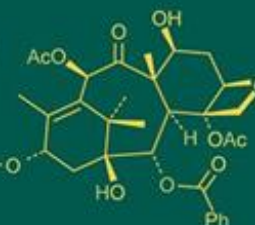
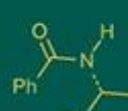
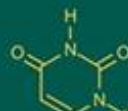
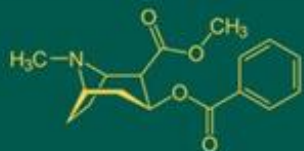


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Line X Tester analysis studies in maize under non stress situation

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Abstract

A study was conducted to estimate the combining ability of maize (*Zea mays* L.) inbred lines under non-stress conditions using a line $\times$ tester mating design. Thirty inbred lines were crossed with five testers to generate 150 single-cross hybrids. These hybrids, along with 35 parents and standard commercial checks, were evaluated during early spring 2013 (11 December 2013) under a restricted randomized block design (RBD) with two replications. Each genotype was planted in a single 4 m row with a spacing of 75 $\times$ 20 cm. Under non-stress conditions, the crop received recommended agronomic practices along with regular furrow irrigation at 10-12 day intervals to ensure the absence of moisture stress throughout the crop growth period. Analysis of combining ability revealed significant variation among the hybrids for grain yield and related traits. Three hybrids, namely (Rajkumar $\times$ CML446 Inbred Line 3) $\times$ HS4, (NK6240 $\times$ CI4 Inbred Line 12) $\times$ HS4, and (Allrounder $\times$ HS17 Inbred Line 34) $\times$ HS7, exhibited significant specific combining ability (SCA) effects coupled with superior mean grain yield. These hybrids also recorded high standard heterosis over the commercial check, ranging from 27.85% to 38.29% for grain yield. The superior performance of these hybrids indicates their potential for exploitation in hybrid maize breeding programmes. However, further evaluation across diverse environments and multilocation trials is recommended before their commercial release.

Keywords: *Zea mays* L., combining ability, line $\times$ tester analysis, specific combining ability, heterosis, maize hybrids, grain yield

Introduction

Maize (*Zea mays* L.) is one of the world's most important cereal crops owing to its high yield potential, wide adaptability, and diverse end uses. It belongs to the family Poaceae, tribe Maydeae, and is believed to have originated in Central and South America. Maize is a diploid species ($2n = 20$), monoecious in nature, and is considered to have been domesticated nearly 8,000 years ago. Its closest wild relatives include *Tripsacum* (gama grass) and *Teosinte* (*Zea* spp.), which have contributed significantly to understanding maize evolution and genetic improvement.

Globally, maize is cultivated across a broad range of agro-climatic regions because of its remarkable genetic diversity and adaptability. It serves as a staple food, livestock feed, and industrial raw material, making it one of the most versatile cereal crops. In India, maize is the third most important cereal after rice and wheat in terms of production. Approximately 52% of the total maize production is utilized as animal and poultry feed, about 23% is consumed as food, and nearly 13% is used for industrial purposes, including starch, ethanol, and processed food industries. The increasing demand for maize in food processing, livestock production, and biofuel industries has further enhanced its economic importance.

According to recent estimates, maize occupies nearly 199 million hectares globally, with an annual production of approximately 1,129.20 million tonnes and an average productivity of 5,820 kg ha⁻¹ (Anon., 2024) [1]. In India, maize is cultivated over 12.84 million hectares, producing 46.15 million tonnes with an average productivity of 3,595 kg ha⁻¹. Karnataka is one of the leading maize-producing states, cultivating the crop on 1.90 million hectares with a production of 6.35 million tonnes and an average productivity of 3,339 kg ha⁻¹ (Anon., 2025-26) [2].

Despite its high genetic yield potential, maize productivity is severely constrained by several abiotic stresses, particularly drought and poor soil fertility. Since a large proportion of tropical maize is cultivated under rainfed conditions, drought remains the most significant environmental factor limiting grain yield.

Moisture stress during flowering and grain filling stages reduces pollination efficiency, kernel set, and grain development, leading to substantial yield losses. Global estimates indicate that drought causes an average annual reduction of approximately 15-17% in maize production, depending on the production environment (Edmeades *et al.*, 2000; Edmeades *et al.*, 2001) [3, 4]. Consequently, the development of drought-tolerant, high-yielding hybrids has become a major objective of maize improvement programmes worldwide.

The development of elite inbred lines forms the foundation of successful hybrid breeding programmes. Broad-based base populations possessing desirable agronomic traits and stress tolerance are essential for generating superior inbred lines capable of producing high-performing hybrids (Prashanth, 2008) [5]. Among the various breeding approaches, combining ability analysis has proven to be an effective tool for identifying superior parental lines and understanding the nature of gene action governing economically important traits. General combining ability (GCA) primarily reflects additive gene effects, whereas specific combining ability (SCA) represents non-additive genetic effects, including dominance and epistatic interactions (Falconer, 1964) [6].

Estimation of GCA and SCA enables breeders to select appropriate parents and hybrid combinations for developing superior cultivars.

The line $\times$ tester mating design developed by Kempthorne (1957) [7] is one of the most widely used approaches for evaluating combining ability in maize. It facilitates the identification of superior parental lines and promising hybrid combinations by partitioning genetic variance into GCA and SCA components. Hybrids possessing high SCA effects coupled with superior mean performance are particularly valuable for commercial hybrid development because they effectively exploit heterosis for grain yield and associated traits. Research efforts in maize breeding have increasingly focused on developing highyielding single-cross hybrids adapted to diverse agro-ecological regions while maintaining tolerance to drought and other abiotic stresses. Compared with openpollinated varieties and composite cultivars, single-cross hybrids generally exhibit greater heterosis, better yield stability, and enhanced stress tolerance due to their superior genetic constitution. Therefore, identifying high-performing parental lines with desirable combining ability is essential for accelerating hybrid development.

In view of the above considerations, the present investigation was undertaken to evaluate the combining ability of maize inbred lines using a line $\times$ tester mating design under non-stress conditions, with the objective of identifying superior parental lines and promising hybrid combinations for grain yield and related agronomic traits that can be exploited in future maize breeding programmes.

Materials and Methods

The present investigation was conducted during kharif, rabi, and summer seasons of 2011-12, 2012-13, and 2013-14 at the Main Agricultural Research Station (MARS), Dharwad, Karnataka, India (15°25' N latitude, 75°07' E longitude; 678 m above mean sea level). Meteorological data, including minimum and maximum temperatures and rainfall recorded during the crop growth period, were obtained from the agrometeorological observatory of the station and are presented in Appendix I. During the evaluation period (rabi 2013-14), the

mean minimum and maximum temperatures ranged from 16.0 °C to 30.87 °C, and the total rainfall received was 11.40 mm.

Development of Experimental Material

Early-generation testing was undertaken to identify superior inbred lines for combining ability using the line $\times$ tester mating design. Initially, 200 maize inbred lines were evaluated, and the best 30 inbred lines were selected based on superior grain yield (mean + 1 SD), shorter anthesis-silking interval (ASI; mean - 1 SD), and a higher number of cobs per plant (mean + SD). These selected lines were crossed with five testers during the summer season (03 April 2013), resulting in 150 F hybrids. The harvested hybrid seed was processed, dried, and stored under appropriate conditions until field evaluation.

Field Evaluation

The 150 F hybrids, along with 35 parental lines and standard commercial checks, were evaluated during the early spring season of 2013 (11 December 2013) under nonstress conditions. The experiment was laid out in a Restricted Randomized Block Design (RBD) with two replications. Each experimental plot consisted of a single row of 4 m length, maintaining a spacing of 75 cm $\times$ 20 cm between rows and plants, respectively.

All experimental entries were raised following the recommended agronomic practices for maize cultivation. Under non-stress conditions, irrigation was provided through the furrow method at 10-12 day intervals throughout the crop growth period to ensure that the plants did not experience moisture stress.

Data Recording

Observations were recorded on five randomly selected competitive plants from each genotype in each replication. The characters evaluated included days to 50% anthesis, days to 50% silking, anthesis-silking interval (ASI), plant height (cm), ear height (cm), days to maturity, cob length (cm), cob girth (cm), number of cobs per plant, number of kernel rows per cob, number of kernels per row, shelling percentage, 100-grain weight (g), grain yield per plant (g), relative water content (RWC), and chlorophyll content. The mean values of the five sampled plants were used for statistical analysis.

Statistical Analysis

The mean performance of each genotype was subjected to line $\times$ tester analysis to estimate the combining ability effects. The total genetic variation among the hybrids was partitioned into general combining ability (GCA) and specific combining ability (SCA) components following the method proposed by Kempthorne (1957) [7]. Statistical analyses were performed using WINDOSTAT version 8.0 software.

Results and Discussion

Analysis of Variance for Combining Ability

The analysis of variance (ANOVA) for combining ability under non-stress conditions is presented in Table 1. The mean sum of squares due to crosses was significant for several important agronomic traits, including cob length, cob girth, number of kernel rows per cob, number of kernels per row, grain yield per plant, grain yield (kg ha⁻¹), and number of cobs per plant, indicating the presence of substantial genetic variability among the hybrids.

The mean squares due to lines were significant for most of the traits studied under nonstress conditions, except days to maturity, chlorophyll content at 60 and 90 days, cob length, number of kernels per row, 100-grain weight, grain yield per plant, grain yield (kg ha^{-1}), and shelling percentage. Similarly, testers exhibited significant variation for days to 50% anthesis, chlorophyll content at 90 days, cob length, number of cobs per plant, and grain yield per plant.

The line $\times$ tester interaction was significant for cob length, cob girth, number of kernel rows per cob, number of kernels per row, grain yield per plant, and grain yield (kg ha^{-1}), indicating the importance of specific parental combinations and the presence of nonadditive gene action governing these traits.

The estimates of variance components further revealed that the specific combining ability (SCA) variance exceeded the general combining ability (GCA) variance for most of the characters evaluated, except days to 50% anthesis, days to 50% silking, chlorophyll content at 90 days, relative water content at 60 days, and relative water content at 90 days. The predominance of SCA variance over GCA variance, reflected by GCA/SCA ratios of less than unity for most traits, suggests that non-additive gene effects, including dominance and epistatic interactions, played a major role in the inheritance of these characters. Such findings indicate that the exploitation of heterosis through hybrid breeding would be effective for improving grain yield and associated traits under non-stress conditions.

The proportional contribution of lines to the total genetic variation was greater than that of testers for almost all characters studied, indicating the greater influence of female parents on trait expression. Furthermore, the contribution of the line $\times$ tester interaction was higher than that of testers alone for most of the traits, except number of cobs per plant, demonstrating the importance of specific parental combinations in hybrid performance.

General Combining Ability Effects

The estimates of general combining ability (GCA) effects of the 30 inbred lines and five testers for different agronomic traits are presented in Table 2.

For days to 50% anthesis, the GCA effects of the inbred lines ranged from -1.30 (NK6240 $\times$ CI4 Inbred Line 37) to 1.60 (Rajkumar $\times$ CML446 Inbred Line 37), whereas the testers ranged from -0.48 (HS7) to 0.41 (CI4). Among the 30 inbred lines, only two exhibited significant GCA effects, and NK6240 $\times$ CI4 Inbred Line 37 recorded a significant negative GCA effect (-1.30), indicating its potential as a desirable parent for developing early flowering hybrids.

For days to 50% silking, the GCA effects varied from -1.55 (Allrounder $\times$ HS17 Inbred Line 34) to 1.34 (Rajkumar $\times$ CML446 Inbred Line 37) among the lines and from -0.42 (HS7) to 0.27 (CI4) among the testers. Three inbred lines exhibited significant GCA effects, of which NK6240 $\times$ CI4 Inbred Line 37 (-1.35) and Allrounder $\times$ HS17 Inbred Line 34 (-1.55) possessed significant negative GCA effects, suggesting their usefulness in breeding programmes aimed at earliness. For anthesis-silking interval (ASI), the GCA effects among the inbred lines ranged from -0.55 (Rajkumar $\times$ CML446 Inbred Line 1) to 0.74 (Rajkumar $\times$ CML446 Inbred Line 25), while among the testers they ranged from -0.14 (CI4) to 0.06 (HS10). Six inbred lines showed significant GCA effects, and Rajkumar $\times$ CML446 Inbred Line 1 (-0.55) together with NK6240 $\times$ CI4 Inbred Line 37 exhibited significant negative

GCA effects. A reduced anthesis-silking interval is considered a desirable trait under drought and non-stress environments because it promotes synchronized flowering and improves pollination efficiency, ultimately contributing to enhanced grain set and yield. Overall, the identification of parents with significant and desirable GCA effects indicates the presence of favorable additive gene action for flowering traits. Such parental lines can be effectively utilized in maize breeding programmes for the development of early-maturing and high-yielding hybrids with improved combining ability.

Days to Maturity

Under non-stress conditions, the GCA effects of lines and testers for days to maturity ranged from -2.22 (NK6240 $\times$ CI4 Inbredline 37) to 1.07 (Allrounder $\times$ HS17 Inbredline 45) and -0.36 (HS4) to 0.27 (HS7), respectively. Among the evaluated parents, one line exhibited significant GCA effects, with NK6240 $\times$ CI4 Inbredline 37 (-2.22) showing a desirable negative GCA effect, indicating its potential contribution towards early maturity.

Chlorophyll Content at 60 Days (mg cm^{-2})

The GCA effects for chlorophyll content at 60 days under non-stress conditions varied from -3.90 (Rajkumar $\times$ CML446 Inbredline 25) to 4.00 (NAC6002 $\times$ CI4 Inbredline 7) among lines and from -0.78 (KDMI16) to 0.68 (HS7) among testers. Four parents showed significant GCA effects, of which NAC6002 $\times$ CI4 Inbredline 7 (4.00) exhibited a significant positive GCA effect, suggesting its usefulness for improving chlorophyll retention and photosynthetic efficiency.

Chlorophyll Content at 90 Days (mg cm^{-2})

For chlorophyll content at 90 days, GCA effects among lines ranged from -2.93 (NK6240 $\times$ CI4 Inbredline 18) to 3.29 (Rajkumar $\times$ CML446 Inbredline 37), while tester effects ranged from -1.26 (KDMI16) to 1.94 (HS7). One line, Rajkumar $\times$ CML446 Inbredline 37 (3.29), showed a significant positive GCA effect, indicating its superiority for maintaining higher chlorophyll content during later crop growth stages.

Relative Water Content at 60 Days (%)

Under non-stress conditions, the GCA effects for relative water content at 60 days ranged from -0.079 (NK6240 $\times$ CI4 Inbredline 42) to 0.068 (Allrounder $\times$ HS17 Inbredline 34) among lines and from -0.007 (HS4) to 0.011 (HS10) among testers. Five parents exhibited significant GCA effects. Among these, Allrounder $\times$ HS17 Inbredline 39 (0.057), Allrounder $\times$ HS17 Inbredline 21 (0.063), and Allrounder $\times$ HS17 Inbredline 34 (0.068) recorded significant positive GCA effects, indicating their potential for improving plant water status.

Relative Water Content at 90 Days (%)

The GCA effects for relative water content at 90 days varied from -0.132 (NK6240 $\times$ CI4 Inbredline 37) to 0.130 (Allrounder $\times$ HS17 Inbredline 21) among lines and from -0.031 (CI4) to 0.026 (HS10) among testers. Six parents exhibited significant GCA effects. The lines Allrounder $\times$ HS17 Inbredline 34 (0.10), Allrounder $\times$ HS17 Inbredline 25 (0.12), and Allrounder $\times$ HS17 Inbredline 21 (0.13) showed significant positive GCA effects, suggesting their importance in improving water retention ability. Plant Height (cm) the GCA effects for plant height ranged from -22.97 (Rajkumar $\times$ CML446 Inbredline 3) to 12.82 (Rajkumar $\times$ CML446 Inbredline 38) among lines and from -2.56 (KDMI16) to 3.09 (HS10) among testers. Three

lines exhibited significant GCA effects. Among them, Rajkumar $\times$ CML446 Inbredline 38 (12.82) showed a desirable positive GCA effect, whereas Rajkumar $\times$ CML446 Inbredline 8 (-18.17) and Rajkumar $\times$ CML446 Inbredline 3 (-22.97) exhibited significant negative effects.

Ear Height (cm)

For ear height, GCA effects among lines ranged from -17.63 (Rajkumar $\times$ CML446 Inbredline 3) to 14.41 (Rajkumar $\times$ CML446 Inbredline 1), whereas tester effects ranged from -2.20 (HS4) to 3.29 (HS10). Three lines showed significant positive GCA effects, namely NK6240 $\times$ CI4 Inbredline 42 (9.86), NK6240 $\times$ HS17 Inbredline 10 (11.86), and Rajkumar $\times$ CML446 Inbredline 1 (14.41). Conversely, Rajkumar $\times$ CML446 Inbredline 18 (-11.38), Rajkumar $\times$ CML446 Inbredline 38 (-13.38), and Rajkumar $\times$ CML446 Inbredline 3 (-17.63) exhibited significant negative GCA effects.

Cob Length (cm)

The GCA effects for cob length ranged from -1.70 (Rajkumar $\times$ CML446 Inbredline 8) to 2.13 (Rajkumar $\times$ CML446 Inbredline 25) among lines and from -0.56 (KDMI16) to 0.86 (HS7) among testers. Significant positive GCA effects were recorded in Rajkumar $\times$ CML446 Inbredline 18 (1.67) and Rajkumar $\times$ CML446 Inbredline 25 (2.13). Among testers, HS7 (0.86) showed a significant positive GCA effect, indicating its suitability for improving cob length.

Cob Girth (cm)

Under non-stress conditions, GCA effects for cob girth ranged from -0.42 (Rajkumar $\times$ CML446 Inbredline 8) to 0.25 (Rajkumar $\times$ CML446 Inbredline 18) among lines and from -0.054 (HS10) to 0.038 (HS7) among testers. Four lines showed significant positive GCA effects, namely Allrounder $\times$ HS17 Inbredline 25 (0.16), NK6240 $\times$ CI4 Inbredline 42 (0.19), NK6240 $\times$ CI4 Inbredline 24 (0.21), and Rajkumar $\times$ CML446 Inbredline 18 (0.25), indicating their usefulness in improving cob development traits.

The variation observed in GCA effects among parental lines indicates considerable genetic diversity for the studied traits. Parents exhibiting significant positive GCA effects for yield-associated and physiological traits can serve as valuable sources in hybrid breeding programmes. The presence of desirable negative GCA effects for traits such as days to anthesis, silking and maturity suggests the possibility of developing early maturing hybrids. Significant positive GCA effects for chlorophyll content and relative water content indicate the contribution of favourable alleles associated with enhanced photosynthetic activity and improved plant physiological status. These findings confirm that selection of superior combiners is essential for improving complex quantitative traits in maize breeding programmes. The predominance of significant GCA effects for several traits also suggests the importance of additive gene effects in the inheritance of these characters under non-stress conditions.

Number of Kernel Rows per Cob

Under non-stress conditions, the GCA effects for number of kernel rows per cob ranged from -1.10 (Rajkumar $\times$ CML446 Inbredline 1) to 1.35 (Rajkumar $\times$ CML446 Inbredline 40) among lines and from -0.17 (KDMI16) to 0.30 (CI4) among testers. Five lines exhibited positive GCA effects, namely NK6240 $\times$ CI4 Inbredline 35 (0.69), NAC6002 $\times$ CI4 Inbredline 7 (0.89), Allrounder $\times$ HS17 Inbredline 25 (0.96), Rajkumar $\times$

CML446 Inbredline 46 (1.09), and Rajkumar $\times$ CML446 Inbredline 40 (1.35). Among testers, CI4 (0.30) recorded a desirable positive GCA effect, indicating its potential contribution towards increasing kernel row number.

Number of Kernels per Row

The GCA effects for number of kernels per row ranged from -3.09 (NK6240 $\times$ HS17 Inbredline 14) to 3.53 (Rajkumar $\times$ CML446 Inbredline 25) among lines and from -0.55 (KDMI16) to 0.75 (HS7) among testers. Two lines, namely Rajkumar $\times$ CML446 Inbredline 37 (2.63) and Rajkumar $\times$ CML446 Inbredline 25 (3.53), exhibited significant positive GCA effects, indicating their suitability for improving kernel number per row.

Number of Cobs per Plant

Under non-stress conditions, the GCA effects for number of cobs per plant varied from -0.18 (Rajkumar $\times$ CML446 Inbredline 25) to 0.41 (NK6240 $\times$ CI4 Inbredline 12) among lines and from -0.072 (HS10) to 0.09 (HS4) among testers. Three lines showed positive GCA effects, namely NK6240 $\times$ CI4 Inbredline 24 (0.21), Allrounder $\times$ HS17 Inbredline 34 (0.28), and NK6240 $\times$ CI4 Inbredline 12 (0.41). Among testers, HS7 (0.07) and HS4 (0.09) showed positive GCA effects, suggesting their usefulness in improving cob number.

100 Grain Weight (g)

The GCA effects for 100-grain weight ranged from -4.74 (Rajkumar $\times$ CML446 Inbredline 8) to 1.78 (Rajkumar $\times$ CML446 Inbredline 46) among lines and from -0.22 (CI4) to 0.26 (HS10) among testers. None of the evaluated lines exhibited significant positive GCA effects for this trait, indicating limited contribution of additive genetic effects among the studied parental lines for improving grain weight.

Grain Yield per Plant (g)

For grain yield per plant under non-stress conditions, GCA effects among lines ranged from -20.72 (Parbhat $\times$ CI4 Inbredline 5) to 45.08 (Rajkumar $\times$ CML446 Inbredline 18), while tester effects ranged from -11.38 (KDMI16) to 12.96 (HS7).

Among the evaluated parents, Rajkumar $\times$ CML446 Inbredline 18 (45.08) exhibited a significant positive GCA effect. Among testers, HS7 (12.96) showed a desirable positive GCA effect, indicating its usefulness for improving grain yield per plant.

Grain Yield (kg ha⁻¹)

The GCA effects for grain yield ranged from -931.74 (Parbhat $\times$ CI4 Inbredline 5) to 854.57 (NK6240 $\times$ CI4 Inbredline 24) among lines and from -298.55 (HS10) to 206.21 (CI4) among testers. Two lines exhibited significant positive GCA effects, namely NK6240 $\times$ CI4 Inbredline 12 (784.73) and NK6240 $\times$ CI4 Inbredline 24 (854.57). Among testers, CI4 (206.21) showed a desirable positive GCA effect, indicating its potential as a good general combiner for grain yield improvement.

Shelling Percentage (%)

Under non-stress conditions, GCA effects for shelling percentage ranged from -6.63 (NK6240 $\times$ CI4 Inbredline 18) to 4.50 (NK6240 $\times$ CI4 Inbredline 42) among lines and from -0.67 (CI4) to 0.49 (HS10) among testers. Two lines, namely NK6240 $\times$ CI4 Inbredline 35 (4.507) and NK6240 $\times$ CI4 Inbredline 42 (4.508), recorded significant positive GCA effects, suggesting

their suitability for improving shelling percentage in maize breeding programmes.

The significant variation in GCA effects among parental lines and testers for yield and yield-related traits indicates the presence of substantial genetic variability within the breeding material. Traits such as number of kernel rows per cob, kernels per row, number of cobs per plant and grain yield showed desirable positive combiners, which can be effectively utilized in hybrid breeding programmes.

The identification of NK6240 × CI4 Inbredline 12 and NK6240 × CI4 Inbredline 24 as superior general combiners for grain yield indicates their potential contribution of favourable alleles for productivity improvement. Similarly, the positive GCA effect of Rajkumar × CML446 Inbredline 18 for grain yield per plant highlights its usefulness in developing high-yielding hybrids.

The predominance of favourable GCA effects for yield components suggests the importance of additive genetic variance in controlling these traits under non-stress conditions. Such parental lines can be utilized in recurrent selection programmes for accumulation of favourable genes and in hybrid development programmes for exploiting heterosis. The superior combining ability of tester CI4 and HS7 further emphasizes their importance in identifying promising hybrid combinations. These findings demonstrate that combining ability analysis provides an effective approach for selecting elite parents and improving grain yield potential in maize.

The specific combining ability effects of 150 crosses are presented in Table 2. Days to 50 per cent anthesis, Under non-stress situation, the SCA effects for days to 50 per cent anthesis ranged from -2.91 (NK6240 × CI 4 Inbredline 24) × HS7 to 2.03 (NK6240 × CI 4 Inbredline 37) × KDMI16 (Table16). One hybrid viz. (NK6240 × CI 4 Inbredline24)×HS7 (-2.91) showed significant SCA effects in negative direction. Days to 50 per cent silking, Under non-stress situation, the SCA effects for days to 50 per cent silking ranged from -3.47 (Rajkumar × CML446 Inbredline 18) × CI4 to 2.55 (NK6240 × CI4 Inbredline 37) × KDMI16). One hybrid viz. (Rajkumar × CML446 Inbredline 18) × CI4 (-3.47) showed significant SCA effect in negative direction. Whereas under stress situation, SCA effects for days to 50 per cent silking ranged from (Allrounder × HS17 Inbredline 21) × HS7 (-3.58) to (Allrounder × HS17 Inbredline 45) × CI4 (3.55). One hybrid viz. (Allrounder × HS17 Inbredline 21) × HS7 (-3.58) showed significant SCA effect in negative direction.

Anthesis to silking interval (ASI), Under non-stress situation, the SCA effects for ASI ranged from -1.26 (Rajkumar × CML446 Inbredline 18) × HS7 to 1.74 (NK6240 × HS17 Inbredline 20) × HS10. One hybrid viz. (Rajkumar × CML446 Inbredline 18) × HS7 (-1.26) showed significant SCA effect in negative direction. Days to maturity, Under non-stress situation, the SCA effects for days to maturity ranged from -2.64 (Rajkumar × CML446 Inbredline 46) × HS4 to 3.17 (NK6240 × CI4 Inbredline 18) × CI4. One hybrid viz. (Rajkumar × CML446 Inbredline 46) × HS4 (-2.64) showed significant SCA effect in negative direction.

Chlorophyll content (mg/cm²) at 60 days , Under non-stress situation, the SCA effects for chlorophyll at 60 days ranged from -9.16 (NK6240 × CI 4 Inbredline 24) × KDMI16 to 8.62 (Rajkumar × CML446 Inbredline 37) × KDMI16. Three hybrids viz. (NK6240 × HS17 Inbredline 10) × HS10 (6.74) (Rajkumar × CML446 Inbredline 46) × HS4 (7.49) and (Rajkumar × CML446 Inbredline 37) × KDMI16 (8.62) showed significant SCA effects in positive direction. Chlorophyll content (mg/cm²)

at 90 days, Under non-stress situation, the SCA effects for chlorophyll at 90 days ranged from -7.92 (NK6240 × HS17 Inbredline 22) × HS7 to 7.78 (Rajkumar × CML446 Inbredline 37) × KDMI16. The three hybrids viz. (NK6240 × CI 4 Inbredline 12) × HS7 (6.96) (Allrounder × HS17 Inbredline 25) × HS7 (7.22) and (Rajkumar × CML446 Inbredline 37) × KDMI16 (7.78) showed significant SCA effects in positive direction.

Relative water content at 60 days, Under non-stress situation, the SCA effects for relative water content at 60 days ranged from -0.14 (Rajkumar × CML446 Inbredline 37) × HS7 to 0.13 (NK6240 × HS17 Inbredline 20) × HS4. One hybrid viz. (NK6240 × HS17 Inbredline 20) × HS4 (0.13) showed significant SCA effects in positive direction. Relative water content at 90 days, Under non-stress situation, the SCA effects for relative water content at 90 days ranged from -0.25 (Rajkumar × CML446 Inbredline 38) × CI4 to 0.24 (Rajkumar × CML446 Inbredline 1) × HS7. Three hybrids viz. (Rajkumar × CML446 Inbredline 37) × HS4 (0.217) (NK6240 × CI4 Inbredline 35) × CI4 (0.220) and (Rajkumar × CML446 Inbredline 1) × HS7 (0.248) showed significant SCA effects in positive direction. Plant height (cm), Under non-stress situation, the SCA effects for plant height ranged from -54.76 (NK6240 × HS17 Inbredline 14) × HS7 to 25.09 (NK6240 × HS17 Inbredline 14) × HS4, three hybrids viz. (Rajkumar × CML446 Inbredline 46) × HS7 (-26.81) (Allrounder × HS17 Inbredline 21) × KDMI16 (-27.53) and (NK6240 × HS17 Inbredline 14) × HS7 (-54.76) showed significant SCA effect in negative direction.

Ear height (cm), Under non-stress situation, the SCA effects for ear height ranged from -31.82 (NK6240 × HS17 Inbredline 5) × HS7 to 27.18 (Allrounder × HS17 Inbredline 34) × HS7. Seven hybrids in which four hybrids viz. (NK6240 × HS17 Inbredline 14) × HS7 (22.93) (NK6240 × HS17 Inbredline 22) × HS10 (22.95) (NK6240 × HS17 Inbredline 20) × KDMI16 (26.22) and (Allrounder × HS17 Inbredline 34) × HS7 (27.18) showed significant SCA effects in positive direction and three hybrids viz. (Allrounder × HS17 Inbredline 34) × HS4 (-22.79) (NK6240 × HS17 Inbredline 14) × HS10 (-23.795) and (NK6240 × HS17 Inbredline 5) × HS7 (-31.82) showed significant SCA effect in negative direction.

Cob length (cm), Under non-stress situation, the SCA effects for cob length ranged from -3.51 (Allrounder × HS17 Inbredline 34) × HS4 to 2.82 (Allrounder × HS17 Inbredline 34) × KDMI16. Eight hybrids viz. (G57 × NAC6002 Inbredline 25) × KDMI16 (2.48) (Allrounder × HS17 Inbredline 21) × HS10 (2.51) (Rajkumar × CML446 Inbredline 38) × HS4 (2.62) (Allrounder × HS17 Inbredline 25) × HS10 (2.63) (Rajkumar × CML446 Inbredline 46) × HS4 (2.66), (Rajkumar × CML446 Inbredline 25) × HS10 (2.76), (NK6240 × CI 4 Inbredline 18) × HS7 (2.77) and (Allrounder × HS17 Inbredline 34) × KDMI16 (2.82) showed significant SCA effects in positive direction. Cob girth (cm), Under non-stress situation, the SCA effects for cob girth ranged from -0.54 (Allrounder × HS17 Inbredline 34) × HS10 to 0.53 (Allrounder × HS17 Inbredline 21) × HS10. seven hybrids viz. (Parbhat × CI4 Inbredline 5) × HS4 (0.402) (NK6240 × HS17 Inbredline 10) × CI4 (0.403) (Rajkumar × CML446 Inbredline 37) × CI4 (0.413) (NK6240 × CI4 Inbredline 35) × HS10 (0.434) (Allrounder × HS17 Inbredline 34) × HS7 (0.475), (Allrounder × HS17 Inbredline 34) × KDMI16 (0.503) and (Allrounder × HS17 Inbredline 21) × HS10 (0.530) showed significant SCA effects in positive direction. Number of kernel rows per cob, Under non-stress situation, the SCA effects for number of kernel rows per cob

ranged from -1.79 (Allrounder × HS17 Inbredline 21) × HS7 to 2.37 (Rajkumar × CML446 Inbredline 18) × HS10. Eight hybrids viz. (NK6240 × CI4 Inbredline 35) × HS10 (1.512) (NK6240 × CI4 Inbredline 18) × CI4 (1.562) (Rajkumar × CML446 Inbredline 37) × CI4 (1.566) (NK6240 × HS17 Inbredline 5) × KDMI16 (1.573) (NAC6002 × CI 4 Inbredline 7) × HS10 (1.643) (Rajkumar × CML446 Inbredline 8) × KDMI16 (2.037) (Parbhat × CI4 Inbredline 5) × HS4 (2.075) and (Rajkumar × CML446 Inbredline 18) × HS10 (2.379) showed significant SCA effects in positive direction.

Number of kernels per row, Under non-stress situation, the SCA effects for number of kernels per row ranged from -7.57 (NK6240 × CI 4 Inbredline 18) × KDMI16 to 7.81 (Rajkumar × CML446 Inbredline 46) × HS4. Six hybrids viz. (Allrounder × HS17 Inbredline 45) × KDMI16 (5.70) (Allrounder × HS17 Inbredline 21) × HS10 (5.84) (NK6240 × CI 4 Inbredline 37) × HS7 (6.00) (Rajkumar × CML446 Inbredline 38) × HS4 (6.31) (Allrounder × HS17 Inbredline 25) × HS10 (7.18) and (Rajkumar × CML446 Inbredline 46) × HS4 (7.81) showed significant SCA effects in positive direction. Number of cobs per plant, Under non-stress situation, the SCA effects for Number of cobs per plant ranged from -0.46 (Allrounder × HS17 Inbredline 21) × HS4 to 0.66 (Allrounder × HS17 Inbredline 45) × KDMI16. Three hybrids viz. (Allrounder × HS17 Inbredline 25) × HS10 (0.40) (NK6240 × CI 4 Inbredline 24) × HS4 (0.47) and (Allrounder × HS17 Inbredline 45) × KDMI16 (0.66) showed significant SCA effects in positive direction.

100 grain weight (g), Under non-stress situation, the SCA effects for 100 grain weight ranged from -5.76 (Rajkumar × CML446 Inbredline 46) × KDMI16 to 6.74 (Rajkumar × CML446 Inbredline 46) × HS4. Three hybrids viz. (Rajkumar × CML446 Inbredline 1) × HS4 (4.79) (G57 × NAC6002 Inbredline 17) × KDMI16 (5.51) and (Rajkumar × CML446 Inbredline 46) × HS4 (6.74) showed significant SCA effects in positive direction. Grain yield per plant (g), Under non-stress situation, the SCA effects for grain yield per plant ranged from -51.62 (Rajkumar × CML446 Inbredline 18) × KDMI16 to 100.86 (NK6240 × HS17 Inbredline 14) × HS7. Four hybrids viz. (NK6240 × CI 4 Inbredline 37) × HS7 (51.87) (Rajkumar × CML446 Inbredline 38) × HS7 (62.76) (Rajkumar × CML446 Inbredline 18) × HS4 (82.17) and (NK6240 × HS17 Inbredline 14) × HS7 (100.86) showed significant SCA effects in positive direction.

Grain yield (kg/ha), Under non-stress situation, the SCA effects for grain yield (kg/ha) ranged from -2707.35 (NAC6002 × CI 4 Inbredline 7) × HS7 to 3502.08 (Allrounder × HS17 Inbredline 34) × HS7. Four hybrids viz. (Rajkumar × CML446 Inbredline 3) × HS4 (2046.41) (NK6240 × CI 4 Inbredline 12) × HS4 (2127.90) (Allrounder × HS17 Inbredline 39) × HS10 (2522.86) and (Allrounder × HS17 Inbredline 34) × HS7 (3502.08) showed significant SCA effects in positive direction. Shelling percentage, Under non-stress situation, the SCA effects for shelling percentage ranged from -15.73 (Rajkumar × CML446 Inbredline 25) × CI4 to 10.30 (Rajkumar × CML446 Inbredline 46) × KDMI16. One hybrid viz. (Rajkumar × CML446 Inbredline 46) × KDMI16 (10.30) showed significant SCA effects in positive direction.

The per cent heterosis over mid parent (relative heterosis) and over best check (standard heterosis) was worked out against commercial check Rajkumar under nonstress condition (Table 2). Days to 50 per cent anthesis, The per cent heterosis over mid parent ranged from -7.48 (NK6240 × CI 4 Inbredline 24) × HS7 to 4.76 (NK6240 × HS17 Inbredline 20) × HS4 under non-stress

condition. The per cent standard heterosis under non-stress condition, ranged from -4.70 (NK6240 × CI 4 Inbredline 24) × HS7 to 4.70 (Rajkumar × CML446 Inbredline 36) × CI4. 11 hybrids under non-stress exhibited significant negative heterosis over mid parent for this trait. None of the crosses under non-stress.

Days to 50 per cent silking, the per cent heterosis over mid parent ranged from -6.98 (Rajkumar × CML446 Inbredline 18) × CI4 to 3.42 (NK6240 × HS17 Inbredline 20) × HS4 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -4.11 (Rajkumar × CML446 Inbredline 18) × CI4 to 5.48 (Rajkumar × CML446 Inbredline 36) × CI4. 11 hybrids under non-stress exhibited significant negative heterosis over mid parent for this trait. None of the crosses under non-stress. Anthesis to silking interval (ASI), The per cent heterosis over mid parent ranged from -69.23 (Rajkumar × CML446 Inbredline 1) × KDMI16 to 250 (Rajkumar × CML446 Inbredline 36) × HS7 under non-stress condition. The per cent standard heterosis under non-stress condition ranged from -33.33 (Parbhat × CI4 Inbredline 5) × HS4 to 166.67 (NK6240 × HS17 Inbredline 20) × HS10. 13 hybrids under non-stress exhibited significant negative heterosis over mid parent. None of the crosses exhibited negative significant heterosis over check under both condition. Days to maturity, The per cent heterosis over mid parent ranged from -4.15 (NK6240 × CI 4 Inbredline 37) × HS4 to 2.94 (Rajkumar × CML446 Inbredline 25) × HS7 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -4.55 (NK6240 × CI 4 Inbredline 37) × HS4 to 1.65 (NK6240 × CI4 Inbredline 18) × CI4. Five hybrids under non-stress exhibited significant negative heterosis over mid parent, respectively. 12 hybrids under non-stress exhibited significant negative heterosis over check, respectively. Top five hybrids viz. (Rajkumar × CML446 Inbredline 46) × HS4 (-4.55) (NK6240 × HS10 Inbredline 37) × HS10 (-4.55) (NK6240 × HS4 Inbredline 37) × HS4 (-4.55) (Rajkumar × CML446 Inbredline 37) × HS4 (-3.72) and (NK6240 × KDMI16 Inbredline 35) × KDMI16 (-3.72).

Chlorophyll content (mg/cm²) at 60 days, The per cent heterosis over mid parent ranged from -29.96 (NK6240 × CI 4 Inbredline 42) × KDMI16 to 20.14 (NK6240 × CI 4 Inbredline 24) × HS7 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -22.53 (NK6240 × CI 4 Inbredline 42) × KDMI16 to 18.65 (Rajkumar × CML446 Inbredline 37) × KDMI16. One hybrid under non-stress exhibited significant positive heterosis over mid parent. Chlorophyll content (mg/cm²) at 90 days, The per cent heterosis over mid parent ranged from -30.92 (NK6240 × CI4 Inbredline 18) × CI4 to 26.30 (Allrounder × HS17 Inbredline 25) × HS7 under nonstress condition. The per cent standard heterosis under non-stress condition, ranged from -25.54 (NK6240 × CI 4 Inbredline 24) × KDMI16 to 21.52 (Rajkumar × CML446 Inbredline 37) × KDMI16. Two hybrids under non-stress exhibited significant positive heterosis over mid parent.

Relative water content at 60 days, The per cent heterosis over mid parent ranged from -20.47 (Rajkumar × CML446 Inbredline 46) × CI4 to 24.04 (NK6240 × HS17 Inbredline 20) × HS4 under non-stress condition. The per cent standard heterosis under non-stress condition ranged from -16.67 (NK6240 × CI 4 Inbredline 37) × HS4 to 23.61 (NK6240 × HS17 Inbredline 20) × HS4. Five hybrids under non-stress exhibited significant positive heterosis over mid parent, respectively. One hybrid under non-stress exhibited significant

positive heterosis. viz. (NK6240 × HS17 Inbredline 20) × HS4 (23.61) over check.

Relative water content at 90 days, The per cent heterosis over mid parent ranged from -53.91 (Rajkumar × CML446 Inbredline 38) × CI4 to 75.46 (Allrounder × HS17 Inbredline 34) × KDMI16 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -54.72 (Rajkumar × CML446 Inbredline 18) × HS4 to 28.69 (Rajkumar × CML446 Inbredline 1) × HS7. Two hybrids under nonstress exhibited significant positive heterosis over mid parent. Plant height (cm), The per cent heterosis over mid parent ranged from -31.31 (NK6240 × HS17 Inbredline 14) × HS7 to 13.11 (NK6240 × HS17 Inbredline 20) × KDMI16 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -27.27 (NK6240 × HS17 Inbredline 14) × HS7 to 13.37 (Rajkumar × CML446 Inbredline 38) × HS7. Five hybrids under non-stress exhibited significant negative heterosis over mid parent, respectively. Two hybrids under non-stress exhibited significant negative heterosis over check.

Ear height (cm) , The per cent heterosis over mid parent ranged from -37.7 (NK6240 × HS17 Inbredline 5) × HS7 to 44.34 (NK6240 × HS17 Inbredline 20) × KDMI16 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -38.54 (NK6240 × HS17 Inbredline 5) × HS7 to 23.96 (NK6240 × HS17 Inbredline 20) × KDMI16. Two hybrids under non-stress exhibited significant positive heterosis over mid parent. Three hybrids under non-stress exhibited significant negative heterosis over mid parent. None of the crosses under non-stress exhibited significant positive standard heterosis over check. cob length (cm), The per cent heterosis over mid parent ranged from -21.19 (Allrounder × HS17 Inbredline 34) × HS4 to 26.41 (Rajkumar × CML446 Inbredline 25) × HS10 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -25.97 (Allrounder × HS17 Inbredline 34) × HS4 to 19.83 (Rajkumar × CML446 Inbredline 25) × HS10. Five hybrids under non-stress exhibited significant positive heterosis over mid parent. One hybrid exhibited significant positive heterosis viz. (Rajkumar × CML446 Inbredline 25) × HS10 (19.83), over check under non-stress condition.

cob girth (cm) , The per cent heterosis over mid parent ranged from -15.68 (Rajkumar × CML446 Inbredline 8) × HS10 to 15.83 (Allrounder × HS17 Inbredline 34) × HS7 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -14.47 (Rajkumar × CML446 Inbredline 8) × HS10 to 11.7 (Allrounder × HS17 Inbredline 34) × HS7. Seven hybrids under non-stress exhibited significant positive heterosis over mid parent. Two hybrids exhibited significant positive heterosis viz.,(Allrounder × HS17 Inbredline 21) × HS10 (11.06) and (Allrounder × HS17 Inbredline 34) × HS7 (11.70) over check under non-stress condition. Number of kernel rows per cob, The per cent heterosis over mid parent ranged from -20.00 (Rajkumar × CML446 Inbredline 3) × KDMI16 to 19.99 (Rajkumar × CML446 Inbredline 40) × HS7 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -21.75 (Rajkumar × CML446 Inbredline 3) × KDMI16 to 14.12 (Rajkumar × CML446 Inbredline 18) × HS10. Seven hybrids under non-stress exhibited significant positive heterosis over mid parent. One hybrid exhibited significant positive standard heterosis viz. (Rajkumar × CML446 Inbredline 18) × HS10 (14.12) over check under non-stress condition.

Number of kernels per row, The per cent heterosis over mid parent ranged from -30.07 (Allrounder × HS17 Inbredline 25) × CI4 to 28.13 (Rajkumar × CML446 Inbredline 25) × KDMI16 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -44.03 (Allrounder × HS17 Inbredline 25) × CI4 to -6.71 (Rajkumar × CML446 Inbredline 46) × HS4. Four hybrids under non-stress exhibited significant positive heterosis over mid parent. 122 hybrids under non-stress exhibited significant negative standard heterosis over check. Number of cobs per plant, The per cent heterosis over mid parent ranged from -33.44 (Rajkumar × CML446 Inbredline 38) × CI4 to 83.50 (Allrounder × HS17 Inbredline 21) × HS7 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -14.16 (Parbhat × CI4 Inbredline 5) × CI4 to 71.67 (NK6240 × CI 4 Inbredline 24) × HS4. 14 hybrids under non-stress exhibited significant positive heterosis over mid parent. Seven hybrids exhibited significant positive heterosis viz., Allrounder × HS17 Inbredline 45) × KDMI16 ,(Allrounder × HS17 Inbredline 21) × HS7 (Allrounder × HS17 Inbredline 34) × CI4 (Allrounder × HS17 Inbredline 34) × HS4 (NK6240 × CI 4 Inbredline 12) × HS4 (NK6240 × CI 4 Inbredline 12) × HS7 (57.51) and (NK6240 × CI 4 Inbredline 24) × HS4 (71.67) over check under non-stress condition.

100 grian weight, The per cent heterosis over mid parent ranged from -29.86 (Rajkumar × CML446 Inbredline 8) × KDMI16 to 30.43 (Rajkumar × CML446 Inbredline 46) × HS4 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -38.39 (Rajkumar × CML446 Inbredline 8) × KDMI16 to 27.33 (Rajkumar × CML446 Inbredline 46) × HS4. Four hybrids under non-stress exhibited significant positive heterosis over mid parent, respectively. One hybrid exhibited significant positive heterosis viz. (Rajkumar × CML446 Inbredline 46) × HS4 (27.33) over check under non-stress condition. Grain yield per plant (g), The per cent heterosis over mid parent ranged from -73.68 (Rajkumar × CML446 Inbredline 46) × HS10 to 171.57 (NK6240 × HS17 Inbredline 14) × HS7 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -67.7 (Parbhat × CI 4 Inbredline 5) × HS10 to 89.99 (Rajkumar × CML446 Inbredline 18) × HS4. Seven hybrids under non-stress exhibited significant positive heterosis over mid parent. Two hybrids exhibited significant positive heterosis viz. (NK6240 × HS17 Inbredline 14) × HS7 (86.76) and (Rajkumar × CML446 Inbredline 18) × HS4 (89.99) over check under non-stress condition.

Grain yield (kg/ha), The per cent heterosis over mid parent ranged from -62.76 (Rajkumar × CML446 Inbredline 38) × HS10 to 133.78 (Allrounder × HS17 Inbredline 34) × HS7 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -64.17 (Parbhat × CI4 Inbredline 5) × CI4 to 38.29 (Allrounder × HS17 Inbredline 34) × HS7. Six hybrids under non-stress exhibited significant positive heterosis over mid parent. Twenty hybrids under non-stress exhibited significant negative standard heterosis over check. Shelling percentage, The per cent heterosis over mid parent ranged from -24.87 (Rajkumar × CML446 Inbredline 25) × CI4 to 23.12 (NK6240 × CI4 Inbredline 35) × HS10 under non-stress condition. The per cent standard heterosis under non-stress condition, ranged from -21.90 (Rajkumar × CML446 Inbredline 25) × CI4 to 22.98 (Rajkumar × CML446 Inbredline 46) × KDMI16. Six hybrids under non-stress exhibited significant positive heterosis over mid parent. Three hybrids exhibited significant positive heterosis viz. (Rajkumar ×

CML446 Inberdline46) X KDMI16 (22.98) (NK6240 X HS10 Inberdline35) X HS10 (22.01) and (NK6240 X HS7 Inberdline35) X HS7 (21.15) over check under non-stress condition. Drought susceptibility index (DSI), Drought susceptibility index (DSI) presented in Table 18. 150 hybrids along with 35 parents and 3 checks, the hybrids viz. (NK6240 × HS17 inbredline 10) recorded highest (1.81) and (Allrounder × HS17 inbredline 39) × CI4 lowest (0.04) DSI values for grain yield (kg/ha) with an overall mean of (0.87).

Analysis of variance indicated mean sum of squares due to lines was significant for anthesis to silking interval (ASI), days to 50 per cent anthesis, days to 50 per cent silking, relative water content at 60 days, relative water content at 90 days, plant height, ear height, cob girth, number of kernel rows per cob and number of cobs per plant under non-stress situation. indicating there was considerable variability for these traits among lines under non-stress situation (Table 1).

The variability due to tester was significant for days to 50 per cent anthesis, chlorophyll at 90 days, cob length, number of cobs per plant and grain yield per plant under non-stress situation indicating the presence of variability among the selected lines.

Mean sum of square for line × tester was significant for cob length, cob girth, number of kernel rows per cob, number of kernels per row, grain yield per plant and grain yield (kg/ha) under non-stress situation indicated the presence of average heterosis. These results are in agreement with that of *Joshi et al.* (2002) [8], *Asif et al.* (2007) [9], *Premalatha and Kalamani* (2010) [10], *Aminu and Izge* (2013) [11] and *Kuchanur et al.* (2013) [12].

Maize a highly allogamous species is expected to contain predominant of non additive gene action. As per the expectation, the variance due to SCA was considerably high compared to that of variance due to GCA for all the characters under non-stress situation, except number of cobs per plant under non-stress situation. 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 for non-stress situation, except number of cobs per plant under non-stress situation. The predominance of non-additive gene action for most of the growth and productivity traits have been reported by *Sharma et al.* (2004) [13], *Sandhu et al.* (2006) [14], *Singh et al.* (1983) [15], *Paul and Duara* (1991) [16], *Sedhom* (1994) [17], *Mohammad* (1993) [18] and *Satyanarayana et al.* (1994) [19]. Whereas, *Olaoye* (2005) [20] and *Aminu and Izge* (2013) [11] reported predominance of both GCA and SCA for most of the traits under stress and non stress situations.

These results also in agreement with *Rojas and Sprague* (1952) [21] and *Gama et al.* (1995) who worked on millet and maize respectively. These results exhibited that parental lines would be utilized in the development of maize hybrids. 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.

The contribution of lines to total variances was higher than testers for most of the traits which signifies the prevalence of high diversity among the lines used for this investigation. This is mainly attributed to the enormous diversity in different source populations 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 *Kadlubiec et al.* (2000) [22], *Ramesh et al.* (2000) [23], *Rosa et al.* (2000) [24], *Mandal et al.* (2001) [25] and *Sandhu et al.* (2006) [14].

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 given based on the GCA effects of the parents (Table 2). 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*) [26]. Under non-stress situation, among the lines, *Rajkumar × CML446 inberdline 37* and *NK6240 × CI4 inberdline 24* exhibited maximum positive GCA effect for quantitative traits, the pooled score for GCA effects for these two female parents was highest (+4) proving them to be potential general combiner (Table 15). *NK6240 × CI4 inberdline 12*, *Allrounder × HS17 inberdline 34* and *Allrounder × HS17 inberdline 25* were the next best general combiners with pool score of +3. Among the other lines, *Rajkumar × CML446 inberdline 18*, *Allrounder × HS17 inberdline 21* and *NAC6002 × CI4 inberdline 7* recorded a positive score of +for GCA effects. Among the testers, *HS7* recorded pool score of +4 indicating its superiority for utilization in hybridization programme.

For anthesis to silking interval two parents viz., *NK6240 × CI4 inberdline 37* and *Rajkumar × CML446 inberdline 1* exhibited significant GCA effects in desirable direction under non stress situation. Anthesis silking interval is a trait used mostly in screening genotypes for tolerance to stresses (*EL-Hosary et al., 1994*) [27]. It is a measure of nicking (synchronization) of pollen shed with silking as reported by *Paul and Debenth* (1999) [28] and (*Olaoye et al., 2005*) [20]. For number of cobs per plant three parents viz., *NK6240 × CI4 inberdline 24*, *Allrounder × HSinberdline 34* and *NK6240 × CI4 inberdline 12* exhibited significant GCA effects in desirable direction. Among testers, *HS7* and *HS4* exhibited significant GCA effects in desirable direction under non stress situation.

The GCA effects for grain yield per plant *Rajkumar × CML446 inberdline* exhibited significant GCA effect in desirable direction non-stress situation. Among testers *HS7* exhibited significant GCA effect in desirable direction non-stress situation. The parents with a high GCA effects for traits could produce superior segregants in F₂ as well as in later generations. Significant GCA effects in desirable direction for most of the quantitative traits. Therefore, these parents could be utilized in a hybridization programme for selection of superior recombinants. These findings are in accordance with *Mandal et al.* (2001) [25], *Malik et al.* (2004) [29], *Koinuma et al.* (2004) [30], *Fan et al.* (2004) [31], *kanta et al.* (2005), *Prashanth* (2008) [5], *Kuchanur* (2010) [32], *Premalatha and Kalamani* (2010) [10], *Izge and Dugje* (2011) [33], *Aminu and Izge* (2013) [11] and *Praveen Kumar et al.* (2014) [34]

The estimates of specific combining ability effects for traits in maize nonstress situation are presented in Table 16. These estimates are used to identify the best cross-combinations for hybrids production (*Izge et al., 2007*) [35]. Among 150 hybrids evaluated, 45 hybrid combinations recorded positive score under non-stress situation across triats, indicating them as heterotic hybrids for these traits. Under non-stress situation, among hybrids viz. (*Allrounder × HS17 Inberdline 34*) × *HS7* exhibited maximum positive GCA effect for quantitative traits with a pooled score for SCA effects of +5 and (*Rajkumar × CML446 Inberdline 46*) × *HS4* (*NK6240 × CI4 Inberdline 12*) × *HS4* (*Allrounder × HS17 Inberdline 45*) × *KDMI16* (*Allrounder × HS17 Inberdline 39*) × *HS10* (*Allrounder × HS17*

Inberdline 25) × HS10 and (Allrounder × HS17 Inberdline 21)
× HS10 recorded a positive score of +for SCA effects.

Table 1: ANOVA for Line x Tester under non stress and stress situations during post *rabi* 2013

Character	Crosses	Line Effect	Tester Effect	Line* Tester Eff.	Line* Tester Eff.	Error	s ² GCA	s ² SCA	s ² GCA/s ² SCA	Contribution of Lines	Contribution of Testers	Contribution of Line* Tester
DF	149	29	4	116	149	299	Non stress	Non stress	Non stress	Non stress	Non stress	Non stress
Anthesis to silking interval	0.836	1.232*	0.438	0.750	0.644	1.485	0.003	0.014	0.214	0.287	0.014	0.699
Chlorophyll at 60 DAS (mg/cm ²)	28.130	30.792	16.940	27.85	22.521	26.401	0.028	2.488	0.011	0.213	0.016	0.771
Chlorophyll at 90 DAS (mg/cm ²)	24.916	28.6	60.364*	22.773	23.617	26.430	0.577	-0.762	-0.757	0.223	0.065	0.712
Relative water content at 60 DAS (%)	0.007	0.014**	0.004	0.005	0.007	0.007	0.000	-0.001	0.000	0.401	0.014	0.585
Relative water content at 90 DAS (%)	0.027	0.047**	0.026	0.022	0.024	0.025	0.000	-0.001	0.000	0.340	0.027	0.633
Cob length (cm)	5.154**	5.379	17.289**	4.679**	2.743	3.948	0.234	0.775	0.302	0.203	0.090	0.707
Cob girth (cm)	0.119**	0.224**	0.114	0.093**	0.060	0.091	0.003	0.013	0.231	0.366	0.026	0.608
No. of Kernel rows/cob	2.123**	3.963**	2.321	1.657**	1.020	1.566	0.057	0.254	0.224	0.363	0.029	0.607
No. of Kernels/row	21.596*	23.833	16.919	21.199*	14.910	18.267	0.122	2.547	0.048	0.215	0.021	0.764
100-Seed weight (g)	14.143	18.964	2.743	13.330	12.618	13.363	-0.045	0.460	-0.098	0.261	0.005	0.734
Grain yield kg/ha	2393382**	2642579	3430880	2295307**	1379333	2142234	42326	369996	0.114	0.215	0.038	0.747
Shelling%	58.124	79.590	13.419	54.299	49.665	60.540	-0.108	2.008	-0.054	0.267	0.006	0.727

* & ** - Significant at 0.05 and 0.01 level of probability, respectively

Table 2: Top five hybrids based on mean performance and their SCA effects, standard heterosis and GCA status of parents for 12 traits in maize under nonstress situation

Characters	Cross combination	Mean	SCA effects	GCA effects		Standard heterosis over Bio-9681	Standard heterosis over Rajkumar
				Female	Male		
Anthesis to silking interval	(Parbhat XCI4 line 5) X HS4	1.00	-0.843	-0.257	0.043	-71.43 **	-33.33
	(Allrounder X HS17 line 34) X HS10	1.00	-0.76	-0.357	0.06	-71.43 **	-33.33
	(Allrounder X HS17 line 39) X CI4	1.00	-0.56	-0.357	-0.14	-71.43 **	-33.33
	(Allrounder X HS17 line 45) X CI4	1.00	-0.56	-0.357	-0.14	-71.43 **	-33.33
	(NK6240 X CI4 line 24) X CI4	1.00	-1.06	0.143	-0.14	-71.43 **	-33.33
Chlorophyll content at 60 DAS	(Allrounder X HS17 line 34) X KDMI16	51.80	6.318	1.772	-0.788	27.34 *	13.15
	(NK6240 X HS17 line 5) X HS7	51.80	5.321	1.295	0.686	27.34 *	13.15
	(Rajkumar X CML446 line 46) X HS4	52.02	7.492*	-0.019	0.044	27.86 *	13.62
	(NAC6002 XCI4 line 7) X HS10	53.38	4.718	4.003**	0.161	31.22 **	16.60
	(Rajkumar X CML446 line 37) X KDMI16	54.32	8.625*	1.985	-0.788	33.53 **	18.65
Chlorophyll content at 90 DAS	(Rajkumar X CML446 line 46) X HS4	46.86	4.676	1.28	0.83	22.94	14.17
	(NAC6002 XCI4 line 7) X HS10	47.14	5.006	2.331	-0.281	23.65	14.82
	(NK6240 XCI4 line 12) X HS7	47.30	6.961*	-0.934	1.194	24.08	15.23

	(Allrounder X HS17 line 25) X HS7	48.22	7.227*	-0.285	1.194	26.48 *	17.45
	(Rajkumar X CML446 line 37) X KDMI16	49.89	7.780*	3.292*	-1.266*	30.86 *	21.52
Relative water content at 60 DAS	(Allrounder X HS17 line 34) X KDMI16	86.00	0.052	0.068**	-0.006	10.19	20.14
	(Rajkumar X CML446 line 18) X HS7	86.00	0.109	-0.004	0.006	9.55	19.44
	(G57 X NAC6002 line 17) X KDMI16	86.00	0.087	0.029	-0.006	9.55	19.44
	(Allrounder X HS17 line 34) X HS10	88.00	0.045	0.068**	0.011	11.46	21.53
	(NK6240 X HS17 line 20) X HS4	89.00	0.132*	0.015	-0.007	13.38	23.61*
Relative water content at 90 DAS	(NK6240 X CI4 line 35) X CI4	74.00	0.220*	0.002	-0.031	34.55	21.31
	(Rajkumar X CML446 line 37) X HS4	74.00	0.217*	-0.029	0.003	34.55	21.31
	(Allrounder X HS17 line 39) X HS7	78.00	0.154	0.078	-0.006	40.91	27.05
	(Rajkumar X CML446 line 1) X HS7	78.00	0.248*	-0.006	-0.006	42.73	28.69
	(Allrounder X HS17 line 21) X HS4	79.00	0.103	0.130**	0.003	42.73	28.69
Cob length (cm)	(NK6240 X CI4 line 37) X HS7	20.73	2.251	-0.183	0.867**	16.82	10.68
	(NK6240 X CI4 line 18) X HS7	20.91	2.779*	-0.531	0.867**	17.83	11.64
	(Rajkumar X CML446 line 25) X HS7	21.52	0.718	2.130**	0.867**	21.21 *	14.84
	(Rajkumar X CML446 line 18) X HS4	21.65	2.322	1.676**	-0.148	21.97 *	15.56
	(Rajkumar X CML446 line 25) X HS10	22.45	2.762*	2.130**	-0.242	26.48 **	19.83*
Cob girth (cm)	(Rajkumar X CML446 line 40) X HS7	5.12	0.342	0.116	0.038	16.82	8.94
	(NK6240 X CI4 line 35) X HS10	5.13	0.434*	0.126	0.038	8.13	9.15
	(Allrounder X HS17 line 34) X KDMI16	5.20	0.503**	0.113	-0.04	8.34	10.64
	(Allrounder X HS17 line 21) X HS10	5.22	0.530**	0.12	0.038	9.82	11.06*
	(Allrounder X HS17 line 34) X HS7	5.25	0.475*	0.113	0.038	10.24	11.70*
No. of Kernel rows/cob	(NK6240 X CI4 line 18) X CI4	17.00	1.562*	0.427	0.303*	13.33	10.86
	(NK6240 X CI4 line 35) X HS10	17.00	1.512*	0.693*	0.087	13.33	10.86
	(Rajkumar X CML446 line 40) X HS7	17.00	1.014	1.358***	-0.08	13.33	10.86
	(NAC6002 X CI4 line 7) X HS10	17.33	1.643*	0.892**	0.087	15.53 *	13.01
	(Rajkumar X CML446 line 18) X HS10	17.50	2.379**	0.326	0.087	16.67 *	14.12*
No. of Kernels/ row	(Rajkumar X CML446 line 18) X CI4	39.83	3.576	2.47	-0.107	16.60	-10.81
	(NK6240 X CI4 line 37) X HS7	40.5	6.008*	-0.163	0.759	18.54	-9.32
	(NK6240 X CI4 line 18) X HS7	40.67	4.944	1.071	0.759	19.04	-8.94
	(Rajkumar X CML446 line 25) X KDMI16	41.00	4.125	3.538**	-0.559	20.01	-8.21
	(Rajkumar X CML446 line 46) X HS4	41.67	7.816**	-0.329	0.287	21.97	-6.71
100- Grain weight (g)	(NK6240 X HS17 line 14) X HS7	31.68	4.141	0.575	0.067	26.09	13.55
	(Rajkumar X CML446 line 38) X HS4	31.75	3.719	1.042	0.102	26.41	13.84

	(NK6240 X HS17 line 22) X HS4	31.80	4.367	0.444	0.102	26.61	14.02
	(Rajkumar X CML446 line 1) X HS4	33.55	4.995*	1.556	0.102	33.54 *	20.25
	(Rajkumar X CML446 line 46) X HS4	35.52	6.743**	1.783	0.102	41.40 **	27.33*
Grain yield (kg/ha)	(Rajkumar X CML446 line 18) X CI4	6623.27	1463.763	459.743	206.217	8.80	14.49
	(NAC6002 X CI4 line 7) X HS4	6844.1	1728.082	461.243	161.233	12.43	18.31
	(Rajkumar X CML446 line 3) X HS4	7395.76	046.412*	694.573	161.233	21.49*	27.85*
	(NK6240 X CI4 line 12) X HS4	7567.42	2127.907*	784.738*	161.233	24.31*	30.81**
	(Allrounder X HS17 line 34) X HS7	7999.92	502.080**	-146.586	150.884	31.42	38.29**
Shelling%	(Allrounder X HS17 line 21) X HS4	83.64	7.504	2.853	0.162	24.37 *	19.22
	(Allrounder X HS17 line 45) X HS4	84.08	6.609	4.193	0.162	25.04 *	19.86
	(NK6240 X CI4 line 35) X HS7	84.99	7.651	4.507*	-0.289	26.38 *	21.15*
	(NK6240 X CI4 line 35) X HS10	85.59	7.476	4.507*	0.491	27.28 *	22.01*
	(Rajkumar X CML446 line 46) X KDMI16	86.27	10.309*	2.539	0.306	28.29 **	22.98*

* & ** - Significant at 0.05 and 0.01 level of probability, respectively

Table 3: Top five hybrids based on mean performance and their SCA effects, standard heterosis and GCA status of parents for 12 traits in maize under stress situation

Characters	Cross combination	Mean	SCA effects	GCA effects		Standard heterosis over NK6240	Standard heterosis over Rajkumar
				Female	Male		
Anthesis to silking interval	(Allrounder X HS17 line 25) X HS7	1.00	-0.92	-0.33	-0.18	-71.43 *	-60.00
	(Allrounder X HS17 line 34) X CI4	1.00	-1.137	-0.43	0.137	-71.43 *	-60.00
	(Allrounder X HS17 line 39) X HS10	1.00	-0.903	-0.53	0.003	-71.43 *	-60.00
	(NK6240 X CI4 line 12) X CI4	1.00	-2.137 *	0.57	0.137	-71.43 *	-60.00
	(NK6240 X HS17 line 10) X HS10	1.00	-1.103	-0.33	0.003	-71.43 *	-60.00
Chlorophyll content at 60 DAS	(NK6240 X HS17 line 5) X HS7	46.67	3.279	2.337	0.06	14.91	6.42
	(Rajkumar X CML446 line 40) X HS7	47.12	5.302	0.769	0.06	16.03	7.46
	(NK6240 X HS17 line 22) X HS4	47.22	2.48	2.135	1.611 **	16.26	7.67
	(Allrounder X HS17 line 34) X HS4	47.57	3.161	1.804	1.611 **	17.13	8.47
	(G57 X NAC6002 line 17) X HS4	48.01	4.912	0.503	1.611 **	18.23	9.50
Chlorophyll content at 90 DAS	(Allrounder X HS17 line 45) X HS7	34.40	5.193	2.492	-0.479	8.88	9.90
	(NK6240 X CI4 line 12) X CI4	34.77	5.018	2.676	-0.123	10.03	11.07
	(Parbhat X CI4 line 5) X HS4	35.60	1.989	6.103 **	0.314	12.68	13.74
	(Parbhat x CI4 line 5) X KDMI16	36.25	3.07	6.103 **	-0.117	14.73	15.81
	(NK6240 X HS17 line 10) X HS7	36.72	8.084 *	1.916	-0.479	16.21	17.30
Relative water content at 60 DAS	(NK6240 X CI4 line 35) X HS7	88.00	0.074	0.048	0.011	14.29	16.56
	(Rajkumar X CML446 line 1) X HS4	88.00	0.054	0.075 **	0.004	14.29	16.56
	(Rajkumar X CML446 line 8) X HS7	88.00	0.076	0.046	0.011	14.29	16.56
	(Rajkumar X CML446 line 25) X HS7	88.00	0.09	0.027	0.011	13.64	15.89

	(Allrounder X HS17 line 45) X CI4	90.00	0.161 *	-0.009	0.001	16.88	19.21
Relative water content at 90 DAS	(NK6240 X HS17 line 20) X HS4	67.00	0.076	0.057	0.00	19.64	9.84
	(Allrounder X HS17 line 21) X HS4	69.00	0.085	0.063	0.00	22.32	12.30
	(Allrounder X HS17 line 34) X HS4	69.00	0.081	0.072 *	0.00	23.21	13.11
	(Allrounder X HS17 line 34) X KDMI16	69.00	0.09	0.072 *	-0.009	23.21	13.11
	(NK6240 X CI4 line 42) X HS7	71.00	0.126	0.006	0.036 **	25.89	15.57
	(NK6240 X CI4 line 12) X HS7	19.27	1.664	1.406 *	0.439	23.89 *	25.92 *
Cob length (cm)	(NK6240 X HS17 line 22) X KDMI16	19.40	2.629 *	1.453 *	-0.433	24.79 *	26.83 *
	(Parbhat X CI4 line 5) X HS4	19.50	3.069 *	0.489	0.186	25.40 *	27.45 *
	(NK6240 X CI4 line 12) X CI4	19.60	2.225	1.406 *	0.213	26.05 *	28.10 *
	(Rajkumar X CML446 line 3) X HS4	22.75	4.930 **	1.878 **	0.186	46.30 **	48.69 **
Cob girth (cm)	(Allrounder X HS17 line 25) X HS10	4.63	0.204	0.244 *	-0.015	9.59	13.90
	(Rajkumar X CML446 line 18) X HS4	4.66	0.292	0.172	0.003	10.41	14.76
	(G57 X NAC6002 line 25) X HS7	4.73	0.361	0.121	0.05	11.95	16.36 *
	(NK6240 X HS17 line 14) X HS7	4.80	0.352	0.200 *	0.05	13.61	18.08 *
	(NK6240 X HS17 line 22) X KDMI16	4.89	0.607 **	0.146	-0.056	15.86 *	20.42 **
No. of Kernel rows/cob	(G57 X NAC6002 line 25) X HS7	17.33	2.117 *	0.920 *	-0.453 **	22.21 *	15.53
	(Rajkumar X CML446 line 3) X HS4	17.34	2.849 **	-0.466	0.206	22.25 *	15.57
	(Allrounder X HS17 line 21) X HS10	17.66	3.251 **	-0.479	0.147	24.58 **	17.77 *
	(Rajkumar X CML446 line 38) X CI4	17.66	1.461	1.187 **	0.271	24.58 **	17.77 *
	(NK6240 X CI4 line 37) X KDMI16	17.67	2.308 **	0.787 *	-0.171	24.61 **	17.80 *
No. of Kernels/ row	(Rajkumar X CML446 line 37) X HS7	35.50	3.149	2.395	0.417	12.90	13.29
	(NK6240 X HS17 line 22) X KDMI16	37.50	4.668	3.526 **	-0.233	19.26	19.67
	(Rajkumar X CML446 line 3) X HS4	37.50	4.743	3.428 **	-0.21	19.26	19.67
	(Rajkumar X CML446 line 18) X CI4	37.50	4.766	2.928 *	0.267	19.26	19.67
	(NK6240 X CI4 line 12) X CI4	38.33	4.969	3.560 **	0.267	21.91	22.34
100- Grain weight (g)	(Allrounder X HS17 line 39) X CI4	22.34	4.465 *	-0.282	-0.195	17.31	39.64 *
	(NK6240 X CI4 line 12) X HS7	22.55	1.299	2.335 *	0.569	18.43	40.98 *
	(NK6240 X HS17 line 14) X HS7	22.92	2.443	1.561	0.569	20.38	43.29 *
	(Rajkumar X CML446 line 46) X HS10	23.91	5.400 *	0.384	-0.221	25.58	49.48 *
	(NK6240 X CI4 line 37) X KDMI16	25.83	5.382 *	2.156 *	-0.055	35.66 *	61.49 **
Grain yield (kg/ha)	(Rajkumar X CML446 line 18) X HS7	4010.79	906.016	515.05	261.302 *	31.57*	42.69**
	(Rajkumar X CML446 line 46) X HS4	4011.63	1242.208	367.052	73.944	31.60*	42.72**
	(Allrounder X HS17 line 34) X HS7	4077.46	1853.845 **	-	366.109	261.302 *	33.76*
	(NK6240 X HS17 line 14) X HS7	4153.3	1363.851 *	199.72	261.302 *	36.25**	47.76**
	(Allrounder X HS17 line 45) X HS10	4393.29	2200.558 **	103.22	-238.915 *	44.12**	56.30**
	(Allrounder X HS17 line 34) X HS4	77.30	8.144	-1.676	0.372	20.06	9.27

(G57 X NAC6002 line 25) X KDMI16	77.31	5.49	2.133	-0.773	20.07	9.28
(NK6240 X HS17 line 14) X HS7	78.42	5.324	1.335	1.296	21.79 *	10.84
(NK6240 X CI4 line 35) X HS10	78.66	7.423	1.535	-0.758	22.17 *	11.19
(Rajkumar X CML446 line 25) X HS10	78.66	4.379	4.579 *	-0.758	22.17 *	11.19

* & ** - Significant at 0.05 and 0.01 level of probability, respectively

26 hybrid combinations were found to be inferior with negative score for SCA effects across traits under non-stress. 79 hybrid combinations scored zero under nonstress, 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 16). The study revealed that hybrids with high SCA effects involved at least one or two of the several higher general combiners as parent. Gama *et al.* (1995), Kadams *et al.* (1999) [36] Asif *et al.* (2007) [9], Kuchanur (2010) [32], Premalatha and Kalamani (2010) [10], Aminu and Izge (2013) [11] and Praveen Kumar *et al.* (2014) [34] reported similar result where a hybrid with high SCA effects involved one or both of the good general combiners as parents. Specific combining ability effects of selected triats. The results of these triats presented in (Table 2). Under non stress situation, for anthesis to silking interval the hybrid viz. (Rajkumar × CML446 Inberdline 18) × HS7 exhibited significant SCA effect in negative direction. Whereas, under stress situation, the hybrids viz. (Rajkumar × CML446 Inberdline 40) × KDMI16 and (NK6240 × CIInberdline 12) × CI exhibited significant SCA effects in negative direction. Negativity of these traits is important, implying that these hybrids could mature earlier and could eSCAPE drought. Similar results were reported by Bello and Olaoye (2009) [37], Kuchanur (2010) [32] and Aminu and Izge (2013) [11]. Under non stress situation, for grain yield per plant the hybrids viz. (NK6240 × CI Inberdline 37) × HS7 and (Rajkumar × CML446 Inberdline 38) × HS7 (Rajkumar × CML446 Inberdline 18) × HS and (NK6240 × HS17 Inberdline 14) × HS7 exhibited significant SCA effects in positive direction,

These are good hybrids when breeding for drought stress and grain yield. These hybrids probably have potential as parents of hybrid varieties, as well as for inclusion in breeding programmes, since they may contribute superior alleles in new populations for high grain yield and other abiotic stresses in maize production especially in areas where low rainfall. These results are in line with earlier independent studies of Perez-Velasquez *et al.* (1996) [38], Kumar *et al.* (1998) and Joshi *et al.* (1998) who reported that maize grain yield and flowering traits were under the control of non-additive (SCA effects) type of gene action. Similar results were reported by Asif *et al.* (2007) [9], Kuchanur (2010) [32], Premalatha and Kalamani (2010) [10] and Aminu and Izge (2013) [11].

Drought susceptibility index (DSI) among 150 hybrids along with 35 parents and checks (Allrounder × HS17 inbredline 39) × CI4 (0.04) lowest DSI values for grain yield (kg/ ha).

It is conclud that under non stress situation, Three hybrids exhibited significant SCA effects with a superior mean performance for grain yield (kg/ha) viz. (Rajkumar × CML446 Inberdline 3) × HS4 (NK6240 × CIInberdline 12) × HS and (Allrounder × HS17 Inberdline 34) × HS7. These three hybrids need to be further evaluated in large SCA trials before these are identified for commercial cultivation.

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