*Original Research Article*

# Stability Analysis of Quality Protein Maize Hybrids ~~for Yield,~~ Qualitative and Quantitative Traits under Heat ~~stress~~ Stress ~~in~~ across Different Environments of Prayagraj District in Central India.


## 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. Where was the study conducted? Please indicate weather and soils conditions.Geographiccoordinates? What is the experimental design?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. A stability study was carried out to determine the grain yield of 45 maize hybrids under three environments ($E_1$, $E_2$ and $E_3$), using Eberhart and Russel model. The a~~A~~nalysis of variance for combining ability revealed the mean squares due to general combing ability (GCA) and specific combing ability (SCA) were highly significant for all ~~the~~ characters studiedy. Inbred lines~~The parents,~~ $P_4$, $P_5$ and $P_2$~~had~~ showed significant to highly significant positive GCA effects ~~for~~ on grain yield per plant and its attributes, indicatingedthat ~~these two~~both parents were good general combiners for this trait. Four hybrids (~~The cross combinations,~~ $P_5$ x $P_7$, $P_5$ x $P_6$, $P_4$ x $P_8$ and $P_4$ x $P_5$h) exhibited ~~ad~~ 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 top cross combinations (~~, namely~~ $P_5$ x $P_7$, $P_5$ x $P_6$, $P_4$ x $P_8$, $P_5$ x $P_9$ and $P_4$ x $P_5$), exhibitinged highly significant positive standard heterosis~~. after critical evaluation for~~ regarding their high ~~superior~~ and stable performance ~~over~~ across environments.~~StabilityStudy 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 foundpromising for the majority of characters studied, with high mean performance across ~~the~~ environments.Based on a rRegression coefficient ~~near~~ close to unity ($\beta_i \approx 1$) and a non-significant deviation from regression ($s^2di$), ~~.~~




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~~There by~~ indicating ~~its~~ their adaptability ~~over~~ across all environments investigated~~thus~~, five best performing ~~these~~ hybrids ($P_1 \times P_8$, $P_2 \times P_6$, $P_1 \times P_6$, $P_9 \times P_{10}$ and $P_3 \times P_5$) were identified. ~~as stable over the all three environmentsand~~Unclear Conclusion of abstract. Please choose the most relevant criterion to determine the best performing hybrids. Here you have 5 + 3 + 5 = 13 hybrids best performing following three analyses.But the conclusion indicate only three best hybrids.

Prospective?? (Before being released, promising hybrid idenfied must undergo additional observation tests across different environmental conditions). ~~moreover, hybrids, $P_5 \times P_6$, $P_4 \times P_9$, $P_4 \times P_5$ and $P_3 \times P_6$ 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,~~ Combining ability, G x E interaction, Heterosis effect, Diallel crossing, Cereal crop, Dominance effect~~and Eberhart & Russell~~.

## Introduction

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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~~ over 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~~ maize has increased at a CAGR ???of 11% in last five years. Today, ~~Maize~~ maize is a source of more than 3500 products including specialised m~~M~~aize like ~~QPM~~ "Quality Protein Maize – QPM –" (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



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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 $04^{th}$ 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 $5^{th}$ 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).

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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 program~~me~~s 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, which could be ~~for~~ cultivated~~ion~~ 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~~ tested~~over~~ across 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~~ on testing and cultivar release ~~programmes~~programs. 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~~ traitsinvestigated differ ~~among~~ across 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

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**Formatted:** No underline, Font color: Text 1, Highlight a range of environments with the ability to utilize the resources in high yielding environments. Further in the state of U.P., only full season of maize hybrids are available, therefore an attempThe objective of this study twas made to identify promising early to extra early QPM hybrids under high stress conditions, without compromising their yield potentialwith the yield levels under HS condition.

## Materials and methods

Study area ?

The study was conducted at central research farm, SHUATS (Prayagraj) in India. Which geographic part of India? Which geographic coordinates? What are Climatic conditions and major soil types of the experimental site ?

QPM inbred lines tested ?

Description of inbred lines tested (main traits interesting known). Table ?

…..

**Table 1. Name, origin and heat stress status of QPM inbred lines.**

| QPM 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.

Experimental design

To access the stability performances of 45 single cross hybrids (Table 2) for yield and its components The experiment was conducted following ain randomized block design (RBD) with how many inbred lines??and three replications along with 1 check (HQPM 5). Why not a RCBD where C stands for complete? The experiment was laid out across three different

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environments *viz*., $E_1$, $E_2$ and $E_3$ during kharif season of 2020.Experiment was designed with following 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% percenttasselingtasselling, days to 50% percentsilking, anthesis-silking interval and days to maturity. Data were recordedacrossall three environmentson following 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 contentwere recorded in all three environments.QPMuality protein inbred lines (Table 1) obtained from different research centres in India, were used to generate single cross hybrids (Table 1).

**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.

A tTotal of 45 $F_1$s were obtained using diallel fashion with non-reciprocals. Among them, 10 selected inbred lines which were selected are crossed in all possible ways without reciprocals to produce 45 $F_1$s. MThe 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. The rRegression coefficient (bi) obtained was considered as an indication of genotype the



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response~~ of the genotype~~ to a 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, expressed as percent deviation from the mid parent, 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).

Some key relevant equations need to be displayed for a better understanding of calculation procedures.

## Results and Discussion

Which Sub-title? Analysis of variance?

T~~Pooled~~ he analysis of variance for eighteen~~ characters of~~ quantitative and qualitative traits over different environments ~~(presented in~~ Table4~~)which acknowledge the~~ shows that mean squares due to genotypes, parents, hybrids and parent vs. hybrids were highly significant for all the characters studied, which 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~~



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## General combining ability (GCA)

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~~ whileamong all ~~this~~parental line~~s~~ $P_{10}$~~f~~was 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 $P_5$ showed~~n~~ 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 $P_9$ showed~~s~~ positive GCA for quality parameters like oil content and starch content. A ~~and a~~mong 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~~ weredesirable 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% ~~percenttasseling~~tasselling, 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~~tasselling, days to 50 percent silking and plant height,while~~,the~~ parents~~,~~ $P_5$ 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 for these traits and can be used as parent for development of early maturing hybrids. For ~~the~~ plant height, negative GCA effects are desirable. ~~The P~~Parents $P_2$ and $P_{10}$ had highly significant negative GCA effects for plant height and ear height, and therefore were~~as~~ grouped as good general combiners for these traits. These findings are in 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.

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## Specific combining ability (SCA)

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E~~The e~~stimates of specific combining ability (SCA) effects for eighteen quantitative and qualitative traits (Table 6) ~~revealed~~ showed that~~ the~~ten cross combinations (~~, namely,~~ $P_1$ x $P_{10}$, $P_3$ x $P_5$, $P_3$ x $P_7$, $P_3$ 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 $P_9$) had 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 the~~i~~se 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~~heat stress. The results obtained in this investigation are partially in accordance with findings reported by 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 and~~/~~ 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.

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Hybrids $P_1$ x $P_4$, $P_1$ x $P_5$, $P_1$ x $P_{10}$, $P_5$ x $P_9$, $P_5$ x $P_{10}$ showed~~s~~ negative SCA in environment $E_1$. F1s $P_2$ 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 $P_5$, while~~and~~ $P_8$ x $P_{10}$ depicted~~s~~ great SCA effects in environments $E_1$ and $E_2$. ~~and o~~Only $P_1$ x $P_4$, $P_7$ x $P_8$ and $P_5$ x $P_7$~~are~~ gavesignificantly negative SCA in environment $E_3$;~~, over A~~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 $P_8$ shows significantly 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~~across environmentsinvestigated ~~$E_1$, $E_2$ 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 significantly negative SCA effects for days to 50%~~ per cent~~ maturity. Combinations F1s $P_4$ x $P_7$, $P_4$ x $P_{10}$,

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$P_6$ x $P_8$, and $P_6$ x $P_9$ exhibited highly significant negative SCA effects for plant height,.aAlthough, none of the crosses exhibited significantly negative SCA effects for ear height acrossin all three environments. Subsequently, 30 hybrids showeds significantlypositive SCA for chlorophyll content, whereas and15 $F_1$s depicteds negative specific combining ability in all threeacross environments.among Among them, $P_2$x $P_7$, $P_4$x $P_5$, $P_5$ x $P_8$, $P_7$ x $P_9$, and $P_9$ x $P_{10}$reveal showedhighest negative SCA.followed, hHybrids $P_1$ 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 exhibitedhighest significant positive SCA in all environments. $E_1$, $E_2$ and $E_3$ andfor canopy temperature deficit HHybrids $P_1$ x $P_2$, $P_3$ x $P_5$, $P_4$ x $P_6$, $P_6$ x $P_9$ showeds significant positive specific combing ability regarding canopy temperature deficit 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 themhybrids $P_1$ 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 $P_9$ showeds significant and positive combining ability ers for ear length and ear girth in all threeacross environments. andMmoreover, hybrids $P_2$ x $P_3$ and $P_5$ x $P_6$are weregreat in all the yield attributing characters except forthe number of kernel row per cob. Additionally,Hybrids $P_1$ x $P_8$ and $P_7$ x $P_9$ $F_1$s were also revealed asthat these are good combiners in all the yield attributingcharacters traitsin all theacross environments. For quality parameters like oil content and starch contentTen hybrids,namely $P_1$ 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$P_9$ total of 10 hybrids, exhibited positive SCA across environmentsfor quality parameters like oil content and starch contentin 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 maize 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 $P_3$ x $P_8$ (6.22***), $P_3$x $P_6$ (4.03**), $P_1$x $P_4$ (3.41***). Single cross hybrids like $P_4$x $P_9$ (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 $E_3$across environments. On the other hand, hybrids $P_2$ x $P_6$ (-4.13), $P_3$ x $P_7$ (-3.51), and $P_6$ x $P_8$ (-4.61) were the worst three combinations for seed index,among Among them,the third environment effects were moreworsethan the 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 effect**

The estimates of standard heterosis over the check (-HQPM-5) for eighteen quantitative and qualitative traits revealed the percent of standard heterosis for grain yield, ranginged from 0.71% ($P_2$ x $P_6$) to 45.11 % ($P_5$ x $P_6$) in underE1, from 0.42% ($P_1$ x $P_7$) to 5.769 % ($P_1$ x $P_8$) in under$E_2$ and 18.922% ($P_4$ x $P_8$) in under$E_3$;. Data for this character further revealed that hybrid $P_5$ x $P_6$ (45.11 %) exhibited highest significantly positive significant standard heterosis for sSeed yield,followed by hybrids $P_5$ x $P_7$ (44.69%), $P_4$ x $P_5$ (34.944 %), $P_4$ x $P_8$ (33.922 %), $P_4$ x $P_9$ (30.216 %) in environment $E_1$. Similarly in underenvironment $E_2$, 5.769 %. ($P_1$ x $P_8$) depicted the highest significantly positive significant value followed by hybrids $P_1$ x $P_{10}$ (4.218 %), $P_2$ x $P_3$ (2.328 %), $P_5$ x $P_7$ (0.555 %), $P_1$ x $P_7$ (0.422 %).However, whereas underin environment $E_3$, 18.922 % ($P_4$ x $P_8$) exhibited the highest significantly positive significant standard heterosis value for sSeed 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 all the locations $E_1$, $E_2$ and $E_3$investigated. Days to 50% per centtasseling and days to 50% percentsilking 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 the highest negative significant standard heterosis for days to 50 % tasseling and for days to 50 % silkingvaried 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

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hybrids which recorded significant heterosis over the check. Similarly, over the check, HQPM-5 aa total of 12 hybrids recorded significant standard heterosis in desirable positive direction in regardingleaf area index. These results were in line with the findings reported byof Mohammed and Yousif (2020) and karim *et al*., (2018). Ffor the yield attributing traits like the number of kernel rows per cob, number of kernels per row, ear length and ear girth, hybrids $P_{3}$ x $P_5$ and $P_5$ x $P_6$ showed positive standard heterosis. Furthermore for the quality parameters like oil content and starch content, hybrids $F_1$s $P_2$ 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 $P_9$ showeds significantly positive heterosisin under all the environments studied$E_1$, $E_2$ and $E_3$. Hence, these hybrids can be exploited earliness after critical testing over environments. Similar results were reported by Ambikabathyet al., (2019), Kumar and Babu (2016), Kumar et al., (2015), Oforiet al., (2015), Lahaneet al., (2014). Hence, Tthese hybrids may be exploited commercially after critical evaluation for their performance and stability over acrossdifferent environments.

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## Stability analysis

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TFor days to tasseling the mean value of days to tasselling over the threeacross environmental conditionss was 52 days. Days to 50% tasseling revealed that out of 45 hybrids, A total of 32 hybrids out of 45 regarding days to 50% tasseling, showed non-significant deviation from regression ($s^2di$), hence Ttheir behavior was predictable, while 13 hybrids showed significant deviation from regression ($s^2di$) and therefore by their behavediorwas unstable. The hybrid ($P_1$ × $P_8$) had exhibited a negative phenotypic index ($P_i$<1), a regression coefficient near closeto unity ($\beta_i \approx 1$) and a non-significant deviation from regression ($s^2di$), there by indicating its stability over allacross environments and suitability for early tasseling. H The hybrids $P_1$ x $P_8$, $P_1$ x $P_2$, and $P_6$ x $P_9$ showed non-significant deviation from regression ($s^2di$), with had negative phenotypic index ($P_i$‹1), and a regression coefficient greater than unity ($\beta_i$>1), indicating their adaptability under un-favorable environments and their suitabilitylityle for early tasseling. For days to silking, out of 45 hybrids, 32 hybrids out of 45 showed non-significant deviation from regression ($s^2di$), with therefore a predictable hence their behavior, was predictable, In contrast, while 13 hybrids remaining showed significant deviation from regression ($s^2di$), with an unpredictable there by their behavior was unstable. The hybrid ($P_1$ × $P_8$)had presented anegative phenotypic index ($P_i$<1), a regression coefficient near closeto unity ($\beta_i \approx 1$) and a non-significant deviation from regression ($s^2di$), there by indicating its adaptability over allacross environments and

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suitability for early silking.~~ The~~H~~h~~ybrids $P_1$ x $P_8$~~,~~and $P_4$ x $P_8$showed non-significant deviation from regression ($s^2di$) ~~had ~~with anegative phenotypic index ($P_i$‹1), and a regression coefficient greater than unity ($\beta_i$>1), indicating their adaptability and suitability for early silking~~under un-favorable environments and suitable for early silking ~~across different environments.

~~For plant height ~~T~~t~~he highest mean plant height (184.1~~08~~ cm) was recorded for hybrid $P_1$ x $P_8$whereas the ~~tallest and ~~lowest mean~~ plant height~~ (131.5~~2~~ cm) was observed ~~for ~~on hybrid $P_6$ x $P_9$, ~~. The~~and the average plant height ~~over the~~across different environments was 163.5~~0~~ cm. All ~~the ~~hybrids tested were significantly deviating from the regression value across ~~the ~~environments.~~ and~~ Over the three environments tested, 26 hybrids showed a non-significant deviation from regression ($s^2di$), with therefore a predictable ~~hence their ~~behavior ~~was predictable.~~ In contrast, ~~ while ~~19 hybrids showed a significant deviation from regression ($s^2di$), with an unpredictable~~there by their~~ behavior~~ was unpredictable~~. The hybrid $P_2$ x $P_6$ had negative phenotypic index ($P_i$<1), a regression coefficient near to unity ($\beta_i \approx 1$) and a non-significant deviation from regression ($s^2di$),~~ there by~~ indicating its adaptability ~~over all~~across environments and suitability for lower plant height.

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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 ($\beta_i$<1), with mean values higher than the population mean, thereby indicating its adaptability under unfavorable environments for increase ear girth. The hybrids, $P_1$ 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 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.



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The hybrids, $P_1$ x $P_7$, $P_4$ x $P_5$, $P_5$ x $P_{10}$ indicating stable performance in different environments for more number of kernel rows per cob. The hybrid $P_2$ x $P_6$had high number of kernels per row (36.66), while $P_8$ x $P_9$ had low number of kernels per row (22.33). While, over the three environments hybrids, $P_1$ x $P_5$, $P_1$ x $P_6$, $P_1$ x $P_9$, $P_4$ x $P_5$, $P_5$ x $P_6$, $P_6$ x $P_8$, $P_7$ x $P_{10}$, $P_8$ x $P_{10}$ 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 $P_7$ x $P_8$ (22.72 g) whereas, maximum kernels per row was exhibited by hybrid $P_3$ x $P_8$ (28.43 g). Among check HQPM-5 (26.88 g) The hybrids $P_1$ x $P_7$, $P_2$ x $P_6$, $P_3$ x $P_5$, $P_4$ x $P_6$, $P_4$ x $P_8$, $P_4$ x $P_9$, $P_4$ x $P_{10}$, $P_5$ x $P_6$, $P_5$ x $P_8$, $P_5$ x $P_7$, $P_7$ x $P_8$, $P_7$ x $P_9$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 $F_1$ $P_5$ x $P_6$ with (256.62 qt/ha) and lowest $F_1$ $P_8$ x $P_9$ (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) $P_5$ x $P_7$, $P_5$ x $P_6$ and $P_4$ x $P_9$ 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 $P_6$ x $P_8$showed their adaptability under favorable environments and depicted low canopy temperature depression and hybrid $P_1$ x $P_2$, $P_1$ x $P_3$, $P_1$ x $P_4$, $P_1$ x $P_5$, $P_1$ x $P_6$, $P_1$ x $P_8$, $P_2$ x $P_3$, $P_3$ x $P_{10}$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

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3 hybrids showed non-significant deviation from regression ($s^2di$), 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 ($s^2di$) hence their behavior was stable, while 14 hybrids showed significant deviation from regression ($s^2di$) there by their behavior was unstable. Hybrids $P_3 \times P_6$, $P_5 \times P_8$ 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.

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**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 | | $E_1$ | 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%** | $E_1$ | 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 | $P_1$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 | 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 | $P_2$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 | 0.429 | 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 | $P_3$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 | -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 | $P_4$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 | 0.596 * | -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 | $P_1$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 | 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 | $P_2$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-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**

The study showed that based onQPM 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 forgrain yield per, threecross combinationshybrids namely,$P_5$ x $P_6$, $P_5$ x $P_7$ and $P_4$ x $P_5$were identified as the best performingexperimental hybrids on the due to basis of high standard heterosis, high specific combining abilitySCA and high general combining abilityGCA offor female parents. Before being released, they must undergo additional observation tests acrossdifferent environmental conditions.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 environmentsFrom this, we can stabilize the production level of the crop and it could improve the national production and productivity.

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