

Original Research Article

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

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, P₄, P₅ and P₂ had 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, P₅ x P₇, P₅ x P₆, P₄ x P₈ and P₄ x P₅ had significant to highly significant SCA effects for grain yield per plant. The estimates of standard heterosis over the best check, HQPM-5 for grain yield per plant revealed the top five cross combinations, namely P₅ x P₇, P₅ x P₆, P₄ x P₈, P₅ x P₉ and P₄ x P₅ exhibited 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 E₁, E₂ and E₃ using Eberhart and Russel model. The single cross hybrids P₅ x P₆, P₅ x P₇ and P₄ x P₅ 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^2_{di}). There by indicating its adaptability over all environments thus, these hybrids P₁ x P₈, P₂ x P₆, P₁ x P₆, P₉ x P₁₀ and P₃ x P₅ were identified as stable over the all three environments and moreover, hybrids, P₅ x P₆, P₄ x P₉, P₄ x P₅ and P₃ x P₆ were not prejudiced much by the season as well as environment and stable across the environments.

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.(FICCI 2022). 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_4 -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 of Agriculture & 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.*, E₁, E₂ and E₃ 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 F₁s 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 F₁s. The mean values on different traits were analysed using model I method II 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 **Panase 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_1 s 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 Table 4 which 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 ($V_A/V_D < 1$). 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 .

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 P₃, P₇ and P₁₀ were noted as poor inbred lines selected as parental material and among all this parental lines P₁₀ found susceptible for Heat-stress. The parent, P₂ 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, P₄ and P₅ shown highly positive GCA for number of kernel row per cob, number of kernels per row and seed yield per plant, while parents P₃ and P₉ shows positive GCA for quality parameters like oil content and starch content and among them parents P₂, P₄ and P₉ 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, P₂ had highly significant negative GCA effects for days to 50 percent tasseling, days to 50 percent silking and plant height while, the parent, P₅ and P₆ had significant to highly significant negative GCA effects for anthesis-silking interval. Hence these two parents, P₂ and P₆ 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 P₂ and P₁₀ 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, P₁ x P₁₀, P₃ x P₅, P₃ x P₇, P₃ x P₈, P₄ x P₈, P₄ x P₁₀, P₅ x P₇, P₅ x P₈, P₅ x P₉ and P₇ x P₉ had significant to highly significant positive SCA effects for grain yield per plant in all three environments E₁, E₂ and E₃ 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 $P_1 \times P_4$, $P_1 \times P_5$, $P_1 \times P_{10}$, $P_5 \times P_9$, $P_5 \times P_{10}$ shows negative SCA in environment E_1 . F_1 s $P_2 \times P_4$, $P_2 \times P_5$, $P_2 \times P_7$, $P_2 \times P_8$, $P_3 \times P_6$, $P_3 \times P_8$, $P_4 \times P_5$ and $P_8 \times P_{10}$ depicts great SCA effects in environment E_1 and E_2 and only $P_1 \times P_4$, $P_7 \times P_8$ and $P_5 \times P_7$ are significant negative SCA in environment E_3 , over all $P_1 \times P_4$ and $P_7 \times P_8$ combinations exhibited highly significant negative SCA effects for days to 50 per cent tasseling and $P_1 \times P_4$, $P_4 \times P_8$, $P_6 \times P_7$ and $P_7 \times P_8$ shows 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 $P_1 \times P_3$, $P_1 \times P_4$, $P_2 \times P_3$, $P_4 \times P_8$, $P_4 \times P_9$, $P_4 \times P_{10}$, $P_5 \times P_6$, $P_5 \times P_7$, $P_5 \times P_{10}$, $P_6 \times P_8$ and $P_7 \times P_9$ exhibited highly significant negative SCA effects for anthesis- silking interval in all three environments E_1 , E_2 and E_3 . Cross combinations $P_1 \times P_5$, $P_1 \times P_6$, $P_1 \times P_7$, $P_2 \times P_7$, $P_3 \times P_9$, $P_4 \times P_6$, $P_6 \times P_7$, $P_6 \times P_8$, $P_7 \times P_9$ and $P_9 \times P_{10}$ had highly significant negative SCA effects for days to 50 per cent maturity. F_1 s $P_4 \times P_7$, $P_4 \times P_{10}$, $P_6 \times P_8$ and $P_6 \times P_9$ 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_1 s depicts negative specific combining ability in all three environments among them, $P_2 \times P_7$, $P_4 \times P_5$, $P_5 \times P_8$, $P_7 \times P_9$ and $P_9 \times P_{10}$ reveal highest negative SCA followed, hybrids $P_1 \times P_7$, $P_2 \times P_3$, $P_2 \times P_6$, $P_2 \times P_{10}$, $P_3 \times P_6$, $P_4 \times P_9$, $P_4 \times P_{10}$, $P_5 \times P_6$, $P_6 \times P_{10}$ shows highest significant positive SCA in all environments E_1 , E_2 and E_3 and for canopy temperature deficit hybrids $P_1 \times P_2$, $P_3 \times P_5$, $P_4 \times P_6$, $P_6 \times P_9$ shows significant positive specific combining 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 $P_1 \times P_3$, $P_1 \times P_8$, $P_2 \times P_3$, $P_3 \times P_8$, $P_5 \times P_6$, and $P_7 \times P_9$ shows significant and positive combiners for ear length and ear girth in all three environments and moreover, hybrids $P_2 \times P_3$ and $P_5 \times P_6$ are great in all the yield attributing characters except number of kernel row per cob. Additionally, $P_1 \times P_8$ and $P_7 \times P_9$ F_1 s 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 $P_1 \times P_4$, $P_1 \times P_6$, $P_3 \times$

P₆, P₃ x P₁₀, P₄ x P₉, P₅ x P₉, P₆ x P₁₀, P₇ x P₈, P₇ x P₁₀, P₈ x P₉ total 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; Niranjana *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 ₅ x 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 P₃ x P₈ (6.22***), P₃ x P₆ (4.03**), P₁ x P₄ (3.41***). Single cross hybrids P₄ x P₉ (6.05), (6.13*), (5.67); P₆ x P₉ (5.61), (5.92*), (4.90); P₆ x P₈ (4.73), (4.51), (0.98) combined well for chlorophyll content in all E₁, E₂ and E₃ environments. On the other hand hybrids P₂ x P₆ (-4.13), P₃ x P₇ (-3.51), P₆ x P₈ (-4.61) were the worst three combinations for seed index among them third environment effects more than other two whereas P₅ x P₉ (-5.58), (-8.41), (-6.68); P₁ x P₆ (-5.91), (-7.35), (-6.93), P₄ x P₅ (-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 % (P₂ x P₆) to 45.11 % (P₅ x P₆) in E₁, from 0.42 % (P₁ x P₇) to 5.69 % (P₁ x P₈) in E₂ and 18.92% (P₄ x P₈) in E₃, Data for this character further revealed that hybrid P₅ x P₆ (45.11 %) exhibited highest positive significant standard heterosis for Seed yield followed by hybrids P₅ x P₇ (44.69%), P₄ x P₅ (34.94 %), P₄ x P₈ (33.92 %), P₄ x P₉ (30.16 %) in environment E₁. Similarly in environment E₂ 5.69 %. (P₁ x P₈) depicted highest positive significant value followed by hybrids P₁ x P₁₀ (4.18 %), P₂ x P₃ (2.28 %), P₅ x P₇ (0.55 %), P₁ x P₇ (0.42 %) whereas in environment E₃, 18.92 % (P₄ x P₈) 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 % ($P_1 \times P_8$) to -14.10 % ($P_3 \times P_6$) in E_1 , from -2.55 % ($P_1 \times P_8$) to -12.74 % ($P_3 \times P_6$) in E_2 and from -1.89 % ($P_7 \times P_8$) to -7.55 % ($P_2 \times P_4$) in E_3 . Data for this character further revealed that hybrid $P_3 \times P_6$ (-14.10 %) exhibited highest negative significant standard heterosis for days to 50 % tasseling and for days to 50 % silking varied from -3.09 ($P_4 \times P_8$) to -14.20 % ($P_3 \times P_6$) in E_1 , from -2.44 ($P_1 \times P_8$) to -12.20 % ($P_3 \times P_6$) in E_2 and from -4.24 ($P_7 \times P_8$) to -9.09 % ($P_3 \times P_8$) in E_3 . Data for this character further revealed that hybrid $P_3 \times P_6$ (-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 $P_3 \times P_5$ and $P_5 \times P_6$ showed positive standard heterosis. Furthermore for the quality parameters like oil content and starch content F_{1S} $P_2 \times P_3$, $P_1 \times P_5$, $P_4 \times P_9$, $P_5 \times P_9$, $P_5 \times P_{10}$ and $P_8 \times P_9$ 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-significant deviation from regression (s^2_{di}) hence their behavior was predictable, while 13 hybrids showed significant deviation from regression (s^2_{di}) 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^2_{di}) there by indicating its stability

over all environments and suitability for early tasseling. The hybrids $P_1 \times P_8$, $P_1 \times P_2$, $P_6 \times P_9$ showed non-significant deviation from regression (s^2_{di}) had negative phenotypic index ($P_i < 1$), and regression coefficient greater than unity ($\beta_i > 1$) indicating their adaptability under unfavorable environments and suitable for early tasseling. For days to silking out of 45 hybrids, 32 hybrids showed non-significant deviation from regression (s^2_{di}) hence their behavior was predictable, while 13 hybrids showed significant deviation from regression (s^2_{di}) 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^2_{di}) there by indicating its adaptability over all environments and suitability for early silking. The hybrids $P_1 \times P_8$, $P_4 \times P_8$ showed non-significant deviation from regression (s^2_{di}) had negative phenotypic index ($P_i < 1$), and regression coefficient greater than unity ($\beta_i > 1$) indicating their adaptability under unfavorable environments and suitable for early silking across different environments

For plant height the highest mean plant height (184.08 cm) was recorded for $P_1 \times P_8$ the tallest and lowest mean plant height (131.52 cm) was observed for $P_6 \times P_9$. 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-significant deviation from regression (s^2_{di}) hence their behavior was predictable, while 19 hybrids showed significant deviation from regression (s^2_{di}) there by their behavior was unpredictable. The hybrid $P_2 \times P_6$ had negative phenotypic index ($P_i < 1$), regression coefficient near to unity ($\beta_i \approx 1$) and non-significant deviation from regression (s^2_{di}) there by indicating its adaptability over all environments and suitability for lower plant height. Cob length for $P_3 \times P_5$ recorded high mean value (20.33 cm) and $P_9 \times P_{10}$ 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, $P_1 \times P_6$, $P_3 \times P_9$, $P_7 \times P_{10}$, $P_9 \times P_{10}$ 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 $P_2 \times P_9$ exhibited maximum (14.85 cm) and $P_7 \times P_8$ recorded minimum (12.67 cm) mean value for cob girth. Out of the 45 hybrids seven hybrids viz., $P_1 \times P_2$, $P_1 \times P_8$, $P_2 \times P_6$, $P_5 \times P_7$, $P_7 \times P_9$, $P_8 \times P_{10}$, $P_9 \times P_{10}$ showed non-significant (s^2_{di}) 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 increase ear girth. The hybrids, $P_1 \times P_2$, $P_1 \times P_8$, $P_2 \times P_6$, $P_5 \times P_7$, $P_6 \times P_9$, $P_8 \times P_{10}$, $P_9 \times P_{10}$ indicating their adaptability under favorable environments and suitable for more ear girth. Data for kernel rows per cob

revealed that out of 45 hybrids, 18 hybrids showed non-significant deviation from regression hence their behavior was stable, while 27 hybrids showed significant deviation 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 environments hybrids, $P_1 \times P_5$, $P_1 \times P_6$, $P_1 \times P_9$, $P_4 \times P_5$, $P_5 \times P_6$, $P_6 \times P_8$, $P_7 \times P_{10}$, $P_8 \times P_{10}$ 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, 22.72 to 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 per row 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^2_{di}) 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^2_{di} 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 $P_6 \times P_8$ showed their 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 $P_1 \times$

P_5 , $P_1 \times P_6$, $P_2 \times P_7$, $P_4 \times P_5$, $P_4 \times P_6$, $P_5 \times P_6$, $P_5 \times P_8$, $P_6 \times P_9$, showed non-significant (s^2_{di}) 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^2_{di}), indicating their stable behavior. Hybrids $P_1 \times P_7$, $P_1 \times P_8$ and $P_3 \times P_6$, 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^2_{di}) hence their behavior was stable, while 14 hybrids showed significant deviation from regression (s^2_{di}) there by their behavior was unstable. Hybrids $P_3 \times P_6$, $P_5 \times P_8$ and $P_8 \times P_9$ indicating its adaptability under unfavorable environments for more amount of starch content whereas, hybrid $P_6 \times P_9$, 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	Kernel s 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	0.03
		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
Treatment s	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	10	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		E ₁	1.161 ***	1.128 ***	0.01	6.294 **	6.528 ***	-0.224	0.012	-1.648	0.008
2	P ₁	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		E ₁	-0.978 ***	-0.872 **	0.083	-6.187 **	-5.494 **	0.343	0.01	0.376	-0.228
5	P ₂	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		E ₁	-0.728 **	-0.817 **	-0.083	-4.412 *	-4.832 **	0.028	-0.199 *	0.98	-0.228
8	P ₃	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		E ₁	0.717 **	0.656 *	-0.056	-2.46	-3.086	0.841	-0.126	-0.735	-0.009
11	P ₄	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		E ₁	-0.144	-0.122	-0.028	3.697	0.656	1.01	0.141	0.76	-0.106
14	P ₅	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		E ₁	-0.45	-0.511	-0.028	-4.397 *	-0.516	-2.176 ***	0.035	-0.125	-0.014
17	P ₆	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		E ₁	-0.644 *	-0.761 **	-0.083	1.742	2.889	0.688	0.025	1.577	0.205
20	P ₇	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		E ₁	1.050 ***	1.017 ***	-0.056	6.852 **	5.648 **	-0.076	0.026	0.308	0.283
23	P ₈	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		E ₁	0.578 *	0.878 **	0.306 ***	1.682	1.675	-0.833	0.053	-1.137	0.099
26	P ₉	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		E ₁	-0.561 *	-0.594 *	-0.056	-2.812	-3.467 *	0.398	0.023	-0.357	-0.009
29	- P ₁₀	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% Gi--Gj at 95%	E ₁	0.617 ***	0.618 ***	0.154 ***	4.927 ***	3.778 ***	1.407 ***	0.184 ***	2.186 ***	0.437 ***
			0.920 ***	0.922 ***	0.230 ***	7.344 ***	5.632 ***	2.098 ***	0.275 ***	3.259 ***	0.651 ***
	Gi < 0 at 95% Gi--Gj at 95%	E ₂	0.495 ***	0.441 ***	0.186 ***	5.527 ***	4.251 ***	1.668 ***	0.159 ***	1.790 ***	0.357 ***
			0.738 ***	0.658 ***	0.277 ***	8.239 ***	6.337 ***	2.486 ***	0.237 ***	2.668 ***	0.533 ***
	Gi < 0 at 95% Gi--Gj at 95%	E ₃	0.533 ***	0.699 ***	0.175 ***	3.514 ***	2.842 ***	1.143 ***	0.149 ***	1.776 ***	0.295 ***
			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% Gi--Gj at 95%	E ₁	0.618 ***	0.299 ***	0.630 ***	1.327 ***	0.591 ***	13.697 ***	0.345 ***	0.049 ***	0.324 ***
			0.921 ***	0.446 ***	0.938 ***	1.978 ***	0.881 ***	20.418 ***	0.514 ***	0.073 ***	0.482 ***
	Gi < 0 at 95% Gi--Gj at 95%	E ₂	0.832 ***	0.333 ***	0.754 ***	1.168 ***	0.492 ***	8.750 ***	0.458 ***	0.022 ***	0.108 ***
			1.241 ***	0.497 ***	1.124 ***	1.741 ***	0.734 ***	13.044 ***	0.683 ***	0.033 ***	0.161 ***
	Gi < 0 at 95% Gi--Gj at 95%	E ₃	0.495 ***	0.244 ***	0.438 ***	1.098 ***	0.558 ***	4.332 ***	0.533 ***	0.012 ***	0.167 ***
			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 ₁ X 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	11.681	0.371	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 ₂ X 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	0.449	5.625	-0.258	0.065	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 ₃ X 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	-2.543	-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 ₄ X 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	0.595 *	-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 ₁ X 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	3.07	-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 ₂ X 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 ₃ X 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 ₄ X 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-silking interval; 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 ² di	mean	Bi	S ² Di	mean	Bi	S ² Di	mean	Bi	S ² Di	mean	Bi	S ² Di	mean	Bi	S ² Di	mean	Bi	S ² Di	mean	Bi	S ² Di
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	P4 X 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	HQM	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

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(continue) Table.6 Stability 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 ² di	mean	Bi	S ² Di	mean	Bi	S ² Di	mean	Bi	S ² Di	mean	Bi	S ² Di	mean	Bi	S ² Di	mean	Bi	S ² Di
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	P4 X 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

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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.

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