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Research Article

Heterosis and combining ability studies for yield and its component traits in Maize (*Zea mays* L.)

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Abstract

Heterosis and combining ability was studied in F_1 hybrids of maize with respect to grain yield and yield attributing traits using twenty-two hybrids which were developed through Line × Tester mating design. The parents and their hybrids were subjected to assess the combining ability and nature of gene action governing the quantitative traits. The results inferred that the predominance of non-additive gene action was observed for all the traits. Among the parents, the overall study of *gca* effects suggested that parent UMI 1200-7-26-1-6-1, N 14, N 107 and N 285 were significant general combiner for yield, these can be used to improve hybrids with desirable traits in future. Significant positive SCA effects were found for all the studied traits. Among the hybrids, N 14 × UMI 1200-7-26-1-6-1 showed desirable standard heterosis percentage over the checks CO 6 and NK 6240 along with good *sca* effects and per se performance for grain yield and other important yield contributing traits over different locations thus it can be used for commercial seed production programme.

Keywords

GCA; SCA; standard heterosis; Grain yield

Introduction

Maize *(Zea mays* L.) is a cereal crop which is cultivated widely throughout the world and has the highest production among all the cereals. The worldwide production of maize was 861 million tonnes in 2015-16. In India, maize is the third most important cereal crop after rice and wheat. It is cultivated in an area of 8.69 million hectares, with a production of 21.81 million tonnes and productivity of 2509 kg ha-1. Hybrids including inbred lines have reformed maize production in many countries. (Shull, 1909) was the first to report augmented yields from F_1 hybrids between inbred lines and drew the method of hybrid breeding. The progress of inbred lines generating superior hybrids have become more effectual as the use of recurrent selection increased. Combining ability analysis helps in identifying the parents, and these parents can be used for hybridization program in order to produce superior hybrids. As a general rule, general

combining ability (GCA) is the result of additive gene effects, while the specific combining ability (SCA) is the result of non-allelic interactions (Jinks, 1954). The estimate of combining ability is useful to predict the relative performance of different lines in hybrid combinations. The information on the nature and magnitude of gene action is important in understanding the genetic potential of a population and deciding the breeding procedure to be adopted in a given population. As the L × T mating design suggested by Kempthrone (1957) is the reliable method for identifying parents and hybrids which are superior based on *gca* and *sca* respectively which also provides the nature of genes involved for expression of desirable traits. Information on the heterotic patterns and combining ability among maize germplasm is essential in maximizing the

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effectiveness of hybrid development (Beck *et al.*, 1990).

In maize, appreciable percentage of heterosis for yield and combining ability were studied by several workers like, highest positive significant sca effects (48.60) along good per se performance (151.67 g/plant) and positive significant economic heterosis (26.39 per cent) for grain yield per plant for hybrid P1 x P5 observed by (Dhoot *et al.*, 2017). For grain yield 52.78 per cent of standard heterosis was observed by (Azad *et al.*, 2014). The exploitation of heterosis in maize helps in developing high yielding hybrids and it depends on the direction and magnitude of heterosis and the type of gene action involved in it. Assessment of the stability of a genotype over different locations is useful for recommending hybrids for commercial seed programme. In this background, the present study was carried out to identify the nature of gene action, evaluation of enviable parents for hybridization and performance of hybrids over their parent in maize, with a view of exploitation of good hybrids with high heterotic value. Thus, a study was undertaken to estimate the nature and magnitude of gene action and to explore suitable heterotic hybrid combinations.

Materials and Methods

Thirteen genotypes of maize were studied in this experiment. Thirteen genotypes comprised of eleven elite inbreds used as lines viz., N 5, N 14, N 27, N 42, N 66, N 90, N 94, N 104, N 107, N 117 and N 285 which were developed at Department of Millets, Centre of Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore and two high beta carotene inbred lines used as Testers viz., UMI 1200-7-26-1-6-1 and UMI 1230-2-70-9-6-1-1 which were developed by Department of Biotechnology, Agricultural College and Research Institute, Madurai. These parents were crossed in a Line × Tester mating design in *kharif* 2017 at Agricultural Research Station, Bhavanisagar, Tamil Nadu Agricultural University. The pure seeds of eleven inbred lines and two testers were raised at Agricultural Research Station, Bhavanisagar, Tamil Nadu Agricultural University during, *kharif* 2017 season in three-meter rows with spacing of 60 cm between rows and 25 cm between the plant to plant in two staggered sowings in order to achieve synchrony in flowering and complete the programmed hybridization.

Standard agronomical and plant protection practices were applied to attain healthy maize crop. The hybridization programme consists of silking, tasseling and hand pollination. Tassel bag method was used for hybridization. Silking was done as and when ear shoot of maize emerging from leaf sheath and before silk emergence, by covering white transparent butter paper called silk bag to avoid undesirable cross pollination. The tasseling was carried out by covering tassel with kraft bag cover known as tassel bag as and when tassels fully emerges out and ready to anther dehiscence in central axis of tassel on the previous day of pollination to collect pollen. On the next day morning between 7 to 9 A.M the pollens were collected by shaking the tassel bag and pollinate silks of respective female inbred line by dusting pollen on silks. The silks were again covered by kraft cover fastened with stapler to prevent foreign pollen cross pollination. Simultaneously, parental lines were selfed to acquire the parental seeds (www.agritech.tnau.ac.in).

Randomized Block Design (RBD) was followed for conducting the experiment with two replications. Seeds were sown in two rows of three meters length. The total entries were 37 which included thirteen parents (eleven lines and two testers), 2 single cross hybrids and two checks (CO 6 and NK 6240). The row to row and plant to plant spacing given was 60 and 25 cm respectively. All the agronomic and plant protection practices applicable for maize crop were adopted as per crop production guide. The observations were recorded individually on five randomly selected plants and hybrids in each replication. The observation comprised of sixteen characters viz., days to 50% tasseling, days to 50% silking, plant height (cm), leaf length (cm), leaf width (cm), length to first cob (cm), tassel length (cm), number of branches per tassel, cob length (cm), cob girth (cm), cob weight (g), number of kernel rows per cob, number of kernels per row, 100 grain weight, grain yield per plant (g) and shelling percentage (%). The replication wise mean values were subjected to the analysis of variance for line Line × Tester interaction.

It was observed that variance in hybrids were significant for all the characters studied (Kempthorne, 1957).

Results and Discussion

The analysis of variance for all the yield and yield component traits studied are presented in Table 1. Variance due to parents was highly significant for all the traits studied, indicating good amount of genetic differences among the parents. The presence of variability among the genotypes for character of interest helps us to select the best hybrid combination. Analysis of variance revealed that 13 parents selected for this study showed highly significant differences among themselves. While partitioning of variances among the hybrids into different components viz., lines, hybrids were significant for all the characters studied.

The knowledge of additive and non-additive gene action is essential to plant a breeder which is useful for the development of an efficient plant breeding programme. The combining ability analysis enables the partitioning of genotypic variation of the hybrids into variation due to general combining ability (main effects) and specific combining ability (interaction effects). Earlier workers suggested that, if additive genetic variation is greater, then the chance of fixing superior genotype in early segregating generations would be greater. If dominant and epistatic interactions are predominant, the selection should be postponed to later generations. It is expressed as a ratio between GCA and SCA. If GCA is greater, it indicates the preponderance of additive gene action and if SCA is greater it implies the non-additive gene action which arises largely due to dominance and epistatic interactions.

In the genotypes studied the ratio of components revealed that the SCA variance was higher than GCA variance for all the characters indicating higher proportion of non-additive genes (Table 2). Similar results were reported for days to 50% tasseling, days to 50% silking, plant height, leaf length, leaf width, length to first cob, tassel length, number of branches per tassel, cob length, cob girth, cob weight, number of kernel rows per cob, number of kernels per row, 100 grain weight, grain yield per plant and shelling percentage by (Abrha *et al.*, 2013; Kanagarasu *et al.*, 2010; Premalatha, 2006; Purushottam and Shanthakumar, 2017) and (Saripalli and Mruthumjaya, 2017).

The estimates of GCA effects showed that there was a significant different among parents revealing general combiner for all the traits in desired direction (Table 3). As the significant GCA effects indicates the good combiner among the parents. The estimates of GCA effects showed that the parents UMI 1230-2-70-9-6-1 between the two testers and N 14, N 42, N 104, N 107 and N 285 among the lines possessed highly significant positive GCA effects for grain yield per plant indicating the presence of additive gene action. Also, the parents N 14, N 27 and N 107 exhibited desirable significant GCA effects for 100 grain weight; UMI 1200-7-26-1-6-1, N 14, N 42, N 66, N 90 and N 285 for shelling percentage; UMI 1230-2-70-9-6-1, N 42, N 104 for number of kernels per row; UMI 1230-2-70-9-6-1, N 42 and N 104 for number of kernel rows per cob; UMI 1230-2-70-9-6-1, N 14, N 42, N 94, N 104, N 107, N 117 and N 285 for cob weight; UMI 1200-7-26-1-6-1, N 42, N 94, N 104 and N 117 for cob girth; UMI 1230-2-70-9-6-1, N 42, N 104, N 107 and N 285 for cob length; N 14, N 27, N 94, N 104, N 117 and N 285 for number of branches per tassel; UMI 1230-2-70-9-6-1, N 90, N 104, N 107 and N 285 for length to first cob; UMI 1200-7-26-1-6-1, N 66, N 94, N 104 and N 107 for leaf width; UMI 1230-2-70-9-6-1, N 42, N 66, N 94, N 107 and N 285 for leaf length recorded significant positive GCA effects. Similarly, for days to 50% tasseling negative GCA effects were possessed by UMI 1200-7-26-1-6-1, N 14, N 90, N 117 and N 285 and for days to 50% silking MI 1200-7-26-1-6-1, N 14, N 117 and N 285 exhibited negative GCA effects. These parents can be used in further breeding programs in maize, similar findings in maize was reported by (Hosana *et al.*, 2015) and (Matin *et al.*, 2016). It is evident that the tester UMI 1230-2-70-9-6-1 and lines N 90, N 94 and N 107 adjudged as the best combiners for plant height and yield relating traits like cob length, cob weight and cob girth, these might be utilized as potential parents since they possessed high *per se* performance with significant *gca* effects for the respective traits. These results indicated that there is a scope for improving combining ability of parents for attributing traits. The best general combiner for grain yield per plant was, UMI 1200-7-26-1-6-1, N 14, N 107 and N 285.

Specific combining ability is the indicative of heterosis for the evaluation of hybrids (Table 4). The SCA was due to non-additive gene interactions (Sprague and Tatum, 1942). Out of 22 hybrids for days to 50% tasseling and days to 50% silking only one cross N 117 × UMI 1200-7-26-1-6-1 recorded highly significant SCA effects. High positive significant SCA effects were exhibited by N 5 × UMI 1200-7-26-1-6-1, N 14 × UMI 1200-7-26-1-6-1, N 27 × UMI 1200-7-26-1-6-1, N 104 × UMI 1200-7-26-1-6-1, N 117 × UMI 1200-7-26-1-6-1, N 285 × UMI 1200-7-26-1-6-1, N 42 × UMI 1230-2-70-9-6-1, N 66 × UMI 1230-2-70-9-6-1, N 90 × UMI 1230-2-70-9-6-1 and N 94 × UMI 1230-2-70-9-6-1 for leaf length and plant height. High significant and positive SCA effects were exhibited by 6 hybrids each for leaf width and number of branches per tassel. For length

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to first cob, the crosses N 27 × UMI 1200-7-26-1-6-1, N 94 × UMI 1200-7-26-1-6-1, N 104 × UMI 1200-7-26-1-6-1, N 117 × UMI 1200-7-26-1-6-1, N 285 × UMI 1200-7-26-1-6-1, N 42 × UMI 1230-2-70-9-6-1 and N 90 × UMI 1230-2-70-9-6-1 exhibited significant positive SCA effects.

High positive significant SCA effects were exhibited by crosses N 5 × UMI 1200-7-26-1-6-1, N 27 × UMI 1200-7-26-1-6-1, N 66 × UMI 1200-7-26-1-6-1, N 117 × UMI 1200-7-26-1-6-1, N 285 × UMI 1200-7-26-1-6-1, N 94 × UMI 1230-2-70-9-6-1, N 104 × UMI 1230-2-70-9-6-1 and N 107 × UMI 1230-2-70-9-6-1 for tassel length. For cob length the crosses N 285 × UMI 1200-7-26-1-6-1, N 5 × UMI 1230-2-70-9-6-1, N 14 × UMI 1230-2-70-9-6-1 and N 90 × UMI 1230-2-70-9-6-1 and for cob girth the crosses N 66 × UMI 1200-7-26-1-6-1, N 107 × UMI 1200-7-26-1-6-1 and N 5 × UMI 1230-2-70-9-6-1 possessed significant positive SCA effects. The crosses N 107 × UMI 1200-7-26-1-6-1, N 5 × UMI 1230-2-70-9-6-1, N 27 × UMI 1230-2-70-9-6-1 and N 117 × UMI 1230-2-70-9-6-1 exhibited significant positive SCA effects for number of kernel rows/ cob.

For cob weight, the crosses N 14 × UMI 1200-7-26-1-6-1, N 66 × UMI 1200-7-26-1-6-1, N 94 × UMI 1200-7-26-1-6-1, N 104 × UMI 1200-7-26-1-6-1, N 107 × UMI 1200-7-26-1-6-1, N 117 × UMI 1200-7-26-1-6-1, N 14 × UMI 1200-7-26-1-6-1, N 285 × UMI 1200-7-26-1-6-1, N 5 × UMI 1230-2-70-9-6-1, N 27 × UMI 1230-2-70-9-6-1, N 42 × UMI 1230-2-70-9-6-1 and N 104 × UMI 1230-2-70-9-6-1 exhibited positive significant SCA effects. It was important to note the predominant involvement of non-additive gene action for good specific combining ability status in the inheritance of this trait. These were reported as good specific combiners for these traits. (Sulaiman and Hussain, 2011) and (Saripalli *et al.*, 2017). The crosses N 66 × UMI 1200-7-26-1-6-1, N 107 × UMI 1200-7-26-1-6-1, N 117 × UMI 1200-7-26-1-6-1, N 285 × UMI 1200-7-26-1-6-1, N 5 × UMI 1230-2-70-9-6-1, N 90 × UMI 1230-2-70-9-6-1, N 104 × UMI 1230-2-70-9-6-1 showed significant positive SCA effects for number of kernels per row.

The crosses N 14 × UMI 1200-7-26-1-6-1, N 66 × UMI 1200-7-26-1-6-1, N 90 × UMI 1200-7-26-1-6-1, N 94 × UMI 1200-7-26-1-6-1, N 117 × UMI 1200-7-26-1-6-1, N 27 × UMI 1230-2-70-9-6-1, N 42 × UMI 1230-2-70-9-6-1 , N 104 × UMI 1230-2-70-9-6-1 and N 107 × UMI 1230-2-70-9-6-1 for shelling percentage and similarly the two crosses N 14 × UMI 1200-7-26-1-6-1 and N 107 × UMI 1230-2-70-9-6-1 exhibited significant positive SCA effects for 100 grain weight. The significant positive SCA effects for number of kernels per row and 100 grain weight are more frequently associated with significant estimates of SCA effects of grain yield. The positive relationship of SCA effect of grain yield and yield attributed characters were observed by (Alam *et al.*, 2008) and (Ivy and Howlader, 2000).

The hybrids N 14 × UMI 1200-7-26-1-6-1, N 66 × UMI 1200-7-26-1-6-1, N 94 × UMI 1200-7-26-1-6-1, N 117 × UMI 1200-7-26-1-6-1, N 285 × UMI 1200-7-26-1-6-1, N 5 × UMI 1230-2-70-9-6-1, N 27 × UMI 1230-2-70-9-6-1, N 42 × UMI 1230-2-70-9-6-1, N 90 × UMI 1230-2-70-9-6-1, N 104 × UMI 1230-2-70-9-6-1 and N 107 × UMI 1230-2-70-9-6-1 recorded significant positive SCA effects for grain yield per plant. The grain yield was predominantly controlled by non-additive gene action (dominance and epistasis). This result is in agreement with those of (Kage *et al.*, 2013; Premalatha, 2006) and (Shakeel *et al.*, 2012). These hybrids could be used in heterosis breeding to exploit hybrid vigour for grain yield.

The percent standard heterosis expressed by the F_1 hybrids over the commercial hybrid check varieties CO 6 and NK 6240, for yield and different yield contributing characters. The degree of heterosis in F1 hybrids varied from character to character or from cross to cross. The possibility of getting better hybrids with desirable yield component trait was explored using potential hybrids. Negative heterosis is considered as desirable for days to 50% tasseling and silking for development of hybrids with early duration. The standard heterosis expressed by F_1 hybrids over the standard checks viz. CO 6 and NK 6240 for different characters are presented.

The extent of heterosis depends on the magnitude on non-additive gene action and wide genetic diversity among parents. When compared to commercial hybrids CO 6 and NK 6240 as checks, 18 hybrids showed significantly positive heterosis for days to 50% tasseling ranged from 0.99% to 10.89% over CO 6 and NK 6240. For days to 50% silking significant positive heterosis ranged from 2.86% to 11.43% over CO 6 and 0.93% to 9.35% over NK 6240. None of the hybrids exhibited negative heterosis. Maize growing areas in south India prefers mid to late duration hybrids and hence the hybrids with positive heterosis for days to 50% tasseling and days to 50% silking will not be a problem for

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commercial hybrid programme. Among 22 hybrids studied, five hybrids ranged from -29.69% to 15.80% and fifteen hybrids with range -15.87% to 38.56% showed significant positive heterosis over the check CO 6 and NK 6240 respectively for plant height. For leaf length 12 hybrids showed positive heterosis over CO 6 (Table 5).

Twelve hybrids recorded significant positive standard heterosis for leaf length over COH(M) 6 varied between -22.91% (N 90 × UMI 1200-7-26-1-6-1) to 37.9% (N 94 × UMI1230-2-70-9-6-1). Whereas, over NK 6240 15 hybrids registered positive heterosis and ranged from -18.69% (N 90 × UMI 1200-7-26-1-6-1) to 45.44% (N 94 × UMI 1230-2-70-9-6-1). For leaf width out of 22 hybrids evaluated for standard heterosis, 13 hybrids each recorded significant positive standard heterosis range between -8.82% (N 42 × UMI 1200-7-26-1-6-1) to 27.63 (N 94 × UMI1230-2-70-9-6-1) over COH(M) 6 and in case of standard check NK 6240 it varied between -7.46 (N 42 × UMI 1200-7-26-1-6-1) to 29.33% (N 94 × UMI1230-2-70-9-6-1). For length to first cob, the heterosis of hybrids over standard check COH(M) 6 ranged from -51.60% (N 42 × UMI 1200-7-26-1-6-1) to 15.6% (N 94 × UMI1230-2-70-9-6-1) only one hybrid showed positive heterosis of 15.6% and in case of NK 6240, standard heterosis ranged from -47.16% (N 42 × UMI 1200-7-26-1-6-1) to 26.20% (N 94 × UMI1230-2-70-9-6-1) and 3 hybrids viz., N 285 × UMI 1200-7-26-1-6-1, N 107 × UMI 1230-2-70-9-6-1 and N 94 × UMI 1230-2-70-9-6-1 showed positive heterosis with 6.99%, 8.15% and 26.20% respectively.

For tassel length 13 hybrids recorded significant positive standard heterosis over COH(M) 6 and 15 hybrids recorded positive heterosis over NK 6240. The variation in standard heterosis for tassel length ranged from -8.41% (N 104 × UMI 1200-7-26-1-6-1) to 65.19% (N 94 × UMI 1230-2-70-9-6-1) and -7.34% to 71.25% over COH(M) 6 and NK 6240 respectively. A total of twelve hybrids registered significant positive heterosis over the check COH(M) 6 and highest and lowest value was recorded by the hybrids N 42 × UMI 1200-7-26-1-6-1 (-35.42%) and N 285 × UMI 1200-7-26-1-6-1 (28.12%) for number of branches per tassel. In case of NK 6240, 14 hybrids registered standard heterosis ranging from -27.06% to 44.71%. For cob length sixteen out of 22 hybrids sixteen recorded significant positive standard heterosis. The range of standard heterosis was from -11.15% (N 5 × UMI 1200-7-26-1-6-1) to 26.63% (N 90 × UMI 1230-2-70-9-6-1) and standard heterosis varied between -24.6% to 7.47% over NK 6240 and none of the hybrids expressed positive heterosis over it. For cob girth, out of 22 hybrids, 7 hybrids have recorded significant standard heterosis in positive direction over COH(M) 6 and the range was from -10.05% (N 285 × UMI 1230-2-70-9-6-1) to 10.96% (N 42 × UMI 1200-7-26-1-6-1). Thirteen hybrids over NK 6240 exhibited positive heterosis with a range of -2.65% to 20.09 %. For cob weight out of 22 hybrids studied, over COH(M) 6 three hybrids *viz.*, N 14 × UMI 1200-7-26-1-6-1, N 42 × UMI 1230-2-70-9-6-1 and N 104 × UMI 1230-2-70-9-6-1. showed significant positive heterosis with 19.83%, 1.87% and 11.54 % respectively. Fourteen hybrids recorded significant standard heterosis over NK 6240 and the maximum and minimum value of -27.88% and 52.79% were recorded by N 27 × UMI 1200-7-26-1-6-1 and N 14 × UMI 1200-7-26-1-6-1 respectively.

In case of number of kernel rows per cob 3 hybrids showed positive heterosis over COH(M) 6 and it ranged from -18.3% (N 107 × UMI 1230-2-70-9-6-1) to 17.97% (N 104 × UMI 1200-7-26-1-6-1). Whereas in NK 6240, 20 hybrids showed positive heterosis with range of 3.31% to 49.17%. Out of 22 hybrids for number of number of kernels per row 15 hybrids recorded significant standard positive heterosis with a range from -9.19% (N 5 × UMI 1200-7-26-1-6-1 to 39.68% (N 107 × UMI 1200-7-26-1-6-1) over COH(M) 6 and standard heterotic value ranged from -30.86% to 6.35% over NK 6240 with none of the hybrids proved their superiority by having standard heterosis.

For shelling percentage, 6 hybrids each exhibited standard positive heterosis. The heterotic value ranged from -16.47% to 6.5% over COH(M) 6 and -15.93% (N 104 × UMI 1200-7-26-1-6-1) to 7.19% (N 90 × UMI 1230-2-70-9-6-1) over NK 6240. For 100 grain weight, none of the hybrids exploited positive heterosis over COH(M) 6 but it showed negative heterosis ranged from -35.3% (N 90 × UMI 1230-2-70-9-6-1) to -1.12% (N 107 × UMI 1230-2-70-9-6-1) over COH(M) 6. In case of NK 6240, the heterosis ranged from -22.9% to 17.83% and only one hybrid exhibited significant positive heterosis. Concordance results are reported by several workers of (Devi *et al.*, 2007; Immanuel *et al.*, 2006; Shukla *et al.*, 2016; Singh *et al.*, 2010 and Sharma *et al.*, 2017). Out of 22 hybrids three hybrids manifested positive standard heterosis over COH(M) 6 for grain yield and the increase ranged from -55.4% to 26.73%

and seven hybrids were having positive standard heterosis over NK 6240 with the range from -46.85% (N 5 × UMI 1200-7-26-1-6- to 51.01% (N 14 × UMI 1200-7-26-1-6-1) and in corroborated with the results of Premalatha, (2006); and Talukder *et al.*, (2016) over checks.

Among the hybrids, the hybrid N 14 × UMI 1200-7-26-1-6-1 manifested significant high SCA effects coupled with excellent heterosis and *per se* performance and showed stability over the locations as it was in corroboration with the previous investigation undertaken at Agricultural Research station, Vaigai Dam, TNAU, Coimbatore by (Bharathi, 2017).

In summary, it is concluded that the parents, UMI 1200-7-26-1-6-1, N 14, N 107 and N 285 showed good general combining ability and the hybrid N 14 × UMI 1200-7-26-1-6-1 showed desirable standard heterosis percentage along with good *sca* effects and per se performance for grain yield and other important yield contributing traits over different locations. Therefore, this hybrid can be commercially exploited for seed production programme.

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Table 1. Analysis of variance for different morphological traits

Source	Df	Mean sum of squares															
		DFT	DFS	PHT	LLT	LWD	LFC	TSL	BPT	CLT	CGT	CWT	NKR	KPR	HGW	GYP	SHP
Replication	1	0.51	2.80	1.15	0.26	0.0001	0.0006	0.25	0.0023	1.23	0.13	2.84	0.69	0.37	0.85	2.12	5.57
Genotype	34	15.54**	14.45**	2248.46**	372.09**	2.51**	316.16**	92.92**	4.69**	8.82**	7.03**	3690.16**	5.53**	37.03**	81.95**	2030.10**	71.89**
Error	34	0.24	0.24	1.05	3.51	0.02	2.54	0.38	0.10	0.23	0.23	1.49	0.21	2.99	22.30	1.68	1.83

*and** indicates significance at 5% and 1 % level respectively, Df= degrees of freedom, DFT= Days to 50 per cent tasseling, DFS= Days to 50 per cent silking, PHT= Plant height (cm), LLT= Leaf length (cm), LWD= Leaf width (cm), LFC= Length to first cob (cm), TSL= Tassel length (cm), BPT= Number of branches per tassel, CLT= Cob length (cm), CGT= Cob girth (cm), CWT= Cob weight (g), NKR= Number of kernel rows per cob, KPR= Number of kernels per row, HGW= 100 grain weight (g), GYP= Grain yield per plant (g) and SHP= Shelling percentage (%).

Table 2. Magnitude of genetic variance for different traits

Sl. No.	Characters	GCA variance	SCA variance	σ^2A	σ^2D	σ^2 A / σ^2D
1.	DFT	0.06	0.70	0.12	0.70	0.171
2.	DFS	0.05	0.44	0.1	0.44	0.227
3.	PHT	2.71	646.38	5.42	646.38	0.008
4.	LLT	1.96	94.00	3.92	94.00	0.042
5.	LWD	0.02	0.30	0.04	0.30	0.133
6.	LFC	1.06	86.58	2.12	86.58	0.024
7.	TSL	0.47	22.89	0.94	22.89	0.041
8.	BPT	0.03	1.67	0.06	1.67	0.036
9.	CLT	0.06	0.68	0.12	0.68	0.176
10.	CGT	0.03	0.24	0.06	0.24	0.250
11.	CWT	5.64	665.51	11.28	665.51	0.017
12.	NKR	0.006	2.11	0.012	2.11	0.006
13.	KPR	0.23	4.56	0.46	4.56	0.101
14.	HGW	0.60	36.72	1.2	36.72	0.033
15.	GYP	3.00	513.21	6	513.21	0.012
16.	SHP	0.45	22.91	0.9	22.91	0.039

GCA= General Combining Ability, SCA= Specific Combining Ability, σ^2 A = Additive genetic variance, σ^2 D= Dominant component, DFT= Days to 50 per cent tasseling, DFS= Days to 50 per cent silking, PHT= Plant height (cm), LLT= Leaf length (cm), LWD= Leaf width (cm), LFC= Length to first cob (cm), TSL= Tassel length (cm), BPT= Number of branches per tassel, CLT= Cob length (cm), CGT= Cob girth (cm), CWT= Cob weight (g), NKR= Number of kernel rows per cob, KPR= Number of kernels per row, HGW= 100 grain weight (g), GYP= Grain yield per plant (g) and SHP= Shelling percentage (%).

Electronic Journal of Plant Breeding, 9 (3) : 1012 - 1023 (Sep 2018) DOI: 10.5958/0975-928X.2018.00126.6
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Table 3. The *gca* effects of parents for different traits

PARENTS	DFT	DFS	PHT	LLT	LWD	LFC	TSL	BPT	CLT	CGT	CWT	NKR	KPR	HGW	GYP	SHP
TESTERS																
UMI 1200-7-26-1-6-1	-0.34**	-0.32**	-16.17**	-7.55**	0.61**	-5.05**	-2.70**	-0.07	-0.62**	0.39 **	-4.09**	-0.24 *	-1.05**	0.64	-4.99 **	0.81 **
UMI 1230-2-70-9-6-1	0.34**	0.32**	16.17 **	7.55 **	-0.61**	5.05**	2.70**	0.07	0.62**	-0.39**	4.09 **	0.24*	1.05**	-0.64	4.99 **	-0.81 **
SE	**0.09**	**0.10**	**0.25**	**0.22**	**0.02**	**0.34**	**0.14**	**0.07**	**0.09**	**0.08**	**0.27**	**0.09**	**0.17**	**0.45**	**0.29**	**0.13**
LINES																
N5	0.66 **	0.14	-17.55**	-6.41**	-0.92**	-4.03**	-4.46**	-0.51 *	-2.18**	-1.10**	-17.30**	-0.20	-2.79 **	1.30	-18.17 **	-1.06 **
N14	-1.59 **	-2.11**	0.50	-2.51**	0.12	2.59**	0.24	0.94**	-0.24	-0.06	25.84 **	-0.17	0.28	6.55 **	23.81**	3.02 **
N 27	0.66 **	1.64 **	-6.75**	-5.71**	-0.30**	-1.08	-3.16**	1.32**	-0.53*	-0.72**	-25.81**	-0.45	-2.25 **	2.68 *	-22.30 **	-2.13 **
N 42	1.41 **	1.14 **	0.75	1.92 **	-0.01	-10.91**	-4.01**	-2.86 **	1.02**	0.73**	7.21 **	1.15 **	3.11 **	-2.13	19.10**	0.75 *
N 66	0.16	0.39	12.88**	4.04 **	0.17*	-2.26 *	-1.86**	-1.21 **	-1.26**	0.20	-13.09**	0.34	-3.62 **	-3.71 **	-8.68 **	3.22 **
N 90	-1.09**	0.39	6.05**	-3.11**	-0.28**	-4.78**	2.14**	-0.11	0.10	-0.48*	-15.33**	-1.05**	0.55	-4.46 **	-2.98 **	7.05 **
N 94	0.91 **	0.64 *	7.75**	6.24 **	0.49**	9.57**	7.94**	0.59**	0.38	0.50 *	8.83 **	-1.00**	0.60	-0.75	-0.45	-0.34
N 104	1.66 **	0.14	-1.20	-2.21**	0.59**	2.14 *	-1.19**	0.89**	1.07**	0.75**	17.05**	2.82 **	-1.35 **	-1.21	7.97 **	-4.35 **
N 107	-0.34	-0.11	17.30**	8.17**	0.55**	6.57**	0.94**	-0.66 **	0.76**	0.12	5.81 **	-0.16	4.07 **	2.50 *	2.38 **	-4.96 **
N 117	-0.59 *	-0.86**	-14.05**	-2.21**	-0.00	-4.88**	0.44	1.02**	-0.41	1.05**	4.26 **	-0.50 *	0.50	1.51	-8.34 **	-5.60 **
N 285	-1.84 **	-1.36**	-5.67 **	1.79 **	-0.38**	7.07 **	2.99 **	0.59**	1.27**	-1.00**	2.53 **	-0.75**	0.90 *	-2.29 *	7.68 **	4.40 **
SE	**0.23**	**0.25**	**0.59**	**0.51**	**0.06**	**0.81**	**0.32**	**0.18**	**0.23**	**0.19**	**0.63**	**0.22**	**0.40**	**1.05**	**0.69**	**00.31**

*and**indicates significance at 5% and 1 % level respectively, DFT= Days to 50 per cent tasseling, DFS= Days to 50 per cent silking, PHT= Plant height (cm), LLT= Leaf length (cm), LWD= Leaf width (cm), LFC= Length to first cob (cm), TSL= Tassel length (cm), BPT= Number of branches per tassel, CLT= Cob length (cm), CGT= Cob girth (cm), CWT= Cob weight (g), NKR= Number of kernel rows per cob, KPR= Number of kernels per row, HGW= 100 grain weight (g), GYP= Grain yield per plant (g) and SHP= Shelling percentage (%).

Table 4. The *sca* effects of hybrids for different traits

Hybrids	DFT	DFS	PHT	LLT	LWD	LFC	TSL	BPT	CLT	CGT	CWT	NKR	KPR	HGW	GYP	SHP
N 5 × UMI 1200-7-26-1-6-1	0.34	0.32	8.87 **	2.55**	0.29**	-1.9	3.40**	-0.43	-0.86*	-0.65*	-23.58**	-0.66*	-2.16**	-0.64	-20.35**	0.35
N 14 × UMI 1200-7-26-1-6-1	0.59	0.57	3.92 **	4.05**	-0.23*	2.72*	0.50	-0.78**	-1.01**	-0.11	36.04**	-0.49	-0.92	10.13**	33.08**	6.19**
N 27 × UMI 1200-7-26-1-6-1	-0.16	-0.18	21.57**	7.25**	0.17	5.15**	2.90**	0.15	-0.18	-0.17	-15.15**	-0.91**	0.80	-0.37	-14.04**	-4.87**
N 42 × UMI 1200-7-26-1-6-1	-0.41	-0.68	-27.73**	-3.83**	-0.63**	-9.32**	-0.05	-0.98**	0.36	0.20	-17.28**	0.29	0.15	2.20	-4.33**	-5.11**
N 66 × UMI 1200-7-26-1-6-1	-0.16	0.57	-13.76**	-10.40**	-0.24*	-0.28	1.90**	-0.13	0.41	0.62*	9.75**	-0.42	1.47*	-1.78	4.09**	1.20*
N 90 × UMI 1200-7-26-1-6-1	0.59	0.07	-21.58**	-9.35**	-0.08	-5.95**	0.00	-1.63**	-0.76 *	-0.09	1.71	0.29	-1.50*	0.99	-3.13**	0.97*
N 94 × UMI 1200-7-26-1-6-1	0.59	-0.18	-18.73**	-8.40**	-0.41**	10.50**	-8.30**	0.27	-0.13	-0.08	2.39 *	0.24	-0.35	-1.22	7.30**	1.11*
N 104 × UMI 1200-7-26-1-6-1	-0.66	0.32	2.02*	5.35**	0.20*	3.82**	-2.12**	0.57*	0.62	-0.11	-23.16**	0.36	-2.40**	-1.45	-20.88**	-2.68**
N 107 × UMI 1200-7-26-1-6-1	0.34	0.07	4.02**	0.18	-0.16	-1.1	-2.60**	1.02**	0.41	0.67*	6.23**	2.68**	1.59*	-8.86**	-5.74**	-1.27*
N 117 × UMI 1200-7-26-1-6-1	-1.41**	-1.18**	17.27**	8.35**	0.75**	7.45**	3.20**	0.25	0.37	-0.46	10.11**	-1.36**	1.65**	0.19	14.17**	3.85**
N 285 × UMI 1200-7-26-1-6-1	0.34	0.32	24.14**	4.25**	0.35**	9.90**	1.15*	1.67**	0.78 *	0.17	12.94**	-0.01	1.67**	0.8	9.83**	0.26
N 5 × UMI 1230-2-70-9-6-1	-0.34	-0.32	-8.87**	-2.55**	-0.29**	1.90	-3.40**	0.43	0.86 *	0.65*	23.58**	0.66*	2.16**	0.64	20.35**	-0.35
N 14 × UMI 1230-2-70-9-6-1	-0.59	-0.57	-3.92**	-4.05**	0.23*	-2.72*	-0.50	0.78**	1.01 **	0.11	-36.04**	0.49	0.92	-10.13**	-33.08**	-6.19**
N 27 × UMI 1230-2-70-9-6-1	0.16	0.18	-21.57**	-7.25**	-0.17	-5.15**	-2.90**	-0.15	0.18	0.17	15.15**	0.91**	-0.80	0.37	14.04**	4.87**
N 42 × UMI 1230-2-70-9-6-1	0.41	0.68	27.73**	3.83**	0.63**	9.32**	0.05	0.98**	-0.36	-0.20	17.28**	-0.29	-0.15	-2.20	4.33**	5.11**
N 66 × UMI 1230-2-70-9-6-1	0.16	-0.57	13.76**	10.40**	0.24*	0.28	-1.90**	0.13	-0.41	-0.62*	-9.75**	0.42	-1.47*	1.78	-4.09**	-1.20*
N 90 × UMI 1230-2-70-9-6-1	-0.59	-0.07	21.58**	9.35**	0.08	5.95**	-0.00	1.63**	0.76 *	0.09	-1.71	-0.29	1.50*	-0.99	3.13**	-0.97*
N 94 × UMI 1230-2-70-9-6-1	-0.59	0.18	18.73**	8.40**	0.41**	10.50**	8.30**	-0.27	0.13	0.08	-2.39*	-0.24	0.35	1.22	-7.30**	-1.11*
N 104 × UMI 1230-2-70-9-6-1	0.66	-0.32	-2.02*	-5.35**	-0.20*	-3.82**	2.12**	-0.57 *	-0.62	0.11	23.16**	-0.36	2.40**	1.45	20.88**	2.68**
N 107 × UMI 1230-2-70-9-6-1	-0.34	-0.07	-4.02 **	-0.18	0.16	1.10	2.60**	-1.02**	-0.41	-0.67*	-6.23**	-2.68**	-1.59*	8.86**	5.74**	1.27*
N 117 × UMI 1230-2-70-9-6-1	1.41**	1.18**	-17.27**	-8.35**	-0.75**	-7.45**	-3.20**	-0.25	-0.37	0.46	-10.11**	1.36**	-1.65**	-0.19	-14.17**	-3.85**
N 285 × UMI 1230-2-70-9-6-1	-0.34	-0.32	-24.14**	-4.25**	-0.35**	-9.90**	-1.15*	-1.67**	-0.78 *	-0.17	-12.94**	0.01	-1.67**	-0.8	-9.83**	-0.26
SE	0.32	0.36	0.84	0.73	0.09	1.15	0.46	0.25	0.33	0.26	0.89	0.31	0.57	1.49	0.97	0.45

*and**indicates significance at 5% and 1 % level respectively, DFT= Days to 50 per cent tasseling, DFS= Days to 50 per cent silking, PHT= Plant height (cm), LLT= Leaf length (cm), LWD= Leaf width (cm), LFC= Length to first cob (cm), TSL= Tassel length (cm), BPT= Number of branches per tassel, CLT= Cob length (cm), CGT= Cob girth (cm), CWT= Cob weight (g), NKR= Number of kernel rows per cob, KPR= Number of kernels per row, HGW= 100 grain weight (g), GYP= Grain yield per plant (g) and SHP= Shelling percentage (%).

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Table 5. Standard heterosis for different morphological characters

Hybrids	Day to 50 % tasseling		Day to 50 % Silking		Plant height		Leaf length		Leaf width		Length to first cob		Length of tassel		Number of branches per tassel	
	diii(a)	**diii(b)**	**diii (a)**	**diii(b)**	**diii (a)**	**diii(b)**	**diii (a)**	**diii(b)**	**diii(a)**	**diii(b)**	**diii (a)**	**diii(b)**	**diii(a)**	**diii(b)**	**diii (a)**	**diii(b)**
N 5 × UMI 1200-7-26-1-6-1	6.93 **	5.88 **	7.62 **	5.61 **	-20.21**	-4.53**	-10.52**	-5.62**	-8.68**	-7.47**	-32.53**	-26.35**	-1.77	1.83	-5.21	7.06
N 14 × UMI 1200-7-26-1-6-1	2.97 **	1.96 *	3.81 **	1.87	-13.42**	3.60 **	-2.74	2.58	-1.84	-0.53	-17.53**	-9.97**	3.54	7.34**	6.25	20.00 **
N 27 × UMI 1200-7-26-1-6-1	5.94 **	4.90 **	9.52 **	7.48 **	-8.03 **	10.04**	-2.74	2.58	-2.11	-0.80	-19.20**	-11.79**	0.59	4.28*	19.79 **	35.29 **
N 42 × UMI 1200-7-26-1-6-1	6.93 **	5.88 **	7.62 **	5.61 **	-29.69**	-15.87*	-7.71 **	-2.66	-8.82**	-7.60**	-51.60**	-47.16**	10.62**	-7.34**	-35.42 **	-27.06 **
N 66 × UMI 1200-7-26-1-6-1	4.95 **	3.92 **	8.57 **	6.54 **	-16.17**	0.31	-14.12**	-9.42**	-1.32	0.06	-28.00**	-21.40**	1.47	5.20*	-9.37 *	2.35
N 90 × UMI 1200-7-26-1-6-1	3.96 **	2.94 **	7.62 **	5.61 **	-23.76**	-8.77**	-22.91**	-18.69*	-5.13**	-3.87 *	-38.93**	-33.33**	7.67**	11.62**	-13.54 **	-2.35
N 94 × UMI 1200-7-26-1-6-1	7.92 **	6.86 **	7.62 **	5.61 **	-21.40**	-5.95**	-8.07 **	-3.04	0.66	2.00	-25.87**	-19.07**	0.29	3.98	13.54 **	28.24 **
N 104 × UMI 1200-7-26-1-6-1	6.93 **	5.88 **	7.62 **	5.61 **	-15.28**	1.36	-0.43	5.02 **	10.00**	11.47**	-16.67**	-9.02**	-8.41**	-5.05*	19.79 **	35.29 **
N 107 × UMI 1200-7-26-1-6-1	4.95 **	3.92 **	6.67 **	4.67 **	-4.66 **	14.07**	7.06 **	12.92**	4.74*	6.13**	-17.33**	-9.75**	-3.54	0.12	8.33 *	22.35 **
N 117 × UMI 1200-7-26-1-6-1	0.99	0.00	2.86 *	0.93	-14.04**	2.85**	3.89 *	9.57 **	9.47**	10.93**	-21.20**	-13.97**	12.09**	16.21**	17.71 **	32.94 **
N 285 × UMI 1200-7-26-1-6-1	1.98 *	0.98	4.76 **	2.80 *	-6.14 **	12.31**	3.75 *	9.42 **	-0.79	0.53	-2.00	6.99**	13.57**	17.74**	28.12 **	44.71 **
N 5 × UMI 1230-2-70-9-6-1	6.93 **	5.88 **	7.62 **	5.61 **	-12.64**	4.53 **	3.89 *	9.57 **	-0.26	1.07	-14.00**	-6.11*	-5.90**	-2.45	5.21	18.82 **
N 14 × UMI 1230-2-70-9-6-1	1.98 *	0.98	2.86 *	0.93	-0.73	18.78**	7.35 **	13.22**	20.39 **	22.00**	-11.33**	-3.20	16.52**	20.80**	23.96 **	40.00 **
N 27 × UMI 1230-2-70-9-6-1	7.92 **	6.86 **	11.43**	9.35 **	-13.63**	3.35 **	-1.87	3.50 *	9.47 **	10.93**	-19.47**	-12.08**	-0.59	3.06	18.23 **	33.53 **
N 42 × UMI 1230-2-70-9-6-1	9.90 **	8.82 **	11.43**	9.35 **	15.80 **	38.56**	25.07**	31.91**	23.82 **	25.47**	-13.27**	-5.31*	5.60**	9.48**	-13.54 **	-2.35
N 66 × UMI 1230-2-70-9-6-1	6.93 **	5.88 **	7.62 **	5.61 **	14.84**	37.41**	37.61**	45.14**	21.12 **	22.73**	-13.80**	-5.90*	6.19**	10.09**	-5.21	7.06
N 90 × UMI 1230-2-70-9-6-1	2.97 **	1.96 *	8.57 **	6.54 **	15.36 **	38.03**	25.79**	32.67**	13.03 **	14.53**	-9.60**	-1.31	23.60**	28.13**	21.88 **	37.65 **
N 94 × UMI 1230-2-70-9-6-1	6.93 **	5.88 **	9.52 **	7.48 **	14.77 **	37.32**	37.90**	45.44**	27.63 **	29.33**	15.60**	26.20**	65.19**	71.25**	9.38 *	23.53 **
N 104 × UMI 1230-2-70-9-6-1	10.89**	9.80 **	7.62 **	5.61 **	-0.62	18.91**	5.91 **	11.70**	20.92 **	22.53**	-13.40**	-5.46*	20.06**	24.46**	9.38 *	23.53 **
N 107 × UMI 1230-2-70-9-6-1	4.95 **	3.92 **	7.62 **	5.61 **	7.93 **	29.14**	28.31**	35.33**	25.00 **	26.67**	-0.93	8.15**	27.73**	32.42**	-11.46 **	0.42
N 117 × UMI 1230-2-70-9-6-1	7.92 **	6.86 **	8.57 **	6.54 **	-15.18**	1.49	1.59	7.14 **	5.79 **	7.20**	-27.60**	-20.96**	9.14**	13.15**	14.06 **	28.82 **
N 285 × UMI 1230-2-70-9-6-1	1.98 *	0.98	4.76 **	2.80 *	-14.40**	2.42 **	13.26**	19.45**	6.05 **	7.47**	-14.93**	-7.13**	22.71**	27.22**	-5.21	7.06
SE	**0.46**	**0.46**	**0.56**	**0.56**	**1.26**	**1.26**	**1.07**	**1.07**	**0.13**	**0.13**	**1.59**	**1.59**	**0.66**	**0.66**	**0.35**	**0.35**

***and**indicates significance at 5% and 1 % level respectively**

diii (a) and diii (b) – indicates standard heterosis over the CO 6 and NK 6240 respectively

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Table 5. Standard heterosis for different morphological characters (contd)

Hybrids	Cob length		Cob girth		Cob weight		Number of kernel rows per ear		Number of kernels per row		100 grain weight		Grain yield per pant		Shelling percentage	
	diii(a)	**diii(b)**	**diii (a)**	**diii(b)**	**diii (a)**	**diii(b)**	**diii (a)**	**diii(b)**	**diii(a)**	**diii(b)**	**diii (a)**	**diii(b)**	**diii(a)**	**diii(b)**	**diii (a)**	**diii(b)**
N 5 × UMI 1200-7-26-1-6-1	-11.15*	-24.60**	-8.63**	-1.11	-43.38**	-27.81*	-8.50*	15.70**	-9.19	-30.86**	-20.25**	-4.97	-55.40**	-46.85**	-7.79**	-7.19**
N 14 × UMI 1200-7-26-1-6-1	1.98	-13.45**	2.92	11.39**	19.83**	52.79**	-7.19*	17.36**	10.65*	-15.75**	-14.47*	1.93	26.73**	51.01**	5.86**	6.55**
N 27 × UMI 1200-7-26-1-6-1	6.02	-10.02 *	-2.34	5.70	-43.43	-27.88*	-11.76**	11.57*	6.91	-18.60**	-16.90**	-0.97	-53.52**	-44.61**	-16.43**	-15.89**
N 42 × UMI 1200-7-26-1-6-1	21.28**	2.93	10.96**	20.09**	-24.43**	-3.65**	6.54	34.71**	28.62**	2.07	-21.44**	-6.38	-9.53**	7.81**	-12.80**	-12.24**
N 66 × UMI 1200-7-26-1-6-1	4.99	-10.90 *	10.16**	19.22**	-20.28**	1.64	-3.33	22.23**	3.75	-21.02**	-32.76**	-19.87**	-26.19**	-12.05**	-0.74	-0.09
N 90 × UMI 1200-7-26-1-6-1	6.38	-9.71 *	0.46	8.23*	-26.61**	-6.42**	-7.84*	16.53**	9.22	-16.84**	-28.67**	-15.00*	-27.50**	-13.61**	4.23**	4.91**
N 94 × UMI 1200-7-26-1-6-1	12.99*	-4.11	7.24*	16.06**	-11.33**	13.06**	-7.84*	16.53**	14.75**	-12.63**	-25.60**	-11.34	-16.35**	-0.31	-5.75**	-5.14**
N 104 × UMI 1200-7-26-1-6-1	23.62**	4.92	8.85**	17.80**	-21.99**	-0.53	17.97**	49.17**	-3.69	-26.67**	-27.00**	-13.01	-33.36**	-20.59**	-16.47**	-15.93**
N 107 × UMI 1200-7-26-1-6-1	19.74**	1.62	9.94**	18.99**	-10.82**	13.70**	13.66**	43.72**	39.68**	6.35	-34.52**	-27.97**	-25.13**	-10.79**	-15.38**	-14.83**
N 117 × UMI 1200-7-26-1-6-1	10.93*	-5.85	8.48**	17.41**	-9.3***	15.53**	-15.03**	7.44	23.50**	-5.96	-18.14**	-2.45	-17.22**	-1.36	-9.22**	-8.63**
N 285 × UMI 1200-7-26-1-6-1	26.19**	7.10	-1.90	6.17	-8.72**	16.39**	-7.84*	16.53**	25.44**	-4.49	-24.63**	-10.19	-7.17**	10.62**	-0.40	0.25
N 5 × UMI 1230-2-70-9-6-1	10.64*	-6.10	-4.75	3.09	-9.33**	15.60**	3.27	30.58**	20.37**	-8.35*	-20.27**	-4.99	-11.77**	5.14*	-3.81**	-3.18**
N 14 × UMI 1230-2-70-9-6-1	25.97**	6.91	-1.21	6.92*	-19.47**	2.67*	2.39	29.46**	28.78**	-1.95	-31.50**	-18.37*	-21.63**	-6.61**	-6.22**	-5.61**
N 27 × UMI 1230-2-70-9-6-1	17.75**	-0.06	-5.56	2.22	-19.75**	2.32*	3.27	30.58**	9.22	-16.84**	-18.01**	-2.29	-20.76**	-5.57**	1.90*	2.56**
N 42 × UMI 1230-2-70-9-6-1	25.17**	6.23	2.34	10.76**	1.87*	29.89**	5.88	33.88**	36.87**	4.21	-33.02**	-20.18**	6.52**	26.94**	6.20**	6.89**
N 66 × UMI 1230-2-70-9-6-1	8.07	-8.28	-4.61	3.24	-27.25**	-7.24**	5.23	33.06**	-0.18	-24.00**	-28.14**	-14.37*	-24.63**	-10.19**	0.91	1.56
N 90 × UMI 1230-2-70-9-6-1	26.63**	7.47	-4.39	3.48	-23.68**	-2.69*	-8.50*	15.70**	32.72**	1.05	-35.30**	-22.90**	-13.52**	3.05	6.50**	7.19**
N 94 × UMI 1230-2-70-9-6-1	24.06**	5.29	2.78	11.23 **	-9.23**	15.73**	-7.84*	16.53**	27.65**	-2.81	-23.26**	-8.55	-20.32**	-5.05*	-3.86**	-3.24**
N 104 × UMI 1230-2-70-9-6-1	23.62**	4.92	4.82	13.45 **	11.54**	42.22**	16.34**	47.11**	28.11**	-2.46	-23.73**	-9.11	11.19**	32.50**	-4.15**	-3.53**
N 107 × UMI 1230-2-70-9-6-1	22.89**	4.30	-5.56	2.22	-13.45**	10.35**	-18.30**	3.31	34.68**	2.54	-1.12	17.83*	-6.65**	11.24**	-6.94**	-6.34**
N 117 × UMI 1230-2-70-9-6-1	14.60**	-2.74	9.50**	18.51 **	-16.79**	6.09**	5.88	33.88**	17.97**	-10.18*	-21.53**	6.49	-33.02**	-20.18**	-14.86**	-14.30**
N 285 × UMI 1230-2-70-9-6-1	23.92**	5.17	-10.05**	-2.65	-19.60**	2.51*	-4.58	20.66**	19.75**	-8.82*	-30.50**	-17.18*	-15.50**	0.70	3.82**	4.49**
SE	**0.65**	**0.65**	**0.40**	**0.40**	**1.31**	**1.31**	**0.52**	**0.52**	**1.07**	**1.07**	**2.76**	**2.76**	**1.78**	**1.78**	**0.60**	**0.60**

***and**indicates significance at 5% and 1 % level respectively**

diii (a) and diii (b) – indicates standard heterosis over the CO 6 and NK 6240 respectively