Original Research Article

Stability Analysis of Quality Protein ofMaize Hybrids for Yield, Qualitative and Quantitative Traits under Heat stress in Different Environments.

Comment [T1]: This scientific work is for journals, it need to reduce from 15084 words, to 5000 words only.

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Abstract

Maize or corn (*Zea mays*. L) is cultivated globally being one of the most important cereal crops worldwide. Maize is the only food cereal crop that can be grown in different seasons and requires moderate climate for growth. This study claims to decide whether such statement holds, and to analyse stability as far as gene action encompassed. Analysis of variance for diallel analysis (model I method II) revealed that mean squares due to genotypes, parents, hybrids and parent vs. hybrids were highly significant for all the eighteen quantitative and qualitative characters under study. Analysis of variance for combining ability revealed the mean squares due to GCA and SCA were highly significant for all the characters study. The parents, P_4, P_5 and P_2had significant to highly significant positive GCA effects for grain yield per plant and its attributes indicated these two parents were good general combiners for this trait. The cross combinations,P_5 x P_7, P_5 x P_6, P_4 x $P_8$and P_4 x P_5had significant to highly significant SCA effects for grain yield per plant. The estimates of standard heterosis over the best check,HQPM-5for grain yield per plant revealed the top five cross combinations, namely P_5 x P_7,P_5 x P_6,P_4 x P_8,P_5 x P_9andP_4xP_5exhibited highly significant positive standard heterosis. after critical evaluation for their superior and stable performance over environments.Stability Study was carried out to determine the grain yield of 45 maize hybrids in three environments E_1, E_2 and E_3 using Eberhart and Russel model. The single cross hybrids P_5 x P_6, P_5 x P_7 and P_4 x P_5 were promising for majority of characters studied with high mean performance across the environments. Regression coefficient near to unity ($\beta_i \approx 1$) and non-significant deviation from regression (s^2di).There by indicating its adaptability over all environments thus,these hybrids P_1 x P_8, P_2 x P_6, P_1 x P_6, P_9 x P_{10} and P_3 x P_5 were identified as stable over the all three environments and moreover, hybrids, P_5 x P_6, P_4 x P_9, P_4 x P_5 and P_3 x P_6 were not prejudiced much by the season as well as environment and stable across the environments.

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Key words

Quality Protein Maize, Heat tolerance, GCA, SCA, G x E and Eberhart & Russell.

Introduction

Maize is a multi-faceted crop used as food, feed and industrial crop globally. Maize has a very prominent role to play in the Indian economy too. Currently this coarse grain is cultivated in about 10.2 Million hectare in India.(FICCI2022). There is a tremendous potential of growth of the Maize value chain in the country. The consumption of Maize has increased at a CAGR of 11% in last five years. Today, Maize is a source of more than 3500 products including specialised Maize like QPM "Quality Protein Maize" (FICCI 2022) baby corn, sweet corn etc. Due to recent research advancements, the quality protein maize, single cross and 3-way cross hybrids have given a fillip to the nutritional quality of this cereal.More than two third of the maize produced in India is consumed for feed and other industrial uses. Feed industry with a CAGR of 6-7% globally and within India at a CAGR of 9% presents a huge opportunity for maize growers. With the largest global livestock population, India has always remained a feed starved country. Besides, the Indian poultry industry i.e. eggs and poultry meat sector, is growing at a CAGR of around 6% and 9% respectively. Keeping these factors in view, maize will continues to remain an important crop for food, feed and fodder purposes. Maize is the only food cereal crop that can be grown in different seasons and requires moderate climate for growth. In the country, more than three-fourths of the area to maize production is contributed by eight states, *viz*., Andhra Pradesh, Bihar, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh and Tamil Nadu. Over the past two decades, the crop has witnessed a growing prominence in these states, though with a varying degree, particularly as a feed crop.

Maize being a C_4 plants it has a competitive edge over C_3 plants. C_4 plants use 3-fold less water, allowing them to grow in conditions of drought, high temperature, and carbon dioxide limitation. It has been recognised that C_4 plant species (including maize) have a higher optimal temperature for undertaking photosynthesis than C_3 plants due to operation of a C_O^2-concentrating system that inhibits Rubisco oxygenase activity. Because of this in maize we can produce Heat stress (HS) tolerant QPM hybrids. Indian maize production depends heavily on the South west monsoon as more than three-fourth of the maize is produced in the Kharif season. Poor monsoon rainfall in 2015 has affected the yield of Kharif maize mainly in Maharashtra, Rajasthan, Gujarat, Karnataka, Andhra Pradesh and Telangana. Dry soils and inadequate irrigation water availability also affected planting of Rabi maize. Area and Production trend over the years from 2012 to 2016 has been depicted herewith. It could be observed that, although harvested area and production has increased during this period but there is non-uniformity in trend over the last five years.In India, rabi maize has been sown in around 19.31 lakh hectares (47.72 lakh acres) as on 04th February 2022 which is higher than 17.51 lakh hectares (43.27 lakh acres) covered during corresponding period of last year. Major maize growing states are Bihar 5.96 lakh ha (14.73 lakh acres), Maharashtra 3.37 lakh ha (8.33 lakh acres), Telangana 1.92 lakh ha (4.74 lakh acres) and Tamil Nadu 1.91 lakh ha (4.72 lakh acres)Only 15% of cultivated area of Maize is under irrigation (Department ofAgriculture & farmers welfare). India stands at 5th rank in Maize hybridization. Bihar and Tamil Nadu has almost reached 100% hybridization in Maize.

The search for hybrid combinations with high grain yield adapted across the environments is one of the most important objectives of the breeders.Combining ability investigations of parental generations should be led conducted under appropriately stressed selection environments for the successful selection of suitable parents that can be used in hybridization programs (Hallauer AR, Miranda 1988). Combining ability is defined as the capacity of an inbred line to transmit any of its superior traits to its offspring (Sprague and Tatum 1942). Successful estimation of combining abilities involves various steps such as parental selection for crossing, performing crosses using a definite mating design, evaluation and data interpretation. The study of the effects of combining ability, both general combining ability (GCA) and specific combining ability (SCA), are important indicators of potential value for assessing inbred lines in hybrid combinations as a step to develop hybrid varieties in maize (Mekasha, G.M*et al.*, 2022). The ratio of SCA and GCA is a good indicator for the predominance of of non-additive effect in the expression of quantitative characters if it is found greater than one (Dodia and Joshi, 2003). Heterosis and combining ability are the prerequisites for formulating hybrid breeding programme. The diallel analysis provides information on the type of gene action and general combining ability and specific combining ability (SCA) of genotypes (Silva *et al.*, 2010, Moterle *et al.*, 2011).Heritability of grain yield has been reported to be low under stress conditions (Badu-Apraku *et al.*, 2004; 2005). Therefore, the use of secondary traits that have strong association with yield under stress conditions has been proposed for yield improvement.

Yield is a complex quantitative character controlled by many genes interacting with the environment and is the product of many factors called yield components (Langade *et al.*, 2013). Association studies could lead plant breeders in the selection of traits contributing towards the characters of concern and ultimately their improvement (Bhusal *et al.*, 2017). The appropriate knowledge of such inter-relationships between yield and its contributing components can significantly improve the efficiency of breeding programmes through the use of appropriate selection indices (Mohammadia *et al.,* 2003).The study of genotype x environment interaction provides information to the plant breeder for developing stable genotypes for cultivation in variable environmental conditions. Stability and adaptability of genotypes evaluated under different environments is very important for maize breeding programs (Vencovsky and Barriga 1992). When varieties are compared over a series of environments, the relative ranking usually differs. For plant breeders, large genotype by environment (GxE) interaction impede progress from selection and have important implications for testing and cultivar release programmes. Statistically, G x E interactions are detected as a significantly different pattern of response among the genotypes across environments and biologically, this will occur when the contributions (or level of expression) of the genes regulating the trait differ among environments (Basford and Cooper, 1998). Therefore, an ideal approach in plant breeding is to develop cultivars that have fairly uniform performance (low G x E) over a range of environments with the ability to utilize the resources in high yielding environment. Further in the state of U.P., only full season of maize hybrids are available, therefore an attempt was made to identify promising early to extra early hybrids without compromising with the yield levels under HS condition.

Materials and methods

To access the stability performances of 45 single cross hybrids (Table 2) for yield and its components experiment was conducted in randomized block design (RBD) with three replications along with 1 check (HQPM-5).The experiment was laid out across three different environments *viz.*, E_1, E_2 and E_3 during kharif season of 2020.Experiment was designed with a row length of 4 m, with inter and intra row spacing of 60cm and 20cm respectively at central research farm, SHUATS, Prayagraj. Five plants from each replication were randomly selected and tagged for recording observations in each genotype except for days to 50 per cent tasseling, days to 50 percent silking, anthesis-silking interval and days to maturity . Data were recorded on different morphological and yield parameters *viz.*, days to anthesis, days to silking, anthesis silking interval, days to maturity, plant height (cm), cob height (cm), tassel length (cm), cob length (cm), cob girth (cm), kernel rows per cob, kernels per row, chlorophyll content, canopy temperature deficit, leaf area index, seed index(100 seed weight), grain yield/ha (kg), oil content and starch content were recorded in all three environments.Quality protein inbred lines (Table 1) obtained from different research centres in India, were used to generate single cross hybrids.

Table 1. Name, origin and heat stress status of parental lines.

Inbred line	Name	Origin	Heat tolerance status
P_1	BHU-QPM-8	B	HT
P_2	BHU-QPM-2	B	HT
P_3	NBPGR-33000	N	HS
P_4	NBPGR-36548	N	HT
P_5	VL-153237	C	HT
P_6	IC-53826	N	HT
P_7	IC-381506	N	HT
P_8	IC-1306641	N	HT
P_9	BHU-N3	B	HT
P_{10}	BHU-B73-BC2	B	HS

B = BHU, Varanasi; N = NBPGR, New Delhi; C = CIMMYT,R/o Hyderabad;
HT = Heat Tolerance; HS = Heat susceptible.

Total of 45 F_1s obtained using diallel fashion with non- reciprocals. Among them, 10 inbred lines which were selected are crossed in all possible ways without reciprocals to produce 45 F_1s. The mean values on different traits were analysed using model I methodII suggested by Eberhart and Russell (1966).The stability of yield performance for each genotype was calculated by regressing the mean yield of individual genotypes on environmental index and calculating the deviations from regressing the mean yield of individual genotypes on environmental index and calculating the deviations from regression. Regression coefficient (bi) was considered as an indication of the response of the genotype to varying environment while the environment and genotype × environment interactions were partitioned into three components *viz.*, environment (linear), genotype x environment (linear) and deviation from regression (pooled deviation over the genotypes). The stability analysis was done using the linear regression model suggested by Eberhart and Russell (1966).

Statistical analysis

The statistical analysis was done by using replication mean values based on the recorded data. The different statistical procedures followed were Analysis of variance, Estimation of Heterosis, Heterobeltiosis and Economic heterosis, Combining ability analysis and Stability Analysis. The data obtained for each character in F_1's and parents were analyzed for each statistical procedure given by **Panse and Sukhatme (1967)**, 'F' test and 'I' test were worked out by the analysis of variance to test the significance. It was carried out according to the procedure of RBD analysis for each character as per methodology of **Fisher and Yates (1938)**.Heterosis expressed as percent deviation from the mid parent. In the present experiment heterosis was estimated for 5-6 hybrids for the 19 characters studied, suggested by **Turner (1953).** The combining ability analysis was computed on data obtained for parents and F_1s only by using diallel mating design (Model-I Method-II), (Griffings, 1956).

Results and Discussion

Pooled analysis of variance for eighteen characters of quantitative and qualitative traits over different environments presented in Table4which acknowledge the mean squares due to genotypes, parents, hybrids and parent vs. hybrids were highly significant for all the characters studied indicated the existence of significant difference. Analysis of variance for combining ability Table 4 revealed the mean squares due to GCA and SCA were highly significant for most of the characters studied indicating that importance of both additive and non-additive gene actions in the expression of most of the quality traits in maize. The dominance variance has greater influence in the inheritance of the trait as it was evident from the ratio of additive to dominance variance which was below unity (VA/VD<1). There was a significant difference among the genotypes tested at both 1 and 5 per cent level of significance for all the characters studied. In the expression of most of the characters in maize except kernel row per cob, chlorophyll content and canopy temperature deficit in E_1 and anthesis-silking interval, kernel row per cob and canopy temperature deficit in E_2 and all the parameters were significant in $E_{3.}$

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General combining ability

The estimates of GCA effects for different characters were either negative or positive (Table 5). For grain yield per plant positive GCA effects is desirable likewise for days to 50% tasseling, days to 50% silking, anthesis-silking interval, plant height and days to maturity suitable for negative GCA effects. The parents, P_2, P_4 and P_5 had highly significant positive

GCA effects and were grouped as good general combiners for grain yield per plant. The lines P_3, P_7 and P_{10} were noted as poor inbred lines selected as parental material and among all thisparental lines P_{10} found susceptible for Heat-stress.The parent, P_2 was good general combiner for chlorophyll content, tassel length, ear length, ear girth, number of kernels per row, oil content in all the environments and had highly significant positive GCA effects.Hence these two parents, P_4 and P_5 shown highly positive GCA for number of kernel row per cob, number of kernels per row and seed yield per plant, while parents P_3 and P_9 shows positive GCA for quality parameters like oil content and starch content and among them parents P_2, P_4 and P_9 can be used directly for the development of high yielding hybrids and synthetic by contributing desirable alleles. Significant positive GCA effects for inbred lines indicated that they are desirable parents for hybrid maize development and involvement in the maize breeding program as they can be source of good alleles in the process of varietal development (Niranjan *et al.*, 2020).Negative GCA effects are desirable for days to 50 percent tasseling, days to 50 percent silking, anthesis-silking interval and days to 50 percent maturity and plant height. The parents, P_2 had highly significant negative GCA effects for days to 50 percent tasseling, days to 50 percent silking and plant height while, the parent, P_5 and P_6 had significant to highly significant negative GCA effects for anthesis-silking interval. Hence these two parents, P_2 and P_6 were good general combiners these traits and can be used as parent for development of early maturing hybrids. For the plant height, negative GCA effects are desirable. The parents P_2 and P_{10} had highly significant negative GCA effects for plant height and ear height and was grouped as good general combiner for these traits. These finding are close conformity with the results of Sowmya, H. H *et al.,* 2018; Niranjan *et al.,* 2020; Nyasha, E. C and Charles, S. M. 2020; Olatise, O. *et al.,* 2022.

Specific combining ability

The estimates of specific combining ability (SCA) effects for eighteen quantitative and qualitative traits (Table 6) revealed that the cross combinations, namely, P_{1X} P_{10}, P_{3X} P_5, P_{3X} P_7, $P_{3\,X}$ P_8, $P_{4\,X}$ P_8, $P_{4\,X}$ P_{10}, $P_{5\,X}$ P_7, $P_{5\,X}$ P_8, $P_{5\,X}$ P_9 and $P_{7\,X}$ P_9had significant to highly significant positive SCA effects for grain yield per plant in all three environments E_1, E_2 and E_3 and were grouped as good specific combinations for this traits. All these hybrids also exhibited significant to highly significant positive SCA effects for one or more yield contributing characters.Preponderance of additive effects is observed when the GCA:SCA ratio is greater than one while preponderance of dominance effects is observed when the ratio is less than one. Dominance or epistatic genetic effects mostly influenced maize grain yield under HS. The results obtained in this investigation are partially in accordance with Hallauer and Miranda (1988). High estimates of SCA effects for these cross combination revealed the preponderance of additive and non-additive gene effects and may be exploited commercially for this trait after critical evaluation over locations/ years. Negative SCA effects are desirable for days to 50 per cent tasseling, days to 50 per cent silking, anthesis-silking interval, days to 50 per cent maturity for earliness and plant height.

Hybrids P_{1X} P_4, P_{1X} P_5, $P_{1\ x}$ P_{10}, $P_{5\ x}$ P_9, $P_{5\ x}$ P_{10} shows negative SCA in environment $E_{1.}$ F_1s P_2 x P_4, P_2 x P_5, P_2 x P_7, P_2 x P_8, P_3 x P_6, P_3 x P_8, P_4 x P_5 and P_8 x P_{10} depicts great SCA effects in environment E_1 and E_2 and only P_1 x P_4, P_7 x P_8 and P_5 x P_7 are significant negative SCA in environment E_3, over all P_1 x P_4 and P_7 x P_8 combinations exhibited highly significant negative SCA effects for days to 50 per cent tasseling and $P_{1\ X}$ P_4, $P_{4\ X}$ P_8, $P_{6\ X}$ P_7 and $P_{7\ X}$ P_8shows significant negative SCA in all the environments E_1, E_2 and $E_3$for days to 50 per cent silking. Among all the cross combinations $P_{1\ X}$ P_3, $P_{1\ X}$ P_4, $P_{2\ X}$ P_3, $P_{4\ X}$ P_8, $P_{4\ X}$ P_9, $P_{4\ X}$ P_{10}, $P_{5\ X}$ P_6, $P_{5\ X}$ P_7, $P_{5\ X}$ P_{10}, $P_{6\ X}$ P_8 and $P_{7\ X}$ P_9 exhibited highly significant negative SCA effects for anthesis- silking interval in all three environments E_1, $E_2$and E_3. Cross combinations $P_{1\ X}$ P_5, $P_{1\ X}$ P_6, $P_{1\ X}$ P_7, $P_{2\ X}$ P_7, $P_{3\ X}$ P_9, $P_{4\ X}$ P_6, $P_{6\ X}$ P_7, $P_{6\ X}$ P_8, $P_{7\ X}$ P_9 and $P_{9\ X}$ P_{10} had highly significant negative SCA effects for days to 50 per cent maturity. F_1s $P_{4\ X}$ P_7, $P_{4\ X}$ P_{10}, $P_{6\ X}$ P_8 and $P_{6\ X}$ P_9 exhibited highly significant negative SCA effects for plant height. Although, none of the crosses exhibited significant negative SCA effects for ear height in all three environments. Subsequently, 30 hybrids shows significant positive SCA for chlorophyll content and 15 F_1s depicts negative specific combining ability in all three environments among them, P_{2X} P_7, P_{4X} P_5, $P_{5\ X}$ P_8, $P_{7\ X}$ P_9 and $P_{9\ X}$ P_{10} reveal highest negative SCA followed, hybrids $P_{1\ X}$ P_7, $P_{2\ X}$ P_3, $P_{2\ X}$ P_6, $P_{2\ X}$ P_{10}, $P_{3\ X}$ P_6, $P_{4\ X}$ P_9, $P_{4\ X}$ P_{10}, $P_{5\ X}$ P_6, $P_{6\ X}$ P_{10} shows highest significant positive SCA in all environments E_1, E_2 and E_3 and for canopy temperature deficit hybrids P_1 x P_2, P_3 x P_5, P_4 x P_6, P_6 x P_9 shows significant positive specific combing ability in all environments.

For yield attributing characters like number of kernel rows per cob, number of kernels per row, ear length and ear width among them $P_{1\ X}$ P_3, $P_{1\ X}$ P_8, $P_{2\ X}$ P_3, $P_{3\ X}$ P_8, $P_{5\ X}$ P_6, and $P_{7\ X}$ P_9 shows significant and positive combiners for ear length and ear girth in all three environments and moreover, hybrids P_2 x P_3 and P_5 x P_6 are great in all the yield attributing characters except number of kernel row per cob. Additionally, P_1 x P_8 and P_7 x P_9 F_1s revealed that these are good combiners in all the yield attributing characters in all the environments. For quality parameters like oil content and starch content $P_{1\ X}$ P_4, $P_{1\ X}$ P_6, P_3

x P_6, P_3 x P_{10}, P_4 x P_9, P_5 x P_9, P_6 x P_{10}, P_7 x P_8, P_7 x P_{10}, P_8 x P_9total of 10 hybrids exhibit positive SCA in all the environments.

The promising cross combinations having significant exceptionally high SCA impacts in desirable direction economically in the wake of checking their performance across all the environments. These outcomes are in close congruity with the discoveries and similar findings were reported by, Charles 2020 and Tulu *et al.*, 2018 and Mohammed and Yousif 2020;Sowmya, H. H *et al.*, 2018; Niranjan *et al.*, 2020; Nyasha, E. C and Charles, S. M. 2020; Olatise, O. *et al.*, 2022..

Table 2. Best and worst cross combinations for grain yield.

High yielding hybrids				Low-yielding hybrids			
Hybrid	Grain yield (q/ha)			Hybrid	Grain yield (q/ha)		
Env	E_1	E_2	E_3		E_1	E_2	E_3
P_3 x P_6	153.57	101.13	83.67	P_8 x P_9	74.81	107.03	91.25
P_4 x P_9	165.73	109.87	84.33	P_1 x P_5	75.17	113.57	83.30
P_5 x P_6	184.77	126.30	79.27	P_2 x P_5	96.70	92.17	75.41
P_5 x P_7	184.23	127.73	95.02	P_3 x P_4	99.93	95.23	88.50
P_5x P_{10}	161.05	109.23	101.83	P_8 x P_{10}	106.27	85.47	84.33

The best cross combinations for the seed index were P_3 x P_8 (6.22***), P_3x P_6 (4.03**), P_1x P_4 (3.41***). Single cross hybrids P_4x P_9 (6.05), (6.13*), (5.67); P_6 x P_9 (5.61), (5.92*), (4.90); P_6 x P_8 (4.73), (4.51), (0.98) combined well for chlorophyll content in all E_1, E_2 and E_3 environments. On the other hand hybrids P_2 x P_6 (-4.13), P_3 x P_7 (-3.51), P_6 x P_8 (-4.61) were the worst three combinations for seed index among them third environment effects more than other two whereas P_5 x P_9 (-5.58), (-8.41), (-6.68); P_1 x P_6 (-5.91), (-7.35), (-6.93), P_4 x P_5 (-3.33), (-2.42), (-3.19), were the worst three combiners for chlorophyll content.

Heterosis

The estimates of standard heterosis over the check, HQPM-5 for eighteen quantitative and qualitative traits revealed the per cent of standard heterosis for grain yield ranged from 0.71 %(P_2 x P_6) to 45.11 % (P_5 x P_6) in E_1, from 0.42 % (P_1 x P_7) to 5.69 %(P_1 x P_8) in E_2 and 18.92% (P_4 x P_8) in E_3, Data for this character further revealed that hybrid P_5 x P_6 (45.11 %) exhibited highest positive significant standard heterosis for Seed yieldfollowed by hybrids P_5 x P_7(44.69%), P_4 x P_5 (34.94 %), P_4 x P_8 (33.92 %), P_4 x P_9 (30.16 %) in environment E_1. Similarly in environment $E_2$5.69 %. (P_1 x P_8) depicted highest positive significant value followed by hybrids P_1 x P_{10} (4.18 %), P_2 x P_3 (2.28 %), P_5 x P_7 (0.55 %), P_1 x P_7 (0.42 %) whereas in environment E_3, 18.92 % (P_4 x P_8) exhibited highest positive significant standard heterosis value for Seed yield**.** These hybrids also exhibited significant to highly significant positive standard heterosis for one or more grain yield contributing traits. Hence, these hybrids can be exploited commercially after critical evaluation for their superiority and stability over the locations E_1, E_2 and E_3. Days to 50 per cent tasseling and days to 50 percent silking regulate the early flowering. The range of standard heterosis for days to 50 per cent tasseling varied from -0.64 % ($P_{1\ X}\ P_8$) to -14.10 % ($P_{3\ X}\ P_6$) in E_1, from -2.55 % ($P_{1\ X}\ P_8$) to -12.74 % ($P_{3\ X}\ P_6$) in E_2 and from -1.89 % ($P_{7\ X}\ P_8$) to - 7.55 % ($P_{2\ X}\ P_4$) in E_3, Data for this character further revealed that hybrid $P_{3\ X}\ P_6$ (-14.10 %) exhibited highest negative significant standard heterosis for days to 50 % tasseling and for days to 50 % silking varied from -3.09 ($P_{4\ X}\ P_8$) to -14.20 % ($P_{3\ X}\ P_6$) in E_1, from -2.44 ($P_{1\ X}\ P_8$) to -12.20 % ($P_{3\ X}\ P_6$) in E_2 and from -4.24 ($P_{7\ X}\ P_8$) to -9.09 % ($P_{3\ X}\ P_8$) in E_3, Data for this character further revealed that hybrid $P_{3\ X}\ P_6$ (-14.20 %) exhibited highest negative significant standard heterosis for days to 50 % silking. While for chlorophyll content there were least number of hybrids which recorded significant heterosis over check. Similarly, over check, HQPM-5 a total of 12 hybrids recorded significant standard heterosis in desirable positive direction in leaf area index. These results were in line with the findings of Mohammed and Yousif (2020) and karim *et al.,* (2018). for the yield attributing traits like number of kernel rows per cob, number of kernels per row, ear length and ear girth hybrids $P_{3X}\ P_5$ and $P_{5\ X}\ P_6$ showed positive standard heterosis. Furthermore for the quality parameters like oil content and starch content F_1s $P_{2\ X}\ P_3$, $P_{1\ X}\ P_5$, $P_{4\ X}\ P_9$, $P_{5\ X}\ P_9$, $P_{5\ X}\ P_{10}$ and $P_{8\ X}\ P_9$ shows significant positive heterosis in all the environments E_1, E_2 and E_3. Hence these hybrids can be exploited earliness after critical testing over environments. Similar results were reported by Ambikabathy et al., (2019), Kumar and Babu (2016), Kumar et al., (2015), Ofori et al., (2015), Lahane et al., (2014). Hence, these hybrids may be exploited commercially after critical evaluation for their performance and stability over environments.

Stability analysis

For days to tasseling the mean value over the three environments was 52 days. Days to 50 % tasseling revealed that out of 45 hybrids, 32 hybrids showed non-significantdeviation from regression (s^2di) hence their behavior was predictable, while 13 hybrids showedsignificant deviation from regression (s^2di) there by their behavior was unstable. The hybrid($P_1 \times P_8$) had negative phenotypic index ($P_i<1$), regression coefficient near to unity ($\beta_i \approx 1$) and non-significant deviation from regression (s^2di) there by indicating its stability over all environments and suitability for early tasseling. The hybrids P_1 x P_8, P_1 x P_2, P_6 x P_9 showed non-significant deviation from regression (s^2di) had negative phenotypic index (P_i‹1), and regression coefficient greater than unity (β_i>1) indicating their adaptability under un-favorable environments and suitable for early tasseling. For days to silking out of 45 hybrids, 32 hybrids showed non-significantdeviation from regression (s^2di) hence their behavior was predictable, while 13 hybrids showedsignificant deviation from regression (s^2di) there by their behavior was unstable. The hybrid($P_1 \times P_8$) had negative phenotypic index (P_i<1), regression coefficient near to unity (β_i≈1) and non-significant deviation from regression (s^2di) there by indicating its adaptability over all environments and suitability for early silking. The hybrids P_1 x P_8, P_4 x P_8showed non-significant deviation from regression (s^2di) had negative phenotypic index (P_i‹1), and regression coefficient greater than unity (β_i>1) indicating their adaptability under un- favorable environments and suitable for early silking across different environments

For plant height the highest mean plant height (184.08 cm) was recorded for P_1 x P_8 the tallest and lowest mean plant height (131.52 cm) was observed for P_6 x P_9. The average plant height over the different environments was 163.50 cm. All the hybrids tested were significantly deviating from regression value across the environments and Over the three environments, 26 hybrids showed non-significantdeviation from regression (s^2di) hence their behavior was predictable, while 19 hybrids showedsignificant deviation from regression (s^2di) there by their behavior was unpredictable. The hybrid P_2 x P_6 had negative phenotypic index (P_i<1), regression coefficient near to unity (β_i≈1) and non-significant deviation from regression (s^2di) there by indicating its adaptability over all environments and suitability for lower plant height. Cob length for P_3 x P_5 recorded high mean value (20.33 cm) and P_9 x P_{10} noticed with low mean value (15.72 cm) for cob length, average value over the environments was 17.63 cm. Across the three environments, out of the 45 hybrids, P_1 x P_6, P_3 x P_9, P_7 x P_{10}, P_9 x P_{10} showed higher mean, regression value near to one and non-significant deviation from regression (Lata *et al.*, 2010). Hence, these genotypes were stable across the environments for cob length. Hybrid P_2 x P_9 exhibited maximum (14.85 cm) and P_7 x P_8 recorded minimum (12.67 cm) mean value for cob girth. Out of the 45 hybrids seven hybrids viz., P_1 x P_2, P_1 x P_8, P_2 x P_6, P_5 x P_7, P_7 x P_9, P_8 x P_{10}, P_9 x P_{10}showed non-significant (s^2di) and regression coefficient lesser than unity (β_i<1), with mean values higher than the population mean, thereby indicating its adaptability under unfavorable environments for increase ear girth.The hybrids, P_1 x P_2, P_1 x P_8, P_2 x P_6, P_5 x P_7, P_6 x P_9, P_8 x P_{10}, P_9 x P_{10}indicating their adaptability under favorable environments and suitable for more ear girth.Data for kernel rows per cobrevealed that out of 45 hybrids, 18 hybrids showed non-significant deviation from regression hence their behavior was stable, while 27 hybrids showedsignificantdeviation from regression there by their behavior was unstable.

The hybrids,$P_1 \times P_7$, $P_4 \times P_5$, $P_5 \times P_{10}$indicating stable performance in different environments for more number of kernel rows per cob. The hybrid $P_2 \times P_6$had high number of kernels per row (36.66), while $P_8 \times P_9$ had low number of kernels per row (22.33). While, over the three environmentshybrids, $P_1 \times P_5$, $P_1 \times P_6$, $P_1 \times P_9$, $P_4 \times P_5$, $P_5 \times P_6$, $P_6 \times P_8$, $P_7 \times P_{10}$, $P_8 \times P_{10}$ showed their adaptability under favorable environments and suitable for more number of kernels per row.The mean value for seed index (100 seed weight) across three environments ranged from, 22.72to 28.43 g with mean value of 25.61 g. Minimum value was exhibited by hybrid $P_7 \times P_8$ (22.72 g)whereas, maximum kernels perrow was exhibited by hybrid$P_3 \times P_8$ (28.43 g). Among check HQPM-5 (26.88 g) The hybrids $P_1 \times P_7$, $P_2 \times P_6$, $P_3 \times P_5$, $P_4 \times P_6$, $P_4 \times P_8$, $P_4 \times P_9$, $P_4 \times P_{10}$, $P_5 \times P_6$, $P_5 \times P_8$, $P_5 \times P_7$, $P_7 \times P_8$, $P_7 \times P_9$showed non-significant deviation from regression (s^2di) had positive phenotypic index ($P_{i.} > 1$), and regression coefficient greater than unity ($\beta_i > 1$) indicating their adaptability under favorable environments and suitable with high yield potential.The highest F_1 $P_5 \times P_6$ with (256.62 qt/ha) and lowest F_1 $P_8 \times P_9$(103.90 qt/ha) mean values were recorded by the hybrids in three environments indicated by their higher mean yield, statistically unit regression and non-significant S^2di value (Eyherabide *et al.*,2016) $P_5 \times P_7$, $P_5 \times P_6$ and $P_4 \times P_9$ were not influenced much by the environment were promising for majority of characters studied with high mean performance across the environments these single cross hybrids, which are stable and prevalent for grain yield could be tried in enormous scope across conditions for their wide variation in diverse ecological regions. From this, we can stabilize the production level of the crop and it could work on the national production and efficiency since, in India production and productivity levels are low by in excess of 50% contrasted with world efficiency.

As per the physiological characters canopy temperature and leaf area index deficit and these makes a key role in heat stress tolerance in that hybrid $P_6 \times P_8$showedtheir adaptability under favorable environments and depicted low canopy temperature depression and hybrid$P_1 \times P_2$, $P_1 \times P_3$, $P_1 \times P_4$, $P_1 \times P_5$, $P_1 \times P_6$, $P_1 \times P_8$, $P_2 \times P_3$, $P_3 \times P_{10}$indicating their adaptability under favorable environments and depicted high chlorophyll content moreover, hybrids P_1

$_X P_5$, $P_{1\ X}\ P_6$, $P_{2\ X}\ P_7$, $P_{4\ X}\ P_5$, $P_{4\ X}\ P_6$, $P_{5\ X}\ P_6$, $P_{5\ X}\ P_8$, $P_{6\ X}\ P_9$, showed non-significant (s^2di) and regression coefficient lesser than unity ($\beta_i<1$), with mean values higher than the population mean, thereby indicating its adaptability under unfavorable environments for high leaf area index. In quality parameters like oil content and starch content revealed that out of 45 hybrids 3 hybrids showed non-significant deviation from regression (s^2di), indicating their stable behavior. Hybrids $P_{1\ X}\ P_7$, $P_{1\ X}\ P_8$ and $P_{3\ X}\ P_6$,with mean values higher than the population mean, thereby indicating its adaptability under unfavorable environments for high oil content. out of 45 hybrids, 31 hybrids showed non-significant deviation from regression (s^2di) hence their behavior was stable, while 14 hybrids showed significant deviation from regression (s^2di) there by their behavior was unstable. Hybrids $P_{3\ X}\ P_6$, $P_{5\ X}\ P_8$ and $P_{8\ X}\ P_9$indicating its adaptability under unfavorable environments for more amount of starch content whereas, hybrid $P_{6\ X}\ P_9$,showed non-significant deviation from and regression coefficient greater than unity ($\beta_i>1$) indicating their adaptability under favorable environments and depicted high starch percentage.

Table 3. Analysis of variance for diallel analysis (Model I and Method II) for eighteen quantitative and qualitative characters in maize

Source of variation	Df	Env	Days to 50% tasseling	Days to 50% silking	ASI	Plant height	Cob height	Tassel length	Ear length	Ear girth	Kernel row per cob	Kernels per row	LAI	Chlorophyll Content	CTD	Seed Index	Grain yield/ plant	Days to maturity	Oil content	Starch content
Replicate	2	E_1	42.62 ***	44.92 ***	0.65 *	2442.61 ***	736.86 **	14.49	0.10	1.55	14.04 *	50.35 *	2.69 ***	148.54 *	12.91 ***	5.65	20665.98 ***	0.55	0.05	1.32
		E_2	0.01	0.46	0.44	687.12	310.13	19.74	1.06 ***	4.52 **	29.19 **	194.96 ***	3.01 ***	125.94 **	94.81 ***	1.06	1733.81	0.99	0.01	003
		E_3	0.92	5.31	0.12	104.33	79.23	12.48	7.91 *	0.99	0.30	10.22	2.16 ***	112.18 *	33.85 ***	5.70	40.28	0.84	0.00	0.02
Treatments	54	E_1	9.12 ***	9.36 ***	0.28 *	853.37 ***	414.37 ***	89.16 ***	7.37 ***	2.50 ***	3.89	36.63 ***	0.60 ***	42.62	1.64	15.29***	2165.46*	26.28***	1.25 ***	59.65***
		E_2	8.42 ***	7.19 ***	0.24	1955.13 ***	765.89 ***	92.33 ***	8.38 *	2.60 ***	5.35	27.23 ***	0.47 ***	43.11 **	1.17	8.38 ***	877.93 *	14.30 ***	1.07 ***	65.51 ***
		E_3	26.73 ***	25.89 ***	0.36 *	657.38 ***	306.53 ***	57.33 ***	12.06 ***	2.09 ***	2.21 *	33.46 ***	0.41 ***	36.52 *	1.13 *	13.22 ***	356.23 ***	21.17 ***	1.08 ***	65.34 ***
Parents	9	E_1	4.67	5.86	0.83 ***	410.88 *	231.51 *	68.66 ***	11.64 ***	7.05 ***	4.76	45.57 **	0.61 *	90.52 *	1.31	17.23 ***	588.75	31.50***	0.53 ***	15.39***
		E_2	24.40 ***	25.72 ***	0.09	411.88	230.52	47.89 *	13.01 *	7.45 ***	3.91	29.35 **	0.67 **	90.36 ***	2.13 *	13.01 ***	687.24	23.44 ***	0.45 ***	19.09 ***
		E_3	19.43 ***	12.09 **	0.03	409.88 ***	230.90 ***	106.73 ***	11.32 ***	7.44 ***	3.90 **	29.30 **	0.65 ***	89.30 ***	2.10 **	15.68 ***	688.20 ***	23.40 ***	0.44 ***	17.51 ***
Hybrids	44	E_1	9.32 ***	9.30 ***	0.18	397.97 **	235.87 ***	39.46 ***	5.04 *	1.22 *	3.79	31.93 ***	0.26	30.66	1.74	9.04 ***	2120.54	25.60***	1.30 ***	69.40***
		E_2	3.37 **	2.73 **	0.26	1363.18 ***	587.96 ***	45.56 **	7.61	1.48 *	5.11	24.21 ***	0.19	31.17	6.76	7.61 ***	935.37 *	12.37 ***	1.12 ***	75.84 ***
		E_3	4.99 ***	5.75*	0.40 *	608.69 ***	243.87 ***	43.75 ***	11.86 ***	1.00 ***	1.76	24.72 ***	0.18	25.37	0.37	13.00 ***	168.73	10.04 ***	1.14 ***	76.18 ***
Parent vs hybrids	1	E_1	40.07 ***	43.39 ***	0.01	24873.18 ***	9913.87 ***	2460.57 ***	71.61 ***	17.51 ***	0.11	162.63 ***	15.69 ***	139.50	0.01	273.22 ***	18332.02 ***	9.50 **	5.60 ***	28.89***
		E_2	86.55 ***	75.33 ***	0.49	41899.23 ***	12404.10 ***	2550.00 ***	0.42 ***	7.83 **	28.71 *	141.38 ***	11.16 ***	142.92 *	1.74 **	0.42	67.07	17.05 **	4.39 ***	28.87 ***
		E_3	1048.90 ***	1035.86 ***	1.42 *	5018.52 ***	3739.18 ***	210.13	27.42 ***	1.73	6.60 *	454.63 ***	7.76 ***	42.70	25.69 ***	0.63	5627.40 ***	490.52 ***	4.28 ***	18.96 ***
Error	108	E_1	2.97	2.99	0.19	189.72	736.86	15.48	2.99	0.70	3.10	13.76	0.27	37.36	1.49	2.73	1466.44	0.93	0.02	0.82
		E_2	1.91	1.52	0.27	238.77	141.24	21.74	1.90	0.87	4.45	10.67	0.20	25.03	1.00	1.90	598.49	1.64	6.00	0.09
		E_3	2.22	3.82	0.24	96.51	63.13	10.22	1.91	0.48	1.50	9.42	0.17	24.66	0.68	2.43	146.66	2.22	0.01	0.02

Significant levels: * = <.05, ** = <.01 &*** = <.001

ASI: Anthesis-silking interval; LAI: Leaf area index; CTD: Canopy temperature deficit.

Table 4: Estimates of general combining ability (GCA) effects of ten parental inbred lines for eighteen quantitative and qualitative characters in maize.

S.NO	Parents	Env.	Days to 50% tasseling	Days to 50% silking	ASI	Plant height	Cob height	Tassel length	LAI	Chlorophyll content	CTD
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	P_1	E_1	1.161 ***	1.128 ***	0.01	6.294 **	6.528 ***	-0.224	0.012	-1.648	0.008
2		E_2	0.850 ***	0.661 ***	-0.117	10.671 ***	9.353 ***	-0.689	0.015	-1.803 *	-0.415 **
3		E_3	0.083	-0.139	-0.128	9.521 ***	7.691 ***	-1.144 *	0.06	-1.939 *	-0.174
4	P_2	E_1	-0.978 ***	-0.872 **	0.083	-6.187 **	-5.494 **	0.343	0.01	0.376	-0.228
5		E_2	-0.261	-0.089	0.133	-3.407	-6.421 ***	-0.419	0.016	0.487	0.152
6		E_3	-0.194	-0.222	0.067	-7.002 ***	-3.999 **	-1.144 *	-0.015	0.581	0.081
7	P_3	E_1	-0.728 **	-0.817 **	-0.083	-4.412 *	-4.832 **	0.028	-0.199 *	0.98	-0.228
8		E_2	-0.067	0.05	0.106	5.732 *	-1.477	-0.028	-0.170 *	1.076	0.249
9		E_3	0.944 ***	1.194 ***	0.067	-8.085 ***	-3.388 **	-1.506 **	-0.188 **	1.08	0.379 **
10	P_4	E_1	0.717 **	0.656 *	-0.056	-2.46	-3.086	0.841	-0.126	-0.735	-0.009
11		E_2	0.600 **	0.578 **	-0.033	3.743	-0.095	1.464 *	-0.089	-0.629	0.027
12		E_3	0.306	0.111	-0.1	-3.602 *	-0.7	1.078 *	-0.074	-0.689	0.062
13	P_5	E_1	-0.144	-0.122	-0.028	3.697	0.656	1.01	0.141	0.76	-0.106
14		E_2	0.294	0.272	-0.033	8.898 ***	5.516 **	0.714	0.148 *	0.513	-0.001
15		E_3	1.028 ***	0.833 **	-0.1	3.776 *	2.049	2.661 ***	0.168 *	0.784	-0.172
16	P_6	E_1	-0.45	-0.511	-0.028	-4.397 *	-0.516	-2.176 ***	0.035	-0.125	-0.014
17		E_2	0.156	0.05	-0.117	-11.907 ***	-5.882 **	-2.925 ***	-0.089	0.028	-0.104
18		E_3	0.194	0.278	-0.017	1.943	-1.293	0.328	-0.066	-0.457	-0.154
19	P_7	E_1	-0.644 *	-0.761 **	-0.083	1.742	2.889	0.688	0.025	1.577	0.205
20		E_2	-0.344	-0.311	0.05	-1.613	1.904	0.186	0.025	1.259	-0.009
21		E_3	-0.222	-0.361	0.039	5.571 ***	2.188	3.022 ***	0.015	1.141	0.163
22	P_8	E_1	1.050 ***	1.017 ***	-0.056	6.852 **	5.648 **	-0.076	0.026	0.308	0.283
23		E_2	0.544 *	0.661 ***	0.106	3.654	5.714 **	1.381	0.038	0.16	-0.024
24		E_3	0.167	0.25	0.178 *	2.976	1.192	-0.533	-0.012	0.389	-0.143
25	P_9	E_1	0.578 *	0.878 **	0.306 ***	1.682	1.675	-0.833	0.053	-1.137	0.099
26		E_2	-0.844 ***	-0.922 ***	-0.061	-5.168 *	-2.786	0.297	0.082	-0.932	0.057
27		E_3	-1.194 ***	-0.667 *	0.067	-4.541 **	-3.559 **	-0.367	0.071	-0.483	-0.013
28	- P_{10}	E_1	-0.561 *	-0.594 *	-0.056	-2.812	-3.467 *	0.398	0.023	-0.357	-0.009
29		E_2	-0.928 ***	-0.950 ***	-0.033	-10.602 ***	-5.826 **	0.019	0.023	-0.158	0.068
30		E_3	-1.111 ***	-1.278 ***	-0.072	-0.557	-0.181	-2.394 ***	0.041	-0.407	-0.029
	Gi <> 0 at 95%	E_1	0.617 ***	0.618 ***	0.154 ***	4.927 ***	3.778 ***	1.407 ***	0.184 ***	2.186 ***	0.437 ***
	Gi--Gj at 95%		0.920 ***	0.922 ***	0.230 ***	7.344 ***	5.632 ***	2.098 ***	0.275 ***	3.259 ***	0.651 ***
	Gi <> 0 at 95%	E_2	0.495 ***	0.441 ***	0.186 ***	5.527 ***	4.251 ***	1.668 ***	0.159 ***	1.790 ***	0.357 ***
	Gi--Gj at 95%		0.738 ***	0.658 ***	0.277 ***	8.239 ***	6.337 ***	2.486 ***	0.237 ***	2.668 ***	0.533 ***
	Gi <> 0 at 95%	E_3	0.533 ***	0.699 ***	0.175 ***	3.514 ***	2.842 ***	1.143 ***	0.149 ***	1.776 ***	0.295 ***
	Gi--Gj at 95%		0.795 ***	1.041 ***	0.260 ***	5.238 ***	4.236 ***	1.704 ***	0.223 ***	2.648 ***	0.440 ***

Significant levels: * = <.05, ** = <.01 &*** = <.001

ASI: Anthesis-silking interval; LAI: Leaf area index; CTD: Canopy temperature deficit.

(continue)Table 4: Estimates of general combining ability (GCA) effects of ten parental inbred lines for eighteen quantitative and qualitative characters in maize

S.NO	Parents	Env.	Ear length	Ear girth	Kernels rows per cob	Kernels per row	Seed Index	Seed yield per plant	Days to maturity	Oil content	Starch content
1		E_1	-0.488	-0.254	0.244	-0.972	0.925 ***	-16.433 **	-0.206	-0.248 ***	0.710 ***
2	P_1	E_2	0.26	-0.051	-0.15	1.517 **	-0.018	5.414	0.544 **	-0.275 ***	0.888 ***
3		E_3	-0.651 **	-0.422 ***	0.078	0.017	-0.697 **	-2.004	1.039 ***	-0.296 ***	0.682 ***
4		E_1	0.814 **	0.845 ***	-0.2	1.167 *	0.644 *	-3.651	0.572 ***	0.182 ***	-2.776 ***
5	P_2	E_2	-0.079	0.909 ***	0.767 *	-0.9	0.647 **	2.317	-0.233	0.165 ***	-2.887 ***
6		E_3	-1.131 ***	0.708 ***	0.522 **	1.350 **	-0.232	2.837	-1.128 ***	0.176 ***	-2.837 ***
7		E_1	-0.766 **	-0.422 **	-0.533	-0.75	1.013 ***	0.824	-1.428 ***	-0.021	1.241 ***
8	P_3	E_2	-0.429	-0.287	-0.372	-1.206 *	0.179	-1.635	-0.761 ***	-0.002	1.550 ***
9		E_3	0.259	0.004	-0.172	0.794	0.272	-2.241	-0.35	0.011 *	1.262 ***
10		E_1	0.437	-0.013	-0.033	0.25	-0.638 *	7.883	-0.567 ***	0.042	-0.388 **
11	P_4	E_2	0.184	0.087	0.378	0.517	-0.883 ***	5.923	-0.344	0.012	-0.277 ***
12		E_3	0.723 **	0.329 **	0.244	1.211 *	0.036	6.586 ***	-0.322	0.004	-0.07
13		E_1	0.462	0.525 ***	-0.144	0.444	-0.284	14.405 *	-0.900 ***	0.308 ***	-0.112
14	P_5	E_2	1.012 **	0.256	-0.261	0.1	0.336	0.519	0.072	0.304 ***	-0.120 *
15		E_3	1.458 ***	0.402 ***	0.022	0.683	0.066	-1.211	-0.1	0.300 ***	-0.215 **
16		E_1	0.253	-0.163	0.244	3.194 ***	-1.005 ***	8.394	0.739 ***	-0.252 ***	1.099 ***
17	P_6	E_2	-0.37	-0.558 ***	-0.178	1.794 ***	-0.369	1.68	0.35	-0.239 ***	0.756 ***
18		E_3	-0.372	-0.312 **	-0.394 *	-0.094	-0.227	-1.861	0.511 *	-0.250 ***	0.855 ***
19		E_1	0.513	-0.159	-0.311	0.167	-0.067	1.919	-0.011	0.015	-2.040 ***
20	P_7	E_2	0.274	-0.104	-0.344	0.378	0.372	0.571	-0.289	0.019	-2.310 ***
21		E_3	0.224	-0.092	-0.033	-0.317	-0.15	-0.016	-0.433	0.028 ***	-2.199 ***
22		E_1	-0.801 **	-0.216	-0.644 *	0.528	-0.011	-3.537	1.683 ***	0.026	0.736 ***
23	P_8	E_2	-0.11	-0.229	-0.539	1.100 *	0.266	-1.869	1.128 ***	-0.006	0.345 ***
24		E_3	-0.332	-0.330 **	-0.228	0.1	0.650 **	-1.365	1.206 ***	0.002	0.802 ***
25		E_1	-0.154	-0.088	0.522	-1.639 **	-0.611 *	-2.906	-0.178	0.182 ***	0.890 ***
26	P_9	E_2	-0.186	-0.071	0.433	-1.622 **	-0.228	-6.327	0.156	0.208 ***	1.329 ***
27		E_3	-0.22	-0.17	0.022	-2.067 ***	0.093	-0.308	0.011	0.198 ***	0.863 ***
28		E_1	-0.27	-0.056	0.856 **	-2.389 ***	0.034	-6.898	0.294	-0.233 ***	0.639 ***
29	- P_{10}	E_2	-0.557	0.049	0.267	-1.678 **	-0.302	-6.592	-0.622 **	-0.186 ***	0.726 ***
30		E_3	0.043	-0.118	-0.061	-1.678 ***	0.188	-0.416	-0.433	-0.174 ***	0.856 ***
	Gi <> 0 at 95%	E_1	0.618 ***	0.299 ***	0.630 ***	1.327 ***	0.591 ***	13.697 ***	0.345 ***	0.049 ***	0.324 ***
	Gi--Gj at 95%		0.921 ***	0.446 ***	0.938 ***	1.978 ***	0.881 ***	20.418 ***	0.514 ***	0.073 ***	0.482 ***
	Gi <> 0 at 95%	E_2	0.832 ***	0.333 ***	0.754 ***	1.168 ***	0.492 ***	8.750 ***	0.458 ***	0.022 ***	0.108 ***
	Gi--Gj at 95%		1.241 ***	0.497 ***	1.124 ***	1.741 ***	0.734 ***	13.044 ***	0.683 ***	0.033 ***	0.161 ***
	Gi <> 0 at 95%	E_3	0.495 ***	0.244 ***	0.438 ***	1.098 ***	0.558 ***	4.332 ***	0.533 ***	0.012 ***	0.167 ***
	Gi--Gj at 95%		0.737 ***	0.363 ***	0.653 ***	1.636 ***	0.831 ***	6.457 ***	0.794 ***	0.018 ***	0.249 ***

Significant levels: * = <.05, ** = <.01 &*** = <.001

ASI: Anthesis-silking interval; LAI: Leaf area index; CTD: Canopy temperature deficit.

Table 5. Specific combining ability (SCA) effects for different characters in maize over three environments

S.NO	Hybrids	Env.	Days to 50%tasselling	Days to 50%Silking	ASI	Plant height	Ear height	Tassel length	LAI	Chlorophyll content	CTD
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	P_1 X P_2	E_1	0.629	0.399	-0.265	1.558	-2.404	1.52	-0.007	1.4	1.753 **
		E_2	-0.753	-0.639	0.068	-7.344	3.688	2.136	0.736 **	1.923	0.368
		E_3	-0.404	-0.487	-0.169	-7.763	-10.855*	5.495 **	0.727 **	0.813	0.46
2	P_1 X P_3	E_1	0.712	0.677	-0.098	10.149	2.933	-5.049 *	-0.041	-2.184	-1.213
		E_2	-0.28	-0.444	-0.237	10.184	-7.257	-1.223	0.408	-2.615	0.004
		E_3	-0.543	-0.904	-0.169	2.32	-7.466	0.856	0.443	-3.472	-0.171
3	P_1 X P_4	E_1	-0.732	-0.795	-0.126	12.061	5.655	0.705	0.262	1.331	1.267
		E_2	-0.947	-0.972	-0.098	16.173	9.695	7.519 **	0.451	-0.654	-0.641
		E_3	-0.947	-0.972	-0.098	16.173	9.695	7.519 **	0.451	-0.654	-0.641
4	P_1X P_5	E_1	-0.205	0.649	0.513 *	-3.846	-4.487	1.987	-0.108	-1.274	-0.702
		E_2	-0.641	-0.333	0.235	0.684	-3.916	-2.731	-0.03	-1.339	0.654
		E_3	0.707	0.79	-0.003	1.459	4.43	-4.977 **	-0.015	-1.866	0.06
5	P_1 X P_6	E_1	0.101	0.371	0.179	11.681	8.594	4.725 *	-0.252	-0.643	-0.027
		E_2	-0.169	-0.111	-0.015	14.823	12.149	5.241 *	-0.172	0.469	0.19
		E_3	1.874 *	1.679	-0.086	4.292	8.773 *	2.023	-0.048	0.475	-0.038
6	P_1 X P_7	E_1	0.629	-0.045	-0.098	4.353	13.700 *	3.242	0.068	4.175	0.12
		E_2	-0.336	-1.083	-0.182	0.862	-3.638	7.463 **	-0.056	3.052	-0.505
		E_3	2.290 **	2.652 *	0.192	6.665	7.292	-3.338	-0.186	3.23	-0.155
7	P_1 X P_8	E_1	0.934	1.177	0.207	12.799	7.897	4.782 *	0.616 *	1.298	-0.558
		E_2	1.109	1.278	0.096	46.928***	27.219***	5.602 *	0.001	0.367	-0.656
		E_3	1.235	1.374	0.053	14.592 **	6.621	2.217	0.065	0.189	-0.082
8	P_1 X P_9	E_1	1.407	0.982	-0.154	12.169	14.327 *	3.516	0.503	-0.487	-0.908
		E_2	1.164	1.194	0.263	2.417	4.72	3.352	0.11	0.396	-0.137
		E_3	2.596 **	1.957	-0.169	10.442	3.038	1.051	0.084	0.481	-0.079
9	P_1 X P_{10}	E_1	-0.455	-0.212	0.207	27.296***	20.218***	13.131 ***	0.576 *	-0.864	0.234
		E_2	0.581	0.556	-0.098	36.517***	40.426***	-3.37	0.005	0.582	0.318
		E_3	1.179	1.235	-0.03	-18.874***	-4.006	1.412	-0.032	0.892	-0.196
10	P_2 X P_3	E_1	1.184	1.01	-0.182	16.987 *	11.575 *	2.155	0.987 ***	4.858	-0.711
		E_2	1.497 *	0.972	-0.487	12.928	12.851 *	7.074 **	0.511 *	3.181	-0.562
		E_3	0.735	0.513	-0.03	-7.158	-6.442	5.856 **	0.508 *	2.518	-0.094
11	P_2 X P_4	E_1	-1.927 *	-1.795	0.124	-5.232	6.096	-0.111	0.554 *	-0.417	-0.13
		E_2	-1.169	-0.889	0.318	19.250 *	-5.532	3.916	-0.023	0.196	-0.241
		E_3	1.04	0.929	-0.197	23.026 ***	16.203***	2.273	-0.016	0.337	-0.743
12	P_2X P_5	E_1	-0.732	-0.351	0.429	-4.012	-8.979	0.943	0.083	1.122	-0.533
		E_2	-1.197	-1.25	-0.015	-10.572	-9.809	-4.667	0.036	1.981	0.221
		E_3	0.985	0.874	-0.197	1.981	2.454	3.356	-0.244	1.764	-0.176
13	P_2 X P_6	E_1	0.573	0.371	-0.237	5.615	7.106	4.359 *	0.05	3.697	-0.358
		E_2	-0.725	-0.361	0.402	5.901	14.590 *	0.638	0.041	3.756	-0.876
		E_3	0.152	0.096	0.053	3.815	0.13	4.356 *	-0.027	4.018	-0.293
14	P_2 X P_7	E_1	-1.899 *	-2.045 *	-0.182	9.676	7.188	4.095	0.12	-5.915	0.256
		E_2	-1.891 *	-1.333 *	0.235	22.606 **	9.803	2.194	0.273	-7.352 **	-0.005
		E_3	1.235	1.068	-0.336	-9.146	0.316	5.995 ***	0.225	-6.936 *	-0.241
15	P_2 X P_8	E_1	-0.927	-0.823	0.124	21.646 **	8.386	4.642 *	0.308	0.134	-1.088
		E_2	-1.114	-0.972	0.179	17.673 *	3.993	7.333 **	0.106	1.137	-0.123
		E_3	1.179	1.79	0.525 *	6.781	-5.689	-3.783 *	0.143	1.135	-0.488
16	P_2 X P_9	E_1	0.879	1.316	0.429	10.449	5.625	-0.258	0.065	-3.754	1.295
		E_2	-0.391	-0.056	0.346	14.162	6.827	6.749 **	0.386	-3.294	0.029

		E_3	2.207 **	2.04	0.303	-7.035	-0.605	0.051	0.403	-2.979	-0.011
17	P_2 X P_{10}	E_1	0.684	0.455	-0.21	5.876	4.04	4.281 *	0.045	2.709	0.803
		E_2	0.359	0.306	-0.015	14.595	3.866	3.694	-0.016	2.799	0.318
		E_3	1.790 *	2.652 *	0.775 **	-20.685 ***	-3.982	-7.255 ***	0.023	2.245	-0.155
18	P_3 X P_4	E_1	2.157 *	2.149 *	-0.043	14.483	9.1	2.17	-0.116	1.026	-0.23
		E_2	-1.364	-1.028	0.346	-13.555	-6.143	1.858	-0.067	0.484	-0.571
		E_3	2.568 **	2.179 *	-0.197	8.442	-6.074	-0.366	0.027	0.355	-0.541
19	P_3X P_5	E_1	0.684	0.593	-0.071	-7.54	-1.442	4.288 *	0.51	0.674	0.334
		E_2	-1.058	-1.056	0.013	25.956 **	4.58	4.608	0.492 *	1.436	0.324
		E_3	3.513 ***	3.457 **	0.136	4.731	4.176	-1.949	0.479 *	1.022	0.36
20	P_3 X P_6	E_1	-2.677 **	-3.018 **	-0.071	-4.58	-4.557	4.967 *	0.21	2.449	0.776
		E_2	-2.919 ***	-2.833 ***	0.096	11.428	2.978	1.247	-0.097	2.577	-0.073
		E_3	0.013	3.346 **	0.386	3.231	3.852	-0.616	-0.08	3.189	-0.435
21	P_3 X P_7	E_1	0.184	0.566	0.318	3.791	-2.828	4.876 *	0.33	-1.81	0.289
		E_2	-0.419	-0.806	-0.404	34.801 ***	19.858 **	1.802	-0.164	-0.987	-0.702
		E_3	3.429 ***	2.985 **	-0.336	-10.063	-6.629	0.023	-0.145	-0.735	-0.642
22	P_3 X P_8	E_1	-2.177 *	-1.879 *	0.29	14.511	3.857	1.533	-0.149	-2.084	0.145
		E_2	-1.641 *	-1.111	0.54	27.867 **	24.382 ***	2.274	0.262	-1.354	-0.787
		E_3	0.707	0.374	-0.141	1.531	-1.967	-1.088	-0.014	-1.043	-0.836
23	P_3 X P_9	E_1	-2.705 **	-2.740 **	-0.071	14.294	5.829	3.817	0.295	-0.885	-0.272
		E_2	0.747	0.806	0.04	17.356 *	2.549	2.691	0.335	-0.543	-0.535
		E_3	1.402	1.29	0.636 *	-24.285 ***	-6.216	-0.588	0.175	-0.301	-0.499
24	P_3 X P_{10}	E_1	-1.899 *	-1.934 *	-0.043	0.901	4.147	6.212 **	-0.219	1.134	0.703
		E_2	0.164	0.5	0.346	-7.877	-6.412	-1.698	0.067	1.43	0.154
		E_3	1.652 *	1.235	-0.225	-5.935	8.073	0.773	0.099	0.303	0.04
25	P_4X P_5	E_1	-0.427	-0.545	-0.098	17.508 *	-2.097	4.275 *	0.163	-3.337	0.948
		E_2	-1.725 *	-1.583 *	0.152	19.945 *	6.865	2.449	0.201	-2.42	0.112
		E_3	0.485	0.54	-0.03	-20.085 ***	-8.845 *	-5.199 **	0.158	-3.192	-0.003
26	P_4 X P_6	E_1	0.545	0.843	0.568 *	-5.866	-3.992	3.261	0.126	0.541	0.023
		E_2	-0.586	-0.694	-0.098	3.417	7.263	3.088	0.276	-0.195	0.548
		E_3	-0.682	-0.904	-0.114	-12.585 *	-6.836	-0.199	0.229	-0.498	0.226
27	P_4 X P_7	E_1	1.073	1.093	-0.043	-1.704	5.003	2.417	0.313	1.292	1.337 *
		E_2	0.247	0.667	0.402	12.789	1.476	-2.356	0.338	2.794	-0.273
		E_3	0.402	1.402	0.831 **	-17.880 **	-8.983 *	-4.561 *	0.274	3.001	-0.071
28	P_4 X P_8	E_1	0.045	-0.018	-0.071	6.952	1.511	1.04	0.294	3.075	0.126
		E_2	0.025	-0.306	-0.321	8.523	2.666	4.116	0.085	2.893	0.068
		E_3	0.013	-0.21	-0.308	-10.619 *	-5.654	-1.338	0.112	2.842	-0.289
29	P_4 X P_9	E_1	-0.482	-0.545	-0.098	14.656	6.35	-3.379	0.325	6.056	-1.258
		E_2	0.081	-0.056	-0.154	19.345 *	6.167	3.199	0.401	6.138 *	-0.713
		E_3	1.707 *	1.04	-0.197	-5.102	1.096	0.162	0.388	5.678 *	-0.766
30	P_4 X P_{10}	E_1	0.99	0.927	-0.071	-16.851 *	-8.618	-9.253 ***	-0.442	2.806	-1.316 *
		E_2	0.164	-0.028	-0.182	-9.555	13.873 *	-3.189	-0.214	3.608	0.209
		E_3	2.290 **	2.318 *	-0.058	-21.752 ***	-15.615***	-2.477	-0.255	3.185	0.067
31	P_5 X P_6	E_1	0.073	-0.045	-0.126	1.445	9.399	-2.811	-0.004	3.279	-0.347
		E_2	-1.28	-1.389 *	-0.098	13.595	4.986	2.505	-0.092	3.54	-0.557
		E_3	2.596 **	2.374 *	-0.114	-19.963 ***	-16.585 ***	-5.116 **	0.204	3.822	-0.236
32	P_5 X P_7	E_1	0.268	0.205	-0.071	8.173	-2.628	-3.985	0.283	-0.886	-0.033
		E_2	0.553	0.306	-0.265	3.634	9.199	-0.273	0.168	-0.044	0.048
		E_3	-0.321	-0.321	-0.169	-16.591 **	-12.400 **	3.523 *	0.15	0.318	-0.49
33	P_5 X P_8	E_1	-1.427	-1.24	0.235	6.329	4.236	0.938	0.031	-3.543	0.189
		E_2	-1.669 *	-2.000 **	-0.321	11.034	14.056 *	-2.134	0.184	-3.505	-0.27
		E_3	0.957	1.402	0.359	-6.33	-17.737 ***	4.078 *	0.187	-3.11	-0.251

34	P_5 X P_9	E_1	-1.288	-1.768	-0.46	11.232	9.408	1.889	0.291	-5.585	-0.127
		E_2	0.386	0.583	0.179	16.856 *	7.89	2.283	0.124	-8.410 **	0.582
		E_3	1.318	0.985	0.136	4.52	-4.32	0.912	0.107	-6.685 *	0.379
35	P_5 X P_{10}	E_1	-0.482	-0.629	-0.098	4.143	-1.427	2.881	-0.206	3.788	-0.686
		E_2	0.803	0.611	-0.182	-11.377	-7.071	4.894	-0.191	2.059	0.138
		E_3	1.568	1.596	-0.058	8.537	3.303	3.606 *	-0.24	0.516	0.335
36	P_6 X P_7	E_1	-1.427	-1.073	0.263	3.05	5.39	2.867	0.523	4.738	-0.624
		E_2	-0.641	-0.806	-0.182	-11.894	1.264	-1.967	0.292	4.541	-0.116
		E_3	0.846	-0.432	-0.253	-0.091	-6.057	-4.144 *	0.263	0.989	0.392
37	P_6 X P_8	E_1	2.212 *	2.149 *	-0.098	-1.411	3.931	1.464	0.384	-2.689	0.998
		E_2	0.47	0.222	-0.237	-25.827 **	-18.546 **	-2.828	0.092	-2.047	-0.334
		E_3	1.457	1.29	-0.058	-8.163	-2.061	8.412 ***	-0.222	-2.513	-0.316
38	P_6 X P_9	E_1	0.684	0.288	-0.46	-0.031	3.337	0.961	0.008	5.613	0.814
		E_2	0.859	0.806	-0.071	-13.005	-2.379	-4.078	0.228	5.921 *	0.785
		E_3	0.818	0.54	0.386	-7.98	-1.644	0.912	0.207	4.909	0.134
39	P_6 X P_{10}	E_1	-1.51	-1.24	0.235	3.153	4.205	-3.307	0.117	5.339	-0.044
		E_2	-0.725	-0.5	0.235	0.095	-5.006	0.533	-0.08	4.421	0.74
		E_3	2.068 *	2.152 *	0.192	0.37	-2.354	1.939	-0.129	4.863	0.081
40	P_7 X P_8	E_1	-0.927	-0.934	-0.043	8.251	7.226	1.223	-0.223	-0.671	-0.488
		E_2	-1.697 *	-1.083	0.596 *	-26.455 **	-8.333	-1.939	0.014	-0.911	0.838
		E_3	-1.793 *	-0.737	0.886 **	1.876	2.124	1.717	0.066	-1.41	-0.353
41	P_7 X P_9	E_1	0.212	-0.129	-0.404	-3.593	0.399	0.344	0.121	-4.449	-0.772
		E_2	-0.641	-0.833	-0.237	0.034	3.835	2.811	0.294	-4.813	-0.743
		E_3	1.568	0.846	-0.336	10.726 *	-3.792	1.884	0.306	-5.135	-0.373
42	P_7 X P_{10}	E_1	-2.316 *	-1.990 *	0.29	1.081	-1.526	0.126	-0.186	-0.306	-0.263
		E_2	-0.225	-0.139	0.068	-1.199	-0.126	3.088	0.012	-1.34	-0.655
		E_3	1.152	1.457	0.136	7.409	4.164	4.578 **	-0.004	-0.644	-0.083
43	P_8 X P_9	E_1	0.184	-0.24	-0.432	12.72	-0.473	4.861 *	0.129	0.857	-0.616
		E_2	0.136	-0.139	-0.293	19.434 *	11.025	3.949	0.194	0.1	-0.362
		E_3	1.513	1.235	0.192	-14.346 **	-9.129 *	1.773	0.19	-0.083	-0.487
44	P_8 X P_{10}	E_1	-0.677	-0.768	-0.071	-0.143	0.335	-1.664	-0.268	2.853	0.826
		E_2	-1.114	-1.111	0.013	5.201	-13.936 *	5.227 *	0.052	2.003	-0.873
		E_3	1.096	0.846	-0.336	5.337	-0.507	-1.199	0.08	1.804	-0.464
45	P_9 X P_{10}	E_1	-0.205	-0.295	-0.098	6.274	2.887	1.24	-0.061	-4.955	0.242
		E_2	2.609 ***	2.806 ***	0.179	-10.311	-5.435	0.311	-0.458	-2.216	-0.754
		E_3	2.457 **	1.763	-0.225	10.854 *	-4.756	1.967	-0.473 *	-2.604	-1.017 *
	Sij <> 0 at 95%	E_1	1.849	1.853	0.462	14.763	11.322	4.217	0.552	6.551	1.308
	Sij--Sik at 95%		2.718	2.724	0.678	21.701	16.642	6.199	0.811	9.63	1.923
	Sij--Skl at 95%		2.591	2.597	0.647	20.691	15.868	5.91	0.774	9.182	1.834
	Sij <> 0 at 95%	E_2	1.483	1.322	0.557	16.562	12.738	4.998	0.477	5.363	1.071
	Sij--Sik at 95%		2.179	1.944	0.818	24.345	18.724	7.346	0.701	7.883	1.574
	Sij--Skl at 95%		2.078	1.853	0.78	23.212	17.852	7.004	0.668	7.516	1.501
	Sij <> 0 at 95%	E_3	1.598	2.094	0.524	10.529	8.516	3.426	0.448	5.322	0.884
	Sij--Sik at 95%		2.349	3.077	0.77	15.477	12.518	5.035	0.658	7.824	1.299
	Sij--Skl at 95%		2.24	2.934	0.734	14.757	11.936	4.801	0.628	7.46	1.239

Significant levels: * = <.05, ** = <.01 &*** = <.001

ASI: Anthesis-silking interval; LAI: Leaf area index; CTD: Canopy temperature deficit.

(continue)Table 5. Specific combining ability (SCA) effects for different characters in maize over three environments

S.NO	Hybrids	Env.	Ear length	Ear girth	Number of grain rows per cob	Number of grains per row	Seed index	Seed yield per plant	Days to maturity	oil content (%)	Starch content (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(12)	
1	P_1 X P_2	E_1	-0.372	0.717	-0.566	-2.801	0.801	3.642	-1.409 **	-0.674 ***	2.488 ***
		E_2	0.965	0.112	-1.902	2.22	0.219	-1.167	-0.293	-0.602 ***	3.037 ***
		E_3	2.518 **	-0.291	-1.242	-4.045 *	0.072	-2.748	1.798 *	-0.566 ***	1.690 ***
2	P_1 X P_3	E_1	1.341	0.77	1.101	2.449	-0.667	-2.067	-0.742	0.122	-0.072
		E_2	2.816 *	0.718	-0.096	4.525 *	1.387	12.985	0.568	0.148 ***	0.497 **
		E_3	3.254 ***	0.373	0.119	-1.823	0.568	-2.123	1.687 *	0.187 ***	0.41
3	P_1 X P_4	E_1	0.204	-0.269	-1.399	-3.551	3.416 ***	-11.792	1.730 **	0.856 ***	2.071 ***
		E_2	-0.131	-0.979	-1.513	2.47	0.949	8.428	0.152	0.383 ***	1.997 ***
		E_3	-0.092	-0.961 *	-0.965	-2.24	-0.528	-6.143	0.659	0.367 ***	1.553 ***
4	P_1X P_5	E_1	-0.887	-1.021 *	0.712	-1.078	0.996	-44.082 *	-3.270 ***	-0.740 ***	-0.426
		E_2	-0.792	-0.348	0.46	-2.114	0.917	3.798	-1.265	-0.732 ***	1.010 ***
		E_3	-2.981 ***	-0.035	-0.076	-3.045	1.795 *	-3.579	-1.23	-0.773 ***	0.851 **
5	P_1 X P_6	E_1	0.322	0.641	0.99	0.838	1.964 *	-2.27	-4.576 ***	0.11	5.376 ***
		E_2	-0.744	-0.011	1.71	-1.475	-0.998	-18.98	-4.210 ***	0.118 ***	5.693 ***
		E_3	-0.898	-0.278	0.341	1.399	-0.272	-7.279	-2.174 **	0.044 *	5.718 ***
6	P_1 X P_7	E_1	-1.138	-0.827	-1.121	-2.134	-0.654	-13.696	-4.826 ***	0.157 *	-4.377 ***
		E_2	0.113	0.245	-0.124	-1.058	-0.639	17.747	-4.571 ***	0.191 ***	-5.107 ***
		E_3	0.957	0.089	0.646	0.621	-0.253	-4.438	-2.230 **	0.202 ***	-5.215 ***
7	P_1 X P_8	E_1	1.376	1.131 *	1.879	1.838	-1.486	18.694	0.813	-0.258 ***	7.506 ***
		E_2	3.663 **	1.259 *	2.071	3.553 *	-1.600 *	26.887 *	2.679 ***	-0.158 ***	8.751 ***
		E_3	2.016 **	0.544	0.841	-0.462	-1.423	-2.725	3.465 ***	-0.202 ***	9.054 ***
8	P_1 X P_9	E_1	1.062	0.149	-0.621	1.672	-3.023 **	3.07	2.008 ***	-0.117	-3.961 ***
		E_2	-0.594	0.536	1.765	-1.725	-1.406	-54.056 ***	1.985 **	0.008	-5.649 ***
		E_3	-1.106	0.017	1.258	0.038	-1.686 *	-15.783 *	1.659 *	0.023	-5.230 ***
9	P_1 X P_{10}	E_1	3.145 **	0.484	-0.288	4.088 *	1.945 *	21.322	3.535 ***	-0.242 **	-6.441 ***
		E_2	2.777 *	0.692	0.932	1.997	0.802	29.686 *	1.763 *	-0.298 ***	-7.512 ***
		E_3	-0.337	-0.078	0.674	0.982	-0.614	12.992 *	1.104	-0.315 ***	-7.110***
10	P_2 X P_3	E_1	1.505	0.581	-0.455	0.311	-1.12	3.069	-1.854 ***	0.862 ***	7.891 ***
		E_2	1.855	1.648 **	-0.346	0.275	-1.012	25.415	0.346	0.745 ***	8.395 ***
		E_3	0.065	0.427	-0.326	1.51	0.903	-2.025	3.187 ***	0.765 ***	9.065 ***
11	P_2 X P_4	E_1	0.702	-0.448	-0.955	-0.023	0.89	-15.674	2.619 ***	-0.707 ***	-2.437 ***
		E_2	-0.792	-0.973	0.237	-2.78	0.35	-21.942	1.596 *	-0.516 ***	-1.342 ***
		E_3	-2.229 **	-0.318	-1.409 *	-0.24	0.073	-19.361 **	1.159	-0.499 ***	-1.899 ***
12	P_2X P_5	E_1	-2.256 *	-1.133 *	-0.177	-0.217	1.11	-35.33	-0.381	0.680 ***	-2.206 ***
		E_2	-2.386	-1.398 **	-0.124	-3.03	-0.835	-14.506	0.513	0.762 ***	-2.818 ***
		E_3	-2.498 **	-1.331 ***	0.813	-0.379	-1.824 *	-16.314 *	-0.063	0.805 ***	-2.584 ***
13	P_2 X P_6	E_1	0.92	-0.278	-0.566	0.699	-2.002 *	2.215	-0.354	-0.400 ***	-2.994 ***
		E_2	0.862	-0.361	-1.207	0.275	-1.897 *	-4.7	0.902	-0.298 ***	-2.358 ***
		E_3	-1.151	-0.731 *	-0.104	2.066	-4.131 ***	-7.404	0.992	-0.234 ***	-2.720 ***
14	P_2 X P_7	E_1	0.76	0.255	1.323	3.727	0.793	15.123	-0.937	0.853 ***	-2.438 ***
		E_2	-2.381	0.141	-0.374	-4.975 **	-0.372	-22.423	-0.126	0.751 ***	-3.399 ***
		E_3	-2.736 ***	-0.66	0.202	-3.379 *	-1.875 *	-2.616	-0.396	0.737 ***	-2.677 ***
15	P_2 X P_8	E_1	2.107 *	-0.291	-0.343	2.033	1.437	12.379	1.035 *	1.189 ***	-2.417 ***
		E_2	2.502 *	0.833	1.487	-0.364	1.035	-4.65	0.79	0.829 ***	-1.997 ***
		E_3	0.516	-0.755 *	0.396	0.871	-0.741	-1.277	-0.369	0.787 ***	-1.748 ***
16	P_2 X P_9	E_1	0.293	0.627	1.823	2.199	0.404	-4.185	0.563	-0.810 ***	-1.059 *
		E_2	0.479	-0.138	2.848 *	1.692	-1.572 *	11.208	1.429 *	-0.855 ***	-2.084 ***

		E_3	0.808	0.337	0.146	-2.962	-2.051 *	6.099	0.492	-0.836 ***	-1.975 ***
17	P_2 X P_{10}	E_1	-2.290 *	-0.825	0.157	-3.384	1.925 *	-7.96	1.758 **	-0.472 ***	-4.154 ***
		E_2	-0.384	-0.768	2.348 *	1.414	1.670 *	2.373	1.207	-0.377 ***	-5.377 ***
		E_3	0.117	0.256	0.896	-0.684	1.720 *	-10.149	1.937 *	-0.450 ***	-4.995 ***
18	P_3 X P_4	E_1	0.015	-0.678	0.045	0.894	2.168 *	-30.049	3.952 ***	-0.088	-1.293 *
		E_2	0.692	-0.43	0.043	0.525	-0.389	-12.89	2.457 ***	0.007	-2.081 ***
		E_3	-2.652 ***	-0.454	-0.715	0.649	0.396	-5.94	3.715 ***	0.027	-3.108 ***
19	P_3X P_5	E_1	1.991 *	0.327	-0.51	2.033	-1.759	15.852	4.619 ***	-0.594 ***	-2.070 ***
		E_2	2.231	-0.279	0.682	-0.725	-1.268	0.747	1.04	-0.665 ***	-3.014 ***
		E_3	2.035 **	-0.408	-0.492	-2.157	-1.791 *	5.86	0.826	-0.686 ***	-3.677 ***
20	P_3 X P_6	E_1	0	0.036	-0.899	-1.717	3.519 ***	23.077	3.980 ***	0.202 **	6.916 ***
		E_2	-0.554	0.701	1.932	-3.086	4.038 ***	-2.748	1.763 *	0.172 ***	7.079 ***
		E_3	2.202 **	1.050 **	2.591 ***	-0.712	0.962	-2.326	0.881	0.165 ***	7.023 ***
21	P_3 X P_7	E_1	-0.993	0.598	-0.343	-1.689	0.018	17.118	-0.604	-0.371 ***	-2.845 ***
		E_2	2.136	-0.073	0.098	3.997 *	-0.437	8.262	1.402 *	-0.399 ***	-2.869 ***
		E_3	3.313 ***	0.627	0.23	-1.823	-3.519 ***	7.155	2.492 **	-0.401 ***	-2.453 ***
22	P_3 X P_8	E_1	1.387	1.289 **	-0.01	-0.717	-0.265	24.897	2.035 ***	1.172 ***	-4.431 ***
		E_2	1.352	0.949	0.293	-1.391	0.202	23.102	-1.015	1.179 ***	-4.280 ***
		E_3	1.199	0.809 *	-0.242	1.093	6.221 ***	8.971	-1.48	1.109 ***	-5.727 ***
23	P_3 X P_9	E_1	1.007	0.35	1.49	3.116	-0.168	27.92	-2.104 ***	-0.244 **	-3.552 ***
		E_2	-0.704	0.071	-1.346	-0.336	-1.17	-14.507	-2.043 **	-0.199 ***	-3.547 ***
		E_3	-0.076	0.768 *	0.174	2.927	-0.555	-6.18	-1.952 *	-0.143 ***	-2.628 ***
24	P_3 X P_{10}	E_1	0.09	0.262	1.157	-0.467	0.94	-1.968	-3.576 ***	0.174 *	0.682
		E_2	-1.367	0.408	1.154	0.386	-0.596	-7.108	-2.265 **	0.163 ***	1.123 ***
		E_3	0.77	0.326	-0.742	1.538	-1.317	-0.038	0.492	0.145 ***	1.516 ***
25	P_4X P_5	E_1	-0.012	0.218	-1.01	4.366 *	1.891 *	28.263	-1.576 **	1.323 ***	-3.897 ***
		E_2	-0.382	-0.386	-1.402	2.22	0.761	-6.078	-1.376 *	1.251 ***	-4.401 ***
		E_3	0.582	-0.499	-0.909	-1.573	1.042	-1.182	0.798	1.251 ***	-4.328 ***
26	P_4 X P_6	E_1	-1.037	0.226	-0.066	-3.051	-0.797	2.744	-1.215 *	-0.271 ***	5.775 ***
		E_2	-0.768	0.671	0.515	-1.808	-0.433	-15.339	-1.654 *	-0.206 ***	7.042 ***
		E_3	1.019	0.855 *	0.174	0.871	2.335 **	-9.409	-1.146	-0.189 ***	6.653 ***
27	P_4 X P_7	E_1	2.970 **	0.045	0.49	3.644	2.255 *	13.319	0.202	-0.107	1.271 *
		E_2	0.856	-0.303	-0.652	1.275	2.658 ***	-0.462	-0.015	-0.037	1.298 ***
		E_3	1.083	-0.088	-0.187	-0.24	2.258 **	-8.548	1.465	-0.107 ***	1.796 ***
28	P_4 X P_8	E_1	0.25	0.533	0.157	1.283	2.519 **	44.898 *	-0.159	-0.618 ***	-3.855 ***
		E_2	-0.028	0.112	0.876	1.886	1.198	6.478	1.568 *	-0.546 ***	-2.497 ***
		E_3	1.206	0.417	0.008	0.343	1.458	7.685	2.826 ***	-0.528 ***	-3.265 ***
29	P_4 X P_9	E_1	0.47	0.184	0.99	3.449	-0.447	39.481	1.702 **	0.929 ***	5.938 ***
		E_2	0.349	-0.102	0.571	-0.725	-1.608 *	6.435	2.207 **	0.910 ***	4.069 ***
		E_3	1.027	-0.343	-0.242	1.51	1.215	-12.039	2.020 *	0.927 ***	4.651 ***
30	P_4 X P_{10}	E_1	-0.613	-0.638	-1.343	1.199	-1.587	14.893	0.563	-0.249 **	1.362 **
		E_2	1.687	0.664	0.071	3.997 *	1.233	12.667	2.318 **	-0.359 ***	0.813 ***
		E_3	2.596 ***	-0.728	-0.159	-0.212	0.886	7.403	1.798 *	-0.355 ***	0.678 **
31	P_5 X P_6	E_1	1.205	0.365	-0.621	5.422 **	-0.641	40.698	2.785 ***	-0.353 ***	1.825 ***
		E_2	2.172	0.219	1.154	3.275	-1.852 *	20.264	1.263	-0.381 ***	1.499 ***
		E_3	2.276 **	0.082	-0.27	-0.601	1.605	-7.755	1.965 *	-0.415 ***	1.941 ***
32	P_5 X P_7	E_1	-0.355	0.04	0.601	0.783	-0.976	46.633 *	0.535	0.667 ***	-0.688
		E_2	0.028	0.128	0.654	2.025	-0.26	22.808	1.568 *	0.698 ***	-0.235
		E_3	0.181	-0.428	-1.298	4.621 **	-1.106	6.149	-0.091	0.733 ***	-0.275
33	P_5 X P_8	E_1	-0.374	0.595	0.934	-1.912	2.132 *	18.292	1.174 *	-0.997 ***	-5.318 ***
		E_2	0.578	0.166	-2.485 *	1.97	0.312	11.848	1.485 *	-0.838 ***	-4.770 ***
		E_3	1.570 *	0.800 *	-0.437	-1.129	-2.272 **	3.882	2.270 **	-0.831 ***	-5.630 ***

34	P_5 X P_9	E_1	0.512	0.223	0.434	-0.412	-0.085	28.271	-2.631 ***	0.547 ***	5.754 ***
		E_2	0.488	-0.128	-0.79	2.359	0.706	11.205	-0.876	0.435 ***	5.166 ***
		E_3	0.791	-0.417	-0.02	2.705	-1.682 *	13.258 *	1.131	0.440 ***	5.643 ***
35	P_5 X P_{10}	E_1	-0.553	0.101	0.005	-1.564	14.923	1.230 *	-0.024	4.472 ***	-0.553
		E_2	-0.958	-0.358	0.71	0.747	-2.486 **	-24.93	0.568	0.780 ***	4.766 ***
		E_3	-0.289	-0.919 *	0.063	-0.351	-0.111	-9.567	2.576 **	0.779 ***	4.873 ***
36	P_6 X P_7	E_1	-0.412	0.405	0.212	-2.967	-0.397	-8.589	-3.770 ***	0.223 **	-0.513
		E_2	-0.424	0.185	-0.096	0.331	-1.088	11.347	-2.043 **	0.215 ***	-0.062
		E_3	-0.989	-0.047	-0.881	-4.268 *	1.854 *	-8.164	-1.035	0.177 ***	-0.122
37	P_6 X P_8	E_1	0.935	-0.07	1.212	0.338	1.017	-16	-7.465 ***	0.249 **	-6.326 ***
		E_2	-0.374	-1.077 *	-0.568	-0.725	-4.315 ***	-15.48	-5.793 ***	0.206 ***	-5.907 ***
		E_3	-2.433 **	-0.619	-0.354	-7.018 ***	-4.613 ***	-9.135	-3.674 ***	0.193 ***	-6.356 ***
38	P_6 X P_9	E_1	0.688	-0.209	-1.288	0.838	2.694 **	-5.81	4.396 ***	0.313 ***	-2.564 ***
		E_2	1.203	0.032	1.126	4.664 *	1.945 *	6.344	2.513 ***	0.139 ***	-3.967 ***
		E_3	-0.212	-0.27	-0.937	-5.184 **	-0.023	-5.012	3.520 ***	0.168 ***	-3.217 ***
39	P_6 X P_{10}	E_1	0.371	1.592***	1.712	2.922	-1.039	1.062	1.924 ***	0.354 ***	4.324 ***
		E_2	-0.593	0.402	-1.374	-0.614	3.320 ***	-1.447	2.624 ***	0.370 ***	3.753 ***
		E_3	-0.142	0.345	-0.854	-4.240 *	2.316 **	-5.904	2.631 **	0.413 ***	3.860 ***
40	P_7 X P_8	E_1	0.408	-0.541	-0.899	1.033	0.325	-4.825	4.619 ***	0.273 ***	9.194 ***
		E_2	-1.184	-0.891	0.265	0.692	2.176 **	-23.237	0.846	0.328 ***	9.242 ***
		E_3	-2.029 **	-0.595	0.285	-0.462	2.410 **	-5.28	1.27	0.308 ***	8.481 ***
41	P_7 X P_9	E_1	1.328	1.217 **	0.066	4.866 *	2.559 **	10.044	-1.187 *	-0.543 ***	-2.874 ***
		E_2	1.56	1.312 *	0.626	3.747 *	1.237	15.521	-1.515 *	-0.672 ***	-3.265 ***
		E_3	0.193	0.544	0.035	2.295	0.967	7.325	-0.202	-0.654 ***	-3.163 ***
42	P_7 X P_{10}	E_1	-0.289	0.065	-0.399	0.616	1.043	-4.231	3.341 ***	0.281 ***	3.017 ***
		E_2	0.164	0.368	-0.54	-0.864	0.245	-9.947	1.929 **	0.285 ***	2.915 ***
		E_3	-0.404	0.359	-0.548	-1.351	1.438	-1.796	1.576	0.321 ***	2.750 ***
43	P_8 X P_9	E_1	-2.358 *	-0.316	-2.399 *	-8.162 ***	2.000 *	-40.023	1.452 **	0.272 ***	5.540 ***
		E_2	0.276	0.936	0.154	-2.308	-0.524	11.394	-0.265	0.285 ***	5.417 ***
		E_3	1.415	0.116	0.23	-3.712 *	0.3	2.828	0.826	0.248 ***	5.686 ***
44	P_8 X P_{10}	E_1	0.892	0.499	0.601	-0.412	2.481 **	-4.575	-0.687	0.387 ***	4.684 ***
		E_2	-1.186	0.126	-0.346	-1.919	-0.716	-9.907	0.179	0.096 **	-0.746 ***
		E_3	0.151	-0.069	-0.354	-3.101	-1.295	-3.98	1.604 *	0.320 ***	4.713 ***
45	P_9 X P_{10}	E_1	-1.322	0.584	-1.232	-0.912	2.734 **	-15.172	-4.159 ***	-0.266 ***	-4.000 ***
		E_2	-0.943	-0.011	-0.652	-0.864	-0.955	-6.916	-3.515 ***	0.146 ***	4.600 ***
		E_3	-1.961 *	0.004	-0.604	0.732	2.195 *	-7.271	-2.202 **	-0.038 *	-1.308 ***
	Sij <> 0 at 95%	E_1	1.852	0.897	1.887	3.977	1.771	41.044	1.033	0.146	0.969
	Sij--Sik at 95%		2.723	1.319	2.773	5.845	2.604	60.332	1.518	0.215	1.425
	Sij--Skl at 95%		2.596	1.258	2.644	5.573	2.483	57.525	1.447	0.205	1.359
	Sij <> 0 at 95%	E_2	2.494	0.999	2.26	3.501	1.476	26.221	1.374	0.067	0.324
	Sij--Sik at 95%		3.666	1.468	3.322	5.146	2.169	38.543	2.019	0.099	0.476
	Sij--Skl at 95%		3.496	1.4	3.168	4.906	2.068	36.749	1.925	0.094	0.454
	Sij <> 0 at 95%	E_3	1.482	0.73	1.313	3.289	1.671	12.98	1.597	0.036	0.5
	Sij--Sik at 95%		2.178	1.073	1.93	4.834	2.456	19.08	2.347	0.052	0.735
	Sij--Skl at 95%		2.077	1.023	1.84	4.609	2.342	18.192	2.238	0.05	0.7

Significant levels: * = <.05, ** = <.01 &*** = <.001

ASI:Anthesis-silkinginterval; LAI: Leaf area index; CTD: Canopy temperature deficit

Table.6 Stability parameters for yield and related traits in maize across three environments.

Sl. no	crosses	Days to 50% tasseling			Days to 50% silking			Plant height			Days to maturity			Ear length			Ear girth			Number of grain rows per cob			Number of grains per row		
		mean	bi	S^2di	mean	Bi	S^2Di	mean	Bi	S^2Di	mean	Bi	S^2Di	mean	Bi	S^2Di	mean	Bi	S^2Di	mean	Bi	S^2Di	mean	Bi	S^2Di
1	**P1 X P2**	51.00	0.88	-0.414	53.11	0.85	-0.74	144.80	1.15	-59.60	82.11	1.76	1.06	18.19	0.36	-0.67	14.62	2.70	-0.24	12.67	0.77	0.77	28.00	1.29	14.53
2	**P1 X P3**	51.66	0.95	-0.676	53.67	0.94	-0.77	160.10	1.43	7.44	82.00	2.04	6.49	19.44	-2.50	0.62	14.01	1.41	-0.20	13.56	1.00	-0.00	30.33	1.48	8.62
3	**P1 X P4**	51.77	1.00	-0.678	53.89	1.03	-0.77	167.60	1.17	33.82	82.78	1.35	-0.50	17.73	1.59	-1.22	13.02	1.59	-0.18	12.44	0.54	-1.06	28.56	0.93	36.01
4	**P1 X P5**	52.00	1.15	-0.827	54.44	1.05	-0.77	159.70	1.02	41.76	80.11	1.52	8.96	16.71	3.92	0.79	13.55	0.43	-0.13	13.78	1.31	-0.72	27.33	1.18	-3.02
5	**P1 X P6**	52.22	1.18*	-0.86	54.33	1.14	-0.48	160.30	0.96	-62.65	79.22	2.09	0.94	16.68	4.28	-1.19	13.40	2.36	0.00	14.44	2.15	-1.03	30.89	1.22	-3.83
6	**P1 X P7**	52.11	1.20	-0.432	53.78	1.32	-0.94	160.70	0.75	-62.81	78.22	2.09	0.94	17.60	-0.88	-0.24	13.34	0.61	0.54	13.11	-0.23	-0.82	28.22	0.69	1.84
7	**P1 X P8**	53.33	0.89	-0.671	55.67	0.80	-0.48	184.10	1.52	455.28	86.00	1.73	3.39	19.22	1.07	6.30	14.34	2.41	-0.13	14.67	1.62	-1.04	31.22	1.51	12.60
8	**P1 X P9**	52.89	0.91	1.031	54.89	0.89	-0.77	160.50	0.94	4.23	84.22	1.14	0.28	16.89	4.95	-1.23	13.75	1.89	0.00	14.67	0.92	0.73	27.22	1.13	-3.98
9	**P1 X P10**	51.22	0.97	-0.786	53.33	0.94	1.03	165.10	2.06	-61.27	84.22	0.85	1.60	18.89	6.93	-0.45	13.95	2.40	-0.01	14.33	1.23	-1.04	29.44	1.28	-2.76
10	**P2 X P3**	51.67	1.15	0.644	53.78	1.18	0.35	145.80	1.82	-58.00	81.33	2.10	4.28	18.28	5.17	-1.08	15.34	1.50	0.62	13.11	0.61	-0.26	29.67	0.43	1.69
11	**P2 X P4**	50.33	1.36	0.138	52.67	1.27	0.35	152.00	0.89	550.25	83.00	0.39	1.67	17.12	8.02	-0.32	14.24	0.46	-0.13	13.33	1.77	1.97	29.00	0.64	8.99
12	**P2 X P5**	50.56	1.45	-0.579	52.89	1.36	-0.95	141.70	0.91	-59.82	81.33	0.53	-0.24	16.04	3.07	-1.25	13.79	1.48	-0.15	13.89	-0.07	-0.55	28.56	0.72	12.08
13	**P2 X P6**	50.44	1.13*	-0.86	52.78	1.12	-0.79	140.80	0.86	-58.10	82.67	0.80	-0.54	17.49	8.52	-1.24	13.88	1.89	-0.19	13.11	0.54	-1.06	32.00	1.09	2.84
14	**P2 X P7**	49.22	1.52	-0.268	51.56	1.43	0.95	150.10	1.57	-26.41	80.89	0.52	-0.35	16.33	9.33	2.72	14.48	2.42	-0.23	14.00	0.77	-0.77	27.89	1.65	42.74
15	**P2 X P8**	50.78	1.23*	-0.86	53.44	1.32	-0.95	160.30	1.41	-37.04	83.44	0.14	2.11	18.74	6.52	-0.42	14.36	2.61	0.72	13.89	0.85	3.16*	30.78	1.04	3.15
16	**P2 X P9**	50.89	1.18	0.999	53.67	1.14	1.77	143.60	1.59	-52.98	82.44	0.34	-0.54	17.79	3.49	-1.21	14.85	1.45	-0.02	15.78	3.08	0.27	27.89	1.73	-3.21
17	**P2 X P10**	50.56	1.18*	-0.86	53.00	1.27	-0.95	135.70	1.66	-62.45	83.00	0.82	2.44	16.33	0.19	-1.10	14.20	-0.01	-0.25	15.33	1.77	1.97	26.56	0.62	0.39
18	**P3 X P4**	52.67	1.43	3.385	54.89	1.36	1.78	146.10	1.09	11.52	84.00	1.59	-0.54	17.07	3.84	-0.36	13.24	-0.03	-0.20	13.11	1.38	-0.93	29.78	0.63	-3.60
19	**P3 X P5**	52.44	1.81	-0.706	54.67	1.81	-0.93	156.90	1.54	981.35	82.89	0.85	1.60	20.33	-1.85	-1.10	13.90	1.32	0.03	12.89	1.15	0.34	28.56	1.21	1.00
20	**P3 X P6**	49.11	1.61	-0.262	52.44	2.12	0.33	142.30	1.04	115.23	83.78	0.72	1.81	17.65	-3.52	0.43	13.88	-0.48	-0.23	14.22	-0.38	2.64	28.22	0.97	1.13
21	**P3 X P7**	51.67	1.70*	-0.768	53.78	1.65	-1.00	155.10	1.90	442.27	81.89	1.76	4.50	19.09	-6.10	0.56	13.90	0.15	-0.03	12.89	0.30	0.86	28.67	1.13	13.06
22	**P3 X P8**	50.56	1.45	-0.579	53.11	1.38	-0.14	162.90	1.80	47.25	82.22	0.75	4.53	18.17	-0.61	-1.02	14.39	1.21	-0.22	12.67	0.84	-0.90	28.67	0.53	-3.42
23	**P3 X P9**	50.33	1.36	2.913	52.89	1.43	2.49	143.50	2.25	-59.27	79.00	1.26	0.42	17.16	0.90	-0.09	13.92	-0.01	-0.20	13.56	0.92	2.81	28.56	0.68	5.50
24	**P3 X P10**	50.11	1.47	2.069	52.33	1.41	3.42	134.80	1.11	-38.36	79.00	2.37	2.09	16.84	-2.75	1.33	13.92	0.69	-0.20	14.00	2.81	-0.83	27.00	0.40	-4.12
25	**P4X P5**	51.33	1.29	-0.437	53.44	1.25	-0.76	156.50	2.13	-46.02	80.44	1.91	2.01	19.07	-1.99	-1.00	14.17	1.39	0.05	12.44	0.54	-1.06	31.56	1.64	-3.47
26	**P4 X P6**	51.22	0.91	-0.675	53.33	0.87	-0.49	135.40	1.17	-37.32	80.67	1.22	-0.47	17.60	-1.92	-0.46	14.24	0.04	-0.25	13.78	1.38	-0.93	29.78	0.77	-4.15
27	**P4 X P7**	51.67	0.95	-0.676	54.22	1.03	-1.00	144.90	1.59	27.37	81.78	1.50	-0.52	20.00	3.44	1.32	13.77	0.62	-0.20	13.33	0.77	-0.77	31.11	1.45	-3.52
28	**P4 X P8**	52.11	0.86	-0.673	54.11	0.85	-0.77	151.30	1.61	-62.80	84.22	1.67	1.58	18.09	-1.61	-1.18	14.09	0.77	-0.16	13.56	1.18	-0.34	31.22	1.14	-2.55
29	**P4 X P9**	51.44	1.06	-0.424	53.56	1.03	-0.09	152.20	1.71	-62.40	83.44	1.02	0.16	18.46	-0.25	-1.00	13.80	1.37	-0.23	14.44	2.15	-1.03	29.11	1.04	3.15
30	**P4 X P10**	51.78	1.13	-0.061	53.78	1.12	-0.09	124.50	1.19	-51.79	82.78	1.02	0.16	18.99	-4.57	-1.03	13.72	1.54	0.98	13.56	1.15	-0.34	29.22	1.15	4.66
31	**P5 X P6**	51.78	1.61*	-0.834	53.78	1.59	-0.94	145.00	1.51	-42.22	84.11	1.19	-0.26	20.28	-0.88	-1.12	14.14	1.45	0.07	13.33	1.69	-0.41	33.56	2.24	-2.27
32	**P5 X P7**	51.11	1.06	-0.297	53.11	1.05	-0.52	151.80	1.46	-45.52	82.00	0.47	0.47	18.84	-0.61	-1.19	14.05	1.74	-0.25	13.11	2.15	-1.03	31.78	0.50	-4.06
33	**P5 X P8**	51.22	1.38*	-0.831	53.56	1.43	-0.76	159.60	1.50	-57.26	84.56	1.35	0.08	18.73	-3.72	-0.41	14.52	0.79	0.07	12.22	0.07	4.56*	29.44	1.12	5.90
34	**P5 X P9**	51.00	1.22	-0.589	53.22	1.23	-0.52	159.60	1.38	-61.68	80.78	1.95	7.54	18.97	-0.63	-1.25	14.04	1.94	-0.11	13.56	1.00	-0.00	29.00	0.67	-2.00
35	**P5 X P10**	51.11	1.27	0.13	53.11	1.25	-0.14	147.20	0.58	47.13	82.78	1.72	-0.54	18.02	-0.21	-0.19	13.61	1.85	-0.24	14.00	1.62	-1.08	27.44	0.97	-3.46
36	**P6 X P7**	50.11	1.33	0.663	51.89	1.16	-0.14	140.10	0.46	172.58	79.89	1.51	0.72	17.14	3.43	-1.15	13.58	1.54	-0.11	12.89	1.85	-0.66	28.22	1.90	2.59
37	**P6 X P8**	52.89	0.97	0.431	55.00	1.00	0.42	133.90	0.58	452.06	78.11	1.97	0.77	16.38	6.75	-1.24	12.67	1.51	0.73	13.00	1.50	1.32	28.56	2.64	-3.88
38	**P6 X P9**	51.22	0.91	-0.675	53.44	0.98	-0.77	131.50	0.79	267.90	85.89	1.22	1.02	17.79	3.88	-1.17	13.26	1.41	-0.24	13.33	2.54	0.38	28.78	2.65	9.27
39	**P6 X P10**	50.00	1.43	-0.274	52.33	1.41	-0.53	137.80	0.60	52.96	84.56	1.10	-0.43	17.03	1.91	0.39	14.26	2.36	0.66	13.56	2.46	8.28**	27.89	2.32	-1.85
40	**P7 X P8**	49.67	0.88	-0.414	52.44	0.98	-1.00	146.90	0.54	658.55	85.22	0.71	11.68	16.57	4.63	-1.14	12.81	1.08	-0.19	12.67	0.07	-0.18	29.89	1.41	-3.46
41	**P7 X P9**	50.44	1.13	1.005	52.44	1.12	1.04	147.60	0.63	-56.59	80.67	1.38	-0.53	18.76	3.75	-1.14	14.66	2.10	-0.21	13.78	1.38	-0.93	29.22	2.23	-3.54
42	**P7 X P10**	49.22	1.31	1.297	51.56	1.30	0.95	145.70	0.52	-16.69	83.67	0.66	3.71	17.48	1.36	-1.26	13.97	0.90	-0.16	13.11	1.31	-0.72	26.44	1.25	-4.16

43	**P8 X P9**	51.67	0.95	1.025	53.89	1.03	1.04	153.70	1.84	-18.93	83.89	1.22	1.02	16.76	-4.60	1.34	13.74	1.36	0.58	12.67	0.15	2.46	22.89	0.76	15.78
44	**P8 X P10**	50.44	1.13	-0.061	52.56	1.09	-0.48	149.30	0.83	-54.29	83.33	1.59	-0.54	16.86	0.51	0.53	13.75	1.96	-0.23	13.33	1.54	0.09	25.67	1.37	-4.06
45	**P9 X P10**	47.22	0.976	-0.303	53.44	0.92	-0.52	140.90	0.53	321.12	78.33	1.54	-0.38	15.72	1.92	-1.23	13.91	1.84	-0.17	13.33	1.62	-1.04	24.78	0.75	-4.04
46	**HQPM**	50.66	0.956	1.03	52.67	0.936	1.033	153.2	0.414	30.33	79.33	-0.55	11.66	20.69	-11.74	-1.00	16.11	-3.59	0.91	14.22	-0.46	-0.09	28.44	0.46	14.49

(continue) Table.6Stability parameters for yield and related traits in maize across three environments.

Sl. no	crosses	Seed index			Seed yield per plant			CTD			Chlorophyll content			LAI			Oil content			Starch content		
		mean	bi	S^2di	mean	Bi	S^2Di	mean	Bi	S^2Di	mean	Bi	S^2Di	mean	Bi	S^2Di	mean	Bi	S^2Di	mean	Bi	S^2Di
1	**P1 X P2**	26.38	-6.52	-0.15	101.10	0.51	-136.25	2.63	1.22	0.51	44.76	2.11	-10.22	3.05	-3.25	0.02	3.49	0.08	-0.002	65.47	-0.71	0.96
2	**P1 X P3**	26.58	-2.41	-0.68	102.60	0.58	240.05	1.44	-0.78	0.49	41.19	2.41	-10.07	2.65	-2.06	-0.05	4.08	0.24	-0.002	67.53	-5.15	-0.08
3	**P1 X P4**	26.44	-9.00	4.17	104.40	0.33	297.94	2.06	-0.98	1.80	42.15	2.54	-7.83	2.84	-0.38	-0.08	4.48	12.03	-0.003	67.52	-0.06	-0.04
4	**P1 X P5**	26.94	0.25	-0.72	90.70	-0.35	480.01	1.68	1.96	-0.14	42.10	1.71	-10.12	2.66	0.08	-0.09	3.49	2.10	-0.001	66.23	-8.86	-0.13
5	**P1 X P6**	25.36	-4.15	3.77	94.00	1.05	-281.09	1.72	1.34	-0.58	42.82	1.18	-9.74	2.36	0.14	-0.08	3.77	2.21	0.003	72.40	-0.30	-0.13
6	**P1 X P7**	25.20	-2.07	-0.74	101.40	0.21	766.44	1.71	-0.69	0.03	47.71	1.90	-8.79	2.52	2.30	-0.09	4.13	0.70	-0.003	58.81	6.10	-0.03
7	**P1 X P8**	24.46	-0.56	-0.54	112.80	1.09	497.74	1.38	-0.81	-0.40	43.81	1.74	-9.37	2.81	4.12	0.00	3.73	0.73	-0.001	74.96	-7.02	0.31
8	**P1 X P9**	23.37	1.23	-0.23	75.30	1.17	666.45	1.44	-0.10	-0.55	42.18	0.10	-9.83	2.86	3.05	-0.06	4.10	-1.38	-0.002	61.98	7.78	0.03
9	**P1 X P10**	26.34	-7.84	1.14	117.40	0.55	81.85	1.90	2.50	-0.55	42.80	0.36	-9.17	2.77	4.13	-0.02	3.45	1.93	-0.002	59.62	5.07	-0.11
10	**P2 X P3**	26.02	3.16	-0.43	113.40	1.01	190.21	1.64	-1.73	0.23	49.75	2.41	-8.94	3.02	3.86	-0.06	5.16	2.77	-0.001	72.10	-4.71	0.12
11	**P2 X P4**	25.89	-0.92	-0.56	93.40	0.97	-275.25	1.62	2.62	-0.62	44.54	0.41	-9.94	2.61	4.13	-0.03	3.82	-2.19	-0.003	60.17	-5.90	-0.13
12	**P2 X P5**	25.47	-7.42	-0.40	88.10	0.68	-246.71	1.71	2.20	0.06	47.49	0.49	-10.03	2.65	2.98	-0.08	5.43	-0.85	-0.002	59.62	4.83	-0.13
13	**P2 X P6**	22.73	-6.12	-0.14	105.00	1.45	-282.01	1.37	-0.48	-0.63	48.82	1.01	-10.25	2.52	2.22	-0.09	3.82	-1.73	-0.001	60.52	-0.25	-0.11
14	**P2 X P7**	25.51	-8.57	-0.77	103.10	1.51	156.83	2.09	1.52	-0.63	39.77	1.39	-8.78	2.76	0.67	-0.08	5.18	3.17	-0.003	57.28	7.47	0.07
15	**P2 X P8**	26.82	-5.64	-0.76	105.50	1.19	-252.02	1.44	2.07	-0.15	46.27	0.17	-9.80	2.74	2.36	-0.08	5.32	9.37	-0.003	60.88	-0.31	0.23
16	**P2 X P9**	24.62	-4.70	0.05	106.80	0.37	-248.97	2.45	2.37	-0.03	40.99	-0.36	-9.94	2.89	-0.82	-0.06	3.74	1.42	-0.002	61.62	5.50	0.01
17	**P2 X P10**	27.69	-0.86	-0.67	95.70	0.64	-208.85	2.30	3.26	-0.61	47.46	1.64	-10.24	2.58	1.21	-0.08	3.75	-1.02	-0.001	58.20	7.45	-0.08
18	**P3 X P4**	26.31	-0.14	5.71	94.60	0.37	-280.27	1.68	0.13	-0.60	45.68	1.40	-10.19	2.20	-0.15	-0.09	4.20	-1.02	-0.003	64.08	4.83	0.73
19	**P3 X P5**	24.51	-0.36	-0.73	116.10	1.99	-119.91	2.34	0.51	-0.43	47.47	0.88	-10.12	2.99	1.01	-0.09	3.85	2.19	-0.003	63.42	6.48	0.74
20	**P3 X P6**	28.38	-6.50	-0.52	112.80	2.31	-159.45	2.10	2.34	-0.45	48.30	0.68	-10.22	2.32	3.20	-0.05	4.13	0.98	-0.003	74.40	0.14	-0.10
21	**P3 X P7**	24.82	-10.56	-0.76	115.70	1.51	-268.87	1.87	0.29	-0.40	45.89	0.56	-10.11	2.37	3.74	-0.05	3.83	0.82	-0.002	61.58	0.00	-0.08
22	**P3 X P8**	28.43	19.91	-0.18	120.80	1.55	-252.75	1.64	1.73	-0.26	44.54	0.05	-10.04	2.40	0.53	0.02	5.36	1.59	-0.001	62.30	2.36	0.82
23	**P3 X P9**	25.20	1.56	0.33	103.30	2.21	284.42	1.71	0.49	-0.61	44.32	-0.10	-10.05	2.68	1.61	-0.07	4.20	-1.52	-0.001	64.27	-4.55	-0.04
24	**P3 X P10**	25.73	-4.09	2.22	96.40	0.87	-210.59	2.41	1.25	-0.64	46.39	2.31	-10.19	2.36	-0.93	-0.07	4.16	-0.24	-0.003	68.33	-5.21	0.01
25	**P4X P5**	26.37	2.52	-0.43	123.40	2.58	117.65	2.25	2.43	-0.27	41.72	1.28	-10.03	2.76	0.63	-0.08	5.80	3.19	-0.003	60.53	2.74	-0.12
26	**P4 X P6**	24.93	13.67	-0.79	107.30	1.82	-157.55	2.17	1.77	-0.55	43.78	2.24	-10.08	2.61	0.75	-0.09	3.75	0.01	-0.003	72.28	-5.91	-0.10
27	**P4 X P7**	27.54	2.24	-0.64	114.10	1.84	-275.05	2.44	1.00	1.11	47.70	0.34	-9.45	2.77	1.04	-0.08	4.16	0.80	0.01	64.16	-0.10	0.27
28	**P4 X P8**	27.12	3.40	0.23	129.30	2.24	-51.60	2.00	2.80	-0.51	47.24	1.00	-10.24	2.62	2.01	-0.08	3.67	0.52	-0.003	62.31	-6.15	-0.10
29	**P4 X P9**	24.57	11.15	0.45	120.00	2.68	-207.03	1.13	0.83	-0.47	49.12	0.91	-10.22	2.88	0.29	-0.08	5.34	1.41	-0.003	70.80	8.32	-0.13
30	**P4 X P10**	25.25	8.29	0.96	118.90	1.10	-277.21	1.66	0.34	0.95	46.91	1.31	-9.75	2.16	-0.41	-0.07	3.70	2.70	-0.003	66.58	2.39	-0.12
31	**P5 X P6**	24.80	10.94	-0.67	130.10	3.43	-282.07	1.40	0.78	-0.62	48.75	0.86	-10.27	2.68	0.20	-0.04	3.88	1.85	-0.002	67.65	4.03	-0.07
32	**P5 X P7**	24.90	-0.39	0.96	135.70	2.92	-250.28	1.83	2.89	-0.62	46.51	0.29	-10.24	2.91	1.71	-0.08	5.23	-0.14	-0.002	62.40	-0.55	-0.13
33	**P5 X P8**	25.99	-7.67	-0.68	118.70	1.93	-274.87	1.80	2.47	-0.29	42.28	0.17	-10.22	2.84	0.24	-0.08	3.63	-1.68	-0.003	60.38	0.46	-0.01
34	**P5 X P9**	25.03	-2.39	1.20	124.00	1.97	-44.72	2.20	1.90	-0.38	37.64	-0.37	-6.30	2.93	1.84	-0.08	5.18	2.82	-0.003	71.54	1.67	-0.12
35	**P5 X P10**	24.22	7.58	-0.29	98.50	2.19	524.72	1.81	0.39	-0.02	47.20	3.66	-8.20	2.50	0.99	-0.09	5.11	1.10	-0.003	70.43	-2.10	-0.08
36	**P6 X P7**	25.23	9.32	-0.79	106.80	1.35	-59.77	1.88	-1.43	-0.54	49.26	6.00	-9.96	2.87	3.15	-0.06	4.18	1.21	-0.002	63.62	1.28	-0.12

37	**P6 X P8**	22.72	-6.10	7.51	92.00	1.06	-271.67	2.03	2.93	1.34	42.38	1.53	-10.13	2.59	5.38	-0.08	4.18	2.36	-0.003	60.47	2.33	-0.13
38	**P6 X P9**	26.35	-2.71	-0.68	103.10	1.22	-260.37	2.50	3.83	-0.54	49.15	1.90	-10.13	2.71	0.39	-0.08	4.36	3.57	-0.003	63.82	8.15	-0.12
39	**P6 X P10**	26.56	8.48	8.46	101.10	1.37	-275.86	2.14	3.19	-0.46	49.08	1.64	-10.06	2.49	2.92	-0.07	4.14	-1.04	-0.002	70.76	5.18	-0.11
40	**P7 X P8**	27.58	6.08	1.90	92.50	1.07	-64.96	2.12	4.33	-0.50	45.31	1.82	-9.94	2.52	-0.32	-0.07	4.53	0.41	-0.003	72.55	4.75	-0.06
41	**P7 X P9**	26.98	-1.09	-0.71	113.70	1.08	-280.09	1.50	-0.52	-0.63	40.38	1.25	-10.13	2.86	-0.05	-0.08	3.80	2.72	-0.002	60.88	2.38	-0.08
42	**P7 X P10**	26.52	3.31	-0.45	95.90	0.81	-205.34	1.76	-0.88	-0.57	44.95	1.22	-9.53	2.52	-0.03	-0.08	4.32	-0.79	-0.001	66.59	2.19	-0.13
43	**P8 X P9**	26.24	2.28	1.11	91.00	-0.59	71.81	1.56	2.16	-0.62	44.43	0.80	-10.01	2.79	0.84	-0.08	4.67	1.21	-0.002	72.34	0.53	-0.08
44	**P8 X P10**	26.02	-3.82	3.78	92.00	0.74	-232.85	1.84	1.88	1.57	46.90	1.67	-9.87	2.53	-0.81	-0.07	4.28	3.78	0.029	69.39	26.18	12.96
45	**P9 X P10**	26.64	6.15	7.02	87.50	0.47	-269.18	1.51	3.29	0.11	40.28	-0.33	-5.16	2.30	3.19	-0.06	4.15	-6.76	0.019	66.67	-46.32	9.21
46	**HQPM**	26.88	-8.82	-0.71	124.10	0.17	-256.62	2.20	2.80	-0.58	44.92	-0.14	-5.65	2.34	-1.70	-0.04	4.02	4.45	0.001	63.83	27.32	0.84

Conclusions

Investigations of difference exhibit that genotype x environment interaction are exceptionally huge, which indicates that genotypes, environments, and their interactions are highly variable. In the present study for grain yield per, the cross combinations, $P_5 \times P_6$, $P_5 \times P_7$ and $P_4 \times P_5$were identified as the best experimental hybrids on the basis of high standard heterosis, high SCA and high GCA for female parent. Thus, these hybrids might be taken advantage of economically after evaluation for their effectiveness over various environmental challenges. These single cross hybrids, which are stable and superior for grain yield could be tried in enormous scale across environments for their wide transformation in diverse environments From this, we can stabilize the production level of the crop and it could improve the national production and productivity.

Comment [T5]: Results vary widely for P5 X P6, P5 X P7 and P4 X P5 at E1-E3, therefore before to be concluded, critically reevaluation is required for their superiority and stability over the locations E1, E2 and E3.

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