) had derived the information from data on plant height from a diallel mating that both gca and sca effects were significant for this traits. Saikumar (2002) reported sca effects for plant height. Malik *et al.* (2004) reported that temperate material gave high gca effects for striking characters contributing towards high grain yield, *i.e.*, plant height.

The results obtained by Fan-Xing Ming *et al.* (2005) showed that the difference in general combining ability and specific combining ability for plant height was highly significant. The variance of additive effect was higher than that of the non-additive effect.

2.4.1.6 Ear height

On the other hand, the preponderance of non-additive genetic variance was reported by various workers using different mating systems (Robinson, 1968 using design I; Darrah and Hallauer, 1972 and Satyanarayana *et al.*, 1990 in diallel analysis; Anuradha *et al.*, 1993 in line $\times$ tester analysis.

The equal importance of additive and non-additive genetic components for ear height were reported by Kalsy and Sharma (1970) in a varietal diallel analysis. Similar results were also recorded by Regazzi *et al.* (1980) for ear height using top cross analysis. Landi *et al.* (1986) inferred that both gca and sca effects were of equal importance for ear height using half diallel analysis. According to Singh and Singh (1998), SCA variance was important for the character like ear height. Paul and Debnath (1999) obtained significant gca and sca effects for the character studied, *viz.*, ear height. Talleei and Kocha Ksarai (1999) observed significant gca effects for ear height. Saikumar (2002) obtained sca effects for ear height.

According to Dhillon and Singh (1976), general combining ability was more important than specific combining ability for the inheritance of ear height. Bhalla and Khehra (1977) reported general and specific combining ability for ear height. They further indicated the importance of additive genetic variance in the inheritance of the ear height. Singh *et al.* (1977) indicated that gca effects were significant for ear height, sca effect was not significant, additive genetic effects were important.

Narain (1978) reported that gca effects were highly significant and sca effects were also significant for this character. Ramamurthy (1980) reported the predominance of non-additive effects was important for ear height, while Sharma *et al.* (1982) reported equal importance of both GCA and SCA for ear height.

Greater importance of GCA variance than SCA variance with both being significant was reported by Zambezi *et al.* (1986) and Catherine and Pollak (1988). Predominant role of additive component in the inheritance of ear height was reported by Nawar (1986), Pal *et al.* (1986), Shahi and Singh (1986). Prasad *et al.* (1988) studied combining ability analysis of maize for cob placement indicating mean square due to GCA and SCA were significant for this traits. Zargar and Singh (1990) suggested that additive components of variance with dominance played a major role in the inheritance of ear height and Mahajan and Khera (1991) also reported the importance of additive component in the inheritance of ear height.

Jha and Khera (1987) reported significant additive effects for ear height. Mahajan and Khehera (1991) and Gupta *et al.* (1994) have also observed similar type of result for this character in a line $\times$ tester analysis.

Mean square due to GCA, SCA were significant for this character studied, while El-Hosary *et al.* (1994b) and Altinbos (1995) reported significance of only GCA variance. However, predominance of SCA variance in the inheritance of ear height was observed by

Sedhom (1994), while Dehghanpour *et al.* (1997) observed predominant role of non-additive component, equal importance of both additive and non-additive genetic variance was stressed by Kumar *et al.* (1998).

Malik *et al.* (2004) reported that temperate material gave high gca effects for striking characters contributing towards high grain yield, *i.e.*, ear height.

Surya Prakash and Ganguli (1989a) revealed that gene action appeared to be non-additive for all traits except for ear height, which are characterised by additive gene action. El-Moula *et al.* (2004) indicated that magnitude of delta 2-GCA was greater for ear heights. Interaction delta 2 SCA $\times$ L was higher than that of delta 2 GCA $\times$ L for all traits indicating that the non-additive type of gene action was more affected by environmental conditions than the additive type.

The results obtained by Fan-Xing Ming *et al.* (2005) reported that the difference in general combining ability and specific combining ability for ear height was highly significant. The variance of additive effect was higher than that of the non-additive effect.

2.4.1.7 Cob weight

Kumar (1974) revealed that SCA was high for cob weight. Alika (1994) observed highly significant variation due to GCA for ear weight. According to Packiraj (1995), SCA variance was high for ear weight indicating that dominance and epistatic gene action played a major role in the expression of this trait. Geetha (1997) observed that proportion of GCA variance was higher than the SCA variance having preponderance of additive genetic effects for character such ear weight. Geetha and Jayaraman (2000b) reported that additive and dominance components were significant for ear weight. Malik *et al.* (2004) reported that temperate material gave high gca effects for striking characters contributing towards high grain yield, *i.e.*, ear weight.

2.4.1.8 Cob length

Greater magnitude of additive genetic variance for controlling ear length in maize has been reported by Agrawal (1967), Cerrate (1968), Hallauer and Sears (1968), Sentz (1971), Dhillon and Singh (1976), Verma and Singh (1980), Qadri *et al.* (1983), Ganguli (1986), Alika (1994), Satyanarayana (1996) and Sinha and Mishra (1997). The importance of dominance variance for ear length has also been reported by several workers (Muthia *et al.*, 1989, Anuradha *et al.*, 1993, Pal and Prodhana, 1994, Choudhary and Singh, 1997).

Kumar (1971) reported that gca and sca effects were of a high magnitude for ear length. The importance of both gca and sca effects controlling ear length was reported by Ijardar (1977) and Baktash *et al.* (1981) in top cross test. In a 9 $\times$ 9 diallel analysis in maize, Debnath and Sarkar (1990) have reported the equal importance of both additive and non-additive genes for ear length. Mallikarjuna (1990) and Singh (1996) also observed the effects of additive and non-additive gene action for this character.

Martin and Hallauer (1976) studied diallel analysis for ear length and concluded that epistasis was more predominant for this character.

Bhalla and Khehra (1977) reported general and specific combining ability for cob length. They further indicated the importance of additive genetic variance in the inheritance of the ear length. Equal importance of both GCA and SCA variance in the inheritance of ear length was observed by Singh *et al.* (1983). As per Ali and Topera (1986), non-additive component was important for this trait. Shen and Lai (1987) stressed upon both the components of variance, GCA and SCA. Prasad *et al.* (1988) studied combining ability analysis of maize for cob length and reported significant mean square due to GCA and SCA for this character studied. A greater role of additive genetic variance was reported by Mahmoud *et al.* (1990). According to Debnath and Sarkar (1990) equal importance of both additive and non-additive effects were observed for ear length. Zargar and Singh (1990) suggested that additive components of variance with dominance played a major role in the inheritance of ear length.

Predominance of SCA variance was evident in the results of Mohammed (1993), Pal and Prodhana (1994), Sedhom (1994) and Sinobas and Moteagudo (1994). Alika (1994) observed highly significant variation due to GCA for ear length. El-Hosary *et al.* (1994b) and

Mathur and Bhatnagar (1995) reported predominant role of GCA variance in the inheritance of ear length. Mathur and Bhatnagar (1995) reported high gca effects for ear length. Khristova *et al.* (1995) observed the importance of non-additive component. For this trait, non-additive component was described to be as important as additive component by Turgut *et al.* (1995) and Kumar *et al.* (1998). Singh and Mishra (1997) studied significant differences for the character ear length.

A greater role of additive genetic variance was reported by Mathur *et al.* (1998). According to Singh and Singh (1998), GCA variance was more important for ear length. Li-Jizhu *et al.* (2004) reported that ear length had significant additive and dominance effects.

Zelleke (2000) had derived an information from data on ear length from a diallel mating that both gca and sca effects were significant for the trait ear length. Fan-Xing Ming *et al.* (2005) observed that the difference in general combining ability and specific combining ability for ear length was highly significant. The variance of additive effect was higher than that of the non-additive effect.

2.4.1.9 Cob girth

Kumar (1971) found that gca and sca effects were of a high magnitude for ear diameter. According to Dhillon and Singh (1976), general combining ability was more important than specific combining ability for the inheritance of ear circumference. Bhalla and Khera (1977) observed predominant role of non-additive genetic variance. Martin and Hallauer (1976) studied diallel analysis for ear circumference and concluded that epistasis was more frequent for this character.

Bhalla and Khehra (1977) reported general and specific combining ability for ear circumference. They further indicated the importance of additive genetic variance in the inheritance of this character.

Sharma *et al.* (1982) reported equal importance of both GCA and SCA for ear diameter. They further indicated the importance of additive genetic variance in the inheritance of the cob girth. Singh *et al.* (1982) reported the importance of additive genetic variance for this trait. As per Sharma *et al.* (1982), both additive and non-additive components were important, while Quadri *et al.* (1983) reported predominant role of GCA variance than SCA variance with both being significant. Ali and Topera (1986) noticed that the non-additive gene action was more important for ear circumference. Singh and Mishra (1996) studied significant differences for character ear girth.

In the inheritance of ear circumference, Pal *et al.* (1986) observed predominant role of non-additive genetic variance. Prasad *et al.* (1988) studied combining ability analysis for cob girth. Mean square due to GCA and SCA were significant for the character studied. According to Debnath and Sarkar (1990), non-additive gene action was preponderant in the inheritance of ear circumference. Mohammad (1993), El-Hosary *et al.* (1994a) and Sinobas and Monteagudo (1994) reported predominant role of SCA variance. Alike (1994) observed highly significant variation due to GCA and SCA for ear circumference. Mathur and Bhatnagar (1995) reported high gca effects for ear girth. Pal and Prodhan (1994) and Mathur and Bhatnagar (1995) observed predominant role of GCA variance for this trait. As per Turgut *et al.* (1995), both additive and non-additive components were important. Kumar *et al.* (1998) reported the predominant role of non-additive genetic variance. Mathur *et al.* (1998) observed the importance of additive genetic variance for this trait. According to Singh and Singh (1998), SCA variance was important for the character like ear circumference.

The results obtained by Fan-Xing Ming *et al.* (2005) showed that the difference in general combining ability and specific combining ability for ear diameter was highly significant. The variance of additive effect was higher than that of the non-additive effect.

2.4.1.10 Number of kernel rows per cob

Darrah and Hallauer (1972) and Satyanarayana *et al.* (1990) concluded that non-additive genetic variance was more important than additive component for number of kernel rows per ear. Pal and Prodhan (1994), De (1996), Rao *et al.* (1996) and Choudhary and Singh (1997) have also reported the similar observation for this character through diallel analysis.

The equal importance of additive as well as non-additive genetic variance was recorded by Khristova (1975), Debnath *et al.* (1988) and Debnath and Sarkar (1990) for number of kernel rows per ear. Geetha and Jayaraman (2000b) reported that additive and dominance components were significant for number of kernel rows per cob.

According to Dhillon and Singh (1976), general combining ability was more important than specific combining ability for the inheritance of number of kernel rows per cob. Martin and Hallauer (1976) studied diallel analysis for number of grain rows per cob and concluded that epistasis was more important for this character. Geetha (1997) observed that proportion of GCA variance was higher than the SCA variance having preponderance of additive genetic effects for character such as number of grains per row.

Narain (1978) reported that gca effects were highly significant for the character number of kernel rows per cob and sca effects were also significant for this trait. Ali and Topera (1986) reported that the non-additive gene action was more important for number of grain rows per ear. Zargar and Singh (1990) suggested that additive components of variance with dominance played a major role in the inheritance of number of kernel rows per cob.

The influence of additive genetic variance for number of kernel rows per ear was reported to be more than the non-additive genetic variance by Verma and Singh (1980), Singh *et al.* (1983), Sanghi *et al.* (1983) and Rai (1988) in a varietal diallel analysis. Prasad *et al.* (1988) studied combining ability analysis of maize for number of kernel rows per cob. Mean square due to GCA, SCA were significant for this trait. Navoda and Cross (1990) reported influence of additive genetic variance for number of kernel rows per ear. Singh (1996) also observed the predominance of additive genetic variance for this character in a diallel set of inbred lines.

According to Packiraj (1995), SCA variance was high for number of grain rows per ear indicating that dominance and epistatic gene action played a major role in the expression of these traits. Pal and Prodhan (1994), Dehghanpour *et al.* (1997), Kumar *et al.* (1998) reported importance of non-additive effects in the inheritance of this trait, while Petrovic (1998) and Mathur *et al.* (1998) observed a significant GCA and the predominance of additive genetic variance. According to Singh and Singh (1998), GCA variance was more important for number of kernel rows per ear. Li-Jizhu *et al.* (2004) reported that number of kernel rows per cob had dominance effect.

Surya Prakash and Ganguli (1986) revealed that gene action appeared to be non-additive for all traits except for number of kernel rows per ear, which are characterised by additive gene action. The results obtained by Fan-Xing Ming *et al.* (2005) showed that the difference in general combining ability and specific combining ability for number of rows per ear was highly significant. The variance of additive effect was higher than that of the non-additive effect.

2.4.1.11 Number of kernels per row

Additive genetic variance for this character was found to be more important than the non-additive components by number of workers using different methods of analysis (Crossa, 1986 and Nevoda and Crossa, 1990 in diallel analysis; Nawar and El-Hosary, 1984 in top cross analysis and Ganguli, 1986, in line $\times$ tester analysis). However, Vadeneev (1987), Rai (1988), Satyanarayana *et al.* (1990) and Pal and Prodhan (1994) reported predominance of non-additive gene action for number of kernels per row in a diallel set of analysis. Muthiah *et al.* (1989) have also recorded dominance effects controlling this trait in a line $\times$ tester experiment.

On the other hand, Prasad *et al.* (1988), Debnath *et al.* (1988) and Debnath and Sarkar (1990) have found the equal importance of both gca and sca effects for number of kernels per row. The role of epistatic effects also for this character was reported by Mukherjee *et al.* (1974) and Ahuja and Mukherjee (1983). Geetha and Jayaraman (2000b) reported that additive and dominance components were significant for number of kernels per row.

According to Packiraj (1995), GCA variance was greater in magnitude than SCA for number of grains per row. Dehghanapour *et al.* (1997) reported the greater importance of non-additive component effects. Geetha (1997) observed that proportion of GCA variance was higher than the SCA variance having preponderance of additive genetic effects for character

such as number of grains per row. Prasad *et al.* (1988) studied combining ability analysis of maize for number of kernels per row. Mean square due to GCA and SCA were significant for this trait. Kumar *et al.* (1998), however, reported that both additive and non-additive types of gene action are important, while Mathur *et al.* (1998) observed the predominance of additive genetic variance in the inheritance of this trait.

Malik *et al.* (2004) reported that temperate material gave high gca effects for striking characters contributing towards high grain yield, *i.e.*, kernels per row.

The results obtained by Fan-Xing Ming *et al.* (2005) showed that the difference in general combining ability and specific combining ability for number of kernels per row was highly significant. The variance of additive effect was higher than that of the non-additive effect.

2.4.1.12 Number of kernels per cob

Kumar (1974) revealed that SCA was high for number of kernels per ear. Cross (1976) and Crossa *et al.* (1990) observed significant effect of additive genetic variance for the kernels per ear in study of diallel set of maize and Nawar and El-Hosary (1984) in line $\times$ tester analysis and Ali and Topera (1986) noticed that the non-additive gene action was more important for number of grains per ear. De (1996) in diallel and line $\times$ tester analysis of inbred and open pollinated varieties also noted significant effects of non-additive types of gene action for number of kernels per ear in maize. According to Singh and Singh (1998), SCA variance was important for the character number of kernels per ear.

2.4.1.13 Hundred kernel weight

Kumar (1974) revealed that GCA was high for 100 kernel weight. Ramamurthy (1980) reported the predominance of additive gene effects for 100 grain weight. The equal importance of both additive and non-additive genetic variance for 100 seed weight was reported by Regazzi *et al.* (1980) using top cross testing. Kimani (1984) reported significant SCA variance. Predominance of additive genetic variance in the inheritance of this trait was emphasised by Shahi and Singh (1985). More or less, equal importance of both additive and non-additive genetic variance was observed by Pal *et al.* (1986). Prasad *et al.* (1988) studied combining ability analysis of maize for 100 grain weight in which mean square due to GCA and SCA were significant. Zargar and Singh (1990) suggested that 100 kernel weight exhibited importance of variance with dominance in a partial to negligible range.

Martin and Hallauer (1976) studied diallel analysis for 100 grain weight and concluded that epistasis was more frequent for this character. The importance of GCA variance in comparison to SCA variance for 100 grain weight was found to be more pronounced by Bhalla and Khehra (1977), Verma and Singh (1980) and Alika (1994) in diallel analysis of inbred lines on the contrary, Goomber (1973), Pajic (1985), Debnath *et al.* (1988), Satyanarayana *et al.* (1990) and Anuradha *et al.* (1993) using diallel analysis inferred that the non-additive genetic component was more important than the additive components for 100-seed weight. Geetha (1997) observed that proportion of GCA variance was higher than the SCA variance having preponderance of additive genetic effects for character such as 100 grain weight. Geetha and Jayaraman (2000b) reported that additive and dominance components were significant for 100 grain weight. Zelleke (2000) had derived an information from data on 1000 grain weight from a diallel mating that both gca and sca effects were significant for the trait. Saikumar (2002) reported sca effects for 100-seed weight.

Mohammad (1993) stressed importance of non-additive genetic variance. Alika (1994) observed highly significant variation due to GCA for 100 kernel weight. According to Packiraj (1995), GCA variance was greater in magnitude than SCA 100 grain weight. Mathur and Bhatnagar (1995) and Turgut *et al.* (1995) observed significant GCA variance in the inheritance of 100 grain weight. Singh and Mishra (1996) observed significant differences for 1000 kernel weight.

Dehghanapour *et al.* (1997) observed the importance of non-additive genetic variance. On the contrary, Joshi *et al.* (1998) stressed importance of additive genetic variance for this trait. According to Singh and Singh (1998) SCA variance was important for the characters like 100 kernel weight.

The results obtained by Fan-Xing Ming *et al.* (2005) showed that the difference in general combining ability and specific combining ability for 100 seed weight was highly significant. The variance of additive effect was higher than that of the non-additive effect.

2.4.1.14 Shelling percentage

Yap and Tan (1974) studied combining ability in inter-varietal crosses of maize and noted that the mean square due to gca for shelling percentage was significant, whereas mean square due to sca was not significant. Cross and Wildaleas (1975) reported high general combining ability for shelling percentage.

Alika (1994) in his study of the ear morphological characters in maize through diallel analysis reported both gca and sca effects to be non-significant for shelling percentage. Mathur and Bhatnagar (1995) on the other hand in study of partial diallel cross analysis for grain yield and its component characters reported that the dominance component played key role in the inheritance of shelling percentage in maize. According to Packiraj (1995), GCA variance was greater in magnitude than SCA for shelling percentage.

Mathur *et al.* (1998) reported variance for shelling percentage in both normal and stress environments. SCA variance was significant for shelling percentage in the normal environment. A predominance of additive gene effects was observed in the expression of this character.

2.4.1.15 Pith weight

There is no report available in the literature on pith weight trait.

2.4.1.16 Grain yield per plant

Griffing (1956a) reported that the non-additive gene action predominated for grain yield per plant. Strube (1967) reported that sca effects were greater than gca effects for yield, while the reverse was true for the other characters. Kumar (1971) found that gca and sca effects were of a high magnitude for grain yield.

Kumar (1974) revealed that SCA was high for yield. Cross and Wildaleas (1975) reported high general combining ability for grain yield. Martin and Hallauer (1976) studied diallel analysis for yield and concluded that epistasis was more frequent for this character.

Bhalla and Khehra (1977) reported general and specific combining ability for yield per plant. They further indicated the importance of additive genetic variance in the inheritance of this character. Singh (1977) indicated that gca effects were significant for grain yield, sca effect was not significant, additive genetic effects were important for this trait.

Ramamurthy (1980) reported the predominance of non-additive effects for grain yield per plant. Murthy *et al.* (1981) observed predominance of both additive and non-additive gene action for grain yield per plant.

As per Ottaviano and Cumussi (1981), both GCA and SCA variances were important. Singh *et al.* (1983) observed predominance of additive genetic variance in the inheritance of grain yield. Singh *et al.* (1983) stressed the importance of SCA variance for this trait. According to Zambezi *et al.* (1986), both GCA and SCA variances were important. Predominance of non-additive genetic variance was evident in the reports of Gue *et al.* (1986). Crossa *et al.* (1990) and Paul and Duara (1991) stressed upon the non-additive genetic variance. Mustytsa *et al.* (1991) noticed high variance. Saindass *et al.* (1992) quoted equal importance of both additive and non-additive genetic variance. Vasal *et al.* (1992) observed significant GCA variance. Greater importance of SCA variance than GCA variance was reported by Mohammad (1993). Pal and Prodhan (1994) emphasised on both additive and non-additive variances. Greater importance of SCA variance than GCA variance was reported by Damborsky *et al.* (1994) and Satyanarayana (1994). Sedhom (1994) stressed the importance of SCA variance for this trait. As per Turgut *et al.* (1995), both GCA and SCA variances were important. Zheng-Zuping *et al.* (1995) noticed high variance. Joshi *et al.* (1998) revealed that there was preponderance of non-additive gene action in the expression of yield per plant. According to Singh and Singh (1998), SCA variance was important for the character like grain yield per plot. Tallei and Kochaksaraei (1999) observed significant gca effects for grain yield per plant. Geetha and Jayaraman (2000b) reported that additive and

dominance components were significant for grain yield. Saikumar (2002) showed highly significant sca effect for grain yield per plant.

Murthy *et al.* (1981) observed significant GCA variance in the inheritance of this trait. Sharma *et al.* (1982) reported equal importance of both GCA and SCA for grain weight per plant.

Sanghi *et al.* (1982) observed the predominance of additive genetic variance in the inheritance of this trait. Yang (1982) noticed the equal importance of both additive and non-additive genetic variance. Pajic (1985) reported that the non-additive gene action predominated for grain yield per plant. Cross (1986) reported high general combining ability effects for high grain yield. Significant maternal effects were reported by Melchinger *et al.* (1986) for yield. Diallel analysis revealed that epistatic variance for yield was significant and negative in 11 out of 15 crosses studied. Ali and Topera (1986) noticed that the non-additive gene action was more important for grain yield. Prasad *et al.* (1988) studied combining ability analysis of maize for grain yield per plant. Mean square due to GCA, SCA were significant for this trait. However, Mohammed (1993) observed the predominance of GCA variance over SCA variance, while El-Hosary *et al.* (1994) reported significant SCA variance in the inheritance of grain yield per plant. In a study with 20 diverse inbred lines through partial diallel mating system, Mathur and Bhatnagar (1995) have reported that the dominant component played a key role in the inheritance of grain yield per plant.

According to Packiraj (1995), SCA variance was high for grain weight per plant indicating that dominance and epistatic gene action played a major role in the expression of these traits. Mathur and Bhatnagar (1995) reported the predominance of non-additive gene action. Singh and Mishra (1996) studied significant differences for yield per plant.

Joshi *et al.* (1998) observed the preponderance of non-additive gene action. Kumar *et al.* (1998) noticed the equal importance both additive and non-additive genetic variance. Desai and Singh (2000) reported that both general and specific combining ability variances were significant for grain yield and its components. Mathur *et al.* (1998) reported the predominance of additive genetic variance in the inheritance of this trait. Li-Jizhu *et al.* (2004) reported that grain weight had significant epistatic effect.

Li-Yul *et al.* (2003) studied the gca effects which were positively significant for grain yield.

El-Moula *et al.* (2004) indicated that magnitude of delta 2 SCA was greater for grain yield. Interaction delta 2 SCA $\times$ L was higher than that of delta 2 GCA $\times$ L for all traits indicating that the non-additive type of gene action was more affected by environmental conditions than the additive type.

2.5 HETEROSIS

Heterosis is one of the most widely recognised term in the field of plant breeding, while heterosis is a biological phenomenon of genetic nature, the hybrid vigour, on the other hand, refers to the manifestation of the superiority of the performance of hybrid (F_1) relative to the parental performance, mostly dealing with quantitative characters.

The expression of hybrid vigour in plant crosses has been recognised nearly 250 years ago. Hybrid vigour in artificial plant hybrids was studied by Koelreuter (1763 and 1766) for several plant species. Darwin and Mendel (1880) reported hybrid vigour in plant crosses. Beal (1880) produced crosses between maize cultivars and reported that in most instances, the crosses had yields greater than the parent cultivars.

The term 'heterosis' was coined by Shull (1908, 1909) as a convenient term for hybrid vigour. Most geneticists thought agreed that heterosis is very complex biological phenomenon of quantitative characters, the exact genetic basis of heterosis has not been understood as yet. Bruce (1910) and Keeble and Pellow (1910) put forth the support for dominance hypothesis, which suggests 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 (1918)

stated that heterosis was due to complementary action of linked dominant favourable genes brought from both parents.

Hayes (1926) reported that yield was very strongly correlated with those characters of inbred lines that are the expressions of vigour. Jorgenson and Brewbakar (1927) concluded that selection of the most vigorous inbred lines was a desirable procedure from a practical stand point.

Ashby (1930 and 1932) suggested that heterosis resulted from the maintenance of the initial advantage in 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 cause of heterosis. Hull (1945, 1946 and 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.*, 1961, Paterniani and Lonnquist, 1964, Wellhausen, 1965, Heidrich Sobrinho and Cordeiro, 1975 and Vasal *et al.*, 1992). Moll *et al.* (1967) reported that heterosis increased with increased divergence within certain limits and extremely divergent crosses in maize resulted in decrease in heterosis.

To describe the improvement of heterozygote over the better parent of the cross, 'heterobeltiosis' term has been proposed (Fronseca and Patterson, 1968). The heterosis over mid parental value was referred as 'relative heterosis'. However, the improvement of the hybrid over the existing ruling variety or standard variety for characters is referred as 'standard heterosis' or 'economic heterosis' (Rai, 1979).

Griffing and Zsiros (1971) viewed heterosis as not entirely the result of genetic stimuli, but rather as a result of the interaction between genetic and environmental stimuli and implicated that the environment was significant factor in the manifestation of heterosis. Annenkova (1973) stated that selecting suitable pollen parents could produced 21.8 to 41.2 per cent higher yield than standard check.

Appadurai and Nagarjan (1975) observed increased yield in 20 combinations exceeding 100 per cent over their respective parents, 33 showed heterosis for plant height, 44 for earliness, 18 for grain rows per ear, 40 for kernel number per row and 45 for grain weight per ear. Dhillon and Singh (1976) obtained heterosis for grain yield over mid-parental and better parental values by 31 and 13 hybrids, respectively.

Mabo (1977) noticed encouraging results by selecting parents with a large number of grain rows per cob. Since the degrees of heterosis for the number of grains per ear, number of grains per row, plant height and grain yield depended on the number of grain rows per ear in the parents.

Debnath (1984) obtained heterosis over mid parental value and better parent for grain yield components in 36 F_1 hybrids from a diallel cross among nine elite diverse inbreds. The heterosis for grain yield ranged from 21.07 to 123.58 per cent over the mid parental value and from -2.96 to 95.07 per cent over the better parent. Heterosis was high for grains per row and ear length. According to Prasad and Singh (1986), the magnitude of heterosis for grain yield per plant and six of its components were greater when the parents were moderately diverse than when they were highly diverse. Lin and Chen (1986) observed significant heterobeltiosis for 100 grain weight due to over-dominance, suggesting importance of non-additive variance for this trait.

Masikevich *et al.* (1989) presented evidence that the increased yield of heterotic hybrids is the result of competitive interaction between photorespiration and photosynthesis. Muthiah (1989) obtained significant positive heterosis for grain yield per plant and other 15 yield related characters in several cross combinations from 9×9 diallel analysis. They have shown that heterotic organisms have a more economical utilisations of energy and nutrient resources than non-heterotic ones and greater autonomy of the protein synthesising system of the chloroplasts in relation to the ribo-nuclease function.

Malhi *et al.* (1993) in their study of relative performance of the single crosses and double crosses observed that the single cross hybrids had significantly higher ranking than the double cross hybrids for yield on average overall crosses and over the five best crosses.

Comparison of yield performance indicated that the single cross hybrids were more stable than the double cross hybrids. Bhatnagar *et al.* (1993) observed high heterotic effects for early silking and grain yield per plant in early maize inbred lines. High heterotic effects for grain yield per plant and time to silk was reported by Vasal *et al.* (1993) based on the combining ability analysis of maize germplasm lines.

Kumar (1995) observed high degree of heterosis for grain yield per plant and earliness in eight hybrids. Lamkey (1995) indicated that hybrids obtained from the crosses between 24 high yielding and 24 low yielding inbred lines differed significantly for group means and heterosis for yield and days to silking.

Ling *et al.* (1996) noticed that mean heterotic effects were highest for grain yield per plant followed by grain weight and ear thickness. Saha and Mukherjee (1996) observed significant positive heterosis for grains per ear and the crosses with highest heterosis for 100 grain weight and grain yield per plant and negative heterosis for percentage grain conversion. Verma and Singh (1996) reported that dominance $\times$ dominance gene interactions were important for improving heterosis for yield. Yurankova *et al.* (1996) obtained considerable instability in heterosis for ear width, ear length and number of grains per row. Heterosis was slight or absent for number of rows per ear.

Geetha (1997) obtained positive heterosis over mid parent in 24 hybrids and significant standard heterosis in 19 hybrids. Nageshkumar *et al.* (1999) observed heterosis for grain yield which ranged from 26.31 to 37.30 per cent over better parent. Stojokovic *et al.* (1999) reported that partial or complete dominance of dominant alleles with additive effects were the main contributors to heterosis in maize. Over-dominance may exist at some loci but of minor importance.

Dass and Arora (1999) reported that negative heterosis will be considered as desirable for the phenological traits as it contributed favourable genes for earliness.

Gupta and Nagda (2000) observed variances due to variety heterosis and its components were significant for all the characters studied. Netaji *et al.* (2000) obtained significant and positive heterosis and heterobeltiosis for grain and moreover the expression of heterobeltiosis was most evident for grain yield per plot followed by test weight, ear length, plant height and number of grain rows per ear. Rosa *et al.* (2000) noticed the highest values of heterosis over the mid-parental value in the hybrid PP-9539 $\times$ AN-453 (11.35%) and PP-9603 $\times$ PP-9539 (11.13%).

Han Li Jun *et al.* (2001) made crosses using North Carolina Design II, the results showed that all the F_1 hybrids exhibited positive heterosis in some degrees and the highest heterosis was in crosses in which MO-17 was the male parent. Kara (2001) observed positive heterosis for all characters studied except for days to tasseling with average hybrid yield being 79.89 per cent above that of the parents. Shahwanth *et al.* (2001) noticed positive and significant heterosis in 17 hybrids, while 11 hybrids showed heterobeltiosis for ears per plant.

Vidal Martinez *et al.* (2001) observed negative heterotic values in pollen yield components and reported heterotic values 30 per cent pollen yield in corn belt genotypes and up to 200 per cent for grain yield in exotic genotypes.

Li-Jizhu (2004) conducted that heterosis was highest for ear grain weight and the lowest for ear row number. All characters studied were controlled by additive gene action. Ear length had significant additive and dominance effects, whereas ear row number and ear grain weight had dominant and epistatic effects, respectively.

2.5.1 Character-wise review

The review of literature pertaining to heterosis in respect of 17 characters, *viz.*, plant height at 30 days after sowing (DAS), plant/stem girth at 30 DAS, leaf area at 30 and 60 DAS, plant height at 60 DAS, ear height at 60 DAS, cob weight, cob length, cob girth, number of kernel rows per cob, number of kernels per row, pith weight, 100 kernel weight, shelling percentage, number of kernels per cob, grain weight per plant, grain weight per hectare is reviewed here under.

2.5.1.1 Plant height at 30 DAS

There are no reports available in the literature on plant height at 30 DAS.

2.5.1.2 Plant girth at 30 DAS

There are no reports available in the literature on plant girth at 30 DAS.

2.5.1.3 Leaf area at 30 DAS

There are no reports available in the literature on leaf area at 30 DAS

2.5.1.4 Leaf area at 60 DAS

Shakoor (1988) observed positive heterosis for leaf area per plant (-0.01 to -54.8) over better parent. Abdul (1995) noticed heterotic effects in leaf area per plant.

2.5.1.5 Plant height at 60 DAS

The extent of heterosis for plant height was reported earlier by many workers on maize. Kravencheko *et al.* (1971) reported that heterosis occurred in plant height. Gonchenko (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 hybrids reported heterosis for plant height. Petrenko (1980) observed high positive heterosis for plant height. Shakoor and Ataullah (1980) reported heterosis for plant height ranging from -12.5 to 27.4 per cent with respect to better parent. Lin and Chem (1986) reported that heterosis took the form of incomplete dominance suggesting additive variance for plant height.

Ganguli *et al.* (1989a) observed positive heterosis over better parent for plant height. A considerable range of heterosis (-23.0 to 0.7%) over check variety for plant height was reported by Ganguli *et al.* (1989a).

Vasal *et al.* (1992) and Reddy and Agrawal (1992) observed high heterosis for this trait. A maximum of 13.9 per cent heterosis for plant height was reported by Bhatnagar (1993).

Alvarez *et al.* (1993) reported low heterosis for plant height. Average heterosis for this trait was not significant (Gomes-e-Gama, 1995). Abdul (1995) noticed heterotic effects for plant height. Nagda *et al.* (1995) obtained significant relative heterosis for plant height in 14 hybrid combinations. Significant negative heterosis ranging from -34.92 to -1.80 per cent over checks was recorded by De (1996) for plant height. Saleh *et al.* (2002) reported moderate heterosis estimates for the character plant height.

2.5.1.6 Ear height

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 per cent. Petrenko (1980) observed high positive heterosis. Whereas Mirandafilmo and Vencovsky (1984) recorded low heterosis for ear height, Ganguli *et al.* (1989a) and Bhatnagar *et al.* (1993) reported positive heterosis over the better parent. Alvarez *et al.* (1993) and Bhatnagar *et al.* (1993) noticed a high heterosis value of 15 and 18.8 per cent respectively for ear height. Nagda *et al.* (1995) obtained significant relative heterosis for ear height in 14 hybrid combinations. Altinbos (1995) observed high heterosis for ear height. Petrovic (1998) reported positive heterosis over the better parent, but Beck *et al.* (1990) reported low heterosis for this character. A considerable range of heterosis over mid parent (-36.76 to 63.74%), over better parent (-35.78 to 75.9%) and over standard varieties (-67.24 to -7.24%) was observed for ear height by De (1996). Saleh *et al.* (2002) reported high estimates of heterosis for ear weight.

2.5.1.7 Cob weight

Dornesai (1973) noticed varying degrees of heterosis in single cross hybrids of maize. Grain weight per ear showed significant heterosis and was directly correlated with ear length. Geetha (2001) observed maximum heterosis for ear weight. Saleh *et al.* (2002) reported high estimates of heterosis for ear weight.

2.5.1.8 Cob length

According to Leng (1954), if over dominance is present, the highest degree of heterosis should be in high $\times$ low crosses. Quite opposite a situation was found in this study where the degree of heterosis was found to be higher in the low $\times$ low and high $\times$ high crosses.

Kravencheko *et al.* (1971) reported that heterosis occurred for ear length. Maister (1971) studied the inheritance of this character in inter line crosses of pop corn and reported the most frequent occurrence of heterosis. Dhillon and Singh (1977b) reported that the heterosis percentage over mid parent varied from 96 to 107. A greater and strong heterosis for ear length was reported by earlier scientists, namely Ivanovic (1979) and Bhalla *et al.* (1979). Shakoor and Ataullah (1980) reported that the heterosis for ear length ranged from -0.62 to 29.39 per cent relative to better parent.

In another study, Verma and Singh (1980) reported it to be ranging from -5.9 to 19.9 per cent over better parent. Genova (1984) reported considerable heterosis for ear length and suggested that over-dominance was the main component of heterosis for this trait. A greater and strong heterosis for ear length was reported by Debnath (1984). In a diallel set of analysis, Mukherjee and Saha (1984) observed positive heterosis for ear length in ten cross combinations. Saha and Mukherjee (1985) reported that the magnitude of heterosis for ear length was low which ranged from -11.8 to 10.1 per cent over better parent. Debnath (1987) recorded significant and positive heterosis over mid and better parental values for ear length.

Turgut *et al.* (1995) reported the heterotic effect was considerable for these traits. De (1996) recorded significant and positive heterosis over mid and better parental values for ear length. Rao *et al.* (1996) observed 16.08 per cent maximum heterosis over better parent and 23.68 per cent over check variety for ear length in maize varieties crosses.

2.5.1.9 Cob girth

Mukherjee *et al.* (1974) in a study of five diverse and heterozygous varieties, their S_1 generation (S_1s), the F_1 and the F_2 of half diallel based on them and some random crosses made among F_1s reported that heterosis effects were most significant in respect of ear diameter. Mukherjee *et al.* (1974) obtained significant heterotic effect for ear circumference. Debnath (1987) observed lower mid parent heterosis for ear circumference.

Turgut *et al.* (1995) reported that heterotic effect was considerable for ear diameter. Saleh *et al.* (2002) reported moderate estimates of heterosis for ear circumference.

2.5.1.10 Number of kernel rows per ear

Kravencheko *et al.* (1971) reported that heterosis occurred in number of kernel rows per ear. Mukherjee *et al.* (1974) obtained significant heterotic effect for grain rows per ear. The magnitude of heterosis for kernel rows exhibited by different cross combinations was reported by Appadurai and Nagarajan (1975) in 57 single crosses of maize. They also reported 18 hybrids showed significant increase for this character over their better parent. Bhalla *et al.* (1979) and Verma and Singh (1980) reported increased heterosis for kernel rows per ear, whereas Genova (1984) reported negative or non-significant positive heterosis for the same trait. Rao *et al.* (1996) estimated maximum heterosis of 6.28 per cent over better parent and 8.94 per cent over check variety for kernel rows per ear. Singh (1996) also observed positive standard heterosis for this character which ranged from 8.72 to 13.33 per cent in a diallel cross of inbred lines. Saleh *et al.* (2002) reported moderate estimates of heterosis for number of kernel rows per ear.

2.5.1.11 Number of kernels per row

Heterotic response for number of kernels per row was reported by Kovacs (1970) and Appadurai and Nagarajan (1975). A high heterosis for this trait was also reported by Debnath (1984). Yurankova *et al.* (1989) reported considerable instability in respect of heterosis for this trait by analysing 5×5 diallel crosses including reciprocals.

In a line $\times$ tester analysis over years, Ganguli (1986) reported a considerable range of heterosis for kernels per row. Marked heterosis was reported by Presolkar and Kamara (1991) in their study number of kernels in a row had strong heterosis than others. De (1996)

reported that 16 crosses showed significant positive heterosis over mid parent for kernels per row. A maximum of 11.07 per cent and 18.24 per cent heterosis over better parent and over check variety, respectively was reported by Rao *et al.* (1996). Salillari and Hoxha (1998) in their study of kernel and spike characters in some maize have stronger heterosis effect than others. Saleh *et al.* (2002) reported moderate estimates of heterosis for number of kernels per ear row.

2.5.1.12 Pith weight

There are no reports available in the literature on pith weight.

2.5.1.13 Hundred seed weight

Kravencheko *et al.* (1971) reported that heterosis for 100 grain weight. 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 (1980) 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%) in inter varietal crosses of maize. Mukherjee and Saha (1984) observed positive heterosis for 100 grain weight in eight cross combinations. Saha and Mukherjee (1985) reported the highest heterosis over better parent for 100 grain weight, whereas Ganguli (1986) observed a considerable range of heterosis over the parental value and also over the standard check variety for the same characters. Kabir (1988) and Yurankova *et al.* (1989) also reported strong and stable heterosis for 100 grain weight. Considerable heterotic effect for this trait was noticed by Alvarez *et al.* (1993) and Turgut *et al.* (1995).

Both the negative and positive heterosis over mid parent, better parent and standard check varieties were recorded by De (1996). A range of -11.30 to 60.01 per cent of heterosis was observed by Bautista and Ramirez (1997) in their study on maize.

2.5.1.14 Shelling percentage

The literature available with respect of the character shelling percentage in maize is meagre.

Saleh *et al.* (2002) reported moderate estimates of heterosis for shelling percentage.

2.5.1.15 Number of kernels per ear

Yang (1982) studied gene effects for several economic characters and reported that the number of grains per ear controlled by additive effects with some dominance and epistasis.

Mukherjee and Saha (1984) observed positive heterosis for number of grains per ear in seven cross combinations. Ganguli (1986) and Satyanarayana (1996) studied line $\times$ tester analysis and reported similar types of findings for kernels per ear, Geetha (2001) obtained maximum heterosis for number of grains per ear.

2.5.1.16 Grain yield per plot

In terms of increasing the productivity of crop plants, the manifestation of heterosis and the commercial utilisation is of greater value. The magnitude of heterosis in increasing the grain yield was first documented in maize crop. Jones (1918) demonstrated that hybrid seed could be obtained cheaply from the double cross seeds. However, he produced the first commercial maize hybrid as 'Burr Leaming Dent hybrid' which was released in the year 1918. Richey (1922) showed that 82.4 per cent of the crosses exceeded the parental average with 55.7 per cent exceeding the highest 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.* (1961), Paterniani and Lonquist (1963), Appaduri and Nagarajan (1975) and Sayed Galal *et al.* (1977). In the individual variety cross heterosis relative to the mid parent ranged from 4.5 per cent for BSK(S)S $\times$ BSTE(FR) (1 to 60.2 per cent for BSSS(R)6 $\times$ BS12(HI)CS (Hallaur and Malithano, 1976). Kravencheko *et al.* (1971)

reported that heterosis occurred in yield and Mukherjee *et al.* (1974) obtained a maximum heterosis of 48.4 and 18.3 per cent, respectively. Mabo (1977) reported that the degree of heterosis for grain yield depended on the number of grain rows per ear in the parents. Verma and Singh (1980) reported a heterosis of 1.3 to 98.6 per cent over better parent.

Jha and Khehra (1992) reported that 16 crosses significantly out-yielded the best hybrid control. Similarly, Mejiya and Lambert (1992) observed heterosis for grain yield over control. The highest heterosis value (34%) was noticed for grain yield by Alvarez *et al.* (1993).

Vasal *et al.* (1992) determined the heterosis and combining ability among sub-tropical and temperate maize germplasm in a diallel experiment. They reported high per cent of heterosis in sub-tropical environment (13%) than under temperate environment (10.2%).

Gomes-e-Gama (1993) observed the average heterosis was (643 kg per hectare) (8.4%) for top crosses. Gupta *et al.* (1994) studied 23 double cross hybrids and reported that 16 out of 23 double cross hybrids showed high degree of heterosis for grain yield than the best standard variety 'Shweta'. Nagda *et al.* (1995) obtained significant positive heterosis for grain yield per plant over the best check in 15 cross combinations. Considerable heterotic effect was noticed for grain yield by Perez Velasquez *et al.* (1995) and Turgut *et al.* (1995).

2.5.1.17 Grain yield

Shehata and Dhawan (1975) found that average heterosis values for grain yield were 24, 19 and 14 per cent over mid parental values in three diallel sets, respectively. Mabo (1977) reported that the degree of heterosis for grain yield depended on the number of grain rows per ear in the parents. Verma and Singh (1983) reported that dominance $\times$ dominance gene interaction was important in heterosis for yield in maize. Dhillon and Singh (1983) also suggested that the hybrids involving more divergent parents generally exhibited higher heterosis than those involving the least divergent parents. Debnath (1984) obtained heterosis with range of 21.07 to 123.68 and 2.69 to 95.07 per cent over mid parent and better parent respectively.

Many plant breeders, namely Prasad and Singh (1986), Lin and Chem (1986), Debnath (1987), Martinez *et al.* (1988) and Kabir (1988) observed increased heterosis for grain yield in maize. Gangule *et al.* (1989) reported positive heterosis over the better parent. Shah and Khehra (1992) reported that 16 crosses significantly out yielded the best hybrid. Similarly Mejiya and Lambert (1992) observed the heterosis for grain yield over control. Vasal *et al.* (1992) noticed the heterosis over mid parent. Gomes-e-Gama (1993) observed the average heterosis of 8.4 per cent for top crosses. Considerable heterosis effect was noticed for grain yield by Turgut *et al.* (1995), Perez-Velasquez *et al.* (1995), Satyanarayana *et al.* (1994).

A considerable range of heterosis over mid parent (28.90 to 98.00%) over better parent (-46.54 to 92.55%) and over check variety (-54.68 to 35.66%) for grain yield was observed by De (1996). In a diallel crosses of 10 varieties, Rao *et al.* (1996) reported highest heterosis for grain yield over better parent (27.33%) and over check variety (38.73%). Singh (1996) recorded a low per cent of heterosis (13.07 to 14.30%) over standard variety for grain yield.

Ahuja *et al.* (1997) reported that the high performance of the inbred lines coupled with significant high per cent of heterosis indicates the feasibility of commercially viable single cross hybrid in maize.

In a study of combining ability and heterosis estimation in local Indian maize varieties, Banerjee *et al.* (1997) observed 38.02 per cent heterosis over best parent for grain yield. Heterotic response of 50 crosses from 10 lines $\times$ 5 tester mating design was worked out over mid parent, better parent and also over best check for grain yield by Dass *et al.* (1997).

Saleem *et al.* (1997) studied heterosis in maize hybrids developed from sub-tropically adapted inbred lines and noted the high degree of heterosis for grain yield.

Vergara *et al.* (1997) found that the least heterosis for grain yield was exhibited by F_1 s involving high yielding parents, while high heterosis for those involving lowest yielding parents.

Larish and Brewbaker (1999) reported 55 per cent mid Parent heterosis for variety cross and 105 per cent for inbred crosses for grain yield. They found 23 crosses showed standard heterosis over the best check KH-510. They also obtained realistic heterotic response over better parent. Saleh *et al.* (2002) reported high estimates of heterosis for grain yield.

III. MATERIAL AND METHODS

The present investigation was carried out at Botanical garden, Agriculture College, Dharwad and Agricultural Research Station, Arabhavi (University of Agricultural Sciences, Dharwad). During *kharif* 2002, base population was raised and selected progenies were advanced from S_0 to S_1 and S_2 . The selected S_2 lines were evaluated using line $\times$ tester design during *kharif* 2005 at All India Coordinated Maize Improvement Project (AICMIP), Agricultural Research Station, Arabhavi.

3.1 GEOGRAPHICAL LOCATION OF THE EXPERIMENT

Geographically, Dharwad is situated at 15°13' N latitude and 70°07' E longitude and at an altitude of 678 m above mean sea level.

Agricultural Research Station, Arabhavi is located in Northern dry zone (Zone-III) of Karnataka. Geographically it lies at 16°12' N latitude and 74°57' E longitude with an altitude of 640 meters above mean sea level. The soils are sandy loam type with pH of 7.2. Source of irrigation water is from Ghataprabha Left Bank Canal (GLBC), which flows from first week of July to the end of February month (8 months).

3.2 WEATHER CONDITIONS

The average annual rainfall was about 700 to 800 mm which was distributed evenly during the cropping period. Crop was raised under irrigated situation. The average rainfall of the Agricultural Research Station, Arabhavi is 546 mm.

The monthly mean meteorological data obtained from the meteorological observatory of Main Agricultural Research Station, Dharwad and Agricultural Research Station, Arabhavi with regard to temperature, humidity, rainfall and number of rainy days during the cropping season *kharif* 2002 and subsequent seasons is presented in Appendix I, II, III, IV and V.

3.3 EXPERIMENTAL MATERIAL

The investigation was carried out in five stages, viz., (Fig. 1)

- (a) Sampling in the base population
- (b) Assessment of variability among S_1 lines
- (c) Assessment of variability among S_2 lines
- (d) Evaluation of S_2 lines by top cross method
- (e) Line $\times$ tester analysis

3.3.1 Base population

Fifty elite breeding lines (Table 2) were received from Directorate of Maize Research (DMR), IARI, New Delhi during *kharif* 1997 for development of full season heterotic yellow pool. These lines were raised and allowed to open pollinate for four generations (intermating) without exercising any selection. In each generation, the plants were raised in half-sib family method and at the end of fourth generation, the seeds were collected and grown as base population during *kharif* 2002 at College of Agriculture, Dharwad in isolation and allowed to open pollinate. Sufficient care was taken to maintain more than 10 thousand plant population. Out of this population, 150 plants were tagged in each grid by dividing entire population into 10 grids of 150 sq. mt. at the time of tassel emergence, based on vigour, standing ability, silk and tassel traits and free from disease incidence, 800 cobs were selected based on grain yield (*per se*) performance and this material formed basis for further inbreeding and isolation of inbred lines.

Fig. 1: Schematic diagram of the experiments carried out during study

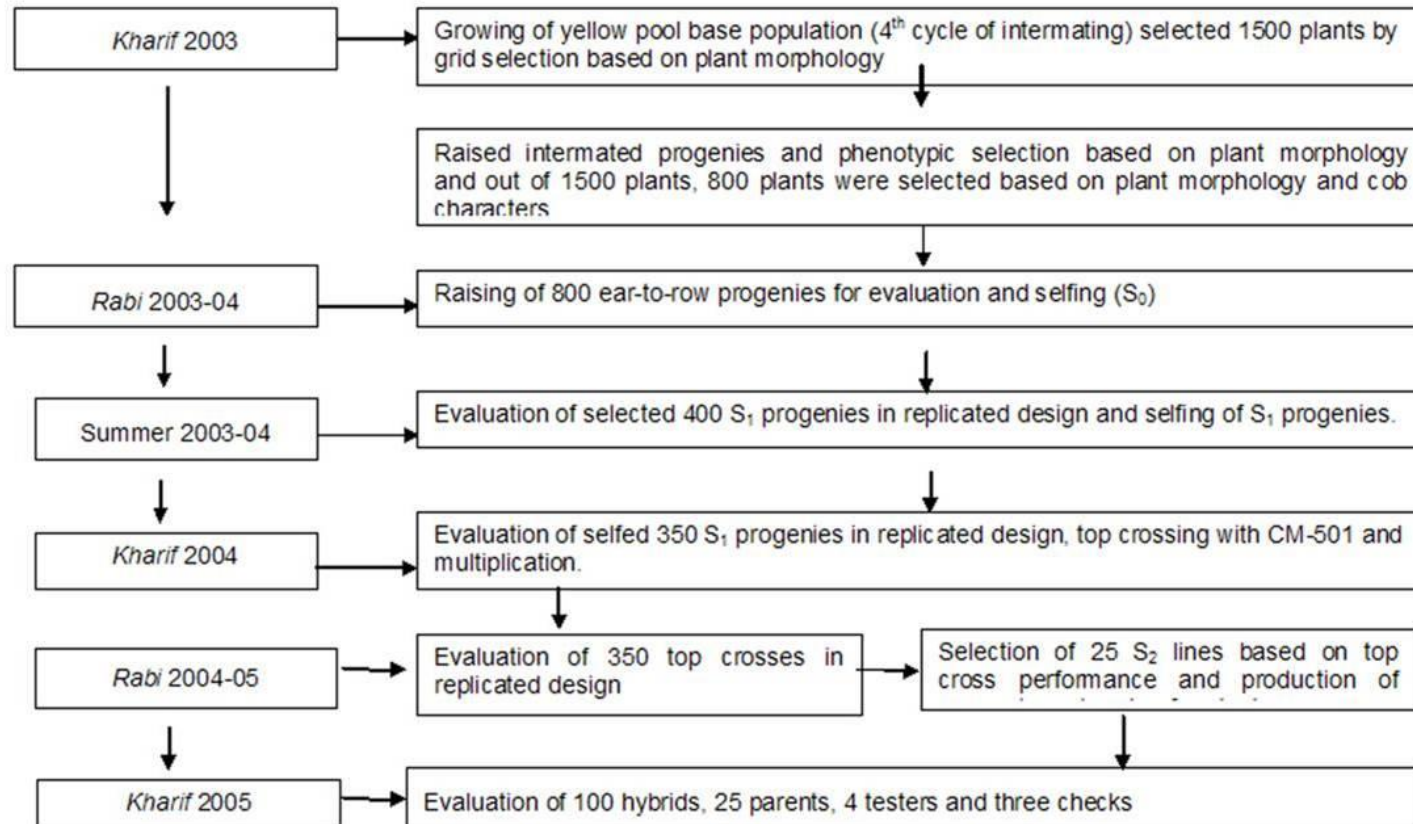


Fig. 1: Schematic diagram of the experiments carried out during study

Table 1: List of constituent lines of yellow pool population (full season)

Sl. No.	Pedigree	Origin	Remarks
1.	Gangu -11	NSC	(CM-204 x CM-1110) CM-501
2.	Prabhat	Ludhiana	J1 15, developed by J54 x Suwan -1 composite
3.	Pro -311	Pro-Agro	Private hybrid, Full season
4.	X-12664	POC	-
5.	Pro-335	Pro-Agro	-
6.	BH-1804	Hyderabad	-
7.	BH-1805	Hyderabad	-
8.	TWC-95017	Dholi	-
9.	CM-207 x CM PMNTV-7 x 115-3-2-1	DMR	Three way cross, Full season
10.	Pro-331	Pro-Agro	-
11.	H-804	Kanchan Ganga	-
12.	SEEDTECH-2324	Bio Seed Tech.	Bisco Private hybrid
13.	SEEDTECH-2304	Bio Seed Tech.	Bisco Private hybrid
14.	PGM-414	Plant gene	Private hybrid
15.	PGM-408	Plant gene	Private hybrid
16.	PAC-777	Advanta	Private hybrid
17.	SWDMR-91-145-1	Advanta	Private hybrid
18.	Pusa-Comp-II	DMR	-
19.	ASE-71-76	DMR	-
20.	MUNENG-8331	-	-
21.	Kesari	Kolhapur	Developed by Ludhiana Local x (J2014 x Parbhat) – 1994
22.	NE COMPEYO NAMGSN LAP	Bhutan	Bhutan collection
23.	Suwan-comp	Suwan	Introduced from Thailand
24.	Suwan-8529	Suwan	This was developed by CIMMYT (i.e., by Suwan)
25.	PAC 780	Cargil	Private hybrid

Contd.....

Sl. No.	Pedigree	Origin	Remarks
26.	Vikram	Ludhiana	A composite, released in 1967, (A-6), (Bas x ETO Amarillo)
27	Prabhat	Ludhiana	G -43, G-44, developed in 1990, composite, G-45, 46, 47, 48, 50 x KU-1
28	Varuna	Hyderabad	Synthetics, B-41, developed in 1990 from Amberpet, Hyderabad
29	Ashwini	Hyderabad	-
30	Mahi-Kanchan	Baraswad	Early variety
31	Navjot	Ludhiana	Developed from composite J-54 x Taruan
32	KH-510	Kanchan Ganga	Private hybrid
33	Bio-9637	Bio seeds	Private hybrid
34	HKH-1075	Karnal	-
35	HKH-1078	Karnal	-
36	MDR-SYH	-	-
37	AH 319	Delhi	-
38	JH 3425	Ludhiana	-
39	Bio – 52331	Bio seeds	-
40	PAC – 744	Advanta	Private hybrid
41	EHB – 1515	Bajaura	-
42	EHB – 1350	Bajaura	-
43	AH – 387	Delhi	-
44	BH - 2202	Hyderabad	Single cross Hybrid, medium maturity
45	Pro – 338	Pro Agro	Private hybrid
46	Bio – 9813	Bio seeds	Private hybrid
47	Megh	Ludhiana	Composite J – 3045, developed from J-51 x Arun – 1983
48	Harsha Comp - 1	Hyderabad	Released during 1988
49	Pusa Comp – 1	DMR	Recombination, selection from A-602, A-603, A-604, early flowering composite, 1988
50	Navan	-	-

3.3.1.1 Identification of superior progenies

The selected individual plants were advanced for identification of superior progenies for seed yield per plant and other morphological traits at S_1 and S_2 generations. Individual plants were selected on the basis of their seed yield per plant which yielded over mean + 2 SD (standard deviation) and these were further advanced.

3.3.2 Raising of S_0 generation

Eight hundred cobs were raised in ear-to-row progenies during *Rabi* 2003 with row spacing of 0.75 m and 0.20 m between plants. Out of 20 plants maintained in a row, five competitive plants were chosen at random and tagged separately. These selected plants were selfed by adopting the "tassel-silk bag" method of selfing technique as detailed under.

Ear shoots of the selected plants were carefully covered with silk bag before silk emerged from the husk covers. Tassel bag (craft bag, 30 × 20 cm) was placed over each tassel (male flower) of the selected plants. Pollen from the selected plants was collected from tassel bag and dusted over the silk of the same plants from which the pollen was collected, after removing silk bag. The silk bag was replaced immediately after pollination to avoid contamination. The pollination was carried out between 9.00 am and 10.00 am during the bright sunshine hours.

3.3.3 Evaluation of S_1 generation

Best 400 ear-to-row progenies selected were evaluated with two replications with a row length of four meter and five plants were tagged randomly in each progeny and the mean grain yield per plant was worked out based on the three uniform plants and the same was considered for selection of 350 progenies.

3.3.4 Raising of S_2 generation

The 350 best selfed cobs selected out of 400 S_1 progenies based on the *per se* were raised during *kharif* 2004 in ear to row progenies with four meter row length, 0.75 meter between rows and 0.20 meter between plants. Out of 20 plants, five competitive plants were chosen at random and tagged. These selected plants were selfed by adopting the tassel silk bag method as done in S_1 generation.

3.3.5 Evaluation of S_2 progenies

The best selected 350 S_2 progenies (based on mean cob weight) were planted during *kharif* 2004 for evaluation for different characters by raising ear to row progenies in RBD with two replications, with a row length of four meter and spacing of 0.75 × 0.2 meter.

3.3.6 Top cross testing

Top crosses were made by using a mixed pollen of atleast 100 plants of CM-501 and the salient features of this are mentioned in the Table 3. The 350 S_2 lines were crossed to a broad based tester CM-501 during *kharif* 2004 to test them for general combining ability. Three hundred and fifty top crosses with two commercial checks *viz.*, DMH-2 and Cargil 900-M were evaluated during *rabi* 2004-05.

3.3.7 Line × tester analysis

Based on the results of top cross evaluation, best 25 S_2 lines were identified (Table 3). The selected S_2 lines were planted along with four testers, namely CM-111, CI-5, KDMI-10 and NEI-9202B to make design in line × tester crosses during *kharif* 2005. The salient features of the above mentioned four testers are mentioned in the Table 2. One hundred hybrids were made by crossing the best 25 S_2 lines with four testers in line × tester mating design.

Table 2: Description of tester material used in the investigation

Sl. No.	Description	CM – 501	KDMI – 10	CM – 111	CI – 5	NEI-9202B
1	Tassel size	Medium	Medium	Medium	Medium to large	Small
2	Glume colour	Green with purple tinge	Green with purple tinge	Green with purple tinge	Green with purple tinge	Green with purple tinge
3	Anther colour	Purple	Green with purple tinge	Yellow and purple	Purple	Yellow
4	Tassel shape	Loose, open	Open	Dense	Loose	Semi compact
5	Silk colour	Predominantly green, light purple	Light purple to green	Predominantly green	Predominantly purple	Green
6	Ear shape	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
7	Cob colour (pith)	Purple	White and purple	White	White	White
8	Grain texture	Semi-dent	Flint	Flint	Flint and semi flint	Flint to semi flint
9	Grain colour	Yellow	Yellow / orange	Orange yellow	Yellow, orange	Yellow
10	Special features	White patch on grain	Leaf semi erect	More tassel branches		Erect leaves
11	Combining ability	SCA (very good combiner)	SCA	SCA	SCA	GCA
12	Nature of tester	Narrow based	Broad based	Narrow based	Narrow based	Narrow based

Table 3: Pedigree of derived S₂ lines used in L × T analysis (yellow pool)

Sl. No.	Code number	Pedigree
1	ARYP –21	YP 231 – ⊗ – ⊗
2	ARYP – 4	YP 249 – ⊗ – ⊗
3	ARYP – 5	YP 246 – ⊗ – ⊗
4	ARYP – 3	YP 269 – ⊗ – ⊗
5	ARYP –18	YP 278 – ⊗ – ⊗
6	ARYP – 1	YP 236 – ⊗ – ⊗
7	ARYP –9	YP 283 – ⊗ – ⊗
8	ARYP –23	YP 315 – ⊗ – ⊗
9	ARYP – 7	YP 264 – ⊗ – ⊗
10	ARYP –19	YP 398 – ⊗ – ⊗
11	ARYP –14	YP 176 – ⊗ – ⊗
12	ARYP –20	YP 365 – ⊗ – ⊗
13	ARYP –13	YP 185 – ⊗ – ⊗
14	ARYP –17	YP 417 – ⊗ – ⊗
15	ARYP –24	YP 302 – ⊗ – ⊗
16	ARYP –8	YP 296 – ⊗ – ⊗
17	ARYP –25	YP 151 – ⊗ – ⊗
18	ARYP –10	YP 284 – ⊗ – ⊗
19	ARYP –12	YP 446 – ⊗ – ⊗
20	ARYP –22	YP 484 – ⊗ – ⊗
21	ARYP –16	YP 653 – ⊗ – ⊗
22	ARYP – 2	YP 508 – ⊗ – ⊗
23	ARYP – 6	YP 616 – ⊗ – ⊗
24	ARYP –11	YP 800 – ⊗ – ⊗
25	ARYP –15	YP 559 – ⊗ – ⊗

Table 4: Experimental details followed at various stages in the present investigation

Sl. No.	Particulars	Evaluation of S ₁ progenies	Evaluation of S ₂ progenies	Top cross testing	Line × tester analysis
1.	Location of experiment	ARS, Arabhavi	ARS, Arabhavi	ARS, Arabhavi	ARS, Arabhavi
2.	Season and year	Summer 2003-04	<i>Kharif</i> 2004	<i>Rabi</i> 2004-05	<i>Kharif</i> 2005
3.	Experimental design	Randomized block design	Randomized block design	Randomized block design	Randomized block design
4.	Number of replications	2	2	2	3
5.	Number of entries	400	350	350	132
6.	Row length	4m	4m	4m	5m
7.	Plot size	3 m ²	3 m ²	3 m ²	7.5 m ²
8.	Number of rows per entry	1	1	1	2
9.	Spacing between rows	75 cm	75 cm	75 cm	75 cm
10.	Spacing between plants	20 cm	20 cm	20 cm	20 cm
11.	Number of testers	-	-	1	4
12.	Number of hybrids	-	-	350	100
13.	Number of checks	-	-	2	3

The 100 crosses along with 25 S₂ lines, four testers, viz., CM-111, CI-5, KDMI-10 and NEI-9202B and three commercial checks, viz., DMH-2, Cargil 900M and Prabha were evaluated during *kharif 2005* at Agricultural Research Station, Arabhavi.

3.4 EXPERIMENTAL DETAILS

The experiments were laid out at Agricultural Research Station, Arabhavi from *Rabi 2003* to *kharif 2005* and summary of experimental details are mentioned below under Table 4.

After thorough land preparation, hand dibbling was done with two seeds per hill and thinned out to maintain single plant per hill during second week after sowing (10-15 days after sowing). The crop was applied with recommended dose of fertilisers (150 kg N, 75 kg K₂O₅ and 37.5 kg K₂O and 10 kg ZnSO₄/ha). The entire dose of P₂O₅, K₂O and one third of nitrogen was applied as basal dose and the rest of the two third nitrogen was applied as top dressing in two equal splits at fourth and seventh week after planting. The crop was raised with the recommended package of practices as per schedule.

3.5 OBSERVATIONS ON QUANTITATIVE TRAITS

In these investigations, data were collected in respect of 18 quantitative traits. Observations on quantitatively inherited traits were recorded on five competitive randomly selected plants. The average was taken as the mean of the treatment. The way in which observations were recorded is described below.

3.5.1 Plant height at 30 days after sowing (cm)

Seedling height at 30 days after sowing (DAS) was measured in centimetre (cm) from ground level to the tip of the middle whorl leaf of the plant.

3.5.2 Plant girth / stem thickness at 30 days after sowing (cm)

The third internode of the plant from the bottom was marked and its thickness at the middle was measured in centimetre (cm) using vernier callipers.

3.5.3 Leaf area at 30 days after sowing (cm²)

The third open leaf selected from top whorl for observation and leaf area was worked out as product of leaf length, breadth and the factor 0.75 and expressed in square centimeters.

3.5.4 Plant height at 60 days after sowing (cm)

Plant height was expressed in centimetres by measuring the plant stalk from the ground level to the base of the last leaf sheath of the plant.

3.5.5 Ear height at 60 days after sowing (cm)

This observation was recorded at the same time as plant height (at harvest), measured as the height of the plant from the ground level to the uppermost ear bearing node and expressed in centimetre.

3.5.6 Leaf area at 60 days after sowing (cm²)

The average of five leaves from five different plants at 60 days after sowing was calculated by using formula $L \times B \times 0.75$ and expressed in square centimetre (Montgomery, 1911).

3.5.7 Ear weight (g)

Five ears were sun dried and weight in grams was recorded at stable moisture content.

3.5.8 Ear length (cm)

Length of the ear was measured and recorded in centimetres at the time of harvest as its total length (from the base to the tip of the ear).

3.5.9 Ear circumference (cm)

Ear circumference at one-third length from the base of the ear was measured and recorded in centimetre.

3.5.10 Number of kernel rows per cob

Number of kernel rows in each ear was counted for five cobs and mean was worked out.

3.5.11 Number of kernels per row

The number of kernels in any one of the row in each ear was counted and mean was worked out.

3.5.12 Number of kernels per ear

Total number of kernels in each ear of the selected plants was recorded.

3.5.13 Hundred grain weight (g)

One hundred randomly selected grains per cob were weighed and weight was recorded in grams.

3.5.14 Shelling percentage

The ratio of grain weight to the ear weight was expressed in percentage.

$$\text{Shelling percentage} = \frac{\text{Grain weight}}{\text{Cob weight}} \times 100$$

3.5.15 Pith / shank / heart weight (g)

The total pith / shank / heart weight from each ear was recorded and the average heart weight was expressed as heart weight per plant in grams.

3.5.16 Kernel yield per plant (g)

At the time of harvesting, fresh ear weight was recorded in grams per plant. Moisture determinations were made from shelled samples from five random ears of each plot with the help of electronic moisture meter. The fresh ear weight data was used to work out the dry weight at 15 per cent moisture grain yield in grams per plant.

3.5.17 Kernel yield per plot (kg/plot)

At the time of harvest, fresh ear weight was recorded in kilograms for each plot. This fresh ear weight was adjusted to zero per cent grain moisture and recorded as grain yield per plot. Moisture percentage was determined on universal moisture tested in a grain sample

obtained from two rows of each of five ears selected at random at the time of harvest were used for genetical analysis following Combstock (1948) and Robinson (1968).

$$\text{Yield per plot (kg/plot)} = \frac{\text{Fresh ear weight} \times 100 - \text{AVM}}{\text{Final stand harvest}} \times K$$

Where,

$$K = \frac{\text{Average stand/plot of the trial} \times \text{plot area} \times 0.9412}{100 \times \text{plot area}}$$

AVM = Average moisture

3.5.18 Kernel / grain yield per hectare (q/ha)

Fresh dehusked ear weight per plot was recorded at the time of harvest. Moisture content of 100 grams of fresh kernels was recorded by moisture meter of each entry and the moisture percentage was calculated by using moisture conversion charts. Kernel yield per hectare was calculated using the formula given below:

$$\text{Yield (q/ha)} = \frac{\text{Fresh ear weight} \times 100 - \text{AVM}}{\text{Final stand harvest}} \times K$$

Where,

$$K = \frac{\text{Average stand of the trial} \times \text{Area (ha)} \times 0.9412}{100 \times \text{plot area}}$$

AVM – Average moisture

3.6 OBSERVATIONS ON QUALITATIVE TRAITS

The data were collected in respect of 12 qualitative characters and procedure of recording is described below.

3.6.1 Seedling vigour

The seedling vigour at 30 days after sowing was grouped into high vigour, medium vigour and low vigour based on plant height, stem girth, leaf length and leaf width of ear-to-row progenies.

3.6.2 Seedling colour

The seedling colour at 30 days after sowing was scored for green and purple colour at the base of the stem and recorded.

3.6.3 Leaf shape

Thirty days after sowing, narrow and broad leaf shape was recorded on the basis of leaf length and breadth.

3.6.4 Tassel size

At the time of 50 per cent flowering, tassel size was recorded as small, medium and large shape on visual selection.

3.6.5 Tassel shape

At the time of pollen shedding, tassel shape was measured and classified and expressed as open, compact and semi compact.

3.6.6 Silk colour

Silk colour was recorded at the time of silking stage.

3.6.7 Anther colour

At the time of pollen shedding, anther colour was recorded.

3.6.8 Kernel type

Kernel type of each cob was closely observed and classified into dent, semi-dent, flint and semi-flint types.

3.6.9 Kernel / grain size

Kernel of each cob of ear-to-row progenies were closely observed and scored as very bold, medium, small and very small size.

3.6.10 Kernel colour

Kernel colour of each cob was observed under natural day light and classified into yellow, light yellow, orange, orange yellow colour and white kernel colour.

3.6.11 Pith colour

Shank of each cob was observed and scored into red, light red and white colour and was recorded.

3.6.12 Tip filling of cob

Tip filling of each cob was closely observed and scored into complete, moderate tip filling and no tip tilling. As explained below complete tip filling: Tip of the cob was completely filled without leaving any space. Moderate tip filling : Top 2 cm of cob not filled with grains, No tip filling : More than 2 cm tip of cob not filled with grains.

3.7 STATISTICAL ANALYSIS

3.7.1 Analysis of variance

The data were subjected to statistical analysis for randomised block design (RBD) as described by Panse and Sukhatme (1962). The mean values of the entries in each replication were used for analysis of variance (ANOVA). The significant difference among genotypes was tested by 'F' test at one per cent and five per cent levels of probability. The structure of ANOVA table is presented below.

Source of variation	df	SS	MSS	F value calculated
Replication	(r-1)	R	R/(r-1)	
Treatment	(t-1)	Tr	Tr/(t-1)	Tr.MSS/E.MSS
Error	(r-1) (t-1)	E	E/(r-1) (t-1)	
Total	(rt-1)	T	T/(rt-1)	

Where

r : Number of replications

t : Number of treatments or entries

$$SEM = \sqrt{\frac{E.MSS}{r}}$$

The significance was tested by referring to table given by Snedecor and Cochran (1967).

3.7.2 Estimation of variance

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

$$\text{Genotypic variance } (V_g) = \frac{\text{Tr.MSS} - E.MSS}{r}$$

$$\text{Error variance } (V_e) = E.MSS/r$$

$$\text{Phenotypic variance } (V_p) = V_g + V_e$$

3.7.3 Coefficient of variability

Genotypic and phenotypic coefficients of variability were computed according to Burton and Devane (1953).

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

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

Where V_g : Genotypic variance

V_p : Phenotypic variance

$\bar{X}$: General mean of the character

PCV and GCV were classified low, moderate or high following Sivasubramanian and Menon (1973) as shown below:

0-10 % : Low
 10-20 : Moderate
 20% and above : High

3.7.4 Estimation of Heritability

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

$$\text{Heritability (h}^2\text{)} = \frac{V_g}{V_p} \times 100$$

Where V_g = Genotypic variance

V_p = Phenotypic variance

The heritability percentage was categorized as follows by following Robinson *et al.* (1949).

0-30 % : Low
 30-60% : Moderate
 60% and above : High

3.7.5 Genetic advance (GA)

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

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

Where i = selection differential (2.06) at 5 per cent selection intensity.

h^2 = Broad sense heritability

the genetic advance (GA) as percent of mean was categorized as low, moderate or high as suggested by Johnson *et al.* (1955) which is as follows

0-10%: low
 10-20%: moderate
 20% and above :High

3.7.6 Genetic advance over mean (GAM)

Genetic advance over mean was computed by the formula:

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

Where $\bar{X}$ = mean of the population

3.7.7 Combining ability analysis

3.7.7.1 Analysis of variance

The mean of each character for each entry were subjected to line $\times$ tester analysis and the variance of general combining ability of different cross combinations were estimated by the procedure developed by Kempthorne (1957). The form of analysis is given in the table below.

Sources of variation	Degrees of freedom	Mean sum of squares	Expected mean sum of squares
Replication	(r-1)		
Line	(f-1)	M_1	$\sigma^2 + r V_{sca} + rf V_{gca}$
Tester	(m-1)	M_2	$\sigma^2 + r V_{sca} + r MV_{gca} (f)$
L $\times$ T	(f-1) (m-1)	M_3	$\sigma^2 e + r V_{sca}$
Error	(fm-1)	M_4	$\sigma^2 e$

Where,

- r : Number of replications
- f : Number of females (lines)
- m : Number of males (testers)
- V_{sca} : Covariance of full sibs
- V_{gca} : Covariance of half sibs
- M_1 : Mean sum of squares due to females (lines)
- M_2 : Mean sum of squares due to males (testers)
- M_3 : Mean sum of squares due to females $\times$ male
- M_4 : Mean sum of squares due to error

3.7.7.2 Estimation of variance components

From the mean squares, covariance of full sibs (FS) and covariance of half sibs (HS) were estimated as per Sing and Choudhary (1985).

$$\text{Covariance} = \frac{(M_1 - M_4) + (M_2 - M_4) + (M_3 - M_4)}{3r} + \frac{6r \text{ COV (HS)} - r (f+m) \text{ COV (HS)}}{3r}$$

$$\text{Covariance of half sib} = \frac{(M_1 - M_3) + (M_2 - M_3)}{r (M+f)}$$

Where,

f : Number of lines (Females)

M : Number of testers (males)

r : Number of replications

Variance due to GCA = COV (HS) (Average)

Variance due to SCA = COV (FS) – 2 COV (HS)

After estimating the COV. HS and COV. FS the GCA variance of lines and testers and SCA variance of hybrids were calculated using the following formula.

GCA variance for females = $(M_1 - M_3)/r.m.$

SCA variance = $(M_3 - M_4)/r$

Where,

M₁ : Mean sum of squares due to females

M₂ : Mean sum of squares due to males

M₃ : Mean sum of squares due to females × males

M₄ : Mean sum of squares due to error

3.7.7.3 Proportional contribution of lines, testers and line × tester

$$\text{a. Contribution of lines (\%)} = \frac{SS (f)}{SS (c)} \times 100$$

$$\text{b. Contribution of testers (\%)} = \frac{SS (m)}{SS (c)} \times 100$$

$$\text{c. Contribution of lines} \times \text{testers} = \frac{SS (f \times m)}{SS (c)} \times 100$$

Where,

SS (c) : Sum of squares due to crosses

SS (f) : Sum of squares due to lines

SS (m) : Sum of squares due to testers

SS (f × m) : Sum of squares due to females × males

3.7.7.4 Estimation of combining ability effects

The models used to estimate gca and sca effect of ijk observations was as follows.

$$X_{ij} = \mu + g_i + g_j + s_{ij} + e_{ijk}$$

Where,

- μ : Population mean
- g_i : gca effects of the i^{th} female parent
- g_j : gca effects of the j^{th} male parent
- s_{ij} : sca effects of the ij^{th} cross combination
- i : Number of female parents involved
- j : Number of male parents involved
- k : Number of replications
- e_{ijk} : Error associated with the observation X_{ijk}

The individual effects were estimated as follows.

3.7.7.4.1 General combining ability (gca) effects

$$\text{a. Lines } (g_i) = \frac{X_{i..}}{mr} - \frac{X_{..}}{mfr}$$

Where,

$X_{i..}$: Total of i^{th} female parent over all male (m) parents and replications (r).

$X_{..}$: Total of all the hybrids over all male parents (m), female parents (f) and replications (r).

$$\text{b. Testers } (g_j) = \frac{X_{j..}}{fr} - \frac{X_{..}}{mfr}$$

Where,

$X_{j..}$: Total of the j^{th} male parent over all female parents (f) and replications (r).

3.7.7.4.2 Specific combining ability (sca) effects

$$X_{ij} = \frac{X_{ij..}}{r} - \frac{X_{i..}}{mr} - \frac{X_{.j.}}{fr} + \frac{X_{..}}{mfr}$$

Where,

X_{ij} : ji^{th} combination total over all replications (r)

3.7.7.4.3 Standard error for combining ability effects

The standard error (SE) pertaining to gca effects of males and females and sca effects of different combinations were calculated as under.

a) SE for gca effects of lines

$$SE \ g_i = (M_4/rm)^{1/2}$$

b) SE for gca effects of testers

$$SE \ g_j = (M_4/rf)^{1/2}$$

c) SE for sca effects

$$SE\ g_{ij} = (M_4/r)^{1/2}$$

3.7.7.4.4 Critical difference (CD)

The critical difference values in each case were computed by multiplying their corresponding SE values with Table 't' value at error degrees of freedom at 5 and 1 per cent level of significance.

3.7.8 Estimation of heterosis

Heterosis expressed as per cent increase or decrease of F_1 hybrid over mid-parent (average or relative heterosis), better parent (heterobeltiosis) and commercial checks (standard heterosis) were computed for each character using the following formulae (Turner, 1953 and Hayes *et al.*, 1955). The standard heterosis over three commercial check hybrids for each character is worked out.

$$\text{a. Heterosis over mid parent (relative heterosis)} = \frac{F_1 - MP}{MP} \times 100$$

$$\text{b. Heterosis over better parent (heterobeltiosis)} = \frac{F_1 - BP}{BP} \times 100$$

$$\text{c. Heterosis over check (standard heterosis)} = \frac{F_1 - CC}{CC} \times 100$$

Where,

F_1 : Mean performance of F_1

MP : Mean mid-parental value = $(P_1 + P_2)/2$

P_1 : Mean performance of parent one

P_2 : Mean performance of parent two

BP : Mean performance of better parent

CC : Mean performance of the best commercial check

The difference in the magnitude of heterosis were tested following the procedure given by Panse and Sukhatme (1962).

$$\text{a. Critical difference for mid-parent heterosis} = (3\ Me/2r)^{1/2} \times t$$

$$\text{b. Critical difference for better parent heterosis} = (2\ Me/r)^{1/2} \times t$$

$$\text{c. Critical difference for commercial check} = (2\ Me/r)^{1/2} \times t$$

Where,

r : Number of replications

Me : Error mean sum of square from analysis of variance table

t : Table value of 't' test at error degrees of freedom corresponding to 5% or 1% level of significance.

3.7.9 Association analysis between seed yield and its components

3.7.9.1 Genotypic and phenotypic correlation coefficients

Genotypic and phenotypic correlation coefficients were worked out as per the methods suggested by Johnson *et al.* (1955) to find out the relationship between yield and its contributing characters. Analysis of covariance was done similar to that of analysis of variance taking two characters at a time. The genotypic and phenotypic co-variances were derived as detailed for genotypic variance. The genotypic and phenotypic variance and co-variance components were utilized to calculate genotypic and phenotypic correlation coefficients (r) by applying the formula.

$$r = \sqrt{\frac{\text{Cov. g.}_{1.2}}{(\sigma^2 g_1) \times (\sigma^2 g_2)}} \text{ and } \sqrt{\frac{\text{Cov. p.}_{1.2}}{(\sigma^2 p_1) \times (\sigma^2 p_2)}}$$

Where,

Cov.g. _{1.2} : Genotypic covariance between two traits (1 and 2)

Cov.p. _{1.2} : Phenotypic covariance between two traits (1 and 2)

$\sigma^2 g_1$: Genotypic covariance for first trait

$\sigma^2 p_1$: Phenotypic covariance for first trait

$\sigma^2 g_2$: Genotypic covariance for second trait

$\sigma^2 p_2$: Phenotypic covariance for second trait

Referring to correlation table of Snedecor and Cochran (1967), the significance of phenotypic correlation coefficient was tested.

IV. EXPERIMENTAL RESULTS

The present investigations were conducted from *kharif* 2002 to *kharif* 2005 at the Botanical garden, Agriculture College, Dharwad and Agricultural Research Station, Arabhavi, University of Agricultural Sciences, Dharwad. The experiments were conducted to develop inbred lines, to study the nature of genetic variability in newly developed inbred lines both at S_1 and S_2 generations and to study the combining ability and heterotic potential of isolated lines derived from the Yellow pool base population.

The results obtained under various generations are presented in the following headings.

- 4.1 Performance of yellow pool base population
- 4.2 Performance of yellow pool S_0 population
- 4.3 Performance of S_1 lines derived from the yellow pool population
- 4.4 Performance of S_2 lines derived from yellow pool
- 4.5 Evaluation of S_2 lines by Top cross test
- 4.6 Line $\times$ tester analysis studies
- 4.7 Heterosis

4.1 PERFORMANCE OF YELLOW POOL BASE POPULATION

4.1.1 Mean and range values for ten quantitative traits among selected progenies in yellow pool base population

The yellow pool base population comprising of 10,000 plants was raised during *kharif* 2002. A total of 1500 plants were initially tagged based on plant morphological traits and finally 800 cobs were selected based on plant morphology and cob characters. The cobs harvested from such selected plants were assessed for following ten quantitative traits whose results are presented below.

4.1.1.1 Cob weight (g)

The cob weight among 800 progenies ranged from 91.90 to 375.00 g. and the mean cob weight was 160.35g (Table 5). However, the median value (155.31g) was comparatively lower than mean value, while the mode value (170.00g) was relatively higher than the mean cob weight. The skewness of the results indicated the negative distribution in the base population. The kurtosis (1.57) and skewness (0.89) values supported the deviation from normal distribution. The cob weight trait recorded higher co-efficient of variance (23.49%) with coefficient range value of 0.61.

4.1.1.2 Cob length (cm)

The cob length ranged from 9.00 to 23.00 cm (Table 5). The median (15.00 cm) and mode (15.00cm) values were comparable with the mean value (15.08 cm). The mode value (15.00cm) was equal to the mean value indicating a positively skewed distribution in the base population and a marginal deviation from the normal distribution. The cob length recorded higher coefficient of variance (13.89%) with a coefficient range of 0.44. As many as 312 progenies (39%) recorded cob length ranging from 15.08 to 17.17 cm (Table 6).

4.1.1.3 Cob girth (cm)

The cob girth in population ranged from 10.00 to 18.00 cm with a mean of 13.08cm (Table 5). The magnitude of median (13.00) and mode (13.00) were comparable with mean value. This indicated the positive skewness and narrow deviation from the normal distribution. The cob girth recorded relatively lower coefficient of variation (9.25) with a coefficient range of 0.29.

Table 5: Mean and range for ten quantitative traits among selected progenies in maize yellow pool base population (4th generation) (*kharif*, 2002)

Description	Cob weight (g)	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Number of kernels per cob	100-Seed weight (g)	Shelling (%)	Pith weight (g)	Grain yield per plant (g)
Mean	160.35	15.08	13.08	13.79	30.90	428.09	29.55	86.05	22.14	138.15
Standard error	1.33	0.07	0.04	0.07	0.20	3.88	0.18	0.10	0.22	1.19
Median	155.31	15.00	13.00	14.00	31.00	420.00	29.21	86.24	21.24	133.93
Mode	170.00	15.00	13.00	14.00	28.00	336.00	29.28	86.65	20.29	151.91
Standard deviation	37.66	2.09	1.21	2.03	5.68	109.74	4.99	2.70	6.17	33.53
Sample variance	1418.40	4.39	1.46	4.11	32.24	12043.32	24.87	7.30	38.10	1124.21
Kurtosis	1.57	0.43	0.21	-0.19	-0.40	-0.02	0.42	0.76	2.40	1.45
Skewness	0.89	0.33	0.30	0.19	0.30	0.58	0.42	-0.43	1.05	0.90
Range	283.10	14.00	8.00	12.00	30.00	574.00	30.00	20.90	46.74	245.45
Minimum	91.90	9.00	10.00	8.00	18.00	200.00	16.53	74.71	10.08	72.73
Maximum	375.00	23.00	18.00	20.00	48.00	774.00	46.53	95.60	56.82	318.18
Coefficient of range	0.61	0.44	0.29	0.43	0.45	0.60	0.48	0.12	0.70	0.63
Number	800.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00
CV %	23.49	13.89	9.25	14.69	18.38	25.64	16.88	3.14	27.88	24.27

4.1.1.4 Number of kernel rows per cob

The number of kernel rows per cob ranged between 8.00 to 20.00 rows per cob (Table 5). The magnitude of median (14.00) and mode (14.00) were comparable with the mean number of kernel rows per cob (13.79). The magnitude of kurtosis indicated negative distribution (-0.19) while the skewness indicated positive distribution (+0.19). The data indicated negatively skewed distribution with narrow deviation from the normal distribution. The coefficient of variance with respect to number of kernel rows per cob was 14.69 with a coefficient range value of 0.43.

4.1.1.5 Number of kernels per row

The number of kernels per row ranged from 18.00 to 48.00 with a mean value of 30.90 (Table 5). The magnitude of median (31.00) was comparable with the mean value, while the mode value (28.00) was relatively lower than mean value. The skewness recorded positive distribution (0.30), while the kurtosis (-0.40) recorded negative distribution indicating the deviation from normal distribution. The coefficient of variation was 18.38 per cent with a co-efficient range of 0.45.

4.1.1.6 Number of kernels per cob

The number of grains per cob ranged from 200.00 to 774.00 with a mean of 428.09 (Table 5). The magnitude of median (420.00) and mode (336.00) were relatively lower than mean value. This indicated negatively skewed distribution from the normal distribution. The kurtosis was negative (-0.02) while skewness (0.58) had positive. The number of grains per cob recorded higher coefficient of variation value (25.64%) with a coefficient of range of 0.60.

4.1.1.7 Hundred seed weight (g)

The range of 100-seed weight was between 16.53 to 46.53 g with a mean value of 29.55g (Table 5). The median value (29.21) and mode value (29.28) were relatively lower than the mean (29.55 g). This indicated negatively skewed distribution and deviation from the normal distribution in the base population. However, the kurtosis (0.42) and skewness (0.42) indicated relatively lesser deviation. The 100-seed weight recorded coefficient of variation of 16.88 per cent with a coefficient range of 0.48.

4.1.1.8 Shelling percentage (%)

The shelling per cent in the base population ranged between 74.71 to 95.60 per cent (Table 5). The mean shelling percentage was 86.05. The magnitude of median (86.24) and mode (86.65) were comparable with the mean value (86.05) indicating negatively skewed distribution. The kurtosis value of 0.76 and skewness of -0.43 were recorded for the shelling percentage. The shelling percentage recorded minimum coefficient of variation (3.14) with a coefficient of range of 0.12.

4.1.1.9 Pith weight (g)

The pith weight ranged from 10.08 to 56.82 g with a mean value of 22.14g (Table 5). Both median (21.24) and mode (20.29) values were lower than the mean value (22.14g) indicating positively skewed distribution and deviation from the normal distribution. Further, kurtosis (2.40) and skewness (1.05) value supported the deviation from the normal distribution for pith weight. The coefficient of variation was higher (27.88%) with coefficient of range of 0.70.

4.1.1.10 Grain yield per plant (g)

The grain yield per plant ranged between 72.73 to 318.18g, with a mean value of 138.15 g (Table 5). The median (133.93) was lesser than the mean value (138.15), while the mode value (151.91) was relatively higher than mean value. This indicated both negative and positive skewed distribution in the base population. The kurtosis (1.45) and skewness (0.90) were appreciably deviated from the normal distribution. The grain yield per plant recorded coefficient of variation of 24.27 per cent with a coefficient of range of 0.63.

4.1.2 Frequency distribution of progenies for various quantitative traits in maize yellow pool base population

The frequency distribution of the progenies for different quantitative characters such as cob weight, cob length, cob girth, number of kernel rows per cob, number of kernels per row, pith weight, 100-seed weight, shelling percentage, number of kernels per cob and grain yield per plant are presented here under.

4.1.2.1 Cob weight (g)

Out of 800 progenies in the base population, the class, mean minus one standard deviation to mean ($M - SD$ to M) comprised of 277 progenies with a range of 122.70 to 160.35 g, while the class, mean to mean plus one standard deviation (M to $M + SD$) comprised of 176 progenies with a range of 160.35 to 198.01 (Table 6). As many as 96 progenies belonged to class mean plus one standard deviation to mean plus two standard deviation ($M + SD$ to $M + 2 SD$) with range between 198.01 to 235.67 and 31 progenies (3.88%) exhibited higher values belonging to class ($>M + 2 SD$) values greater than 235.67g. As many as 453 progenies recorded higher cob weight than the population mean (160.35 g) which accounted for 56.63 per cent of total progenies.

4.1.2.2 Cob length (cm)

Among the 800 progenies in the base population, five recorded cob length with class value of less than 10.80 cm that belonged to the class less than $M - 2 SD$ (Table 6). Equal number of progenies (312) belonged to the class $M - SD$ to M (12.99 to 15.08) and M to $M + SD$ (15.08 to 17.17). Large number of progenies (406) belonged to the higher class M to $M + SD$ to $>M + 2 SD$ (>19.26) accounting for 50.75 per cent of the 800 progenies.

4.1.2.3 Cob girth (cm)

The frequency distribution for cob girth based on the class values indicated that maximum number of progenies (259) belonging to $M - SD$ to M (11.87 to 13.08) followed by 258 lines to the class values of M to $M + SD$ (13.08 to 14.29) (Table 6). The minimum numbers of progenies (12) belonged to the class value of less than 10.66cm. The total number of progenies belonging to the higher class commencing from M to $M + SD$ to more than $M + 2 SD$ (363) accounted for 45.38 per cent of the total base population based on cob girth.

4.1.2.4 Number of kernel rows per cob

The frequency distribution recorded equal number of progenies (266) under both classes $M - SD$ to M (11.76 to 13.79) and M to $M + SD$ (13.79 to 15.82), followed by 167 progenies (20.88%) belonging to the class $M + SD$ to $M + 2 SD$ with a class value of 15.82 to 17.85 number of kernel rows per cob (Table 6). The progenies which belonged to higher class values were 477, accounting for 59.63 per cent of the base population.

4.1.2.5 Number of kernels per row

The frequency distribution for 800 progenies based on the class values revealed that 300 progenies belonged to the class values of $M - SD$ to M to $M + SD$ (25.22 to 30.90) to (30.90 to 36.58) (Table 6). As many as 145 progenies belonged to a class value of 36.58 to 42.26 ($M + SD$ to $M + 2 SD$). The total number of progenies in the favourable class values (461) accounted for 57.63 percentage of the base population.

4.1.2.6 Number of kernels per cob

Out of 800 base progenies frequency distribution revealed equal number lines (153) belonged to two classes viz., 318.35 to 428.09 (M to $M + SD$) to 428.09 to 537.83 (M to $M + SD$) kernel number (Table 6). The maximum numbers of progenies (268) belong to the class value ranging from $M + SD$ to $M + 2 SD$ (88.75 to 91.45). The total number of progenies with desirable number of kernels per cob were 471, accounting for 58.88 per cent of the total progenies in the base population.

4.1.2.7 100-seed weight (g)

Out of 800 progenies, 282 belonged to the class $M - SD$ to M followed by 281 belonging to the class M to $M + SD$ (29.55 to 34.54) (Table 6). Minimum number of lines (8)

Table 6: Frequency distribution of progenies for various quantitative traits in maize yellow pool base population (4th generation) (*kharif*, 2002)

Classes based on SD	Cob weight (g)		Cob length (cm)		Cob girth (cm)		Number of kernel rows per ear		Number of kernels per row	
	Class value	Number	Class value	Number	Class value	Number	Class value	Number	Class value	Number
<M - 2 SD	<85.20	0 (0.00)	<10.80	5 (0.63)	<10.66	12 (1.50)	<9.73	2 (0.25)	<19.54	3 (0.38)
M - 2 SD to M - SD	85.20 to 122.68	120 (15.00)	10.90 to 12.99	77 (9.63)	10.66 to 11.87	66 (8.25)	9.73 to 11.76	55 (6.88)	19.54 to 25.22	36 (4.50)
M - SD to M	122.69 to 160.35	277 (34.63)	12.99 to 15.08	312 (39.00)	11.87 to 13.08	259 (32.38)	11.76 to 13.79	266 (33.25)	25.22 to 30.90	300 (37.50)
M to M + SD	160.35 to 198.01	176 (22.00)	15.08 to 17.17	312 (39.00)	13.08 to 14.29	258 (32.25)	13.79 to 15.82	266 (33.25)	30.90 to 36.58	300 (37.50)
M + SD to M + 2 SD	198.01 to 235.67	96 (12.00)	17.17 to 19.26	74 (9.25)	14.29 to 15.50	82 (10.25)	15.82 to 17.85	167 (20.88)	36.58 to 42.26	145 (18.13)
>M + 2 SD	>235.67	31 (3.88)	>19.26	20 (2.50)	>15.50	23 (2.88)	>17.85	44 (5.50)	>42.26	16 (2.00)

Classes based on SD	Number of kernels per ear		100-Seed weight (g)		Shelling %		Pith weight (g)		Grain yield per plant (g)	
	Class value	Number	Class value	Number	Class value	Number	Class value	Number	Class value	Number
<M - 2 SD	<208.61	14 (0.50)	<19.57	8 (1.00)	<80.65	1 (0.13)	<9.8	0 (0.00)	<71.08	0 (0.00)
M - 2 SD to M - SD	208.61 to 318.35	162 (20.25)	19.57 to 24.56	109 (13.63)	80.65 to 83.35	4 (0.50)	9.8 to 15.97	127 (15.88)	71.08 to 104.62	123 (15.38)
M - SD to M	318.35 to 428.09	153 (19.13)	24.56 to 29.55	282 (35.26)	83.35 to 86.05	393 (49.13)	15.97 to 22.14	276 (34.50)	104.62 to 138.15	280 (35.00)
M to M + SD	428.09 to 537.83	153 (19.13)	29.55 to 34.54	281 (35.13)	86.05 to 88.75	393 (49.13)	22.14 to 28.31	275 (34.38)	138.15 to 171.68	279 (34.88)
M + SD to M + 2 SD	537.83 to 647.57	268 (33.50)	34.54 to 39.53	86 (10.75)	88.75 to 91.45	9 (1.13)	28.31 to 34.48	98 (12.25)	171.68 to 205.21	85 (10.63)
>M + 2 SD	>647.57	50 (6.25)	>39.53	34 (4.25)	>91.45	0 (0.00)	>34.48	24 (3.00)	>205.21	33 (4.13)

was recorded in a class with value less than 19.57g of 100-seed weight. The total Number of progenies which belong to higher seed weight category (M to M+SD to > M+2 SD) (401) accounted for 50.13 per cent of the total progenies.

4.1.2.8 Shelling percentage (%)

The frequency distribution of 800 progenies revealed equal number of progenies (393) belonging to the two classes viz., M-SD to M and M to M+SD (83.35 to 86.05 and 86.05 to 88.75) (Table 6). None of the lines belonged to the class value of more than 91.45 shelling per cent under the category >M+2 SD. The total number of progenies with better shelling values (402) accounted for the 50.25 per cent of the base population.

4.1.2.9 Pith weight (g)

The frequency distribution for 800 progenies indicated that maximum lines i.e., 276 (34.50%) fall between 15.97 and 22.14 (M-SD to M) class interval, 275 lines (34.38%) fall between 22.14 and 28.31 (M to M+SD) class interval, 127 lines (15.88%) fall between 9.8 and 15.97, 98 lines (12.25%) fall between 28.31 and 34.48 (M+SD to M+2 SD), 24 progenies (3.00%) in the group of more than 34.48 class value (Table 6).

4.1.2.10 Grain yield per plant (g)

Out of 800 progenies, thirty five per cent (280) exhibited grain yield per plant between 104.62 to 138.15g (M-SD to M) per plant followed by 279 (34.88%) progenies, whose class values were between 138.15 to 171.68g (M to M+SD) per plant (Table 6). As many as 85 progenies belonged to the class of M + SD to M + 2 SD (171.68 to 205.21g), accounting nearly for 10.63 per cent of the total progenies. However, there were only 33 (4.13%) progenies which recorded grain yield per plant higher than 205.21g per plant.

4.1.3 Distribution of progenies for various qualitative traits in base population

The distribution for qualitative traits of the progenies in yellow pool base population were studied for grain colour, grain size, grain texture pith colour and tip filling and the same is presented here under.

4.1.3.1 Grain colour

Out of 800 progenies in the base population, 369 progenies were with yellow colour followed by 309 with orange yellow and 122 progenies had yellow orange grain colour (Table 7). The frequency of yellow population was relatively high (46.13%) followed by orange yellow (38.63%). The frequency of yellow orange progenies was minimum with per cent value of 15.25.

4.1.3.2 Grain size

Among the 800 progenies, 546 had medium grain size accounting for 68.25 per cent of the population followed by 219 progenies with bolder grain size (27.37%) (Table 7). Thirty four progenies recorded smaller grain size, while only one progeny recorded very bold grain size. Highest number of progenies (95.6%) recorded grain size which ranged between bold to medium grain size.

4.1.3.3 Grain texture

Out of the 800 progenies, 713 possessed flint grain texture accounting to 89.13 per cent of the population (Table 7). The other progenies exhibited grain texture such as dent (8 progenies), semident (26 progenies) and semi-flint (53 progenies) accounting to 10.87 per cent of the base population.

4.1.3.4 Pith colour

Among the 800 progenies, 699 (87.38%) recorded white pith colour followed by 82 progenies (10.25%) with red pith colour (Table 7). Nine progenies recorded dark red and ten progenies recorded red pith colour accounting to 1.13 and 1.25 per cent of the base population respectively.

Table 7: Frequency distribution of progenies for various qualitative traits in maize yellow pool base population (4th generation) (kharif, 2002)

Sl. No.	Grain Color	Frequency	Grain Size	Frequency	Grain texture	Frequency	Pith color	Frequency	Tip filling	Frequency
1	Orange yellow	309 (38.62)	Very Bold	001 (0.12)	Flint	713 (89.12)	Dark Red	009 (01.12)	Complete Tip Filling	037 (04.62)
2	Yellow	369 (46.12)	Bold	219 (27.37)	Semi Flint	053 (06.62)	Light Red	010 (01.25)	Medium Tip Filling	437 (54.62)
3	Yellow orange	122 (15.25)	Medium	546 (68.25)	Dent	008 (01.00)	Red	082 (10.25)	No Tip Filling	326 (40.75)
4			Small	034 (04.25)	Semi dent	026 (03.25)	White	699 (87.37)		
	Total	800	Total	800	Total	800	Total	800	Total	800

Figures in parenthesis indicate percent values

4.1.3.5 Tip filling

Moderate tip filling was recorded by 437 progenies accounting to 54.63 per cent, while 326 lines exhibited no tip filling accounting to 40.75 per cent of the base population (Table 7). Only 37 progenies recorded complete tip filling accounting for 4.63 per cent of the base population.

4.2 PERFORMANCE OF YELLOW POOL S₀ POPULATION

4.2.1 Mean and range for early vigour, grain yield and its components in S₀ generation of yellow pool population

Various characters were studied for S₀ population under yellow pool back ground. A total of 800 ear-to-row progenies were grown and five S₀ plants in each progenies were selected based on desirable plant morphology and selfed. The progenies were evaluated for early vigour, grain yield and its components.

4.2.1.1 Seedling height at 30 DAS (cm)

The seedling height ranged from 14.04 to 34.60 cm with an average height of 27.48 cm (Table 8). The magnitude of median (28.80cm) was almost equal to mean, whereas the mode value (29.60 cm) was higher than mean value, indicating a negatively skewed distribution and a marginal deviation from the normal distribution. Further, kurtosis (0.64) and skewness (-1.16 cm) also indicated platykurtic deviation from the normal distribution in the S₀ progenies for seedling height. The seedling height recorded coefficient of variation of 14.40 per cent with coefficient of range value of 0.42.

4.2.1.2 Seedling girth at 30 DAS (cm)

Seedling girth among 800 progenies ranged between 0.90 to 4.10 cm with an average of 1.73 cm (Table 8). The magnitudes of median (1.78) and mode values (1.88) were more than the mean seedling girth (1.73), indicating a negatively skewed distribution and a small deviation from normal distribution. The kurtosis value of 4.29 showed leptokurtic deviation from the normal distribution in the S₀ population for seedling girth. Seedling girth recorded 17.23 per cent of co-efficient of variation with a range value of 0.64.

4.2.1.3 Leaf length at 30 DAS (cm)

The leaf length ranged from 15.30 to 54.80 cm with a mean length of 32.83cm (Table 8). The magnitude of median (34.00) and mode value (35.20) were more than mean value indicating negatively skewed distribution (-0.52) and a marginal deviation from the normal distribution. Further, kurtosis of 0.09 indicated platykurtic deviation from the normal distribution in the S₀ population. The leaf length recorded coefficient of variation of 19.68 per cent with coefficient of range value of 0.56.

4.2.1.4 Leaf width at 30 DAS (cm)

The leaf width ranged between 1.08 to 4.94 cm, with a mean of 3.25cm (Table 8). The magnitude of median (3.54) and mode (3.80) were higher than mean values (3.25) indicating a negatively skewed distribution and a marginal deviation from the normal distribution. Further, kurtosis (-0.50) and the skewness (-0.83) values also indicated platykurtic with negatively skewed distribution from the normal distribution. The leaf width recorded coefficient of variation of 32.31 per cent with coefficient of range value of 0.64.

4.2.1.5 Leaf area at 30 DAS (cm²)

The leaf area ranged from 18.64 to 267.42 cm with average leaf area of 112.57 cm (Table 8). The magnitude of median (121.79) and mode values (152.00cm) when compared with mean value indicated equal distribution. Further, kurtosis (-0.46) and the skewness (-0.41) also indicated platykurtic skewed distribution from the normal distribution. The seedling leaf area exhibited higher coefficient of variation of 43.57 per cent with coefficient of range value of 0.87.

Table 8: Mean and range for early vigour, grain yield and its components in S₀ generation of yellow pool population of maize

Description	Early vigor at 30 DAS					At maturity		
	1	2	3	4	5	6	7	8
	Seedling height (cm)	Seedling girth (cm)	Leaf length (cm)	Leaf width (cm)	Leaf area (cm ²)	Plant height (cm)	Ear height (cm)	Cob weight (g)
Mean	27.48	1.73	32.83	3.25	112.57	178.27	88.53	134.90
Standard Error	0.14	0.01	0.23	0.04	1.73	0.61	0.53	1.39
Median	28.80	1.78	34.00	3.54	121.79	180.00	88.00	140.48
Mode	29.60	1.88	35.20	3.80	152.00	195.00	102.00	115.25
Standard Deviation	3.96	0.30	6.46	1.05	49.05	17.35	15.12	39.18
Sample Variance	15.65	0.09	41.76	1.10	2405.75	301.08	228.58	1535.07
Kurtosis	0.64	4.29	0.09	-0.50	-0.46	-0.06	0.09	-0.85
Skewness	-1.16	0.27	-0.52	-0.83	-0.41	-0.60	0.19	-0.10
Range	20.56	3.20	39.50	3.86	248.78	91.00	95.00	192.89
Minimum	14.04	0.90	15.30	1.08	18.64	122.00	53.00	55.51
Maximum	34.60	4.10	54.80	4.94	267.42	213.00	148.00	248.40
Coefficient of range	0.42	0.64	0.56	0.64	0.87	0.27	0.47	0.63
Number	800	800	800	800	800	800	800	800
CV %	14.40	17.23	19.68	32.31	43.57	9.73	17.08	29.04

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Description	At maturity								
	9	10	11	12	13	14	15	16	17
	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Number of kernels per cob	100- Seed weight (g)	Shelling %	Pith weight (g)	Grain yield per plant (g)
Mean	12.05	13.31	13.63	24.90	341.91	26.76	85.24	19.20	115.70
Standard Error	0.05	0.05	0.06	0.15	2.93	0.18	0.13	0.18	1.25
Median	12.00	13.33	14.00	24.67	342.33	27.49	85.71	19.06	120.37
Mode	11.00	14.00	14.00	24.33	336.00	22.12	85.19	22.51	102.12
Standard Deviation	1.56	1.55	1.71	4.29	82.85	5.08	3.58	5.13	35.47
Sample Variance	2.42	2.41	2.93	18.43	6863.75	25.78	12.84	26.30	1258.05
Kurtosis	0.48	-0.24	-0.33	-0.02	-0.27	2.45	16.02	-0.33	-0.73
Skewness	0.57	0.08	0.16	0.18	0.13	0.15	-2.84	0.31	-0.10
Range	10.50	10.17	9.33	27.67	472.00	49.18	38.27	25.31	190.12
Minimum	8.17	9.00	10.00	13.33	148.00	12.19	55.52	8.52	32.41
Maximum	18.67	19.17	19.33	41.00	620.00	61.37	93.78	33.82	222.53
Coefficient of range	0.39	0.36	0.32	0.51	0.61	0.67	0.26	0.60	0.75
Numbers	800	800	800	800	800	800	800	800	800
C.V %	12.94	11.64	12.55	17.23	24.23	18.98	4.20	26.71	30.66

4.2.1.6 Plant height at 60 DAS (cm)

At 60 DAS the plant height ranged from 122 cm to 213 cm with a mean of 178.27cm (Table 8). The magnitude of median (180.00) and mode values (195.00) were higher than the mean (178.27), indicating negatively skewed distribution and deviation from the normal distribution of progenies in the population. Further, kurtosis (-0.06) and skewness (-0.60) also indicated platykurtic negative distribution deviation from the normal distribution. The plant height recorded lower coefficient of variation of 9.73 with lesser coefficient of range value of 0.27.

4.2.1.7 Ear height (cm)

The ear height ranged from 53.00 to 148.00 cm with a mean value of 88.53cm (Table 8). The magnitude of median (88.00) was almost equal to mean (88.53), whereas the mode value was higher than mean value. The kurtosis (0.09) and the skewness values (0.19) also indicated platykurtic positively skewed deviation from the normal distribution. The ear height recorded coefficient of variation of 17.08 per cent and coefficient of range value of 0.47.

4.2.1.8 Cob weight (g)

The cob weight ranged from 55.51 to 248.40 g with mean cob weight of 134.90g (Table 8). However, the median value (140.48) was higher than mean value, whereas the mode value (115.25) was lesser than mean value. Further, kurtosis (-0.85) and the skewness (-0.10) indicated platykurtic skewed negative deviation from the normal distribution. The trait recorded high coefficient of variation of 29.04 with coefficient of range value of 0.63.

4.2.1.9 Cob length (cm)

The cob length ranged from 8.17 to 18.67 cm with a mean of 12.05 cm (Table 8). The magnitude of median (12.00) was almost equal to mean, whereas the mode value (11.00) was lesser than mean indicating deviation from normal distribution. Further, kurtosis (0.48) and the skewness (0.57) values indicated platykurtic positively skewed deviation from the normal distribution. The cob length exhibited moderate coefficient of variation of 12.94 per cent with coefficient of range value of 0.39.

4.2.1.10 Cob girth (cm)

The mean cob girth ranged from 9.00 to 19.17 cm with an average cob girth of 13.31 cm (Table 8). The magnitude of median (13.33) and mode values (14.00) were more than mean value indicating a negatively skewed distribution and a marginal deviation from the normal distribution. The kurtosis (-0.24) and skewness (0.08) showed platykurtic negative deviation from normal distribution. The cob girth recorded co-efficient of variation of 11.64 per cent with coefficient of range value of 0.36.

4.2.1.11 Number of kernel rows per cob

The number of kernel rows per cob ranged from 10.00 to 19.33 with an average of 13.63 (Table 8). The magnitude of median (14.00) and mode (14.00) values were more than mean indicating negatively skewed distribution. Further, the kurtosis (-0.33) and skewness (0.16) indicated platykurtic deviation from the normal distribution in the S_0 population. The coefficient of variation was moderate (12.55) with coefficient of range value of 0.32.

4.2.1.12 Number of kernels per row

Number of kernels per row ranged from 13.33 to 41.00 with an average number of kernels of 24.90 (Table 8). The magnitude of median (24.67) and mode (24.33) values were lesser than mean (24.90), indicating positively skewed distribution from normal distribution. Kurtosis (-0.02) and skewness (0.18) showed platykurtic negative deviation from the normal distribution. The number of kernels per row showed coefficient of variation of 17.23 per cent with coefficient of range value of 0.51.

4.2.1.13 Number of kernels per cob

The number of kernels per cob ranged from 148.00 to 620.00 with a mean of 341.91 (Table 8). The median (342.33) and mode values (336.00) were comparable with mean value (341.91) indicating static distribution. The kurtosis value (-0.27) indicated platykurtic negative

deviation from the normal distribution. The coefficient of variation for the trait was 24.23 per cent with coefficient of range of 0.61.

4.2.1.14 Hundred seed weight (g)

Hundred seed weight among S_0 progenies ranged from 12.19 to 61.37 g with an average value of 26.76g (Table 8). The magnitude of median value (27.49) and mode values are (22.12) comparable with the mean value which did not indicate any relationship in the pattern of distribution. The kurtosis (2.45) and skewness (0.15) showed platykurtic positive deviation from the normal distribution. The 100-seed weight exhibited coefficient of variation of 18.98 per cent with coefficient of range value of 0.67.

4.2.1.15 Shelling percentage (%)

The shelling percentage ranged from 55.52 to 93.78 per cent with an average shelling percentage of 85.24 (Table 8). The magnitude of median (85.71) and mode (85.19) values were more than the mean value indicating negatively skewed distribution. The kurtosis of 16.02 indicated leptokurtic positive deviation from the normal distribution. The coefficient of variation for shelling per cent was 4.20 per cent with coefficient of range value of 0.26.

4.2.1.16 Pith weight (g)

The pith weight ranged between 8.52 to 33.82 g with an average pith weight of 19.20g (Table 8). The median value (19.06) and mode (22.51) did not follow any relationship with the mean. Further, kurtosis (-0.33) and skewness (0.31) values indicated the platykurtic negative deviation from the normal distribution. The pith weight recorded 26.71 per cent coefficient of variation and coefficient of range value of 0.60.

4.2.1.17 Grain yield per plant (g)

The grain weight ranged from 32.41 to 222.53 g with a mean value of 115.70g (Table 8). The magnitude of median (120.37) and mode (102.12) values when compared with mean value (115.70) indicated static distribution. The kurtosis value of -0.73 showed platykurtic negative distribution. The trait exhibited high coefficient of variation (30.66) with coefficient of range value of 0.75.

4.2.2 Distribution for early vigour, grain yield and its components in S_0 generation

The results of frequency distribution for early vigour, grain yield and its components in S_0 generation such as seedling height and girth, leaf length, width and area, plant height, ear height, cob weight and length, cob girth, number of kernel rows per cob, number of kernels per row, pith weight, 100-seed weight, shelling percentage number of kernels per cob and grain yield per plant of S_0 progenies of yellow pool is presented below.

4.2.2.1 Seedling height at 30 DAS (cm)

Out of 800 progenies, an equal number of lines (312) belonged to both the categories M-SD to M (23.52 to 27.48) and M to M+SD (27.48 to 31.44) comprising nearly 78 per cent of the S_0 population (Table 9). The category M+SD to M+2 SD (31.44 to 35.40) recorded minimum number of lines (52), while there were no lines with greater values than M+2 SD (>35.40). The higher classes based on standard deviation (SD) from M to M+SD (27.48 to 31.44) to >M+2 SD (>35.40) comprised of 364 lines accounting for 45.5 per cent of S_0 population.

4.2.2.2 Seedling girth (cm)

Out of 800 progenies an equal number of lines (278) were in category of M-SD to M (1.43 to 1.73) and M to M+SD (1.73 to 2.03) followed by 124 lines in M - 2 SD to M-SD (1.13 to 1.43) category (Table 9). Only seven lines were in the category of >M+2 SD (>2.33). The cumulative total of progenies belonging to class values of 27.48 to 31.44 (M to M+SD) and greater than 35.75 (>M+2 SD) comprised of 376 lines accounting for 47.0 per cent of the S_0 population.

Table 9: Frequency distribution for early vigour, grain yield and it's components in S₀ generation of yellow pool population of maize

Classes based on SD	1		2		3		4		5		6	
	Seedling height (cm)		Seedling girth (cm)		Leaf length (cm)		Leaf width (cm)		Leaf area (cm ²)		Plant height (cm)	
	Class value	Number	Class value	Number	Class value	Number	Class value	Number	Class value	Number	Class value	Number
<M-2SD	<19.56	58 (7.25)	<1.13	22 (2.75)	<19.91	27 (3.38)	<1.15	10 (1.25)	<14.47	0 (0.00)	<143.57	29 (3.63)
M-2SD to M-SD	19.56 to 23.52	66 (8.25)	1.13 to 1.43	124 (15.50)	19.91 to 26.37	136 (17.00)	1.15 to 2.20	158 (19.75)	14.47 to 63.52	167 (20.88)	143.67 to 160.92	104 (14.75)
M-SD to M	23.52 to 27.48	312 (39.00)	1.43 to 1.73	278 (34.75)	26.37 to 32.83	274 (34.25)	2.20 to 3.25	274 (34.25)	63.52 to 112.57	289 (36.13)	160.92 to 178.27	247 (30.88)
M to M+SD	27.48 to 31.44	312 (39.00)	1.73 to 2.03	278 (34.75)	32.83 to 39.28	273 (34.13)	3.25 to 4.30	274 (34.25)	112.57 to 161.62	289 (36.13)	178.27 to 195.62	286 (35.75)
M+SD to M+2SD	31.44 to 35.40	52 (6.50)	2.03 to 2.33	91 (11.38)	39.28 to 45.75	84 (10.50)	4.30 to 5.35	84 (10.50)	161.62 to 210.67	54 (6.75)	195.62 to 212.92	133 (16.63)
>M+2SD	>35.40	0 (0.00)	>2.33	7 (0.88)	>45.75	9 (1.13)	>5.35	0 (0.00)	>210.67	1 (0.13)	>212.97	1 (0.13)

Classes Based on SD	7		8		9		10		11		12	
	Ear height (cm)		Cob weight (g)		Cob length (cm)		Cob girth (cm)		Number of kernel rows per ear		Number of kernels per row	
	Class value	Number	Class value	Number	Class value	Number	Class value	Number	Class value	Number	Class value	Number
<M-2SD	<58.29	13 (1.63)	<56.54	4 (0.50)	<8.93	6 (0.75)	<10.21	12 (1.50)	<10.21	22 (2.75)	<16.31	13 (1.63)
M-2SD to M-SD	58.29 to 73.41	118 (14.75)	56.55 to 95.72	183 (22.88)	8.93 to 10.49	101 (12.63)	10.21 to 11.76	136 (17.00)	10.21 to 11.92	53 (6.63)	16.32 to 20.61	106 (13.25)
M-SD to M	73.41 to 88.53	276 (34.50)	95.72 to 134.90	242 (30.25)	10.49 to 12.05	282 (32.25)	11.76 to 13.31	262 (32.75)	11.92 to 13.63	304 (41.0)	20.62 to 24.90	275 (34.38)
M to M+SD	88.53 to 103.65	278 (34.75)	134.90 to 174.08	241 (30.13)	12.05 to 13.61	282 (32.25)	13.31 to 14.86	262 (32.75)	13.63 to 15.34	304 (41.0)	24.90 to 29.19	275 (34.38)
M+SD to M+2SD	103.65 to 118.77	95 (11.88)	174.08 to 213.26	121 (15.13)	13.61 to 15.17	100 (12.50)	14.86 to 16.41	112 (14.00)	15.34 to 17.05	102 (12.75)	29.19 to 33.48	112 (14.00)
>M+2SD	>118.77	20 (2.50)	>213.26	9 (1.13)	>15.17	29 (3.63)	>16.41	16 (2.00)	>17.05	15 (1.88)	>33.48	20 (2.50)

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Classes Based on SD	13		14		1		16		17	
	Number kernels per ear		100-seed weight (g)		Shelling %		Pith weight (g)		Grain yield per plant (g)	
	Class value	Number	Class value	Number	Class value	Number	Class value	Number	Class value	Number
<M-2SD	<176.21	13 (1.63)	<16.6	20 (2.50)	<78.08	26 (3.25)	<8.94	4 (0.50)	<44.76	8 (1.00)
M-2SD to M-SD	176.21 to 259.06	134 (16.75)	16.7 to 21.68	117 (14.63)	78.08 to 81.66	56 (7.00)	8.95 to 14.07	155 (19.38)	44.76 to 80.23	173 (21.63)
M-SD to M	259.06 to 341.91	262 (32.75)	21.68 to 26.76	281 (35.13)	81.66 to 85.24	326 (40.75)	14.07 to 19.20	259 (32.38)	80.23 to 115.70	247 (30.88)
M +M+SD	341.91 to 424.76	261 (32.63)	26.76 to 31.84	281 (35.13)	85.24 to 88.82	325 (40.63)	19.20 to 24.33	258 (32.25)	115.70 to 151.17	246 (30.75)
M+SD to M+2SD	424.76 to 507.61	111 (13.88)	31.84 to 36.92	88 (11.00)	88.82 to 92.40	66 (8.25)	24.33 to 29.46	95 (14.88)	151.17 to 186.64	117 (14.63)
>M+2SD	>507.61	19 (2.38)	>36.92	13 (1.63)	>92.40	1 (0.13)	>29.46	29 (3.63)	>186.64	9 (1.13)

4.2.2.3 Leaf length (cm)

Maximum number of progenies (274) belonged to M-SD to M (26.37 to 32.83) category followed by M to M+SD (32.83 to 39.28) with 273 lines. The minimum number of lines (9) was recorded in category with $>M+2\text{ SD}$ (>45.75) (Table 9). The number of progenies with higher values than mean comprised of 366 lines accounting for 45.75 per cent of the S_0 population.

4.2.2.4 Leaf width (cm)

Out of 800, an equal number of progenies (274) in each class of M-SD to M (2.20 to 3.25) and M to M+SD (3.25 to 4.30) category accounted for 68.5 per cent of the S_0 population (Table 9). Minimum number of lines (10) was recorded in M - 2 SD category. There were no lines in category greater than M + 2 SD. The progenies greater than overall mean comprised of 358 lines accounting for 44.75 per cent of the S_0 population.

4.2.2.5 Leaf area (cm^2)

Out of 800 progenies, 289 belonged to category with values ranging from 63.52 to 112.57 (M-SD to M) and 112.57 to 161.62 (M to M+SD) nearly 76.26 per cent of the S_0 population (Table 9). Only one line recorded (0.13%) greater than 210.67 ($>M+2\text{ SD}$). The higher category i.e. greater than mean comprised of 344 lines accounting to 43 per cent of the S_0 population.

4.2.2.6 Plant height (cm)

Among 800 progenies, maximum (286) number of progenies fall under the category of M to M+SD (178.27 to 195.62) followed by 247 progenies in M-SD to M (160.92 to 178.27) category accounting to 35.75 and 30.88 per cent of S_0 population, respectively (Table 9). The progenies greater than mean comprised of 420 accounting for 52.5 per cent of the S_0 population,

4.2.2.7 Ear height (cm)

Out of 800 progenies, 278 lines belonged to M to M+SD (88.53 to 103.65) category followed by 276 lines in M-SD to M (73.41 to 88.53) category which accounted for 34.75 and 34.50 per cent of the S_0 population, respectively (Table 9). The higher class comprised of 393 progenies accounting for 49.13 per cent of the S_0 population.

4.2.2.8 Cob weight (g)

Maximum number of progenies (242) were in the category where mean cob weight values varied from 95.72 to 134.90 (M-SD to M) followed by 241 progenies in 134.90 to 174.08 (M to M+SD) class accounting for 30.25 and 30.13 per cent of the S_0 population, respectively (Table 9). Minimum number of lines (4) were in class lower than 56.54 ($>M - 2\text{ SD}$) category. The higher category comprised of 371 lines accounting for 46.78 per cent of the S_0 population.

4.2.2.9 Cob length (cm)

Among the 800 progenies, an equal number of progenies (282) were distributed in M-SD to M (10.49 to 12.05) and M to M+SD (12.05 to 13.61) categories accounting for 64.50 per cent of the S_0 population (Table 9). Minimum number of progenies (6) were in class lower than M-2 SD (<8.93) category with a class value lower than 8.93 cm. The total number of progenies with higher values than mean (411) accounted for 51.38 per cent of the S_0 population.

4.2.2.10 Cob girth (cm)

Out of 800 progenies, an equal number of progenies (262) were in each category i.e., 11.76 to 13.31 (M-SD to M) and 13.31 to 14.86 (M to M+SD) accounting for 65.50 per cent of the S_0 population (Table 9). Minimum number of lines (12) were in the category with a class value of lower than 10.21 cm ($>M - 2\text{ SD}$). The cumulative of higher category comprised of 390 lines accounting for 48.75 per cent of the S_0 population.

4.2.2.11 Number of kernel rows per cob

Among the 800 progenies, an equal number of progenies (304) belonged to M-SD to M (11.92 to 13.63) and M to M+SD (13.63 to 15.34) categories accounting for 82 per cent of the S_0 population (Table 9). The highest category recorded minimum number of lines (15) with a class value of greater than 17.05 number of kernel rows per cob. The cumulative progenies i.e. better than population mean comprised of 421 lines accounting for 52.63 per cent of the S_0 population.

4.2.2.12 Number of kernels per row

A total of 550 progenies belonged to the class with value ranging from M-SD to M (20.62 to 24.90) and M to M+SD (24.90 to 29.19) accounting for 68.76 per cent of the S_0 population (Table 9). Minimum number of progenies (13) were recorded in M - 2 SD category with a class value lower than 16.31.

4.2.2.13 Number of kernels per cob

Out of 800 progenies, 262 were in the category of M-SD to M (259.06 to 341.91) followed by 261 in M to M+SD (341.91 to 424.76) category accounting for 32.75 and 32.63 per cent of the S_0 population, respectively (Table 9). Minimum progenies (13) were observed in category with lower than M - 2 SD class with a value of less than 176.21 number of kernels per cob. The superior progenies above population mean consisted of 391 lines accounting nearly 48.88 per cent of the S_0 population.

4.2.2.14 Hundred seed weight (g)

An equal number of progenies (281) were observed in M-SD to M and M to M+SD (21.68 to 26.76 and 26.76 to 31.84) classes accounting for 70.26 per cent of the S_0 population (Table 9). Minimum number of progenies (13) were observed in >M+2 SD category with a class value of 36.92 g. The progenies i.e. greater than population mean comprised of 382 progenies accounting for 47.75 per cent of the S_0 population.

4.2.2.15 Shelling percentage (%)

Maximum numbers of lines (326) were in the range of 81.66 to 85.24 under M-SD to M category followed by 325 in the range of 85.24 to 88.82 under M to M+SD category accounting nearly 40.75 and 40.63 per cent of the S_0 population, respectively (Table 9). The progenies with higher mean shelling percentage consisted of 392 lines accounting for 49.00 per cent of the S_0 population.

4.2.2.16 Pith weight (g)

Maximum number of progenies (259) were scored in category M-SD to M (14.07 to 19.20) followed by 258 progenies in M to M+SD (19.20 to 24.33) class, accounting for 32.38 and 32.25 per cent of the S_0 population, respectively (Table 9). Minimum number (4) of progenies were observed in class having lower than M - 2 SD category with a class value of less than 8.94 g. The cumulative higher category comprised of 382 lines accounting for 47.75 per cent of the S_0 population.

4.2.2.17 Grain yield per plant (g)

Among the 800 progenies, 247 belonged to the category M-SD to M (80.23 to 115.70) followed by 246 in M to M+SD (115.70 to 151.17) category sharing 30.88 and 30.75 per cent of the S_0 population, respectively (Table 9). The number of progenies which had greater than population mean was 372 lines accounting for 46.50 per cent of the S_0 population.

4.2.3 Distribution of progenies for various qualitative traits in S_0 generation

The distribution of progenies for various qualitative traits for different characters such as seedling vigour, stem colour, leaf shape, pith colour, grain type, grain size and colour and tip filling was made and the same is presented here under.

4.2.3.1 Seedling vigour at 30 DAS

Out of 800 progenies, 677 belonged to the high vigour category accounting for 84.63 per cent of the S_0 population followed by 100 progenies in the medium vigour category accounting for 12.50 per cent of the S_0 population and only 23 lines belonged to the low vigour category (2.88%) (Table 10).

4.2.3.2 Stem colour at 30 DAS

Based on stem colour, 800 progenies were classified in to green and purple. As many as 468 lines with green colour accounted for 58.50 per cent while 332 lines with purple colour accounted for 41.50 per cent of the S_0 population (Table 10).

4.2.3.3 Leaf shape

Among the 800 progenies, 520 were with broad leaf shape accounting for 65 per cent of the S_0 population, while and 280 lines had narrow leaf shape accounting for 35 per cent of the S_0 population (Table 10).

4.2.3.4 Pith colour

Out of the 800 progenies, 702 were with white pith colour accounting for 87.75 per cent of the S_0 population followed by red colour (89 progenies) and purple colour (9) progenies with 11.13 and 1.13 per cent of the S_0 population, respectively (Table 10).

4.2.3.5 Grain type

Among the 800 progenies, flint grain type (650) accounted for 81.25 per cent of the S_0 population while 62 progenies with dent and 52 with semiflint grain types accounting for 7.75 and 6.50 per cent of S_0 population, respectively (Table 10). The semiflint recorded lowest number of progenies (36) (4.50%) in the S_0 population.

4.2.3.6 Grain size

Majority of the S_0 progenies had bold to medium grain size. Maximum number of progenies (461) exhibited medium size followed by bold size (310) which accounted for 57.63 and 38.75 per cent of the S_0 population, respectively (Table 10). The small grain size category comprised of 29 lines accounting for 3.63 per cent of the S_0 population.

4.2.3.7 Grain colour

Out of the 800 S_0 progenies, 309 were with yellow background followed by 298 lines with orange yellow and 193 lines with yellow orange grain colour background (Table 10).

4.2.3.8 Tip filling

Eight hundred S_0 progenies were classified based on tip filling of cob into three main groups. Among them, 286 progenies had complete tip filling (35.75%) followed by no tip filling group (268 lines with 33.50%) and moderate tip filling in 246 progenies (30.75%) (Table 10).

4.3 PERFORMANCE OF S_1 PROGENIES OF YELLOW POOL POPULATION

4.3.1 Analysis of variance

The analysis of variance for 16 quantitative traits in S_1 progenies is presented in Table 11. The variance due to genotypes for all the 16 characters was highly significant.

4.3.2 Genetic variability

Mean, range and the components of genetic variation, viz., phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad sense heritability, genetic advance (GA) and genetic advance as per cent of mean (GAM) were worked out for the 16 quantitative characters and results obtained in the present investigation are presented in Table 12.

Table 10: Frequency distribution of progenies for various qualitative traits for maize yellow pool population S₀ generation

	1		2		3		4	
Sl. No.	Seedling Character	Frequency	Seedling Color	Frequency	Leaf shape	Frequency	Pith Color	Frequency
1	Vigour	677 (84.63)	Green	468 (58.50)	Broad	520 (65.00)	Red	089 (11.13)
2	Medium Vigour	100 (12.50)	Purple	332 (41.50)	Narrow	280 (35.00)	Purple	009 (01.13)
3	Low	023 (2.88)					White	702 (87.75)
	Total	800	Total	800	Total	800	Total	800

	5		6		7		8	
Sl. No.	Grain type	Frequency	Grain Size	Frequency	Grain Color	Frequency	Tip Filling	Frequency
1	Flint	650 (81.25)	Bold	310 (38.75)	Orange Yellow	298 (37.25)	Complete Tip Filling	286 (35.75)
2	Semi flint	036 (4.50)	Medium	461 (57.63)	Yellow	309 (38.63)	Medium Tip Filling	246 (30.75)
3	Dent	062 (07.75)	Small	029 (03.63)	Yellow Orange	193 (24.13)	No Tip Filling	268 (33.50)
4	Semi Dent	052 (6.50)						
	Total	800	Total	800	Total	800	Total	800

Figures in parenthesis indicate percent values

4.3.2.1 Plant height at 30 DAS (cm)

Mean plant height of 400 S₁ progenies was 48.53 cm at 30 DAS. It ranged from 27.90 to 82.50 cm. with high PCV (20.70) and moderate GCV (17.42) (Table 12 and 13). However, high heritability (84.16%) was exhibited by this trait. Genetic advance (GA) was 17.41 and while genetic advance as per cent mean (GAM) was 35.89 %.

4.3.2.2 Plant girth at 30 DAS (cm)

The mean value of the 400 S₁ progenies for plant girth at 30 DAS was 2.09 cm with a range of 1.55 to 3.00 cm (Table 12 and 13). PCV (16.21) and GCV (8.17) were moderate to low coupled with moderate (50.40%) heritability. The GA was low (0.35) with a GAM value of 16.83 per cent.

4.3.2.3 Leaf area at 30 DAS (cm²)

The mean value of 400 S₁ progenies for leaf area at 30 DAS was 214.13 cm² with a range of 74.24 to 321.35cm² (Table 12 and 13). PCV (21.84) and GCV (18.91) were moderate and high, respectively. High heritability (86.56) was recorded for this trait. Higher GA was recorded (83.48) with GAM of 38.92 per cent.

4.3.2.4 Plant height at 60 DAS (cm)

The plant height at 60 DAS of 400 S₁ progenies ranged from 107.50 to 195.50 cm with a mean value of 153.34 cm (Table 12 and 13). Both PCV (10.90) and GCV (10.03) exhibited moderate values coupled with higher heritability (92.02%). GA exhibited was high (31.69) and GAM was 20.67 per cent.

4.3.2.5 Ear height at 60 DAS (cm)

The ear height at 60 DAS S₁ progenies recorded a mean value of 76.30 cm (Table 12 and 13). The range of the ear height varied from 53.00 to 96.00cm. Both the PCV (11.27) and GCV (10.01) values were moderate coupled with high heritability estimate (88.82%). The estimated GA was moderate (15.75) and GAM was 20.63 per cent.

4.3.2.6 Leaf area at 60 DAS (cm²)

The mean value of leaf area at 60 DAS recorded was 398.45 cm² and the range of this trait was from 245.00 to 584.20 cm² (Table 12 and 13). Both PCV (15.12) and GCV (14.13) estimates had moderate values with high heritability (93.44%). High GA was recorded (115.99) along with GAM of 29.11 per cent for this trait.

4.3.2.7 Cob weight (cm)

The mean value of cob weight was 148.38 g and the range of this trait varied from 76.96 to 268.89g (Table 12 and 13). Both PCV (24.51) and GCV (23.80) recorded higher values coupled with higher heritability (97.11%). The genetic advance (72.75) was high with GAM of 49.04 per cent.

4.3.2.8 Cob length (cm)

Genetic variability parameters of cob length were estimated. The mean value of 400 S₁ progenies was 14.32 cm and it ranged from 10.00 to 22.33 cm (Table 12 and 13). Phenotypic (14.34) and genotypic coefficient of variation (12.20) revealed moderate variation coupled with high heritability (85.03). The genetic advance recorded was low (3.60) with GAM value of 25.13 per cent.

4.3.2.9 Cob girth (cm)

The mean cob girth of 13.66 cm was recorded for 400 S₁ progenies. The range of cob girth varied from 10.33 to 17.00 cm (Table 12 and 13). Both PCV (9.16) and GCV (7.75) estimates recorded lower values coupled with higher heritability (82.91%). The genetic advance (2.14) was low with GAM value of 15.64 per cent.

Table 11: Analysis of variance for Sixteen Quantitative traits in S₁ progenies of yellow pool population in maize

		1	2	3	4	5	6	7	8
Source	D.F	Plant height at 30 DAS (cm)	Plant girth at 30 DAS (cm)	Leaf area at 30 DAS (cm ²)	Plant height at 60 DAS (cm)	Ear height at 60 DAS (cm)	Leaf area at 60 DAS (cm ²)	Cob Weight (g)	Cob Length (cm)
Replication	1	2844.09	0.90	41696.08	3353.81	1150.56	103597.10	947.12	25.30
Genotype	399	172.38**	0.14**	3833.84**	516.21**	132.50**	6801.48**	2570.45**	7.27**
Error	399	29.44	0.09	549.50	42.84	15.63	460.61	75.48	1.17
CD AT 5%		10.67	0.58	46.08	12.87	7.77	42.19	17.08	2.12
CD AT 1%		14.04	0.76	60.66	16.94	10.23	55.54	22.48	2.80

		9	10	11	12	13	14	15	16
Source	D.F	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Pith weight (g)	100-seed weight (g)	Shelling (%)	Number of kernels per Cob	Grain yield per plant (g)
Replication	1	6.30	0.37	36.09	55.39	18.65	0.23	11658.88	638.53
Genotype	399	2.64**	3.58**	47.11**	47.24**	32.46**	21.00**	12391.05**	2088.76**
Error	399	0.49	0.52	5.03	6.15	4.48	4.30	1572.59	49.29
CD AT 5%		1.38	1.41	4.41	4.87	4.16	4.07	77.95	13.80
CD AT 1%		1.81	1.86	5.80	6.42	5.47	5.36	102.16	18.17

* and ** significant at 1% and 5% level of probability, respectively

Table 12: Estimation of genetic variability parameters in S₁ progenies of yellow pool population in maize

Sl. No.	Character	Mean	Range		PCV %	GCV %	Heritability %	GA	GAM %
			Minimum	Maximum					
1	Plant height at 30 DAS (cm)	48.53	27.90	82.50	20.70	17.42	84.16	17.41	35.89
2	Plant girth at 30 DAS (cm)	2.09	1.55	3.00	16.21	8.17	50.40	0.35	16.83
3	Leaf area at 30 DAS (cm ²)	214.31	74.24	321.35	21.84	18.91	86.56	83.48	38.95
4	Plant height at 60 DAS (cm)	153.34	107.50	195.50	10.90	10.03	92.02	31.69	20.67
5	Ear height at 60 DAS (cm)	76.30	53.00	96.00	11.27	10.01	88.82	15.75	20.63
6	Leaf area at 60 DAS (cm ²)	398.45	245.00	584.20	15.12	14.13	93.44	115.99	29.11
7	Cob weight (g)	148.38	76.96	268.89	24.51	23.80	97.11	72.75	49.04
8	Cob length (cm)	14.32	10.00	22.33	14.34	12.20	85.03	3.60	25.13
9	Cob girth (cm)	13.66	10.33	17.00	9.16	7.75	82.91	2.14	15.64
10	Number of kernel rows per cob	13.83	10.33	21.50	10.35	8.94	86.46	2.55	18.43
11	Number of Kernels per row	28.91	15.50	42.67	17.66	15.84	89.84	9.45	32.69
12	Pith weight (g)	19.91	10.71	42.53	25.96	22.77	87.74	9.34	46.91
13	100-seed weight (g)	27.48	15.76	36.65	15.64	13.61	87.04	7.71	28.04
14	Shelling %	85.93	65.90	93.15	4.14	3.36	81.22	5.95	6.92
15	Number of kernels per cob	400.61	190.00	614.89	20.86	18.36	88.02	151.51	37.82
16	Grain yield per plant (g)	128.05	64.38	232.15	25.53	24.94	97.67	65.78	51.37

Table 13: Estimation of genetic variability parameters in S₁ progenies of yellow pool population

Sl. No.	Character	Mean	Range		PCV (%)	GCV (%)	Heritability (%)	GAM (%)
			Minimum	Maximum				
1	Plant height at 30 DAS (cm)	48.53	27.90	82.50	H	M	H	H
2	Plant girth at 30 DAS (cm)	2.09	1.55	3.00	M	L	M	M
3	Leaf area at 30 DAS (cm)	214.31	74.24	321.35	H	M	H	H
4	Plant height at 60 DAS (cm)	153.34	107.50	195.50	M	M	H	H
5	Leaf area at 60 DAS (cm)	398.45	245.00	584.20	M	M	H	H
6	Ear at 60 DAS (cm)	76.30	53.00	96.00	M	M	H	H
7	Cob weight (g)	148.38	76.95	268.89	H	H	H	H
8	Cob length (cm)	14.32	10.00	22.33	M	M	H	H
9	Cob girth (cm)	13.66	10.33	17.00	L	L	H	M
10	Number of Kernel rows per cob	13.83	10.33	21.50	M	L	H	M
11	Number of Kernels per row	28.91	15.50	42.67	M	M	H	H
12	Pith weight (g)	19.91	10.71	42.53	H	H	H	H
13	100-Seed weight (g)	27.48	15.76	36.65	M	M	H	H
14	Shelling (%)	85.93	65.90	93.15	L	L	H	L
15	Number of Kernels per cob	400.61	190.50	614.89	H	M	H	H
16	Grain yield per plant (g)	128.05	64.38	232.15	H	H	H	H

4.3.2.10 Number of kernel rows per cob

Four hundred S₁ progenies recorded higher mean value (13.83) with wider range from 10.33 to 21.50 kernel rows (Table 12 and 13). The progenies recorded moderate to lower values for variability parameters, viz., PCV (10.35) and GCV (8.94). However, higher heritability of 86.46 per cent was observed. This trait recorded lower GA value of 2.55 and GAM value of 18.43 per cent.

4.3.2.11 Number of kernels per row

The mean value of 400 S₁ progenies was 28.91 with wider range from 15.50 to 42.67 kernels per row (Table 12 and 13). The PCV (13.66) and GCV (15.84) were moderate, whereas heritability was higher (89.84%). This trait recorded lower genetic advance (9.45) and GAM value of 32.69 per cent.

4.3.2.12 Pith weight (cm)

The mean pith weight of 19.91 g was recorded for 400 S₁ progenies with wider range from 10.71 to 42.53 g (Table 12 and 13). The genetic parameters like both PCV (25.96) and GCV (22.77) were higher and also expressed higher heritability (87.74%). The genetic advance was low (9.34) and GAM recorded was 46.91 per cent.

4.3.2.13 Hundred Seed weight (cm)

The 100-seed weight of 400 S₁ progenies recorded mean value of 27.48g. The range varied from 15.76 to 36.65g (Table 12 and 13). The genetic parameters like PCV (15.64) and GCV (13.61) exhibited moderate values and the progenies recorded higher heritability (87.04%). The genetic advance (7.71) was low with GAM value of 28.04 per cent.

4.3.2.14 Shelling percentage (%)

Mean shelling percentage of 400 S₁ progenies value was 85.93 per cent and the range was from 65.90 to 93.51 per cent (Table 12 and 13). When the progenies were compared on the basis of variability parameters, they exhibited lower PCV (4.14) and GCV (3.36), but on the contrary, the progenies exhibited higher values of heritability (81.22%). The genetic advance (5.95) was low and GAM value recorded was 6.92 per cent.

4.3.2.15 Number of kernels per cob

Number of kernels per cob is the most important character in which plant breeder is most interested and exercises all his skills for the improvement of this character. The expression of this character is highly dependent on other quantitative characters like number of kernels per row, number of kernel rows per cob, cob length, cob girth. The mean number of kernels per cob of 400 S₁ progenies was 400.61 and it ranged from 190.00 to 614.89 (Table 12 and 13). When the progenies were compared on the basis of variability parameters, progenies exhibited higher value of PCV (20.86) and moderate value of GCV (18.36) coupled with higher heritability value (88.02%). The genetic advance (151.51) was high and GAM value was 37.82 per cent.

4.3.2.16 Grain yield per plant (g)

The trait grain yield per plant is one of the important characters in selection of inbred lines. The expression of this character is highly dependent on other quantitative characters like cob weight, cob length and girth, number of kernel rows per cob, number of kernels per cob, tip filling and 100-seed weight.

The mean grain yield per plant (128.05 g) of 400 S₁ progenies varied between 64.38 to 232.15 g (Table 12 and 13). The variability parameters viz., PCV (25.53) and GCV (24.94) showed higher values coupled with higher heritability (97.67%). The genetic advance (65.78) was high and GAM value recorded was 51.37 per cent.

4.3.3 Association studies in S₁ progenies

Among all traits, selection for seed yield is a complex phenomenon that involved interaction among different growth and yield contributing character of a genotype. In the present investigation an attempt was made to understand association of different traits at population level contributing towards yield improvement.

The phenotypic and genotypic correlation of grain yield with 16 other yield components among S₁ progenies were worked out and the same is presented in Table 14 and 15.

A general observation of the data across different characters under study revealed that seed yield exhibited significant positive correlation with few yield traits, but also exhibited significant negative association with few other traits. The results obtained on the basis of association of individual trait with grain yield are presented below.

4.3.3.1 Plant height at 30 days after sowing (cm)

A highly significant positive association of plant height at 30 days after sowing was recorded with all other characters studied, except shelling percentage which recorded only significant association (5%) at both genotypic (0.115) and phenotypic (0.103) levels (Table 14 and 15).

4.3.3.2 Plant girth at 30 days after sowing (cm)

A significant positive association with plant girth at 30 days was recorded with all the characters studied, except shelling percentage (Table 14). Phenotypic correlation values were highly significant in desirable direction, except ear height, cob length, number of kernel rows per cob, number of kernels per row which exhibited only significant positive association, while shelling percentage has recorded non significant association (Table 15).

4.3.3.3 Leaf area at 30 days after sowing (cm²)

The trait leaf area at 30 days after sowing recorded highly significant positive genotypic association with all traits (Table 14). Similarly, highly significant positive association was exhibited for all the traits at phenotypic level, except the traits like, ear height (0.121), number of kernel rows per cob (0.127) and shelling percentage (0.102) which recorded only significant association in positive direction (Table 15).

4.3.3.4 Plant height at 60 days after sowing (cm)

Plant height at 60 DAS showed highly significant association in positive direction with other traits under study except for shelling percentage which had non-significant association with this trait (0.086) only at genotypic level (Table 14). Whereas highly significant phenotypic association was recorded in desirable direction, except for number of kernels per rows (0.112) which expressed only significant association in positive direction (Table 15).

4.3.3.5 Ear height (cm)

All the traits exhibited highly significant positive association with the ear height, except shelling percentage (0.072) which was non-significant at genotypic level (Table 14). A highly significant positive phenotypic association was recorded for all the traits studied, except for plant girth at 30 DAS (0.108), leaf area at 30 DAS (0.121), number of kernel rows per cob (0.110) and number of kernels per row (0.123), at five per cent level of probability (Table 15).

4.3.3.6 Leaf area at 60 days after sowing (cm²)

The data revealed significant positive genotypic association with all traits except for number of kernel rows per cob (0.028), shelling percentage (0.082) and number of grains per cob (0.184) which recorded non-significant association (Table 14).

A highly significant positive phenotypic association was recorded for all the traits studied, except for number of kernel rows per cob (0.036) and shelling percentage (0.070) (Table 15).

Table 14: Genotypic correlation among S₁ progenies for early vigour, grain yield and its components in maize

	Pl Ht 30	Pl Grt 30	LA 30	Pl Ht 60	Ear Ht 60	L A 60	Cb Wt	Cb Len	Cb Grt	K R	K / R	Pit Wt	100 S Wt	Shelg %	Grn No	Grn Wt
1	1.00	0.599**	0.513**	0.437**	0.359**	0.277**	0.415**	0.229**	0.312**	0.140**	0.217**	0.314**	0.378**	0.115*	0.249**	0.403**
2		1.00	0.482**	0.335**	0.251**	0.289**	0.394**	0.223**	0.390**	0.163**	0.208**	0.349**	0.249**	0.039	0.257**	0.393*
3			1.00	0.203**	0.130**	0.255**	0.370**	0.225**	0.325**	0.153**	0.248**	0.226**	0.297**	0.165**	0.283**	0.370**
4				1.00	0.741**	0.295**	0.286**	0.148**	0.291**	0.221**	0.200**	0.239**	0.316**	0.086	0.221**	0.287**
5					1.00	0.234**	0.240**	0.159**	0.221**	0.146**	0.150**	0.224**	0.198**	0.072	0.198**	0.235**
6						1.00	0.295**	0.211**	0.233**	0.028	0.199**	0.255**	0.283**	0.082	0.184	0.277**
7							1.00	0.602**	0.726**	0.301**	0.624**	0.619**	0.648**	0.413**	0.669**	0.969**
8								1.00	0.370**	0.062	0.640**	0.549**	0.438**	0.061	0.565**	0.553**
9									1.00	0.542**	0.425**	0.541**	0.597**	0.155**	0.609**	0.672**
10										1.00	0.101*	0.153**	0.139**	10.159**	0.549**	0.288**
11											1.00	0.443**	0.406**	0.208**	0.884**	0.595**
12												1.00	0.457**	-0.450**	0.442**	0.494**
13													1.00	0.240**	0.925**	0.618**
14														1.00	0.252**	0.514**
15															1.00	0.637**
16																1.00

1. Plant height at 30 DAS (cm)

5. Ear at 60 DAS (cm)

9. Cob girth (cm)

13. 100-Seed weight (g)

2. Plant girth at 30 DAS (cm)

6. Leaf area at 60 DAS (cm)

10. Number of Kernel rows per cob

14. Shelling (%)

3. Leaf area at 30 DAS (cm)

7. Cob weight (g)

11. Number of Kernels per row

15. Number of Kernels per cob

4. Plant height at 60 DAS (cm)

8. Cob length (cm)

12. Pith weight (g)

16. Grain yield per plant (g)

Table 15: Phenotypic correlation among S₁ progenies for early vigour, grain yield and its components in maize

	PI Ht 30	PI Grt 30	LA 30	PI Ht 60	Ear Ht 60	LA 60	Cb Wt	Cb Len	Cb Grt	K R	K / R	Pit Wt	100 SWt	Shelg %	Grn No	Grn Wt
1	1.00	0.368**	0.466**	0.366**	0.308**	0.243**	0.348**	0.171**	0.242**	0.144**	0.170**	0.229**	0.276**	0.103*	0.209**	0.350**
2		1.00	0.239**	0.158**	0.108*	0.155**	0.207**	0.122*	0.194**	0.117*	0.102*	0.182**	0.150**	0.009	1.126**	0.206**
3			1.00	0.192**	0.121*	0.206**	0.324**	0.178**	0.268**	0.127*	0.191**	0.204**	0.248**	0.102*	0.220**	0.332**
4				1.00	0.664**	0.265**	0.263**	0.131**	0.240**	0.172**	0.112*	0.206**	0.267**	0.075	0.176**	0.275**
5					1.00	0.205**	0.210**	0.146**	0.173**	0.110*	0.123*	0.184**	0.153**	0.056	0.156**	0.223**
6						1.00	0.268**	0.170**	0.197**	0.036	0.170**	0.209**	0.236**	0.070	0.159**	0.259**
7							1.00	0.537**	0.631**	0.284**	0.578**	0.573**	0.580**	0.352**	0.613**	0.992**
8								1.00	0.315**	0.068	0.559**	0.480**	0.352**	0.053	0.491**	0.533**
9									1.00	0.476**	0.338**	0.453**	0.496**	0.142**	0.503**	0.627**
10										1.00	0.103*	0.155**	0.121*	0.125*	0.56**	0.296**
11											1.00	0.386**	0.328**	0.182**	0.875**	0.580**
12												1.00	0.418**	-0.499**	0.390**	0.493**
13													1.00	0.153**	0.318**	0.574**
14														1.00	0.212**	0.509**
15															1.00	0.621**
16																1.00

1. Plant height at 30 DAS (cm)

5. Ear at 60 DAS (cm)

9. Cob girth (cm)

13. 100-Seed weight (g)

yield per plant (g)

2. Plant girth at 30 DAS (cm)

6. Leaf area at 60 DAS (cm)

10. Number of Kernel rows per cob

14. Shelling (%)

3. Leaf area at 30 DAS (cm)

7. Cob weight (g)

11. Number of Kernels per row

15. Number of Kernels per cob

4. Plant height at 60 DAS (cm)

8. Cob length (cm)

12. Pith weight (g)

16. Grain

4.3.3.7 Cob weight (cm)

All the traits exhibited highly significant association with cob weight at both genotypic and as well as phenotypic level in the desirable direction (Table 14 and 15).

4.3.3.8 Cob length (cm)

The trait cob length exhibited highly significant positive genotypic association with all the characters, except for number of kernel rows per cob (0.062) and shelling percentage (0.061) (Table 14). A similar association of cob length with all the characters at phenotypic level was exhibited except for plant height at 30 DAS (0.122), number of kernel rows per cob (0.068) and shelling percentage (0.053) (Table 15).

4.3.3.9 Cob girth (cm)

It is interesting to note that all the traits under study exhibited highly significant association in the desirable direction in both genotypic as well as phenotypic level with cob weight (Table 14 and 15).

4.3.3.10 Number of kernel rows per cob

Majority of the characters exhibited highly significant positive genotypic association with number of kernel rows per cob, except for the traits like, number of kernels per row (0.101), leaf area at 60 DAS (0.028) and cob length (0.062) (Table 14). Similarly, a highly significant positive phenotypic association was recorded for all the traits studied, except the characters like plant girth at 30 DAS (0.117), leaf area at 30 DAS (0.127), ear height (0.110), number of kernels per row (0.103) and shelling percentage (0.125), which recorded significance only at five per cent level of probability (Table 15). But, the traits such as leaf area at 60 DAS (0.036) and cob length (0.068) exhibited non-significant association.

4.3.3.11 Number of kernels per row

A highly significant positive genotypic association with number of kernels per row was observed for all the characters under study, except for number of kernel rows per cob which exhibited significance at five per cent level of probability in positive direction (0.101) (Table 14). Similarly, with phenotypic correlation, trait under study had highly significant positive association with all the characters except for plant girth at 30 DAS (0.102), plant height at 60 DAS (0.112), ear height (0.123) and number of kernel rows per cob (0.103) which exhibited only a positive significant association at five per cent level of probability (Table 15).

4.3.3.12 Pith weight (cm)

The study revealed that the trait pith weight exhibited highly significant association at one per cent and five per cent level of probability with all the traits under study at genotypic and phenotypic levels, except with shelling percentage which had significance in negative direction (Table 14 and 15).

4.3.3.13 Hundred seed weight (g)

From the results of present study, it is clear that all the characters exhibited highly significant association with 100-seed weight at both genotypic and phenotypic levels, except for number of kernel rows per cob (0.121) which recorded positive association with phenotypic level at five per cent level of probability (Table 14 and 15).

4.3.3.14 Shelling percentage (%)

The character shelling percentage exhibited highly significant positive genotypic association with all the traits under study, except for plant height at 30 DAS (0.115) which recorded only significant positive association (Table 14). The characters plant girth at 30 DAS (0.039, 0.009), plant height at 60 DAS (0.086, 0.075), ear height (0.072, 0.056), leaf area at 60 DAS (0.082, 0.070) and cob length (0.061, 0.053) exhibited non-significant association, whereas pith weight (-0.450, -0.450) recorded highly significant negative association at both genotypic and phenotypic levels (Table 14 and 15). Similarly at phenotypic level, a highly significant positive association was recorded for all the traits, except for plant height at 30 DAS (0.103), leaf area at 30 DAS (0.102) and number of kernel rows per cob (0.125) at five per cent level of probability (Table 14 and 15).

4.3.3.15 Number of kernels per cob

Number of kernels per cob recorded highly significant positive association at both genotypic and phenotypic levels, except for leaf area at 60 DAS (0.184) which showed non-significant association at genotypic level (Table 14 and 15).

4.3.3.16 Grain yield per plant (g)

In maize, increase in grain yield is mainly achieved by manifestation of many characters like number of kernel rows per cob, number of kernels per row, cob length, cob girth, 100-seed weight, *etc.* Therefore it is necessary to understand the nature of association existing between all characters and grain yield, particularly in early generation (S_1).

Grain yield per plant had highly significant positive association with all the characters at both genotypic and phenotypic levels, except for plant girth at 30 DAS (0.393) which showed significance only at five per cent level of probability at genotypic level (Table 14 and 15).

4.4 PERFORMANCE OF S_2 PROGENIES DERIVED FROM YELLOW POOL

4.4.1 Analysis of variance

The analysis of variance for 16 quantitative traits in S_2 progenies of yellow pool base population are presented in Table 16. The variance due to genotype for all the 16 characters was highly significant.

4.4.2 Genetic variability studies

Genetic variability parameters of S_2 progenies like mean, range and the components of genetic variability viz., phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad sense heritability, genetic advance (GA) and genetic advance as per cent mean (GAM) were worked out for the 16 quantitative characters. Results obtained in the present investigation for each character is presented in Table 17 and 18.

4.4.2.1 Plant height at 30 days after sowing (cm)

The mean value of 350 S_2 progenies for plant height was 31.67 cm, with wider range from 18.00 to 45.60 cm (Table 17 and 18). The variability parameters, like PCV (13.86) and GCV (10.54) estimates were moderate values coupled with high heritability (76.08%).

4.4.2.2 Plant girth at 30 DAS (cm)

Mean value of plant girth at 30 DAS of 350 S_2 progenies was 1.71 cm with range from 1.00 to 3.00 cm (Table 17 and 18). The variability parameters like PCV (17.10) and GCV (13.12) exhibited moderate values coupled with higher per cent of heritability (76.71%). The genetic advance (0.46) was lower with higher GAM (27.02%).

4.4.2.3 Leaf area at 30 DAS (cm²)

The mean value of 350 S_2 progenies for leaf area at 30 DAS recorded was 239.54 cm with wider range of 110.05 to 450.60 cm² (Table 17 and 18). The genetic variability components, viz., PCV (28.57) and GCV (24.38) exhibited high values coupled with higher heritability (85.36%). The genetic advance was high (120.33) coupled with GAM value of 50.23 per cent.

4.4.2.4 Plant height at 60 DAS (cm)

Plant height at 60 DAS among 350 S_2 progenies ranged from 120.00 to 205.50 cm with a mean value of 164.79 cm (Table 17 and 18). Genetic components of both PCV (11.05) and GCV (10.28) were moderate coupled with high heritability (93.02%). The GA (34.91) was high with GAM of 21.18 per cent.

4.4.2.5 Ear height at 60 DAS (cm)

The mean value of 350 S_2 progenies for ear height at 60 DAS was 75.44 cm which ranged from 45.30 to 115.50 cm (Table 17 and 18). The variability components of both PCV

Table 16: Analysis of variance for sixteen quantitative traits in S₂ progenies of yellow pool population of maize

		1	2	3	4	5	6	7
Source	D.F	Plant height at 30 (cm) DAS	Plant girth at 30 (cm) DAS	Leaf area at 30 (cm ²) DAS	Plant height at 60 (cm) DAS	Ear height 60 (cm) DAS	Leaf area at 60 (cm ²) DAS	Cob weight (g) DAS
Replication	1	0.52	1.80	160529.40	13457.13	25.35	82398.81	973.48
Genotype	349	30.41**	0.14**	8094.37**	618.95**	249.64**	133349.26**	3876.32**
Error	349	8.11	0.04	1270.47	44.71	23.50	1463.42	227.74
CD (0.05)		5.60	0.37	70.09	13.15	9.43	75.23	29.68
CD (0.01)		7.38	0.48	92.30	17.32	12.55	99.06	39.08

		8	9	10	11	12	13	14	15	16
Source	D.F	Cob length (cm)	Cob girth (cm)	Number of Kernel Rows per cob	Number of Kernels per row	Pith weight (g)	100-seed weight (g)	Shelling (%)	Number of kernels per cob	Grain yield per plant (g)
Replication	1	1.52	14.86	1.34	7.12	3.58	0.09	20.84	30.17	1070.02
Genotype	349	10.57**	2.88**	4.47**	41.88**	102.40**	35.52**	31.14**	15108.63**	3066.15**
Error	349	0.69	0.39	0.44	6.00	5.32	4.43	4.85	1908.03	213.71
CD (0.05)		1.63	1.23	1.3	4.81	4.54	4.14	4.33	85.90	28.75
CD (0.01)		2.15	1.61	1.72	6.34	5.97	5.45	5.70	113.12	37.86

* and ** significant at 1% and 5% level of probability, respectively

Table 17: Estimation of genetic variability parameters in S₂ progenies of yellow pool population of maize

SL No	Characters	Mean	Range		PCV %	GCV %	Heritability %	GA	GAM %
			Minimum	Maximum					
1	Plant height at 30 DAS (cm)	31.67	18.00	45.60	13.86	10.54	76.08	6.88	21.72
2	Plant girth at 30 DAS (cm)	1.71	1.00	3.00	17.10	13.12	76.71	0.46	27.02
3	Leaf area at 30 DAS (cm ²)	239.54	110.05	450.60	28.57	24.38	85.36	120.33	50.23
4	Plant height at 60 DAS (cm)	164.79	120.00	205.50	11.05	10.28	93.02	34.91	21.18
5	Ear height at 60 DAS (cm)	75.44	45.30	115.50	15.49	14.10	90.99	21.91	29.04
6	Leaf area at 60 DAS (cm ²)	393.78	163.40	600.10	21.85	19.58	89.58	158.81	40.33
7	Cob weight (g)	144.13	56.55	276.90	31.43	29.63	94.29	87.99	61.05
8	Cob length (cm)	15.83	9.55	22.25	14.99	14.04	93.66	4.58	28.92
9	Cob girth (cm)	13.39	10.15	17.30	9.54	8.33	87.30	2.30	17.16
10	Number of kernel rows per cob	14.40	10.60	19.20	10.88	9.86	90.62	2.93	20.31
11	Number of kernels per row	30.02	18.55	46.00	16.30	14.11	86.56	8.73	29.06
12	Pith weight (g)	25.01	10.84	47.19	29.34	27.86	94.93	14.35	57.38
13	100-seed weight (g)	27.05	16.92	42.43	16.52	14.58	88.23	8.12	30.03
14	Shelling %	82.09	65.31	90.67	5.17	4.42	85.46	7.47	9.10
15	Number kernels per cob	4.33.92	235.65	733.60	21.26	18.72	88.08	167.30	38.57
16	Grain yield per plant (g)	118.79	44.65	232.86	34.09	31.79	93.26	77.80	65.49

Table 18: Estimation of genetic variability parameters in S₂ progenies of yellow pool population in maize

Sl. No.	Characters	Mean	Range		PCV (%)	GCV (%)	Heritability (%)	GAM (%)
			Minimum	Maximum				
1	Plant height at 30 DAS (cm)	31.67	18.00	45.60	M	M	H	H
2	Plant girth at 30 DAS (cm)	1.71	1.00	3.00	M	M	H	H
3	Leaf area at 30 DAS (cm)	239.54	110.05	450.60	H	H	H	H
4	Plant height at 60 DAS (cm)	164.79	120.00	205.50	M	M	H	H
5	Leaf area at 60 DAS (cm)	393.78	163.40	600.10	H	M	H	H
6	Ear at 60 DAS (cm)	75.44	45.30	115.50	M	M	H	H
7	Cob weight (g)	144.13	56.55	276.90	H	H	H	H
8	Cob length (cm)	15.83	9.55	22.25	M	M	H	H
9	Cob girth (cm)	13.39	10.15	17.30	L	L	H	H
10	Number of Kernel rows per cob	14.40	10.60	19.20	M	L	H	H
11	Number of Kernels per row	30.02	18.55	46.00	M	M	H	H
12	Pith weight (g)	25.01	10.84	47.19	H	H	H	H
13	100-Seed weight (g)	27.05	16.92	42.43	M	M	H	H
14	Shelling (%)	82.09	65.31	90.67	L	L	H	L
15	Number of Kernels per cob	433.92	235.65	733.60	H	M	H	H
16	Grain yield per plant (g)	118.79	44.65	232.86	H	H	H	H

(15.49) and GCV (14.10) estimates had moderate value coupled with high heritability (90.99%). The genetic advance was 21.91 with GAM value of 29.04 per cent.

4.4.2.6 Leaf area at 60 DAS

The mean value of 350 S₂ progenies for leaf area at 60 DAS was 393.78 cm² and it varied from 163.40 to 600.10 cm² (Table 17). Higher PCV (21.85%) and moderate GCV (19.58%) and higher heritability (89.58%) values were observed. The GA (158.81) was high with GAM of 40.33 per cent for this trait.

4.4.2.7 Cob weight (g)

The character cob weight had a mean value of 144.13 g and it ranged from 56.55 to 276.90 g (Table 17 and 18). For variability parameters, progenies recorded higher value for both PCV (31.43) and GCV (29.63). The heritability estimate was 94.29 per cent and this trait also had higher GA (87.99%) coupled with GAM of 61.05 percent.

4.4.2.8 Cob length (cm)

The mean value of 350 S₂ progenies for cob length was 15.83 cm and it ranged from 9.55 to 22.25 cm (Table 17 and 18). Critical observation of phenotypic and genotypic coefficient of variation revealed the moderate values of 14.99 and 14.04, respectively. The heritability recorded for this trait was higher (93.66%). The genetic advance estimate was low (4.58) with GAM of 28.53 per cent.

4.4.2.9 Cob girth (cm)

The mean value of 350 S₂ progenies for cob girth was 13.39cm with its values ranging from 10.15 to 17.30 cm (Table 17 and 18). The variability components, viz., PCV (9.54) and GCV (8.33) exhibited lower values coupled with higher heritability (87.30%). The genetic advance (2.30) was low coupled with GAM of 17.16 per cent.

4.4.2.10 Number of kernel rows per cob

The trait number of kernel rows per cob recorded mean of 14.40 which ranged from 10.60 to 19.20 (Table 17 and 18). The progenies recorded moderate PCV (10.88%) and low GCV (9.86%) values. The heritability was high (90.62%) and GA (2.93) was lower with GAM value of 20.31 per cent.

4.4.2.11 Number of kernels per row

The mean value of 350 S₂ progenies for number of kernels per row was 30.02 with wider range from 18.55 to 46.00 (Table 17 and 18). The variability parameters like PCV (16.30) and GCV (14.11) exhibited moderate values coupled with higher heritability (86.56%). The genetic advance (8.73) showed lower value coupled with GAM of 29.06 per cent.

4.4.2.12 Pith weight (g).

The character pith weight had population mean value of 25.01 g and values ranged from 10.84 to 47.19 g (Table 17 and 18). The progenies recorded higher value of both PCV (29.34) and GCV (27.86). High heritability (94.93%) were recorded for this trait. Genetic advance estimate was moderate (14.35) coupled with GAM of 57.38 per cent.

4.4.2.13 Hundred seed weight (g)

The 350 S₂ progenies recorded overall mean of 27.05 g and it ranged from 16.92 to 42.43 g (Table 17 and 18). Genetic variability parameters like PCV (16.52) and GCV (14.58) values were moderate for this trait. However, higher heritability (88.23%) was recorded for this trait. The genetic advance (8.12) showed lower value coupled GAM of 30.03 per cent.

4.4.2.14 Shelling percentage (%)

The mean value of 350 S₂ progenies for shelling percentage was 82.09 which ranged from 65.31 to 90.67 (Table 17 and 18). When the progenies were compared on the basis of variability parameters, the progenies exhibited lower PCV (5.17) and GCV (4.42) coupled with higher heritability value (85.46%). The genetic parameters like GA also exhibited lower value (7.47) coupled with GAM of 9.10 per cent.

4.4.2.15 Number of kernels per cob

The mean of number of kernels per cob of 350 S₂ progenies was 433.92. The range for this trait varied from 235.65 to 733.60 (Table 17 and 18). When the progenies were compared on the basis of variability parameters. The progenies recorded higher values for PCV (21.26) and moderate values for GCV (18.72) coupled with higher heritability (80.08%). Other parameters like GA was high (167.30) with GAM of 38.57 per cent for this trait.

4.4.2.16 Grain yield per plant (g)

Grain yield per plant is one of the important characters in selection of inbred lines. This trait is highly depending on many quantitative characters, namely cob weight, cob length, cob girth, number of kernel rows per cob, number of kernels per row, tip filling and 100-seed weight.

The mean of 350 S₂ progenies was 118.79 g per plant and it ranged from 44.65 to 232.86 g (Table 17 and 18). The variability components like, PCV (34.09) and GCV (31.79) exhibited higher values coupled with high heritability (93.26%). The genetic advance (77.80) estimate was high coupled with high GAM of 65.49 per cent.

4.4.3 Association studies

The results obtained in the present investigation on the basis of association of individual characters with grain yield in S₂ progenies is presented in Table 19 and 20.

4.4.3.1 Plant height at 30 DAS (cm)

A highly significant positive association was recorded at both genotypic and phenotypic levels for all the traits study, except for number of kernel rows per cob (0.112) at phenotypic level (Table 19 and 20).

4.4.3.2 Plant girth at 30 DAS (cm)

A highly significant positive genotypic association was recorded for all the traits, except number of kernel rows per cob which recorded non-significant association (0.008) and shelling percentage which exhibited significance only at five per cent level of probability (0.107) (Table 19). Similarly at phenotypic level, a highly significant positive association was recorded for all the characters, except for number of kernel rows per cob (0.018) and shelling percentage (0.091) (Table 20).

4.4.3.3 Leaf area at 30 DAS (cm²)

The leaf area at 30 DAS recorded a highly significant positive association for all the characters at genotypic level, except for number of kernels per cob (0.096) which recorded non-significant association (Table 19). Similarly, all the characters recorded highly significant positive phenotypic association with this trait except leaf area at 60 DAS which was significant only at five per cent of level of probability (0.132) whereas other characters namely number of kernel rows per cob (0.094), number of kernels per row (0.310) and pith weight (0.196) exhibited non-significant association (Table 20).

4.4.3.4 Plant height at 60 DAS (cm)

A highly significant positive genotypic association was recorded for all the traits, except for shelling percentage (0.107) which exhibited only significant positive genotypic association at five per cent level of probability (Table 19). Similar results were also observed at phenotypic level for all characters except for 100-seed weight (0.237) and shelling percentage (0.074) which had non-significant association (Table 20).

4.4.3.5 Ear height at 60 DAS (cm)

A highly significant positive association was recorded for ear height with all characters for both at genotypic and phenotypic levels (Table 19 and 20).

4.4.3.6 Leaf area at 60 DAS (cm²)

The leaf area at 60 DAS exhibited highly significant association both at one per cent and five per cent in positive direction for all the traits, except for shelling percentage (0.081,

Table 19: Genotypic correlation among S₂ progenies for early vigour, grain yield and it's components in maize

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.00	0.355**	0.444**	0.357**	0.408**	0.204**	0.490**	0.365**	0.373**	0.150**	0.434**	0.344**	0.262**	0.269**	0.404**	0.495**
2		1.00	0.231**	0.260**	0.239**	0.201**	0.336**	0.271**	0.224**	0.008	0.255**	0.268**	0.216**	0.107*	0.194**	0.336**
3			1.00	0.312**	0.307**	0.161**	0.336**	0.315**	0.278**	0.096	0.386**	0.241**	0.182**	0.156**	0.347**	0.340**
4				1.00	0.808**	0.764**	0.422**	0.363**	0.398**	0.164**	0.362**	0.369**	0.280**	0.107*	0.362**	0.417**
5					1.00	0.648**	0.505**	0.415**	0.442**	0.188**	0.472**	0.412**	0.296**	0.185**	0.458**	0.502**
6						1.00	0.292**	0.222**	0.297**	0.192**	0.248**	0.247**	0.192**	0.081	0.292**	0.288**
7							1.00	0.756**	0.765**	0.238**	0.803**	0.782**	0.561**	0.398**	0.735**	0.993**
8								1.00	0.508**	0.071	0.790**	0.672**	0.444**	0.194**	0.641**	0.734**
9									1.00	0.382**	0.551**	0.626**	0.457**	0.258**	0.610**	0.762**
10										1.00	0.187**	0.193**	-0.130*	0.064	0.659**	0.236**
11											1.00	0.612**	0.339**	0.353**	0.860**	0.799**
12												1.00	0.458**	-0.239**	0.563**	0.702**
13													1.00	0.230**	0.186**	0.556**
14														1.00	0.303**	0.500**
15															1.00	0.730**
16																1.00

1. Plant height at 30 DAS (cm)

5. Ear at 60 DAS (cm)

9. Cob girth (cm)

13. 100-Seed weight (g)

* and ** significant at 1% and 5% level of probability, respectively

2. Plant girth at 30 DAS (cm)

6. Leaf area at 60 DAS (cm)

10. Number of Kernel rows per cob

14. Shelling (%)

3. Leaf area at 30 DAS (cm)

7. Cob weight (g)

11. Number of Kernels per row

15. Number of Kernels per cob

4. Plant height at 60 DAS (cm)

8. Cob length (cm)

12. Pith weight (g)

16. Grain yield per plant (g)

Table 20: Phenotypic correlation among S₂ progenies for early vigor, grain yield and it's components in maize

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.00	0.283**	0.341**	0.268**	0.333**	0.180**	0.359**	0.251**	0.235**	0.112	0.299**	0.245**	0.216**	0.194**	0.284**	0.365**
2		1.00	0.255**	0.280**	0.203**	0.142**	0.262**	0.211**	0.175**	0.018	0.183**	0.207**	0.145**	0.091	0.150**	0.263**
3			1.00	0.259**	0.269**	0.132*	0.284**	0.263**	0.211**	0.094	0.310	0.196	0.154**	0.140**	0.290**	0.289**
4				1.00	0.726**	0.693**	0.376**	0.322**	0.348**	0.143**	0.294**	0.337**	0.237	0.074	0.301**	0.365**
5					1.00	0.582**	0.450**	0.360**	0.356**	0.159**	0.380**	0.365**	0.262**	0.161**	0.373**	0.444**
6						1.00	0.247**	0.193**	0.237**	0.148**	0.202**	0.217**	0.155**	0.057	0.231**	0.244**
7							1.00	0.711**	0.682**	0.240**	0.728**	0.756**	0.507**	0.416**	0.683**	0.989**
8								1.00	0.484**	0.080	0.720**	0.651**	0.400**	0.157**	0.599**	0.682**
9									1.00	0.361**	0.486**	0.566**	0.381**	0.221**	0.554**	0.670**
10										1.00	0.182**	0.191**	-0.103	0.076	0.642**	0.236**
11											1.00	0.562**	0.279**	0.295**	0.866**	0.716**
12												1.00	0.410**	-0.241**	0.528**	0.666**
13													1.00	0.208**	0.160**	0.501**
14														1.00	0.267**	0.520**
15															1.00	0.671**
16																1.00

1. Plant height at 30 DAS (cm)

5. Ear at 60 DAS (cm)

9. Cob girth (cm)

13. 100-Seed weight (g)

2. Plant girth at 30 DAS (cm)

6. Leaf area at 60 DAS (cm)

10. Number of Kernel rows per cob

14. Shelling (%)

3. Leaf area at 30 DAS (cm)

7. Cob weight (g)

11. Number of Kernels per row

15. Number of Kernels per cob

4. Plant height at 60 DAS (cm)

8. Cob length (cm)

12. Pith weight (g)

16. Grain yield per plant (g)

* and ** significant at 1% and 5% level of probability, respectively

0.057), which showed significance only at five per cent level of probability at both genotypic and phenotypic level (Table 19 and 20).

4.4.3.7 Cob weight (cm)

A highly significant positive association of cob weight with all the traits was recorded at both genotypic and phenotypic levels (Table 19 and 20).

4.4.3.8 Cob length (cm)

The character cob length showed highly significant positive association with all the traits, except for number of kernel rows per cob (0.071, 0.080) which recorded non significant association at both genotypic and phenotypic levels (Table 19 and 20).

4.4.3.9 Cob girth (cm)

Cob girth exhibited highly significant positive association with all the characters both at genotypic and phenotypic levels (Table 19 and 20).

4.4.3.10 Number of kernel rows per cob

For this character, highly significant positive genotypic and phenotypic association was recorded with all the traits, except for plant girth at 30 DAS (0.008, 0.018), leaf area at 30 DAS (0.096, 0.094), cob length (0.071, 0.080), and shelling percentage (0.064, 0.076), which exhibited non-significant association at both genotypic and phenotypic levels (Table 19 and 20). However, the character 100-seed weight exhibited significant correlation in negative direction at (-0.130) genotypic level and non significant association at phenotypic level.

4.4.3.11 Number of kernels per row

The correlation coefficient across traits revealed that a highly significant positive association of this trait with all the other traits was observed at both genotypic and phenotypic levels, except for leaf area at 30 DAS (0.310) which exhibited significance only at genotypic level (Table 19 and 20).

4.4.3.12 Pith weight (g).

The trait pith weight recorded highly significant positive association with all the characters except shelling percentage which recorded highly significant negative association both at genotypic (-0.239) and phenotypic (-0.241) levels and leaf area at 30 DAS (0.196) which recorded significant association at genotypic level (Table 19 and 20).

4.4.3.13 Hundred Seed weight (g)

Majority of the traits exhibited highly significant genotypic positive association with 100-seed weight except number of kernel rows per cob (-0.130) which recorded significant negative association (Table 19). Similarly, a highly significant positive phenotypic association was recorded with all the traits, except for plant height at 60 DAS (0.237) and number of kernel rows per cob (-0.103) (Table 20).

4.4.3.14 Shelling percentage (%)

The character shelling percentage exhibited a lot of variation in association with different characters under study. A highly significant genotypic association was recorded for all the characters except for plant girth at 30 DAS (0.107) and plant height at 60 DAS (0.107) which recorded significant positive association at 5% level of probability and the other characters like leaf area at 60 DAS (0.081) and number of kernel rows per cob (0.064), which exhibited non-significant association (Table 19). Shelling percentage exhibited highly significant positive phenotypic association with majority of the traits, except for plant girth at 30 DAS (0.091), plant height at 60 DAS (0.074), leaf area at 60 DAS (0.057) and number of kernel rows per cob (0.076) traits (Table 20).

4.4.3.15 Number of kernels per cob

The character number of kernels per cob exhibited highly significant positive genotypic and phenotypic association with all the characters under this investigation (Table 19 and 20).

4.4.3.16 Grain yield per plant (g)

Study of nature of association in 350 S_2 progenies based on grain yield per plant is another important aspect which helps for selection of lines in early generation based on other traits. Hence, it is necessary to understand the nature of association existing among the different traits with grain yield per plant. The trait grain yield per plant exhibited highly significant association in positive direction with all the traits under study at both genotypic and phenotypic levels (Table 19 and 20).

4.5 EVALUATION OF S_2 LINES BY TOP CROSS TEST

4.5.1 Analysis of variance

The analysis of variance for 13 quantitative characters involving 350 top crosses of S_2 lines along with two checks DMH-2 and Cargil 900-M is presented in Table 21. The variance due to genotypes for all the 13 characters was highly significant, indicating presence of significant differences among the top crosses.

4.5.2 Mean performance of top crosses over check hybrids

4.5.2.1 Plant height (cm)

The plant height exhibited overall mean of 352 top crosses was 152.39 cm and it ranged from 126.50 to 192.50 cm (Appendix VI). Nine hybrids recorded significantly taller plant height than the check DMH-2 (162.00 cm) and five hybrids over the check Cargil 900-M (166.00 cm).

4.5.2.2 Ear height (cm)

Mean ear height was 80.53 cm and it ranged from 63.50 (270 × CM-501) to 98.50 cm (259 × CM-501) (Appendix VI). None of the hybrids had lower ear height than the check DMH-2 (63.50 cm), while 13 hybrids recorded significantly lower ear height over Cargil 900-M (79.50 cm). One hundred forty-eight hybrids had lower than average ear height. Two hundred and one hybrids exhibited ear height of more than overall average ear height.

4.5.2.3 Cob weight (g)

Mean cob weight of 350 hybrids was 140.40 g. The range of cob weight varied from 85.93 (316 × CM-501) to 198.78 g (283 × CM-501) (Appendix VI). Seven hybrids recorded significantly higher cob weight over DMH-2 (171.66 g). However, none of the hybrids were superior over Cargil 900-M (183.48 g).

4.5.2.4 Cob length (cm)

The cob length ranged from 12.20 (497 × CM-501) to 19.20 cm (246 × CM-501) with a mean of 15.83 cm (Appendix VI). None of the hybrids recorded significant superiority over Cargil 900-M, while two hybrids scored significantly larger cob length over DMH-2 (17.46 cm).

4.5.2.5 Cob girth (cm)

The range of cob girth among top crosses varied from 11.70 (630 × CM-501) to 17.00 cm (283 × CM-501) with a mean value of 13.95 cm (Appendix VI). Twenty-one hybrids recorded significantly higher cob girth than DMH-2 (14.80 cm) and two hybrids recorded superiority over Cargil 900-M (15.71 cm).

4.5.2.6 Number of kernel rows per cob

The number of kernel rows per cob ranged from 12.60 (258 × CM-501) to 18.50 (632 × CM-501) with an average of 15.07 (Appendix VI). Twenty-nine hybrids recorded significantly higher number of kernel rows per cob over DMH-2 (15.40), while 10 hybrids recorded superiority over Cargil 900-M (16.00).

Table 21: Analysis of variance for thirteen quantitative characters in top crosses of S₂ lines in maize

Source	D.F	Plant height (cm)	Ear height (cm)	Cob weight (g)	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob
Replication	1	75.14	2.63	89.01	4.41	0.62	0.94
Top crosses + two commercial checks	351	270.50**	59.28**	970.01**	3.92**	2.20**	2.18**
Error	351	71.66	17.21	82.69	0.43	0.29	0.34
CD 5%		16.65	8.16	17.88	1.29	1.06	1.15
CD 1%		21.92	10.74	23.55	1.70	1.39	1.52

Source	D.F	Number of kernels per row	Number kernels per cob	Pith weight (g)	100-seed weight (g)	Shelling percentage	Grain yield per plant (gm)	Grain yield per plot (kg)
Replication	1	4.83	29625.60	31.61	0.36	10.31	14.54	0.15
Top crosses + two commercial checks	351	19.23**	4972.58**	33.99**	28.78**	14.42**	802.84**	0.07**
Error	351	2.79	4084.09	4.10	3.79	2.69	75.31	0.04
CD 5%		3.29	125.67	3.98	3.83	3.23	17.07	0.41
CD 1%		4.33	165.49	5.24	5.04	4.25	22.47	0.54

* and ** significant at 1% and 5% level of probability, respectively

4.5.2.7 Number of kernels per row

Number of kernels per row ranged from 22.00 (598 × CM-501) to 40.50 (267 × CM-501) with an average of 29.32 kernels (Appendix VI). Thirty-five hybrids recorded significant superiority over DMH-2 (30.00) and one hybrid over Cargil 900-M (35.60).

4.5.2.8 Number of kernels per cob

The number of kernels per cob ranged from 317.20 (598 × CM-501) to 662.30 (398 × CM-501) with an average of 441.86 (Appendix VI). Thirty-five hybrids recorded significantly higher number of kernels over DMH-2 (461.40) and one hybrid over Cargil 900-M (569.28).

4.5.2.9 Pith weight (g)

The range of pith weight varied from 15.08 (24 × CM-501) to 40.57 g (158 × CM-501) with an average pith weight of 24.14 g (Appendix VI). Two hundred eighty-five hybrids had significantly lesser pith weight than check hybrid DMH-2 (31.64 g) and 185 hybrids recorded significant superiority over Cargil 900-M (27.55 g).

4.5.2.10 Hundred seed weight (g)

The range of 100-seed weight varied from 16.55 (802 × CM-501) to 38.96 g (249 × CM-501) with an average 100-seed weight of 26.90 g (Appendix VI). Eight hybrids recorded higher seed weight than check DMH-2 (31.71 g) and 26 hybrids were superior than check Cargil 900-M (32.00 g).

4.5.2.11 Shelling percentage (%)

The shelling percentage among top crosses ranged from 68.96 (21 × CM-501) to 90.32 per cent (151 × CM-501) with an average of 82.58 per cent (Appendix VI). Sixty-six hybrids showed significantly higher shelling percentage than DMH-2 (81.57%) and five hybrids over Cargil 900-M (84.99%).

4.5.2.12 Grain yield per plant (g)

The mean grain yield per plant was 116.26g and it ranged from 65.19 (502 × CM-501) to 172.90 g (417 × CM-501) (Appendix VI). Twelve hybrids recorded significant superiority over the check DMH-2 (140.02 g), while none were superior over Cargil 900-M (155.93 g) for grain yield per plant.

4.5.2.13 Grain yield per plot (kg)

The mean value of 350 top crosses (hybrids) for grain yield was 1.25 kg and it ranged from 0.738 (554 × CM-501) to 1.773 kg (231 × CM-501) (Appendix VI). Only one hybrid showed significantly higher grain yield per plot over the check DMH-2 (1.358 kg) and none of the top cross hybrids exhibited superiority over Cargil 900-M.

4.5.3 Mean performance of identified top test cross hybrids on the basis of grain yield per plot

4.5.3.1 Plant height (cm)

Among the top 25 hybrids, the plant height ranged from 132.50 (508 × CM-501) to 179.50 cm (264 × CM-501) as compared to the tallest check Cargil 900-M (166 cm) (Table 22). As many as three hybrids recorded higher plant height than Cargil 900-M.

4.5.3.2 Ear height (cm)

Among top 25 hybrids, the ear height ranged from 72.00 (446 × CM-501) to 89.50 cm (315 × CM-501, 796 × CM-501) (Table 22). None of the hybrids recorded ear height lower than DMH-2 (63.50 cm). However, eight hybrids exhibited lower ear height compared to Cargil 900-M check.

4.5.3.3 Cob weight (g)

Among the top 25 hybrids, the cob weight ranged from 170.40 (284 × CM-501) to 198.78 g (283 × CM-501) as compared to the superior check Cargil 900-M (183.48 g). As

many as 13 hybrids exhibited superiority over best check and it ranged from 0.33 to 8.34 per cent (Table 22).

4.5.3.4 Cob length (cm)

Out of the 25 top hybrids, the cob length ranged from 14.15 (446 × CM-501) to 19.20 cm (246 × CM-501) as compared to best check Cargil 900-M (18.15 cm) (Table 22). As many as six hybrids recorded numerical superiority over check and mean values ranged from 18.25 to 19.20 cm.

4.5.3.5 Cob girth (cm)

Among the top 25 hybrids, the cob girth ranged from 13.70 (249 × CM-501) to 17.00 cm (283 × CM-501) as compared to the check Cargil 900-M (15.71 cm) (Table 22). As many as 17 hybrids out of 25 recorded higher cob girth over best check and superiority ranged from 0.25 to 8.21 per cent.

4.5.3.6 Number of kernel rows per cob

Number of kernel rows per cob ranged from 14.50 (269 × CM-501) to 18.10 (236 × CM-501) as compared to check Cargil 900-M (Table 22). As many as 12 hybrids exhibited numerical superiority for number of kernel rows per cob over best check. Out of these, three hybrids recorded more than ten per cent superiority over best check hybrid.

4.5.3.7 Number of kernels per row

Out of 25 identified hybrids, on the basis of grain yield, the number of kernels per row ranged from 30.00 (278 × CM-501) to 38.50 kernels (176 × CM-501) per row as compared to the best check Cargil 900-M, (35.60) (Table 22). As many as four hybrids recorded numerical superiority over best check.

4.5.3.8 Number of kernels per cob

Among the top 25 hybrids, the number of kernels per cob ranged from 460.50 (417 × CM-501) to 662 kernels per cob (398 × CM-501) as compared to best check Cargil 900-M (569.28) (Table 22). Out of these, 398 × CM-501 recorded highest per cent of superiority (16.34%), whereas other two hybrids viz., 176 × CM-501 and 616 × CM-501 showed superiority of over five per cent over Cargil 900-M for this trait.

4.5.3.9 Pith weight (g)

The pith weight ranged from 17.93 (151 × CM-501) to 33.51 g (653 × CM-501) as compared to the lowest pith weight check Cargil 900-M (27.55 g) (Table 22). As many as nine hybrids exhibited 10 per cent lower pith weight compared to the best check.

4.5.3.10 Hundred seed weight (g)

Among the top 25 hybrids, the hundred seed weight ranged from 24.37 (653 × CM-501) to 38.96 g (249 × CM-501) as compared to better check Cargil 900-M (32.00 g) (Table 22). As many as eight hybrids recorded higher hundred seed weight *i.e.*, more than 10 per cent over best check.

4.5.3.11 Shelling percentage

Among the top 25 hybrids, the shelling percentage ranged from 81.82 (284 × CM-501) to 90.32 per cent (151 × CM-501) as compared to the highest shelling percentage check Cargil 900-M (84.99%) (Table 22). As many as 12 hybrids exhibited better mean shelling percentage over best check.

4.5.3.12 Grain yield per plant (g)

Among the top 25 hybrids, the grain yield per plant ranged from 139.49 (284 × CM-501) to 172.90 g (417 × CM-501) per plant as compared to the high yielding check Cargil 900-M (155.93 g per plant) (Table 22). As many as 13 hybrids recorded 10 per cent higher grain yield over best check.

Table 22: Mean performance of top twenty five test crosses identified based on grain yield

Sl. No.	Top crosses	Plant height (cm)	Percent superiority over DMH-2	Percent superiority over Cargil 900-M	Ear height (cm)	Percent superiority over DMH-2	Percent superiority over Cargil 900-M	Cob weight (g)	Percent superiority over DMH-2	Percent superiority over Cargil 900-M	Cob length (cm)	Percent superiority over DMH-2	Percent superiority over Cargil 900-M
1	231 × CM-501	157.50	-2.78	-5.12	84.50	33.07	6.29	198.03	15.36	7.93	18.10	3.67	-0.28
2	249 × CM-501	162.00	0.00	-2.41	81.50	28.35	2.52	173.22	0.91	-5.59	17.75	1.66	-2.20
3	246 × CM-501	159.00	-1.85	-4.22	88.50	39.37	11.32	175.68	2.34	-4.25	19.20	9.97	5.79
4	269 × CM-501	171.50	5.86	3.31	86.50	36.22	8.81	174.26	1.51	-5.02	18.15	3.95	0.00
5	278 × CM-501	152.50	-5.86	-8.13	77.00	21.26	-3.14	193.82	12.91	5.63	17.65	1.09	-2.75
6	236 × CM-501	154.00	-4.94	-7.23	84.50	33.07	6.29	187.68	9.33	2.29	18.10	3.67	-0.28
7	283 × CM-501	156.00	-3.70	-6.02	84.50	33.07	6.29	198.78	15.80	8.34	18.30	4.81	0.83
8	315 × CM-501	162.50	0.31	-2.11	89.50	40.94	12.58	185.64	8.14	1.18	16.90	-3.21	-6.89
9	264 × CM-501	179.50	10.80	8.13	81.00	27.56	1.89	189.06	10.13	3.04	18.15	3.95	0.00
10	398 × CM-501	144.00	-11.11	-13.25	82.00	29.13	3.14	175.81	2.42	-4.18	18.50	5.96	1.93
11	176 × CM-501	152.00	-6.17	-8.43	84.50	33.07	6.29	183.15	6.69	-0.18	17.80	1.95	-1.93
12	365 × CM-501	144.00	-11.11	-13.25	75.00	18.11	-5.66	180.84	5.35	-1.44	18.15	3.95	0.00
13	185 × CM-501	145.50	-10.19	-12.35	80.50	26.77	1.26	184.09	7.24	0.33	17.80	1.95	-1.93
14	417 × CM-501	147.50	-8.95	-11.14	76.50	20.47	-3.77	194.85	13.51	6.20	19.05	9.11	4.96
15	302 × CM-501	154.00	-4.94	-7.23	77.00	21.26	-3.14	183.41	6.85	-0.04	18.25	4.52	0.55
16	296 × CM-501	167.50	3.40	0.90	89.50	40.94	12.58	171.79	0.08	-6.37	18.00	3.09	-0.83
17	151 × CM-501	152.50	-5.86	-8.13	84.50	33.07	6.29	185.32	7.96	1.00	18.10	3.67	-0.28
18	284 × CM-501	148.00	-8.64	-10.84	73.50	15.75	-7.55	170.40	-0.74	-7.13	18.30	4.81	0.83
19	446 × CM-501	144.00	-11.11	-13.25	72.00	13.39	-9.43	181.31	5.62	-1.18	14.15	-18.96	-22.04
20	484 × CM-501	149.00	-8.02	-10.24	79.50	25.20	0.00	184.14	7.27	0.36	18.15	3.95	0.00
21	653 × CM-501	145.00	-10.49	-12.65	79.00	24.41	-0.63	184.36	7.40	0.48	18.05	3.38	-0.55
22	508 × CM-501	132.50	-18.21	-20.18	75.50	18.90	-5.03	194.54	13.33	6.03	18.15	3.95	0.00
23	616 × CM-501	143.50	-11.42	-13.55	88.00	38.58	10.69	173.64	1.15	-5.36	18.15	3.95	0.00
24	800 × CM-501	164.50	1.54	-0.90	85.00	33.86	6.92	192.15	11.93	4.72	16.50	-5.50	-9.09
25	559 × CM-501	160.00	-1.23	-3.61	83.00	30.71	4.40	176.99	3.10	-3.54	17.10	-2.06	-5.79
	DMh2	162.00			63.50			171.66			17.46		
	900M	166.00			79.50			183.48			18.15		
	CD at 5%	16.65			8.16			17.88			1.26		
	CD at 1%	21.92			10.74			23.55			1.70		

Contd.....

Sl. No.	Top crosses	Cob girth (cm)	Percent superiority over DMH-2	Percent superiority over Cargil 900-M	Number of kernel rows per cob	Percent superiority over DMH-2	Percent superiority over Cargil 900-M	Number of Kernels per row	Percent superiority over DMH-2	Percent superiority over Cargil 900-M	Number of Kernels per cob	Percent superiority over DMH-2	Percent superiority over Cargil 900-M
1	231 × CM-501	16.25	9.80	3.44	16.10	4.55	0.63	34.00	13.33	-4.49	547.40	18.64	-3.84
2	249 × CM-501	13.70	-7.43	-12.79	15.20	-1.30	-5.00	35.50	18.33	-0.28	539.60	16.95	-5.21
3	246 × CM-501	16.65	12.50	5.98	16.00	3.90	0.00	33.50	11.67	-5.90	536.00	16.17	-5.85
4	269 × CM-501	15.15	2.36	-3.56	14.50	-5.84	-9.38	36.50	21.67	2.53	530.00	14.87	-6.90
5	278 × CM-501	16.75	13.18	6.62	16.40	6.49	2.50	30.00	0.00	-15.73	491.60	6.55	-13.65
6	236 × CM-501	16.00	8.11	1.85	18.10	17.53	13.13	33.00	10.00	-7.30	597.30	29.45	4.92
7	283 × CM-501	17.00	14.86	8.21	15.00	-2.60	-6.25	31.00	3.33	-12.92	464.00	0.56	-18.49
8	315 × CM-501	16.35	10.47	4.07	16.50	7.14	3.13	33.00	10.00	-7.30	544.50	18.01	-4.35
9	264 × CM-501	16.65	12.50	5.98	16.50	7.14	3.13	30.50	1.67	-14.33	503.10	9.04	-11.63
10	398 × CM-501	16.15	9.12	2.80	17.90	16.23	11.88	37.00	23.33	3.93	662.30	43.54	16.34
11	176 × CM-501	16.00	8.11	1.85	15.60	1.30	-2.50	38.50	28.33	8.15	600.80	30.21	5.54
12	365 × CM-501	16.35	10.47	4.07	15.00	-2.60	-6.25	35.00	16.67	-1.69	525.00	13.78	-7.78
13	185 × CM-501	14.75	-0.34	-6.11	16.00	3.90	0.00	33.00	10.00	-7.30	528.00	14.43	-7.25
14	417 × CM-501	16.25	9.80	3.44	15.10	-1.95	-5.63	30.50	1.67	-14.33	460.50	-0.20	-19.11
15	302 × CM-501	15.15	2.36	-3.56	16.90	9.74	5.62	32.00	6.67	-10.11	541.00	17.25	-4.97
16	296 × CM-501	16.40	10.81	4.39	16.00	3.90	0.00	34.50	15.00	-3.09	552.10	19.66	-3.02
17	151 × CM-501	16.00	8.11	1.85	17.60	14.29	10.00	32.50	8.33	-8.71	572.20	24.01	0.51
18	284 × CM-501	16.40	10.81	4.39	16.00	3.90	0.00	30.50	1.67	-14.33	487.90	5.74	-14.30
19	446 × CM-501	15.75	6.42	0.25	16.10	4.55	0.63	35.50	18.33	-0.28	571.70	23.91	0.43
20	484 × CM-501	16.45	11.15	4.71	16.00	3.90	0.00	31.50	5.00	-11.52	503.60	9.15	-11.54
21	653 × CM-501	16.60	12.16	5.67	16.00	3.90	0.00	34.50	15.00	-3.09	552.00	19.64	-3.04
22	508 × CM-501	15.85	7.09	0.89	16.60	7.79	3.75	34.50	15.00	-3.09	573.60	24.32	0.76
23	616 × CM-501	15.45	4.39	-1.65	17.10	11.04	6.88	35.00	16.67	-1.69	598.50	29.71	5.13
24	800 × CM-501	15.65	5.74	-0.38	16.30	5.84	1.88	34.00	13.33	-4.49	553.90	20.05	-2.70
25	559 × CM-501	16.70	12.84	6.30	16.00	3.90	0.00	36.00	20.00	1.12	576.20	24.88	1.22
	DMh2	14.80			15.40			30.00			461.40		
	900M	15.71			16.00			35.60			569.28		
	CD at 5%	1.06			1.15			3.29			125.67		
	CD at 1%	1.39			1.52			4.33			165.49		

Contd.....

Sl. No.	Top crosses	Pith weight (g)	Percent superiority over DMH-2	Percent superiority over Cargil 900-M	100-seed weight (g)	Percent superiority over DMH-2	Percent superiority over Cargil 900-M	Shelling (%)	Percent superiority over DMH-2	Percent superiority over Cargil 900-M	Grain yield per plant (g)	Percent superiority over DMH-2	Percent superiority over Cargil 900-M	Grain yield per plot (kg)	Percent superiority over DMH-2	Percent superiority over Cargil 900-M
1	231 × CM-501	30.38	-3.99	10.26	31.81	0.32	-0.59	84.67	3.79	-0.38	167.66	19.74	7.52	1.773	30.33	24.82
2	249 × CM-501	24.29	-23.23	-11.83	38.96	22.86	21.75	86.00	5.43	1.19	148.93	6.36	-4.49	1.755	29.07	23.62
3	246 × CM-501	21.89	-30.82	-20.56	31.70	-0.04	-0.95	87.45	7.21	2.89	153.79	9.83	-1.37	1.728	27.07	21.70
4	269 × CM-501	24.47	-22.68	-11.20	32.07	1.12	0.20	85.89	5.29	1.06	149.80	6.98	-3.93	1.720	26.49	21.14
5	278 × CM-501	23.61	-25.39	-14.31	34.29	8.15	7.17	87.81	7.65	3.32	170.21	21.56	9.16	1.693	24.46	19.20
6	236 × CM-501	27.80	-12.14	0.91	37.52	18.34	17.26	85.17	4.42	0.22	159.88	14.19	2.54	1.629	19.76	14.70
7	283 × CM-501	32.01	1.16	16.18	35.32	11.39	10.38	83.91	2.87	-1.27	166.77	19.10	6.95	1.611	18.46	13.45
8	315 × CM-501	29.64	-6.33	7.58	35.63	12.37	11.35	84.04	3.03	-1.12	156.00	11.41	0.05	1.608	18.24	13.25
9	264 × CM-501	27.60	-12.76	0.20	30.42	-4.06	-4.93	85.38	4.68	0.46	161.45	15.31	3.54	1.605	18.02	13.04
10	398 × CM-501	28.22	-10.81	2.43	31.99	0.87	-0.04	83.95	2.92	-1.23	147.59	5.41	-5.35	1.599	17.59	12.62
11	176 × CM-501	22.96	-27.43	-16.66	35.57	12.17	11.15	87.45	7.21	2.90	160.19	14.40	2.73	1.591	17.01	12.06
12	365 × CM-501	24.28	-23.26	-11.86	34.42	8.54	7.55	86.58	6.14	1.87	156.55	11.81	0.40	1.587	16.71	11.78
13	185 × CM-501	28.00	-11.51	1.63	33.34	5.13	4.17	84.79	3.95	-0.23	156.09	11.48	0.10	1.584	16.48	11.56
14	417 × CM-501	21.95	-30.63	-20.33	34.33	8.25	7.27	88.73	8.78	4.40	172.90	23.48	10.88	1.556	14.41	9.58
15	302 × CM-501	30.04	-5.04	9.05	38.54	21.53	20.43	83.62	2.52	-1.61	153.37	9.53	-1.64	1.552	14.11	9.29
16	296 × CM-501	27.27	-13.81	-1.02	32.83	3.52	2.58	84.15	3.17	-0.98	144.52	3.21	-7.32	1.545	13.57	8.77
17	151 × CM-501	17.93	-43.34	-34.93	31.21	-1.59	-2.48	90.32	10.73	6.27	167.39	19.55	7.35	1.538	13.12	8.34
18	284 × CM-501	30.91	-2.32	12.19	32.39	2.15	1.23	81.86	0.35	-3.69	139.49	-0.38	-10.54	1.533	12.75	7.98
19	446 × CM-501	27.17	-14.12	-1.37	26.04	-17.87	-18.62	85.02	4.23	0.04	154.14	10.08	-1.15	1.523	11.95	7.22
20	484 × CM-501	22.50	-28.88	-18.32	27.03	-14.75	-15.52	87.78	7.61	3.28	161.64	15.44	3.66	1.507	10.78	6.10
21	653 × CM-501	33.51	5.91	21.63	24.37	-23.13	-23.83	81.82	0.31	-3.72	150.85	7.73	-3.26	1.502	10.42	5.75
22	508 × CM-501	33.33	5.33	20.96	33.46	5.51	4.55	82.88	1.60	-2.49	161.21	15.14	3.39	1.494	9.86	5.22
23	616 × CM-501	27.08	-14.40	-1.69	32.68	3.06	2.13	84.42	3.50	-0.67	146.55	4.67	-6.01	1.485	9.18	4.57
24	800 × CM-501	31.00	-2.01	12.53	35.39	11.61	10.60	83.87	2.82	-1.32	161.14	15.09	3.34	1.485	9.21	4.60
25	559 × CM-501	27.26	-13.84	-1.05	38.10	20.16	19.07	84.58	3.69	-0.49	149.73	6.93	-3.98	1.458	7.22	2.69
	DMh2	31.64			31.71			81.57			140.02			1.358		
	900M	27.55			32.00			84.99			155.93			1.420		
	CD at 5%	3.98			3.83			3.23			17.05			0.41		
	CD at 1%	5.24			5.04			4.25			22.47			0.51		

4.5.3.13 Grain yield per plot (kg)

Among the top 25 hybrids, the grain yield per plot ranged from 1.458 (559 × CM-501) to 1.773 kg per plot (231 × CM-501) as compared to highest yielding check Cargil 900-M, (1.420 kg per plot) (Table 22). As many as 13 hybrids recorded 10 per cent higher grain yield over best check.

4.6 LINE × TESTER ANALYSIS STUDIES

A line × tester analysis comprising of 100 hybrids 25 S₂ lines, 4 testers viz., CI-5, KDMI-10, CM-111 and NEI-9202B and 3 checks viz., DMH-2, Prabha and Cargil 900-M were evaluated during *kharif* 2005, at Agricultural Research Station, Arabhavi, University of Agricultural Sciences, Dharwad. Results of this experiment are presented in the following sub headings.

1. Analysis of variance.
2. Mean performance of lines, testers and hybrids.
3. Combining ability analysis.

4.6.1 Analysis of variance

The analysis of variance for entries including parents, hybrids and checks for all 17 characters is presented in Table 23. The variance due to lines was significant for plant girth at 30 DAS, plant height at 60 DAS, ear height at 60 DAS, cob weight, cob girth, number of kernel rows per cob and pith weight. Testers exhibited significant mean sum of square for plant height at 30 DAS, leaf area at 30 DAS, plant height at 60 DAS, ear height at 60 DAS, cob weight, cob length and number of kernels per cob. Significant mean sum of squares for plant height at 30 DAS, leaf area at 30 DAS, plant height at 60 DAS, ear height at 60 DAS, leaf area at 60 DAS, cob weight, cob length, cob girth, number of kernels per row, pith weight and shelling percentage traits. The ratio of GCA/SCA variance for all the characters was less than unity except ear height at 60 DAS indicating the predominance of non-additive genetic variance for majority of traits under study.

The variance due to line × tester was significant for 11 traits except plant girth at 30 DAS, number of kernel rows per cob, number of kernels per cob, grain yield per plant and grain yield per ha revealing the importance of SCA variance for expression of the 11 traits.

4.6.2 Mean performance of lines, testers, hybrids and checks

Mean performance of lines, testers, hybrids and commercial checks are given in Appendix VII, VIII, IX and X.

4.6.2.1 Plant height at 30 DAS (cm)

The mean plant height at 30 DAS in lines (female parents) ranged from 31.00 (ARYP-2) to 39.60 cm (ARYP-4) and 36.87 (NEI-9202B) to 39.07 cm (CI-5) among males, 28.80 (ARYP-16 × CM-111) to 46.13 cm (ARYP-25 × NEI-9202B) among hybrids and mean plant height of checks ranged from 33.27 (Cargil 900-M) to 33.40 cm (DMH-2) (Appendix VII, VIII, IX and X). Fifty-six hybrids were taller than the better check DMH-2; four hybrids were taller than tallest male CI-5 (39.07 cm). In the line × tester cross combinations, only one hybrid involving CM-111 tester (ARYP-22 × CM-111 (33.40 cm)), 11 hybrids involving CI-5 tester, six hybrids of KDMI-10 tester, 14 hybrids of NEI-9202B tester were dwarfier than best check.

Significant superiority over best check Prabha, was exhibited by three hybrids viz., ARYP-20 × NEI-9202B (42.67), ARYP-21 × NEI-9202B (42.00) and ARYP-25 × NEI-9202B (46.13) for this trait.

4.6.2.2 Plant girth at 30 DAS (cm)

The range of plant girth at 30 DAS varied from 1.40 cm (ARYP-15) to 1.93 cm (ARYP-18) in females, 1.60 (KDMI-10) to 1.83 cm (CM-111) in testers (male), 1.45 cm (ARYP-6 × NEI-9202B) to 1.95 cm (ARYP-4 × CI-5) in hybrids, 1.49 (Cargil 900-M) to 1.82 cm (Prabha) among standard checks. ARYP-18 had maximum plant girth (1.93 cm) among male lines (Appendix VII, VIII, IX and X). Fifteen hybrids had greater plant girth than the check

Table 23: Analysis of variance for combining ability for seventeen quantitative traits in maize

Source	DF	1	2	3	4	5	6	7	8	9
		Plant height at 30 DAS (cm)	Plant girth at 30 DAS (cm)	Leaf area at 30 DAS (cm) ²	Plant height at 60 DAS (cm)	Leaf area 60 DAS (cm) ²	Ear height at 60 DAS (cm)	Cob Weight (g)	Cob length (cm)	Cob girth (cm)
Replication	2	188.7232	1.9378	77724.9206	380.8041	14402.4374	879.9481	1170.5132	5.2545	2.7212
Line	24	18.0708	0.0543*	2850.1035	161.1735**	8635.1751	148.9289**	838.2884*	2.2826	1.9087**
Tester	3	117.8522**	0.0774	31476.4358**	1829.9537**	2882.5584	1033.8576**	188.9962*	17.3332*	0.5742
L × T	72	19.0856**	0.0339	2940.5397**	79.6250**	13716.1780**	71.9433**	541.5643**	1.7012**	0.8482**
Error	198	3.3441	0.0516	1693.7143	55.5084	3978.1319	51.0960	366.0017	1.3671	0.6646
GCA		0.0196	0.0000	6.0239	0.5204	-11.1505	0.3417	0.8060	0.0044	0.0018
SCA		5.2472	-0.0059	415.6085	8.0389	3246.0154	0.09492	58.5208	0.1114	0.0612
GCA x SCA		0.0077	0.000	0.0145	0.0647	0.0034	6.0492	0.0137	0.0395	0.0294
Contribution of Lines		20.07	32.75	18.26	25.63	17.22	30.15	31.06	23.89	42.18
Contribution of Testers		16.36	5.84	25.21	36.38	0.72	36.16	8.75	22.68	1.59
Contribution of L × T		63.58	61.41	56.53	77.99	82.06	43.69	60.19	53.43	56.23
CV (%)		8.08	7.33	13.83	4.21	11.94	8.08	10.48	5.25	4.60

* and ** significant at 1% and 5% level of probability, respectively

Contd.....

Source	DF	10	11	12	13	14	15	16	17
		Number of Kernel rows per cob	Number of Kernels per row	Number of kernels per cob	100-Seed weight (g)	Shelling (%)	Pith weight (g)	Grain yield per Plant (g)	Grain yield per hectare (kg/ha)
Replication	2	2.6249	18.4357	1765.6136	29.6543	15204.5209	70.6986	0.2954	5761793.6087
Line	24	3.9948**	21.0529	4638.5030	30.2220	6.9984	60.0993*	820.8019	211.1483
Tester	3	3.0499	22.8841	12756.6608*	11.4730	1.5747	25.7303	420.2932	54.5347
L × T	72	1.6921	14.5483*	4193.7520	19.8109	5.5696**	36.7123**	418.9897	140.2844
Error	198	1.3133	10.7046	4069.1593	18.7795	2.8791	21.9808	366.2371	107.5697
GCA		0.0001	0.0131	2.6253	0.0172	0.0016	0.0381	0.6965	0.1042
SCA		0.1263	1.2812	41.5309	0.3438	0.8968	4.9105	17.5842	10.9049
GCA x SCA		0.0079	0.0102	0.0632	0.0500	0.0018	0.0078	0.0396	0.0096
Contribution of Lines		21.20	31.16	24.65	33.60	29.28	34.65	38.53	33.05
Contribution of Testers		5.50	4.23	8.48	1.56	0.82	1.85	2.47	1.07
Contribution of L × T		73.30	64.60	66.87	64.84	69.90	63.50	59.00	65.83
CV (%)		5.92	6.56	7.89	8.09	1.67	13.51	10.97	14.16

* and ** significant at 1% and 5% level of probability, respectively

Prabha (1.82 cm). Four hybrids of CM-111 cross combinations, six hybrids of CI-5, four hybrids of KDMI-10 cross combinations, one hybrid of NEI-9202B has higher plant girth compared to best check Prabha.

Four hybrids exhibited superior plant girth over DMH-2, viz., ARYP-7 × CM-111 (1.90 cm), ARYP-4 × CI-5 (1.95 cm), ARYP-18 × CI-5 (1.93 cm) and ARYP-21 × CI-5 (1.91 cm). However, none of the hybrids were superior over Prabha and Cargil 900-M.

4.6.2.3 Leaf area at 30 DAS (cm²)

The range for mean leaf area at 30 DAS varied from 189.45 (ARYP-19) to 305.12 cm² (ARYP-9) among females, 144.05 (CI-5) to 269.13 cm² (KDMI-10) among testers, 164.04 (ARYP-17 × CM-111) to 338.06 cm² (ARYP-14 × KDMI-10) in hybrids, 198.43 (Cargil 900-M) to 253.87 cm² (DMH-2) among standard check (Appendix VII, VIII, IX and X). Fifty-one hybrids exhibited more leaf area than standard checks.

Out of 100 hybrids, one hybrid ARYP-14 × KDMI-10 (333.66CM²) exhibited superiority over DMH-2, 16 hybrids recorded significant superiority over Prabha and mean of these hybrids ranged from 333.66 (ARYP-14 × KDMI-10) to 297.62 cm² (ARYP-21 × NEI-9202B) for this trait.

4.6.2.4 Plant height at 60 DAS (cm)

The trait plant height at 60 DAS ranged from 162.13 (ARYP-11) to 186.87 cm (ARYP-17) among females, 162.60 (KDMI-10) to 177.67 cm (NEI-9202B) in males, 163.64 (ARYP-11 × KDMI-10) to 195.80 cm (ARYP-20 × NEI-9202B) in hybrids and 176.07 (DMH-2) to 185.40 cm (Prabha) among standard checks (Appendix VII, VIII, IX and X). In females, no line was taller than the tallest check Prabha, but eight lines were taller than the check DMH-2 (ARYP-2, ARYP-6, ARYP-17, ARYP-18, ARYP-19, ARYP-21, ARYP-22 and ARYP-23) and two lines were taller than check Cargil 900-M, viz., ARYP-17 (186.87 cm), ARYP-23 (181.80 cm). A total of 23 hybrids were taller than tallest check Prabha. Line × tester cross combinations like line × CM-111, line × CI-5, line × NEI-9202B produced eight, three and thirteen taller hybrids, respectively compared to checks.

Three hybrids, viz., ARYP-1 × CM-111 (194.33), ARYP-9 × CI-5 (193.87) and ARYP-20 × NEI-9202B (195.80) recorded significantly taller plant height over best check Cargil 900-M.

4.6.2.5 Ear height at 60 DAS (cm)

The range of ear height varied from 59.47 (ARYP-5) to 81.00 cm (ARYP-24) among females, 68.27 (KDMI-10) to 78.87 cm (NEI-9202B) in male lines, 64.33 (ARYP-11 × KDMI-10) to 95.53 cm (ARYP-1 × CM-111) in hybrids and 71.53 (DMH-2) to 85.80 cm (Prabha) among checks (Appendix VII, VIII, IX and X). Eleven females, namely, ARYP-2 (64.87 cm), ARYP-5 (59.47 cm), ARYP-7 (67.67 cm), ARYP-10 (71.20), ARYP-11 (70.53cm), ARYP-12 (69.67 cm), ARYP-13 (69.33cm), ARYP-14 (60.67cm), ARYP-15 (70.00cm) ARYP-20 (63.27cm) and ARYP-25 (70.53 cm) had lower ear height than check DMH-2 (71.53 cm). Among the hybrids, one hybrid in cross combination with CM-111, three hybrids in cross combination of line with CI-5 and five hybrids in cross combination of line with KDMI-10 have recorded lower plant height than checks.

Fifteen hybrids recorded significant superiority for reduced ear height having CM-111 as one of the parents. The mean values, ranged from 67.80 (ARYP-13 × CM-111) to 83.40 (ARYP-6 × CM-111), further 18 hybrids having CI-5 as one of the parents had a range values from 67.20 (ARYP-25 × CI-5) to 81.20 (ARYP-7 × CI-5), likewise 24 hybrids with KDMI-10 as a common parent had range values from 64.33 (ARYP-11 × KDMI-10) to 84.13 (ARYP-3 × KDMI-10) and 14 hybrids with NEI-9202B as one of the parents had values ranging from 75.97 (ARYP-12 × NEI-9202B) to 83.93 (ARYP-13 × NEI-9202B) for this trait.

4.6.2.6 Leaf area at 60 DAS (cm²)

The range of leaf area at 60 DAS in lines and testers varied from 456.15 (ARYP-1) to 717.65 cm² (ARYP-23) and 477.93 (KDMI-10) to 599.08 cm² (CM-111), respectively and 534.36 (ARYP-5 × CM-5) to 851.67 cm² (ARYP-21 × NEI-9202B) among test hybrids and 542.20 (Cargil 900-M) to 587.70 cm² (Prabha) among checks (Appendix VII, VIII, IX and X).

Nine females recorded higher leaf area than the tester CM-111 (599.08 cm²) and the standard check DMH-2 (587.70 cm²), 17 females over Cargil 900-M, 14 females over Prabha, 23 hybrids of CM-111 cross combinations, 24 hybrids of CI-5 cross combinations, 23 hybrids of NEI-9202B cross combinations and all hybrids of KDMI-10 cross combinations recorded higher leaf area than the checks.

Thirty six hybrids exhibited significant superiority over check DMH-2, ten hybrids in combination with CM-111 and mean values ranged from 698.68 (ARYP-8 × CM-111) to 779.27 (ARYP-9 × CM-111). Ten hybrids in combination with CI-5 and their mean ranged from 703.58 (ARYP-18 × CI-5) to 811.54 (ARYP-9 × CI-5). Seven hybrids in cross combinations with KDMI-10 had values ranging from 702.56 (ARYP-3 × KDMI-10) to 793.65 (ARYP-14 × KDMI-10). Nine hybrids in cross combination with NEI-9202B, which mean values ranging from 669.09 (ARYP-16 × NEI-9202B) to 85.00 (ARYP-21 × NEI-9202B) for this trait.

4.6.2.7 Cob weight (g)

The range of cob weight in lines and testers varied from 119.99 (ARYP-13) to 214.83 g (ARYP-3) and 145.08 (CM-111) to 192.61 g (NEI-9202B), respectively and it was 171.06 (ARYP-9 × KDMI-10) to 243.58 g (ARYP-20 × NEI-9202B) in hybrids and 185.28 (Prabha) to 206.04 g (DMH-2) in checks (Appendix VII, VIII, IX and X). ARYP-2 (214.83 g), ARYP-3 (214.47 g), ARYP-8 (200.04 g), ARYP-11 (194.35 g), ARYP-6 (201.12 g), ARYP-18 (203.84 g), ARYP-21 (204.34 g) and ARYP-23 (212.53 g) recorded more cob weight than the top performing tester. Ten hybrids of CM-111, 14 hybrids of CM-5, six hybrids of KDMI-10 and 12 hybrids of NEI-9202B tester combinations recorded higher cob weight than best check.

Two hybrids [ARYP-15 × NEI-9202B (240.19) and ARYP-20 × NEI-9202B (243.58)] exhibited significant superiority over best check DMH-2 for this character.

4.6.2.8 Cob length (cm)

The range of cob length in lines and testers varied from 16.33 (ARYP-19) to 20.60 cm (ARYP-23) and 15.33 (CI-5) to 19.60 cm (NEI-9202B), respectively (Appendix VII, VIII, IX and X). The mean cob length varied from 16.87 (ARYP-25 × CI-5) to 21.13 cm (ARYP-12 × NEI-9202B) in hybrids and from 18.33 (DMH-2) to 19.83 cm (Cargil 900-M) in checks. Four females viz., ARYP-3 (20.33 cm), ARYP-8 (20.57 cm), ARYP-10 (19.67 cm) and ARYP-23 (20.60 cm) females recorded more cob length than males. Three hybrids with CM-111, five hybrids with CI-5, seven hybrids with NEI-9202B testers recorded higher cob length than best check.

Ten hybrids recorded significant superiority over check DMH-2, and cob length ranged from 20.40 (ARYP-12 × NEI-9202B) to 21.13 (ARYP-12 × NEI-9202B) for this trait.

4.6.2.9 Cob girth (cm)

The cob girth ranged from 13.67 (ARYP-1, ARYP-11) to 15.97 cm (ARYP-6) among females, 14.27 (CM-111) to 15.07 cm (CI-5) among males, 14.10 (ARYP-14 × NEI-9202B) to 17.63 cm (ARYP-8 × KDMI-10) among hybrids, 13.63 (Prabha) to 15.83 cm (Cargil 900-M) among standard checks (Appendix VII, VIII, IX and X). Two female parents viz., ARYP-6 (15.97 cm) and ARYP-14 (15.87 cm) recorded higher cob girth than testers and checks. Six hybrids with CM-111, six hybrids with CI-5, seven hybrids with KDMI-10 and 10 hybrids with NEI-9202B tester cross combinations recorded higher cob girth than the top check.

One hybrid, ARYP-8 × KDMI-10 (17.63) exhibited significant superiority over check Cargil 900-M and four hybrids recorded significant superiority over DMH-2 and mean cob girth ranged from 16.63 (ARYP-17 × NEI-9202B) to 17.63 cm (ARYP-8 × KDMI-10).

4.6.2.10 Number of kernel rows per cob

The mean number of kernel rows per cob ranged from 12.53 (ARYP-11) to 15.33 (ARYP-16) among females, 12.53 (NEI-9202B) to 13.87 (KDMI-10) in males and 12.27 (ARYP-19 × CM-111) to 16.27 (ARYP-25 × CI-5) in hybrids and 12.93 (Prabha) to 15.73 (Cargil 900-M) among checks (Appendix VII, VIII, IX and X). Three hybrids *viz.*, ARYP-13 × CM-111 (15.87), ARYP-25 × CI-5 (16.27) and ARYP-17 × CM-111 (16.00) had more number of kernel rows per ear.

Eight hybrids exhibited significant superiority over DMH-2 and mean values ranged from 15.60 (ARYP-24 × CM-111) to 16.27 (ARYP-25 × -5) for this character.

4.6.2.11 Number of kernels per row

Number of kernels per row ranged from 32.67 (ARYP-1) to 41.20 (ARYP-8) in females, 30.07 (CI-5) to 39.07 (NEI-9202B) in males, 34.07 (ARYP-22 × KDMI-10) to 43.33 (ARYP-19 × KDMI-10) in hybrids, 33.93 (DMH-2) to 40.07 kernels (Prabha) in checks (Appendix VII, VIII, IX and X).

The females ARYP-6, ARYP-8, ARYP-14, and ARYP-23 had more number of kernels per row than male parents and checks.

None of the hybrids recorded significant superiority over checks.

4.6.2.12 Number of kernels per cob

Number of kernels per cob ranged from 444.13 (ARYP-20) to 605.63 (ARYP-9) among females, 397.41 (CI-5) to 495.25 (NEI-9202B) in males, 473.81 (ARYP-22 × KDMI-10) to 645.33 (ARYP-17 × CM-111) in hybrids and 473.47 (DMH-2) to 634.99 (Cargil 900-M) among checks (Appendix VII, VIII, IX and X). None of the hybrids recorded higher number of kernels per cob than checks used in the study.

Significant superiority over best check Prabha was recorded by three hybrids *viz.*, ARYP-3 × CM-111 (626.63), ARYP-13 × CM-111 (639.92) and ARYP-17 × CM-111 (645.33) for this trait.

4.6.2.13 Hundred seed weight (g)

The mean 100 grain weight ranged from 26.38 (ARYP-13) to 38.71 g (ARYP-23) in females, 27.25 (CM-111) to 38.08 g (CI-5) in males, 28.48 (ARYP-9 × KDMI-10) to 39.35 g (ARYP-6 × NEI-9202B) in hybrids and 31.13 (Cargil 900-M) to 38.53 (DMH-2) g in checks (Appendix VII, VIII, IX and X). Only one female *i.e.*, ARYP-23 (38.71 g) recorded higher 100-seed weight than male parents/checks. Hybrids ARYP-12 × CI-5 (39.16 g), ARYP-6 × NEI-9202B (39.35 g) and ARYP-24 × NEI-9202B (38.53 g) were superior hybrids which recorded higher 100-seed weight than DMH-2 (38.53 g).

Two hybrids *viz.*, ARYP-12 × CI-5 (39.16) and ARYP-6 × NEI-9202B (39.35) recorded significant superiority over check Prabha (38.33), for this character. Twelve hybrids recorded significant superiority over Cargil 900-M and mean weight ranged from 36.87 (ARYP-22 × KDMI-10) to 39.35 (ARYP-6 × NEI-9202B) for this trait.

4.6.2.14 Shelling percentage (%)

The mean shelling percentage ranged from 80.76 (ARYP-1) to 86.82 per cent (ARYP-9) among female parents, 82.74 (CM-111) to 84.90 per cent (NEI-9202B) in males, 79.67 (ARYP-15 × NEI-9202B) to 87.04 per cent (ARYP-19 × KDMI-10) among hybrids and 82.61 (Prabha) to 86.56 per cent (Cargil 900-M) among checks (Appendix VII, VIII, IX and X).

Five females recorded higher shelling percentage than males, ARYP-9, ARYP-24 were two females which recorded higher shelling percentage than checks. The hybrids ARYP-19 × KDMI-10 (87.04%), ARYP-20 × KDMI-10 (86.57%), ARYP-24 × KDMI-10

(86.77%), ARYP-19 × NEI-9202B (86.85%) and ARYP-24 × NEI-9202B (86.85%) recorded relatively higher shelling percentage than checks.

Twenty five hybrids exhibited significant superiority over check Prabha, and their mean values ranged from 85.59 (ARYP-20 × CM-111) to 89.53 (ARYP-10 × CI-5) for this trait.

4.6.2.15 Pith weight (g)

The mean pith weight ranged from 19.86 (ARYP-24) to 36.25 g (ARYP-3) in females, 23.89 (CI-5) to 28.82 g (NEI-9202B) in males, 23.90 (ARYP-19 × NEI-9202B) to 48.10 g (ARYP-15 × NEI-9202B) in hybrids and 26.36 (DMH-2) to 31.64 g (Prabha) among checks (Appendix VII, VIII, IX and X). Eleven females had lower pith weight compared to mean pith weight of males.

None of the hybrids showed significant superiority for lower pith weight over checks for this character.

4.6.2.16 Grain yield per plant (g)

Grain yield per plant ranged from 99.60 (ARYP-13) to 180.13 g (ARYP-23) among females, 120.42 (CM-111) to 163.80 g (NEI-9202B) in males, 143.06 (ARYP-9 × KDMI-10) to 200 g (ARYP-24 × NEI-9202B) in hybrids and 153.64 (Prabha) to 168.61 g (Cargil 900-M) among checks (Appendix VII, VIII, IX and X). Five females had higher grain yield per plant than best tester. Among experimental hybrids, 13 hybrids with CM-111, 15 hybrids with CI-5 and 10 hybrids with KDMI-10 and 16 hybrids with NEI-9202B combinations showed higher mean grain yield per plant than the check Cargil 900-M.

Five hybrids viz., ARYP-3 × CM-111 (196.86), ARYP-14 × C1-5 (199.35), ARYP-3 × KDMI-10 (197.99), ARYP-2 × NEI-9202B (198.42) and ARYP-24 × NEI-9202B (200.09) exhibited significant superiority over best check DMH-2.

4.6.2.17 Grain yield per hectare (kg)

The mean grain yield per hectare ranged from 3694.94 (ARYP-13) to 7303.30 kg (ARYP-2) among female parents, 4130.04 (CM-111) to 6278.94 kg (NEI-9202B) among males, 5473.97 (ARYP-5 × CM-111) to 8445.67 kg (ARYP-24 × CM-111) among hybrids and 5684.15 (Prabha) to 6795.26 kg (Cargil 900-M) among the checks (Appendix VII, VIII, IX and X). ARYP-2 (7303.70 kg), ARYP-4 (6455.84 kg), ARYP-9 (6443.24 kg), ARYP-21 (6407.88 kg) were recorded more than 10 per cent mean grain yield among lines. Among the crosses, 16 hybrids with CM-111, 18 hybrids with CI-5, eight hybrids with KDMI-10 and 19 hybrids with NEI-9202B combinations recorded higher mean grain yield per hectare than the standard check Cargil 900-M.

Two hybrids viz., ARYP-15 × CM-111 (8076.91) and ARYP-24 × CM-111 (8445.67) exhibited significant superior grain yield over best check Cargil 900-M. However, over DMH-2, twelve hybrids recorded significantly superiority for grain yield which ranged from 7509.66 (ARYP-16 × C-5) to 8445.67 kg per ha (ARYP-24 × CM-111).

4.6.3 ANOVA for combining ability

4.6.3.1 General combining ability effects

The gca effects of 25 parental lines and four testers for various characters is presented in Table 24.

4.6.3.1.1 Plant height at 30 DAS

The gca effects of lines and testers for plant height varied from -1.79 (ARYP-16) to 2.69 (ARYP-18, ARYP-25) and -1.32 (CM-111) to 1.68 (NEI-9202B), respectively (Table 24). Seven out of 29 parents showed significant gca effects, among them four viz., ARYP-18 (2.69), ARYP-21 (2.51), ARYP-25 (2.69) and NEI-9202B (1.68) showed highly significant positive gca effects, where as two lines viz., ARYP-1 (-1.26) and ARYP-11 (-1.59) exhibited highly significant gca effects in negative direction. Among the testers, NEI-9202B (1.68) exhibited highly significant positive gca effects, while CM-111 (-1.32) exhibited gca effects in negative direction.

4.6.3.1.2 Plant girth at 30 DAS

None of the lines and testers exhibited significant gca effect for this trait.

4.6.3.1.3 Leaf area at 30 DAS

Five lines exhibited significant gca effects, out of which three lines viz., ARYP-21, ARYP-23 and ARYP-25 had significant positive gca effects (26.12, 23.66 and 25.07, respectively) while two lines viz., ARYP-7 and ARYP-11 had significant negative gca effects (-24.30 and -25.47) (Table 24). The gca effect of testers for leaf area varied from -27.09 (CM-111) to 20.99 (KDMI-10). Among them, CM-111, KDMI-10 (20.99) had significant effect in positive direction.

4.6.3.2.4 Plant height at 60 DAS

The gca effect of lines and testers for plant height at 60 DAS varied from -8.42 (ARYP-11) to 7.55 (ARYP-1) and -6.37 (KDMI10) to 5.46 (NEI-9202B), respectively (Table 24). Six out of 29 parents exhibited significant gca effect and among them, three were in positive direction and three were in negative direction. Two parents ARYP-1 (7.55) and NEI-9202B (5.46) showed highly significant gca effect in positive and two lines ARYP-11 (-8.42) and ARYP-12 (-6.65) exhibited highly significant gca effect in negative direction. Among tester parents, NEI-9202B (5.46) showed significant gca effect in positive direction and KDMI-10 (-6.37) showed in negative direction.

4.6.3.1.5 Ear height

The magnitude of gca effect varied from -5.33 (ARYP-11) to 7.39 (ARYP-1) among lines, two of the lines ARYP-1 (7.39) and ARYP-3 (6.87) showed highly significant gca effect in positive direction, ARYP-5 (5.19) showed only significant gca effect in positive direction (Table 24). The lines ARYP-11 (-5.33), ARYP-18 (-4.43) and ARYP-15 (-5.16) exhibited significant gca effect in negative direction. However, among testers, all have shown significant gca effect, but CM-111 (2.16) and NEI-9202B (3.92) showed effect in positive direction and KDMI-10 (-4.24) and CI-5 (-1.83) showed significant gca effect in negative direction.

4.6.3.1.6 Leaf area at 60 DAS

The gca effect for leaf area of lines varied from -50.44 (ARYP-23) to 35.18 (ARYP-3) and out of 25 females, five of them exhibited significant gca effect (Table 24). The line ARYP-21 (48.89) showed highly significant positive gca effect, while ARYP-2 (-45.03), ARYP-5 (-41.27) and ARYP-15 (-39.58) exhibited only significant gca effect and the line ARYP-23 (-50.44) exhibited highly significant gca effect in negative direction. Among the testers, none of them exhibited significant gca effect for this trait.

4.6.3.1.7 Cob weight

The gca effect for cob weight varied from -17.89 (ARYP-19) to 16.93 (ARYP-3) in lines and -5.82 (KDMI-10) to 6.33 (NEI-9202B) among testers (Table 24). Out of 25 lines, five lines exhibited significant gca effects, among them, ARYP-3 (16.93) ARYP-15 (11.82) and had highly significant positive effect. Among tester parents, KDMI-10 (-5.82) showed highly significant gca effect in negative direction and NEI-9202B (6.33) showed highly significant positive gca effect for this trait.

4.6.3.1.8. Cob length

The gca effect of lines and testers varied from -0.72 (ARYP-1) to 0.80 (ARYP-14) and -0.61 (KDMI-10) to 0.55 (NEI-9202B) (Table 24). Out of 25 lines, two lines viz., ARYP-14 (0.80) and ARYP-3 (0.72) showed significant gca effect in positive direction. Among testers, highly NEI-9202B (0.55) recorded significant gca effect in positive direction.

4.6.3.1.9 Cob girth

The gca effect of lines and testers for cob girth varied from -0.91 (ARYP-19) to 0.82 (ARYP-15) and -0.92 (CI-5) to 0.06 cm (KDMI-10 and NEI-9202B), respectively (Table 24). Four out of 29 parents showed significant gca effect and three lines viz., ARYP-8 (0.64), ARYP-15 (0.82) and ARYP-24 (0.77) showed highly significant gca effect in positive direction. None of the testers exhibited significant gca effect for this trait.

Table 24: Magnitude of gca effects of parents for early vigor, grain yield and its components in maize

SL. No	Lines	Plant Height 30 DAS (cm)	Plant Girth 30 DAS (cm)	Leaf Area 30 DAS (cm ²)	Plant Height 60 DAS (cm)	Leaf Area 60 DAS (cm ²)	Ear height at 60 DAS (cm)	Cob Weight (g)	Cob Length (cm)	Cob Girth (cm)	Number of kernel Rows per cob	Number of Kernels Per row	Pith Weight (g)	100-Seed Weight (g)	Shelling Percentage	Number of Kernels per cob	Grain Yield per plant (g)	Grain yield per hectare (kg)
1	ARYP-1	-1.26*	-0.04	-5.79	7.55**	-5.26	7.39**	-13.15*	-0.73*	-0.33	-0.66*	0.84	-0.09	-1.84	-1.13*	-15.88	-14.25**	465.80*
2	ARYP-2	-1.69	0.08	-1.42	-0.10	-45.03*	1.01	1.97	-0.20	0.14	0.01	-0.30	1.96	0.16	-0.68	-3.88	2.23	-331.52
3	ARYP-3	-0.16	0.05	1.07	7.43	35.18	6.87**	16.93**	0.72*	0.19	0.23	1.07	0.56	1.98*	1.07*	26.09*	18.59**	230.46
4	ARYP-4	-0.39	0.10	2.27	-3.63	29.00	0.74	-6.60	-0.49	-0.06	-0.23	-0.16	-2.09	-0.52	0.51	-9.82	-5.62	-302.84
5	ARYP-5	-0.29	-0.02	-12.46	-1.55	-41.27*	5.19*	-4.48	-0.65	-0.30	-0.23	-0.98	0.75	-1.77	-1.27**	-21.52	-9.60	-411.33*
6	ARYP-6	0.41	-0.06	-5.54	-0.37	25.52	0.97	0.83	0.61	-0.24	0.06	-0.05	1.05	1.00	-0.29	0.85	2.00	-59.76
7	ARYP-7	-0.91	0.06	-24.30*	0.17	-28.52	2.32	-8.85	-0.41	-0.40	-0.91**	-0.43	0.20	-0.61	-1.15	-41.80**	-13.51*	-418.15*
8	ARYP-8	-0.32	-0.04	12.82	0.55	7.02	1.16	3.58	-0.23	0.64**	0.84**	-0.51	0.07	-0.24	0.52	24.39	5.73	223.73
9	ARYP-9	-0.16	0.02	-6.40	4.36*	11.55	2.22	-3.32	0.37	-0.14	-0.19	-1.25	0.20	-0.01	-0.15	-23.86	-1.30	105.06
10	ARYP-10	0.16	-0.09	6.75	0.08	11.36	0.69	-4.38	0.06	0.16	-0.93**	0.22	-0.51	1.47	0.07	-31.92*	-1.65	88.90
11	ARYP-11	-1.59**	-0.08	-25.47*	-8.42**	-24.78	-5.33**	-4.37	-0.36	-0.17	0.17	1.53*	0.97	-0.76	-0.55	-14.98	-3.12	94.96
12	ARYP-12	0.09	-0.07	-14.64	-6.65**	-12.17	-3.69	8.83	0.43	-0.04	-0.11	0.30	3.43*	0.65	-1.33**	0.79	0.95	-345.70
13	ARYP-13	-0.26	0.07	13.34	-2.07	18.48	-2.83	-1.79	-0.36	0.40	0.67*	-0.88	-0.68	0.01	0.20	14.57	1.10	39.86
14	ARYP-14	-0.84	-0.09	8.56	3.63	-5.20	-2.18	5.29	0.80*	-0.43	-0.36	2.64**	1.12	-0.74	0.04	22.68	6.38	498.96*
15	ARYP-15	-0.91	-0.07	-2.09	-1.35	-39.58*	-5.16*	11.82*	-0.28	0.82**	0.66*	-1.31	7.07**	0.84	-2.39**	5.56	4.04	434.57*
16	ARYP-16	-1.79	-0.05	-16.31	2.67	-1.09	0.24	-0.62	-0.19	-0.25	0.37	0.27	-1.50	-1.84	0.86	15.86	3.09	-186.17
17	ARYP-17	-0.66	-0.02	-14.22	-3.65	4.42	-2.14	3.39	-0.29	0.26	0.94**	-0.08	0.37	-2.07*	-0.40	35.66**	-3.93	269.57
18	ARYP-18	2.69**	0.01	12.48	-0.78	0.49	-4.43*	-11.95*	0.33	-0.44	0.11	-0.90	-0.93	0.75	-0.61	-8.45	-12.13*	-286.92
19	ARYP-19	0.59	-0.01	14.13	-0.43	-11.04	-3.14	-17.89**	0.18	-0.91**	-1.29**	1.95**	-6.04**	-0.14	2.00**	-24.76	-9.63	-375.55
20	ARYP-20	0.93	0.03	-17.45	1.45	0.79	2.16	3.42	0.49	0.04	-0.31	-0.30	-2.60	3.17**	1.28**	-15.35	2.46	206.62
21	ARYP-21	2.51**	0.03	26.12*	-3.63	48.89**	-2.58	-6.69	-0.25	-0.07	-0.23	0.97	-1.68	-0.95	0.43	5.59	-2.80	-160.00
22	ARYP-22	0.19	-0.09	3.00	-0.95	18.07	1.54	9.68	0.58	0.24	-0.19	-0.01	2.47	1.30	-0.13	-7.73	9.43	-95.71
23	ARYP-23	0.29	0.06	23.66*	1.88	-50.44**	-2.33	2.62	-0.03	0.14	0.47	-0.48	-1.61	-0.12	0.90	11.66	3.11	-12.38
24	ARYP-24	0.63	0.09	22.45	2.40	34.46	3.72	9.40	-0.09	0.77**	0.27	-0.01	-1.90	1.64	1.52**	10.02	11.85*	639.43**
25	ARYP-25	2.69**	0.11	25.07*	0.37	19.16	-2.44	6.25	-0.05	-0.01	0.87**	0.89	-0.61	-1.35	0.68	46.27**	6.58	-307.90
	SE	0.52	0.06	11.88	2.15	18.20	2.06	5.52	0.33	0.23	0.26	0.73	1.35	0.98	0.48	13.27	5.52	194.49
1	CM -111	-1.32**	0.01	-27.09**	1.55	-0.72	2.16**	-1.11	0.12	-0.12	0.13	0.57	1.12*	-1.25**	-0.66**	12.88*	-1.88	119.81
2	CI -5	0.03	0.03	8.79	-0.65	8.16	-1.83*	0.61	-0.07	-0.00	-0.06	-0.77*	0.08	0.89*	0.04	-12.67*	0.71	83.56
3	KDMI-10	-0.39	0.01	20.99**	-6.37**	-6.92	-4.24**	-5.82**	-0.61**	0.06	0.04	-1.11**	-2.05**	-0.44	0.52**	-14.36**	-4.31	-348.83**
4	NEI98002B	1.68**	-0.05	-2.70	5.46**	-0.52	3.92**	6.33**	0.55**	0.06	-0.12	1.31**	0.84	0.80*	0.10	14.16**	5.47*	145.47
	SE	0.21	0.02	4.75	0.86	7.28	0.82	2.20	0.13	0.09	0.10	0.29	0.54	0.39	0.19	5.31	2.20	77.79

* and ** significant at 1% and 5% level of probability, respectively

4.6.3.1.10 Number of kernel rows per cob

The range of gca effects varied from -1.29 (ARYP-19) to 0.94 (ARYP-17) among male parents. The magnitude gca effect varied from -0.12 (NEI-9202B) to 0.13 kernel rows (CM-111) for testers (Table 24).

The lines ARYP-8 (0.84), ARYP-17 (0.88) and ARYP-25 (0.87) showed highly significant gca effects in positive direction and ARYP-13 (0.67) and ARYP-15 (0.66) showed only significant gca effect in positive direction. The lines ARYP-7 (-0.91), ARYP-10 (-0.99), ARYP-1 (0.66) and ARYP-19 (-1.29).

4.6.3.1.11 Number of kernels per row

The magnitude of gca effects for number of kernels per row ranged from -1.31 (ARYP-15) to 2.64 kernels (ARYP-14) among lines (Table 24). Out of 25 female, three lines showed significant gca effect i.e., two lines ARYP-14 (2.64) and ARYP-19 (1.95) showed highly significant positive gca effect and one line ARYP-11 (1.53) exhibited only significant gca effect in positive direction. Among tester parents, three of them showed significant gca effect and values varied from -1.11 (KDMI-10) to 1.31 (NEI-9202B). The male line KDMI-10 (-1.11) and CI-5 (-0.77) showed significant gca effect in negative direction and NEI-9202B (1.31) showed highly significant positive gca effect for this character.

4.6.3.1.12 Pith weight

The gca effect for pith weight varied from -6.04 (ARYP-19) to 7.04 (ARYP-15) in females, -2.05 (KDMI-10) to 1.12 (CM-111) in testers (Table 24). Two lines (ARYP-15) and (ARYP-14). However, line ARYP-10 and ARYP-13 exhibited significant negative gca effect. Among tester parents, KDMI-10 showed significant negative gca effect and CM-111 showed only significant positive gca effect for this trait.

4.6.3.1.13 Hundred seed weight

The range of gca effects for 100-seed weight varied from -2.07 (ARYP-17) to 3.17 (ARYP-20) in lines (Table 24). Among 25 lines, two lines ARYP-20 (3.17) and ARYP-3 (1.98) exhibited significant positive gca effect, while ARYP-17 (-2.07) showed significant negative gca effect. The range among testers varied from -1.25 (CM-111) to 0.89 (CI-5). One male line CM-111 (-1.25) exhibited highly significant negative gca effect and other two males CI-5 (0.89) and NEI-9202B (0.80) also showed significant gca effect in positive direction at 5 per cent level probability.

4.6.3.1.14 Shelling percentage

The magnitude of gca effects for shelling percentage varied from -2.39 (ARYP-15) to 2.00 (ARYP-19) (Table 24). Out of 25 lines, highly significant gca effect was exhibited by four lines ARYP-19 (2.00), ARYP-20 (1.28), ARYP-24 (1.52) and ARYP-3 (1.07) in positive direction. Among tester parents, gca effect ranged from -0.66 (CM-111) to 0.52 (KDMI-10) per cent and KDMI-10 exhibited. Among male parents, highly significant gca effect in positive direction for the trait.

4.6.3.1.15 Number of kernels per cob

The gca effect of lines and testers for number of kernels per cob varied from -41.80 (ARYP-7) to 46.27 kernels (ARYP-25) and -14.36 (KDMI-10) to 14.16 kernels (NEI-9202B), respectively (Table 24). Two lines viz., ARYP-25 (46.22) and ARYP-17 (35.66) and ARYP-3 (26.09) showed highly significant positive gca effect. Tester line NEI-9202B (14.16) exhibited highly significant gca effect in positive direction, whereas KDMI-10 (-14.36) showed highly significant gca effect in negative direction.

4.6.3.1.16 Grain yield per plant

The magnitude of range of gca effects for grain yield per plant varied from -14.25 (ARYP-1) to 18.59 (ARYP-3) (Table 24). The magnitude among testers varied from -4.31 (KDMI-10) to 5.47 (NEI-9202B). Among 25 lines, five lines showed significant gca effect. The line ARYP-3 (18.59) showed highest significant positive gca effect, while ARYP-24 (11.85)

had only significant positive gca effect. Among testers only NEI-9202B (5.47) showed highly significant gca effect in positive direction.

4.6.3.1.17 Grain yield per hectare

The magnitude of range of gca effects of lines and testers for grain yield per hectare varied from -4.18 (ARYP-7) to 639.43 (ARYP-24) and -348.83 (KDMI-10) to 119.81 (CM-111), respectively (Table 24). Six of the lines showed significant gca effect, out of which ARYP-1 (465.80), ARYP-14 (498.96), ARYP-15 (434.57) the lines showed only significant positive gca effect, while ARYP-24 (639.43) showed highly significant gca effect in positive direction. Among testers, only one tester KDMI-10 (-348.83) showed highly significant gca effect in negative direction.

4.6.4 Specific combining ability effect

The specific combining ability effects of 100 crosses are presented in Table 24.

4.6.4.1 Plant height at 30 DAS

The range of sca effects varied from -6.27 (ARYP-25 × KDMI-10) to 8.75 (ARYP-25 × NEI-9202B) (Table 25). Nine hybrids viz., ARYP-18 × CM-111 (6.62), ARYP-2 × KDMI-10 (3.68), ARYP-20 × NEI-9202B (7.05), ARYP-21 × NEI-9202B (5.20) and ARYP-25 × NEI-9202B (8.75) showed highly significant sca effects in positive direction.

4.6.4.2 Plant girth at 30 DAS

None of the crosses exhibited significant sca effect in any direction. However, the range of sca effect varied from -0.20 (ARYP-18 × CI-5) to 0.20 (ARYP-18 × CI-5) (Table 24).

4.6.4.3 Leaf area at 30 DAS

Out of hundred crosses, only six hybrids viz., ARYP-1 × CM-111 (49.94), ARYP-15 × CM-111 (46.75), ARYP-11 × KDMI-10 (57.25), ARYP-14 × KDMI-10 (52.30), ARYP-5 × NEI-9202B (72.73) and ARYP-17 × NEI-9202B (77.01) showed significant positive sca effect (Table 25).

4.6.4.4 Plant height at 60 DAS

The magnitude varied from -13.32 (ARYP-7 × NEI-9202B) to 10.17 (ARYP-9 × CI-5) (Table 25). Five crosses showed significant sca effect, two of them viz., ARYP-9 × CI-5 (10.17), ARYP-20 × NEI-9202B (8.90) had significant positive sca effects, where as other three crosses viz., ARYP-1 × KDMI-10 (-8.97), ARYP-7 × NEI-9202B (-10.28) and ARYP-9 × NEI-9202B (-9.14) showed significant sca effect in negative direction.

4.6.4.5 Leaf area at 60 DAS

The magnitude of range of sca effect of leaf area ranged from -147.32 (ARYP-9 × NEI-9202B) to 125.69 (ARYP-14 × KDMI-10) (Table 25). Twenty-three hybrids showed significant sca effect for this trait. The hybrids viz., ARYP-9 × CI-5 (111.75), ARYP-14 × KDMI-10 (125.69), ARYP-16 × KDMI-10 (117.35), ARYP-5 × NEI-9202B (125.35), ARYP-20 × NEI-9202B (104.65) and ARYP-21 × NEI-9202B (123.21) showed highly significant sca effects in positive direction and seven hybrids showed only significant positive sca effect. Ten hybrids showed significant sca effect in negative direction.

4.6.4.6 Ear height

The magnitude range of sca effect for this trait ranged from -11.87 (ARYP-13 × CM-111) to 8.41 (ARYP-25 × KDMI-10) (Table 25). Four out of 100 hybrids showed significant positive sca effects for ear height. These crosses, namely, ARYP-9 × CI-5 (8.33), ARYP-25 × KDMI-10 (8.41), ARYP-14 × NEI-9202B (8.31) exhibited significant positive sca effect.

4.6.4.7 Cob weight

The range of sca effect for cob weight varied from -28.99 (ARYP-16 × NEI-9202B) to 28.74 (ARYP-20 × NEI-9202B) (Table 25). Totally six hybrids showed significant sca effects. Among them, one hybrid ARYP-20 × NEI-9202B (28.74) showed highly significant sca effect

Table 25: Magnitude of sca effects of hybrids for early vigorous, grain yield and its components in maize

SL. No	Hybrids	Plant height 30 DAS (cm)	Plant girth 30 DAS (cm)	Leaf area 30 DAS (cm ²)	Plant height 60 DAS (cm)	Leaf area 60 DAS (cm ²)	Ear height (cm)	Cob weight (g)	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Pith weight (g)	100-seed weight (g)	Shelling percentage	Number of kernels per cob	Grain yield per plant (g)	Grain yield per hectare (kg)
1	ARYP-1 x CM-111	1.97	0.10	49.94*	5.25	31.44	5.64	-3.55	0.41	-0.38	-1.30*	2.40	0.62	-0.25	-0.44	-19.43	-1.11	173.35
2	ARYP-2 x CM-111	0.27	-0.06	-12.54	-5.77	51.56	-0.24	-3.49	0.18	-0.18	-0.36	1.73	-0.47	-1.57	0.19	11.10	-3.38	-504.07
3	ARYP-3 x CM-111	1.33	0.11	12.03	-2.90	62.25	-1.04	6.87	0.36	-0.13	0.65	0.96	-2.23	1.78	1.49	40.30	8.74	36.40
4	ARYP-4 x CM-111	-1.63	-0.18	4.51	-0.70	0.63	-2.24	4.75	0.23	-0.18	0.14	0.66	0.94	-0.25	0.15	13.68	6.79	-346.59
5	ARYP-5 x CM-111	0.27	-0.15	-22.89	-1.52	15.90	0.51	-16.48	-0.27	-0.41	-0.40	-1.92	-0.42	-1.65	-0.62	-40.89	-9.82	-637.07
6	ARYP-6 x CM-111	-1.23	0.08	-16.82	-6.37	13.40	-0.07	-3.56	-0.20	-0.03	0.25	-1.59	2.50	-2.38	-1.67	-12.99	-6.41	-141.07
7	ARYP-7 x CM-111	0.62	0.13	31.08	3.70	19.60	3.98	-11.99	-0.17	-0.18	-0.65	0.93	-1.79	-1.12	0.42	-12.95	-3.88	-278.92
8	ARYP-8 x CM-111	-0.03	-0.03	-20.49	4.05	12.29	-4.92	-6.85	-0.62	-0.78	-0.13	-2.05	-2.72	-1.14	0.86	-34.64	-4.48	45.06
9	ARYP-9 x CM-111	0.40	0.08	20.08	0.31	88.36*	2.41	1.22	-0.62	0.10	-0.16	1.41	-1.53	2.22	0.96	12.81	2.41	297.66
10	ARYP-10 x CM-111	0.35	-0.04	37.80	0.45	63.61	3.48	9.85	-0.48	0.57	0.44	-0.59	0.51	1.95	0.53	9.20	8.99	-82.26
11	ARYP-11 x CM-111	0.17	-0.06	31.30	-3.18	-37.17	-1.84	-3.44	-0.09	0.03	0.80	-2.37	-2.57	-0.32	0.85	-5.78	-1.22	412.10
12	ARYP-12 x CM-111	-1.32	-0.17	-37.77	-6.75	-51.21	-3.61	11.72	-0.92	0.67	-0.05	0.46	-0.20	-0.93	-0.57	6.25	-8.43	-786.42*
13	ARYP-13 x CM-111	-1.37	0.08	7.21	1.00	-31.52	-11.87**	11.82	0.74	-0.78	0.84	2.18	-2.57	-3.81	0.49	6.10*	-9.60	-215.36-
14	ARYP-14 x CM-111	-0.85	0.08	-26.51	0.23	-38.22	-2.59	-4.47	-1.02	-0.18	-0.40	-2.20	0.72	-0.42	-0.75	-44.50	-5.54	430.92
15	ARYP-15 x CM-111	0.75	-0.01	46.75*	2.55	34.34	4.33	2.60	0.03	0.07	0.72	-2.52	0.38	1.59	0.24	-11.30	4.79	667.63
16	ARYP-16 x CM-111	-1.10	0.08	2.91	1.13	-96.30**	2.13	11.98	0.10	0.31	-0.30	2.56	2.63	1.87	-0.30	24.16	9.00	299.87
17	ARYP-17 x CM-111	-0.92	-0.00	-51.45*	7.05	-39.30	7.71	12.23	0.28	-0.17	0.70	1.31	1.39	-1.04	-0.80	49.42	-0.35	319.27
18	ARYP-18 x CM-111	6.62**	-0.12	13.63	3.12	-92.24*	-0.81	-1.07	-0.25	0.47	0.20	-0.34	2.61	-1.36	-1.28	3.80	-0.69	-570.74
19	ARYP-19 x CM-111	-0.02	0.10	-34.81	7.10	-11.11	5.58	-1.71	1.17	0.07	-0.80	0.61	-1.40	0.35	0.61	-24.82	-0.66	-721.23
20	ARYP-20 x CM-111	-3.08**	0.03	-11.37	-4.18	-79.79*	-2.32	-8.44	-0.81	-0.14	-1.51**	-0.67	-1.35	1.86	0.48	-66.76*	-1.61	-285.15
21	ARYP-21 x CM-111	-1.67	-0.04	-1.29	-0.70	44.70	-1.59	-3.92	0.77	0.40	-0.13	0.80	1.92	-0.35	-1.25	4.06	-6.18	198.01
22	ARYP-22 x CM-111	1.52	-0.03	-8.29	-6.58	47.82	-2.97	8.87	0.97	0.52	1.04	0.05	2.22	-0.99	-0.36	41.70	6.30	272.65
23	ARYP-23 x CM-111	-0.25	0.06	-5.43	2.25	-14.40	1.56	16.67	0.64	0.35	-0.83	0.25	2.19	2.88	0.45	-26.44	17.46	669.06
24	ARYP-24 x CM-111	0.65	-0.01	8.91	-2.33	33.51	-0.22	2.98	-0.50	0.32	0.97	-1.09	1.06	1.48	-0.41	22.93	3.23	831.53*
25	ARYP-25 x CM-111	-1.32	-0.03	-16.48	2.77	-28.16	-0.99	-8.95	0.08	-0.33	0.24	-0.99	-2.44	1.62	0.74	-4.06	-4.36	-84.64

SL. No	Hybrids	Plant height 30 DAS (cm)	Plant girth 30 DAS (cm)	Leaf area 30 DAS (cm ²)	Plant height 60 DAS (cm)	Leaf area 60 DAS (cm ²)	Ear height (cm)	Cob weight (g)	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Pith weight (g)	100-seed weight (g)	Shellin g percent age	Number of kernels per cob	Grain yield per plant (g)	Grain yield per hectare (kg)
26	ARYP-1 x CI-5	2.36*	-0.18	-13.85	5.18	-64.52	3.50	-9.19	-0.25	0.50	0.76	-1.13	-2.10	0.21	0.58	15.32	-3.85	-215.56
27	ARYP-2 x CI-5	-0.41	0.05	-7.40	-0.97	4.44	-3.58	-1.42	-0.25	-0.03	-0.04	-0.40	0.14	0.66	-0.09	-5.03	-1.74	110.21
28	ARYP-3 x CI-5	-0.34	0.11	22.26	3.43	-27.42	2.08	-26.75*	-0.68	-0.55	-0.04	-3.23*	-2.96	-2.99	-0.30	-63.29*	-23.98*	-119.79
29	ARYP-4 x CI-5	1.29	0.13	-17.26	3.63	-72.19*	5.15	-3.69	0.10	0.27	-0.08	-1.60	1.94	0.99	-1.01	-24.74	-2.49	205.25
30	ARYP-5 x CI-5	-1.14	0.13	-33.47	-5.99	-11261**	-3.70	-7.86	-0.17	0.43	0.19	-1.58	-0.85	0.48	-0.27	-17.34	-7.94	1053.16**
31	ARYP-6 x CI-5	-0.18	-0.10	14.73	0.50	-45.09	-3.75	6.01	1.16	0.14	0.04	3.95**	-0.40	-2.07	0.68	58.19*	6.21	202.00
32	ARYP-7 x CI-5	0.07	-0.05	5.48	3.16	9.06	0.37	-0.60	-0.38	-0.63	-0.59	1.67	-2.25	-0.61	0.82	-0.23	-1.87	671.36
33	ARYP-8 x CI-5	-0.31	0.01	-13.14	-7.69	-4.94	-2.00	-2.60	-0.36	-0.31	0.32	0.35	-0.89	1.63	0.13	17.95	-1.89	-306.57
34	ARYP-9 x CI-5	-0.21	-0.10	-7.18	10.17*	111.75**	8.33*	19.86	1.34*	0.34	0.29	-1.18	3.64	2.29	-0.25	-5.83	16.02	542.46
35	ARYP-10 x CI-5	1.07	-0.08	-33.21	-1.35	-19.81	0.13	4.76	0.01	0.18	-0.18	0.48	0.84	-1.31	-0.06	0.43	3.73	-219.14
36	ARYP-11 x CI-5	-0.11	-0.07	-34.71	4.21	68.15	2.75	10.28	1.17	-0.09	-0.34	0.63	5.87*	0.86	-1.93*	-2.36	4.23	-309.82
37	ARYP-12 x CI-5	-0.19	0.05	28.50	6.98	89.34*	5.58	-1.77	0.35	-0.49	-0.73	-1.33	-0.52	3.58	0.61	-46.48	5.23	143.23
38	ARYP-13 x CI-5	1.29	-0.02	-0.23	-5.87	-33.86	4.38	18.43	0.47	0.57	-0.44	-0.08	0.88	0.67	1.03	-18.63	17.37	19.45
39	ARYP-14 x CI-5	0.81	0.05	31.47	-0.30	42.74	-4.20	25.39*	1.05	0.83	0.32	2.33	4.35	1.65	-0.23	45.07	20.85	191.40
40	ARYP-15 x CI-5	1.61	0.09	9.37	-0.45	-54.20	-2.35	-5.71	-1.01	-0.18	0.31	1.68	-2.24	1.71	0.78	35.96	-0.75	591.03
41	ARYP-16 x CI-5	-1.98	-0.20	-36.44	2.20	-41.65	-4.88	5.46	0.66	-0.25	0.16	-1.77	-0.89	0.96	0.66	-19.33	6.15	757.37
42	ARYP-17 x CI-5	0.89	-0.15	-13.37	-4.69	84.19*	-2.37	-10.81	-0.76	-0.42	-0.44	-1.22	-5.62*	-0.71	1.27	-37.03	-12.89	109.76
43	ARYP-18 x CI-5	-2.26*	0.20	-9.83	-0.89	14.82	-0.22	6.73	0.61	-0.29	-1.14*	2.00	2.50	-0.12	-0.46	-15.09	7.38	277.50
44	ARYP-19 x CI-5	0.64	0.02	8.66	-1.10	-58.55	-4.50	0.40	-0.57	0.08	0.35	-2.18	1.80	0.11	-0.90	-13.28	1.59	382.56
45	ARYP-20 x CI-5	-1.49	-0.05	-2.88	2.01	19.30	5.87	2.65	1.32	0.03	-0.39	2.60	2.08	-1.62	-0.50	17.94	6.21	622.54
46	ARYP-21 x CI-5	-2.14*	0.16	10.10	0.96	-74.52*	1.20	12.34	-1.20	0.84	0.19	0.33	-1.60	-0.03	1.37	12.73	13.31	152.66
47	ARYP-22 x CI-5	1.51	0.04	38.95	-1.32	62.29	0.08	-2.09	-0.97	-0.44	0.02	0.85	0.79	0.83	-0.62	11.46	-3.08	-500.98
48	ARYP-23 x CI-5	2.01	0.02	10.89	-6.35	24.84	-32	-16.07	0.54	-0.31	0.42	1.38	-2.45	-1.44	0.28	35.99	-10.47	-484.50
49	ARYP-24 x CI-5	-1.59	-0.01	9.95	1.26	39.02	3.30	-7.60	-0.04	-0.13	0.22	-0.75	-0.56	-2.79	-0.59	-2.05	12.23	-528.38
50	ARYP-25 x CI-5	-1.19	-0.04	32.60	-6.70	39.44	-8.87*	-16.15	-1.87**	-0.09	1.22*	-1.78	-1.92	-2.94	-0.99	19.62	-21.93*	240.68
51	ARYP-1 x KDMI-10	-1.22	-0.11	-15.41	-8.97*	83.09*	-9.16*	13.68	0.00	0.11	1.06*	-1.99	-0.13	-0.62	0.45	14.93	4.08	344.33

SL. No	Hybrids	Plant height 30 DAS (cm)	Plant girth 30 DAS (cm)	Leaf area 30 DAS (cm ²)	Plant height 60 DAS (cm)	Leaf area 60 DAS (cm ²)	Ear height (cm)	Cob weight (g)	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Pith weight (g)	100-seed weight (g)	Shellin g percent age	Number of kernels per cob	Grain yield per plant (g)	Grain yield per hectare (kg)
52	ARYP-2 x KDMI-10	3.68**	0.04	38.49	7.02	-8.06	0.29	20.11	0.48	-0.03	1.06*	-0.66	2.72	1.69	-0.17	30.08	17.92	579.31
53	ARYP-3 x KDMI-10	1.88	-0.09	-8.43	1.02	-5.79	1.16	13.37	0.06	0.22	-0.03	0.31	1.61	2.35	0.13	4.88	12.30	285.85
54	ARYP-4 x KDMI-10	1.91	0.09	23.27	4.88	73.02*	4.22	3.83	0.40	0.01	-0.18	2.41	1.58	0.31	-0.28	29.30	6.12	659.36
55	ARYP-5 x KDMI-10	0.54	0.03	-16.37	7.60	-28.64	7.11	12.06	0.26	-0.43	-0.31	1.49	3.93	2.29	-0.30	9.71	15.24	1333.29**
56	ARYP-6 x KDMI-10	1.64	0.16	-5.86	4.95	-54.59	6.92	-14.34	-1.27	-0.45	-0.06	-2.97*	-4.42	0.94	1.08	-43.51	-9.39	-19.22
57	ARYP-7 x KDMI-10	0.56	0.06	-22.33	3.42	2.37	-1.43	11.69	0.52	0.64	0.24	-0.06	1.87	2.24	-0.80	9.73	0.35	-136.40
58	ARYP-8 x KDMI-10	2.18*	-0.01	14.94	-2.03	-2.45	-0.73	-7.01	0.51	1.36**	0.62	-1.37	-0.69	-0.86	-0.22	4.26	-5.79	341.13
59	ARYP-9 x KDMI-10	-0.32	0.02	-18.96	-1.33	-52.80	-2.53	-24.83*	-0.16	-1.19*	-0.34	0.83	-1.55	-5.10**	-1.14	-0.00	-22.75*	-1068.49**
60	ARYP-10 x KDMI-10	-1.31	0.15	-10.74	1.37	-27.08	-2.46	6.10	0.35	-0.02	-0.28	2.29	-0.53	0.65	0.81	20.14	7.15	280.42
61	ARYP-11 x KDMI-10	1.44	0.13	57.25*	-1.73	-45.99	-6.44	0.09	-0.36	-0.12	-1.24*	1.71	0.54	1.72	-0.19	-22.59	0.08	-208.49
62	ARYP-12 x KDMI-10	2.16*	-0.00	3.58	7.23	-5.89	3.12	-6.02	-0.72	0.31	0.77	-1.66	-1.74	-1.41	0.87	4.68	2.92	473.36
63	ARYP-13 x KDMI-10	1.64	-0.07	-20.85	4.45	0.24	4.99	-1.10	-0.36	0.28	-0.28	0.26	4.40	2.73	-2.58**	-9.31	-4.97	83.12
64	ARYP-14 x KDMI-10	1.89	-0.10	52.30*	-4.65	125.69**	-1.53	-10.28	-0.22	0.44	0.22	-0.06	-3.09	-1.42	0.84	7.56	-6.67	-306.66
65	ARYP-15 x KDMI-10	0.09	-0.07	-24.69	-1.27	35.41	-0.01	-13.89	0.46	-0.24	-0.53	-0.24	-6.92*	-4.53*	1.52	-22.11	-15.20	-33.46
66	ARYP-16 x KDMI-10	1.84	-0.03	19.84	-2.88	117.35**	-0.34	11.55	-0.24	0.49	0.72	-1.19	2.26	-1.18	-0.11	-0.55	-9.83	-261.72
67	ARYP-17 x KDMI-10	0.91	0.07	-7.19	-3.23	-18.10	-0.43	9.19	0.34	-0.15	-0.14	-0.27	5.41*	1.37	-1.06	-10.67	13.48	-378.67
68	ARYP-18 x KDMI-10	-2.64*	0.01	-0.96	-5.63	43.79	-0.14	-1.97	-0.62	0.21	0.62	-1.79	-1.04	-0.05	-0.35	-3.21	-10.40	-451.00
69	ARYP-19 x KDMI-10	-0.07	0.03	24.92	-4.38	78.10*	-2.03	11.65	0.10	0.16	0.08	3.96**	1.91	-0.07	0.04	57.19*	10.27	653.25
70	ARYP-20 x KDMI-10	-2.47*	-0.03	23.58	-6.73	-44.16	-7.59	-22.95*	-0.11	-0.93*	0.37	-2.39	-2.55	0.97	0.28	-19.43	-14.03	-221.31
71	ARYP-21 x KDMI-10	-1.39	-0.13	-26.20	-3.32	-93.40*	-3.06	2.62	0.66	-0.41	0.49	1.01	0.60	-1.91	-0.03	33.70	2.55	-869.92*
72	ARYP-22 x KDMI-10	-2.61*	-0.05	-29.94	0.80	-72.07*	-0.11	-11.95	-0.84	0.10	-0.21	-3.34*	-4.91	1.98	1.58	-51.46	-6.51	-96.14
73	ARYP-23 x KDMI-10	-2.91**	-0.13	-12.06	0.50	-7.17	-0.51	-9.35	-0.66	-0.34	-0.34	-0.87	-0.78	-1.96	-0.94	-27.89	-18.04	-990.02*
74	ARYP-24 x KDMI-10	-1.17	0.04	20.90	-0.08	-59.75	2.24	-4.88	0.66	0.01	1.61**	3.39*	-0.32	-0.73	0.25	-15.30	-2.36	-5.22
75	ARYP-25 x KDMI-10	-6.27**	-0.02	-59.07*	3.02	-33.14	8.41*	12.62	0.76	-0.02	-0.74	1.96	1.83	0.59	0.35	-0.10	13.82	13.32
76	ARYP-1 x NEI-9202B	-3.10**	0.19	-20.68	-1.46	-50.02	0.01	-0.93	0.11	-0.23	-0.52	0.73	1.62	0.66	-0.59	-10.82	0.88	-302.13
77	ARYP-2 x NEI-9202B	-3.53**	-0.03	-18.55	-0.28	-47.94	3.53	-15.20	-0.41	0.24	-0.65	-0.67	-2.39	-0.78	0.08	-36.16	-12.80	-185.45

SL. No	Hybrids	Plant height 30 DAS (cm)	Plant girth 30 DAS (cm)	Leaf area 30 DAS (cm ²)	Plant height 60 DAS (cm)	Leaf area 60 DAS (cm ²)	Ear height (cm)	Cob weight (g)	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Pith weight (g)	100-seed weight (g)	Shelling percentage	Number of kernels per cob	Grain yield per plant (g)	Grain yield per hectare (kg)
78	ARYP-3 x NEI-9202B	-2.87**	-0.12	-25.85	-1.55	-29.04	-2.20	6.51	0.26	0.45	-0.21	1.96	3.58	-1.14	-1.32	18.11	2.94	-122.46
79	ARYP-4 x NEI-9202B	-1.57	-0.04	-10.52	-7.81	-1.46	-7.17	-4.89	-0.73	-0.10	0.12	-1.47	-4.46	-1.04	1.15	-18.24	-10.42	-518.02
80	ARYP-5 x NEI-9202B	0.33	-0.00	72.73**	-0.10	125.35**	-3.92	12.27	0.17	0.40	0.52	2.10	-2.66	-1.12	1.19	48.52	2.52	356.95
81	ARYP-6 x NEI-9202B	-0.23	-0.14	7.95	0.92	86.28*	-3.10	11.89	0.31	0.35	-0.23	0.67	2.32	3.51	-0.08	-1.69	9.58	-41.71
82	ARYP-7 x NEI-9202B	-1.25	-0.15	-14.23	-10.28*	-31.03	-2.92	0.90	0.03	0.17	1.00	-2.54	2.17	-0.52	-0.45	3.44	5.40	-256.04
83	ARYP-8 x NEI-9202B	-1.83	0.03	18.69	5.67	-4.89	7.65	16.46	0.48	-0.27	-0.82	3.08*	4.30	0.37	-0.77	12.42	12.17	-79.63
84	ARYP-9 x NEI-9202B	0.13	0.00	6.06	-9.14*	-147.32**	-8.22*	3.75	-0.55	0.75	0.22	-1.06	-0.56	0.59	-0.43	-6.98	4.32	228.37
85	ARYP-10 x NEI-9202B	-0.12	-0.03	6.15	-0.46	-16.72	-1.15	-20.71	0.12	-0.72	0.02	-2.19	-0.83	-1.28	-1.28	-29.77	-19.88	20.98
86	ARYP-11 x NEI-9202B	-1.50	-0.00	-53.83*	0.70	15.02	5.53	-6.93	-0.72	0.18	0.78	0.03	-3.84	-2.26	1.28	30.72	-3.09	106.21
87	ARYP-12 x NEI-9202B	-0.65	0.12	5.69	-7.46	-32.24	-5.10	-3.94	1.29	-0.49	-0.00	2.53	2.45	-1.25	-0.91	35.54	0.28	169.83
88	ARYP-13 x NEI-9202B	-1.57	0.01	13.87	0.42	65.14	2.50	-5.51	-0.85	-0.06	-0.12	-2.36	-2.71	0.42	1.06	-37.17	-2.80	112.79
89	ARYP-14 x NEI-9202B	-1.85	-0.03	-57.26*	4.72	-130.21**	8.31*	-10.63	0.19	-1.10*	-0.15	-0.07	-1.98	0.19	0.14	-8.14	-8.64	-315.66
90	ARYP-15 x NEI-9202B	-2.45*	-0.02	-31.44	-0.83	-15.55	-1.97	17.01	0.53	0.35	-0.50	1.08	8.78**	1.24	-2.53**	-2.56	11.16	-43.14
91	ARYP-16 x NEI-9202B	1.23	0.15	13.69	-0.45	20.61	3.10	-28.99**	-0.53	-0.55	-0.58	1.16	-4.01	-1.66	-0.25	-4.28	-24.98*	-795.52*
92	ARYP-17 x NEI-9202B	-0.90	0.08	72.01**	0.87	-26.79	-4.92	-10.61	0.15	0.75	-0.12	0.18	-1.18	0.38	0.59	-1.73	-0.24	169.17
93	ARYP-18 x NEI-9202B	-1.72	-0.09	-2.84	3.40	33.64	1.16	-3.69	0.26	-0.39	0.23	0.13	-4.06	1.52	2.09*	14.49	3.72	744.24
94	ARYP-19 x NEI-9202B	-0.55	-0.16	1.24	-1.61	-8.44	0.95	-10.34	-0.69	-0.31	0.37	-2.39	-2.31	-0.39	0.26	19.09	-8.03	-315.48
95	ARYP-20 x NEI-9202B	7.05**	0.05	-9.34	8.90*	104.65**	4.05	28.74**	-0.40	1.04*	1.75**	0.46	1.82	-1.21	-0.26	68.25*	9.43	-116.09
96	ARYP-21 x NEI-9202B	5.20**	0.01	17.39	3.05	123.21**	3.45	-11.04	-0.23	-0.82	-0.55	-2.14	-1.36	2.29	-0.09	-50.48	-9.67	519.25
97	ARYP-22 x NEI-9202B	-0.42	0.04	-0.71	7.10	-38.05	3.00	5.17	0.84	-0.17	-0.85	2.44	1.90	-1.82	-0.59	-1.70	3.29	324.47
98	ARYP-23 x NEI-9202B	1.15	0.06	6.60	3.60	-3.27	1.26	8.75	-0.52	0.30	0.75	-0.76	1.04	0.53	0.21	18.33	11.05	805.45*
99	ARYP-24 x NEI-9202B	2.22*	-0.02	-39.76	1.15	-12.78	-5.32	9.50	-0.13	-0.20	0.42	-1.56	-0.19	2.05	0.75	-5.58	11.36	-297.94
100	ARYP-25 x NEI-9202B	8.75**	0.09	42.95	0.92	21.86	1.45	12.48	1.03	0.45	-0.72	0.81	2.53	0.73	-0.09	-15.46	12.46	-169.36
	SE	1.05	0.13	23.76	4.30	36.41	4.12	11.06	0.67	0.47	0.53	1.47	2.70	1.96	0.97	26.55	11.04	388.98

* and ** significant at 1% and 5% level of probability, respectively

in positive direction and another hybrid ARYP-16 × NEI-9202B (-28.99) showed only significant sca effects in negative direction. Four hybrids showed negative significant sca effect for the trait cob weight.

4.6.4.8 Cob length

The magnitude range of sca effect varied from -1.87 (ARYP-25 × CI-5) to 1.34 (ARYP-9 × CI-5) (Table 25). The cross ARYP-9 × CI-5 (1.34) had sca effect in positive direction while the hybrid ARYP-25 × CI-5 (-1.87) had significant sca effect in negative direction for this trait.

4.6.4.9 Cob girth

The sca effect ranged from -1.19 (ARYP-9 × KDMI-10) to 1.36 (ARYP-8 × KDMI-10) (Table 25). The cross ARYP-8 × KDMI-10 (1.36) showed highly significant sca effect in positive direction, ARYP-20 × NEI-9202B (1.04) showed only significant positive sca effect, while three crosses showed significant sca effect in negative direction for this character.

4.6.4.10 Number of kernel rows per cob

Among 100 hybrids, nine showed significant sca effect. The crosses viz., ARYP-25 × CI-5 (1.22), ARYP-1 × KDMI-10 (1.00), ARYP-2 × KDMI-10 (1.06) and ARYP-20 × NEI-9202B (1.75) expressed sca effect in positive direction and five crosses expressed sca effect in negative direction (Table 25). The sca effect ranged from -1.61 (ARYP-24 × KDMI-10) to 1.75 (ARYP-20 × NEI-9202B) kernel rows per cob for this trait.

4.6.4.11 Number of kernels per row

The range of sca effects varied from -3.34 (ARYP-22 × KDMI-10) to 3.96 kernels (ARYP-19 × KDMI-10). Totally seven crosses showed significant sca effect, out of which ARYP-6 × CI-5 (3.95) and ARYP-19 × KDMI-10 (3.96) crosses showed highly significant positive sca effect and the hybrids ARYP-24 × KDMI-10 (3.39) and ARYP-8 × NEI-9202B (3.08) showed only significant positive sca effect (Table 25). The cross, ARYP-3 × CI-5 (-3.23), ARYP-6 × KDMI-10 (-2.97) and ARYP-22 × KDMI-10 (-3.34) crosses showed significant sca effect in negative direction for this trait.

4.6.4.12 Pith weight

The sca effect ranged from -6.92 (ARYP-15 × KDMI-10) to 8.78 (ARYP-15 × NEI-9202B). Five crosses exhibited significant sca effect, out of which the hybrid ARYP-15 × NEI-9202B (8.78) showed highly significant sca effect in positive direction (Table 25). The hybrids viz., ARYP-11 × CI-5 (5.87) and ARYP-17 × KDMI-10 (5.41) showed only significant positive sca effect, while ARYP-17 × CI-5 (-5.62) and ARYP-15 × KDMI-10 (-6.92) showed significant negative sca effect for this trait.

4.6.4.13 Hundred seed weight

The sca effect for 100-seed weight ranged from -5.10 (ARYP-9 × KDMI-10) to 3.58 (ARYP-12 × CI-5). The cross ARYP-9 × KDMI-10 (-5.10) and ARYP-15 × KDMI-10 (-6.92) showed highly significant sca effect in negative direction (Table 25).

4.6.4.14 Shelling percentage

The sca effect ranged from -2.53 (ARYP-15 × NEI-9202B) to 2.09 (ARYP-18 × NEI-9202B). Among the hybrids, ARYP-18 × NEI-9202B (2.09) showed significant positive sca effect, whereas other three crosses showed significant sca effect in negative direction for this character (Table 25).

4.6.4.15 Number of kernels per cob

The sca effect ranged from -66.76 (ARYP-20 × CM-111) to 68.25 (ARYP-20 × NEI-9202B) for the number of kernels per cob (Table 25). Four hybrids showed significant sca effect, out of which the hybrids viz., ARYP-13 × CM-111 (6.10), ARYP-6 × CI-5 (58.19), ARYP-19 × KDMI-10 (57.19) and ARYP-20 × NEI-9202B (68.25) showed significant sca effect

in positive direction and where as other hybrids ARYP-20 × CM-111 (-66.76) and ARYP-3 × CI-5 (-63.29) showed significant sca effect in negative direction for this trait.

4.6.4.16 Grain yield per plant

The sca effect ranged from -24.98 (ARYP-16 × NEI-9202B) to 20.85 (ARYP-14 × CI-5). None of the hybrids showed significant positive sca effect, where as four crosses showed significant sca effect in negative direction (Table 25).

4.6.4.17 Grain yield per hectare

The magnitude of range of sca effects of grain yield per hectare ranged from -1068.49 (ARYP-9 × KDMI-10) to 1333.29 (ARYP-5 × KDMI-10) (Table 25). Nine hybrids showed significant sca effect. Among them, the crosses ARYP-5 × CI-5 (1053.16) and ARYP-5 × KDMI-10 (1333.29) showed highly significant sca effects in positive direction and other crosses ARYP-24 × CM-111 (831.53) and ARYP-3 × NEI-9202B (805.45) showed only significant positive sca effect for this character.

4.7 HETEROSIS OVER MID-PARENT, BETTER PARENT and CHECKS

The per cent heterosis over mid parent (relative heterosis), better parent (heterobeltiosis) and over three checks (standard heterosis) was worked out against DMH-2 hybrid, Prabha composite and private hybrid Cargil 900-M, which are recommended hybrids for the both *kharif* as well as *rabi* seasons.

4.7.1 Plant height at 30 DAS (cm)

The percentage heterosis over mid parent, better parent and commercial checks DMH-2, Cargil 900-M and Prabha ranged from -20.33 (ARYP-16 × CI-5) to 28.51 (ARYP-25 × NEI-9202B), -25.09 (ARYP-16 × CI-5) to 25.14 (ARYP-25 × NEI-9202B) and -13.77 (ARYP-16 × CM-111) to 38.12 (ARYP-25 × NEI-9202B), over DMH-2, -12.63 (ARYP-25 × KDMI-10) to 38.68 (ARYP-25 × NEI-9202B) over Cargil 900-M and -22.02 (ARYP-16 × CM-111) to 24.91 (ARYP-26 × NEI-9202B) over Prabha, respectively (Table 26).

Three hybrids exhibited highly significant positive heterosis. While, thirty five hybrids exhibited significant negative mid parent for this trait.

Twenty-nine crosses exhibited significant heterosis over their better parents, out of which four crosses exhibited significant positive heterosis. Four hybrids showed significant positive standard heterosis over Cargil 900-M, 44 and 5 hybrids showed significant standard heterosis over Prabha and DMH-2, respectively for this trait.

4.7.2 Plant girth at 30 DAS (cm)

None of the crosses exhibited significant heterosis over mid parent and better parent. However, three hybrids, viz., ARYP-4 × CI-5 (29.07), ARYP-18 × CI-5 (27.75) and ARYP-21 × CI-5 (26.43) showed significant positive heterosis over the check DMH-2. Ten hybrids showed significant positive heterosis over Cargil 900-M and none of them showed significant heterosis over check Prabha.

Hybrids viz., ARYP-18 × NEI-9202B (30.80), ARYP-11 × KDMI-10 (30.80), ARYP-4 × CI-5 (30.80), ARYP-25 × KDMI-10 (29.46) and ARYP-18 × CI-5 (29.46) exhibited significant superiority over Cargil 900 M for plant girth at 30 DAS (Table 26).

4.7.3 Leaf area at 30 DAS (cm²)

In case of mid parent heterosis, 11 crosses showed significant heterosis, out of which ARYP-14 × KDMI-10 (34.57) and ARYP-19 × KDMI-10 (38.17) showed highly significant heterosis in positive direction and three crosses viz., ARYP-2 × KDMI-10 (32.85), ARYP-11 × KDMI-10 (27.32) and ARYP-17 × NEI-9202B (29.63) showed only significant positive heterosis. In case of better parent, ten crosses showed significant positive heterosis but in undesirable direction, over Cargil 900-M 36 crosses showed significant heterosis, among them, 16 and 20 crosses exhibited highly significant and only significant heterosis in desirable

Table 26: Mid, better parent and standard heterosis for plant height, plant girth and leaf area at 30 days after sowing in maize

Sl. No.	Hybrids	Plant height at 30 DAS (cm)					Plant girth at 30 DAS (cm)					Leaf area at 30 DAS (cm ²)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
1	ARYP-1 x CM-111	-8.30	12.27*	-2.99	-2.61	-12.27	6.43	-3.64	16.74	18.30	-2.93	7.91	5.53	7.88	38.02*	-5.47
2	ARYP-2 x CM-111	-10.89	-18.05**	-9.38	-9.02	-18.05	3.59	-5.45	14.54	16.07	-4.76	-7.08	-16.86	-15.01	8.73	-25.53
3	ARYP-3 x CM-111	-4.36	-11.01	-1.60	-1.20	-11.01	11.33	1.82	23.35	25.00	2.56	-10.62	-14.44	-4.35	22.37	-16.19
4	ARYP-4 x CM-111	-15.32**	-19.68**	-11.18	-10.82	-19.68*	-8.41	-10.91	7.93	9.38	-10.26	-5.61	-8.87	-6.84	19.18	-18.37
5	ARYP-5 x CM-111	-8.12	-14.26*	-5.19	-4.81	-14.26*	-6.12	-16.36	1.32	2.68	-15.75	-30.69**	-35.50**	-23.44	-2.05	-32.91**
6	ARYP-6 x CM-111	-12.97*	-16.43**	-7.58	-7.21	-16.43**	2.57	-5.82	14.10	15.63	-5.13	-15.03	-20.10	-18.32	4.50	-28.42*
7	ARYP-7 x CM-111	-12.86*	-14.98*	-5.99	-5.61	-14.98*	16.80	3.64	25.55	27.23*	4.40	0.61	-8.87	-6.84	19.18	-18.37
8	ARYP-8 x CM-111	-12.15*	-15.16*	-6.19	-5.81	-15.16*	-8.41	-10.91	7.93	9.38	-10.26	-22.61	-24.31	-22.63	-1.01	-32.20**
9	ARYP-9 x CM-111	-13.07*	-13.54*	-4.39	-4.01	-13.54*	0.00	-1.82	18.94	20.54	-1.10	-13.79	-20.23	-4.13	22.66	-15.99
10	ARYP-10 x CM-111	-7.65	-12.82*	-3.59	-3.21	-12.82	-10.78	-14.18	3.96	5.36	-13.55	-0.49	-5.98	8.04	38.22*	-5.33
11	ARYP-11 x CM-111	-19.36**	-20.63**	-9.38	-9.02	-18.05**	-9.09	-14.55	3.52	4.91	-13.92	-1.16	-9.24	-7.22	18.71	-18.69
12	ARYP-12 x CM-111	-19.04**	-20.52**	-8.78	-8.42	-17.51**	-13.84	-19.64	-2.64	-1.34	-19.05	-26.06*	-31.68*	-30.16*	-10.64	-38.80**
13	ARYP-13 x CM-111	-13.93*	-18.59**	-9.98	-9.62	-18.59**	4.67	1.82	23.35	25.00	2.56	3.25	-3.56	-1.42	26.13	-13.61
14	ARYP-14 x CM-111	-13.96*	-18.77**	-10.18	-9.82	-18.77**	3.30	-7.27	12.33	13.84	-6.59	-14.21	-18.40	-16.58	6.72	-26.90*
15	ARYP-15 x CM-111	-6.06	-14.62*	-5.59	-5.21	-14.62*	1.03	-10.91	7.93	9.38	-10.26	17.68	5.73	8.08	38.27*	-5.29
16	ARYP-16 x CM-111	-19.25**	-22.02**	-13.77*	-13.43	-22.02**	0.97	-5.45	14.54	16.07	-4.76	-9.23	-16.65	-14.79	9.01	-25.33*
17	ARYP-17 x CM-111	-14.23*	-18.41**	-9.78	-9.42	-18.41**	-1.18	-8.36	11.01	12.50	-7.69	-32.66*	-3679**	-35.38*	-17.33	-43.38**
18	ARYP-18 x CM-111	9.53	8.08	22.75**	23.25**	11.01	-15.04	-17.24	5.73	7.14	-12.09	-9.19	-15.82	0.77	28.92	-11.70
19	ARYP-19 x CM-111	-3.20	-12.64*	-3.39	-3.01	-12.64*	4.85	-1.82	18.94	20.54	-1.10	-6.88	-19.45	-17.66	5.35	-27.84*
20	ARYP-20 x CM-111	-17.04**	-20.04**	-11.58	-11.22	-20.04**	0.00	-3.64	16.74	18.30	-2.93	-23.03	-23.46	-20.87	1.24	-30.66*
21	ARYP-21 x CM-111	-10.05	-11.99	-2.59	-2.20	-11.91	-2.67	-7.27	12.33	13.84	-6.59	4.06	-1.92	0.27	28.28	-12.14
22	ARYP-22 x CM-111	-7.56	-9.57	0.00	0.40	-9.57	-12.29	-13.09	5.29	6.70	-12.45	-14.24	-14.95	-11.60	13.10	-22.53
23	ARYP-23 x CM-111	-13.30*	-14.08*	-4.99	-4.61	-14.08*	3.40	-0.36	20.70	22.32	0.37	0.67	-4.45	-2.33	24.96	-14.41
24	ARYP-24 x CM-111	-9.71	-11.01	-1.60	-1.20	-11.01	-2.01	-2.55	18.06	19.64	-1.83	-1.78	-4.06	2.84	31.58	-9.88
25	ARYP-25 x CM-111	-7.98	-10.47	-1.00	-0.60	-10.47	-0.37	-2.18	18.50	20.09	-1.47	-11.68	-14.92	-6.13	20.10	-17.74
26	ARYP-1 x CI-5	-6.23	-12.63*	2.20	2.61	-7.58	-8.72	-16.67	-0.88	0.45	-17.58	-11.97	-20.84	-3.12	23.95	-15.10

Sl. No.	Hybrids	Plant height at 30 DAS (cm)					Plant girth at 30 DAS (cm)					Leaf area at 30 DAS (cm ²)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
27	ARYP-2 x CI-5	-11.70*	-20.82**	-7.39	-7.01	-16.25**	12.27	3.33	22.91	24.55	2.20	-0.39	-17.36	1.14	29.40	-11.37
28	ARYP-3 x CI-5	-8.18	-16.72**	-2.59	-2.20	-11.91	13.25	4.44	24.23	25.89	3.30	-2.80	-7.01	13.81	45.61*	-0.27
29	ARYP-4 x CI-5	-6.00	-13.14*	1.60	2.00	-8.12	10.57	8.52	29.07*	30.80*	7.33	-9.25	-19.34	-1.28	26.30	-13.50
30	ARYP-5 x CI-5	-11.07*	-19.11**	-5.39	-5.01	-14.44*	12.99	1.48	20.70	22.32	0.37	-28.22**	-29.30*	-13.47	10.70	-24.18**
31	ARY7-6 x CI-5	-8.94	-14.85*	-0.40	0.00	-9.93	-6.40	-13.33	3.08	4.46	-14.29	1.91	-11.56	8.24	38.49	-5.15
32	ARYP- 7x CI-5	-13.21*	-17.58**	-3.59	-3.21	-12.82*	8.07	-3.33	14.98	16.52	-4.40	-5.32	-20.58	-2.79	24.37	-14.82
33	ARYP-8 x CI-5	-11.80*	-17.06**	-2.99	-2.61	-12.27*	-4.53	-6.30	11.45	12.95	-7.33	-14.23	-22.87*	-5.60	20.77	-17.28
34	ARYP-9 x CI-5	-13.58*	-16.38**	-2.20	-1.80	-11.55	-8.04	-8.89	8.37	9.82	-9.89	-18.15	-18.89	-0.73	27.01	-13.01
35	ARYP-10 x CI-5	-4.64	-12.29*	2.59	3.01	-7.22	-11.45	-14.07	2.20	3.57	-15.02	-20.61*	-23.04*	-5.80	20.52	-17.45
36	ARYP-11 x CI-5	-18.83**	-19.80**	-6.19	-5.81	-15.16*	-7.81	-12.59	3.96	5.36	-13.55	-22.16	-33.89**	-19.08	3.52	-29.09*
37	ARYP-12 x CI-5	-14.90**	-15.70**	-1.40	-1.00	-10.83	0.39	-5.56	12.33	13.84	-6.59	5.29	-10.06	10.08	40.83*	-3.54
38	ARYP-13 x CI-5	-5.37	-12.80*	2.00	2.40	-7.76	0.38	-1.48	17.18	18.75	-2.56	4.00	-10.30	9.79	40.46*	-3.79
39	ARYP-14 x CI-5	-8.16	-15.53**	-1.20	-0.80	-10.65	2.86	-6.67	11.01	12.50	-7.69	12.18	-1.64	20.39	54.02**	5.50
40	ARYP-15 x CI-5	-2.60	-13.65*	1.00	1.40	-8.66	9.17	-2.96	15.42	16.96	-4.03	5.46	-12.18	7.49	37.52*	-5.81
41	ARYP-16 x CI-5	-20.33	-25.09**	-12.38	-12.02	-20.76**	-13.73	-18.52	-3.08	-1.79	-19.41	-19.35	-3150**	-16.16	7.27	-26.53*
42	ARYP-17 x CI-5	-8.10	-14.85*	-0.40	0.00	-9.93	-8.12	-14.07	2.20	3.57	-15.02	-11.47	-23.40*	-6.25	19.94	-17.85
43	ARYP-18 x CI-5	-13.07	-14.33*	0.20	0.60	-9.39	3.57	0.00	27.75*	29.46*	6.23	-12.71	-13.67	5.66	35.19	-7.41
44	ARYP-19 x CI-5	-0.39	-12.29*	2.59	3.01	-7.22	2.35	-3.33	14.98	16.52	-4.40	15.32	-7.19	13.60	45.34*	-0.45
45	ARYP-20 x CI-5	-11.45*	-16.89**	-2.79	-2.40	-12.09*	-2.86	-5.56	12.33	13.84	-6.59	-14.42	-21.06	-3.39	23.61	-15.34
46	ARYP-21 x CI-5	-10.30	-14.51*	0.00	0.40	-9.57	10.60	6.30	26.43*	28.13*	5.13	11.70	-2.86	18.89	52.11**	4.18
47	ARYP-22 x CI-5	-6.63	-11.09	3.99	4.41	-5.96	-7.04	-7.04	10.57	12.05	-8.06	7.05	-1.02	21.15	55.00**	6.16
48	ARYP-23 x CI-5	-6.19	-9.56	5.79	6.21	-4.33	3.24	0.37	19.38	20.98	-0.73	10.39	-3.40	18.23	51.26**	3.61
49	ARYP-24 x CI-5	-14.41**	-17.92**	-3.99	-3.61	-13.18*	-0.37	-0.74	18.94	20.54	-1.10	2.26	-4.09	17.38	50.18**	2.86
50	ARYP-25 x CI-5	-6.67	-11.60*	3.39	3.81	-6.50	0.56	-0.37	18.50	20.09	-1.47	9.43	-4.04	27.34	62.92**	11.59
51	ARYP-1 x KDMI-10	-15.75**	-20.28**	-9.78	-9.42	-18.41**	0.65	-2.92	2.64	4.02	-14.65	-0.78	-4.67	1.08	29.32	-11.43
52	ARYP-2 x KDMI-10	0.58	-8.47	3.59	4.01	-6.32	17.34	14.17	20.70	22.32	0.37	32.85*	16.97	24.03	58.68**	8.69
53	ARYP-3 x KDMI-10	-1.34	-9.17	2.79	3.21	-7.04	6.41	3.75	9.69	11.16	-8.79	-2.19	-4.71	6.53	36.29*	-6.65

Sl. No.	Hybrids	Plant height at 30 DAS (cm)					Plant girth at 30 DAS (cm)					Leaf area at 30 DAS (cm ²)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
54	ARYP-4 x KDMI-10	-3.76	-9.70	2.20	2.61	-7.58	13.60	9.23	25.11	26.79*	4.03	18.28	12.69	19.49	52.87**	4.71
55	ARYP-5 x KDMI-10	-5.83	-13.05*	-1.60	-1.20	-11.01	12.53	6.67	12.78	14.29	-6.23	-12.73	-17.39	-1.93	25.47	-14.06
56	ARYP-6 x KDMI-10	-3.44	-8.29	3.79	4.21	-6.14	14.89	12.50	18.94	20.54	-1.10	7.05	-1.03	4.94	34.26	-8.04
57	ARYP-7 x KDMI-10	-11.52*	-14.64*	-3.39	-3.01	-12.64*	21.41	14.58	21.15	22.77	0.73	-3.64	-14.12	-8.94	16.50	-20.21
58	ARYP-8 x KDMI-10	-4.52	-8.82	3.19	3.61	-6.68	-0.80	-4.62	9.25	10.71	-9.16	8.24	3.99	10.26	41.07*	-3.38
59	ARYP-9 x KDMI-10	-13.54*	-14.98*	-3.79	-3.41	-13.00*	3.37	-1.51	14.98	16.52	-4.40	-12.09	-17.27	-0.56	27.22	-12.86
60	ARYP-10 x KDMI-10	-10.86	-16.75**	-5.79	-5.41	-14.80*	7.29	4.33	16.74	25.89	-2.93	-2.36	-6.14	7.86	37.99*	-5.48
61	ARYP-11 x KDMI-10	-14.49**	-14.86*	-2.79	-2.40	-12.09*	9.13	8.68	15.86	30.80*	-3.66	27.32*	15.01	21.94	56.02**	6.86
62	ARYP-12 x KDMI-10	-8.41	-9.04	4.39	4.81	-5.60	2.51	2.08	7.93	22.32	-10.26	9.03	-0.91	5.07	34.42	-7.93
63	ARYP-13 x KDMI-10	-3.86	-10.05	1.80	2.20	-7.94	2.40	-1.54	12.78	4.46	-6.23	9.33	0.41	6.47	36.22*	-6.70
64	ARYP-14 x KDMI-10	-4.63	-10.93	0.80	1.20	-8.84	-0.87	-5.00	0.44	16.52	-16.48	34.57**	25.81	33.40	70.67**	16.90
65	ARYP-15 x KDMI-10	-6.47	-15.87**	-4.79	-4.41	-13.90*	4.44	-2.08	3.52	12.95	-13.92	5.48	-6.74	-1.12	26.51	-13.35
66	ARYP-16 x KDMI-10	-9.51	-13.58*	-2.20	-1.80	-11.55	1.25	1.25	7.05	9.82	-10.99	15.71	4.51	10.81	41.78*	-2.89
67	ARYP-17 x KDMI-10	-7.59	-13.05*	-1.60	-1.20	-11.01	10.74	9.58	15.86	3.57	-3.66	3.35	-4.75	0.99	29.21	-11.50
68	ARYP-18 x KDMI-10	-13.73**	-13.88*	-2.20	-1.80	-11.55	-2.64	-11.03	13.66	5.36	-5.49	0.97	-4.08	13.96	45.80*	-0.14
69	ARYP-19 x KDMI-10	-1.88	-12.53*	-0.80	-0.40	-10.29	8.33	8.33	14.54	13.84	-4.76	38.17**	17.71	24.81	59.68**	9.37
70	ARYP-20 x KDMI-10	-13.78*	-17.81**	-6.99	-6.61	-15.88*	3.43	0.39	12.78	18.75	-6.23	6.81	5.48	11.84	43.09*	-1.99
71	ARYP-21 x KDMI-10	-7.83	-10.76	1.00	1.40	-8.66	-1.02	-2.81	6.61	12.50	-11.36	11.33	3.17	9.39	39.96*	-4.14
72	ARYP-22 x KDMI-10	-17.41**	-20.11	-9.58	-9.22	-18.23**	-7.84	-12.96	3.52	16.96	-13.92	-5.88	-6.80	-1.19	26.42	-13.41
73	ARYP-23 x KDMI-10	-18.99**	-20.63**	-10.18	-9.82	-18.77**	-1.01	-3.92	7.93	-1.79	-10.26	15.24	7.51	14.00	45.85*	-0.10
74	ARYP-24 x KDMI-10	-12.94*	-15.17*	-3.99	-3.61	-13.18*	7.42	1.10	21.15	3.57	0.73	18.66	18.01	26.50	61.85**	10.85
75	ARYP-25 x KDMI-10	-20.07**	-23.10**	-12.97	-12.63	-21.30**	6.93	1.98	18.94	29.46*	-1.10	-11.23	-12.96	-3.97	22.87	-15.84
76	ARYP-1x NEI-9202B	-14.07*	-17.72**	-9.18	-8.82	-17.87**	14.16	8.00	18.94	16.52	-1.10	-9.36	-10.45	-10.33	14.72	-21.43
77	ARYP-2 x NEI-9202B	-13.16*	-20.07**	-11.78	-11.42	-20.22**	6.92	2.00	12.33	13.84	-6.59	2.01	-7.90	-7.77	17.99	-19.18
78	ARYP-3 x NEI-9202B	-7.77	-14.10*	-5.19	-4.81	-14.26*	-1.26	-5.60	3.96	28.13*	-13.55	-14.75	-19.20	-9.67	15.57	-20.84
79	ARYP-4 x NEI-9202B	-6.48	-11.21	-2.00	-1.60	-11.37	0.78	-1.15	13.22	12.05	-5.86	-0.83	-3.29	-3.16	23.90	-15.14

Sl. No.	Hybrids	Plant height at 30 DAS (cm)					Plant girth at 30 DAS (cm)					Leaf area at 30 DAS (cm ²)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
80	ARYP-5 x NEI-9202B	0.87	-5.79	3.99	4.41	-5.96	4.52	-2.80	7.05	20.98	-10.99	13.17	4.31	23.83	58.43**	8.51
81	ARYP-6 x NEI-9202B	-1.60	-5.42	4.39	4.81	-5.60	9.58	-13.20	-4.41	20.54	-20.51	6.27	0.91	1.04	29.27	-11.46
82	ARYP-7 x NEI-9202B	-9.63	-11.75	-2.59	-2.20	-11.91	1.51	-6.00	3.52	20.09	-13.92	-7.24	-15.20	-15.08	8.64	-25.59
83	ARYP-8 x NEI-9202B	-8.70	-11.75	-2.59	-2.20	-11.91	-3.92	-5.77	7.93	4.02	-10.26	3.52	2.27	2.41	31.02	-10.26
84	ARYP-9 x NEI-9202B	-5.54	-5.97	3.79	4.21	-6.14	-2.91	-5.66	10.13	22.32	-8.42	-9.26	-16.83	-0.04	27.88	-12.41
85	ARYP-10 x NEI-9202B	-0.29	-5.79	3.99	4.41	-5.96	-9.13	-9.84	0.88	11.16	-16.12	-2.18	-8.47	5.18	34.56	-7.83
86	ARYP-11 x NEI-9202B	-15.73**	-17.13**	-5.39	-5.01	-14.44*	-4.47	-6.00	3.52	26.79*	-13.92	-25.82*	-31.23*	-31.14*	-11.90	-39.66**
87	ARYP-12 x NEI-9202B	-9.22	-10.96	2.20	2.61	-7.58	4.51	2.00	12.33	14.29	-6.59	3.37	-3.56	-3.43	23.55	-15.38
88	ARYP-13 x NEI-9202B	-5.83	-10.85	-1.60	-1.20	-11.01	1.96	-0.00	14.54	20.54	-4.76	17.34	10.66	10.81	41.77*	-2.90
89	ARYP-14 x NEI-9202B	-8.13	-13.20	-4.19	-3.81	-13.36*	-2.13	-8.00	1.32	22.77	-15.75	-15.88	-19.20	-19.09	3.51	-29.10*
90	ARYP-15 x NEI-9202B	-6.56	-15.01	-6.19	-5.81	-15.16*	1.74	-6.40	3.08	10.71	-14.29	-4.30	-13.23	-13.11	11.16	-23.86
91	ARYP-16 x NEI-9202B	-4.21	-7.41	2.20	2.61	-7.58	6.94	4.80	15.42	16.52	-4.03	6.72	-1.07	-0.94	26.74	-13.19
92	ARYP-17 x NEI-9202B	-5.60	-10.13	-0.80	-0.40	-10.29	5.57	2.40	12.78	25.89	-6.23	29.63*	22.69	22.85	57.18**	7.66
93	ARYP-18 x NEI-9202B	-4.63	-5.98	6.79	7.21	-3.43	-12.96	-18.97	3.52	30.80*	-13.92	-5.49	-13.22	3.89	32.92	-8.96
94	ARYP-19 x NEI-9202B	-4.30	-5.79	3.99	4.41	-5.96	-8.98	-10.80	-1.76	22.32	-18.32	21.48	6.01	6.15	35.80*	-6.98
95	ARYP-20 x NEI-9202B	19.96**	15.73*	27.74**	28.26**	15.52*	2.97	1.96	14.54	4.46	-4.76	-12.01	-13.40	-10.46	14.56	-21.54
96	ARYP-21 x NEI-9202B	17.34**	15.01*	26.95**	27.45**	14.80*	1.80	1.60	11.89	16.52	-6.96	23.00	17.08	17.23	49.99**	2.73
97	ARYP-22 x NEI-9202B	-4.52	-6.51	3.19	3.61	-6.68	-7.69	-11.11	5.73	12.95	-12.09	-1.02	-2.84	1.00	29.21	-11.50
98	ARYP-23 x NEI-9202B	-1.19	-1.99	8.18	8.62	-2.17	4.95	3.92	16.74	9.82	-2.93	16.71	11.86	12.01	43.31*	-1.84
99	ARYP-24 x NEI-9202B	3.21	1.81	12.38	12.83	1.62	-1.15	-5.15	13.66	3.57	-5.49	-10.02	-12.99	-6.73	19.33	-18.26
100	ARYP-25 x NEI-9202B	28.51**	25.14**	38.12**	38.68**	24.91**	7.96	4.91	22.47	5.36	1.83	20.57	15.00	26.89	62.34**	11.19
	SE	1.99	2.29				0.17	0.19				30.79	35.56			
	DMH -2 (C)			0.00	0.40	-9.57			0.00	18.75	-10.26			0.00	27.94	-12.37
	Cargil 900-M (C)			-0.40	0.00	-9.93			-1.32	12.50	-16.85			-21.84	0.00	-31.51
	PRABHA (C)			10.58	11.02	0.00			20.26	16.96	-17.95			14.12	46.00	0.00
	Min			-13.77	-13.43	-22.02			-4.41	-1.79	0.00			-35.38	-17.33	-43.38
	Max			38.12	38.68	24.91			29.07	3.57	-20.51			33.40	70.67	16.90
	Avg			-1.18	-0.78	-10.63			12.03	29.46*	7.33			1.16	29.42	-11.36

MP – Mid parent, BP – Better parent, 900-M – Cargil 900-M, PRA – Prabha
* and ** significant at 1% and 5% level of probability, respectively

direction, respectively. In case of other checks DMH-2, Prabha showed significant heterosis in undesirable direction.

The crosses namely, ARYP-14 × KDMI-10 (70.67), ARYP-25 × CI-5 (62.92), ARYP-25 × NEI-9202B (62.34), ARYP-24 × KDMI-10 (61.85) and ARYP-2 × KDMI-10 (58.68) were the top five hybrids which exhibited significant superiority over superior Cargil 900-M for this trait (Table 26).

4.7.4 Plant height at 60 DAS (cm)

The percentage heterosis over mid parent ranged from -7.37 (ARYP-17 × KDMI-10) to 17.07 (ARYP-1 × CI-5). The percentage heterosis over better parent ranged from -10.77 (ARYP-17 × KDMI-10) to 16.03 cm (ARYP-1 × CI-5). The percentage of heterosis over checks DMH-2, Cargil 900-M and Prabha ranged from -7.16 (ARYP-11 × KDMI-10) to 11.21 (ARYP-20 × NEI-9202B), -9.95 (ARYP-11 × KDMI-10) to 7.86 (ARYP-20 × NEI-9202B) and -11.83 (ARYP-11 × KDMI-10) to 5.61 (ARYP-20 × NEI-9202B), respectively (Table 27).

Thirty five hybrids exhibited significant positive heterosis over mid parent. Fourteen crosses exhibited significant positive heterosis in desirable direction over better parent. Twelve crosses exhibited significant positive heterosis over DMH-2. Three crosses exhibited significant positive heterosis over check Cargil 900-M. Two hybrids namely ARYP-20 × NEI-9202B (7.86) and ARYP-1 × CM-111 (7.05) recorded significant superiority over check Cargil 900-M for this trait (Table 27).

4.7.5 Leaf area at 60 DAS (CM²)

The percentage heterosis for leaf area over mid parent, better parent and commercial checks ranged from -8.79 (ARYP-23 × CM-111) to 53.67 (ARYP-14 × KDMI-10), -14.37 (ARYP-23 × CM-111) to 57.13 (ARYP-1 × KDMI-10) and -9.08 (ARYP-5 × CI-5) to 44.91 (ARYP-21 × NEI-9202B over Cargil 900-M, -1.45 (ARYP-5 × CI-5) to 57.08 (ARYP-21 × NEI-9202B) over DMH-2, -4.24 (ARYP-5 × CI-5) to 52.63 (ARYP-21 × NEI-9202B) over Prabha, respectively (Table 27).

In case of mid parent, 60 crosses showed significant heterosis. Among them, 39 hybrids showed highly significant heterosis in positive direction and 21 hybrids showed only significant positive heterosis. Thirty four hybrids showed significant heterosis over better parent. Thirty seven hybrids showed significant standard heterosis over DMH-2, 39 crosses showed significant standard heterosis over Cargil 900-M and 54 crosses showed significant standard heterosis over check Prabha for leaf area at 60 DAS.

Top five hybrids viz., ARYP-21 × NEI-9202B (57.08) ARYP-9 × CI-5 (49.68), ARYP-20 × NEI-9202B (44.78), ARYP-9 × CM-111 (43.72) and ARYP-17 × CI-5 (43.28) exhibited significant superiority over Cargil 900-M (Table 27).

4.7.6 Ear height (cm)

The percentage heterosis over mid parent, better parent and commercial checks DMH-2, Cargil 900-M and Prabha ranged from -8.09 (ARYP-13 × CM-111) to 38.41 (ARYP-5 × KDMI-10), -13.30 (ARYP-13 × CM-111) to 29.49 (ARYP-5 × KDMI-10), -10.07 (ARYP-11 × KDMI-10) to 33.55 (ARYP-17 × CM-111) and -23.72 (ARYP-11 × KDMI-10) to 13.28 (ARYP-1 × CM-111), respectively (Table 27).

Twenty-five hybrids showed significant positive heterosis over mid parent, five hybrids exhibited significant heterosis in desirable direction over better parent. Twenty eight hybrids showed significant heterosis over check DMH-2, 15 hybrids showed highly significant positive heterosis over check Cargil 900-M and eleven hybrids showed significant heterosis over check Prabha in undesirable direction (Table 27).

The five hybrids viz., ARYP-1 × CM-111 (33.55), ARYP-8 × NEI-9202B (30.10), ARYP-1 × NEI-9202B (28.15), ARYP-20 × NEI-9202B (26.47) and ARYP-14 × NEI-9202B (26.37) exhibited significant superiority over DMH-2.

Table 27: Mid, better parent and standard heterosis for plant height, ear height and leaf area at 60 days after sowing in maize

Sl. No.	Hybrids	Plant height at 60 DAS (cm)					Leaf area at 60 DAS (cm ²)					Ear height at 60 DAS (cm)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
1	ARYP-1 x CM-111	13.36**	9.59**	10.37**	7.05*	4.82	33.72**	17.77	20.05*	30.13**	26.44**	22.17**	22.17**	33.55**	13.28	11.34
2	ARYP-2 x CM-111	-1.75	-2.55	-0.23	-3.23	-5.25	27.07**	14.49	16.71	26.50*	22.92*	16.40*	6.48	16.40	-1.26	-2.95
3	ARYP-3 x CM-111	5.62	4.92	5.68	2.50	0.36	18.01*	8.27	32.18**	43.27**	39.21**	12.96	12.96	23.49**	4.74	2.95
4	ARYP-4 x CM-111	0.89	0.49	1.21	-1.84	-3.88	17.72*	17.10	20.64*	30.76**	27.06**	7.33	3.58	13.23	-3.95	-5.59
5	ARYP-5 x CM-111	4.47	0.64	1.36	-1.69	-3.74	14.85	9.17	11.28	20.62*	17.20	28.14**	12.79	23.30**	4.58	2.80
6	ARYP-6 x CM-111	-2.58	-3.71	-0.72	-3.71	-5.72	26.21**	19.90*	22.22*	32.48**	28.72**	7.66	6.65	16.59*	-1.11	-2.80
7	ARYP-7 x CM-111	6.21*	4.55	5.30	2.13	0.00	14.64	11.91	14.08	23.65*	20.15*	21.76**	13.55	24.14**	5.30	3.50
8	ARYP-8 x CM-111	6.99*	4.96	5.72	2.53	0.40	15.06	13.54	18.88*	28.86**	25.21*	-0.63	-1.91	10.07	-6.64	-8.24
9	ARYP-9 x CM-111	6.22*	5.00	5.76	2.57	0.43	29.58**	29.08**	32.60**	43.72**	39.65**	11.76	11.42	21.81*	3.32	1.55
10	ARYP-10 x CM-111	7.12*	2.67	3.41	0.29	-1.80	27.80**	25.92**	28.35**	39.13**	35.19**	16.02*	10.83	21.16*	2.77	1.01
11	ARYP-11 x CM-111	0.12	-4.17	-3.48	-6.39	-8.34*	2.31	1.58	5.06	13.87	10.65	1.30	-3.67	5.31	-10.67	-12.20
12	ARYP-12 x CM-111	-3.76	-5.19	-4.51	-7.38	-9.31**	-3.02	-8.44	4.81	13.61	10.39	1.71	-3.84	5.13	-10.83	-12.35
13	ARYP-13 x CM-111	5.27	1.77	2.50	-0.59	-2.66	23.92**	11.22	13.38	22.89*	19.41	-8.09	-13.30	-5.22	-19.60*	-20.98**
14	ARYP-14 x CM-111	7.44*	4.55	5.30	2.13	0.00	10.21	6.15	8.21	17.29*	13.97*	11.59	-0.60	8.67	-7.83	-9.40
15	ARYP-15 x CM-111	7.34*	3.05	3.79	0.66	-1.44	20.19*	12.53	14.70	24.33	20.81	10.21	4.43	14.17	-3.16	-4.82
16	ARYP-16 x CM-111	5.76	4.51	5.26	2.09	-0.04	-0.52	-2.85	-0.97	7.34	4.30	12.41	8.53	18.64*	0.63	-1.09
17	ARYP-17 x CM-111	1.56	-1.03	5.04	1.87	-0.25	10.76	7.58	9.66	18.86	15.50	11.52	10.45	23.11*	4.43	2.64
18	ARYP-18 x CM-111	3.55	3.41	4.43	1.29	-0.83	3.55	-1.91	-0.01	8.38	5.31	-0.13	-1.19	8.01	-8.38	-9.95
19	ARYP-19 x CM-111	6.23*	6.13	6.89	3.67	1.51	12.20	9.70	11.83	21.21*	17.78	10.16	8.61	18.73*	0.71	-1.01
20	ARYP-20 x CM-111	2.98	0.83	1.55	-1.51	-3.56	4.65	0.21	2.15	10.73	7.59	16.40*	5.29	15.10	-2.37	-4.04
21	ARYP-21 x CM-111	-0.21	-0.34	0.64	-2.39	-4.42	28.24**	27.46**	31.52**	42.56**	38.52**	0.56	0.17	9.51	-7.11	-8.70
22	ARYP-22 x CM-111	-2.85	-3.80	-1.17	-4.15	-6.15	16.39*	9.36	26.81**	37.45**	33.56**	2.66	1.67	13.33	-3.87	-5.52
23	ARYP-23 x CM-111	3.40	2.13	5.45	2.28	0.14	-6.66	-14.37	4.56	13.34	10.13	4.83	4.52	14.26	-3.08	-4.74
24	ARYP-24 x CM-111	2.60	2.41	3.14	0.04	-2.05	26.02**	24.75**	27.16**	37.83**	33.93**	8.04	6.17	20.22*	1.98	0.23
25	ARYP-25 x CM-111	5.73	4.14	4.88	1.73	-0.40	19.21*	11.90	14.07	23.64*	20.14*	6.32	1.11	10.53	-6.25	-7.85
26	ARYP-1 x CI-5	17.07**	16.03**	9.09*	5.80	3.60	22.02*	10.93	5.23	14.07	10.83	21.19**	14.32	24.98**	6.01	4.20
27	ARYP-2 x CI-5	3.99	-1.11	1.25	-1.80	-3.85	24.79*	16.16	10.20	19.45	16.07	13.16	9.52	6.15	-9.96	-11.50

Sl. No.	Hybrids	Plant height at 60 DAS (cm)					Leaf area at 60 DAS (cm ²)					Ear height at 60 DAS (cm)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
28	ARYP-3 x CI-5	12.68**	8.69*	8.03*	4.77	2.59	9.18	-2.99	18.43	28.37**	24.73*	18.57*	11.85	22.27*	3.72	1.94
29	ARYP-4 x CI-5	6.54*	2.50	2.42	-0.66	-2.73	10.93	6.54	9.76	18.97	15.60	18.82*	16.04	17.99*	0.08	-1.63
30	ARYP-5 x CI-5	5.10	4.54	-2.42	-5.36	-7.34*	-2.61	-4.16	-9.08	-1.45	-4.24	24.22**	15.38	11.84	-5.14	-6.76
31	ARY7-6 x CI-5	4.30	-1.14	1.93	-1.14	-3.20	21.95*	19.94*	13.78	23.33*	19.83*	3.70	-1.30	5.87	-10.20	-11.73
32	ARYP- 7x CI-5	9.25**	6.33	3.75	0.62	-1.47	18.56*	17.20	13.80	23.35*	19.85*	18.54*	17.12	13.51	-3.72	-5.36
33	ARYP-8 x CI-5	3.36	0.94	-2.20	-5.14	-7.12*	17.72*	12.18	17.46	27.32**	23.71*	3.83	-3.24	8.57	-7.91	-9.48
34	ARYP-9 x CI-5	15.44**	11.89**	10.11**	6.79	4.57	39.77**	34.42**	38.09**	49.68**	45.44**	21.12**	14.58	24.51**	5.61	3.81
35	ARYP-10 x CI-5	9.51**	9.51*	1.14	-1.91	-3.96	19.38*	16.93	15.67	25.38*	21.83*	12.90	11.42	10.90	-5.93	-7.54
36	ARYP-11 x CI-5	7.86*	7.71*	-0.53	-3.53	-5.54	25.56**	20.37*	24.49*	34.93**	31.11**	8.58	7.66	6.15	-9.96	-11.50
37	ARYP-12 x CI-5	7.37*	4.42	2.04	-1.03	-3.09	24.57**	14.02	30.24**	41.17**	37.17**	15.68*	15.41	12.40	-4.66	-6.29
38	ARYP-13 x CI-5	4.47	3.54	-2.65	-5.58	-7.55	30.17**	20.69*	14.49	24.10*	20.58*	15.48	15.48	11.93	-5.06	-6.68
39	ARYP-14 x CI-5	10.57**	8.86*	3.75	0.62	-1.47	30.47**	30.18**	23.50*	33.86**	30.07**	10.97	4.04	0.84	-14.47	-15.93*
40	ARYP-15 x CI-5	9.01	8.83*	0.83	-2.20	-4.24	10.07	6.63	1.15	9.64	6.53	1.91	1.43	-0.75	-15.81*	-17.25*
41	ARYP-16 x CI-5	9.73**	6.39	4.62	1.47	-0.65	14.40	13.05	9.84	19.05	15.68	3.94	1.47	3.26	-12.41	-13.91
42	ARYP-17 x CI-5	-2.14	-8.49*	-2.88	-5.80	-7.77	38.45**	37.58**	32.18**	43.28**	39.22**	-0.72	-7.19	3.45	-12.25	-13.75
43	ARYP-18 x CI-5	4.39	-0.07	0.91	-2.13	-4.17	28.69**	26.19**	19.71*	29.76**	26.08**	1.28	-3.48	3.26	-12.41	-13.91
44	ARYP-19 x CI-5	4.71	0.46	0.98	-2.06	-4.10	9.50	8.08	5.27	14.10	10.87	-2.48	-6.75	-0.93	-15.97*	-17.40*
45	ARYP-20 x CI-5	9.94**	7.57*	3.82	0.70	-1.40	28.11**	27.05**	20.52*	30.64**	26.94**	30.52**	24.81**	20.97*	2.61	0.85
46	ARYP-21 x CI-5	3.80	-0.64	0.34	-2.68	-4.71	13.86	9.27	12.75	22.21*	18.75*	4.99	-0.60	7.83	-8.54	-10.10
47	ARYP-22 x CI-5	3.11	-2.10	0.57	-2.46	-4.49	24.07**	12.78	30.78**	41.76**	37.74**	7.51	0.50	12.02	-4.98	-6.60
48	ARYP-23 x CI-5	1.55	-3.81	-0.68	-3.67	-5.68	3.93	-7.67	12.75	22.21*	18.75	0.45	-4.97	3.26	-12.41	-13.91
49	ARYP-24 x CI-5	7.88*	3.58	3.94	0.81	-1.29	33.11**	29.78**	29.61**	40.49**	36.51**	13.79	5.60	19.57*	1.42	-0.31
50	ARYP-25 x CI-5	3.41	0.58	-1.74	-4.70	-6.69	37.91**	33.96**	27.08**	37.74**	33.84**	-3.91	-4.73	-6.06	-20.32**	-21.68**
51	ARYP-1 x KDMI-10	1.69	-0.54	-2.20	-5.14	-7.12	60.80**	57.13**	27.78**	38.51**	34.58**	1.50	-4.94	3.91	-11.86	-13.36
52	ARYP-2 x KDMI-10	2.17	0.15	2.54	-0.55	-2.62	29.40**	29.05*	5.51	14.36	11.12	16.27	13.38	8.20	-8.22	-9.79
53	ARYP-3 x KDMI-10	4.60	4.04	3.41	0.29	-1.80	17.54*	-2.08	19.54*	29.58**	25.90*	14.88*	7.54	17.61	-0.24	-1.94
54	ARYP-4 x KDMI-10	0.76	-0.04	-0.11	-3.12	-5.14	43.11**	28.04**	31.90**	42.97**	38.92**	14.99	11.26	13.33	-3.87	-5.52
55	ARYP-5 x KDMI-10	6.48*	3.77	2.04	-1.03	-3.09	18.54*	11.75	2.65	11.26	8.11	38.41**	29.49**	23.58**	4.82	3.03

Sl. No.	Hybrids	Plant height at 60 DAS (cm)					Leaf area at 60 DAS (cm ²)					Ear height at 60 DAS (cm)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
56	ARYP-6 x KDMI-10	0.49	-1.84	1.21	-1.84	-3.88	26.65**	19.46	9.59	18.79	15.43	15.86*	9.47	17.43	-0.40	-2.10
57	ARYP-7 x KDMI-10	2.74	2.35	0.64	-2.39	-4.42	23.41*	13.39	10.09	19.33	15.95	13.29	12.79	7.64	-8.70	-10.26
58	ARYP-8 x KDMI-10	0.16	-0.58	-2.23	-5.18	-7.16*	23.98**	10.14	15.32	25.00*	21.46*	3.05	-4.65	6.99	-9.25	-10.80
59	ARYP-9 x KDMI-10	1.99	1.95	0.33	-2.69	-4.72	16.84	4.67	7.52	16.55	13.24	3.84	-2.49	5.96	-10.12	11.66
60	ARYP-10 x KDMI-10	4.29	1.12	-0.57	-3.56	-5.57	24.13**	13.08	11.87	21.25*	17.82	6.60	4.40	3.91	-11.86	-13.36
61	ARYP-11 x KDMI-10	-2.49	-5.58	-7.16*	-9.95**	-11.83**	10.96	-0.89	2.50	11.10	7.95	-7.30	-8.79	-10.07	-23.72**	-25.02**
62	ARYP-12 x KDMI-10	0.93	0.62	-1.06	-4.04	-6.04	14.00	-2.42	11.47	20.82*	17.40	9.52	8.42	5.59	-10.43	-11.97
63	ARYP-13 x KDMI-10	3.94	1.66	-0.04	-3.05	-5.07	45.01**	44.76**	17.73*	27.61**	23.99*	13.76	12.88	9.41	-7.19	-8.78
64	ARYP-14 x KDMI-10	1.25	-0.31	-1.97	-4.92	-6.90*	53.67**	43.00**	35.04**	46.38**	42.23**	12.31	6.05	1.21	-14.15	-15.62
65	ARYP-15 x KDMI-10	1.70	-1.23	-2.88	-5.80	-7.77**	33.72**	28.00**	13.83	23.39*	19.89*	2.60	1.33	-0.84	-15.89*	-17.33*
66	ARYP-16 x KDMI-10	0.15	0.15	-1.51	-4.48	-6.47	50.52**	38.26**	34.32**	45.60**	41.47**	7.75	4.40	6.24	-9.88	-11.42
67	ARYP-17 x KDMI-10	-7.37*	-10.77**	-5.30	-8.15**	-10.07**	26.51**	16.79	12.21	21.63*	18.18	-0.63	-7.78	2.80	-12.81	-14.30
68	ARYP-18 x KDMI-10	-4.71	-5.96	-5.04	-7.90*	-9.82**	41.53**	33.88**	22.08*	32.32**	28.57**	-1.20	-6.53	0.00	-15.18*	-16.63*
69	ARYP-19 x KDMI-10	-3.58	-4.63	-4.13	-7.01*	-8.95**	40.95**	29.32**	25.95**	36.52**	32.66**	-1.66	-6.67	-0.84	-15.89*	-17.33*
70	ARYP-20 x KDMI-10	-1.87	-2.77	-4.39	-7.27*	-9.21**	22.74*	14.86	7.16	16.16	12.86	7.45	3.52	-1.21	-16.21*	-17.64*
71	ARYP-21 x KDMI-10	-5.02	-6.26	-5.34	-8.19*	-10.10**	15.95	3.67	6.97	15.94	12.66	-3.38	-9.19	-1.49	-16.44*	-17.87*
72	ARYP-22 x KDMI-10	-2.00	-4.09	-1.48	-4.44	-6.44	6.81	-9.15	5.35	14.20	10.96	4.77	-2.76	8.39	-8.06	-9.63
73	ARYP-23 x KDMI-10	-0.83	-2.19	-0.04	-3.05	-5.07	2.97	-14.23	4.74	13.53	10.31	0.37	-5.75	2.42	-13.12	-14.61
74	ARYP-24 x KDMI-10	0.59	-0.42	-0.08	-3.08	-5.11	21.68*	10.38	10.24	19.49	16.10	9.96	1.32	14.73	-2.69	-4.35
75	ARYP-25 x KDMI-10	2.57	2.23	0.53	-2.50	-4.53	31.38**	25.42*	12.16	21.58*	18.13	18.25*	16.35	14.73	-2.69	-4.35
76	ARYP-1x NEI-9202B	11.62**	7.80*	8.78*	5.51	3.31	19.50*	6.05	6.22	15.14	11.88	16.72*	16.23*	28.15**	8.70	6.84
77	ARYP-2 x NEI-9202B	3.41	2.66	5.11	1.95	-0.18	9.73	-0.35	-0.19	8.19	5.12	23.56**	12.60	24.14**	5.30	3.50
78	ARYP-3 x NEI-9202B	8.51**	7.69*	8.67*	5.40	3.20	5.00	-4.43	16.67	26.47*	22.88*	13.24	12.76	24.32**	5.45	3.65
79	ARYP-4 x NEI-9202B	-1.02	-1.50	-0.61	-3.60	-5.61	18.43*	16.79	20.32*	30.41**	26.72**	2.73	-1.27	8.85	-7.67	-9.25
80	ARYP-5 x NEI-9202B	7.49*	3.45	4.39	1.25	-0.86	35.34**	29.73**	29.94**	40.84**	36.85**	23.66**	8.45	19.57*	1.42	-0.31

Sl. No.	Hybrids	Plant height at 60 DAS (cm)					Leaf area at 60 DAS (cm ²)					Ear height at 60 DAS (cm)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
81	ARYP-6 x NEI-9202B	3.56	2.46	5.64	2.46	0.32	40.34**	34.44**	34.65**	45.95**	41.82**	5.57	4.14	14.82	-2.61	-4.27
82	ARYP-7 x NEI-9202B	0.34	-1.31	-0.42	-3.42	-5.43	6.97	5.33	5.50	14.35	11.11	14.19	6.09	16.96	-0.79	-2.49
83	ARYP-8 x NEI-9202B	10.07**	7.88*	8.86*	5.58	3.38	13.24	10.78	15.99	25.73*	22.17*	16.97*	15.95*	30.10**	10.36	8.47
84	ARYP-9 x NEI-9202B	2.96	1.69	2.61	-0.48	-2.55	-8.79	-9.93	-7.47	0.29	-2.55	-0.04	-0.76	9.41	-7.19	-8.78
85	ARYP-10 x NEI-9202B	8.78**	4.17	5.11	1.95	-0.18	15.25	14.53	14.72	24.35*	20.82*	11.68	6.26	17.15	-0.63	-2.33
86	ARYP-11 x NEI-9202B	4.61	0.04	0.95	-2.09	-4.14	11.96	10.20	13.97	23.53*	20.03	13.07	7.10	18.08*	0.16	-1.55
87	ARYP-12 x NEI-9202B	-2.02	-3.56	-2.69	-5.62	-7.59*	0.82	-5.39	8.07	17.14	13.82	1.62	-4.31	5.50	-10.51	-12.04
88	ARYP-13 x NEI-9202B	7.11*	3.45	4.39	1.25	-0.86	43.33**	29.65**	29.86**	40.76**	36.77**	13.27	6.42	17.33	-0.47	-2.18
89	ARYP-14 x NEI-9202B	12.20**	9.08**	10.07**	6.76	4.53	-4.84	-7.56	-7.41	0.36	-2.48	29.57**	14.62	26.37**	7.19	5.36
90	ARYP-15 x NEI-9202B	7.55*	3.15	4.09	0.95	-1.15	12.38	6.08	6.25	15.17	11.90	3.63	-2.20	7.83	-8.54	-10.10
91	ARYP-16 x NEI-9202B	6.99*	5.63	6.59	3.38	1.22	20.57*	18.76*	18.95*	28.94*	25.28*	15.52*	11.07	22.46**	3.87	2.10
92	ARYP-17 x NEI-9202B	0.22	-2.25	3.75	0.62	-1.47	13.97	11.65	11.82	21.21*	17.78	-2.65	-3.18	7.92	-8.46	-10.02
93	ARYP-18 x NEI-9202B	5.89	5.77	6.82	3.60	1.44	26.93**	21.24*	21.44*	31.63**	27.90**	4.25	2.70	13.23	-3.95	-5.59
94	ARYP-19 x NEI-9202B	3.42	3.23	4.17	1.03	-1.08	13.70	12.14	12.32	21.74*	18.29	5.98	4.06	14.73	-2.69	-4.35
95	ARYP-20 x NEI-9202B	12.66**	10.21**	11.21**	7.86*	5.61	38.09**	33.36**	33.57**	44.78**	40.68**	27.30**	14.71	26.47**	7.27	5.44
96	ARYP-21 x NEI-9202B	4.01	3.97	5.00	1.84	-0.29	42.53*	40.44**	44.91**	57.08**	52.63**	8.82	7.95	19.01	0.95	-0.78
97	ARYP-22 x NEI-9202B	6.88*	5.93	8.82*	5.55	3.34	3.86	-3.22	12.23	21.65*	18.20	11.98	11.37	24.14**	5.30	3.50
98	ARYP-23 x NEI-9202B	6.23*	5.02	8.44*	5.18	2.98	-4.18	-12.79	6.49	15.43	12.16	6.26	5.49	16.31	-1.34	-3.03
99	ARYP-24 x NEI-9202B	6.68*	6.38	7.35*	4.11	1.94	19.30*	19.13*	19.32*	29.33**	25.67**	3.42	2.06	15.56	-1.98	-3.65
100	ARYP-25 x NEI-9202B	6.81*	5.10	6.06	2.86	0.72	29.34**	22.41*	22.61*	32.90**	29.14**	11.47	5.58	16.40	-1.26	-2.95
	SE	5.33	6.15				48.09	55.53				5.54	6.40			
	DMH -2 (C)			0.00	-3.01	-5.03			0.00	8.39	5.32			0.00	-15.18*	-16.63
	900-M (C)			3.10	0.00	-2.09			-7.74	0.00	-2.83			17.89*	0.00	-1.71
	PRABHA (C)			5.30	2.13	0.00			-5.05	2.92	0.00			19.94*	1.74	0.00
	Min			-7.16	-9.95	-11.83			-9.08	-1.45	-4.24			-10.07	-23.72	-25.02
	Max			11.21	7.86	5.61			44.91	57.08	52.63			33.55	13.28	11.34
	Avg			2.22	-0.85	-2.92			15.72	25.43	21.88			12.32	-4.73	-6.36

MP – Mid parent, BP – Better parent, 900-M – Cargil 900-M, PRA – Prabha
 * and ** significant at 1% and 5% level of probability, respectively

4.7.7 Cob weight (g)

The magnitude range of heterosis for cob weight varied from -2.76 (ARYP-10 × NEI-9202B) to 64.83 per cent (ARYP-13 × CI-5) for relative heterosis, from -9.57 (ARYP-23 × CI-5) to 49.95 per cent (ARYP-15 × CM-111) for heterobeltiosis -11.23 (ARYP-9 × KDMI-10) to 26.40 per cent (ARYP-20 × NEI-9202B) standard heterosis over DMH-2, -12.26 (ARYP-9 × KDMI-10) to 24.93 per cent (ARYP-20 × NEI-9202B) over standard heterosis for Cargil 900-M and -7.67 (ARYP-9 × KDMI-10) to 31.47 per cent (ARYP-20 × NEI-9202B) over Prabha, respectively (Table 28).

Sixty hybrids showed significant positive heterosis over mid parent heterosis, out of which 45 hybrids showed highly significant heterosis in positive direction and 15 hybrids showed significant heterosis in positive direction. Thirty-four hybrids showed significant heterobeltiosis, 18 hybrids showed highly significant positive heterosis over standard check DMH-2. Six crosses showed significant positive heterosis over Cargil 900-M and 20 crosses showed significant positive standard heterosis over Prabha (Table 28).

Top five hybrids viz., ARYP-20 × NEI-9202B (24.93), ARYP-15 × NEI-9202B (23.19), ARYP-3 × NEI-9202B (20.43), ARYP-24 × NEI-9202B (18.10) and ARYP-25 × NEI-9202B (18.02) exhibited significant superiority over Cargil 900-M (Table 28).

4.7.8 Cob length (cm)

The magnitude of range of heterosis for cob length varied from -7.30 (ARYP-23 × KDMI-10) to 25.05 per cent (ARYP-14 × CI-5) for mid parent, -14.72 (ARYP-23 × KDMI-10) to 16.79 per cent (ARYP-14 × CI-5) for better parent, -8.00 (ARYP-25 × CI-5) to 15.27 per cent (ARYP-12 × NEI-9202B) for standard heterosis over DMH-2, 14-96 (ARYP-25 × CI-5) to 6.55 per cent (ARYP-12 × NEI-9202B) for Cargil 900-M and -12.00 (ARYP-25 × CI-5) to 10.26 per cent (ARYP-12 × NEI-9202B) for check Prabha (Table 28).

Totally 16 crosses showed significant heterosis over mid parent. Seven crosses showed significant better heterosis, out of which three crosses viz., ARYP-14 × CI-5 (16.79), ARYP-19 × CM-111 (12.34) and ARYP-19 × CI-5 (12.65) showed significant positive heterosis over better parent.

Nine crosses showed significant negative heterosis over Cargil 900-M (Table 28). Ten crosses showed significant negative heterosis over check DMH-2 and none of the crosses exhibited heterosis in positive direction.

Five hybrids viz., ARYP-12 × NEI-9202B (15.27), ARYP-22 × NEI-9202B (13.64), ARYP-14 × CI-5 (12.55), ARYP-20 × CI-5 (12.36) and ARYP-6 × CI-5 (12.18) exhibited significant heterosis in positive direction over DMH-2 check (Table 28).

4.7.9 Cob girth (cm)

The magnitude of cob girth ranged from -8.84 (ARYP-14 × NEI-9202B) to 18.10 per cent (ARYP-24 × CM-111) for mid parent, -11.13 (ARYP-14 × NEI-9202B) to 15.89 per cent (ARYP-24 × CM-111) for better parent. The cob girth ranged from -7.44 (ARYP-14 × NEI-9202B) to 15.75 per cent (ARYP-8 × KDMI-10) over check DMH-2, -10.95 (ARYP-14 × NEI-9202B) to 11.77 per cent (ARYP-8 × KDMI-10) over Cargil 900-M and 3.42 (ARYP-14 × NEI-9202B) to 29.34 per cent (ARYP-8 × KDMI-10) over check Prabha (Table 28).

Totally twenty-five crosses exhibited relative heterosis, out of which 24 crosses showed highly significant positive heterosis heterosis. Nine crosses showed significant positive heterosis over better parent. The cross ARYP-8 × KDMI-10 (15.75) showed highly significant positive heterosis and the crosses ARYP-15 × NEI-9202B (10.280) and ARYP-17 × NEI-9202B (9.19) over standard heterosis DMH-2. The cross ARYP-8 × KDMI-10 showed highly significant positive heterosis (11.37) over Cargil 900-M. Eighty-one crosses showed significant heterosis over check Prabha, out of which 61 crosses exhibited highly significant positive heterosis and 20 crosses showed only significant heterosis in positive direction.

Table 28: Mid, better parent and standard heterosis for cob weight, cob length and cob girth in maize

Sl. No.	Hybrids	Cob weight (g)					Cob length (cm)					Cob girth (cm)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
1	ARYP-1 x CM-111	14.34	2.64	-2.85	-3.97	1.05	6.16	3.13	1.82	-5.88	-2.61	5.49	3.27	-3.28	-6.95	8.07
2	ARYP-2 x CM-111	12.47	-5.79	5.03	3.81	9.24	3.64	2.52	3.45	-4.37	-1.04	4.64	1.54	1.09	-2.74	12.96**
3	ARYP-3 x CM-111	26.67**	6.18	18.17*	16.80	22.91*	4.42	-1.31	9.45	1.18	4.70	4.47	0.61	1.75	-2.11	13.69**
4	ARYP-4 x CM-111	31.99**	25.42*	4.86	3.64	9.07	-0.44	-4.10	2.18	-5.55	-2.26	3.99	1.56	-0.22	-4.00	11.49*
5	ARYP-5 x CM-111	19.03*	12.69	-5.05	-6.16	-1.25	3.44	-0.18	-1.45	-8.91	-5.74	4.99	3.27	-3.28	-6.95	8.07
6	ARYP-6 x CM-111	16.23	0.04	4.41	3.19	8.59	4.77	2.46	5.82	-2.18	1.22	0.33	-5.01	-0.44	-4.21	11.25*
7	ARYP-7 x CM-111	12.56	1.59	-5.00	-6.10	-1.19	1.75	1.66	0.36	-7.23	-4.00	2.41	0.68	-2.41	-6.11	9.05
8	ARYP-8 x CM-111	16.28	0.31	4.13	2.92	8.30	-6.21	-11.83*	-1.09	-8.57	-5.39	3.38	-0.22	0.44	-3.37	12.22*
9	ARYP-9 x CM-111	20.90*	6.90	4.73	3.52	8.93	1.54	-0.35	2.18	-5.55	-2.26	2.67	-2.12	1.09	-2.74	12.96**
10	ARYP-10 x CM-111	24.80**	9.92	8.66	7.40	13.02	-1.68	-5.59	1.27	-6.39	-3.13	7.78*	2.75	6.13	2.11	18.58**
11	ARYP-11 x CM-111	15.55	0.90	1.77	0.58	5.85	1.33	-4.79	1.09	-6.55	-3.30	9.55*	7.24	0.44	-3.37	12.22*
12	ARYP-12 x CM-111	46.32**	38.78**	16.49	15.13	21.16**	2.87	2.21	0.91	-6.72	-3.48	10.93**	9.30*	5.47	1.47	17.85**
13	ARYP-13 x CM-111	43.59**	31.17**	-1.24	-2.39	2.72	8.70	7.00	5.64	-2.35	1.04	5.61	5.61	-1.09	-4.84	10.51*
14	ARYP-14 x CM-111	26.17**	14.08	6.24	5.01	10.50	4.94	3.68	2.36	-5.38	-2.09	-1.55	-6.51	-2.63	-6.32	8.80
15	ARYP-15 x CM-111	50.22**	49.95**	13.30	11.98	17.84	6.64	3.50	2.18	-5.55	-2.26	15.84**	14.49**	7.22	3.16	19.80**
16	ARYP-16 x CM-111	39.24**	31.15**	11.71	10.42	16.19	4.81	4.42	3.09	-4.71	-1.39	5.92	3.33	1.75	-2.11	13.69**
17	ARYP-17 x CM-111	40.60**	31.30**	13.92	12.60	18.49*	2.61	0.53	3.45	-4.37	-1.04	10.95**	8.88	1.97	-1.89	13.94**
18	ARYP-18 x CM-111	9.42	-6.35	-0.94	-2.09	3.03	1.15	-2.72	4.00	-3.87	-0.52	3.46	-1.07	1.53	-2.32	13.45**
19	ARYP-19 x CM-111	24.56*	22.17*	-4.35	-5.46	-0.52	18.10**	12.34*	10.91	2.52	6.09	0.57	-1.13	-4.16	-7.79	7.09
20	ARYP-20 x CM-111	30.29**	24.09*	3.25	2.05	7.39	1.73	0.36	1.82	-5.88	-2.61	4.90	2.45	0.66	-3.16	12.47*
21	ARYP-21 x CM-111	10.65	-5.40	0.32	-0.85	4.34	8.13	7.73	6.36	-1.68	1.74	5.23	0.42	3.50	-0.42	15.65**
22	ARYP-22 x CM-111	35.85**	21.93*	15.45	14.10	20.07*	10.99*	8.64	12.00*	3.53	7.13	12.11**	10.71*	6.35	2.32	18.83**
23	ARYP-23 x CM-111	24.83**	5.02	15.83	14.48	20.47*	1.29	-4.85	6.91	-1.18	2.26	6.94	2.58	4.60	0.63	16.87**
24	ARYP-24 x CM-111	48.69**	48.30**	12.24	10.94	16.74	2.99	1.66	0.36	-7.23	-4.00	18.10**	15.89**	8.53	4.42	21.27**
25	ARYP-25 x CM-111	21.83*	8.61	4.42	3.21	8.61	3.00	0.99	3.75	-4.10	-0.77	1.12	-3.21	-0.88	-4.63	10.76*
26	ARYP-1 x CI-5	10.38	0.49	-4.88	-5.99	-1.07	8.27	2.77	-4.33	-11.56*	-8.49	9.51*	4.42	3.28	-0.63	15.40**
27	ARYP-2 x CI-5	13.13	-4.02	7.00	5.76	11.29	8.37	0.90	0.00	-7.56	-4.35	3.64	3.30	2.84	-1.05	14.91**

Sl. No.	Hybrids	Cob weight (g)					Cob length (cm)					Cob girth (cm)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
28	ARYP-3 x CI-5	7.54	-8.70	1.61	0.43	5.69	5.61	-7.38	2.73	-5.04	-1.74	-0.24	-1.34	-0.22	-4.00	11.49*
29	ARYP-4 x CI-5	25.70**	21.25*	1.37	0.20	5.44	5.54	-5.80	0.36	-7.23	-4.00	4.99	4.65	3.50	-0.42	15.65**
30	ARYP-5 x CI-5	23.89*	19.06	0.31	-0.85	4.34	11.71*	6.73	-2.00	-9.41	-6.26	8.78*	4.20	3.06	-0.84	15.16**
31	ARY7-6 x CI-5	21.13*	5.65	10.26	8.98	14.68	20.04**	8.63	12.18*	3.70	7.30	-0.32	-3.13	1.53	-2.32	13.45**
32	ARYP- 7x CI-5	18.93*	8.86	1.81	0.62	5.89	7.78	-0.37	-1.82	-9.24	-6.09	-2.57	-3.54	-4.60	-8.21	6.60
33	ARYP-8 x CI-5	18.16*	3.29	7.22	5.98	11.52	1.39	-11.51*	-0.73	-8.24	-5.04	4.61	3.70	4.38	0.42	16.63**
34	ARYP-9 x CI-5	31.27**	17.68*	15.30	13.96	19.92*	20.12**	9.04	11.82*	3.36	6.96	2.38	0.21	3.50	-0.42	15.65**
35	ARYP-10 x CI-5	21.11*	8.15	6.91	5.67	11.20	7.81	-4.07	2.91	-4.87	-1.57	3.25	1.06	4.38	0.42	16.63**
36	ARYP-11 x CI-5	22.98**	8.85	9.78	8.51	14.18	12.64*	0.68	6.91	-1.18	2.26	6.54	1.59	0.48	-3.33	12.27*
37	ARYP-12 x CI-5	36.59**	31.50**	10.38	9.10	14.80	17.87**	9.51	6.73	-1.34	2.09	1.01	-0.22	-1.31	-5.05	10.27*
38	ARYP-13 x CI-5	64.83**	48.48**	15.35	14.01	19.97*	15.01**	7.79	3.09	-4.71	-1.39	12.73**	9.73*	8.53	4.42	21.27**
39	ARYP-14 x CI-5	43.58**	31.68**	22.63*	21.20*	27.54**	25.05**	16.79**	12.55*	4.03	7.65	3.23	0.63	4.81	0.84	17.11**
40	ARYP-15 x CI-5	43.40**	41.44**	9.88	8.60	14.28	8.14	2.74	-4.55	-11.76*	-8.70	11.72**	7.52	6.35	2.32	18.83**
41	ARYP-16 x CI-5	34.12**	28.22**	9.22	7.95	13.60	15.72**	7.24	5.09	-2.86	0.52	0.22	0.00	-1.09	-4.84	10.51*
42	ARYP-17 x CI-5	25.09**	18.55	2.86	1.66	6.98	3.70	-6.01	-3.27	-10.59*	-7.48	6.94	2.21	1.09	-2.74	12.96**
43	ARYP-18 x CI-5	13.37	-1.68	4.00	2.79	8.17	12.98*	0.68	7.64	-0.50	2.96	-3.37	-5.12	-2.63	-6.32	8.80
44	ARYP-19 x CI-5	25.19**	24.71*	-2.36	-3.50	1.55	16.21**	12.65*	0.36	-7.23	-4.00	-1.23	-2.21	-3.28	-6.95	8.07
45	ARYP-20 x CI-5	36.60**	32.07**	9.89	8.61	14.30	21.41**	10.75	12.36*	3.87	7.48	4.11	3.76	2.63	-1.26	14.67**
46	ARYP-21 x CI-5	19.36*	3.40	9.64	8.37	14.04	4.10	-3.53	-5.45	-12.61*	-9.57	6.18	4.03	7.22	3.16	19.80**
47	ARYP-22 x CI-5	28.39**	16.87	10.65	9.36	15.09	7.50	-2.65	0.36	-7.23	-4.00	3.48	1.99	0.88	-2.95	12.71*
48	ARYP-23 x CI-5	6.11	-9.57	-0.27	-1.43	3.73	7.42	-6.31	5.27	-2.69	0.70	0.65	-0.86	1.09	-2.74	12.96*
49	ARYP-24 x CI-5	40.37**	38.57**	7.65	6.40	11.96	13.25*	5.86	1.82	-5.88	-2.61	12.50**	7.52	6.35	2.32	18.83**
50	ARYP-25 x CI-5	16.87	5.65	1.57	0.39	5.65	-1.27	-10.44	-8.00	-14.96**	-12.00*	0.87	-0.85	1.53	-2.32	13.45*
51	ARYP-1 x KDMI-10	18.05*	9.50	3.65	2.44	7.80	2.04	1.35	-4.36	-11.60*	-8.52	8.23*	4.29	1.09	-2.74	12.96**
52	ARYP-2 x KDMI-10	19.35*	3.01	14.83	13.50	19.44*	3.54	0.18	1.09	-6.55	-3.30	5.12	3.74	3.28	-0.63	15.40**
53	ARYP-3 x KDMI-10	23.91**	7.01	19.10*	17.72*	23.87*	1.15	-6.39	3.82	-4.03	-0.70	6.27	4.07	5.25	1.26	17.60**
54	ARYP-4 x KDMI-10	23.90**	21.92*	1.94	0.76	6.03	-1.36	-7.00	-0.91	-8.40	-5.22	4.71	4.01	2.19	-1.68	14.18**
55	ARYP-5 x KDMI-10	29.92**	27.37**	7.31	6.07	11.62	4.69	3.28	-2.55	-9.92	-6.78	4.32	0.90	-2.19	-5.89	9.29

Sl. No.	Hybrids	Cob weight (g)					Cob length (cm)					Cob girth (cm)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
56	ARYP-6 x KDMI-10	4.00	-7.67	-3.63	-4.75	0.23	-2.85	-7.04	-4.00	-11.26*	-8.17	-2.82	-6.47	-1.97	-5.68	9.54
57	ARYP-7 x KDMI-10	20.19*	12.11	4.84	3.63	9.05	3.86	1.66	0.18	-7.39	-4.17	7.45	7.45	4.16	0.21	16.38**
58	ARYP-8 x KDMI-10	9.98	-2.13	1.60	0.42	5.67	-2.11	-9.89*	1.09	-6.55	-3.30	17.17**	15.00**	15.75**	11.37**	29.34**
59	ARYP-9 x KDMI-10	-0.77	-9.39	-11.23	-12.26	-7.67	2.31	-1.77	0.73	-6.89	-3.65	-6.23	-9.11*	-6.13	-9.68*	4.89
60	ARYP-10 x KDMI-10	15.98	5.47	4.27	3.06	8.45	0.99	-5.08	1.82	-5.88	-2.61	3.39	0.21	3.50	-0.42	15.65**
61	ARYP-11 x KDMI-10	11.28	0.30	1.16	-0.02	5.21	-4.62	-9.93	-4.36	-11.60*	-8.52	7.85	3.84	0.66	-3.16	12.47*
62	ARYP-12 x KDMI-10	27.17**	24.90*	4.84	3.62	9.04	2.18	0.56	-2.00	-9.41	-6.26	7.92*	7.67	4.38	0.42	16.63**
63	ARYP-13 x KDMI-10	42.27**	25.86*	1.88	0.69	5.96	0.67	0.00	-4.36	-11.60*	-8.52	12.33	10.43*	7.05	2.99	19.61**
64	ARYP-14 x KDMI-10	15.79	8.22	0.78	-0.39	4.82	7.72	6.60	2.73	-5.04	-1.74	2.07	-1.47	2.63	-1.26	14.67**
65	ARYP-15 x KDMI-10	30.73**	26.38*	2.30	1.11	6.40	7.38	6.55	0.55	-7.06	-3.83	12.89	9.71*	6.35	2.32	18.83**
66	ARYP-16 x KDMI-10	31.28**	28.02*	9.05	7.78	13.42	1.13	-0.74	-2.73	-10.08	-6.96	6.61	5.78	4.16	0.21	16.38**
67	ARYP-17 x KDMI-10	31.06**	26.67**	9.91	8.63	14.31	1.20	-3.00	-0.18	-7.73	-4.52	10.41*	6.55	3.28	-0.63	15.40*
68	ARYP-18 x KDMI-10	2.99	-9.10	-3.85	-4.97	0.01	-2.62	-8.33	-2.00	-9.41	-6.26	1.32	-1.49	1.09	-2.74	12.96**
69	ARYP-19 x KDMI-10	25.77**	23.71*	0.14	-1.02	4.15	10.21	7.13	1.09	-6.55	-3.30	0.68	0.68	-2.41	-6.11	9.05
70	ARYP-20 x KDMI-10	13.64	12.10	-6.73	-7.81	-2.99	3.81	0.18	1.64	-6.05	-2.78	-0.90	-1.56	-3.28	-6.95	8.07
71	ARYP-21 x KDMI-10	8.31	-4.50	1.26	0.08	5.32	5.86	3.90	1.82	-5.88	-2.61	-0.61	-3.57	-0.61	-4.38	11.05*
72	ARYP-22 x KDMI-10	16.38	7.94	2.20	1.01	6.29	-0.55	-4.76	-1.82	-9.24	-6.09	8.62*	8.13	4.81	0.84	17.11**
73	ARYP-23 x KDMI-10	4.46	-9.43	-0.12	-1.28	3.89	-7.30	-14.72**	-4.18	-11.43*	-8.35	1.87	-0.64	1.31	-2.53	13.20*
74	ARYP-24 x KDMI-10	35.00**	30.61**	5.73	4.50	9.96	7.82	6.81	2.73	-5.04	-1.74	15.09**	11.06*	7.66	3.58	20.29**
75	ARYP-25 x KDMI-10	27.82**	17.72	13.17	11.86	17.71	4.98	0.71	3.45	-4.37	-1.04	2.74	-0.00	2.41	-1.47	14.43**
76	ARYP-1x NEI-9202B	5.21	2.42	2.38	1.19	6.48	2.55	-4.08	2.55	-5.21	-1.91	4.87	0.00	-1.09	-4.84	10.51
77	ARYP-2 x NEI-9202B	-2.74	-7.77	2.82	1.62	6.94	-1.31	-4.08	2.55	-5.21	-1.91	5.84	5.49	5.03	1.05	17.36**
78	ARYP-3 x NEI-9202B	15.36*	9.48	21.85*	20.43*	26.73**	2.17	0.33	11.27*	2.86	6.43	6.76	5.58	6.78	2.74	19.32**
79	ARYP-4 x NEI-9202B	13.00	3.77	3.72	2.51	7.88	-6.98	-7.14	-0.73	-8.24	-5.04	3.00	2.65	1.53	-2.32	13.45**
80	ARYP-5 x NEI-9202B	23.48**	13.78	13.73	12.40	18.29*	3.93	-3.40	3.27	-4.54	-1.22	9.01*	4.42	3.28	-0.63	15.40**

Sl. No.	Hybrids	Cob weight (g)					Cob length (cm)					Cob girth (cm)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
81	ARYP-6 x NEI-9202B	13.82	11.42	16.28	14.93	20.94**	5.54	3.74	10.91	2.52	6.09	1.40	-1.46	3.28	-0.63	15.40**
82	ARYP-7 x NEI-9202B	9.11	5.60	5.55	4.33	9.78	1.06	-2.89	3.82	-4.03	-0.70	3.24	2.21	1.09	-2.74	12.96**
83	ARYP-8 x NEI-9202B	17.87*	15.68	20.08*	18.69*	24.90**	-2.07	-4.38	7.27	-0.84	2.61	5.26	4.35	5.03	1.05	17.36**
84	ARYP-9 x NEI-9202B	11.06	9.96	9.91	8.63	14.31	0.17	-1.87	4.91	-3.03	0.35	5.41	3.18	6.56	2.53	19.07**
85	ARYP-10 x NEI-9202B	-2.76	-3.29	-3.34	-4.46	0.54	-0.17	-0.37	6.91	-1.18	2.26	-2.16	-4.24	-1.09	-4.84	10.51*
86	ARYP-11 x NEI-9202B	3.40	2.94	3.82	2.61	7.98	-6.14	-6.46	0.00	-7.56	-4.35	8.82*	3.76	2.63	-1.26	14.67**
87	ARYP-12 x NEI-9202B	22.05**	12.27	12.22	10.92	16.72	12.81**	7.82	15.27**	6.55	10.26	1.46	0.22	-0.88	-4.63	10.76*
88	ARYP-13 x NEI-9202B	30.55**	5.94	5.89	4.66	10.14	-1.97	-7.14	-0.73	-8.24	-5.04	8.86*	5.97	4.81	0.84	17.11**
89	ARYP-14 x NEI-9202B	10.74	6.96	6.91	5.67	11.19	9.48*	4.08	11.27*	2.86	6.43	-8.84*	-11.13**	-7.44	-10.95	3.42
90	ARYP-15 x NEI-9202B	42.03**	24.70**	24.64**	23.19**	29.64**	7.37	0.34	7.27	-0.84	2.61	15.86**	11.50*	10.28*	6.11	23.23**
91	ARYP-16 x NEI-9202B	1.88	-5.65	-5.69	-6.78	-1.91	-0.44	-4.59	2.00	-5.71	-2.43	1.33	-1.55	-2.63	-6.32	8.80
92	ARYP-17 x NEI-9202B	13.47	5.98	5.93	4.70	10.18	0.17	-1.70	5.09	-2.86	0.52	15.51**	10.40*	9.19*	5.05	22.00**
93	ARYP-18 x NEI-9202B	-1.27	-3.99	1.57	0.39	5.64	2.04	2.04	9.09	0.84	4.35	-3.58	-5.33	-2.84	-6.53	8.56
94	ARYP-19 x NEI-9202B	6.63	-4.93	-4.97	-6.07	-1.16	5.19	-3.57	3.09	-4.71	-1.39	-3.46	-4.42	-5.47	-9.05*	5.62
95	ARYP-20 x NEI-9202B	38.02**	26.46**	26.40**	24.93**	31.47**	2.09	-0.51	6.36	-1.68	1.74	11.21**	10.84*	9.63	5.47	22.49**
96	ARYP-21 x NEI-9202B	-2.44	-5.24	0.48	-0.69	4.51	0.80	-3.40	3.27	-4.54	-1.22	-4.23	-6.16	-3.28	-6.95	8.07
97	ARYP-22 x NEI-9202B	20.62**	17.44*	17.39*	16.03	22.10*	8.23	6.29	13.64*	5.04	8.70	5.72	4.20	3.06	-0.84	15.16**
98	ARYP-23 x NEI-9202B	9.95	4.80	15.58	14.23	20.21*	-6.14	-8.41	2.91	-4.87	-1.57	5.01	3.43	5.47	1.47	17.85**
99	ARYP-24 x NEI-9202B	36.06**	19.54*	19.49*	18.10*	24.28**	3.13	-2.04	4.73	-3.19	0.17	12.50	7.52	6.35	2.32	18.83**
100	ARYP-25 x NEI-9202B	21.78**	19.46*	19.40*	18.02*	24.19**	6.16	4.08	11.27*	2.86	6.43	4.78	2.99	5.47	1.47	17.85**
	SE	14.62	16.88				0.88	1.02				0.58	0.67			
	DMH -2 (C)			0.00	-1.16	4.01			0.00	-7.56	-4.35			0.00	-3.79	11.74
	900-M (C)			1.18	0.00	5.23			8.18	0.00	3.48			3.94	0.00	16.14
	PRABHA (C)			-3.85	-4.97	0.00			4.55	-3.36	0.00			-10.50	-13.89	0.00
	Min			-11.23	-12.26	-7.67			-8.00	-14.96	-12.00			-7.44	-10.95	3.42
	Max			26.40	24.93	31.47			15.27	6.55	10.26			15.75	11.37	29.34
	Avg			6.40	5.16	10.66			2.87	-4.91	-1.60			2.18	-1.70	14.17

MP – Mid parent, BP – Better parent, 900-M – Cargil 900-M, PRA – Prabha
* and ** significant at 1% and 5% level of probability, respectively

Hybrid ARYP-8 × KDMI-10 (11.37) exhibited significant superiority over check Cargil 900-M and ARYP-8 × KDMI-10 (15.75), ARYP-15 × NEI-9202B (10.28) and ARYP-17 × NEI-9202B (9.19) exhibited significant superiority over DMH-2 for this trait (Table 28).

4.7.10 Number of kernel rows per cob

Twenty five, thirteen and five of the crosses exhibited highly significant positive relative heterosis, heterobeltiosis and standard heterosis respectively. Thirty four crosses showed significant positive heterosis in positive direction over check Prabha. However, none of the hybrids showed significant heterosis over standard check DMH-2 and Cargil 900-M

The magnitude of heterosis ranged from -10.24 (ARYP-19 × CM-111) to 21.05 per cent (ARYP-23 × NEI-9202B) for relative heterosis, from -14.04 (ARYP-22 × NEI-9202B) to 20.21 per cent (ARYP-11 × NEI-9202B) for heterobeltiosis and -12.38 (ARYP-19 × CM-111) to 16.19 per cent (ARYP-25 × CI-5) over DMH-2, -22.03 (ARYP-19 × CM-111) to 3.39 per cent (ARYP-25 × CI-5) over Cargil 900-M and -5.15 (ARYP-19 × CM-111) to 25.77 per cent (ARYP-25 × CI-5) over Prabha showed heterosis (Table 29).

Top five crosses viz., ARYP-25 × CI-5 (16.19), ARYP-17 × CM-111 (14.29), ARYP-13 × CM-111 (13.33), ARYP-15 × CM-111 (12.38) and ARYP-8 × KDMI-10 (12.38) exhibited significant superiority over check DMH-2 (Table 29).

4.7.11 Number of kernels per row

The magnitude of heterosis varied from -10.26 (ARYP-6 × KDMI-10) to 26.39 (ARYP-20 × CI-5) for relative heterosis, from -15.82 (ARYP-6 × KDMI-10) to 21.04 (ARYP-19 × KDMI-10) for heterobeltiosis and from 0.39 (ARYP-22 × KDMI-10) to 27.70 (ARYP-19 × KDMI-10) for DMH-2 from -12.80 (ARYP-22 × KDMI-10) to 10.92 (ARYP-19 × KDMI-10) and for Cargil 900-M -14.98 (ARYP-22 × KDMI-10) to 8.15 (ARYP-19 × KDMI-10) for standard heterosis Prabha (Table 29).

Thirty five hybrids showed highly significant positive heterosis for relative heterosis, five crosses showed highly significant positive heterobeltiosis. Fifty seven hybrids showed significant positive heterosis over check DMH-2. One hybrid showed significant positive heterosis over check Cargil 900-M and none of them showed significant heterosis over Prabha.

Hybrids ARYP-19 × KDMI-10 (10.92) and five hybrids viz., ARYP-19 × KDMI-10 (27.70), ARYP-3 × NEI-9202B (26.33), ARYP-12 × NEI-9202B (25.74), ARYP-8 × NEI-9202B (24.95) and ARYP-14 × NEI-9202B (24.05) exhibited significant superiority over Cargil 900-M and other check, respectively for this trait (Table 29).

4.7.12 Number of kernels per cob

The magnitude of heterosis ranged from -9.46 (ARYP-6 × KDMI-10) to 38.22 (ARYP-13 × CM-111) for mid parent, from -16.73 (ARYP-6 × KDMI-10) to 36.93 (ARYP-13 × CM-111) for better parent and from 0.07 (ARYP-8 × CM-111) to 36.30 (ARYP-17 × CM-111) over DMH-2, from -25.38 (ARYP-22 × KDMI-10) to 1.63 (ARYP-17 × CM-111) over check Cargil 900-M and from -10.57 (ARYP-22 × KDMI-10) to 21.81 (ARYP-17 × CM-111) over check Prabha (Table 29).

Thirty eight crosses showed significant positive heterosis for relative heterosis. Twelve crosses showed significant positive heterosis for heterobeltiosis. Eight hybrids showed significant positive heterosis for standard check DMH-2, however, none of the hybrids showed significant heterosis over Cargil 900-M and five crosses showed significant and three crosses showed only significant positive heterosis over check Prabha.

Among crosses which exhibited significant superiority over DMH-2, top crosses were viz., ARYP-17 × CM-111 (36.30), ARYP-13 × CM-111 (35.16), ARYP-3 × CM-111 (32.35), ARYP-3 × NEI-9202B (27.94) and ARYP-8 × NEI-9202B (26.38) exhibited superiority which varied from 26.33 to 36.30 (Table 29).

Table 29: Mid, better parents and standard heterosis for number of kernel rows per cob, number of kernels per row and pith weight in maize

Sl. No.	Hybrids	Number of kernel rows per cob					Number of kernels per row					Number of kernels per cob				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
1	ARYP-1 x CM-111	-10.14*	14.68**	-11.43	-21.19**	-4.12	24.88**	20.49**	24.75**	8.36	5.66	12.44	10.50	10.87	-17.33**	-0.92
2	ARYP-2 x CM-111	0.48	-5.41	0.00	-11.02*	8.25	16.59**	15.37*	19.45**	3.75	1.16	16.88*	10.75	19.85*	-10.63	7.11
3	ARYP-3 x CM-111	13.12**	9.86	8.81	-3.18	17.78**	11.57*	6.56	21.22**	5.29	2.66	25.88**	16.70*	32.35**	-1.32	18.28*
4	ARYP-4 x CM-111	4.90	0.94	1.90	-9.32	10.31	9.09	5.69	16.70**	1.37	-1.16	14.16*	6.50	19.14*	-11.16	6.48
5	ARYP-5 x CM-111	4.57	4.04	-1.90	-12.71**	6.19	-0.82	-4.40	6.68	-7.34	-9.65	3.91	-0.35	5.15	-21.60**	-6.03
6	ARYP-6 x CM-111	6.80	1.85	4.76	-6.78	13.40*	-1.40	-8.32	10.41	-4.10	-6.49	4.65	-6.92	15.76	-13.68*	3.46
7	ARYP-7 x CM-111	-5.88	-9.43	-8.57	-18.64**	-1.03	0.33	11.86*	16.70**	1.37	-1.16	5.61	1.38	6.76	-20.39**	-4.59
8	ARYP-8 x CM-111	12.44**	9.71	7.62	-4.24	16.49**	-4.28	-11.33*	7.66	-6.48	-8.82	7.49	-2.61	16.16*	-13.38*	3.82
9	ARYP-9 x CM-111	-0.94	-7.89	0.00	-11.02*	8.25	4.71	-1.51	15.72*	0.51	-2.00	3.21	-9.32	16.00*	-13.51*	3.66
10	ARYP-10 x CM-111	2.46	-0.95	-0.95	-11.86*	7.22	5.25	0.69	14.15*	-0.85	-3.33	7.76	-0.28	13.53	-15.35*	1.46
11	ARYP-11 x CM-111	19.79**	17.35**	9.52	-2.54	18.56**	-4.52	-8.81	3.73	-9.90	-12.15*	14.44*	11.43	13.95	-15.04*	1.83
12	ARYP-12 x CM-111	5.19	1.91	1.43	-9.75*	9.79	13.15*	12.83*	17.49**	2.05	-0.50	19.43**	15.45*	19.82*	-10.66	7.08
13	ARYP-13 x CM-111	16.10**	11.21*	13.33*	0.85	22.68**	19.06**	14.99*	19.06**	3.41	0.83	38.22**	36.95**	35.16**	0.78	20.79**
14	ARYP-14 x CM-111	-0.49	-4.67	-2.86	-13.56**	5.15	4.40	-2.63	16.50**	1.19	-1.33	3.66	-7.21	13.72	-15.21*	1.63
15	ARYP-15 x CM-111	14.01**	8.26	12.38*	0.00	21.65**	-1.58	-3.47	3.93	-9.73	-11.98	12.10	4.49	17.12*	-12.67*	4.67
16	ARYP-16 x CM-111	-0.92	-10.00*	2.86	-8.47	11.34	19.70**	19.35**	23.58**	7.34	4.66	18.05**	7.52	26.78**	-5.47	13.30
17	ARYP-17 x CM-111	19.40**	16.50**	14.29**	1.69	23.71**	10.30*	6.14	18.86**	3.24	0.67	31.58**	23.57**	36.30**	1.63	21.81**
18	ARYP-18 x CM-111	10.55*	8.91	4.76	-6.78	13.40*	4.32	1.07	11.59	-3.07	-5.49	15.38*	10.13	17.35*	-12.50*	4.87
19	ARYP-19 x CM-111	-10.24*	-14.02**	-12.38*	-22.03**	-5.15	21.60**	18.60**	22.79**	6.66	3.99	9.23	7.20	7.86	-19.58**	-3.61
20	ARYP-20 x CM-111	-5.05	-6.00	-10.48	-20.34**	-3.09	11.39*	8.54	12.38*	-2.39	-4.83	5.93	4.25	0.99	-24.70**	-9.75
21	ARYP-21 x CM-111	2.94	-0.94	0.00	-11.02*	8.25	12.27*	8.50	20.43**	4.61	2.00	15.01*	7.04	20.37*	-10.25	7.57
22	ARYP-22 x CM-111	7.55	0.00	8.57	-3.39	17.53**	10.86*	10.34	15.32*	0.17	-2.33	19.03**	10.08	25.50**	-6.42	12.16
23	ARYP-23 x CM-111	8.25	7.14	0.00	-11.02*	8.25	3.28	-3.16	14.54*	-0.51	-3.00	12.20	6.18	15.21	-14.10*	2.96
24	ARYP-24 x CM-111	17.00**	14.71**	11.43	-0.85	20.62**	10.36*	8.16	11.98	-2.73	-5.16	29.27**	29.20**	25.29**	-6.58	11.97
25	ARYP-25 x CM-111	14.85**	11.54*	10.48	-1.69	19.59**	5.41	0.34	14.93*	-0.17	-2.66	20.77**	11.76	27.24**	-5.12	13.72
26	ARYP-1 x CI-5	2.88	-1.83	1.90	-9.32	10.31	19.49**	14.69*	10.41	-4.10	-6.49	22.44**	12.44	12.81	-15.88**	0.82
27	ARYP-2 x CI-5	0.95	-4.50	0.95	-10.17*	9.28	14.99**	7.75	9.23	-5.12	-7.49	15.58*	2.61	11.05	-17.20**	-0.76
28	ARYP-3 x CI-5	3.45	0.96	0.00	-11.02*	8.25	3.69	-7.77	4.91	-8.87	-11.15*	6.49	-7.35	5.07	-21.65**	-6.10

Contd.....

Sl. No.	Hybrids	Number of kernel rows per cob					Number of kernels per row					Number of kernels per cob				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
29	ARYP-4 x CI-5	1.46	-1.89	-0.95	-11.86*	7.22	6.61	-3.91	6.09	-7.85	-10.15	7.90	-5.57	5.63	-21.24**	-5.60
30	ARYP-5 x CI-5	7.07	7.07	0.95	-10.17*	9.28	3.63	-7.04	3.73	-9.90	-12.15*	10.56	-0.75	4.73	-21.91**	-6.41
31	ARY7-6 x CI-5	3.38	-0.93	1.90	-9.32	10.31	17.48**	1.96	22.79**	6.66	3.99	20.40**	0.83	25.40**	-6.50	12.07
32	ARYP- 7x CI-5	-7.32	-10.38*	-9.52	-19.49**	-2.06	19.14**	10.17	14.93*	-0.17	-2.66	9.97	-1.19	4.06	-22.41**	-7.01
33	ARYP-8 x CI-5	13.86**	11.65*	9.52	-2.54	18.56**	5.52	-8.74	10.81	-3.75	-6.16	19.59**	2.18	21.88**	-9.13	8.92
34	ARYP-9 x CI-5	0.47	-6.14	1.90	-9.32	10.31	1.05	-11.37*	4.13	-9.56	-11.81*	0.70	-16.61**	6.66	-20.47**	-4.68
35	ARYP-10 x CI-5	-3.92	-6.67	-6.67	-16.95**	1.03	12.26*	0.00	13.36*	-1.54	-3.99	7.47	-6.64	6.28	-20.75**	-5.02
36	ARYP-11 x CI-5	8.89	6.06	0.00	-11.02*	8.25	7.38	-4.49	8.64	-5.63	-7.99	17.37*	6.86	9.27	-18.52**	-2.35
37	ARYP-12 x CI-5	-1.72	-4.31	-4.76	-15.25**	3.09	12.33*	3.96	8.25	-5.97	-8.32	10.04	-0.48	3.28	-22.99**	-7.70
38	ARYP-13 x CI-5	4.85	0.93	2.86	-8.47	11.34	17.20**	12.42	8.45	-5.80	-8.15	22.73**	13.56	12.08	-16.43**	0.16
39	ARYP-14 x CI-5	2.91	-0.93	0.95	-10.17*	9.28	20.94**	5.25	25.93**	9.39	6.66	23.24**	3.83	27.24**	-5.12	13.72
40	ARYP-15 x CI-5	9.13*	4.30	8.10	-3.81	17.01**	14.51**	4.38	12.38*	-2.39	-4.83	24.17**	8.58	21.70**	-9.26	8.76
41	ARYP-16 x CI-5	0.46	-8.33	4.76	-6.78	13.40*	11.59*	3.82	6.88	-7.17	-9.48	11.17	-4.85	12.20	-16.34**	0.27
42	ARYP-17 x CI-5	8.91	6.80	4.76	-6.78	13.40*	7.15	-4.04	7.47	-6.66	-8.99	15.99*	2.12	12.64	-16.01**	0.67
43	ARYP-18 x CI-5	-1.50	-2.48	-6.19	-16.53**	1.55	15.10**	3.74	14.54*	-0.51	-3.00	13.35	1.32	7.96	-19.50**	-3.52
44	ARYP-19 x CI-5	-3.64	-7.24	-5.48	-15.89**	2.32	18.28**	12.38*	10.61	-3.92	-6.32	13.68	4.26	4.90	-21.78**	-6.25
45	ARYP-20 x CI-5	1.51	1.00	-3.81	-14.41**	4.12	26.39**	20.20**	18.07**	2.56	0.00	27.69**	20.97*	13.48	-15.39	1.41
46	ARYP-21 x CI-5	3.41	0.00	0.95	-10.17*	9.28	15.35**	3.72	15.13**	0.00	-2.50	18.95**	3.87	16.80*	-12.91	4.38
47	ARYP-22 x CI-5	-1.41	-7.89	0.00	-11.02*	8.25	17.80**	8.83	13.75*	-1.19	-3.66	14.90*	-0.25	13.72	-15.21*	1.63
48	ARYP-23 x CI-5	15.90**	14.14*	7.62	-4.24	16.49**	10.16*	-3.65	13.95*	-1.02	-3.49	27.83**	13.36	23.00**	-8.29	9.92
49	ARYP-24 x CI-5	9.45*	7.84	4.76	-6.78	13.40*	15.99**	9.68	9.04	-5.29	-7.65	26.71**	18.20*	14.62	-14.54*	2.43
50	ARYP-25 x CI-5	20.20**	17.31**	16.19**	3.39	25.77**	6.96	-5.17	8.64	-5.63	-7.99	28.27**	11.42	26.85**	-5.42	13.36
51	ARYP-1 x KDMI-10	3.29	0.92	4.76	-6.78	13.40*	5.94	1.30	6.88	-7.17	-9.48	9.77	7.63	12.37	-16.21**	0.43
52	ARYP-2 x KDMI-10	6.98	3.60	9.52	-2.54	18.56**	3.89	1.86	7.47	-6.66	-8.99	11.09	9.13	18.11*	-11.94*	5.55
53	ARYP-3 x KDMI-10	4.33	4.33	3.33	-8.05	11.86*	4.30	0.52	14.34*	-0.68	-3.16	9.37	5.03	19.12*	-11.18	6.45
54	ARYP-4 x KDMI-10	-0.95	-1.89	-0.95	-11.86*	7.22	8.28	5.87	16.90*	1.54	-1.00	7.91	4.31	16.69*	-12.99*	4.28

Sl. No.	Hybrids	Number of kernel rows per cob					Number of kernels per row					Number of kernels per cob				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
55	ARYP-5 x KDMI-10	1.48	-0.96	-1.90	-12.71**	6.19	2.99	0.18	11.79	-2.90	-5.32	4.88	4.33	10.08	-17.92**	-1.62
56	ARYP-6 x KDMI-10	0.94	-0.93	1.90	-9.32	10.31	-10.26*	-15.82**	1.38	-11.95*	-14.14**	-9.46	-16.73**	3.57	-22.78**	-7.44
57	ARYP-7 x KDMI-10	-2.86	-3.77	-2.86	-13.56**	5.15	3.75	3.17	8.84	-5.46	-7.82	0.90	0.47	5.80	-21.11**	-5.45
58	ARYP-8 x KDMI-10	14.01**	13.46*	12.38*	0.00	21.65**	-7.71	-13.75**	4.72	-9.04	-11.31*	6.07	-0.55	18.63*	-11.55	6.01
59	ARYP-9 x KDMI-10	-5.50	-9.65*	-1.90	-12.71**	6.19	-2.20	-7.19	9.04	-5.29	-7.65	-7.42	-15.93*	7.54	-19.82**	-3.90
60	ARYP-10 x KDMI-10	-6.22	-6.67	-6.67	-16.95**	1.03	7.54	3.81	17.68**	2.22	-0.33	0.88	-3.30	10.09	-17.92**	-1.62
61	ARYP-11 x KDMI-10	0.00	-4.81	-5.71	-16.10**	2.06	1.08	-2.59	10.81	-3.75	-6.16	1.27	0.23	4.64	-21.98**	-6.48
62	ARYP-12 x KDMI-10	7.43	7.18	6.67	-5.08	15.46**	1.41	0.74	6.29	-7.68	-9.98	9.26	8.93	13.73	-15.20*	1.64
63	ARYP-13 x KDMI-10	4.27	2.80	4.76	-6.78	13.40*	7.39	2.79	8.45	-5.80	-8.15	11.95	8.89	13.69	-15.23*	1.60
64	ARYP-14 x KDMI-10	0.47	-0.93	0.95	-10.17*	9.28	4.71	-1.48	17.88**	2.39	-0.17	4.83	-2.93	18.96*	-11.30	6.32
65	ARYP-15 x KDMI-10	1.41	-0.92	2.86	-8.47	11.34	-0.83	-1.82	5.70	-8.19	-10.48*	0.77	-2.68	9.08	-18.67**	-2.52
66	ARYP-16 x KDMI-10	2.68	-4.17	9.52	-2.54	18.56**	1.04	-0.19	5.30	-8.53	-10.82*	4.18	-1.79	15.81	-13.65*	3.50
67	ARYP-17 x KDMI-10	9.18*	8.65	7.62	-4.24	16.49**	0.45	-2.46	9.23	-5.12	-7.49	9.78	6.85	17.85*	-12.12*	5.33
68	ARYP-18 x KDMI-10	9.76*	8.17	7.14	-4.66	15.98**	-5.19	-7.30	2.36	-11.09*	-13.31*	4.39	3.34	10.11	-17.90**	-1.59
69	ARYP-19 x KDMI-10	-7.11	-8.41	-6.67	-16.95**	1.03	25.24**	21.04**	27.70**	10.92*	8.15	16.50*	14.39	19.43*	-10.95	6.73
70	ARYP-20 x KDMI-10	5.39	3.37	2.38	-8.90	10.82	0.48	-2.98	2.36	-11.09*	-13.31*	6.18	0.79	5.23	-21.54**	-5.96
71	ARYP-21 x KDMI-10	3.81	2.83	3.81	-7.63	12.37*	7.26	4.60	16.11*	0.85	-1.66	11.48	7.49	20.87*	-9.87	8.02
72	ARYP-22 x KDMI-10	-4.59	-8.77	-0.95	-11.86*	7.22	-4.40	-4.84	0.39	-12.80*	-14.98**	-8.36	-12.22	0.07	-25.38**	-10.57
73	ARYP-23 x KDMI-10	8.00	3.85	2.86	-8.47	11.34	-5.00	-10.13	6.29	-7.68	-9.98	2.53	0.60	9.15	-18.62**	-2.46
74	ARYP-24 x KDMI-10	-5.83	-6.73	-7.62	-17.80**	0.00	17.35**	13.97*	20.24**	4.44	1.83	10.70	6.76	11.46	-16.89**	-0.39
75	ARYP-25 x KDMI-10	3.85	3.85	2.86	-8.47	11.34	7.86	3.60	18.66**	3.07	0.50	12.10	7.45	22.33**	-8.79	9.32
76	ARYP-1x NEI-9202B	-4.43	-11.01*	-7.62	-17.80**	0.00	14.47**	4.37	22.00**	5.97	3.33	10.24	7.99	12.96	-15.77**	0.95
77	ARYP-2 x NEI-9202B	-1.46	-9.01	-3.81	-14.41**	4.12	4.95	-2.02	14.54*	-0.51	-3.00	3.51	1.77	10.14	-17.87**	-1.57
78	ARYP-3 x NEI-9202B	7.07	1.92	0.95	-10.17*	9.28	9.54*	8.07	26.33**	9.73	6.99	17.37**	12.81	27.94**	-4.61	14.34*
79	ARYP-4 x NEI-9202B	5.00	-0.94	0.00	-11.02*	8.25	-0.95	-3.70	12.57*	-2.22	-4.66	4.10	0.72	12.67	-15.99**	0.69
80	ARYP-5 x NEI-9202B	11.92*	9.09	2.86	-8.47	11.34	5.42	3.03	20.43**	4.61	2.00	18.32**	17.81*	24.30**	-7.32	11.09

Sl. No.	Hybrids	Number of kernel rows per cob					Number of kernels per row					Number of kernels per cob				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
81	ARYP-6 x NEI-9202B	3.47	-3.24	-0.48	-11.44*	7.73	0.33	-1.14	19.06**	3.41	0.83	3.44	-4.78	18.42*	-11.70	5.83
82	ARYP-7 x NEI-9202B	6.50	0.47	1.43	-9.75*	9.79	-1.78	-7.06	8.64	-5.63	-7.99	5.28	4.93	10.50	-17.61**	-1.25
83	ARYP-8 x NEI-9202B	7.61	2.91	0.95	-10.17*	9.28	4.86	2.91	24.95**	8.53	5.82	12.90*	5.95	26.38**	-5.77	12.94
84	ARYP-9 x NEI-9202B	1.92	-7.02	0.95	-10.17*	9.28	-5.62	-5.85	10.61	-3.92	-6.32	-3.59	-12.37*	12.09	-16.42**	0.17
85	ARYP-10 x NEI-9202B	-0.50	-5.71	-5.71	-16.10**	2.06	-3.07	-4.54	11.59	-3.07	-5.49	-3.34	-7.27	5.57	-21.28**	5.65
86	ARYP-11 x NEI-9202B	20.21**	20.21**	7.62	-4.24	16.49**	-2.04	-3.36	12.97*	-1.88	-4.33	17.88**	16.56*	21.93**	-9.09	8.96
87	ARYP-12 x NEI-9202B	5.79	0.48	0.00	-11.02*	8.25	13.78**	7.56	25.74**	9.22	6.49	21.19**	20.72**	26.27**	-5.85	12.85
88	ARYP-13 x NEI-9202B	9.45*	2.80	4.76	-6.78	13.40	1.10	-7.73	7.86	-6.31	-8.65	11.98	8.82	13.83	-15.13*	1.73
89	ARYP-14 x NEI-9202B	1.49	-4.67	-2.86	-13.56**	5.15	5.65	4.43	24.95**	8.53	5.82	7.13	-0.72	21.67**	-9.28	8.74
90	ARYP-15 x NEI-9202B	5.42	-1.83	1.90	-9.32	10.31	3.94	-0.17	16.70**	1.37	-1.16	10.05	6.38	19.23*	-11.10	6.56
91	ARYP-16 x NEI-9202B	-2.80	-13.33**	-0.95	-11.86*	7.22	10.63*	4.03	21.61**	5.63	3.00	8.80	2.66	21.05*	-9.74	8.18
92	ARYP-17 x NEI-9202B	13.71**	8.74	6.67	-5.08	15.46**	2.83	0.67	17.68**	2.22	-0.33	17.05**	14.02	25.77**	-6.22	12.40
93	ARYP-18 x NEI-9202B	11.79*	7.92	3.81	-7.63	12.37*	1.30	-1.51	15.13*	0.00	-2.50	13.54*	12.51	19.88*	-10.62	7.13
94	ARYP-19 x NEI-9202B	-1.49	-7.48	-5.71	-16.10**	2.06	7.85	-0.67	16.11*	0.85	-1.66	6.56	4.53	9.34	-18.47**	-2.29
95	ARYP-20 x NEI-9202B	18.56**	15.00**	9.52	-2.54	18.56**	9.59	0.84	17.88**	2.39	-0.17	30.81**	24.06**	29.77	-3.24	15.98*
96	ARYP-21 x NEI-9202B	0.00	-5.66	-4.76	-15.25**	3.09	-0.00	-2.52	13.95*	-1.02	-3.49	0.55	-2.96	9.12	-18.64**	-2.48
97	ARYP-22 x NEI-9202B	-5.77	-14.04**	-6.67	-16.95**	1.03	12.51**	6.55	24.56**	8.19	5.49	6.68	2.28	16.61*	-13.05*	4.21
98	ARYP-23 x NEI-9202B	21.05**	19.79**	9.52	-2.54	18.56**	-3.26	-3.82	13.75*	-1.19	-3.66	17.25**	15.15*	24.93**	-6.85	11.65
99	ARYP-24 x NEI-9202B	13.27**	8.82	5.71	-5.93	14.43*	4.27	-3.53	12.77*	-2.05	-4.49	18.61**	14.28	19.54*	-10.87	6.83
100	ARYP-25 x NEI-9202B	8.08	2.88	1.90	-9.32	10.31	5.77	4.71	22.40**	6.31	3.66	14.54*	9.89	25.11**	-6.72	11.81
	SE	0.64	0.74				1.81	2.09				32.89	37.98			
	DMH -2 (C)			0.00	-11.02	8.25			0.00	-13.14	-15.31			10.50	-17.60	-1.24
	900-M (C)			12.38	0.00	21.65			15.13	0.00	-2.50			0.00	-25.44	-10.63
	PRABHA (C)			-7.62	-17.80	0.00			18.07	2.56	0.00			34.11	0.00	19.86**
	Min			-12.38	-22.03	-5.15			0.39	-12.80	-14.98			11.90	-16.57	0.00
	Max			16.19	3.39	25.77			27.70	10.92	8.15			0.07	-25.38	-10.57
	Avg			1.62	-9.57	10.01			13.54	-1.38	-3.84			36.30	1.63	21.81
														15.61	-13.80	3.32

MP – Mid parent, BP – Better parent, 900-M – Cargil 900-M, PRA – Prabha
* and ** significant at 1% and 5% level of probability, respectively

4.7.13 Hundred Seed weight

The magnitude of heterosis ranged from -36.43 (ARYP-23 × CI-5) to 28.79 (ARYP-15 × CM-111) for relative heterosis, from -19.54 (ARYP-25 × CI-5) to 28.40 (ARYP-15 × CM-111) for heterobeltiosis. Standard heterosis ranged from -26.09 (ARYP-9 × KDMI-10) to 2.11 (ARYP-6 × NEI-9202B) over DMH-2, -8.52 (ARYP-9 × KDMI-10) to 26.40 (ARYP-6 × NEI-9202B) over Cargil 900-M and -13.93 (ARYP-9 × KDMI-10) to 18.92 (ARYP-6 × NEI-9202B) over Prabha check hybrid (Table 30).

Thirteen hybrids showed significant positive heterosis and one hybrid exhibited negative heterosis over mid parent. Four hybrids showed significant heterosis over better parent. Eight hybrids showed highly significant positive heterosis over check Cargil 900-M and one cross showed significant positive heterosis for check Prabha. However, none of the hybrids showed significant heterosis over check DMH-2.

Top five hybrids viz., ARYP-6 × NEI-9202B (26.40), ARYP-12 × CI-5 (25.80), ARYP-20 × CM-111 (21.47), ARYP-15 × CI-5 (20.37) and ARYP-22 × CI-5 (19.05) exhibited significant superiority over Cargil 900-M for this trait (Table 30).

4.7.14 Shelling percentage

The magnitude of heterosis for shelling percentage ranged from -5.57 (ARYP-15 × NEI-9202B) to 4.04 per cent (ARYP-3 × KDMI-10) for relative heterosis, from -6.16 (ARYP-15 × NEI-9202B) to 4.04 per cent (ARYP-3 × CM-111) for heterobeltiosis and from -6.07 (ARYP-15 × NEI-9202B) to 2.62 per cent (ARYP-19 × KDMI-10) over check DMH-2, from -7.96 (ARYP-15 × NEI-9202B) to 0.55 per cent (ARYP-19 × KDMI-10) over check Cargil 900-M and from -1.12 (ARYP-15 × CM-111) to 5.37 per cent (ARYP-19 × KDMI-10) over check Prabha (Table 30).

Nine crosses showed significant positive heterosis over mid parent. One cross showed significant positive heterosis over better parent. None of the crosses showed significant heterosis over the checks DMH-2 and Cargil 900-M and eight crosses showed significant positive heterosis over the check Prabha.

Five crosses viz., ARYP-24 × NEI-9202B (5.14), ARYP-19 × NEI-9202B (5.13), ARYP-24 × KDMI-10 (5.04), ARYP-20 × KDMI-10 (4.80) and ARYP-22 × KDMI-10 (4.66) exhibited high percentage significant over check Prabha (Table 30).

4.7.15 Pith weight (g)

The magnitude range from -11.08 (ARYP-19 × NEI-9202B) to 79.01 (ARYP-15 × NEI-9202B) for relative heterosis, from -19.76 (ARYP-3 × CI-5) to 66.92 (ARYP-15 × NEI-9202B) for heterobeltiosis and from -19.63 (ARYP-19 × NEI-9202B) to 61.78 (ARYP-15 × NEI-9202B), for check DMH-2, -9.34 (ARYP-19 × NEI-9202B) to 82.49 (ARYP-15 × NEI-9202B) for standard check Cargil 900-M and -24.47 (ARYP-19 × NEI-9202B) to 52.03 (ARYP-15 × NEI-9202B) for standard heterosis Prabha (Table 30).

Twenty seven crosses showed significant positive heterosis for mid parent. Thirteen crosses showed significant positive heterosis for better parent. Four crosses showed positive standard heterosis over check DMH-2, 18 crosses showed significant positive significant heterosis over standard checks Cargil 900-M and two crosses showed significant positive standard heterosis over check Prabha.

Top five hybrids viz., ARYP-15 × NEI-9202B (82.49), ARYP-15 × CM-111 (51.67), ARYP-11 × CI-5 (45.41), ARYP-12 × NEI-9202B (44.09) and ARYP-8 × NEI-9202B (38.95) exhibited significant superiority over Cargil 900-M (Table 29). However, none of the hybrids were showed negatively significant standard heterosis for this trait.

4.7.16 Grain yield per plant (g)

The magnitude of heterosis for grain yield per plant ranged from -5.16 (ARYP-18 × KDMI-10) to 69.11 (ARYP-13 × CI-5) for relative heterosis, from -16.45 (ARYP-18 × KDMI-10)

Table 30: Mid, better parents and standard heterosis for 100-seed weight, shelling percentage and number of kernels per cob in maize

Sl. No.	Hybrids	100-seed weight (g)					Shelling percentage					Pith weight (g)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
1	ARYP-1 x CM-111	10.26	8.00	-20.36**	-1.42	-7.25	0.62	-0.58	-3.02	-4.98	-0.43	32.79*	31.54	11.18	25.41	4.48
2	ARYP-2 x CM-111	1.20	-9.71	-18.59*	0.77	-5.19	-0.92	-2.50	-1.74	-3.72	0.89	28.95*	21.02	14.42	29.07	7.52
3	ARYP-3 x CM-111	22.26**	14.03	-5.16	17.40	10.46	5.42**	4.40*	1.84	-0.21	4.57**	1.32	-14.88	3.79	17.07	-2.47
4	ARYP-4 x CM-111	5.74	-3.86	-16.94*	2.82	-3.26	0.82	-0.43	-0.39	-2.40	2.27	26.74	26.25	5.51	19.01	-0.86
5	ARYP-5 x CM-111	4.16	0.77	-23.78**	-5.65	-11.23	-1.90	-2.82	-3.39	-5.34*	-0.80	38.77*	33.27*	10.51	24.65	3.85
6	ARYP-6 x CM-111	4.85	-3.83	-18.49	0.89	-5.07	-2.26	-3.44	-3.47	-5.41*	-0.88	30.61*	17.95	21.33	36.86*	14.01
7	ARYP-7 x CM-111	3.51	-5.19	-19.41*	-0.24	-6.14	-0.86	-2.12	-2.03	-4.00*	0.60	19.29	13.70	4.04	17.36	-2.24
8	ARYP-8 x CM-111	6.30	-1.36	-18.50*	0.89	-5.08	1.49	0.03	0.47	-1.56	3.16	13.36	6.49	0.49	13.35	-5.57
9	ARYP-9 x CM-111	17.73*	8.69	-9.20	12.40	5.75	-0.17	-2.51	-0.21	-2.22	2.46	26.06	25.63	4.90	18.33	-1.43
10	ARYP-10 x CM-111	19.95*	9.33	-6.05	16.30*	9.42	1.44	0.84	-0.46	-2.47	2.21	16.72	4.65	9.41	23.41	2.81
11	ARYP-11 x CM-111	10.65	5.49	-17.73*	1.84	-4.18	1.42	1.16	-0.81	-2.81	1.85	24.56	23.71	4.00	17.32	-2.27
12	ARYP-12 x CM-111	10.36	2.67	-15.65*	4.41	-1.76	0.64	-0.97	-3.40	-5.35*	-0.82	34.20*	24.88	20.26	35.66*	13.01
13	ARYP-13 x CM-111	8.07	6.34	-24.80**	-6.92	-12.42	1.97	1.79	-0.35	-2.36	2.32	29.98	18.75	-1.51	11.09	-7.45
14	ARYP-14 x CM-111	2.85	-7.65	-17.94*	1.58	-4.43	-0.80	-2.03	-2.00	-3.98*	0.62	32.21	25.77	15.57	30.36	8.60
15	ARYP-15 x CM-111	28.79**	28.40**	-8.64	13.09	6.40	-1.94	-2.58	-3.70*	-5.64**	-1.12	61.26**	60.40**	34.46**	51.67**	26.35*
16	ARYP-16 x CM-111	17.28	14.29	-14.83	5.42	-0.81	0.80	-0.37	-0.52	-2.52	2.15	35.06*	33.67*	13.19	27.68	6.36
17	ARYP-17 x CM-111	5.64	2.57	-22.99*	-4.67	-10.31	-1.80	-3.41	-2.59	-4.55*	0.02	40.55**	39.07*	15.33	30.10	8.38
18	ARYP-18 x CM-111	1.34	-11.23	-16.51*	3.35	-2.76	-2.23	-3.46	-3.40	-5.34**	-0.81	23.27	10.93	15.01	29.73	8.07
19	ARYP-19 x CM-111	22.46*	21.09*	-14.37	5.99	-0.28	3.93*	3.39	1.91	-0.15	4.64	1.14	0.59	-15.66	-4.86	-20.75
20	ARYP-20 x CM-111	25.93**	15.26	-1.87	21.47*	14.29	3.77*	3.45	0.91	-1.12	3.62	8.05	1.19	-3.88	8.42	-9.68
21	ARYP-21 x CM-111	-0.67	-12.89	-18.29*	1.14	-4.84	-0.23	-0.77	-2.14	-4.11*	0.48	13.65	-0.72	10.21	24.32	3.57
22	ARYP-22 x CM-111	3.50	-9.82	-14.13	6.30	0.01	0.36	-0.00	-1.75	-3.73*	0.89	36.52**	24.63	25.15	41.17*	17.61
23	ARYP-23 x CM-111	7.75	-8.20	-7.78	14.16	7.41	1.66	0.40	0.41	-1.61	3.10	16.05	2.19	11.34	25.59	4.63
24	ARYP-24 x CM-111	26.17**	21.07*	-6.84	15.32	8.50	0.30	-1.94	0.14	-1.88	2.82	42.36**	28.51	6.58	20.23	0.16
25	ARYP-25 x CM-111	13.20	6.12	-14.23	6.17	-0.11	3.30*	3.02	0.50	-1.53	3.19	30.78	-8.31	-0.87	11.82	-6.85
26	ARYP-1 x CI-5	0.15	-12.56	-13.60	6.95	0.63	1.95	-0.00	-1.00	-2.99	1.66	19.46	16.51	-1.52	11.09	-7.45
27	ARYP-2 x CI-5	-1.82	-6.12	-7.23	14.83	8.04	-1.16	-2.02	-1.26	-3.25	1.38	29.18*	19.48	12.97	27.43	6.15
28	ARYP-3 x CI-5	-3.26	-10.92	-11.98	8.96	2.52	3.30*	1.56	0.56	-1.47	3.25	-3.27	-19.76	-2.17	10.35	-8.07

Contd.....

Sl. No.	Hybrids	100-seed weight (g)					Shelling percentage					Pith weight (g)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
29	ARYP-4 x CI-5	-0.80	-7.04	-8.14	13.71	6.98	-0.47	-0.98	-0.95	-2.94	1.71	28.61	26.13	5.42	18.91	-0.94
30	ARYP-5 x CI-5	0.08	-7.65	-12.69	8.07	1.68	-1.38	-1.58	-2.16	-4.13*	0.47	34.74*	39.39	5.58	19.09	-0.79
31	ARY7-6 x CI-5	-4.27	-11.08	-12.13	8.77	2.33	0.62	0.14	0.11	-1.91	2.79	17.99	5.08	8.10	21.94	1.58
32	ARYP-7x CI-5	-4.82	-11.48	-12.52	8.28	1.88	-0.29	-0.84	-0.74	-2.74	1.92	15.25	8.22	-0.97	11.71	-6.94
33	ARYP-8 x CI-5	3.90	-4.60	-5.73	16.69	9.79	0.70	-0.02	0.42	-1.60	3.11	18.07	9.30	3.15	16.35	-3.07
34	ARYP-9 x CI-5	5.90	-2.28	-3.45	19.52	12.45	-1.49	-3.11	-0.82	-2.81	1.84	45.05**	42.33*	18.83	34.04*	11.66
35	ARYP-10 x CI-5	-1.41	-7.84	-8.93	12.73	6.06	0.80	0.65	-0.34	-2.35	2.33	15.76	2.37	7.01	20.71	0.56
36	ARYP-11 x CI-5	2.82	-8.01	-9.10	12.52	5.86	-1.83	-2.31	-3.28	-5.23*	-0.69	56.79**	53.31**	28.91*	45.41**	21.14
37	ARYP-12 x CI-5	12.31	2.85	1.63	25.80**	18.36*	0.87	-0.21	-1.19	-3.18	1.45	31.00*	20.15	15.71	30.53*	8.74
38	ARYP-13 x CI-5	10.49	-6.49	-7.60	14.37	7.61	2.69	2.11	1.10	-0.94	3.81	43.10**	32.64	6.58	20.22	0.15
39	ARYP-14 x CI-5	-0.87	-5.87	-6.98	15.15	8.34	-0.08	-0.59	-0.57	-2.57	2.10	44.33**	35.27*	24.30	40.22*	16.81
40	ARYP-15 x CI-5	14.42	-1.59	-2.76	20.37*	13.26	-1.19	-1.27	-2.25	-4.22*	0.37	48.81**	45.73**	22.16	37.80*	14.79
41	ARYP-16 x CI-5	1.97	-10.57	-11.62	9.40	2.93	2.02	1.59	1.44	-0.60	4.16*	18.63	15.60	-2.11	10.42	-8.02
42	ARYP-17 x CI-5	-4.05	-15.57*	-16.57*	3.28	-2.83	0.75	0.17	0.68	-1.35	3.38	9.29	8.73	-11.73	-0.44	-17.06
43	ARYP-18 x CI-5	-4.31	-6.61	-7.71	14.24	7.48	-1.15	-1.68	-1.61	-3.59*	1.02	20.80	7.21	11.17	25.40	4.47
44	ARYP-19 x CI-5	7.87	-8.33	-9.42	12.13	5.50	2.18	1.95	0.94	-1.09	3.65	11.62	9.21	-8.36	3.37	-13.89
45	ARYP-20 x CI-5	2.95	-4.18	-5.32	17.20	10.27	2.65	1.58	0.57	-1.45	3.27	18.83	9.68	4.17	17.50	-2.11
46	ARYP-21 x CI-5	-8.49	-10.82	-11.87	9.09	2.64	3.00	2.79	1.77	-0.28	4.50*	0.71	-13.19	-3.63	8.71	-9.44
47	ARYP-22 x CI-5	-0.88	-2.68	-3.83	19.05*	12.01	0.14	-0.25	-1.23	-3.22	1.41	29.30*	16.38	16.87	31.83*	9.82
48	ARYP-23 x CI-5	-13.11*	-13.82	-13.42	7.17	0.84	1.54	1.03	1.04	-0.99	3.75*	-2.54	-15.33	-7.74	4.07	-13.31
49	ARYP-24 x CI-5	-0.27	-11.30	-12.35	8.50	2.08	0.17	-1.35	0.74	-1.29	3.44	32.71*	21.52	-2.37	10.13	-8.25
50	ARYP-25 x CI-5	-11.48	-19.54*	-20.49*	-1.58	-7.40	1.29	0.27	-0.72	-2.72	1.94	3.39	-9.88	-2.57	9.90	-8.44
51	ARYP-1 x KDMI-10	2.35	-3.98	-19.19	0.02	-5.89	2.02	-0.27	-0.59	-2.59	2.08	18.33	15.96	-1.99	10.56	-7.90
52	ARYP-2 x KDMI-10	5.55	2.03	-8.01	13.87	7.14	-1.02	-1.56	-0.79	-2.79	1.87	30.35*	21.11	14.50	29.16	7.60
53	ARYP-3 x KDMI-10	17.66*	16.97	-1.57	21.84	14.64	4.04*	1.95	1.63	-0.42	4.35*	4.43	-13.04	6.03	19.60	-0.36
54	ARYP-4 x KDMI-10	1.58	0.26	-13.38	7.23	0.89	0.62	0.45	0.48	-1.54	3.18	17.84	16.13	-2.96	9.46	-8.81

Sl. No.	Hybrids	100-seed weight (g)					Shelling percentage					Pith weight (g)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
55	ARYP-5 x KDMI-10	10.83	5.23	-11.45	9.61	3.13	-1.19	-1.32	-1.63	-3.62*	1.00	45.40**	41.12*	14.50	29.16	7.60
56	ARYP-6 x KDMI-10	9.21	8.82	-7.78	14.15	7.40	1.32	1.18	1.15	-0.89	3.86*	-5.00	-15.03	-12.59	-1.40	-17.86
57	ARYP-7 x KDMI-10	8.09	7.54	-8.59	13.15	6.46	-1.97	-2.18	-2.08	-4.05*	0.55	22.45	15.51	5.71	19.24	0.66
58	ARYP-8 x KDMI-10	1.14	0.23	-15.67	4.39	-1.78	0.52	0.14	0.58	-1.44	3.28	10.18	2.46	-3.32	9.06	-9.15
59	ARYP-9 x KDMI-10	-11.85	-12.16	-26.09**	-8.52	-13.93	-2.30	-3.58*	-1.31	-3.29	1.34	14.42	12.81	-5.80	6.25	-11.48
60	ARYP-10 x KDMI-10	8.99	7.86	-7.31	14.73	7.95	2.07	1.58	1.25	-0.79	3.97	2.61	-8.87	-4.73	7.46	-10.48
61	ARYP-11 x KDMI-10	10.60	6.56	-10.34	10.99	4.43	0.48	-0.34	-0.66	-2.66	2.01	25.70	23.49	3.83	17.13	-2.43
62	ARYP-12 x KDMI-10	2.49	1.27	-14.78	5.49	-0.75	1.41	-0.01	-0.33	-2.34	2.34	17.74	8.46	4.45	17.82	-1.84
63	ARYP-13 x KDMI-10	23.58**	12.06	-5.70	16.72	9.82	-1.39	-2.28	-2.59	-4.55*	0.02	48.61**	37.13*	11.27	25.51	4.56
64	ARYP-14 x KDMI-10	-5.69	-8.19	-18.42	0.99	-4.98	1.41	1.23	1.26	-0.78	3.97*	6.49	0.26	-7.87	3.92	-13.43
65	ARYP-15 x KDMI-10	-0.07	-7.78	-22.40*	-3.95	-9.63	-0.07	-0.49	-0.80	-2.80	1.86	20.35	18.42	-0.73	11.97	-6.72
66	ARYP-16 x KDMI-10	0.02	-5.71	-20.66*	-1.79	-7.60	1.33	1.24	1.09	-0.94	3.80	22.20	19.65	1.32	14.29	-4.79
67	ARYP-17 x KDMI-10	7.23	1.46	-14.63	5.67	-0.57	-1.78	-2.35	-1.51	-3.50	1.13	45.63**	45.49**	18.19	33.32*	11.07
68	ARYP-18 x KDMI-10	-0.11	-5.37	-10.99	10.18	3.66	-0.79	-0.98	-0.91	-2.91	1.74	-0.32	-11.16	-7.89	3.90	-13.44
69	ARYP-19 x KDMI-10	13.04	2.96	-13.37	7.23	0.89	3.52*	2.94	2.62	0.55	5.37	2.87	1.20	-15.14	-4.28	-20.26
70	ARYP-20 x KDMI-10	15.72*	15.05	-2.05	21.25	14.08	3.81	2.39	2.06	0.00	4.80**	-7.53	-14.27	-18.57	-8.14	-23.48
71	ARYP-21 x KDMI-10	-10.33	-14.94	-20.23*	-1.26	-7.10	1.55	1.00	0.68	-1.35	3.38	-0.99	-14.31	-4.87	7.30	-10.61
72	ARYP-22 x KDMI-10	6.68	0.47	-4.32	18.44	11.44	2.99	2.25	1.93	-0.13	4.66*	-0.27	-9.85	-9.48	2.11	-14.93
73	ARYP-23 x KDMI-10	-11.41	-18.60*	-18.23	1.22	-4.76	0.32	0.16	0.17	-1.85	2.86	-4.55	-16.73	-9.28	2.33	-14.75
74	ARYP-24 x KDMI-10	11.17	6.42	-10.47	10.83	4.27	1.38	0.17	2.30	0.23	5.04**	23.40	12.49	-8.72	2.97	-14.22
75	ARYP-25 x KDMI-10	3.28	1.24	-14.81	5.45	-0.78	3.12*	1.74	1.42	-0.62	4.14*	8.71	-4.85	2.87	16.03	-3.34
76	ARYP-1x NEI-9202B	9.23	1.34	-12.65	8.12	1.73	0.06	-2.38	-2.29	-4.26*	0.33	25.22	17.21	13.60	28.14	6.75
77	ARYP-2 x NEI-9202B	0.72	-1.50	-11.20	9.92	3.42	-1.41	-1.74	-0.98	-2.97	1.68	11.79	10.42	7.03	20.73	0.58
78	ARYP-3 x NEI-9202B	9.34	7.43	-7.42	14.60	7.83	1.58	-0.66	-0.57	-2.57	2.09	11.84	0.38	22.38	38.05*	15.00
79	ARYP-4 x NEI-9202B	0.07	-0.05	-13.65	6.89	0.57	1.62	1.59	1.69	-0.36	4.41*	-4.23	-10.83	-13.58	-2.51	-18.79
80	ARYP-5 x NEI-9202B	2.48	-3.79	-17.08	2.64	-3.43	-0.11	-0.45	-0.36	-2.37	2.31	17.81	5.31	2.07	15.14	-4.08

Sl. No.	Hybrids	100-seed weight (g)					Shelling percentage					Pith weight (g)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
81	ARYP-6 x NEI-9202B	19.47*	18.48*	2.11	26.40*	18.92	-0.74	-0.80	-0.71	-2.71	1.96	19.93	16.47	19.81	35.14*	12.58
82	ARYP-7 x NEI-9202B	2.20	1.50	-12.53	8.28	1.88	-2.25	-2.25	-2.15	-4.13*	0.47	23.62	20.16	16.46	31.37*	9.44
83	ARYP-8 x NEI-9202B	7.52	5.30	-9.25	12.34	5.69	-0.82	-0.98	-0.56	-2.56	2.11	28.79*	27.09	23.18	38.95*	15.76
84	ARYP-9 x NEI-9202B	8.31	6.65	-8.08	13.78	7.05	-1.16	-2.25	0.06	-1.96	2.74	18.90	10.67	7.26	20.99	0.79
85	ARYP-10 x NEI-9202B	5.64	5.48	-9.09	12.53	5.88	-1.11	-1.79	-1.70	-3.68*	0.93	3.22	-0.54	3.99	17.30	2.28
86	ARYP-11 x NEI-9202B	0.58	-4.20	-17.43*	2.20	-3.84	1.53	0.49	0.59	-1.44	3.28	9.21	1.98	-1.16	11.49	-7.12
87	ARYP-12 x NEI-9202B	5.57	3.10	-11.14	9.99	3.49	-1.54	-3.00	-2.91	-4.86*	-0.31	32.76**	32.34*	28.27*	44.69**	20.54
88	ARYP-13 x NEI-9202B	18.36*	6.18	-8.49	13.28	6.58	2.25	1.12	1.21	-0.82	3.93*	17.31	0.17	-2.90	9.53	-8.76
89	ARYP-14 x NEI-9202B	1.67	0.14	-11.02	10.14	3.63	-0.11	-0.14	-0.05	-2.07	2.63	11.85	8.94	5.59	19.11	-0.78
90	ARYP-15 x NEI-9202B	21.77**	11.15	-4.20	18.58*	11.57	-5.57**	-6.16**	-6.07**	-7.96**	-3.55	79.01**	66.92**	61.78**	82.49**	52.03**
91	ARYP-16 x NEI-9202B	1.22	-5.63	-18.67*	0.68	-5.27	0.48	0.36	0.45	-1.57	3.14	-0.94	-7.19	-10.05	1.47	-15.47
92	ARYP-17 x NEI-9202B	6.70	-0.17	-13.95	6.51	0.22	-0.52	-0.90	-0.05	-2.06	2.63	18.75	9.10	5.74	19.27	-0.64
93	ARYP-18 x NEI-9202B	6.86	2.39	-3.69	19.21*	12.17	1.40	1.39	1.48	-0.57	4.19*	-8.61	-11.59	-8.34	3.40	-13.86
94	ARYP-19 x NEI-9202B	14.66	3.32	-10.95	10.23	3.71	3.08*	2.29	2.39	0.33	5.13**	-11.08	-17.07	-19.63	-9.34	-24.47
95	ARYP-20 x NEI-9202B	11.49	10.81	-4.50	18.21	11.22	2.45	0.84	0.93	-1.10	3.64*	10.33	9.23	5.86	19.42	-0.52
96	ARYP-21 x NEI-9202B	4.35	0.12	-6.09	16.24	9.37	0.78	0.04	0.12	-1.89	2.81	-5.48	-11.47	-1.73	10.85	-7.65
97	ARYP-22 x NEI-9202B	-1.81	-6.47	-10.93	10.25	3.73	-0.30	-1.21	-1.12	-3.11	1.53	24.80	22.63	23.14	38.90*	15.71
98	ARYP-23 x NEI-9202B	-2.00	-8.96	-8.55	13.21	6.51	0.98	0.94	1.03	-1.01	3.74*	3.50	-2.21	6.54	20.17	0.11
99	ARYP-24 x NEI-9202B	22.58	16.01	-0.02	23.76	16.44	1.28	0.27	2.40	0.34	5.14**	23.93	4.67	1.46	14.45	-4.66
100	ARYP-25 x NEI-9202B	6.35	3.04	-11.20	9.92	3.42	1.89	0.33	0.42	-1.60	3.11	12.12	6.32	14.94	29.65	8.01
	SE	2.53	2.92				1.30	1.50				3.60	4.17			
	DMH -2 (C)			0.00	23.79	16.47			0.00	-2.01	2.68			0.00	12.80	-6.03
	900-M (C)			-19.21	0.00	-5.91			2.06	0.00	4.79			-11.35	0.00	-16.69
	PRABHA (C)			-14.14	6.28	0.00			-2.61	-4.57	0.00			6.42	20.04	0.00
	Min			-26.09	-8.52	-13.93			-6.07	-7.96	-3.55			-19.63	-9.34	-24.47
	Max			2.11	26.40	18.92			2.62	0.55	5.37			61.78	82.49	52.03
	Avg			-11.67	9.34	2.87			-0.39	-2.40	2.28			5.63	19.15	-0.74

MP – Mid parent, BP – Better parent, 900-M – Cargil 900-M, PRA – Prabha

* and ** significant at 1% and 5% level of probability, respectively

Table 31: Mid, better parents and standard heterosis for grain yield per plant and grain weight per hectare in maize

Sl. No.	Hybrids	Grain yield per plant (g)					Grain yield per hectare (Kg/ ha)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
1	ARYP-1 x CM-111	25.66*	23.39	-5.40	-8.57	0.34	53.46**	31.43**	20.23*	12.05	33.95**
2	ARYP-2 x CM-111	20.93*	6.53	3.32	-0.14	9.59	7.39	-15.95*	-3.06	-9.66	8.00
3	ARYP-3 x CM-111	43.01**	27.10*	20.79*	16.75	28.13**	52.85**	35.48**	14.35	6.57	27.40**
4	ARYP-4 x CM-111	33.00**	25.27*	4.74	1.24	11.11	19.50*	-2.02	-0.12	-6.92	11.28
5	ARYP-5 x CM-111	25.05*	24.65	-7.89	-10.97	-2.30	51.06**	43.49**	-6.42	-12.79	4.26
6	ARYP-6 x CM-111	13.50	-3.18	1.32	-2.07	7.47	37.52**	18.39	6.97	-0.31	19.17
7	ARYP-7 x CM-111	11.28	-0.57	-6.65	-9.77	-0.97	33.35**	18.78	-0.87	-7.62	10.44
8	ARYP-8 x CM-111	20.94*	5.43	4.79	1.28	11.16	45.65**	24.53*	14.38	6.60	27.43**
9	ARYP-9 x CM-111	20.00	4.06	4.70	1.20	11.07	39.55**	14.50	16.50	8.57	29.79**
10	ARYP-10 x CM-111	26.40*	10.94	8.53	4.90	15.12	49.41**	33.87**	10.24	2.74	22.82*
11	ARYP-11 x CM-111	20.97	8.19	1.36	-2.03	7.52	52.68**	31.94**	18.15**	10.10	31.63**
12	ARYP-12 x CM-111	27.83*	21.73	-0.56	-3.89	5.48	34.96**	29.10*	-7.80	-14.08	2.72
13	ARYP-13 x CM-111	46.3**	33.72*	-1.19	-4.50	4.81	73.78**	64.63**	7.37	0.06	19.62
14	ARYP-14 x CM-111	25.01*	11.98	4.54	1.04	10.89	72.12**	56.37**	24.82**	16.33	39.06**
15	ARYP-15 x CM-111	42.06**	36.48**	9.44	5.78	16.09	80.09**	66.89**	27.54**	18.86*	42.10**
16	ARYP-16 x CM-111	40.04**	39.69*	11.45	7.72	18.22	48.52**	30.90**	11.93	4.31	24.70*
17	ARYP-17 x CM-111	25.43*	15.50	1.39	-2.00	7.55	78.14**	73.41**	19.44*	11.31	33.06**
18	ARYP-18 x CM-111	6.80	-9.43	-3.85	-7.06	1.99	18.99*	-0.56	-3.40	-9.98	7.62
19	ARYP-19 x CM-111	29.27*	26.44*	-2.29	-5.56	3.65	29.89**	19.46	-7.18	-13.50	3.41
20	ARYP-20 x CM-111	34.94**	28.98*	4.55	1.05	10.90	48.99**	34.50**	8.90	1.49	21.32*
21	ARYP-21 x CM-111	10.05	-6.30	-1.49	-4.78	4.50	33.09	9.44	10.74	3.20	23.37*
22	ARYP-22 x CM-111	35.71**	21.41	13.68	9.87	20.58	50.54**	33.14**	12.93	5.24	25.82*
23	ARYP-23 x CM-111	26.50**	5.53	16.65	12.75	23.74*	44.74**	18.96*	20.51*	12.30	34.26**
24	ARYP-24 x CM-111	49.84**	46.53**	13.28	9.49	20.16	86.18**	70.87**	33.37**	24.29**	48.58**
25	ARYP-25 x CM-111	25.58*	12.17	5.39	1.86	11.79	47.04**	36.48**	3.94	-3.14	15.80
26	ARYP-1 x CI-5	22.84*	22.42	-5.50	-8.66	0.25	43.36**	24.09*	13.52	5.79	26.47**
27	ARYP-2 x CI-5	21.61*	9.21	5.91	2.37	12.35	16.42	-8.03	6.07	-1.15	18.17
28	ARYP-3 x CI-5	18.80	7.65	2.30	-1.12	8.52	45.48**	30.38**	10.05	2.56	22.61*

Contd.....

Sl. No.	Hybrids	Grain yield per plant (g)					Grain yield per hectare (Kg/ ha)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
29	ARYP-4 x CI-5	25.16*	20.35	0.64	-2.73	6.75	27.97**	5.96	8.03	0.67	20.35*
30	ARYP-5 x CI-5	25.95*	22.87	-5.15	-8.32	0.62	37.68**	29.24*	-13.56	-19.44*	-3.70
31	ARY7-6 x CI-5	21.70*	5.74	10.65	6.95	17.38	42.32**	23.75*	11.81	4.20	24.57*
32	ARYP- 7x CI-5	12.43	2.44	-3.82	-7.04	2.02	51.07**	36.08**	13.57	5.83	26.52**
33	ARYP-8 x CI-5	22.28*	8.63	7.97	4.36	14.53	36.40**	17.86	8.26	0.89	20.61*
34	ARYP-9 x CI-5	28.96**	13.95	14.65	10.82	21.62	42.07**	17.74*	19.79*	11.64	33.46**
35	ARYP-10 x CI-5	22.15*	9.27	6.89	3.31	13.38	44.08**	30.55**	7.51	0.19	19.78*
36	ARYP-11 x CI-5	24.40*	13.45	6.29	2.74	12.75	35.75**	18.57	6.17	-1.05	18.29
37	ARYP-12 x CI-5	37.72**	33.94**	9.40	5.75	16.05	53.73**	48.86**	6.31	-0.93	18.43
38	ARYP-13 x CI-5	69.11**	51.50**	16.95	13.04	24.05	76.48**	65.21**	10.50	2.98	23.11*
39	ARYP-14 x CI-5	43.44**	31.03**	22.32**	18.23	29.75**	64.23**	50.92**	20.47*	12.27	34.21**
40	ARYP-15 x CI-5	36.78**	34.23**	7.64	4.04	14.18	49.46**	40.13**	7.10	-0.20	19.31
41	ARYP-16 x CI-5	6.99**	30.50**	11.29	7.56	18.05	55.63**	38.68**	18.59*	10.51	32.12**
42	ARYP-17 x CI-5	15.52	8.55	-4.71	-7.89	1.08	65.13**	62.75**	12.09	4.46	24.88
43	ARYP-18 x CI-5	12.01	-3.27	2.69	-0.74	8.93	33.42**	12.64	9.42	1.97	21.90*
44	ARYP-19 x CI-5	27.83*	27.76*	-1.27	-4.57	4.73	51.72**	41.16**	9.68	2.21	22.19*
45	ARYP-20 x CI-5	40.20**	36.86**	10.94	7.23	17.68	65.92**	51.50**	22.66*	14.31	36.65**
46	ARYP-21 x CI-5	22.92*	6.59	12.06	8.31	18.87	30.24**	8.17	9.45	2.00	21.94*
47	ARYP-22 x CI-5	28.22**	16.96	9.51	5.85	16.17	32.02**	18.07	0.14	-6.67	11.57
48	ARYP-23 x CI-5	7.70	-8.54	1.09	-2.29	7.24	20.96*	0.42	1.72	-5.20	13.33
49	ARYP-24 x CI-5	36.42**	36.32**	5.38	1.86	11.79	53.61**	42.62**	11.32	3.74	24.02*
50	ARYP-25 x CI-5	12.41	2.39	-3.81	-7.02	2.04	51.71**	42.47**	8.51	1.12	20.88*
51	ARYP-1 x KDMI-10	22.22	19.01	-3.71	-6.93	2.14	47.08**	26.29**	15.53	7.67	28.71*
52	ARYP-2 x KDMI-10	29.17**	18.47	14.89	11.05	21.88*	17.88*	-7.53	6.65	-0.61	18.82
53	ARYP-3 x KDMI-10	38.09**	27.83*	21.48*	17.42	28.87**	47.83**	31.38**	10.89	3.34	23.54*
54	ARYP-4 x KDMI-10	25.01*	22.99	2.84	-0.60	9.09	29.35**	6.30	8.37	0.99	20.73**

Sl. No.	Hybrids	Grain yield per plant (g)					Grain yield per hectare (Kg/ ha)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
55	ARYP-5 x KDMI-10	37.37**	31.01*	6.00	2.46	12.44	88.73**	78.76**	17.30	9.31	30.68**
56	ARYP-6 x KDMI-10	5.63	-6.35	-2.00	-5.28	3.95	30.14**	12.33	1.49	-5.42	13.07
57	ARYP-7 x KDMI-10	8.08	0.61	-5.54	-8.70	0.20	26.09*	12.61	-6.02	-12.42	17.79
58	ARYP-8 x KDMI-10	13.69	3.12	2.49	-0.93	8.72	41.82**	21.56*	11.66	4.06	24.40*
59	ARYP-9 x KDMI-10	-3.28	-12.76	-12.22	-15.16	-6.89	4.59	-13.98	-12.48	-18.43*	-2.49
60	ARYP-10 x KDMI-10	18.51	8.27	5.91	2.37	12.34	46.75**	31.84**	8.57	1.18	20.96*
61	ARYP-11 x KDMI-10	15.32	7.45	0.67	-2.70	6.79	30.12**	12.73	0.95	-5.93	12.46
62	ARYP-12 x KDMI-10	29.05**	28.44*	4.91	1.40	11.28	52.80**	46.60**	4.69	-2.44	16.64
63	ARYP-13 x KDMI-10	41.05**	23.80	0.16	-3.19	6.25	68.89**	59.53**	4.68	-2.45	16.62
64	ARYP-14 x KDMI-10	17.47	9.64	2.36	-1.06	8.58	45.45**	32.51**	5.78	-1.43	17.84
65	ARYP-15 x KDMI-10	18.80	18.27	-4.31	-7.51	1.50	53.58**	42.72**	9.07	1.65	21.52*
66	ARYP-16 x KDMI-10	32.94**	29.54*	10.46	6.76	17.17	26.60*	11.87	-4.33	-10.85	6.58
67	ARYP-17 x KDMI-10	28.51**	23.48*	8.39	4.77	14.98	50.22**	46.67**	1.02	-5.86	12.54
68	ARYP-18 x KDMI-10	-5.16	-16.45	-11.29	-14.26	-5.90	11.93	-6.23	-8.91	-15.12	1.48
69	ARYP-19 x KDMI-10	30.13**	27.21*	2.93	-0.52	9.18	49.49**	37.87**	7.12	-0.17	19.35
70	ARYP-20 x KDMI-10	17.85	17.74	-4.57	-7.76	1.23	39.86**	26.61*	2.51	-4.47	14.20
71	ARYP-21 x KDMI-10	10.06	-2.62	2.38	-1.04	8.60	3.68	-14.54	-13.52	-19.41*	-3.66
72	ARYP-22 x KDMI-10	19.55	11.42	4.33	0.84	10.67	32.56**	17.55	-0.29	-7.08	11.08
73	ARYP-23 x KDMI-10	-2.45	-15.52	-6.63	-9.75	-0.95	4.13	-14.21	-13.09	-19.01*	-3.18
74	ARYP-24 x KDMI-10	36.98**	33.92**	8.36	4.74	14.94	56.96**	44.46**	12.75	5.08	25.62*
75	ARYP-25 x KDMI-10	31.59**	22.46*	15.05	11.20	22.04*	38.37**	28.79*	-1.91	-8.59	9.28
76	ARYP-1x NEI-9202B	13.26	-0.18	0.33	-3.03	6.42	18.69*	14.10	13.13	5.43	26.04*
77	ARYP-2 x NEI-9202B	3.35	1.53	2.05	-1.36	8.25	-4.53	-7.23	2.38	-4.59	14.06
78	ARYP-3 x NEI-9202B	24.52**	21.13*	21.75**	17.68	29.15**	22.30**	13.21	12.25	4.61	25.06*
79	ARYP-4 x NEI-9202B	7.20	-1.81	-1.31	-4.61	4.69	-2.95	-4.28	-2.42	-9.06	8.71
80	ARYP-5 x NEI-9202B	19.81	3.67	4.19	0.71	10.52	38.99**	10.62	9.69	2.22	22.20*

Sl. No.	Hybrids	Grain yield per plant (g)					Grain yield per hectare (Kg/ ha)				
		MP	BP	DMH -2	900-M	PRA	MP	BP	DMH -2	900-M	PRA
81	ARYP-6 x NEI-9202B	12.74	10.51	15.64	11.77	22.67*	14.98	9.87	8.94	1.53	21.37*
82	ARYP-7 x NEI-9202B	6.55	3.04	3.56	0.10	9.86	9.41	0.75	-0.10	-6.90	11.30
83	ARYP-8 x NEI-9202B	19.58*	18.91	19.52	15.52	26.78*	18.13*	13.78	12.82	5.14	25.69*
84	ARYP-9 x NEI-9202B	9.77	9.71	10.39	6.70	17.10	15.29*	13.82	15.81	7.93	29.02**
85	ARYP-10 x NEI-9202B	-3.87	-5.15	-4.67	-7.86	1.12	23.72**	13.24	12.28	4.64	25.09
86	ARYP-11 x NEI-9202B	7.85	4.23	4.73	1.22	11.09	20.53*	14.69	13.72	5.98	26.70**
87	ARYP-12 x NEI-9202B	19.98*	8.74	9.29	5.64	15.93	26.29**	8.63	7.70	0.37	19.99
88	ARYP-13 x NEI-9202B	33.02**	6.95	7.49	3.90	14.03	43.44**	13.92	12.95	5.26	25.84*
89	ARYP-14 x NEI-9202B	10.54	6.61	7.15	3.56	13.66	26.76**	14.41	13.44	5.72	26.38*
90	ARYP-15 x NEI-9202B	30.46**	17.27	17.86	13.92	25.03*	32.96**	17.72	16.73	8.78	30.04**
91	ARYP-16 x NEI-9202B	2.39	-5.37	-4.89	-8.07	0.89	2.93	-4.14	-4.96	-11.43	5.89
92	ARYP-17 x NEI-9202B	12.56	5.44	5.97	2.43	12.41	39.83**	18.48*	17.47	9.47	30.87**
93	ARYP-18 x NEI-9202B	0.04	-2.63	3.37	-0.08	9.65	19.99*	18.77*	17.77	9.75	31.20**
94	ARYP-19 x NEI-9202B	9.91	-2.79	-2.30	-5.56	3.64	12.69	0.50	-0.35	-7.14	11.01
95	ARYP-20 x NEI-9202B	27.59**	15.25	15.83	11.96	22.87*	24.33**	12.93	11.97	4.35	24.75*
96	ARYP-21 x NEI-9202B	-1.88	-4.04	0.88	-2.49	7.01	16.02*	14.85	16.22	8.31	29.48**
97	ARYP-22 x NEI-9202B	19.85*	15.75	16.34	12.45	23.41*	24.10**	15.13	14.16	6.38	27.18**
98	ARYP-23 x NEI-9202B	11.10	6.06	17.23	13.31	24.35*	22.79**	21.49*	23.07*	14.69	37.11**
99	ARYP-24 x NEI-9202B	38.09**	22.16*	22.78*	18.67	30.24**	30.85**	16.93	15.94	8.04	29.16**
100	ARYP-25 x NEI-9202B	23.64*	19.61	20.22	16.20	27.52**	17.51*	3.89	3.01	-4.00	14.76
	SE	14.61	16.87				499.77	571.31			
	DMH -2 (C)			0.00	-3.34	6.08			0.00	-6.81	11.41
	900-M (C)			3.46	0.00	9.75			7.31	0.00	19.55
	PRABHA (C)			-5.73	-8.88	0.00			-10.24	-16.35	0.00
	Min			-12.22	-15.16	-6.89			-13.56	-19.44	-3.70
	Max			22.78	18.67	30.24			33.37	24.29	48.58
	Avg			5.18	1.66	11.57			8.25	0.88	20.60

MP – Mid parent, BP – Better parent, 900-M – Cargil 900-M, PRA – Prabha

* and ** significant at 1% and 5% level of probability, respectively

to 51.50 (ARYP-13 $\times$ CI-5) for heterobeltiosis, from -12.22 (ARYP-9 $\times$ KDMI-10) to 22.78 (ARYP-24 $\times$ NEI-9202B) over DMH-2, from -15.16 (ARYP-9 $\times$ KDMI-10) to 18.67 (ARYP-24 $\times$ NEI-9202B) over check Cargil 900-M and -6.89 (ARYP-9 $\times$ KDMI-10) to 30.24 (ARYP-24 $\times$ NEI-9202B) over Prabha composite (Table 31).

Fifty eight hybrids showed significant positive heterosis for relative heterosis, 26 hybrids showed significant positive heterobeltiosis. Five crosses showed significant positive heterosis over check DMH-2. None of hybrids showed significant heterosis over check Cargil 900-M. Fifteen hybrids showed significant positive heterosis over other composite check Prabha.

Among crosses which exhibited significant superiority over DMH-2 top crosses namely ARYP-24 $\times$ CM-111 (33.37), ARYP-15 $\times$ CM-111 (27.54), ARYP-14 $\times$ CM-111 (24.82), ARYP-20 $\times$ CI-5 (22.66) and ARYP-23 $\times$ NEI-9202B (21.49) exhibited superiority which ranged from 20.48 to 22.32 per cent (Table 31).

4.7.17 Grain yield per hectare (kg/ha)

The magnitude of heterosis ranged from -4.53 (ARYP-2 $\times$ NEI-9202B) to 88.73 (ARYP-5 $\times$ KDMI-10) for relative heterosis, from -15.95 (ARYP-2 $\times$ CM-111) to 78.76 (ARYP-5 $\times$ KDMI-10) for heterobeltiosis, from -13.56 (ARYP-5 $\times$ CI-5) to 33.37 (ARYP-24 $\times$ CM-111) for check DMH-2, from -19.44 (ARYP-5 $\times$ CI-5) to 24.29 (ARYP-24 $\times$ CM-111) over check Cargil 900-M and from -3.70 (ARYP-5 $\times$ CI-5) to 48.58 (ARYP-24 $\times$ CM-111) over check Prabha (Table 31).

Eighty seven crosses showed positive significant heterosis over mid parent, 51 crosses showed significant positive heterosis over better parent, 12 crosses showed significant positive heterosis over check DMH-2, two crosses showed significant positive heterosis over other check Prabha.

Among crosses, ARYP-24 $\times$ CM-111 (24.29) and ARYP-15 $\times$ CM-111 (18.86) which exhibited significant superiority over Cargil 900-M and the same two crosses also exhibited significant superiority over DMH-2 (Table 31).

V. DISCUSSION

Maize is an important cereal crop and the demand for its grain is increasing every year because of its diverse use. One of the major achievements in plant breeding has been the exploitation of heterosis through the commercial cultivation of hybrid. The cultivation of hybrids is in use in cross pollinated, often cross pollinated and even in self pollinated crops. The commercial exploitation of hybrid vigour through the single crosses was suggested by the Shull (1909) in a publication "A pure line method of corn breeding" outlining three essential steps a) large scale inbreeding to obtain many homozygous or near homozygous lines. b) testing the selected pure lines in all possible crosses and c) utilizing the best cross for practical corn production.

Hybrid maize breeding in India started with introduction of germplasm from USA, Mexico and Latin America by the Rock Feller foundation. The large scale inbreeding programme were carried out in India and adapted exotic germplasm coupled with the use of off season nursery and early generation testing has led to the development of inbred lines, which were poor in yield and other agronomic traits as these were derivatives of either indigenous or some what adapted exotic varieties. As a result four double cross hybrids instead of single crosses were released for cultivation during 1961 in India. The programme to obtain superior inbred lines through population improvement rather started late in our country in early eighty's due to the impact of composite varieties which yielded on par with then released hybrids. The hybrid development programme at a later period emphasized on

1. Improvement of source base population.
2. Use of non-conventional approaches for inbred line development and
3. Development of single crosses.

In the present investigation an attempt was made to develop/ isolate inbred lines from a newly constituted base population *i.e.*, yellow pool derived from the well known source populations and the single crosses contributed by the both public and private sector organizations involved in the maize crop improvement. As many as fifteen hundred individual plants were visually selected based on plant morphology in a fourth cycle of intermating generation of yellow pool, the selected (*per se*) eight hundred ear to row progenies were raised and subjected to self pollination. Out of these, based on plant morphological and seed yield traits, four hundred individual plants were identified to raise S_1 generation and subsequently S_2 generation. S_2 lines were subjected for early testing using the top cross test and selected twenty five S_2 lines based on top cross test using four testers were further analyzed for their combining ability by using a line $\times$ tester analysis (Kempthorn 1957) in addition to the heterosis studies for grain yield and its components. The brief results obtained in the present investigation are discussed under the following sub headings.

- 5.1 Characterization of yellow pool base population based on quantitative and qualitative traits
- 5.2 Performance of selected S_0 progenies based on quantitative and qualitative traits
- 5.3 Performance of S_1 progenies based on quantitative and qualitative traits
 - 5.3.1 Mean performance of quantitative and frequency distribution for qualitative traits in S_1 progenies
 - 5.3.2 Genetic variability and association studies in S_1 progenies
- 5.4 Performance of S_2 progenies based on quantitative and qualitative traits
 - 5.4.1 Variability, heritability and genetic advance and mean performance in S_2 generation
 - 5.4.2 Genetic variability and association studies in S_2 progenies

- 5.5 Evaluation of S_2 generation by top cross test
- 5.6 Combining ability analysis
- 5.7 Heterosis studies
- 5.8 Identification of superior crosses for practical utility
- 5.9 Future line of work

5.1 CHARACTERIZATION OF YELLOW POOL BASE POPULATION BASED ON QUANTITATIVE AND QUALITATIVE TRAITS

The proportion of superior inbred lines is determined by the proportion of the superior genotypes in the base population and the effectiveness of selection during the inbreeding. Hence, selection of proper germplasm source is an essential part of breeding programme. The breeding methods, efficiency of selection and final success are highly dependent on the base population chosen. Tannar and Smith (1987) studied various maize population derived from synthetics using two methods of recurrent selection and population derived from open pollinated variety based on the changes in grain yield, grain moisture and lodging. The study indicated the importance of effective population size and selection during S_1 or S_2 was more effective in eliminating unfavourable allele in the population.

In an another attempt, made to establishing inbreeding tolerant base population, Choudhary and Choudhari (2001) using DH-8644 and Jogia local as a base population indicated the possibilities of establishing inbreeding tolerant base population by selecting crosses which showed non-significant inbreeding depression with better yield performance.

Out of ten quantitative characters recorded in 800 selected progenies on cob characters, the progenies exhibited very high coefficient of variation for cob weight, pith weight, number of kernels per cob and grain yield per plant coupled with relatively high estimates of coefficient of range values indicating the presence of high variability in the base population. Further the median and mode values indicated positive skewed distribution for pith weight with high mode value suggesting the greater scope for selection of progenies for lower pith weight there by shelling percentage can be improved. It is interesting to note that out of the traits which recorded high estimates of coefficient of variability, cob weight and the grain yield per plant revealed platykurtic distribution with a high mode value than their respective mean values indicating the presence of relatively high proportion of superior progenies with higher mean values for both the characters in base population. Carlone and Russell (1989) selected 247 progenies from BSSS population and advanced to S_2 generation. Similarly, Venkatesh *et al.* (2001) selected 500 progenies from CMIP2-7 population and selfed it for two generation to obtain S_2 generation. The results on the *per se* performance of line, crosses vis-à-vis revealed that high yielding sister line crosses (SLCs) recorded high values for various yield related traits.

Cob girth and shelling percentage exhibited lower coefficient of variability with a 0.29 and 0.12 coefficients of range values, respectively with a platykurtic distribution in both the cases. However, shelling percentage had the greater mode value than the mean indicating the presence of superior progenies with a high shelling percentage in the base population comparatively with cob girth. It is interesting to note that cob length, number of kernels per cob, number of kernels per row and 100-seed weight had more or less a similar coefficient of range value varying from 0.43 to 0.48 revealing the presence of moderate variability for these traits in the selected progenies in base population. Wide range of cluster mean for various traits were observed by Saxena and Sandhu (1989) in a divergence study involving 140 genotypes belonging to diverse geographic region.

Selected 800 progenies were grouped into different classes based on their superiority over the mean (Table 31). When superior progenies were scored based on greater values than mean + two standard deviation ($>M + 2 SD$) for ten quantitative traits, two traits namely

number of kernels per cob and number of kernel rows per cob had high frequency of progenies *i.e.*, 6.25 per cent for number of kernels per cob and 5.50 per cent for number of kernel rows per cob followed by 100-seed weight and grain yield per plot. However, there were no superior progenies for shelling percentage under this class. Similar results were quoted by earlier workers. Marker and Joshi (2005) reported genetic gain for two traits *vis-à-vis* 100-grain weight and ear diameter through full sib family selection.

In a similar frequency classification made considering the class value of $M + SD$ to $M + 2 SD$, high frequency of superior progenies were scored for number of kernels per cob (33.50%) and number of kernel rows per cob (20.88%). These two traits also had similar trend in the higher class value. However, as many as 49.00 per cent progenies had shelling percentage between M to $M + 2 SD$ followed by cob length with 39.00 per cent of the progenies. Out of ten traits under study, the base population had maximum number of superior progenies in higher class values for number of kernel rows per cob and number of kernels per cob which are important components of a grain yield, revealing the importance of the Yellow pool population for isolation of productive inbred lines at later generations.

These were also scored for grain colour, grain size, grain texture, pith colour and tip filling characters. As many as 713 (89%) progenies were flint type, 546 (68.25%) with medium grain size and 437 (54.60%) with a medium tip filling traits. However, there were only 37 (4.60%) plants with a complete tip filling and 122 progenies with a yellow orange grain colour. Majority of the progenies (87.40%) had the white pith colour.

The grouping made on the basis of qualitative cob character clearly revealed the presence of desirable alleles for grain texture, grain size and tip filling in the Yellow pool population.

5.2 PERFORMANCE OF SELECTED S_0 PROGENIES BASED ON QUANTITATIVE AND QUALITATIVE TRAITS

The pre selected progenies of base population (800) were raised in an ear-to-row fashion and these were evaluated for early vigour at 30 days after sowing and grain yield and its components at the time of maturity (Table 33).

Five traits related for early vigour at 30 days after sowing the progenies exhibited high degree of variation for leaf area and leaf width based on coefficient of variation compared to seedling girth and seedling height which recorded a moderate variation. These results reveal that relatively high *per se* was seen with reference to the leaf area in inbred progenies.

Further the median and mode values of S_0 progenies indicated the negative skewed distribution for all the five traits coupled with platykurtic distribution except for seedling girth, clearly suggest the existence of greater scope to select the progenies for improving the early vigour of the inbred lines based on these traits. There are no reports available in the literature on such distribution at early stages involving S_0 progenies

Among the other traits studied at the time of maturity, cob weight, pith weight, number of kernels per cob and grain yield showed high coefficient of variability coupled with high coefficient of range values for these traits. Whereas, plant height and shelling percentage exhibited very low coefficient of variation and coefficient of range values in the S_0 population. These results reveal the scope of improvement of grain yield per plant, based on number of kernels per cob, pith weight and the cob weight. Whereas, there is no much scope to improve the shelling percentage and plant height at the time of maturity. Mani and Bisht (1996) also reported the limited variability for shelling percentage involving 38 local germplasm from Uttar Pradesh hills.

The distribution pattern for plant height, ear height, cob girth, the number of kernels per cob, number of kernels per row followed negatively skewed distribution. Based on the mean, mode and median values with a platykurtic distribution for these traits, the study indicated the existence of scope for selection of superior progenies as higher proportion progenies with a higher mean values was indicated in the base population.

Table 32: Per cent superior progenies in base population (yellow pool)

Sl. No.	Trait	Frequency Classes		
		>M+2SD	M+SD to M+2SD	M to M+SD
1	Cob weight (g)	3.88	12.00	22.00
2	Cob length (cm)	2.50	9.25	39.00
3	Cob girth (cm)	2.88	10.25	32.25
4	Number of Kernel rows per cob	5.50	20.88	33.25
5	Number of Kernels per row	2.00	18.13	37.50
6	Pith weight (g)	3.00	12.25	34.38
7	100-Seed weight (g)	4.25	10.75	35.13
8	Shelling (%)	0.00	1.13	49.13
9	Number of Kernels per cob	6.25	33.50	19.13
10	Grain yield per plant (g)	4.13	10.63	34.88

Table 33: Per cent superior progenies in S₀ population (yellow pool)

Sl. No.	Traits	Frequency Classes		
		>M+2SD	M+SD to M+2SD	M to M+SD
01	Seedling height (cm)	0.00	6.50	39.00
02	Seedling girth (cm)	0.88	11.38	34.75
03	Leaf length (cm)	1.13	10.50	34.13
04	Leaf width (cm)	0.00	10.50	34.25
05	Leaf area (cm ²)	0.13	6.75	36.13
06	Plant height (cm)	0.13	16.63	35.75
07	Ear height (cm)	2.50	11.88	34.75
08	Cob weight (g)	1.13	15.13	30.13
09	Cob length (cm)	3.63	12.50	32.25
10	Cob girth (cm)	2.00	14.00	32.75
11	Number of Kernel rows per cob	1.88	12.75	41.00
12	Number of Kernels per row	2.50	14.00	34.38
13	Pith weight (g)	3.63	14.88	32.25
14	100-Seed weight (g)	1.63	11.00	35.13
15	Shelling (%)	0.13	8.25	40.63
16	Number of Kernels per cob	2.38	13.88	32.63
17	Grain yield per plant (g)	1.13	14.63	30.75

The frequency distribution of 800 S_0 progenies revealed the presence of higher proportion (2.38 to 3.63%) of progenies having mean values greater than $M + 2$ SD for traits like cob length, ear height, number of kernel rows per cob and number of kernels per cob compared to other traits, which is an indication of presence of superior alleles in the S_0 population. As much as 14.63, 14.00 and 15.13 per cent progenies for grain yield per plant, number of kernels per row and cob weight, respectively exhibited superior *per se* performance with the mean values ranging between $M + SD$ to $M + 2$ SD for these traits indicating the presence of superior progenies in the S_0 population for improvement of the grain yield and its components. Khehra and Dhillon (1993) suggested the importance of desirable genes in the base population and further suggested cumulative selection which mentioned the genetic variability for grain yield.

When these progenies were scored based on qualitative traits like early seedling traits and grain and cob filling traits. It is interesting to note that 84.63 per cent of the progenies were classified as vigorous followed by 65.00 per cent progenies which had a broader leaf shape and 58.50 per cent of seedlings had green stem color at seedling stage. These results support the presence of high proportion of vigorous seedling progenies in the S_0 generation. Cross (1983) and Hunter (1980) reported that increase in yield resulted from the greater assimilation rate produced by larger leaf area.

When the progenies were classified based on the tip filling at the time of harvest in to three classes *i.e.*, complete tip filling, medium and no tip filling, the progenies were distributed more or less in a equal proportion in these categories. Whereas for grain texture, 81.25 per cent of progenies had flint texture and 57.63 per cent had a medium grain size. Majority of the progenies (87.75%) had white pith color. Further when the proportion of superior progenies for the tip filling was compared between the base population and S_0 generation, there was increase in the per cent of progenies with a complete tip filling from 4.63% in base population to 35.75% in S_0 generation which is an indication for improvement of inbred lines. There are no reports available in the literature on tip filling.

5.3 PERFORMANCE OF S_1 PROGENIES BASED ON QUANTITATIVE AND QUALITATIVE TRAITS

The variance due to genotype was highly significant for all quantitative traits indicating prevalence of high variability. This was also evidenced by high PCV, high heritability and genetic advance for most of the productivity traits in the present study.

5.3.1 Mean performance of quantitative and frequency distribution for qualitative traits in S_1 progenies

Mean performance of traits related to early vigour like seedling height, seedling girth and leaf area were superior in S_1 compare to S_0 progenies because of selection for high vigour individuals for advancement through selfing. All productivity related traits were improved by selecting leptokurtically distributed individuals in S_0 generation. This was also reflected by high heritability estimates of other traits. Mean ear height of S_1 progenies was less (76.30 cm) compare to S_0 (88.53 cm) which was advantageous as a result of conscious selection in S_0 generation.

Moderate GAM for cob girth, number of kernel rows per cob and low GAM for shelling percentage was mainly because of low PCV although heritability was high. Hence, selection for these traits could give more response indicating direct selection for grain yield along with important productivity traits could be highly effective in inbred line improvement programme. Similar results of high heritability, GAM were reported by Kumar *et al.* (2006) in S_0 , S_1 lines derived from inbreeding of VC-2 population for yield per plot, plant height, ear length and diameter.

Frequency of vigorous progenies in S_1 were high (86.50%) compare to S_0 generation (84.60%), which was because of selection and further advancement of high vigour plants to develop inbreds with reduced inbreeding depression. This was also evidenced by the higher proportion of lines with broader leaves in S_1 generation (70.00%) than S_0

generation (65.00%). However, Uchimiya and Takahashi (1973) reported the vigour in the hybrid was due to their higher rate of cell division, which resulted in large leaf area and internode increased grain yield.

Development of inbreeding tolerant lines for producing single cross hybrid is given emphasis in recent years to achieve higher seed yield (Tiwari and Verma, 1999). More proportion of seedlings of purple colour lines were advanced to S_1 generation as the purple colour is advantageous to avoid pest and disease incidence.

The frequency of flint grain type was high in S_1 (84.00%) compared to S_0 generation (81.25%) and frequency of bold grain lines was also high in S_1 (53.30%) than that of S_0 (38.75%) generation. These grain characters are desirable traits for achieving higher seed weight and yield. This was supported by higher test weight and grain yield in S_1 compared to S_0 generation.

The advancement of lines from S_0 to S_1 was done based on superior cob characters like cob length and girth, number of kernel rows per cob, number of kernels per row and number of kernels per cob. However, tip filling was low in superior lines. Although frequency of lines with complete tip filling was high in S_0 (35.75%) compared to S_1 (8.00%), those lines which were inferior for quantitative cob characters were not advanced.

5.3.2 Genetic variability and association studies in S_1 progenies

In general genotypic correlation was higher in magnitude than that of phenotypic correlation. Similar trend of higher values of genotypic correlation coefficients than phenotypic coefficient correlation was also reported in earlier studies. Muhammad Rafique *et al.* (2004) reported higher GCV in case of grain yield per plant followed by plant height, ear height, kernels per row, 1000-kernel weight and ear length. Number of kernels per row had significant correlation with seed yield followed by plant height, ear height, cob diameter and length of cob. Similar results were also reported by earlier worker, Khatum *et al.* (1999) and Devi *et al.* (2001).

Grain yield per plant exhibited positive association with all growth and yield parameters in the present investigation. Most of the growth and yield parameters are inter dependent as evidenced by significant and positive correlation among themselves. However, number of kernel rows per cob was not associated significantly with leaf area and cob length indicating these as independent traits. Likewise shelling percentage was also found to be independent of plant girth at 30 DAS, plant height at 30 DAS, ear height at 30 DAS, leaf area at 60 DAS and cob length as it has recorded non-significant correlation with these traits. As expected pith weight exhibited significant and negative association with shelling percentage, which are interdependent among the productivity traits. Cob weight, cob length, cob girth, grain number per cob, number of kernels per cob, 100-seed weight and shelling percentage recorded high correlation coefficient more than 0.50 indicating these are important yield contributing traits. Similar reports were also made by Kumar (1974), Bhalla and Khehra (1977) and Ramamurthy (1980) (Table 33 and 34).

5.4 PERFORMANCE OF S_2 PROGENIES BASED ON QUANTITATIVE AND QUALITATIVE TRAITS

5.4.1 Variability, heritability and genetic advance and mean performance in S_2 generation

ANOVA revealed presence of highly significant differences for all growth and productivity related traits studied in this investigation indicating high variability among the S_2 progenies. This was also evidenced by wide range values for all the traits under study.

Growth parameters like plant height, plant girth, and leaf area at 30 DAS recorded moderate variability as evidenced by GCV. However, GAM was high mainly because of high heritability recorded for these traits. GAM was also high for grain yield and most of its yield components as heritability was high for all the traits studied with moderate to high coefficient

of variability. Cob girth recorded moderate GAM although its heritability was high mainly because of very low variability present in this population (Table 33). Similarly GAM was low for shelling percentage mainly on account of very low variability.

Mean grain yield per plant in S_2 progenies was 118.79 g with range of 44.65 to 232.85 g and the mean grain yield per plant in S_1 was higher (128.05 g). This could be because of inbreeding depression. Inbreeding depression was more pronounced in 100-seed weight as evidenced by lower 100-seed weight in S_2 (27.05 g) compare to S_1 generation (27.48 g) and shelling percentage ($S_1=85.93$ and $S_2=82.09\%$). However, the mean performance with respect to cob weight, cob length, number of kernel rows per cob, number of kernels per row and number of kernels per cob was slightly more in S_2 compared to S_1 progenies (Table 34).

The superior performance of productivity related traits could be because of discarding poor and inferior progenies while advancing from S_1 (400) to S_2 (350) generation. Interestingly the variability of most of the growth and yield parameters has increased in S_2 progenies compared to S_1 progenies as evidenced by GCV which is unexpected. This increase in variability in second generation of selfing could be attributed to tolerance to inbreeding depression (Table 35).

Genetic advance (GAM) was high for most of the productive traits in S_2 than that in S_1 generation which was mainly on account of higher heritability.

5.4.2 Genetic variability and association studies in S_2 generation

In S_2 generation also all the growth and yield parameters had highly significant and positive association with grain yield (Table 19 and 20). Among these, productivity traits *viz.*, ear height, cob weight, cob length, cob girth, number of kernels per row, pith weight, 100-seed weight, shelling percentage and grain numbers per cob were main yield contributing traits with high correlation coefficient with grain yield. This is in conformity with the results obtained in S_1 generation and also in confirmation with earlier report of Debnath and Khan (1991), Nawar *et al.* (1999), Geetha and Jayaram (2000a) and Umakanth and Khan (2001).

Most of the growth and yield components were inter dependent exhibiting significant positive correlation among themselves as that of S_1 progenies. As per the expectation, number of kernel rows per cob and 100-seed weight had significant negative association, similarly pith weight and shelling percentage were correlated with highly significant negative value. The association studies comprising of both S_1 and S_2 generations indicated that by selection of lower pith weight one can increase shelling percentage in maize (Table 35).

5.5 EVALUATION OF S_2 GENERATION BY TOP CROSS TEST

The use of top cross test provides an efficient method for preliminary evaluation of inbred lines. The use of top cross evaluation is one of the methods for early testing of inbred lines. Top cross test is especially useful for determining general combining ability of a large number of inbred lines. The top cross test with a heterogeneous tester gives valuable information for characters which are not complex in inheritance.

Top cross testing of S_2 progenies with standard open pollinated line CM-501 was done for the early testing for general combining ability. ANOVA indicated the presence of highly significant differences among top crosses for all the 13 characters studied.

Wide range of performance for different growth and yield parameters was observed among 350 top crosses with CM-501. The overall mean grain yield per plot of top cross hybrids was 1.25 kg with a range from 0.74 to 1.77 kg per plot. Twenty four top cross hybrids were superior by exhibiting more than five per cent superiority for grain yield per plot over best check Cargil 900-M (1.42 kg/plot).

Among superior twenty five top crosses whose lines were further utilized for line $\times$ tester analysis were critically evaluated for their *per se* performance and growth parameters. It is found that 13 top cross hybrids 231 $\times$ CM-501, 249 $\times$ CM-504, 246 $\times$ CM-501, 269 $\times$ CM-

Table 34: Mean performance of S₁ and S₂ progenies for 16 quantitative traits in maize

Sl. No.	Characters	Mean		Minimum		Maximum	
		S ₁	S ₂	S ₁	S ₂	S ₁	S ₂
1	Plant height at 30 DAS (cm)	48.53	31.67	27.29	18.00	82.50	45.60
2	Plant girth at 30 DAS (cm)	2.09	1.71	1.55	1.00	3.00	3.00
3	Leaf area at 30 DAS (cm)	214.31	239.54	74.24	110.05	321.35	450.60
4	Plant height at 60 DAS (cm)	153.34	164.79	107.50	120.00	195.50	205.50
5	Leaf area at 60 DAS (cm)	398.45	393.78	245.00	163.40	584.20	600.10
6	Ear at 60 DAS (cm)	76.30	75.44	53.00	45.30	96.00	115.50
7	Cob weight (g)	148.38	144.13	76.96	56.55	268.89	276.90
8	Cob length (cm)	14.32	15.83	10.00	9.55	22.33	22.25
9	Cob girth (cm)	13.66	13.39	10.33	10.15	17.00	17.30
10	Number of Kernel rows per cob	13.83	14.40	10.33	10.60	21.50	19.20
11	Number of Kernels per row	28.91	30.02	15.50	18.55	42.67	46.00
12	Pith weight (g)	19.91	25.01	10.71	10.84	42.53	47.19
13	100-Seed weight (g)	27.48	27.05	15.76	16.92	36.65	42.43
14	Shelling (%)	85.93	82.09	65.90	65.31	93.15	90.67
15	Number of Kernels per cob	400.61	433.92	190.00	235.65	614.89	733.60
16	Grain yield per plant (g)	128.05	118.79	64.38	44.65	232.15	232.86

Table 35: Estimation of genetic variability parameters in S₁ and S₂ progenies of yellow pool population in maize

Sl. No.	Characters	PCV (%)		GCV (%)		Heritability (%)		GAM (%)	
		S ₁	S ₂	S ₁	S ₂	S ₁	S ₂	S ₁	S ₂
1	Plant height at 30 DAS (cm)	20.70	13.86	17.42	10.54	84.16	76.08	35.89	21.72
2	Plant girth at 30 DAS (cm)	18.21	17.10	8.17	13.12	50.40	76.71	16.83	27.02
3	Leaf area at 30 DAS (cm)	21.84	28.57	18.97	24.38	86.56	85.36	38.95	50.23
4	Plant height at 60 DAS (cm)	10.90	11.05	10.03	10.28	92.92	93.92	20.67	21.18
5	Leaf area at 60 DAS (cm)	15.12	21.85	14.13	19.58	93.44	89.58	39.11	40.33
6	Ear at 60 DAS (cm)	11.27	15.49	10.01	14.10	98.82	90.59	30.68	29.04
7	Cob weight (g)	24.51	31.43	23.80	29.63	97.71	94.29	49.04	61.05
8	Cob length (cm)	14.34	14.99	12.20	14.04	85.03	93.56	35.13	28.92
9	Cob girth (cm)	9.16	9.58	7.75	8.33	82.91	87.30	15.64	17.16
10	Number of Kernel rows per cob	10.35	10.88	8.94	9.86	86.46	90.62	18.43	20.31
11	Number of Kernels per row	17.66	16.30	15.84	14.11	89.84	86.56	32.69	29.06
12	Pith weight (g)	25.96	29.34	22.77	27.86	87.74	94.93	46.91	57.38
13	100-Seed weight (g)	15.64	16.52	13.61	14.58	87.04	88.23	28.04	30.03
14	Shelling (%)	4.14	5.17	3.36	4.42	81.22	85.46	6.92	9.16
15	Number of Kernels per cob	30.86	21.26	18.36	18.72	88.02	88.08	37.82	38.57
16	Grain yield per plant (g)	25.53	34.09	24.94	31.79	97.67	93.26	51.37	65.49

501, 278 × CM-501, 236 × CM-501, 283 × CM-501, 315 × CM-501, 264 × CM-501, 398 × CM-501, 176 × CM-501, 365 × CM-501 and 185 × CM-505 recorded more than ten per cent superiority with respect to grain yield compare to best check Cargil 900-M (1.42 kg/plot). In general most of these hybrids had higher grain number per plant and lower pith weight compared to remaining identified hybrids. Davis (1927) evaluated the S₂ lines for combining ability by top cross test. The studies of Jenkins (1935), Lonnquist (1950) and Wellhansen (1952) have clearly indicated the early detection of lines having high combining ability by early testing.

5.6 COMBINING ABILITY ANALYSIS

Line × tester mating design is a modified form of the top cross scheme proposed by Davis in 1927 for inbred evaluation. In recent years, development and cultivation of single cross hybrids is gaining importance in all maize growing countries. Single crosses are highest yielders under optimal conditions and also show higher uniformity than other type of hybrid.

The efficiency and success of hybrid maize breeding depends on contribution of heterotic effects of superior inbred lines. The superior cross combination may be exploited as commercial single cross hybrids. Hence, there is lot of scope for the selection of parents for hybridization based on *per se* performance, combining ability and gene action. It is in close agreement with finding of Sandhu *et al.* (2006).

Among the different parametrical methods employed for studying combining ability and gene action, line × tester analysis proposed by Kempthorne (1957) is commonly used in maize by many breeders (Kravencheko *et al.* 1971, Muthaih, 1989 and Yurankova *et al.*, 1996).

5.6.1 Analysis of variance for line × tester

Analysis of variance indicated sum of squares due to lines was highly significant for plant height at 60 days after sowing (DAS), ear height at 60 DAS, cob girth and number of kernel rows per cob, while it was significant at five per cent for plant girth at 60 DAS, cob weight and pith weight indicating there was considerable variability for these traits among lines used in this study. The variability due to tester was significant for plant height at 30 DAS, leaf area at 30 DAS, plant height 60 DAS, ear height at 60 DAS, cob weight, cob length and number of kernels per cob.

Mean sum of square for line × tester was significant for most of the traits studied except for plant girth at 30 DAS, number of kernel rows per cob, 100- seed weight, number of kernels per cob, grain yield per plant and grain yield per hectare indicating the diverse performance of hybrids for most of the traits.

The contribution of lines to total variances was higher than testers for most of the traits studied except leaf area at 30 DAS, plant height at 60 DAS and ear height at 60 DAS which signifies the prevalence of high diversity among the lines used for this investigation. This is mainly attributed to the enormous diversity in the base population yellow pool from which these lines have been derived. The contribution of either lines or tester revealed the importance of specific contribution for expression of all the traits studied in hybrids. Similar observations were also reported by Sandhu *et al.* (2006), Kadlubiec *et al.* (2000), Ramesh *et al.* (2000), Rosa *et al.* (2000) and Mandal *et al.* (2001).

Maize a highly allogamous species is expected to contain predominant non additive gene action. As per the expectation, the variance due to SCA was considerably high compare to that of variance due to GCA for all the characters studied in this investigation. The ratio of GCA to SCA variance was much below unity indicating preponderance of non additive gene effects in the inheritance of all traits under study. The predominance of non-additive gene action for most of the growth and productivity traits have been reported by Sandhu *et al.* (2006), Singh *et al.* (1983), Paul and Duara (1991), Sedhom (1994), Mohammad (1993) and Satyanarayana *et al.* (1994).

Exploitation of hybrid vigour has gained much significance in view of enormous higher yield in hybrids, which is the only way to harness the predominant non-additive gene action.

5.6.2 Mean performance of parents and hybrids

Among parental lines ARYP-18 recorded early vigour and its related traits over best check Prabha indicating its ability for quick establishment and early seedling growth. Among the checks composite Prabha recorded superior performance for early vigour traits like seedling height, girth and leaf area at 30 DAS. The line ARYP-2 recorded superior grain yield. Higher seed yield in this inbred was mainly because of high 100-seed weight (34.70 g) compare to other lines.

High number of superior inbreds for grain yield per hectare could be attributed to efficient selection procedure employed during selfing and advancement during inbreeding to derive inbreeding tolerant lines. Among the testers NEI-9202B recorded maximum grain yield (6279kg/ha) which is a promising inbred line received from Directorate of Maize Research (DMR).

Among 100 test hybrids, two hybrids viz., ARYP-24 $\times$ CM-111 (8446 kg/ha) and ARYP-15 $\times$ CM-111 (8077 kg/ha) recorded significantly superior grain yield over best commercial hybrid check Cargil 900-M (6795 kg/ha). Hundred seed weight is the main yield component responsible for superior grain yield in these two hybrids compared to Cargil 900-M. These two hybrids were also superior for early vigour compare to Cargil 900-M which is advantageous for better plant stand, growth and early vigour.

Besides these, ten other hybrid combinations involving ARYP-1 $\times$ CM-111, ARYP-11 $\times$ CM-111, ARYP-13 $\times$ CM-111, ARYP-17 $\times$ CM-111, ARYP-23 $\times$ CM-111, ARYP-9 $\times$ CI-5, ARYP-14 $\times$ CI-5, ARYP-16 $\times$ CI-5, ARYP-20 $\times$ CI-5 and ARYP-23 $\times$ NEI-9202B crosses recorded more than ten per cent grain yield over Cargil 900-M. It is interesting to note that many hybrids involving CM-111 as one of the testers recorded superior grain yield indicating this as the best parent for general combiner.

5.6.3 Combining ability analysis

5.6.3.1 General combining ability

A high gca effect for specific trait in a parent indicates presence of additive gene effects for that trait. When parents possessing high gca effects were combined by hybridization, a large proportion of progenies would have high value for the trait concerned facilitating easy selection for that trait.

In the present study a score was made based on the gca effects of the parents (Table 36). The total score of each parent across the characters was worked out for the classification of parents as high or best combiner and low or poor combiner (Thenmozhi, 1983).

Among the lines, ARYP-3 exhibited maximum positive gca effect for number of growth and yield parameters, the pooled score for gca effects for this female parent was highest (+7) indicating this as potential general combiner ARYP-24 and ARYP-25 were the next best general combiners with pool score of +4, among other lines, ARYP-8, ARYP-9, ARYP-13, ARYP-14, ARYP-17, ARYP-20, ARYP-21 also recorded positive score for gca effects. Among the testers NEI-9202B recorded pool score of +9 indicating its superiority for utilization in hybridization programme.

The lines ARYP-21 and ARYP-25 which exhibited significant positive gca effect for early vigour traits like plant height and leaf area at 30 DAS which can be utilized in breeding for developing early vigour hybrids. The parents, ARYP-1, ARYP-9 and tester NEI-9202B also exhibited significant positive gca effect for plant height at 60 DAS. The lines ARYP-11, ARYP-18, ARYP-15 and testers CI-5 and KDMI-10 with significant negative gca effects for ear height. The parent ARYP-21 with significant positive gca effect for leaf area at 60 DAS, the lines ARYP-3, ARYP-15 and tester NEI-9202B with significant positive gca effect for cob weight, lines ARYP-3, ARYP-14 and tester NEI-9202B with significant positive gca effect for

cob length, the line ARYP-8, ARYP-15 and ARYP-24 exhibited significant positive gca effect for cob girth. These lines could be considered for development of superior population or synthetics.

Five lines viz., ARYP-8, ARYP-13, ARYP-15, ARYP-17 and ARYP-25 exhibited significant positive gca effect for number of kernel rows per cob. The S₂ lines ARYP-11, ARYP-14, ARYP-19 and tester NEI_98008B had significant positive gca effect for number of kernels per row. The lines ARYP-12 and ARYP-15 and tester CM-111 with significant positive gca effect and the line ARYP-19 and tester KDMI-10 had significant negative gca effect for pith weight. The parent ARYP-3, ARYP-20 and tester CI-5 and NEI-9202B with significant positive gca effect for 100-seed weight. The lines ARYP-3, ARYP-19, ARYP-20, ARYP-24 and tester KDMI-10 with significant positive gca effect for shelling percentage. The line ARYP-3, ARYP-17, ARYP-25 and tester CM-111, NEI-9202B had significant positive gca effect for grain numbers per cob. The parents ARYP-3, ARYP-24 and tester NEI-9202B exhibited significant positive gca effect for grain weight per plant. The parent ARYP-1, ARYP-14, ARYP-15, ARYP-24 with significant positive gca effect for grain yield per hectare. These parents can be utilized for development of hybrids with superiority for respective traits.

The lines ARYP-21, ARYP-25 were good general combiners for early vigour traits like plant height and leaf area at 30 DAS. Likewise as many as five parents were good general combiners with significant gca effect in favorable direction (Table 37) for different characters in the present investigation. Significant gca for most of the quantitative traits were reported by Mandal *et al.* (2001), Malik *et al.* (2004), Koinuma *et al.* (2004) and Fan *et al.* (2004).

5.6.3.2 Specific combining ability

For early vigour traits like plant height at 30 DAS nine hybrids recorded significant positive sca effects which can be exploited as early vigour hybrids. The 12 hybrids were not good combinations for early vigour as sca effects of these hybrids were negatively significant. Likewise, nine hybrids were superior for leaf area at 30 DAS with significant positive sca effect. However, more number of hybrids (13) were superior for leaf area at 60 DAS with significant positive sca effect.

Quite a few number of hybrid combinations recorded significant sca effects for different plant, cob and yield parameters in favorable direction. However, none of the hybrid combinations were superior for 100-seed weight and grain yield per plant with significantly positive sca effects (Table 38).

Among 100 hybrids evaluated, 29 hybrid combinations recorded positive score when recorded across the 17 traits indicating them as heterotic hybrids for these traits. Out of the hybrids which recorded significant positive score across traits, ARYP-20 × NEI-9202B (+7), ARYP-9 × CI-5 (4) and ARYP-19 × KDMI-10 (+3) hybrids scored relatively high in positive direction. However, none of these hybrids exhibited significant positive sca effect for grain yield per ha. Out of 100 test hybrids, two viz., ARYP-5 × KDMI-10 and ARYP-23 × NEI-9202B exhibited significant sca effects for grain yield (kg/ha). Twenty seven hybrid combinations were found to be inferior with negative score for sca effects across 17 traits. Forty four hybrid combinations scored zero, because of cancellation positive and negative significant sca effects for different characters. Such hybrids may also be considered as heterotic hybrids depending on the importance of productivity trait with positive significant sca effects (Table 38).

Table 36: Classification of parents based on general combining ability effects over seventeen characters in maize

Sl. No.	Parents	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
1	ARYP-1	-1	0	0	+1	0	+1	-1	-1	0	-1	0	0	0	-1	0	-1	+1	-3
2	ARYP-2	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1
3	ARYP-3	0	0	0	0	0	+1	+1	+1	0	0	0	0	+1	+1	+1	+1	0	+7
4	ARYP-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	ARYP-5	0	0	0	0	-1	+1	0	0	0	0	0	0	0	-1	0	0	-1	-2
6	ARYP-6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	ARYP-7	0	0	-1	0	0	0	0	0	0	-1	0	0	0	0	-1	-1	-1	-5
8	ARYP-8	0	0	0	0	0	0	0	0	+1	+1	0	0	0	0	0	0	0	+2
9	ARYP-9	0	0	0	+1	0	0	0	0	0	0	0	0	0	0	0	0	0	+1
10	ARYP-10	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	-1	0	0	-2
11	ARYP-11	-1	0	-1	-1	0	-1	0	0	0	0	+1	0	0	0	0	0	0	-3
12	ARYP-12	0	0	0	-1	0	0	0	0	0	0	0	+1	0	-1	0	0	0	-1
13	ARYP-13	0	0	0	0	0	0	0	0	0	+1	0	0	0	0	0	0	0	+1
14	ARYP-14	0	0	0	0	0	0	0	+1	0	0	+1	0	0	0	0	0	+1	+2
15	ARYP-15	0	0	0	0	-1	-1	+1	0	+1	+1	0	+1	0	-1	0	0	+1	+2
16	ARYP-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	ARYP-17	0	0	0	0	0	0	0	0	0	+1	0	0	-1	0	+1	0	0	+1
18	ARYP-18	+1	0	0	0	0	-1	-1	0	0	0	0	0	0	0	0	-1	0	-2
19	ARYP-19	0	0	0	0	0	0	-1	0	-1	-1	+1	-1	0	+1	0	0	0	-2
20	ARYP-20	0	0	0	0	0	0	0	0	0	0	0	0	+1	+1	0	0	0	+2
21	ARYP-21	+1	0	+1	0	+1	0	0	0	0	0	0	0	0	0	0	0	0	+3
22	ARYP-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	ARYP-23	0	0	+1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
24	ARYP-24	0	0	0	0	0	0	0	0	+1	0	0	0	0	+1	0	+1	+1	+4
25	ARYP-25	+1	0	+1	0	0	0	0	0	0	+1	0	0	0	0	+1	0	0	+4
Testers																			
1	CM-111	-1	0	-1	0	0	+1	0	0	0	0	0	+1	-1	-1	+1	0	0	-1
2	CI-5	0	0	0	0	0	-1	0	0	0	0	-1	0	+1	0	-1	0	0	-1
3	KDMI-10	0	0	+1	-1	0	-1	-1	-1	0	0	-1	-1	0	+1	-1	0	-1	-7
4	NEI-9202B	+1	0	0	+1	0	+1	+1	+1	0	0	+1	0	+1	0	+1	+1	0	+9

1. Plant height at 30 DAS (cm)

2. Plant girth at 30 DAS (cm)

3. Leaf area at 30 DAS (cm)

4. Plant height at 60 DAS (cm)

6. Leaf area at 60 DAS (cm)

6. Ear height at 60 DAS (cm)

7. Cob weight (g)

8. Cob length (cm)

9. Cob girth (cm)

10. Number of Kernel rows per cob

11. Number of Kernels per row

12. Pith weight (g)

13. 100-Seed weight (g)

14. Shelling (%)

15. Number of Kernels per cob

16. Grain yield per plant (g)

17. Grain yield per ha (kg/ha)

Table 37: List of parents and crosses with significant gca effects and sca effects for seventeen quantitative traits in maize

Sl. No.	Character	No. of parents with gca effect				No. of hybrids with sca effect			
		+ve	-ve	Total	Range of	+ve	-ve	Total	Range of
1	Plant height at 30 DAS (cm)	4	3	7	-1.59 to 2.69	9	12	21	-6.27 to 8.75
2	Plant girth at 30 DAS (cm)	0	0	0	-0.09 to 11.00	0	0	0	-0.20 to 0.20
3	Leaf area at 30 DAS (cm)	4	3	7	-27.09 to 20.99	6	4	10	-59.07 to 72.79
4	Plant height at 60 DAS (cm)	3	3	6	-8.42 to 7.55	2	2	4	-13.32 to 10.17
5	Leaf area at 60 DAS (cm)	1	4	5	-50.44 to 35.18	13	10	23	-147.32 to 125.69
6	Ear at 60 DAS (cm)	5	5	10	-5.33 to 7.39	3	2	5	-11.87 to 8.41
7	Cob weight (g)	3	4	7	-17.89 to 16.93	2	4	6	-28.99 to 28.74
8	Cob length (cm)	3	2	5	-0.72 to 0.80	1	1	2	-1.87 to 1.34
9	Cob girth (cm)	3	1	4	-0.92 to 0.82	2	3	5	-1.19 to 1.36
10	Number of Kernel rows per cob	5	4	9	-1.29 to 2.64	4	5	9	-1.61 to 1.75
11	Number of Kernels per row	4	2	6	-1.31 to 0.94	4	3	7	-3.34 to 3.96
12	Pith weight (g)	3	2	5	-6.04 to 7.04	3	2	5	-6.92 to 8.78
13	100-Seed weight (g)	4	2	6	-2.07 to 3.17	0	2	2	-5.10 to 3.58
14	Shelling (%)	5	5	10	-2.39 to 2.00	1	3	4	-2.53 to 2.09
15	Number of Kernels per cob	5	4	9	-41.80 to 46.27	4	2	6	-66.76 to 68.25
16	Grain yield per plant (g)	3	3	6	-14.25 to 18.59	0	4	4	-24.98 to 17.92
17	Grain yield per hectare (kg)	4	3	7	-348.83 to 639.43	4	5	9	-1068.49 to 1333.29

Table 38: Score of crosses based on specific combining ability effects for 17 character in maize

Sl. No.	Parents	Plant height at 30 DAS (cm)	Plant girth at 30 DAS (cm)	Leaf area at 30 DAS (cm)	Plant height at 60 DAS (cm)	Leaf area at 60 DAS (cm)	Ear height at 60 DAS (cm)	Cob weight (g)	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Pith weight (g)	100-seed weight (g)	Shelling (%)	Number of kernels per cob	Grain yield per plant (g)	Grain yield per hectare (kg)	Total
1	ARYP-1xCM-111	0	0	+1	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0
2	ARYP-2xCM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	ARYP-3xCM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	ARYP-4 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	ARYP-5 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	ARYP-6 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	ARYP-7 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	ARYP-8 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	ARYP-9 x CM-111	0	0	0	0	+1	0	0	0	0	0	0	0	0	0	0	0	0	+1
10	ARYP-10 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	ARYP-11 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	ARYP-12 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1
13	ARYP-13 x CM-111	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	+1	0	0	0
14	ARYP-14 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	ARYP-15 x CM-111	0	0	+1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1
16	ARYP-16 x CM-111	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1
17	ARYP-17 x CM-111	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
18	ARYP-18 x CM-111	+1	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
19	ARYP-19 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	ARYP-20 x CM-111	-1	0	0	0	-1	0	0	0	0	-1	0	0	0	0	-1	0	0	-4
21	ARYP-21 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	ARYP-22 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	ARYP-23 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	ARYP-24 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	+1
25	ARYP-25 x CM-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	ARYP-1 x CI-5	+1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1
27	ARYP-2 x CI-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	ARYP-3 x CI-5	0	0	0	0	0	0	-1	0	0	0	-1	0	0	-1	-1	0	0	-4
29	ARYP-4 x CI-5	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1
30	ARYP-5 x CI-5	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	+1	0
31	ARYP-6 x CI-5	0	0	0	0	0	0	0	0	0	0	+1	0	0	0	+1	0	0	+2
32	ARYP-7 x CI-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	ARYP-8 x CI-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Contd...

Sl. No.	Parents	Plant height at 30 DAS (cm)	Plant girth at 30 DAS (cm)	Leaf area at 30 DAS (cm)	Plant height at 60 DAS (cm)	Leaf area at 60 DAS (cm)	Ear height at 60 DAS (cm)	Cob weight (g)	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Pith weight (g)	100-seed weight (g)	Shelling (%)	Number of kernels per cob	Grain yield per plant (g)	Grain yield per hectare (kg)	Total
34	ARYP-9 x CI-5	0	0	0	+1	+1	+1	0	+1	0	0	0	0	0	0	0	0	0	+4
35	ARYP-10 x CI-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	ARYP-11 x CI-5	0	0	0	0	0	0	0	0	0	0	0	-1	0	-1	0	0	0	-2
37	ARYP-12 x CI-5	0	0	0	0	0	+1	0	0	0	0	0	0	0	0	0	0	0	+1
38	ARYP-13 x CI-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	ARYP-14 x CI-5	0	0	0	0	0	0	+1	0	0	0	0	0	0	0	0	0	0	+1
40	ARYP-15 x CI-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	ARYP-16 x CI-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	ARYP-17 x CI-5	0	0	0	0	0	+1	0	0	0	0	0	+1	0	0	0	0	0	+2
43	ARYP-18 x CI-5	-1	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	-2
44	ARYP-19 x CI-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	ARYP-20 x CI-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	ARYP-21 x CI-5	-1	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	-2
47	ARYP-22 x CI-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	ARYP-23 x CI-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	ARYP-24 x CI-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	ARYP-25 x CI-5	0	0	0	0	0	0	0	-1	0	+1	0	0	0	0	0	0	0	0
51	ARYP-1 x KDMI-10	0	0	0	-1	-1	+1	0	0	0	+1	0	0	0	0	0	0	0	0
52	ARYP-2 x KDMI-10	+1	0	0	0	0	0	0	0	0	+1	0	0	0	0	0	0	0	+2
53	ARYP-3 x KDMI-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	ARYP-4 x KDMI-10	0	0	0	0	0	+1	0	0	0	0	0	0	0	0	0	0	0	+1
55	ARYP-5 x KDMI-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	+1
56	ARYP-6 x KDMI-10	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	-1
57	ARYP-7 x KDMI-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	ARYP-8 x KDMI-10	+1	0	0	0	0	0	0	0	+1	0	0	0	0	0	0	0	0	+2
59	ARYP-9 x KDMI-10	0	0	0	0	0	0	-1	0	-1	0	0	0	-1	0	0	-1	-1	-5
60	ARYP-10 x KDMI-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	ARYP-11 x KDMI-10	0	0	+1	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0
62	ARYP-12 x KDMI-10	+1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1
63	ARYP-13 x KDMI-10	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	-1
64	ARYP-14 x KDMI-10	0	0	+1	0	0	+1	0	0	0	0	0	0	0	0	0	0	0	+2
65	ARYP-15 x KDMI-10	0	0	0	0	0	0	0	0	0	0	0	+1	-1	0	0	0	0	0
66	ARYP-16 x KDMI-10	0	0	0	0	0	+1	0	0	0	0	0	0	0	0	0	0	0	+1
67	ARYP-17 x KDMI-10	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0

Contd.:1..

Sl. No.	Parents	Plant height at 30 DAS (cm)	Plant girth at 30 DAS (cm)	Leaf area at 30 DAS (cm)	Plant height at 60 DAS (cm)	Leaf area at 60 DAS (cm)	Ear height at 60 DAS (cm)	Cob weight (g)	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Pith weight (g)	100-seed weight (g)	Shelling g (%)	Number of kernels per cob	Grain yield per plant (g)	Grain yield per hectare (kg)	Total
68	ARYP-18 x KDMI-10	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
69	ARYP-19 x KDMI-10	0	0	0	0	0	+1	0	0	0	0	+1	0	0	0	+1	0	0	+3
70	ARYP-20 x KDMI-10	-1	0	0	0	0	0	-1	0	-1	0	0	0	0	0	0	0	0	-3
71	ARYP-21 x KDMI-10	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	-1	-2
72	ARYP-22 x KDMI-10	-1	0	0	0	0	-1	0	0	0	0	-1	0	0	0	0	0	0	-3
73	ARYP-23 x KDMI-10	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-2
74	ARYP-24 x KDMI-10	0	0	0	0	0	0	0	0	0	+1	+1	0	0	0	0	0	0	+2
75	ARYP-25 x KDMI-10	-1	0	-1	0	+1	0	0	0	0	0	0	0	0	0	0	0	0	-1
76	ARYP-1 x NEI-9202B	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
77	ARYP-2 x NEI-9202B	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
78	ARYP-3 x NEI-9202B	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
79	ARYP-4 x NEI-9202B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	ARYP-5 x NEI-9202B	0	0	+1	0	0	+1	0	0	0	0	0	0	0	0	0	0	0	+2
81	ARYP-6 x NEI-9202B	0	0	0	0	0	+1	0	0	0	0	0	0	0	0	0	0	0	+1
82	ARYP-7 x NEI-9202B	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
83	ARYP-8 x NEI-9202B	0	0	0	0	0	0	0	0	0	0	+1	0	0	0	0	0	0	+1
84	ARYP-9 x NEI-9202B	0	0	0	-1	-1	-1	0	0	0	0	0	0	0	0	0	0	0	-3
85	ARYP-10 x NEI-9202B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86	ARYP-11 x NEI-9202B	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
87	ARYP-12 x NEI-9202B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	ARYP-13 x NEI-9202B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89	ARYP-14 x NEI-9202B	0	0	-1	+1	-1	0	0	0	-1	0	0	0	0	0	0	0	0	-2
90	ARYP-15 x NEI-9202B	-1	0	0	0	0	0	0	0	0	0	0	+1	0	-1	0	0	0	-1
91	ARYP-16 x NEI-9202B	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	-1	-1	-3
92	ARYP-17 x NEI-9202B	0	0	+1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1
93	ARYP-18 x NEI-9202B	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	0	0	+1
94	ARYP-19 x NEI-9202B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95	ARYP-20 x NEI-9202B	+1	0	0	+1	0	+1	+1	0	+1	+1	0	0	0	0	+1	0	0	+7
96	ARYP-21 x NEI-9202B	+1	0	0	0	0	+1	0	0	0	0	0	0	0	0	0	0	0	+2
97	ARYP-22x NEI-9202B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	ARYP-23 x NEI-9202B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	+1
99	ARYP-24 x NEI-9202B	+1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1
100	ARYP-25 x NEI-9202B	+1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1

5.7 HETEROSIS STUDIES

The magnitude of relative, better parent and standard heterosis over Cargil 900-M has been summarized for seventeen characters and is presented in the Table 39. The heterosis studies have been carried out at early seedling stage and also at the time of harvest and traits have been divided in to two groups for discussion purpose.

Out of 17 traits under study, the first five traits are related to early vigour and the remaining traits are related to grain yield and its components. When the range of the mid parent, better parent and standard heterosis across the traits related to early vigour was studied, leaf area at both 30 and 60 days after sowing exhibited wide range of mid parent heterosis compared to other traits related to early vigour. In a similar exercise carried out for better parent and standard heterosis also revealed that the same two traits recorded wide range of heterosis in addition plant height at 30 days after sowing which exhibited a wide range over the better parent. Masikevich *et al.* (1989) reported similar reports for early vigour heterosis.

Based on magnitude of range of heterosis for grain yield and its components, grain yield per hectare followed by grain yield per plant and pith weight exhibited wider range of values for both mid and better parent heterosis compared to remaining traits. Such high heterosis levels were also reported by Verma and Singh (1980), Debnath (1989), Jha and Khera (1992), Kumar (1995) and Larish and Brewbaker (1999) observed high degree of heterosis for grain yield per plant and also by Han Li Jun *et al.* (2001) Kara (2001), Shahwanth *et al.* (2001) and Li-Jizhu *et al.* (2004).

In a similar exercise based on range of heterosis over Cargil 900-M, pith weight exhibited the widest range of heterosis (-9.34 to 82.49%) followed by 100-seed weight (-8.52 to 26.40%), cob weight (-12.26 to 24.93%) and the grain yield kg/ha (-19.44 to 24.29%) compared to other traits. For 100-grain weight, high degree of heterosis was also reported by Alvarez *et al.* (1993) and Turgut *et al.* (1995), Salillmar and Hoxha (1998) and Petrovic (1998). For cob weight Dornesai (1973) and Geetha (2001) noticed high degree of heterosis. High heterosis for grain yield per hectare was reported by Sayed Galal *et al.* (1977), Appadurai and Nagarajan (1975), Vasal *et al.* (1992) and Netaji *et al.* (2000).

A. Heterosis at early seedling stage for plant morphological traits

Out of 100 test hybrids, three, four and four hybrids exhibited significant heterosis in desirable direction over mid parent, better parent and standard heterosis respectively for plant height at 30 days after sowing. However, none of the hybrids were superior over mid parent and better parent for plant girth at 30 days after sowing except ten hybrids which were superior over the Cargil 900-M.

Expression of standard heterosis for leaf area at 30 days after sowing was very high which ranged from -73.33 to 70.67 per cent with 36 crosses exhibiting significant positive standard heterosis as against five crosses recording positive significant relative heterosis for this trait. For plant height at early stage, heterosis was reported by Ganguli *et al.* (1989), Vasal *et al.* (1982), Reddy and Agrawal (1992), Bhatnagar *et al.* (1993) and Saleh *et al.* (2002).

As many as 34, 13 and two hybrids recorded significant superior relative, better parent and standard heterosis for plant height at 60 days after sowing. When the number of hybrids with significant heterosis were compared for plant height between 30 and 60 days after sowing, there was a three to ten fold increase in the number of hybrids for relative and better parent heterosis whereas there was reduction in number of hybrids from four to two for standard heterosis indicating the better expression of heterosis for plant height at 60 days after sowing over mid and better parents compared to 30 days after sowing.

This is also supported by the large number of hybrids which showed significant relative, better and standard heterosis for leaf area at 60 days after sowing. In the present study, 65 hybrids over standard check, 60 over mid parent and 33 over better parent exhibited significant positive heterosis for leaf area at 60 days after sowing. These results indicate

Table 39: List of number of crosses exhibiting significant relative, better parent and standard heterosis and their range in maize

Sl. No.	Characters	Relative heterosis			Heterobeltiosis			Standard heterosis		
		+ve	-ve	Range	+ve	-ve	Range	+ve	-ve	Range
1	Plant height at 30 DAS (cm)	3	35	-20.33 to 28.51	4	59	-25.09 to 25.14	4	0	-13.43 to 38.68
2	Plant girth at 30 DAS (cm)	0	0	-15.04 to 21.41	0	0	-19.64 to 14.58	10	0	-1.79 to 30.80
3	Leaf area at 30 DAS (cm)	5	6	-32.85 to 34.57	0	10	-36.79 to 25.81	36	0	-17.33 to 70.67
4	Plant height at 60 DAS (cm)	34	1	-7.37 to 17.07	13	2	-10.77 to 16.03	2	5	-9.95 to 7.86
5	Leaf area at 60 DAS (cm)	60	0	-8.79 to 60.80	31	0	-14.37 to 57.13	65	0	-1.45 to 57.08
6	Ear at 60 DAS (cm)	25	0	-8.09 to 38.41	5	0	-13.30 to 29.49	0	10	-23.72 to 13.28
7	Cob weight (g)	60	0	-2.74 to 48.69	33	0	-9.57 to 49.95	7	0	-12.26 to 24.93
8	Cob length (cm)	16	0	-7.30 to 25.05	3	4	-14.72 to 16.79	0	9	-14.96 to 6.55
9	Cob girth (cm)	24	1	-8.84 to 18.10	13	1	-11.13 to 15.89	1	2	-10.95 to 11.37
10	Number of Kernel rows per cob	25	2	-10.24 to 21.05	13	5	-14.04 to 20.21	0	51	-22.03 to 3.39
11	Number of Kernels per row	36	1	-10.26 to 26.39	12	4	-15.82 to 21.04	1	4	-12.80 to 10.92
12	Pith weight (g)	27	0	-11.08 to 49.01	13	0	-19.76 to 66.92	18	0	-9.34 to 82.49
13	100-Seed weight (g)	13	1	-13.11 to 28.79	4	3	-19.54 to 28.45	8	0	-8.52 to 26.40
14	Shelling (%)	9	1	-5.57 to 4.04	1	2	-6.16 to 4.40	0	22	-7.96 to 0.55
15	Number of Kernels per cob	40	0	-9.46 to 38.22	12	3	-16.73 to 36.95	0	60	-25.38 to 1.63
16	Grain yield per plant (g)	58	0	-5.16 to 69.11	26	0	-16.45 to 51.50	0	0	-15.16 to 18.67
17	Grain yield per hectare (kg)	87	0	-04.53 to 88.73	51	1	-15.95 to 78.76	2	4	-19.44 to 24.29

presence of large number of hybrids with high degree of heterosis for early vigour which is a good indicator of hybrids potential for grain yield. The heterosis for leaf area at 60 DAS was reported by Shakoor (1988) and Abdul (1995).

B. Heterosis for grain yield and its components

When the crosses were identified based on significant heterosis over the mid parent, as many as 87 for grain yield, 60 for cob weight, 58 for grain yield per plant, 40 for number of kernels per cob, 36 for number of kernels per row and 27 for pith weight and 13 hybrids for 100-seed weight exhibited positive heterosis for these traits.

Mukherjee and Saha (1984) reported highest positive heterosis over mid parent for 100-seed weight.

The highest mid parent heterosis expression was observed for grain yield per hectare. As many as 87 crosses showed significant heterosis over the mid parent. Similar reports were recorded by Debnath (1984), Vasal *et al.* (1992), De (1996), Dass *et al.* (1997), Larish and Brewbaker (1999).

Dornesai (1973), Geetha (2001) and Saleh *et al.* (2002) reported varying degree of heterosis for cob weight.

Netaji *et al.* (2000) and Nageshkumar *et al.* (1999) reported positive heterosis ranging from 25.16 to 69.11 per cent. Considerable heterosis effect was also reported by Perez *et al.* (1995) for grain yield per plant.

Geetha (2001) reported maximum heterosis for grains per plant. De (1996) reported that 16 crosses showed significant positive heterosis over mid parent for number of kernels per row. However, there are no reports available in the literature on heterosis for pith weight.

The study of better parent heterosis for grain yield and its components revealed more or less a similar trend which was observed for the mid parent heterosis. When the number of hybrids with significant better parent heterosis in positive direction were scored for the grain yield per hectare, 51 hybrids exhibited significant better parent heterosis which was followed by grain yield per plant (26), cob weight (33), cob girth (13), number of kernel rows per cob, pith weight (13 each) and number of kernels per row (12) traits.

Whereas, for grain yield per plant, Verma and Singh (1980) reported a heterosis of 1.3 to 98.6 per cent over better parent. Verma and Singh (1980) reported heterosis of 1.3 to 98.6 per cent, Debnath (1984) reported heterosis of 2.6 to 95.07 per cent and Rao *et al.* (1996) reported 27.33 per cent of heterosis over better parent for grain yield per hectare.

Significant positive heterobeltiosis was expressed in the present investigation for cob girth. Considerable heterotic effect for this trait was noticed by Debnath (1987) and Turgut *et al.* (1995).

For number of kernel rows per cob, Rao *et al.* (1996) reported maximum heterosis of 6.28 per cent over better parent. Significant positive standard heterosis for 100-seed weight was also reported by different workers (Ganguli, 1986; Alvarez *et al.*, 1993 and Turgut *et al.*, 1995).

Significant standard heterosis for cob weight as observed in the present study was reported by Geetha (2001) and Saleh *et al.* (2002).

Larish and Brewbakar (1999) was reported significant standard heterosis for grain yield per hectare in maize.

Significant positive standard heterosis for number of kernels per row observed in the present investigation. The results are in accordance with those of Rao *et al.* (1996).

Turgut *et al.* (1995) reported significant standard heterosis for cob girth.

When top five hybrids were identified based on grain yield per hectare, only two hybrids viz., ARYP-24 × CM-111 and ARYP-15 × CM-111 recorded significantly superior standard heterosis for the grain yield per hectare. When superiority of these hybrids was analyzed for the contribution made by different component traits, cob girth, number of kernel rows per cob, cob length simultaneously contributed for the superior performance of top performing hybrids.

5.8 IDENTIFICATION OF SUPERIOR CROSSES FOR PRACTICAL UTILITY

In order to identify the superior crosses for practical utilization, the top five crosses based on their mean performance for each of the trait were identified along with their sca effects, gca status of parents and standard heterosis over the Cargil 900-M and the same is presented in the Table 40.

It is interesting to note that there were no common crosses across the traits out of the identified hybrids based on the mean performance. However, when the top five crosses were looked across the traits related to early vigour, none of the crosses recorded significant sca effects for plant girth at 30 DAS, leaf area at 30 DAS, ear height at 60 DAS. The hybrid ARYP-20 × NEI-9202B, ARYP-21 × NEI-9202B exhibited high mean performance for plant height at 30 DAS, leaf area at 60 DAS with a significant sca effects for these traits, in addition to ARYP-20 × NEI-9202B exhibited significant sca effect for plant height at 60 DAS.

These results revealed the superior performance related to the early vigour which could be exploited for improvement of these traits. In general the top hybrids did not exhibit significant effect for traits like, plant girth, leaf area at 30 DAS, whereas top hybrids showed significant the sca effects for plant height at 60 DAS and leaf area at 60 DAS, suggesting the hybrids express the early vigour at 60 DAS which can be used for screening hybrids for early vigour.

Among the top five hybrids identified for grain yield and its components, none of the hybrids exhibited significant sca effects for cob length, 100-seed weight, shelling percentage and grain yield per plant. However, one each for cob weight (ARYP-20 × NEI-9202B), number of kernel rows per cob (ARYP-25 × NEI-9202B) and number of kernels per cob (ARYP-13 × CM-111) exhibited significant sca effects with high *per se* performance for these traits. For other components of grain yield two hybrids viz., (ARYP-8 × KDMI-10) and (ARYP-20 × NEI-9202B) for cob girth and the other two hybrids (ARYP-19 × KDMI-10) and (ARYP-8 × NEI-9202B), for number of kernels per row also exhibited the significant sca effects with high *per se* performance. The above hybrids can be utilized for the exploitation of heterosis based on components of the grain yield thereby the grain yield performance can be improved through heterosis breeding.

Grain yield per ha varied from 7631 kg per ha to 8446 kg per ha among the top five hybrids selected on the basis of mean yield. However, out of these only two hybrids namely ARYP-24 × CM-111 and ARYP-23 × NEI-9202B exhibited significant sca effects and with a superior mean performance ranging from 15 to 25 per cent over the best commercial check Cargil 900-M. These two hybrids need to be further evaluated in a large scale trials before these are identified for commercial cultivation.

Table 40: Identified top five crosses based on mean performance and their sca effects, standard heterosis and gca status of parents for seventeen traits in maize

Sl. No.	Characters	Cross combination	Mean	Sca effect	gca Status		Standard heterosis Over Cargill 900-M
					Female	Male	
1	Plant height at 30 DAS (cm)	ARYP-25 x NEI-9202B	46.13	8.75**	2.69**	1.68**	38.68**
		ARYP-20 x NEI-9202B	42.67	7.05**	0.93	1.68**	28.26**
		ARYP-21 x NEI-9202B	42.40	5.20**	2.51**	1.68**	27.45**
		ARYP-18 x CM-111	41.00	6.02**	2.6.88**	-1.32**	23.25**
		ARYP-18 x NEI-9202B	35.67	-1.72	2.69**	1.68**	7.21
2	Plant girth at 30 DAS (cm)	ARYP-4 x CI-5	1.95	0.13	0.10	0.03	30.80*
		ARYP-18 x CI-5	1.93	0.20	0.01	0.03	29.46*
		ARYP-25 x KDMI -10	1.80	0.02	0.11	0.01	29.46*
		ARYP-11 x KDMI-10	1.75	0.13	-0.08	0.01	30.80*
		ARYP-18 x NEI-9202B	1.57	-0.09	0.01	-0.05	30.80*
3	Leaf area at 30 DAS (cm)	ARYP-21 x NEI-9202B	297.62	17.39	26.12*	-2.70	49.99
		ARYP-9 x CI-5	252.01	-7.18	-6.40	8.79	27.01
		ARYP-20 x NEI-9202B	227.31	-9.34	-17.45	-2.70	14.56
		ARYP-9 x CM-111	243.39	20.08	-6.40	-27.09	22.66
		ARYP-17 x CI-5	238.00	-13.37	-14.22	8.79	19.94
4	Plant height at 60 DAS (cm)	ARYP-20 x NEI-9202B	195.80	8.90*	1.45	5.46**	7.86*
		ARYP-1 x CM-111	194.33	5.25	7.55**	1.55	7.05*
		ARYP-14 x NEI-9202B	193.80	4.72	3.63	5.46**	6.76
		ARYP-9 x CI-5	193.87	10.7*	4.36*	-0.65	6.79
		ARYP-1 x CI-5	192.07	5.18	7.55**	-0.65	5.80
5	Ear at 60 DAS (cm)	ARYP-1 x CM-111	95.53	5.64	7.39**	2.16**	13.28
		ARYP-8 x NEI-9202B	93.07	7.65	1.16	3.92**	10.36
		ARYP-1 x NEI-9202B	91.67	0.01	7.39**	3.92**	8.70
		ARYP-20 x NEI-9202B	90.47	4.05	2.16	3.92	7.27
		ARYP-14 x NEI-9202B	90.40	8.31*	-2.18	3.92	7.19

6	Leaf area at 60 DAS (cm)	ARYP-21 x NEI-9202B	851.67	123.21**	48.89**	-0.52	57.08**
		ARYP-9 x CI-5	811.54	111.75**	11.55	8.16	49.68**
		ARYP-20 x NEI-9202B	785.00	104.65**	0.79	-0.52	44.78**
		ARYP-9 x CM-111	779.27	88.36*	11.55	-0.72	43.72**
		ARYP-17 x CI-5	776.85	84.19*	4.42	-0.52	43.28**
7	Cob weight (g)	ARYP-20 x NEI-9202B	243.58	28.74**	3.42	6.33**	24.93**
		ARYP-15 x NEI-9202B	240.19	17.01	11.82*	6.33**	23.19**
		ARYP-3 x NEI-9202B	234.80	6.51	16.93**	6.33**	20.43**
		ARYP-24 x NEI-9202B	230.26	9.50	9.40	6.33**	18.10*
		ARYP-25 x NEI-9202B	230.09	12.48	6.25	6.33**	18.02*
8	Cob length (cm)	ARYP-12 x NEI-9202B	21.13	1.29	0.43	0.55**	6.55
		ARYP-22 x NEI-9202B	20.83	-0.17	0.58	0.55**	5.04
		ARYP-14 x CI-5	20.63	1.05	0.80	-0.03	4.03
		ARYP-20 x CI-5	20.60	1.32	0.49	-0.07	3.87
		ARYP-6 x CI-5	20.57	1.16	0.61	0.07	3.70
9	Cob girth (cm)	ARYP-8 x KDMI-10	17.63	1.36**	0.64**	0.06	11.37**
		ARYP-15 x NEI-9202B	16.80	0.35	0.82**	0.06	6.11
		ARYP-20 x NEI-9202B	16.70	1.04*	0.04	0.06	5.47
		ARYP-17 x NEI-9202B	16.63	0.75	0.26	0.06	5.05
		ARYP-24 x CM-111	16.53	0.32	0.77**	-0.12	4.42
10	Number of Kernel rows per cob	ARYP-25 x CI-5	16.27	1.22*	0.87**	-0.06	3.39
		ARYP-17 x CM-111	16.00	0.70	0.94**	0.13	1.69
		ARYP-13 x CM-111	15.87	0.84	0.67*	0.13	0.85
		ARYP-15 x CM-111	15.73	0.72	0.66*	0.13	0.00
		ARYP-8 x KDMI-10	15.73	0.62	0.84**	0.04	0.00
11	Number of Kernels per row	ARYP-19 x KDMI-10	43.33	3.96**	1.95**	-1.11**	10.92*
		ARYP-3 x NEI-9202B	42.87	1.96	1.07	1.31**	9.73
		ARYP-14 x CI-5	42.73	2.33	2.64**	-0.77*	9.39
		ARYP-12 x NEI-9202B	42.67	2.53	0.30	1.31**	9.22
		ARYP-8 x NEI-9202B	42.40	3.08*	-0.51	1.31**	8.53

12	Number of Kernels per cob	ARYP-17 x CM-111	645.33	49.42	35.66**	12.88*	1.63
		ARYP-13 x CM-111	639.92	6.10*	14.57	12.88*	0.78
		ARYP-3 x CM-111	626.63	40.30	26.09*	12.88*	1.32
		ARYP-3 x NEI-9202B	605.73	18.11	26.09*	14.16**	4.61
		ARYP-8 x NEI-9202B	598.35	12.42	24.39	14.16**	5.77
13	100-Seed weight (g)	ARYP-6 x NEI-9202B	39.35	3.51	1.00	0.80	26.40*
		ARYP-12 x CI-5	39.16	3.58	0.65	0.89*	25.80**
		ARYP-20 x CM-111	37.81	1.86	3.17**	-1.25**	21.47*
		ARYP-15 x CI-5	37.47	1.71	0.84	0.89*	20.37*
		ARYP-22 x CI-5	37.06	0.83	1.30	0.89*	19.05*
14	Shelling (%)	ARYP-24 x NEI-9202B	86.85	0.75	1.52**	0.10	0.34
		ARYP-19 x NEI-9202B	86.85	0.26	2.00**	0.10	0.33
		ARYP-24 x KDMI-10	86.77	0.25	1.52**	0.52**	0.23
		ARYP-20 x KDMI-10	86.57	0.28	1.28**	0.52**	0.00
		ARYP-22 x KDMI-10	86.45	1.58	-0.13	0.52**	-0.13
15	Pith weight (g)	ARYP-15 x NEI-9202B	48.10	8.78**	7.07**	0.84	82.49**
		ARYP-15 x CM-111	39.98	0.38	7.07**	1.12*	51.67**
		ARYP-11 x CI-5	38.33	5.87*	0.97	0.08	45.41**
		ARYP-12 x NEI-9202B	38.14	2.45	3.43*	0.84	44.69**
		ARYP-8 x NEI-9202B	36.62	4.30	0.07	0.84	38.95*
16	Grain yield per plant (g)	ARYP-24 x NEI-9202B	200.09	11.36	11.85*	5.47*	18.67
		ARYP-14 x CI-5	199.35	20.85	6.38	0.71	18.23
		ARYP-3 x NEI-9202B	198.42	2.94	18.59**	5.47*	17.68
		ARYP-3 x KDMI-10	197.99	12.30	18.59**	-4.31	17.42
		ARYP-3 x CM-111	196.86	8.74	18.59**	-1.88	16.75
17	Grain yield per hectare (kg)	ARYP-24 x CM-111	8445.67	831.53*	639.43**	119.81	24.29**
		ARYP-15 x CM-111	8076.91	667.63	434.57*	119.81	18.86*
		ARYP-23 x NEI-9202B	7793.44	805.45*	-12.38	145.47	14.69
		ARYP-20 x CI-5	7767.62	622.54	206.62	83.56	14.31
		ARYP-23 x CM-111	7631.40	669.06	-12.38	119.81	12.30

* and ** significant at 1% and 5% level of probability, respectively

5.9 FUTURE LINE OF WORK

- Two promising single crosses (ARYP-24 × CM-111 and ARYP-15 × CM-111) hybrids identified in the present investigation need to be tested in a large scale multi-location trial and in farmers fields to test their potentiality before their commercial utilization.
- The other promising single cross hybrids with good general combiners as a parent can be advanced for improvement of specific traits of the parental lines.
- The parents with high gca effects for early vigour and grain yield components traits can be used in a multiple crossing programme in order to pool all favourable alleles distributed among the different parents for isolation of improved parental lines.

VI. SUMMARY

In the present investigation an attempt was made to isolate and evaluate the inbred lines derived from a newly constituted yellow pool base population. As many as 1500 individual plants were selected based on plant morphology in the fourth cycle of intermating generation, out of these 800 ear-to-row progenies were raised and subjected to self pollination to derive S_1 and S_2 lines. Genetic variability parameters were estimated for both S_1 and S_2 generation lines. Further an attempt was also made to classify the lines on the basis of frequency distribution both for quantitative and qualitative traits.

The selected 350 S_2 lines were evaluated by top cross test using CM-501 as a tester and based on test cross results 25 lines were selected further evaluated in a line $\times$ tester design using four testers. The resulting 100 hybrids, 25 lines, four testers and three checks were evaluated with three replications at Agricultural Research Station, Arabhavi during *khari* 2005. The salient results obtained in the present investigation are summarized below.

- Progenies in the base population based on cob characters exhibited very high coefficient of variation for cob weight, pith weight, number of kernels per cob and grain yield per plant. The progenies had platykurtic distribution for cob weight and grain yield per plant with a high mode than respective mean values indicating presence of higher proportion of superior progenies for both traits in base population. The median and mode indicated positive skewed distribution for pith weight with high mode value suggesting the greater scope of selection for lower pith weight thereby shelling percent can be improved.
- Evaluation of cobs-to-row progenies raised from previously selected 800 progenies for their early vigour at 30 DAS and grain yield and its components at maturity indicated the presence of high degree of variation for leaf area and leaf width compared to seedling girth and seedling height. Further median and mode values of traits related to early vigour exhibited negative skewed distribution with a platykurtic pattern indicating greater scope of selection among the progenies for improving early vigour. Among the traits studied at the time of maturity cob weight, pith weight, number of kernels per cob and grain yield per plant showed high coefficient of variability. Plant height and shelling percentage exhibited very low coefficient of variation.
- The analysis of variance due to genotype was highly significant for all the traits under study involving 400 S_1 lines suggesting presence of high degree of variability. Mean performance of S_1 progenies related to early vigour traits like seedling height, seedling girth was superior compared to S_0 progenies. A similar trend was also observed for productivity related traits compared to S_0 progenies on account of selection in the S_0 generation. Most of the productivity traits exhibited moderate to high estimates of PCV coupled with high heritability and genetic advance values.
- Frequency distribution of S_1 progenies revealed the presence of higher proportion of vigorous seedling with broader leaves than the S_0 generation. Based on grain characters higher proportion of flint and bold grained lines were observed in S_1 generation compared to S_0 generation. Grain yield per plant exhibited significant positive association with all growth and yield related parameters among the S_1 progenies. However number of kernel rows per cob was not associated with the leaf area and cob length indicating these as independent traits. Cob weight, cob length, cob girth, numbers of kernels per cob, 100 Seed weight and grain number per cob recorded high correlation coefficient value suggesting these as an important contributing traits of grain yield.
- Analysis of variance involving 350 S_2 lines revealed the presence of highly significant differences among these lines for all the growth and yield traits. Early growth parameters like plant height, plant girth and leaf area at 30 DAS exhibited moderate GCV coupled with high heritability estimates coupled with high percentage of genetic advance over the mean (GAM) for these traits. Grain yield also exhibited high GAM as most of its components had high heritability estimates coupled with moderate to

high coefficient of variability parameters. The over all mean grain yield per plant and 100 seed weight in S_2 progenies was lower than S_1 generation. Mean performance in respect of cob weight, cob length, number of kernel rows per cob, number of kernels per row and the number of kernels per cob was slightly more in S_2 compared to S_1 progenies. Association studies revealed similar patterns as observed in the S_1 generation except number of kernel rows per cob, 100-seed weight, shelling percentage and pith weight exhibited significantly negative association among these traits.

- ANOVA carried out involving 350 top crosses along with two check hybrids indicated presence of highly significant differences for all the 13 traits. Out of 350 top cross hybrids 13 hybrids involving the lines 231, 249, 246, 269, 278, 236, 283, 315, 264, 398, 176, 365 and 185 recorded more than 10 percent higher grain yield compared to the best check Cargill 900-M. In general the superiority of these hybrids was due to higher grain number per plant and lower pith weight.
- The mean sum of square due to line $\times$ tester was significant for most of the traits except for plant girth at 30 DAS, number of kernel rows per cob, 100 seed weight, number of kernels per cob, grain yield per plant and grain yield per hectare, indicating diverse performance of hybrids for remaining other ten traits. The variance due to line was highly significant for plant height at 60 DAS, ear height at 60 DAS, plant girth at 60 DAS, cob girth, number of kernel rows per cob, cob weight and pith weight indicating the presence of considerable variability for these traits among the selected S_2 lines. The contribution of lines to the total variance was higher than the tester for all the traits except the traits related to early vigour. The ratio of GCA to SCA variance was much below unity value for all the traits indicating the predominance of non-additive gene effects in the inheritance of the traits under the study.

Among the lines ARYP-3 was the best general combiner with a pool score of + 7 which was followed by ARYP-24 (+4) and ARYP-25 (+3) as a next best general combiners. Among the testers NEI-98008B was an excellent general combiner with a pool score of +9 compare to other testers. The line ARYP-19 and the tester KDMI-10 exhibited significant negative gca effect for pith weight. Whereas other parents ARYP-3, ARYP-20 and the tester CI-5 and NEI-98008B also exhibited significant positive gca effects for 100 seed weight.

Among the 100 hybrids, 29 combinations recorded positive pool score for their sca effect across the 17 traits. Twenty seven hybrid combinations were inferior with the negative score for their sca effects, 44 hybrid combinations scored zero for their sca effects. Based on pool score across traits, ARYP-20 $\times$ NEI-98008B (+7), ARYP-9 $\times$ CI-5 (+4) and ARYP-19 $\times$ KDMI-10 (+3), hybrids scored relatively high heterosis in positive direction. The two hybrids ARYP-5 $\times$ KDMI-10 and ARYP-23 $\times$ NEI-98008B exhibited significant sca effects for grain yield per ha. None of the hybrids exhibited significant sca effect for grain yield per plant.

- Based on the magnitude of mid parent and better parent heterosis across 17 traits revealed that leaf area at 30 DAS and 60 DAS and plant height at 30 DAS exhibited wide range of the heterosis. Among the grain yield and its components grain yield per ha, grain yield per plant and pith weight exhibited wide range of both mid and better parent heterosis compare to the remaining traits under study. In a similar exercise over Cargill 900-M, pith weight followed by 100 seed weight and the grain yield exhibited wide range of standard heterosis compare to other characters. Out of 100 hybrids 51 hybrids exhibited significant better parent heterosis for grain yield followed by grain yield per plant (26), cob weight (33), cob girth (13), number of kernel rows per cob (13), pith weight (13) and number of kernels per row (12).

Two hybrids namely, ARYP-24 $\times$ CM-111 and ARYP-15 $\times$ CM-111 recorded significantly superior grain yield per ha of 24.29 and 18.86 per cent over the best check Cargill 900-M respectively. The superior performance of identified hybrids was probably on account of their better performance. Cob girth, number of kernel rows per cob, cob length and 100 seed weight at the time of maturity. Out of these, first hybrid exhibited significant sca effect revealing the role of the non-additive gene action for its superior performance which can be considered for large scale trials in farmers' fields for confirmation of potentiality.

VII. REFERENCES

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APPENDIX

Appendix I: Mean monthly meteorological data for the year 2002-03 and average of past 52 years (1950-2001) recorded at the meteorological observatory of main Research Station, University of Agricultural Sciences, Dharwad

Months	Rainfall (mm)		Number of rainy days	Temperature(°C)				Relative humidity	
				Mean maximum		Mean minimum		2002	1950-2001
	2002	1950-2001		2002	1950-2001	2002	1950-2001		
January	0.00	0.00	0	30.1	29.11	14.5	14.20	55.00	63.72
February	62.70	0.00	1	31.9	34.59	17.9	15.96	50.00	51.22
March	0.00	0.14	0	36.0	35.75	20.0	18.77	49.00	56.69
April	67.00	47.98	5	37.0	37.07	21.7	21.33	53.00	77.83
May	57.90	83.42	4	34.9	36.55	23.0	21.45	62.00	67.00
June	60.50	111.55	4	29.6	29.49	21.9	21.20	80.00	81.86
July	15.00	15.80	0	28.4	27.03	21.3	20.95	79.00	87.74
August	48.10	97.88	7	26.6	27.02	20.5	20.63	82.00	86.71
September	6.60	103.98	1	29.8	28.76	20.0	20.17	73.00	82.65
October	103.60	133.11	6	30.7	30.10	20.4	19.28	67.00	76.80
November	7.00	33.10	1	30.5	29.42	17.1	15.45	62.00	68.41
December	0.00	5.64	0	30.2	29.15	14.4	13.41	47.00	64.39
Total	428.40	767.69	29						

Appendix II: Meteorological data for the year – 2002 at Agricultural Research Station, Arabhavi

Months	Temperature		Relative Humidity %		Average Relative Humidity (%)	Rainfall (mm)	Number of Rainy days	Mean evaporation (mm)
	Min.	Max.	Morning	Evening				
January	15.8	27.1	81.55	54.87	68.1	0	0	1.74
February	15	31.3	84.60	61.96	73.2	8.4	1	1.85
March	18.8	35.8	80.93	57.22	69	0	0	2.71
April	25.2	36.4	75.53	45.46	60.4	33	3	3.3
May	26.2	35.9	82.00	55.70	68.8	12.6	2	3.2
June	24.6	29.7	85.13	69.96	77.5	75.2	4	2.28
July	23.2	28	84.51	76.90	80.7	3.6	0	1.87
August	24	27.6	85.40	76.30	80.5	26.2	4	1.16
September	23.1	26.2	86.90	67.36	77.1	6.6	0	2.01
October	23.4	29.5	82.48	68.00	75.2	83.8	6	1.08
November	21.9	29.4	81.70	67.26	69.4	14.2	1	1.51
December	18.8	28.8	75.25	50.38	62.8	0	0	1.77
Total						263.60	23.00	

Appendix III: Meteorological data for the year – 2003 at Agricultural Research Station, Arabhavi

Months	Temperature		Relative Humidity %		Average Relative Humidity (%)	Rainfall (mm)	Number of Rainy days	Mean evaporation (mm)
	Min.	Max.	Morning	Evening				
January	19	29.4	78.70	42.19	55	0	0	1.32
February	20.7	32.5	71.32	38.03	52.1	0	0	1.71
March	24.8	34.3	62.12	26.74	45.5	0	0	2.17
April	27	35.2	56.63	28.78	47.4	39.3	4	2.4
May	25.9	38.5	59.83	28.62	57.2	57.2	4	3.54
June	24.8	33.2	36.51	46.75	70.5	104.1	5	2.6
July	24.5	30	78.91	64.30	74.4	41.6	4	1.61
August	23.5	29.7	82.27	55.33	79	23.4	2	1.6
September	23	29.3	82.66	58.26	73.4	47	5	2.01
October	18.9	30.2	77.10	63.00	69.7	40.2	2	1.57
November	15.6	30.4	75.93	46.41	61.6	13.5	1	1.75
December	11.3	30	75.76	40.11	60.4	0	0	1.48
Total						172.80	14.00	

Appendix IV: Meteorological data for the year – 2004 at Agricultural Research Station, Arabhavi

Months	Temperature		Relative Humidity %		Average Relative Humidity (%)	Rainfall (mm)	Number of Rainy days	Mean evaporation (mm)
	Min.	Max.	Morning	Evening				
January	19	30.1	75.22	34.86	55	0	0	1.45
February	20.7	30.3	71.75	32.63	52.1	0	0	1.87
March	24.8	35	65.18	25.95	45.5	0	0	2.83
April	27	37.2	71.03	23.90	47.4	39.3	4	2.71
May	25.9	32.7	71.86	22.70	57.2	57.2	4	2.33
June	24.8	28.6	79.16	61.84	70.5	104.1	5	1.46
July	24.5	28.3	82.87	66.12	74.4	41.6	4	1.43
August	23.5	26.3	83.40	77.76	79	23.4	2	0.75
September	23	27.9	81.80	65.18	73.4	47	5	1.32
October	18.9	27.1	76.77	62.77	69.7	40.2	2	3.19
November	15.6	24.4	84.66	38.66	61.6	13.5	1	2.24
December	11.3	27.3	84.48	36.51	60.4	0	0	2.16
Total						366.30	27	

Appendix V: Meteorological data for the year – 2005 at Agricultural Research Station, Arabhavi

Months	Temperature		Relative Humidity %		Average Relative Humidity (%)	Rainfall (mm)	Number of rainy days	Mean Evaporation (mm)
	Min.	Max.	Morning	Evening				
January	16.00	26.37	83.19	45.45	64.32	-	-	2.16
February	14.60	30.10	84.89	31.94	58.41	-	-	5.39
March	18.67	34.11	82.77	23.57	53.17	-	-	7.90
April	23.5	33.10	78.36	32.83	55.59	14.5	1	6.09
May	24.16	34.11	75.67	34.19	54.93	30.5	1	5.95
June	23.34	24.06	85.24	60.19	72.71	105.1	6	4.80
July	22.66	27.37	92.11	74.18	83.14	146.0	9	3.27
August	21.60	27.22	89.90	76.96	83.43	73.8	8	3.26
September	21.40	22.13	91.13	70.32	80.72	93.8	4	2.86
October	20.38	30.00	87.64	56.65	72.15	64.0	7	2.62
November	15.16	29.40	83.66	46.03	64.84	-	-	3.63
December	12.67	29.06	83.67	42.87	63.27	-	-	2.91
Total						527.7	36	

Appendix VI: Mean performance of top crosses of S₂ progenies with CM-501 as tester in maize

Sl. No.	Entry number	Plant height (cm)	Ear height (cm)	Cob weight (cm)	Cob Length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Number of kernels per cob	Pit weight (g)	100-seed weight (g)	Shelling (%)	Grain yield per plant (g)	Grain yield per plot (kg)
	1	2	3	3	4	5	6	7	8	9	10	11	12	13
1	2	149.00	81.50	118.84	15.15	14.85	16.40	28.00	459.20	19.78	29.16	83.38	99.07	1.012
2	4	162.00	86.00	140.41	16.60	14.30	15.00	29.00	435.00	21.56	26.83	84.64	118.85	1.378
3	11	170.50	73.00	126.90	17.00	15.30	15.40	29.00	446.60	23.33	25.37	81.64	103.58	1.397
4	12	164.00	82.00	150.78	14.50	14.50	16.00	30.50	488.00	19.18	29.02	87.29	131.60	1.328
5	17	141.50	66.50	117.08	15.75	13.70	13.60	26.50	359.80	25.10	27.52	78.54	91.98	1.327
6	18	165.50	73.00	172.25	17.51	12.80	14.00	28.50	399.00	30.36	26.69	82.39	141.89	1.331
7	21	166.50	81.00	104.22	14.15	12.70	15.60	30.50	475.60	32.32	24.39	68.96	71.90	1.264
8	24	172.50	84.50	94.04	17.30	12.35	13.00	26.00	338.00	15.08	25.43	84.03	78.96	1.131
9	29	167.50	82.00	139.26	15.10	13.75	13.60	27.00	366.40	20.57	27.88	85.14	118.69	1.110
10	32	186.00	89.50	173.43	17.50	13.10	14.40	31.00	446.40	19.85	27.03	88.56	153.58	1.367
11	34	178.00	80.50	159.64	15.80	13.45	13.00	30.00	389.60	19.62	19.82	87.71	140.02	1.436
12	35	172.50	82.00	144.74	15.30	13.65	13.40	32.00	427.60	21.79	30.40	84.95	122.95	1.459
13	39	168.00	81.00	146.17	16.75	15.90	15.60	29.00	452.80	23.64	26.70	83.83	122.53	1.420
14	42	179.50	81.50	173.24	18.15	14.45	14.00	36.00	504.00	29.12	26.59	83.20	144.12	1.433
15	43	158.00	76.50	123.56	17.15	14.85	14.80	32.00	473.60	25.33	23.22	79.49	98.23	1.214
16	44	168.50	84.50	122.87	15.25	15.00	14.40	30.50	439.40	24.17	26.39	80.34	98.69	1.409
17	47	170.00	79.00	142.59	14.30	14.65	15.40	28.50	439.20	25.95	29.21	81.81	116.65	1.210
18	49	187.00	77.00	155.88	15.50	12.50	15.40	26.00	400.00	22.78	29.87	85.40	133.10	1.279
19	50	173.50	83.00	168.36	16.50	13.25	14.40	35.00	504.00	31.01	27.10	81.61	137.35	1.287
20	55	179.00	79.00	135.56	14.00	14.65	15.80	27.00	426.60	24.80	25.29	81.68	110.76	1.362
21	56	168.00	84.00	132.41	15.65	13.10	14.40	35.00	504.00	21.47	28.09	83.81	110.94	1.363
22	58	169.50	77.00	111.02	13.35	14.50	14.00	25.50	357.00	21.10	30.52	81.02	89.93	1.437
23	62	175.50	83.00	141.34	16.05	13.80	16.60	26.50	439.40	24.61	25.88	82.62	116.73	1.453
24	63	156.00	78.00	140.15	15.00	14.70	15.60	26.50	414.00	18.49	24.29	86.82	121.66	1.514
25	65	146.50	71.00	110.18	14.65	15.65	14.80	29.50	436.80	20.75	30.26	81.21	89.43	1.130
26	66	146.50	77.50	124.30	14.20	12.55	14.70	30.00	441.00	18.67	25.89	85.01	105.64	1.405
27	67	172.00	77.50	143.78	15.40	13.80	15.00	25.00	375.00	21.77	25.53	84.86	122.02	1.385

28	68	151.50	70.50	115.12	15.10	15.20	15.10	27.00	407.80	19.60	24.94	82.98	95.53	1.050
	1	2	3	3	4	5	6	7	8	9	10	11	12	13
29	69	157.50	79.00	166.25	16.30	13.70	15.10	28.50	430.50	21.58	25.27	87.03	144.67	1.191
30	70	165.00	85.50	123.19	15.60	12.45	15.30	26.50	405.80	19.56	22.15	84.06	103.62	1.167
31	71	150.50	80.50	150.80	17.50	14.35	13.20	38.50	508.20	22.93	26.87	84.74	127.87	1.379
32	73	158.00	82.00	128.84	16.60	13.40	15.10	30.00	452.90	25.76	20.53	79.88	103.08	1.272
33	74	143.50	86.50	120.65	12.85	14.35	14.00	28.00	392.00	19.95	26.46	83.41	100.70	1.379
34	76	139.50	77.00	112.04	14.65	14.40	14.00	27.00	378.00	19.90	25.34	82.25	92.14	1.093
35	77	172.00	84.00	127.73	14.40	15.30	17.10	33.00	564.30	21.30	19.97	83.33	106.43	1.207
36	80	140.00	89.50	123.45	16.20	13.75	15.80	30.50	483.40	21.83	26.77	82.32	101.61	1.463
37	81	167.50	75.00	139.41	16.20	14.15	14.90	23.50	350.60	20.83	27.64	85.07	118.57	1.401
38	83	140.50	70.00	160.99	16.15	13.60	14.40	28.00	404.40	26.97	31.41	83.18	134.02	1.283
39	87	167.50	86.00	132.01	16.00	13.15	14.80	31.00	458.80	24.83	26.65	81.14	107.18	1.377
40	90	142.00	80.50	150.24	15.15	13.10	14.40	27.00	389.20	22.97	32.46	84.73	127.28	1.241
41	93	150.00	81.00	159.68	16.35	13.50	14.00	28.50	400.20	21.40	25.60	86.62	138.28	1.171
42	94	148.00	81.00	164.15	16.15	12.85	16.60	32.50	539.80	32.27	28.67	80.35	131.88	1.131
43	100	140.00	88.50	118.96	15.15	12.50	15.60	27.00	420.40	20.12	23.19	83.09	98.84	1.256
44	103	136.50	76.00	118.22	15.70	12.65	14.50	28.00	406.00	18.76	25.98	84.13	99.47	1.360
45	106	143.50	74.50	107.67	12.50	12.40	15.40	27.00	414.60	17.44	24.82	83.74	90.23	1.113
46	107	137.50	75.00	156.71	18.00	12.85	13.60	24.00	326.80	23.64	29.23	84.93	133.07	1.207
47	109	145.00	71.50	119.20	14.90	13.15	15.00	27.50	412.40	22.78	26.31	80.87	96.42	1.071
48	110	152.00	72.50	122.92	15.60	13.90	14.40	32.00	460.00	29.53	23.12	75.93	93.39	1.225
49	111	143.00	76.00	156.40	17.65	13.15	14.50	23.50	341.20	23.57	31.43	84.96	132.84	0.835
50	112	145.00	76.50	157.58	16.80	14.50	14.00	31.50	440.60	34.63	33.75	78.03	122.95	1.462
51	114	169.00	90.00	133.64	17.20	13.40	15.40	27.00	415.60	22.78	26.50	82.96	110.86	1.035
52	115	138.50	72.00	103.90	13.15	13.40	14.00	24.50	342.60	18.62	27.41	82.01	85.27	1.094
53	117	146.50	78.50	136.46	16.15	14.70	14.00	33.50	468.60	24.96	31.67	81.70	111.50	1.191
54	118	133.00	74.50	140.72	14.90	14.65	15.75	32.50	511.75	29.18	26.30	79.28	111.55	1.165
55	128	136.00	79.50	110.46	14.15	13.40	14.60	28.50	417.00	20.79	27.12	81.19	89.67	1.025
56	132	148.00	79.00	128.42	13.60	12.90	17.00	25.00	425.00	23.95	21.32	81.26	104.47	1.298
57	134	148.00	75.00	143.15	16.50	14.35	15.20	27.00	410.40	21.54	23.29	84.85	121.61	1.400
58	139	133.50	70.00	131.20	16.00	12.70	14.70	31.00	455.60	19.18	31.04	85.38	112.02	1.215
59	140	142.50	77.00	167.11	14.85	14.75	15.60	27.50	430.00	19.13	31.00	88.56	147.97	1.197

60	142	146.50	80.00	140.20	16.00	13.50	13.50	29.50	398.00	32.57	28.65	76.77	107.63	1.171
61	143	154.00	79.00	142.22	17.90	15.00	14.80	36.00	532.80	22.90	24.28	83.90	119.32	1.203
62	146	131.50	70.50	123.12	14.80	12.65	13.20	31.50	416.00	18.35	25.72	84.90	104.77	1.238
63	149	139.00	73.50	109.80	15.30	13.90	15.10	26.00	392.70	18.82	20.02	82.86	90.98	1.087
	1	2	3	3	4	5	6	7	8	9	10	11	12	13
64	151	152.50	84.50	185.32	18.10	16.00	17.60	32.50	572.20	17.93	31.21	90.32	167.39	1.538
65	152	153.50	90.00	141.19	17.30	12.45	15.10	27.50	415.00	24.78	28.61	82.45	116.41	1.137
66	154	161.00	84.50	136.14	14.30	14.25	15.70	27.00	424.40	20.69	30.00	84.80	115.44	1.205
67	155	143.00	74.50	170.27	16.15	14.05	15.50	26.50	410.50	17.50	26.31	89.73	152.77	1.199
68	158	152.50	79.50	129.12	16.45	13.50	15.00	30.00	450.00	40.57	23.52	68.59	88.54	1.319
69	160	158.50	77.50	120.41	15.90	14.25	15.20	27.00	410.40	20.63	24.89	82.89	99.78	1.291
70	161	165.00	78.00	155.20	17.35	14.75	13.60	28.50	387.00	20.90	27.21	86.55	134.30	1.329
71	163	146.00	73.00	125.85	13.50	14.05	15.80	28.50	451.20	19.33	28.99	84.66	106.52	1.282
72	164	152.50	72.50	121.95	16.45	13.55	14.20	34.00	482.80	18.70	30.50	84.68	103.25	1.240
73	168	131.50	66.50	115.89	16.30	14.30	14.40	26.50	382.20	20.44	29.68	82.34	95.45	0.967
74	170	154.50	89.50	129.22	16.80	12.65	13.60	35.00	476.00	21.79	25.84	83.18	107.43	1.407
75	172	141.50	73.50	144.99	14.35	12.95	14.40	29.00	418.00	21.19	27.32	85.38	123.80	1.128
76	174	149.50	81.00	166.88	16.00	12.95	15.40	29.00	446.00	23.66	31.73	85.82	143.22	1.349
77	175	148.50	82.50	166.52	16.50	15.80	15.20	25.00	380.00	25.35	26.59	84.78	141.17	1.497
78	176	152.00	84.50	183.15	17.80	16.00	15.60	38.50	600.80	22.96	35.57	87.45	160.19	1.591
79	177	136.00	83.00	126.55	15.25	15.40	16.00	31.00	496.00	19.29	23.64	84.76	107.26	0.948
80	179	155.50	78.00	149.43	15.30	13.85	16.00	31.00	496.00	20.21	27.21	86.50	129.22	1.369
81	180	139.50	77.50	160.42	15.25	14.10	16.00	26.00	416.00	24.21	27.13	84.88	136.21	1.404
82	181	150.00	79.00	119.15	17.50	12.80	13.40	34.00	455.60	22.70	25.37	80.86	96.45	1.086
83	182	137.50	81.50	164.44	15.00	13.80	16.60	27.00	448.20	26.77	37.12	83.72	137.68	1.327
84	183	142.00	83.00	137.27	15.05	14.75	15.00	29.00	435.40	22.95	25.41	83.28	114.33	1.420
85	185	145.50	80.50	184.09	17.80	14.75	16.00	33.00	528.00	28.00	33.34	84.79	156.09	1.584
86	187	153.00	84.50	157.72	15.55	15.15	15.60	34.00	530.40	23.39	29.57	85.18	134.33	1.421
87	188	146.00	78.00	152.06	15.40	15.60	15.40	29.00	446.00	25.92	29.16	82.96	126.14	1.403
88	189	143.00	80.00	161.79	16.15	13.50	15.40	24.00	369.80	22.12	30.93	86.33	139.66	1.040
89	191	142.00	82.50	116.62	16.45	13.35	14.40	26.50	381.00	22.24	25.51	80.96	94.37	1.336
90	195	146.50	77.00	129.24	14.80	13.50	14.80	28.50	421.80	20.52	28.64	84.14	108.72	1.224
91	196	141.00	73.50	155.18	17.50	14.65	15.40	27.50	423.20	29.92	27.76	80.72	125.26	1.436

92	197	146.50	78.00	135.66	13.50	12.75	15.80	26.50	417.80	25.74	25.17	80.94	109.91	1.365
93	199	149.50	77.50	119.39	15.65	15.30	15.90	29.00	461.20	19.74	23.32	83.48	99.65	0.990
94	202	143.00	79.50	122.00	15.75	13.65	15.50	31.00	481.50	19.42	28.38	84.08	102.57	1.217
95	203	151.50	86.00	149.22	15.65	14.00	15.10	29.50	445.40	31.80	30.06	78.65	117.42	1.289
96	205	150.00	82.50	129.03	15.75	13.65	15.60	25.50	398.00	21.95	29.09	82.88	107.07	1.509
97	206	145.00	78.00	131.27	17.25	14.15	15.40	30.00	462.00	25.69	21.23	80.06	105.58	1.464
98	209	156.00	83.00	126.58	16.15	13.35	14.60	31.50	460.20	25.10	25.96	80.18	101.48	1.135
	1	2	3	3	4	5	6	7	8	9	10	11	12	13
99	210	147.50	80.00	128.94	14.75	14.25	14.50	27.00	391.20	24.14	19.78	81.27	104.80	1.364
100	213	153.00	79.50	117.01	14.50	13.25	14.00	30.00	421.60	20.63	28.36	82.39	96.38	1.374
101	215	133.00	74.00	145.61	17.75	13.90	15.60	35.00	546.80	23.70	27.06	83.73	121.91	1.048
102	216	141.00	76.00	154.44	17.15	13.50	16.00	31.50	505.20	20.12	26.71	86.98	134.32	1.075
103	217	148.50	84.50	123.64	15.00	12.50	14.60	31.00	452.60	17.96	26.67	85.39	105.69	0.871
104	220	145.50	77.50	110.15	12.55	13.00	15.40	26.50	407.80	20.36	23.83	81.43	89.79	1.140
105	221	140.00	80.50	148.80	15.00	15.80	16.10	29.50	474.80	22.89	23.93	84.62	125.91	1.017
106	222	144.50	75.50	124.28	14.05	13.55	16.00	29.50	471.60	28.41	22.99	77.15	95.88	1.466
107	224	157.50	86.00	158.82	16.45	13.65	15.85	29.00	459.65	33.22	24.91	79.10	125.59	1.123
108	227	157.00	82.50	130.73	16.15	14.55	15.70	31.00	486.70	26.56	23.18	79.47	104.17	1.200
109	228	154.00	78.50	160.45	16.55	14.00	14.60	28.50	416.40	26.46	23.60	83.53	133.99	1.121
110	229	149.50	83.50	120.78	16.15	14.85	18.40	28.50	524.10	24.18	23.80	79.99	96.60	1.231
111	230	145.50	80.00	121.08	16.60	15.10	15.40	28.00	431.20	22.54	20.46	81.28	98.54	1.070
112	231	157.50	84.50	198.03	18.10	16.25	16.10	34.00	547.40	30.38	31.81	84.67	167.66	1.773
113	233	150.00	83.50	152.29	14.70	14.80	15.20	25.50	387.60	26.82	20.61	82.38	125.47	1.125
114	235	170.50	96.00	112.14	14.60	12.60	15.80	28.00	442.40	18.81	26.48	83.17	93.33	1.353
115	236	154.00	84.50	187.68	18.10	16.00	18.10	33.00	597.30	27.80	37.52	85.17	159.88	1.629
116	237	160.00	78.00	145.20	15.65	13.15	15.60	31.00	483.60	22.52	30.10	84.46	122.68	1.448
117	239	160.50	81.50	135.44	17.85	15.75	15.10	30.00	453.00	22.59	29.74	83.32	112.85	1.203
118	240	163.50	86.00	150.64	15.50	13.00	14.40	33.00	474.40	26.08	24.04	82.64	124.56	1.466
119	242	157.50	82.50	136.19	15.50	13.10	13.50	33.50	452.00	23.34	29.05	82.61	112.85	1.334
120	243	150.50	83.50	121.62	16.25	15.75	15.00	27.50	412.20	19.89	23.13	83.65	101.73	1.395
121	244	160.50	83.50	156.89	16.20	14.10	16.00	31.00	496.00	22.02	24.31	85.96	134.86	1.290
122	245	159.00	85.50	130.85	15.60	14.05	15.40	24.00	369.60	24.41	28.74	81.17	106.45	1.295
123	246	159.00	88.50	175.68	19.20	16.65	16.00	33.50	536.00	21.89	31.70	87.45	153.79	1.728

124	249	162.00	81.50	173.22	17.75	13.70	15.20	35.50	539.60	24.29	38.96	86.00	148.93	1.755
125	251	145.50	80.50	100.17	13.15	13.50	15.90	24.00	381.60	16.88	29.59	83.15	83.29	1.373
126	253	192.00	85.00	134.61	15.55	14.80	14.40	32.00	461.20	19.15	31.47	85.78	115.45	1.171
127	254	175.50	85.00	151.46	14.50	14.30	15.50	27.00	418.50	22.53	32.60	85.12	128.93	1.291
128	255	171.50	77.00	126.46	15.65	13.45	15.50	28.50	441.00	23.28	23.22	81.60	103.18	1.283
129	257	178.50	84.00	101.63	14.40	12.20	13.20	25.50	336.60	18.80	24.25	81.12	82.83	1.311
130	258	152.00	82.50	137.94	15.85	13.65	12.60	29.50	371.40	24.42	22.23	82.05	113.52	1.071
131	259	170.00	98.50	159.66	16.30	13.15	14.60	30.00	438.00	28.57	30.10	81.96	131.09	1.486
132	260	175.50	93.50	140.46	16.45	13.40	13.05	30.50	398.40	26.95	28.04	80.86	113.51	1.441
133	261	163.00	77.50	155.54	16.20	13.65	13.60	28.00	380.80	32.16	29.42	79.30	123.37	1.088
	1	2	3	3	4	5	6	7	8	9	10	11	12	13
134	263	144.50	80.50	172.87	15.65	12.90	15.00	27.00	405.20	24.53	25.21	85.82	148.34	1.306
135	264	179.50	81.00	189.06	18.15	16.65	16.50	30.50	503.10	27.60	30.42	85.38	161.45	1.605
136	266	158.00	87.00	147.77	16.85	14.65	16.30	28.00	456.40	29.25	22.76	80.20	118.52	1.192
137	267	169.50	89.50	185.03	14.60	14.40	13.60	40.50	550.60	27.59	30.09	85.00	157.44	1.338
138	269	171.50	86.50	174.26	18.15	15.15	14.50	36.50	530.00	24.47	32.07	85.89	149.80	1.720
139	270	146.50	63.00	141.63	16.35	13.25	14.00	29.00	405.20	25.89	27.96	81.68	115.74	1.199
140	275	149.00	79.00	134.70	15.85	12.95	13.00	31.00	403.00	21.58	31.61	83.99	113.12	1.020
141	276	160.50	77.00	170.54	16.80	13.35	15.40	29.00	446.00	22.49	30.52	86.78	148.06	1.222
142	277	137.50	74.50	137.14	14.65	13.65	14.75	31.50	464.55	25.61	26.20	81.32	111.53	1.329
143	278	152.50	77.00	193.82	17.65	16.75	16.40	30.00	491.60	23.61	34.29	87.81	170.21	1.693
144	279	158.50	84.00	145.84	17.15	14.35	13.40	31.50	423.00	25.37	26.50	82.58	120.47	1.548
145	280	179.00	94.00	148.32	16.10	12.65	14.40	28.00	402.40	22.19	24.10	85.05	126.13	1.338
146	283	156.00	84.50	198.78	18.30	17.00	15.00	31.00	464.00	32.01	35.32	83.91	166.77	1.611
147	284	148.00	73.50	170.40	18.30	16.40	16.00	30.50	487.90	30.91	32.39	81.86	139.49	1.533
148	285	152.00	78.00	119.56	17.15	13.55	14.70	31.50	462.30	22.60	28.56	81.07	96.96	1.337
149	286	168.50	91.50	159.51	16.55	13.90	14.60	32.00	467.60	28.98	31.69	81.77	130.53	1.200
150	290	156.00	85.00	126.53	15.15	13.05	16.60	29.00	481.20	20.17	19.40	84.04	106.36	1.244
151	291	163.50	87.00	152.40	14.15	14.30	16.60	27.00	448.20	28.71	30.87	81.16	123.69	1.273
152	292	158.00	89.00	97.55	13.10	13.50	16.60	26.00	431.60	20.65	25.01	78.55	76.90	1.072
153	294	157.50	88.00	143.29	15.20	13.85	15.70	30.00	470.70	28.58	30.31	79.95	114.71	1.179
154	296	145.50	81.50	145.58	15.20	13.20	15.20	32.00	486.40	27.66	29.53	81.01	117.92	1.126
155	300	168.00	83.00	156.34	18.00	14.95	15.80	31.00	489.80	27.59	26.43	82.33	128.75	1.216

156	302	154.00	77.00	183.41	18.25	15.15	16.90	32.00	541.00	30.04	38.54	83.62	153.37	1.552
157	305	166.50	96.00	146.15	15.30	13.30	14.65	26.50	387.25	23.86	30.78	83.69	122.29	1.282
158	306	154.50	87.00	165.05	16.25	13.85	15.60	34.00	530.40	28.29	24.42	82.87	136.76	1.277
159	310	179.50	91.50	154.51	17.80	13.20	16.60	30.00	497.60	32.30	30.02	79.05	122.21	1.489
160	311	161.50	79.50	152.41	13.55	14.15	15.70	26.00	408.50	19.71	23.52	87.04	132.70	1.349
161	312	159.50	96.00	160.83	15.95	15.25	16.00	23.00	368.00	30.57	26.59	80.94	130.26	1.313
162	313	150.00	77.50	122.86	15.15	14.20	15.40	30.50	469.40	26.76	21.47	78.20	96.10	1.282
163	314	153.00	86.50	150.01	16.95	13.30	15.40	30.00	462.00	27.57	27.83	81.52	122.44	1.236
164	315	162.50	89.50	185.64	16.90	16.35	16.50	33.00	544.50	29.64	35.63	84.04	156.00	1.608
165	316	160.50	82.50	85.93	14.50	12.80	13.20	26.00	343.20	17.38	30.58	79.78	68.56	0.823
166	321	142.00	76.50	168.07	17.50	13.55	16.25	30.50	495.65	28.76	32.10	82.89	139.31	1.286
167	325	154.00	85.50	160.76	17.90	14.65	15.10	33.00	498.10	22.05	26.95	86.26	138.71	1.127
168	327	152.00	86.00	158.62	15.85	13.50	15.90	31.50	500.50	26.90	30.66	83.03	131.72	1.258
	1	2	3	3	4	5	6	7	8	9	10	11	12	13
169	328	147.00	87.50	150.77	14.50	13.50	15.20	29.50	448.40	25.66	29.52	83.01	125.11	1.417
170	330	159.50	88.00	132.92	15.15	14.05	15.50	30.50	472.50	28.99	29.19	78.19	103.93	1.068
171	332	152.50	80.50	107.38	16.85	12.55	13.10	32.50	425.60	20.81	23.14	80.47	86.57	1.122
172	334	163.00	79.00	94.42	14.40	12.05	13.50	32.50	439.00	23.40	29.91	75.04	71.03	1.059
173	335	152.00	84.50	105.89	15.45	12.70	14.70	25.50	375.10	19.69	25.86	81.19	86.20	1.109
174	336	140.50	81.00	110.45	14.65	13.55	14.00	26.00	364.00	23.80	27.38	78.09	86.65	0.936
175	338	147.00	82.00	104.26	14.80	13.40	14.50	28.00	406.00	18.08	27.22	82.68	86.18	1.125
176	339	154.50	86.50	115.03	14.05	13.75	14.60	25.00	365.00	24.37	28.33	78.85	90.66	1.096
177	340	153.50	84.50	104.89	13.50	13.80	16.90	25.00	422.50	20.56	28.41	80.41	84.34	0.953
178	341	155.00	84.50	137.97	13.50	14.40	14.60	23.00	335.20	19.53	23.06	85.85	118.44	1.323
179	342	155.00	85.50	123.57	15.45	15.40	14.40	28.50	409.80	25.58	28.98	78.98	97.99	1.296
180	344	147.50	84.50	165.39	16.65	13.65	15.50	32.00	495.50	30.76	16.79	81.40	134.63	1.299
181	348	158.00	86.00	127.15	15.75	13.55	17.60	27.00	475.60	24.14	30.30	81.00	103.01	1.249
182	350	148.50	79.00	127.78	15.95	15.40	15.60	27.00	421.20	22.49	25.02	82.37	105.29	1.172
183	355	158.00	81.00	126.95	13.05	13.45	14.30	29.50	422.30	22.36	29.45	82.36	104.59	1.025
184	357	159.00	91.50	123.75	16.00	13.40	12.80	33.50	428.80	21.64	22.80	82.52	102.10	1.108
185	359	156.00	81.00	151.51	16.05	12.35	14.70	30.50	448.10	22.51	23.80	85.16	129.00	1.342
186	361	158.00	81.00	143.83	16.85	12.90	14.80	31.00	458.80	21.47	26.46	85.11	122.36	1.045
187	362	151.50	78.00	133.70	16.00	13.45	16.30	29.50	481.00	25.25	24.73	81.13	108.45	1.047

188	365	144.00	75.00	180.84	18.15	16.35	15.00	35.00	525.00	24.28	34.42	86.58	156.55	1.587
189	373	151.50	83.50	153.65	15.15	13.30	15.20	30.50	463.60	26.28	29.80	82.87	127.37	1.046
190	375	152.50	79.00	116.37	15.90	12.75	14.40	26.50	381.00	19.96	23.43	82.88	96.41	1.134
191	378	146.00	76.00	123.99	14.80	12.75	14.30	26.50	378.20	20.62	25.23	83.36	103.37	0.988
192	379	152.50	78.50	128.52	16.90	12.90	14.50	25.50	369.60	25.55	26.15	80.12	102.97	0.981
193	380	144.00	82.00	110.44	14.65	14.65	16.00	22.50	358.00	20.56	26.73	81.40	89.88	1.010
194	382	152.50	89.50	114.05	15.55	12.85	13.60	26.50	361.00	20.78	21.24	81.80	93.27	1.279
195	384	135.50	75.50	137.28	17.35	15.30	13.60	34.50	469.00	24.07	29.79	82.47	113.21	0.908
196	385	143.00	76.50	127.09	15.15	15.35	13.00	27.00	351.20	24.25	28.30	80.82	102.84	1.322
197	386	145.50	80.50	156.84	14.90	13.35	16.00	30.50	488.00	22.42	25.55	85.72	134.42	1.121
198	388	157.00	84.00	134.56	15.50	14.15	15.40	31.50	484.20	23.33	27.17	82.49	111.23	1.200
199	389	154.00	79.50	145.38	17.20	13.10	17.00	29.50	501.40	27.20	25.60	81.31	118.18	1.125
200	391	155.00	81.00	144.87	15.35	14.05	16.60	26.50	439.00	22.99	22.51	84.15	121.88	1.368
201	397	137.50	72.50	145.30	15.30	14.25	14.60	33.00	481.80	21.98	29.20	84.86	123.32	1.472
202	398	144.00	82.00	175.81	18.50	16.15	17.90	37.00	662.30	28.22	31.99	83.95	147.59	1.599
203	399	137.50	78.50	143.16	16.55	14.30	15.10	29.50	445.30	33.88	26.62	76.25	109.28	0.945
	1	2	3	3	4	5	6	7	8	9	10	11	12	13
204	400	147.50	80.50	167.38	16.95	13.65	13.40	28.50	381.00	21.88	25.80	86.93	145.50	1.042
205	401	154.00	88.00	111.82	14.95	14.30	13.20	29.00	382.80	21.22	21.87	80.77	90.60	1.236
206	402	153.00	82.00	151.79	17.20	16.85	15.20	32.00	486.40	21.37	28.35	85.86	130.43	1.214
207	403	162.50	77.50	116.80	13.75	13.10	15.50	25.00	387.50	18.93	20.42	83.57	97.87	0.992
208	404	155.50	81.50	151.69	15.50	14.05	15.10	31.00	468.10	26.35	29.03	82.61	125.34	0.978
209	405	183.00	96.00	130.34	14.00	12.65	15.30	28.50	435.00	24.29	30.88	81.27	106.05	1.020
210	406	145.00	80.50	149.33	15.35	13.40	14.40	26.00	373.60	27.68	24.26	81.43	121.65	1.267
211	413	157.50	76.50	121.88	15.15	12.55	14.40	31.50	453.00	21.35	23.06	82.48	100.53	0.855
212	415	139.50	81.00	119.09	14.90	13.55	15.00	28.00	420.20	22.42	31.90	81.20	96.68	0.946
213	416	139.50	79.00	119.80	14.00	13.65	15.60	30.00	468.40	21.44	25.66	82.11	98.36	1.024
214	417	147.50	76.50	194.85	19.05	16.25	15.10	30.50	460.50	21.95	34.33	88.73	172.90	1.556
215	419	160.00	82.50	134.54	14.85	13.50	14.00	29.00	405.20	22.13	31.56	83.57	112.41	1.123
216	421	155.00	83.00	143.28	17.65	13.65	15.00	23.50	353.00	20.59	28.44	85.64	122.70	1.387
217	422	163.00	79.50	171.56	15.65	13.90	15.10	29.50	445.60	28.23	19.56	83.55	143.33	1.310
218	423	155.00	88.00	130.98	13.70	12.20	14.40	23.00	332.00	21.34	18.44	83.73	109.64	0.927
219	426	154.50	78.50	106.11	15.85	13.70	15.40	23.50	361.60	21.30	28.03	79.96	84.81	1.235

220	427	163.50	82.00	160.37	14.70	14.15	14.60	28.50	417.00	34.75	25.04	78.30	125.63	1.143
221	428	164.50	79.50	166.84	16.40	13.75	14.40	29.50	425.00	23.09	22.35	86.16	143.75	1.439
222	429	142.50	79.00	163.40	14.80	14.00	14.80	30.50	451.40	20.73	24.88	87.34	142.66	1.147
223	430	144.00	82.00	136.32	18.25	15.90	16.00	28.50	456.00	21.58	23.31	84.12	114.75	0.984
224	437	146.50	77.50	120.61	14.85	13.65	15.40	26.50	407.20	19.54	29.47	83.84	101.08	1.370
225	438	155.50	81.50	168.50	17.60	15.45	17.00	28.50	484.60	20.94	23.29	87.53	147.57	1.241
226	442	164.00	89.00	126.82	15.85	13.65	15.50	27.50	426.50	19.27	19.66	84.76	107.55	1.400
227	445	146.00	75.50	148.47	14.65	15.40	15.90	32.50	516.60	19.53	26.25	86.85	128.94	1.059
228	446	144.00	72.00	181.31	14.15	15.75	16.10	35.50	571.70	27.17	26.04	85.02	154.14	1.523
229	448	146.50	75.00	124.21	14.65	13.80	14.20	30.50	434.00	22.40	23.41	81.87	101.81	1.255
230	450	147.00	79.00	136.25	16.00	13.40	14.80	29.50	436.60	23.22	23.24	82.98	113.03	0.952
231	452	175.50	94.50	124.69	14.30	13.60	14.00	31.00	434.00	31.47	25.05	74.73	93.21	1.351
232	453	148.50	87.00	142.58	17.15	14.00	14.60	28.50	417.00	23.94	27.05	83.21	118.64	1.445
233	458	156.50	81.00	139.16	15.15	16.35	16.80	26.50	445.20	23.11	27.56	83.29	116.05	1.179
234	462	157.50	78.50	152.77	17.00	13.05	14.60	36.00	525.60	24.26	25.35	83.96	128.51	1.316
235	464	160.50	77.50	130.85	17.30	15.80	15.90	22.00	350.00	23.17	27.00	82.28	107.68	1.173
236	466	144.00	81.50	146.41	14.65	14.55	16.50	30.00	494.40	24.97	26.48	82.94	121.44	0.956
237	472	145.50	80.00	122.92	14.05	15.40	14.90	24.00	357.40	19.07	26.62	84.47	103.86	0.875
238	475	139.50	84.50	117.64	14.50	14.60	15.50	25.00	387.00	21.69	21.54	81.56	95.95	0.942
	1	2	3	3	4	5	6	7	8	9	10	11	12	13
239	476	147.00	81.00	98.45	16.60	12.50	14.10	29.00	408.90	17.31	19.43	82.16	81.14	0.939
240	478	156.50	81.50	99.05	16.25	12.85	13.60	30.00	408.40	20.84	28.97	78.87	78.21	1.279
241	479	144.50	85.50	119.80	12.30	13.50	14.30	28.50	407.30	18.78	29.55	84.37	101.02	1.293
242	481	149.00	81.00	137.28	15.50	13.00	14.80	33.00	488.40	31.97	21.97	76.71	105.31	1.213
243	482	146.50	76.50	151.39	17.85	13.20	14.60	28.50	416.40	28.32	27.24	81.27	123.07	1.070
244	483	154.50	78.50	136.84	15.00	13.50	14.40	30.00	432.00	23.12	29.87	83.06	113.73	1.319
245	484	149.00	79.50	184.14	18.15	16.45	16.00	31.50	503.60	22.50	27.03	87.78	161.64	1.507
246	487	146.00	77.00	140.55	14.80	12.75	15.15	32.00	484.80	22.89	24.96	83.73	117.66	0.914
247	489	139.50	78.50	140.70	14.00	13.40	14.00	33.00	462.00	27.75	25.38	80.25	112.95	0.859
248	490	145.50	83.00	132.29	13.85	12.00	14.40	28.50	409.80	19.75	27.67	85.09	112.54	0.784
249	493	136.50	73.50	109.58	14.50	12.40	15.50	31.00	481.00	21.74	26.38	80.17	87.84	1.077
250	496	132.50	78.50	135.16	16.50	13.65	15.60	28.50	445.20	25.61	21.72	80.90	109.56	0.817
251	497	147.00	79.00	109.60	12.20	13.10	15.90	24.50	389.70	24.37	18.85	77.76	85.23	0.794

252	498	145.00	81.50	141.33	16.25	16.35	17.90	26.00	465.50	24.63	21.95	82.57	116.70	1.000
253	502	151.50	81.50	89.49	14.30	12.25	14.00	29.50	413.00	24.30	26.41	72.85	65.19	1.132
254	504	160.50	89.00	121.83	15.90	15.00	15.20	28.00	425.60	22.96	26.94	81.19	98.87	1.291
255	507	169.50	78.00	144.61	14.60	12.80	13.60	27.00	367.60	25.08	27.38	82.65	119.53	1.398
256	508	132.50	75.50	194.54	18.15	15.85	16.60	34.50	573.60	33.33	33.46	82.88	161.21	1.494
257	510	134.00	74.00	146.16	15.50	12.95	16.20	31.00	501.80	20.86	28.88	85.74	125.31	1.283
258	511	143.00	79.00	146.96	13.80	14.80	16.00	28.50	456.00	24.59	27.49	83.28	122.37	1.381
259	512	145.50	82.50	130.61	15.60	13.80	15.60	29.00	451.60	30.22	29.59	76.77	100.39	1.364
260	514	133.00	72.00	153.29	16.60	14.35	17.60	31.50	554.20	29.53	25.24	80.74	123.76	1.259
261	515	136.00	73.50	157.33	15.65	13.80	14.80	29.00	429.60	27.87	24.29	82.27	129.46	1.074
262	516	149.00	85.00	121.77	15.00	13.75	15.50	25.50	394.00	21.36	24.87	82.47	100.41	1.255
263	517	152.50	81.00	164.35	15.35	13.35	14.40	22.50	324.60	32.89	28.36	79.97	131.46	1.438
264	518	144.50	80.00	140.80	16.30	13.00	13.00	31.00	402.80	25.04	24.38	82.22	115.76	1.260
265	519	153.50	82.50	109.13	12.80	13.35	15.50	25.50	395.50	23.38	25.86	78.58	85.75	1.341
266	520	150.00	80.00	129.78	16.45	12.70	14.90	28.00	417.20	21.48	24.96	83.46	108.30	1.129
267	521	156.00	83.00	101.55	14.15	14.05	15.40	24.50	377.60	20.68	21.12	79.51	80.87	1.272
268	526	144.50	79.50	136.69	14.30	12.50	14.00	29.00	406.00	20.81	24.08	84.77	115.88	1.325
269	527	150.50	77.00	121.25	14.25	14.05	14.60	27.50	401.80	25.70	21.61	78.80	95.55	1.457
270	528	147.00	78.00	154.00	15.65	13.50	17.90	29.00	519.20	34.63	24.98	77.50	119.37	1.395
271	529	161.00	75.50	148.65	14.55	14.40	14.40	34.00	489.20	32.72	32.87	77.99	115.93	1.384
272	531	155.00	89.00	164.83	16.30	13.65	15.00	30.50	458.00	27.24	20.71	83.47	137.58	1.289
273	538	155.50	79.50	147.91	17.85	13.50	15.00	29.50	442.60	26.06	23.94	82.39	121.85	1.314
	1	2	3	3	4	5	6	7	8	9	10	11	12	13
274	545	158.50	80.50	135.35	13.65	13.15	15.70	27.50	431.30	20.81	35.14	84.63	114.54	1.251
275	546	144.00	75.00	148.49	17.30	13.15	13.60	30.00	408.80	28.78	33.48	80.64	119.71	1.116
276	548	160.00	78.50	140.36	15.15	13.80	14.20	30.50	432.80	24.51	26.87	82.57	115.85	1.086
277	549	172.50	87.00	160.70	18.10	13.45	13.40	34.00	455.60	23.86	26.68	84.89	136.84	1.305
278	550	150.00	78.50	134.80	15.45	13.10	14.00	29.00	405.20	21.27	26.99	84.25	113.53	1.397
279	552	148.50	80.00	129.52	15.50	14.00	16.50	29.50	486.30	20.06	27.38	84.54	109.47	1.133
280	554	150.00	79.50	107.39	14.60	13.45	14.40	26.00	374.80	18.60	27.45	82.65	88.79	0.738
281	559	160.00	83.00	176.99	17.10	16.70	16.00	36.00	576.20	27.26	38.10	84.58	149.73	1.458
282	560	160.00	86.50	128.25	17.50	11.80	13.20	30.50	402.60	24.81	28.00	80.53	103.45	1.399
283	563	154.50	87.50	147.05	15.15	13.90	14.00	30.00	420.00	26.95	24.74	81.56	120.09	1.396

284	565	157.00	78.00	140.39	16.85	12.35	14.00	30.50	427.00	22.15	29.00	84.00	118.24	1.279
285	569	166.00	82.00	150.53	18.15	13.85	15.00	30.00	450.00	30.58	21.76	79.62	119.95	1.384
286	571	140.50	71.50	150.04	17.15	13.50	15.40	31.50	484.20	27.20	27.20	81.76	122.84	1.394
287	574	143.50	78.00	137.07	16.60	13.75	15.10	33.00	498.20	23.05	27.80	83.16	114.03	1.331
288	581	156.50	83.50	145.25	13.45	15.40	15.50	25.00	388.50	24.52	28.91	83.12	120.74	1.336
289	583	159.00	79.00	166.78	18.15	13.80	14.20	32.00	454.40	34.52	22.97	79.30	132.26	1.396
290	585	149.50	78.50	141.97	17.05	13.65	15.20	32.00	486.40	25.96	24.14	81.68	116.01	1.145
291	586	145.00	77.00	114.05	17.90	13.75	15.00	29.00	434.00	24.23	29.33	78.27	89.82	1.277
292	588	147.00	78.00	172.28	18.05	14.55	14.60	27.00	393.60	27.82	23.07	83.86	144.46	1.378
293	589	143.50	76.50	138.40	18.15	12.85	14.40	30.00	432.00	22.39	29.27	83.82	116.01	1.213
294	591	151.00	84.00	142.11	16.50	13.75	14.40	29.00	417.20	20.63	27.23	85.48	121.48	0.883
295	598	140.50	80.00	146.04	16.65	13.95	14.40	22.00	317.20	23.79	29.16	83.71	122.26	1.349
296	601	139.00	73.50	150.21	16.25	14.15	15.40	27.50	423.20	38.65	30.11	74.28	111.56	1.488
297	604	141.00	73.50	150.87	17.15	13.80	14.40	27.00	388.80	27.44	25.93	81.83	123.43	1.281
298	615	143.00	82.50	155.20	15.30	14.30	15.20	34.00	516.80	24.60	21.76	84.15	130.60	1.299
299	616	143.50	88.00	173.64	18.15	15.45	17.10	35.00	598.50	27.08	32.68	84.42	146.55	1.485
300	630	140.00	77.50	129.78	13.35	11.70	13.00	28.50	370.80	21.29	24.81	83.61	108.49	1.375
301	632	126.50	68.50	139.58	15.60	14.45	18.50	31.00	573.20	30.14	26.84	78.32	109.44	0.947
302	633	151.00	80.50	137.02	13.15	12.85	14.90	33.00	491.70	22.88	27.35	83.26	114.14	1.305
303	635	132.00	75.00	124.47	14.80	13.70	14.40	24.00	344.40	24.70	27.48	80.18	99.77	1.286
304	636	153.50	77.50	110.16	14.30	13.15	14.40	27.00	389.20	21.77	24.25	80.20	88.39	0.941
305	638	131.50	80.00	160.32	17.15	14.70	15.20	30.00	456.00	26.03	25.46	83.76	134.29	1.002
306	640	143.00	78.00	101.36	13.70	13.00	15.00	26.00	390.40	19.56	26.54	80.78	81.80	1.381
307	641	133.50	74.50	113.41	15.80	14.80	15.00	28.00	420.00	21.45	23.96	81.15	91.96	1.156
308	644	134.00	76.00	156.91	16.15	14.50	15.00	31.50	472.20	25.96	24.93	83.37	130.95	1.048
	1	2	3	3	4	5	6	7	8	9	10	11	12	13
309	648	142.00	79.50	134.42	16.90	14.20	14.00	29.00	406.00	26.82	29.00	80.05	107.60	1.343
310	649	154.00	82.00	135.91	16.60	13.95	13.20	29.00	382.80	24.37	28.86	82.09	111.53	1.084
311	651	134.50	85.50	164.40	17.25	13.70	15.40	29.00	446.00	29.68	24.29	81.95	134.73	0.978
312	653	145.00	79.00	184.36	18.05	16.60	16.00	34.50	552.00	33.51	24.37	81.82	150.85	1.502
313	654	151.50	80.50	152.10	16.15	14.35	15.00	27.50	412.80	26.75	26.54	82.43	125.35	1.294
314	662	151.50	81.50	123.46	14.35	13.45	15.00	29.50	442.20	18.64	29.40	84.87	104.82	1.422
315	671	148.50	78.00	135.90	15.45	14.50	15.00	28.00	420.00	22.07	20.71	83.77	113.82	1.245

316	674	157.50	83.50	131.57	15.00	13.50	14.90	28.50	424.20	20.35	26.08	84.54	111.23	1.275
317	675	134.50	69.50	120.85	17.40	12.75	15.10	28.00	422.60	20.58	29.77	82.99	100.28	1.107
318	676	146.50	77.50	141.16	17.95	14.90	14.40	29.00	417.60	24.17	26.50	82.89	116.99	1.419
319	678	158.50	82.50	147.06	17.85	13.65	16.60	30.50	506.20	31.09	25.18	78.66	115.97	1.284
320	680	173.00	79.50	125.99	15.50	13.85	15.40	31.50	485.40	28.60	23.66	77.28	97.39	1.237
321	682	152.50	76.00	131.87	17.10	14.95	15.00	31.00	465.40	24.52	28.24	81.40	107.35	1.390
322	686	126.50	63.50	106.58	14.50	14.60	15.70	30.00	471.00	21.59	28.24	79.78	84.99	1.151
323	689	133.50	76.00	138.68	16.65	15.45	14.70	26.50	389.40	33.06	27.77	76.16	105.62	1.181
324	698	136.00	79.50	135.73	15.10	13.70	15.40	29.00	444.80	27.76	20.03	79.55	107.96	1.098
325	700	139.50	79.00	157.56	16.50	14.85	16.40	33.50	549.70	27.03	23.74	82.85	130.53	1.189
326	706	151.50	87.50	99.34	14.15	15.50	15.40	23.50	361.00	20.24	28.16	79.55	79.10	1.423
327	707	140.50	72.50	107.45	14.20	13.50	14.60	27.00	394.20	27.20	24.12	74.66	80.25	1.366
328	713	142.00	73.50	130.91	15.00	13.90	17.00	27.50	465.00	20.93	29.87	84.02	109.99	1.444
329	717	144.50	82.50	152.52	15.25	12.35	14.50	28.00	407.00	19.64	17.92	87.11	132.87	0.948
330	723	143.00	75.50	157.50	15.15	14.30	16.20	33.00	534.60	23.13	30.99	85.31	134.37	1.265
331	726	138.50	72.00	142.51	17.00	13.65	13.20	29.50	389.40	26.31	26.64	81.53	116.20	1.357
332	728	148.50	78.50	140.27	16.70	13.90	17.20	31.50	542.10	23.89	28.99	82.95	116.38	1.454
333	734	148.00	78.50	162.17	17.15	13.70	15.00	31.00	465.00	22.84	20.28	85.92	139.33	1.114
334	748	153.00	85.50	167.74	17.00	14.55	14.60	26.00	380.80	27.37	19.21	83.69	140.37	1.219
335	752	147.50	75.00	132.78	14.65	13.40	15.00	30.50	457.60	20.19	24.18	84.71	112.59	1.093
336	753	143.50	77.00	126.24	15.60	14.65	15.70	31.00	487.00	21.35	28.84	83.05	104.89	1.421
337	754	161.50	87.50	144.09	17.70	14.50	14.40	24.50	353.00	23.51	29.75	83.61	120.58	1.028
338	756	150.50	75.50	140.45	14.45	13.20	14.00	32.50	455.00	24.77	33.83	82.38	115.67	1.444
339	760	163.50	76.50	146.95	16.00	13.10	15.00	27.00	405.20	23.08	19.39	84.30	123.87	1.385
340	775	166.50	82.50	107.55	14.65	12.85	16.00	30.00	480.80	19.74	29.63	81.62	87.81	1.220
341	779	147.00	78.00	160.33	18.15	14.20	14.00	29.00	406.00	27.85	30.89	82.58	132.48	1.203
342	782	150.00	84.50	126.52	14.30	13.10	14.40	29.50	425.40	21.17	29.29	83.29	105.35	1.052
343	789	138.00	74.50	134.35	15.85	13.00	15.50	28.00	434.00	23.38	28.99	82.61	110.98	1.439
	1	2	3	3	4	5	6	7	8	9	10	11	12	13
344	791	155.00	83.00	159.45	17.65	14.30	14.60	28.50	415.20	23.47	26.88	85.31	135.98	1.228
345	794	163.00	83.50	152.99	15.40	14.20	15.10	26.00	392.70	29.50	29.27	80.71	123.49	1.213
346	796	167.50	89.50	171.79	18.00	16.40	16.00	34.50	552.10	27.27	32.83	84.15	144.52	1.545
347	798	162.00	82.50	127.16	16.35	13.40	14.80	24.50	362.60	18.82	28.05	85.19	108.34	1.126

348	800	164.50	85.00	192.15	16.50	15.65	16.30	34.00	553.90	31.00	35.39	83.87	161.14	1.485
349	801	192.50	71.00	150.23	18.50	13.90	16.00	31.50	504.00	31.95	27.70	78.74	118.28	1.303
350	802	175.50	92.50	154.39	16.25	12.85	16.10	32.50	523.10	31.91	16.55	79.22	122.48	1.252
*	351	162.00	63.50	171.66	17.46	14.80	15.40	30.00	461.40	31.64	31.71	81.57	140.02	1.358
**	352	166.00	79.50	183.48	18.15	15.71	16.00	35.60	569.28	27.55	32.00	84.99	155.93	1.420
	Minimum	126.5	63	85.93	12.2	11.7	12.6	22	317.2	15.08	16.55	68.59	65.19	0.738
	Maximum	192.5	98.5	198.78	19.2	17	18.5	40.5	662.3	40.57	38.96	90.32	172.9	1.773
	Average	152.39	80.53	140.4	15.83	13.95	15.07	29.32	441.86	24.13	26.90	82.58	116.26	1.25

Note: *=DMH -2, **=Cargil 900-M

Appendix VII: Mean performance of inbred lines in line × tester analysis

Sl. No	Parents	Plant height at 30 DAS (cm)	Plant girth at 30 DAS (cm)	Leaf area at 30 DAS (cm)	Plant height at 60 DAS (cm)	Leaf area at 60 DAS (cm)	Ear height at 60 DAS (cm)	Cob weight (g)	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Number of Kernels per cob	Pith weight (g)	100-seed weight (g)	Shelling (%)	Grain yield per plant (g)	Grain yield per hectare (kg)
1	ARYP-1	33.73	1.49	248.06	165.53	456.15	78.20	182.40	17.07	13.67	14.53	32.67	475.04	25.13	28.41	80.76	124.94	5793.07
2	ARYP-2	31.00	1.51	204.85	180.27	480.48	64.87	214.83	18.50	15.17	14.80	34.40	512.40	28.11	34.74	85.48	158.06	7303.70
3	ARYP-3	31.80	1.52	283.81	175.00	717.47	78.20	214.47	20.33	15.41	13.87	38.60	536.96	36.25	32.05	81.15	154.89	5345.13
4	ARYP-4	33.13	1.73	241.59	175.93	605.44	72.73	161.12	19.53	14.97	14.13	37.47	529.65	24.85	33.29	84.85	136.27	6455.84
5	ARYP-5	32.00	1.43	301.37	164.33	539.83	59.47	162.35	16.83	13.80	13.20	37.87	499.57	22.70	29.15	84.32	119.65	3716.19
6	ARYP-6	34.00	1.53	228.55	181.53	539.16	76.73	201.12	18.93	15.97	14.40	40.87	588.85	30.58	32.66	84.80	170.54	5721.63
7	ARYP-7	35.13	1.42	210.60	171.80	570.62	67.67	180.22	18.07	14.77	14.13	35.40	498.61	27.21	32.76	84.90	153.01	5285.04
8	ARYP-8	34.40	1.73	248.06	170.60	615.35	80.27	200.04	20.57	15.33	13.73	41.20	564.75	28.05	31.84	85.19	161.98	5816.64
9	ARYP-9	36.53	1.77	305.12	173.27	603.73	77.73	188.80	18.80	15.73	15.20	39.87	605.63	24.82	32.19	86.82	163.98	6443.24
10	ARYP-10	32.80	1.69	291.72	162.60	581.38	71.20	190.50	19.67	15.73	14.00	38.47	539.01	31.08	33.11	83.73	159.42	5215.09
11	ARYP-11	38.13	1.61	217.12	162.13	607.81	70.53	194.35	19.47	13.67	12.53	38.60	484.16	25.00	30.05	83.16	152.69	5670.45
12	ARYP-12	38.33	1.59	220.11	172.07	671.31	69.67	161.75	17.87	14.70	13.93	35.33	491.39	28.63	31.65	82.18	133.12	4522.45
13	ARYP-13	32.93	1.73	225.28	165.53	476.32	69.33	119.99	17.53	14.27	14.27	32.73	467.28	20.40	26.38	83.03	99.60	3694.94
14	ARYP-14	32.80	1.47	234.15	167.80	555.00	60.67	179.46	17.67	15.87	14.27	40.60	580.24	27.32	34.24	84.84	152.14	5054.95
15	ARYP-15	30.20	1.40	206.78	163.13	522.66	70.00	145.61	17.03	13.93	14.53	36.53	530.67	24.92	27.41	83.84	130.69	4839.70
16	ARYP-16	34.40	1.60	217.08	173.13	570.97	72.80	164.15	17.97	15.00	16.00	34.93	558.29	25.18	28.71	84.69	138.97	5415.25
17	ARYP-17	33.33	1.57	226.99	186.87	564.66	79.73	167.20	18.87	13.73	13.73	38.00	522.24	24.14	28.93	85.54	143.07	4361.54
18	ARYP-18	37.93	1.93	303.91	177.80	535.87	76.53	203.84	19.60	15.63	13.47	37.47	504.48	30.82	36.24	84.88	173.02	6151.37
19	ARYP-19	29.73	1.60	189.45	177.00	572.42	76.00	150.88	16.33	14.77	14.27	33.40	476.37	24.93	26.64	83.60	125.95	4920.26
20	ARYP-20	34.27	1.70	262.48	169.93	548.29	63.27	160.34	18.60	14.97	13.33	33.33	444.13	28.24	32.81	82.23	132.10	5127.20
21	ARYP-21	35.40	1.66	229.72	177.80	606.43	77.60	204.34	17.97	15.70	14.13	37.67	532.40	33.00	36.14	83.64	171.34	6407.88
22	ARYP-22	35.33	1.80	263.88	180.87	681.50	79.73	182.45	18.90	14.63	15.20	35.47	539.79	29.86	36.69	83.34	152.59	5371.36
23	ARYP-23	36.27	1.70	233.09	181.80	717.65	77.73	212.53	20.60	15.53	12.80	40.13	513.71	32.39	38.71	84.83	180.13	6414.96
24	ARYP-24	35.87	1.81	272.13	176.67	586.94	81.00	145.85	17.63	13.73	13.60	33.73	459.12	19.86	29.65	86.62	125.99	4942.70
25	ARYP-25	34.93	1.77	280.11	172.00	525.57	70.53	185.26	18.83	15.60	13.87	38.87	539.04	32.14	31.14	82.29	153.12	4822.85
	Minimum	29.73	1.40	189.45	162.13	456.15	59.47	119.99	16.33	13.67	12.53	32.67	444.13	19.86	26.38	80.76	99.60	3694.94
	Maximum	38.33	1.93	305.12	186.87	717.65	81.00	214.83	20.60	15.97	16.00	41.20	605.63	36.25	38.71	86.82	180.13	7303.70
	Average	34.17	1.63	245.84	173.02	578.12	72.89	178.95	18.53	14.89	14.08	36.94	519.75	27.42	31.82	84.03	146.69	5392.54

Appendix VIII: Mean performance of tester parents in line × tester analysis

Sl. No	Parents	Plant height at 30 DAS (cm)	Plant girth at 30 DAS (cm)	Leaf area at 30 DAS (cm)	Plant height at 60 DAS (cm)	Leaf area at 60 DAS (cm)	Ear height at 60 DAS (cm)	Cob weight (g)	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Number of Kernels per cob	Pith weight (g)	100-seed weight (g)	Shelling (%)	Grain yield per plant (g)	Grain yield per hectare (kg)
1	CM -11	36.93	1.83	259.51	177.33	599.08	78.20	145.08	18.10	14.27	13.07	35.13	458.64	24.65	27.25	82.74	120.42	4130.04
2	CI -5	39.07	1.80	310.71	162.60	557.53	69.33	149.70	15.33	15.07	13.20	30.07	397.41	23.89	38.08	83.98	125.81	4235.63
3	KDMI-10	37.80	1.60	269.17	173.13	477.93	68.27	155.98	17.30	14.77	13.87	35.80	494.32	24.12	32.42	84.55	131.86	4155.35
4	NEI-9008B	36.87	1.67	254.21	177.67	588.65	78.87	192.61	19.60	15.07	12.53	39.67	495.25	28.82	33.21	84.90	163.80	6278.94

Appendix IX: Mean performance of checks in line × tester analysis

Sl. No	Parents	Plant height at 30 DAS (cm)	Plant girth at 30 DAS (cm)	Leaf area at 30 DAS (cm)	Plant height at 60 DAS (cm)	Leaf area at 60 DAS (cm)	Ear height at 60 DAS (cm)	Cob weight (g)	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Pith weight (g)	100-seed weight (g)	Shelling (%)	Number of Kernels per cob	Grain yield per plant (g)	Grain yield per hectare (kg)
1	EH – 42	34.87	1.63	294.84	176.73	564.97	73.87	197.48	18.30	16.40	14.93	35.13	523.20	29.50	35.10	85.06	167.98	6258.16
2	DMH -2	33.40	1.51	253.87	176.07	587.70	71.53	206.04	18.33	15.23	14.00	33.93	473.47	29.73	38.53	84.82	162.97	6332.63
3	Cargill 900 M	33.27	1.49	198.43	181.53	542.20	78.80	204.97	19.83	15.83	15.73	40.40	634.99	26.36	31.13	86.56	168.61	6795.26
4	PRABHA	31.93	1.82	223.04	185.40	558.01	85.80	185.28	19.17	13.63	12.93	41.07	529.79	31.64	33.09	82.61	153.64	5684.15

Appendix X: Mean performance of hybrids in line × tester analysis

Sl. No.	Hybrids	Plant height at 30 DAS (cm)	Plant girth at 30 DAS (cm)	Leaf area at 30 DAS (cm)	Plant height at 60 DAS (cm)	Leaf area at 60 DAS (cm)	Ear height at 60 DAS (cm)	Cob weight (g)	Cob length (cm)	Cob girth (cm)	Number of kernel rows per cob	Number of kernels per row	Number of Kernels per cob	Pith weight (g)	100-seed weight (g)	Shelling (%)	Grain yield per plant (g)	Grain yield per hectare (kg)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	ARYP-1xCM/111	32.40	1.77	273.86	194.33	705.54	95.53	187.22	18.67	14.73	12.40	42.33	524.93	33.06	30.69	82.25	154.17	7613.87
2	ARYP-2xCM/111	30.27	1.73	215.75	175.67	685.90	83.27	202.40	18.97	15.40	14.00	40.53	567.47	34.02	31.37	83.34	168.38	6139.13
3	ARYP-3xCM/111	32.87	1.87	242.81	186.07	776.80	88.33	227.72	20.07	15.50	15.23	41.13	626.63	30.86	36.54	86.38	196.86	7241.58
4	ARYP-4xCM/111	29.67	1.63	236.49	178.20	709.00	81.00	202.07	18.73	15.20	14.27	39.60	564.11	31.37	32.01	84.48	170.70	6325.27
5	ARYP-5xCM/111	31.67	1.53	194.37	178.47	653.99	88.20	182.97	18.07	14.73	13.73	36.20	497.84	32.86	29.37	81.94	150.11	5926.31
6	ARYP-6xCM/111	30.87	1.73	207.36	174.80	718.29	83.40	201.19	19.40	15.17	14.67	37.47	548.11	36.07	31.41	81.88	165.12	6773.88
7	ARYP-7xCM/111	31.40	1.90	236.49	185.40	670.45	88.80	183.07	18.40	14.87	12.80	39.60	505.49	30.93	31.05	83.10	152.14	6277.64
8	ARYP-8xCM/111	31.33	1.63	196.41	186.13	698.68	78.73	200.65	18.13	15.30	15.07	36.53	550.00	29.88	31.40	85.22	170.78	7243.50
9	ARYP-9xCM/111	31.93	1.80	243.39	186.20	779.27	87.13	201.83	18.73	15.40	14.00	39.27	549.20	31.19	34.99	84.64	170.64	7377.43
10	ARYP-10xCM/111	32.20	1.57	274.27	182.07	754.34	86.67	209.40	18.57	16.17	13.87	38.73	537.52	32.53	36.20	84.43	176.87	6981.35
11	ARYP-11xCM/111	30.27	1.57	235.55	169.93	617.41	75.33	196.11	18.53	15.30	15.33	35.20	539.49	30.92	31.70	84.13	165.19	7481.77
12	ARYP-12xCM/111	30.47	1.47	177.31	168.13	615.99	75.20	224.47	18.50	16.07	14.20	39.87	567.29	35.76	32.50	81.93	162.05	5838.59
13	ARYP-13xCM/111	30.07	1.87	250.27	180.47	666.32	67.80	190.31	19.37	15.07	15.87	40.40	639.92	29.28	28.98	84.52	161.03	6799.21
14	ARYP-14xCM/111	30.00	1.70	211.77	185.40	635.94	77.73	204.73	18.77	14.83	13.60	39.53	538.43	34.36	31.62	83.12	170.37	7904.59
15	ARYP-15xCM/111	31.53	1.63	274.37	182.73	674.12	81.67	218.33	18.73	16.33	15.73	35.27	554.51	39.98	35.20	81.68	178.36	8076.91
16	ARYP-16xCM/111	28.80	1.73	216.31	185.33	581.98	84.87	215.28	18.90	15.50	14.40	41.93	600.27	33.65	32.82	84.38	181.63	7088.41
17	ARYP-17xCM/111	30.13	1.68	164.04	184.93	644.48	88.07	219.53	18.97	15.53	16.00	40.33	645.33	34.29	29.68	82.63	165.24	7563.55
18	ARYP-18xCM/111	41.00	1.60	255.82	183.87	587.62	77.27	190.89	19.07	15.47	14.67	37.87	555.60	34.19	32.17	81.94	156.70	6117.05
19	ARYP-19xCM/111	32.27	1.80	209.04	188.20	657.22	84.93	184.32	20.33	14.60	12.27	41.67	510.67	25.08	32.99	86.44	159.24	5877.92
20	ARYP-20xCM/111	29.53	1.77	200.89	178.80	600.36	82.33	198.96	18.67	15.33	12.53	38.13	478.13	28.58	37.81	85.59	170.38	6896.18
21	ARYP-21xCM/111	32.53	1.70	254.54	177.20	772.96	78.33	193.31	19.50	15.77	14.00	40.87	569.89	32.77	31.48	83.00	160.54	7012.72
22	ARYP-22xCM/111	33.40	1.59	224.43	174.00	745.26	81.07	222.47	20.53	16.20	15.20	39.13	594.21	37.21	33.09	83.34	185.26	7151.65
23	ARYP-23xCM/111	31.73	1.83	247.95	185.67	614.53	81.73	223.21	19.60	15.93	14.00	38.87	545.47	33.10	35.54	85.17	190.10	7631.40
24	ARYP-24xCM/111	32.87	1.79	261.08	181.60	747.34	86.00	216.30	18.40	16.53	15.60	38.00	593.20	31.69	35.90	84.93	184.61	8445.67
25	ARYP-25xCM/111	33.07	1.79	238.31	184.67	670.37	79.07	201.22	19.02	15.10	15.47	39.00	602.45	29.47	33.05	85.24	171.75	6582.17

26	ARYP-1xCI-5	34.13	1.50	245.95	192.07	618.47	89.40	183.30	17.54	15.73	14.27	37.47	534.13	29.28	33.29	83.97	154.02	7188.71
27	ARYP-2xCI-5	30.93	1.86	256.77	178.27	647.65	75.93	206.19	18.33	15.67	14.13	37.07	525.79	33.59	35.75	83.75	172.61	6717.15
28	ARYP-3xCI-5	32.53	1.88	288.92	190.20	696.00	87.47	195.81	18.83	15.20	14.00	35.60	497.49	29.09	33.92	85.29	166.73	6969.14
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Contd.....
29	ARYP-4xCI-5	33.93	1.95	250.61	180.33	645.05	84.40	195.35	18.40	15.77	13.87	36.00	500.13	31.34	35.40	84.01	164.01	6840.87
30	ARYP-5xCI-5	31.60	1.83	219.67	171.80	534.36	80.00	193.31	17.97	15.70	14.13	35.20	495.84	31.39	33.64	82.99	154.59	5473.97
31	ARYP-6xCI-5	33.27	1.56	274.79	179.47	668.68	75.73	212.48	20.57	15.47	14.27	41.67	593.73	32.14	33.86	84.91	180.34	7080.71
32	ARYP-7xCI-5	32.20	1.74	246.78	182.67	668.78	81.20	196.19	18.00	14.53	12.67	39.00	492.67	29.44	33.71	84.19	156.74	7191.67
33	ARYP-8xCI-5	32.40	1.69	239.64	172.20	690.33	77.67	206.62	18.20	15.90	15.33	37.60	577.04	30.67	36.33	85.18	175.96	6855.63
34	ARYP-9xCI-5	32.67	1.64	252.01	193.87	811.54	89.07	222.18	20.50	15.77	14.27	35.33	505.01	35.33	37.20	84.13	186.85	7585.99
35	ARYP-10xCI-5	34.27	1.55	239.14	178.07	679.79	79.33	206.02	18.87	15.90	13.07	38.47	503.20	31.82	35.09	84.53	174.20	6808.22
36	ARYP-11xCI-5	31.33	1.57	205.42	175.13	731.61	75.93	211.55	19.60	15.31	14.00	36.87	517.36	38.33	35.03	82.04	173.23	6723.60
37	ARYP-12xCI-5	32.93	1.70	279.45	179.67	765.41	80.40	212.70	19.57	15.03	13.33	36.73	489.01	34.40	39.16	83.81	178.30	6731.99
38	ARYP-13xCI-5	34.07	1.77	278.71	171.40	672.86	80.07	222.28	18.90	16.53	14.40	36.80	530.64	31.69	35.60	85.75	190.59	6997.78
39	ARYP-14xCI-5	33.00	1.68	305.63	182.67	725.79	72.13	236.30	20.63	15.97	14.13	42.73	602.45	36.96	35.84	84.34	199.35	7628.83
40	ARYP-15xCI-5	33.73	1.75	272.88	177.53	594.47	71.00	211.74	17.50	16.20	15.13	38.13	576.21	36.32	37.47	82.91	175.42	6781.99
41	ARYP-16xCI-5	29.27	1.47	212.85	184.20	645.51	73.87	210.47	19.27	15.07	14.67	36.27	531.23	29.10	34.06	86.04	181.36	7509.66
42	ARYP-17xCI-5	33.27	1.55	238.00	171.00	776.85	74.00	198.21	17.73	15.40	14.67	36.47	533.33	26.24	32.15	85.40	155.30	7098.27
43	ARYP-18xCI-5	33.47	1.93	268.25	177.67	703.56	73.87	200.42	19.73	14.83	13.13	38.87	511.16	33.05	35.56	83.45	167.36	6929.04
44	ARYP-19xCI-5	34.27	1.74	288.39	177.80	618.66	70.87	188.15	18.40	14.73	13.23	37.53	496.66	27.25	34.90	85.62	160.91	6945.48
45	ARYP-20xCI-5	32.47	1.70	245.27	182.80	708.33	86.53	211.77	20.60	15.63	13.47	40.07	537.28	30.97	36.48	85.30	180.79	7767.62
46	ARYP-21xCI-5	33.40	1.91	301.82	176.67	662.61	77.13	211.28	17.33	16.33	14.13	39.07	553.01	28.65	33.96	86.32	182.63	6931.12
47	ARYP-22xCI-5	34.73	1.67	307.55	177.07	768.61	80.13	213.23	18.40	15.37	14.00	38.60	538.43	34.75	37.06	83.77	178.48	6341.77
48	ARYP-23xCI-5	35.33	1.81	300.15	174.87	662.64	73.87	192.19	19.30	15.40	15.07	38.67	582.35	27.43	33.36	85.71	164.76	6441.59
49	ARYP-24xCI-5	32.07	1.80	298.00	183.00	761.72	85.53	207.44	18.67	16.20	14.67	37.00	542.67	29.03	33.78	85.45	171.75	7049.51
50	ARYP-25xCI-5	34.53	1.79	323.27	173.00	746.85	67.20	195.74	16.87	15.47	16.27	36.87	600.59	28.97	30.64	84.21	156.77	6871.24
51	ARYP-1xKDMI-10	30.13	1.55	256.60	172.20	750.99	74.33	199.74	17.53	15.40	14.67	36.27	532.05	29.14	31.14	84.32	156.93	7316.20
52	ARYP-2xKDMI-10	34.60	1.83	314.87	180.53	620.08	77.40	221.29	18.53	15.73	15.33	36.47	559.20	34.04	35.45	84.15	187.25	6753.86
53	ARYP-3xKDMI-10	34.33	1.66	270.43	182.07	702.56	84.13	229.51	19.03	16.03	14.47	38.80	563.97	31.52	37.93	86.20	197.99	7022.38
54	ARYP-4xKDMI-10	34.13	1.89	303.33	175.87	775.19	81.07	196.45	18.17	15.57	13.87	39.67	552.48	28.85	33.38	85.23	167.60	6862.58
55	ARYP-5xKDMI-10	32.87	1.71	248.97	179.67	603.25	88.40	206.80	17.87	14.90	13.73	37.93	521.20	34.04	34.12	83.43	172.75	7428.03

56	ARYP-6xKDMI-10	34.67	1.80	266.40	178.20	644.09	84.00	185.70	17.60	14.93	14.27	34.40	490.35	25.99	35.53	85.79	159.71	6427.09
57	ARYP-7xKDMI-10	32.27	1.83	231.17	177.20	647.01	77.00	202.04	18.37	15.87	13.60	36.93	500.93	31.43	35.22	83.06	153.94	5951.51
58	ARYP-8xKDMI-10	34.47	1.65	279.92	172.13	677.73	76.53	195.78	18.53	17.63	15.73	35.53	561.65	28.74	32.50	85.31	167.04	7070.93
59	ARYP-9xKDMI-10	32.13	1.74	252.43	176.65	631.91	75.80	171.06	18.47	14.30	13.73	37.00	509.15	28.01	28.48	83.71	143.06	5542.63
60	ARYP-10xKDMI-10	31.47	1.77	273.81	175.07	657.44	74.33	200.93	18.67	15.77	13.07	39.93	521.23	28.32	35.72	85.88	172.60	6875.39
61	ARYP-11xKDMI-10	32.47	1.75	309.58	163.47	602.39	64.33	194.93	17.53	15.33	13.20	37.60	495.44	30.87	34.55	84.26	164.06	6392.53
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
62	ARYP-12xKDMI-10	34.87	1.63	266.73	174.20	655.10	75.53	202.03	17.97	15.90	14.93	36.07	538.48	31.06	32.84	84.54	170.97	6629.72
63	ARYP-13xKDMI-10	34.00	1.71	270.29	176.00	691.88	78.27	196.32	17.53	16.31	14.67	36.80	538.27	33.08	36.34	82.62	163.24	6629.05
64	ARYP-14xKDMI-10	33.67	1.52	338.66	172.60	793.65	72.40	194.21	18.83	15.63	14.13	40.00	563.25	27.39	31.44	85.89	166.82	6698.37
65	ARYP-15xKDMI-10	31.80	1.57	251.02	171.00	668.99	70.93	197.13	18.43	16.20	14.40	35.87	516.45	29.51	29.90	84.14	155.95	6907.17
66	ARYP-16xKDMI-10	32.67	1.62	281.32	173.40	789.42	76.00	210.14	17.83	15.87	15.33	35.73	548.32	30.12	30.57	85.75	180.02	6058.18
67	ARYP-17xKDMI-10	32.87	1.75	256.39	166.73	659.48	73.53	211.79	18.30	15.73	15.07	37.07	558.00	35.14	32.90	83.54	176.65	6396.97
68	ARYP-18xKDMI-10	32.67	1.72	289.31	167.20	717.44	71.53	185.29	17.97	15.40	15.00	34.73	521.35	27.39	34.30	84.05	144.57	5768.14
69	ARYP-19xKDMI-10	33.13	1.73	316.85	168.80	740.23	70.93	192.97	18.53	14.87	13.07	43.33	565.44	25.23	33.38	87.04	167.74	6783.77
70	ARYP-20xKDMI-10	31.07	1.71	283.93	168.33	629.79	70.67	179.74	18.63	14.73	14.33	34.73	498.23	24.21	37.74	86.57	155.53	6491.39
71	ARYP-21xKDMI-10	33.73	1.61	277.71	166.67	628.65	70.47	195.13	18.67	15.14	14.53	39.40	572.29	28.28	30.74	85.39	166.85	5476.15
72	ARYP-22xKDMI-10	30.20	1.57	250.86	173.47	619.17	77.53	196.94	18.00	15.97	13.87	34.07	473.81	26.91	36.87	86.45	170.02	6314.22
73	ARYP-23xKDMI-10	30.00	1.63	289.40	176.00	615.55	73.27	192.48	17.57	15.43	14.40	36.07	516.77	26.97	31.51	84.96	152.17	5503.67
74	ARYP-24xKDMI-10	32.07	1.83	321.15	175.93	647.87	82.07	203.74	18.83	16.40	12.93	40.80	527.73	27.14	34.50	86.77	176.60	7140.29
75	ARYP-25xKDMI-10	29.07	1.80	243.80	177.00	659.18	82.07	218.09	18.97	15.60	14.40	40.27	579.17	30.58	32.83	86.02	187.50	6211.49
76	ARYP-1xNEI-9202B	30.33	1.80	227.63	191.53	624.28	91.67	197.28	18.80	15.07	12.93	41.40	534.83	33.78	33.66	82.88	163.51	7164.05
77	ARYP-2xNEI-9202B	29.47	1.70	234.13	185.07	586.60	88.80	198.13	18.80	16.00	13.47	38.87	521.49	31.82	34.22	83.99	166.31	6483.41
78	ARYP-3xNEI-9202B	31.67	1.57	229.33	191.33	685.70	88.93	234.80	20.40	16.27	14.13	42.87	605.73	36.39	35.67	84.33	198.42	7108.37
79	ARYP-4xNEI-9202B	32.73	1.71	245.85	175.00	707.11	77.87	199.87	18.20	15.47	14.00	38.20	533.47	25.69	33.27	86.25	160.84	6179.51
80	ARYP-5xNEI-9202B	34.73	1.62	314.37	183.80	763.64	85.53	219.15	18.93	15.73	14.40	40.87	588.53	30.35	31.95	84.51	169.81	6945.99
81	ARYP-6xNEI-9202B	34.87	1.45	256.51	186.00	791.37	82.13	224.08	20.33	15.73	13.93	40.40	560.69	35.62	39.35	84.22	188.46	6898.90
82	ARYP-7xNEI-9202B	32.53	1.57	215.57	175.33	620.01	83.67	203.40	19.03	15.40	14.20	36.87	523.17	34.62	33.71	82.99	168.78	6326.18
83	ARYP-8xNEI-9202B	32.53	1.63	259.97	191.67	681.70	93.07	231.40	19.67	16.00	14.13	42.40	598.35	36.62	34.97	84.34	194.78	7144.47
84	ARYP-9xNEI-9202B	34.67	1.67	253.75	180.67	543.79	78.27	211.79	19.23	16.23	14.13	37.53	530.69	31.89	35.42	84.87	179.90	7333.80
85	ARYP-10xNEI-9202B	34.73	1.53	267.01	185.07	674.20	83.80	186.27	19.60	15.07	13.20	37.87	499.84	30.92	35.03	83.37	155.36	7110.24

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86	ARYP-11xNEI-9202B	31.60	1.57	174.81	177.73	669.80	84.47	200.06	18.33	15.63	15.07	38.33	577.28	29.39	31.82	85.32	170.67	7201.53
87	ARYP-12xNEI-9202B	34.13	1.70	245.15	171.33	635.15	75.47	216.26	21.13	15.10	14.00	42.67	597.87	38.14	34.24	82.35	178.12	6820.49
88	ARYP-13xNEI-9202B	32.87	1.73	281.31	183.80	763.19	83.93	204.05	18.20	15.97	14.67	36.60	538.93	28.87	35.26	85.85	175.19	7153.01
89	ARYP-14xNEI-9202B	32.00	1.53	205.40	193.80	544.15	90.40	206.01	20.40	14.10	13.60	42.40	576.08	31.39	34.29	84.77	174.62	7183.66
90	ARYP-15xNEI-9202B	31.33	1.56	220.57	183.27	624.43	77.13	240.19	19.67	16.80	14.27	39.60	564.53	48.10	36.91	79.67	192.09	7391.80
91	ARYP-16xNEI-9202B	34.13	1.75	251.48	187.67	699.09	87.60	181.74	18.70	14.83	13.87	41.27	573.12	26.74	31.34	85.20	155.00	6018.69
92	ARYP-17xNEI-9202B	33.13	1.71	311.89	182.67	657.20	77.20	204.14	19.27	16.63	14.93	39.93	595.47	31.44	33.16	84.78	172.70	7439.11
93	ARYP-18xNEI-9202B	35.67	1.57	263.74	188.07	713.69	81.00	195.72	20.00	14.80	14.53	39.07	567.57	27.25	37.11	86.07	168.47	7457.69
94	ARYP-19xNEI-9202B	34.73	1.49	269.47	183.40	660.08	82.07	183.13	18.90	14.40	13.20	39.40	517.68	23.90	34.31	86.85	159.23	6310.24
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
95	ARYP-20xNEI-9202B	42.67	1.73	227.31	195.80	785.00	90.47	243.58	19.50	16.70	15.33	40.00	614.43	31.47	36.80	85.61	188.77	7090.91
96	ARYP-21xNEI-9202B	42.40	1.69	297.62	184.87	851.67	85.13	193.63	18.93	14.73	13.33	38.67	516.64	29.22	36.18	84.92	164.41	7359.62
97	ARYP-22xNEI-9202B	34.47	1.60	256.39	191.60	659.59	88.80	226.21	20.83	15.70	13.07	42.27	552.11	36.61	34.32	83.87	189.60	7229.13
98	ARYP-23xNEI-9202B	36.13	1.77	284.37	190.93	625.86	83.20	222.72	18.87	16.07	15.33	38.60	591.52	31.67	35.24	85.69	191.05	7793.44
99	ARYP-24xNEI-9202B	37.53	1.72	236.79	189.00	701.24	82.67	230.26	19.20	16.20	14.80	38.27	565.97	30.16	38.53	86.85	200.09	7341.86
100	ARYP-25xNEI-9202B	46.13	1.85	322.12	186.73	720.59	83.27	230.09	20.40	16.07	14.27	41.53	592.35	34.17	34.22	85.18	195.92	6523.11
	Minimum	28.80	1.45	164.04	163.47	534.36	64.33	171.06	16.87	14.10	12.27	34.07	473.81	23.90	28.48	79.67	143.06	5473.97
	Maximum	46.13	1.95	338.66	195.80	851.67	95.53	243.58	21.13	17.63	16.27	43.33	645.33	48.10	39.35	87.04	200.09	8445.67
	Average	33.01	1.70	256.80	179.98	680.08	80.34	205.03	18.86	15.56	14.23	38.53	547.37	31.41	34.04	84.49	171.41	6854.90
	CV	8.08	7.33	13.83	4.21	11.94	8.80	10.48	5.25	4.60	5.92	6.56	7.89	13.51	8.09	1.67	10.97	14.16
	CD @ 5%	4.51	0.39	69.64	12.34	109.02	12.60	33.09	2.02	1.33	1.49	4.15	74.71	8.21	5.74	2.96	33.26	1131.56
	CD @ 1%	5.94	0.51	91.76	16.26	143.66	16.60	43.60	2.66	1.76	1.96	5.47	98.45	10.82	7.57	3.90	43.83	1491.07

ISOLATION AND EARLY GENERATION EVALUATION OF INBRED LINES DERIVED FROM YELLOW POOL POPULATION OF MAIZE (*Zea mays* L.)

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ABSTRACT

An investigation was undertaken to isolate and to evaluate the inbred lines which were derived from the newly constituted yellow pool population. The 800 ear-to-ear progenies selected from base population showed platykurtic distribution for cob weight and grain yield per plant with high mode values than their respective mean indicating the presence of high proportion of superior progenies for these traits.

The analysis of variance due to genotype was highly significant for all the traits under study involving 400 S_1 progenies which suggested presence of high degree of variability. The analysis of variance involving 350 S_2 lines revealed the presence of highly significant differences among these lines for growth and yield related traits.

Out of 350 top crosses, 13 crosses recorded more than 10 per cent higher grain yield over the standard check. In general superiority of these crosses was due to higher grain number per plant and lower pith weight.

Line $\times$ tester analysis involving 25 best lines selected based on top cross performance and four tester indicated presence of significant variability among the genotypes for yield and yield contributing traits. Among the crosses, ARYP-24 $\times$ CM-111 and ARYP-15 $\times$ CM-111 were the superior crosses for grain yield over best check hybrid.

The analysis of combining ability revealed that SCA variance was higher than GCA indicating predominance of non-additive variance for majority of the traits. Out of 25 lines, ARYP-3, ARYP-19, ARYP-20, ARYP-24 and ARYP-25 were the good general combiners. It is proposed to evaluate two crosses viz., ARYP-24 $\times$ CM-111 and ARYP-15 $\times$ CM-111 on large scale over locations and seasons to confirm their potentiality for exploitation of hybrid vigour.