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Research article

DIALLEL ANALYSES OF SOME AGRONOMIC TRAITS IN MAIZE (ZEA MAYS L.)

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ABSTRACT: The research work carried out on gene action and combining ability in respect of quantitative traits by crossing 8 diverse maize inbred lines in a half diallel mating design. Twenty eight F1 progenies along with their parents were planted in randomized complete block design with four replications in two environments in 2010. Combined analysis of variance showed significant mean squares of general combining ability (GCA) and specific combing ability (SCA) for days to silking (DS), plant height in cm (PH), ear height in cm (EH), 1000-kernel weight in gram(KW), Ear length in cm(EL), number of rows in ear(NR), number of Leaf (NL) and kernel yield(KY) in ton per hectare, indicating the importance of both additive and non additive genetic effects for these traits. However, high narrow-sense heritability estimates, low degree of dominance and the ratio of estimates of GCA to SCA effects for DS, KW, NR ,EL ,EH and NB indicated that additive genetic effect were more important for these traits. The crosses MO17 x L8, MO17 x L12 and L8 x L10 with 11.08, 9.847 and 8.65 t/ha kernel yield had high KY and were considered as good combinations for improving the trait .Most of the crosses with high mean of kernel yield had at least one parent (MO18 and L8) with significant GCA effect for this trait.SC704 (Check) had 9.386 t/ha kernel yield.

Key words: Agronomic traits, Combined analysis, Corn, Dominance, Heritability.

INTRODUCTION

Corn has a remarkable place among cereals and it is used as human food, animal feeding and industry. Maize is the most important cereal crop in the world after wheat and rice. It has great yield potential and attained the leading position among cereals based on production as well as productivity [16]. Advances in maize genomics, breeding and production have significant role on the lives of a large proportion of the world's population [27]. Every part of the plant has economic value; the grain, leaves, stalk, tassel are used to produce hundreds of food and non-food products. The main purpose of maize breeding is to develop new inbred lines and hybrids that will outperform the existing hybrids with respect to a number of traits. In working towards this objective, particular attention is paid to grain yield as the most economically important traits in maize [25]. Grain yield is a complex quantitative trait that depends on a number of factors that are inherited in a quantitative manner [30]. As a quantitative trait, it is greatly influenced by environmental conditions, has a complex mode of inheritance and low heritability [5]. It is also affected by a number of components, including kernel row number and ear lengh. The identification of parental inbred lines that perform superior hybrids is the most costly and timeconsuming phase in maize hybrid development. Per se performance of maize inbred lines does not predict the performance of maize hybrids for grain yields [13].The identification of parental inbred lines that perform superior hybrids is the most costly and timeconsuming phase in maize hybrid development. Per se performance of maize inbred lines does not predict the performance of maize hybrids for grain yields [13]. Predictors of single cross hybrid value or heterosis between parental inbred lines could therefore increase the efficiency of hybrid breeding programs [4].
The main goal of maize breeding is obtaining new hybrids with high genetic potential for yield and positive features that exceed the existing commercial hybrids [23].

Combining ability analysis is ,therefore, an important method to deduce gene actions and it is frequently used by crop breeders to choose parents with a high general combining ability (GCA) and hybrids with high specific combining ability (SCA) effects [28]. Variance for GCA is associated with additive genetic effects, while that of SCA includes non-additive genetic effects, arising largely from dominance and epistatic deviations with respect to certain traits. In a systematic breeding program, it is essential to identify superior parents for hybridization and crosses to expand the genetic variability for selection of superior genotypes [13]. One essential step in hybrid development is testing of inbred lines for their GCA effects. Diallel crosses have been widely used in plant breeding to investigate combining abilities of the parental lines in order to identify superior parents for use in hybrid development programs [10 ,12,14]. Combining ability has been investigated by several researchers in maize [2, ,3, 6, 11,15,17, 22, 24, 26]. Fry stated that heritability of a trait approaches its maximum in successive generations following hybridization[10]. In addition, the presence of additive gene effects for a trait indicates the presence of additive variation, which means that selection could be successful for the trait [9]. Ojo et al reported significant positive heterosis for grain yield and yield components in diallel crosses of seven white maize inbred lines[20]. Additive gene action was also more important than non-additive gene action for grain yield. Ottaviano and Camussi examined several agronomic traits in diallel crosses of 10 inbred lines and their 45 F1 hybrids to study their genetic relationships with grain yield[21].

Beside gene effects, breeders would also like to know how much of the variation in a crop is genetic and to what extent this variation is heritable, because efficiency of selection mainly depends on additive genetic variance, influence of the environment and interaction between genotype and environment [19]. Large genotype × environment effects tend to be viewed as problematic in breeding because the lack of a predictable response hinders progress from selection. Most of the literature about maize, the most extensively studied plant species, suggests that additive effects of genes with partial to complete dominance are more important than dominance effects in determining grain yield [18]. Given the diversity of environments in which maize is cropped in Iran, the hybrid by environment interaction is normally expressive [1]. Therefore it is necessary to identify hybrids that present not only wide adaptation, assessed by the mean yield, but also have high stability, i.e., with homeostasis to adjust to environmental changes. Some studies have already compared stability in different types of hybrids [7]. However, there is little information regarding stability of the GCA and SCA effects. Probably, when identifying single-crosses with higher stability in the GCA and SCA, the hybrid combinations obtained from these parents also present higher homeostasis for environmental variations.

The objectives of the present study were to evaluate GCA and SCA effects of seven maize inbred lines over two environments and also other genetic parameters including degree of dominance and narrow-sense heritability estimates for days to silking and yield components in order to determine superior breeding lines and cross combinations.

MATERIALS AND METHODS

The material under study consisted of eight maize inbred lines; L8, L10, L12, L21, L24, L33, L36 and MO17 which were selected based on different agronomic characters. These lines were crossed in a half diallel mating scheme in 2009. The resulting 28 F1 progenies along with their parents were evaluated using a randomized complete block design with four replications at two locations; Dashtenaz Agronomy Research Station located in Sari, Iran (53° $11'$ E longitude and 36° $37'$ N latitude, 10.5 m above sea level) and Qarakheil Agronomy Research Station located in Qaemshahr, Iran (52° $46'$ E longitude and 36° $27'$ N latitude, 14.7 m above sea level) during spring 2010. The plots consisted of 3 rows, 5 m long and 75 cm apart and intra-row spacing of 20 cm. Crop management practices which included land preparation, crop rotation, fertilizer, and weed control were followed as recommended for each site. All the plant protection measures were adopted to make the crop free from insects. Ten plants from the middle of each row were sampled and the following traits were recorded for each cross at each location: days to silking, plant height in cm, ear height in cm, 1000-kernel weight in gram, Ear length in cm, number of rows in ear, number of Leaf and kernel yield in ton per hectare.

Data were analysed using the following statistical model: $Yijkl = \mu + \alpha l + bkl + vij + (\alpha v)ijl + eijkl, vij = gi + gj + sij$ where Yijkl = observed value from each experimental unit; μ = population mean; αl = location effect; bkl = block or replication effect within each location; vij = F1 hybrid effect = gi + gj + sij (where gi = general combining ability (GCA) for the *i*th parent; gj = GCA effect of *j*th parent; sij = specific combining ability (SCA) for the *ij*th F1 hybrid); (αv)ijl = interaction effect between *ij*th F1 hybrid and location; eijkl = random residual effect.

The combining ability analysis was performed using mean values of the F_1 generation along with parents by using Griffing's method 2[12]. The statistical t-student test was applied to examine the effects GCA and SCA.
Pearson coefficient of correlation was detected based on means values the traits as r = [Covarince (XY)/√(Variance (X). Variance (Y)], where X and Y were considered as different traits under study.
A special SAS software (version 9) tool for diallel analysis developed by Zhang et al. was used to determine GCA effects, SCA effects, and their interaction effects with locations and also coefficient of correlation[29].

RESULTS AND DISCUSSION

Combined analysis of variance

Significant mean squares of GCA and SCA at 1% probability level were detected for all the traits including days to silking (DS), plant height(PH), ear height (EH) ,1000-kernel weight(KW), number of of Leaf (NL), number of rows in ear(NR), Ear length(EL) and kernel yield(KY) indicating the importance of both additive and non additive genetic effects for these traits(Table 1). The narrow-sense heritability estimates ranged from 0.05 to 0.488 for PH and NR, respectively and the degree of dominance for these traits were 5.89 and 1.33, respectively. The ratio of the GCA to SCA effects for the these traits were 0.35 and 4.59 , respectively (Table 1). Therefore due to the moderately high ratio of the GCA to SCA effects estimates, low degree of dominance for DS, KW, NR ,EL ,EH and NB, it was concluded that the additive genetic effect was more important for these traits. Additive genetic effect is important in order to plant breeder can improved suitable traits in maize by transfer these genes in plant. Significant mean square of environments for DS,PH, KW, EH , NB and KW at 1% probability level revealed significant differences between the two environments for these traits. Significant mean square of genotypes for PH, KW, EH , NB , KW and KY indicated significant genetic difference among parents and crosses for these traits. Non significant interaction effects of GCA and environments and also SCA and environments revealed that the trend of GCA effects of parents and SCA effects of the crosses over the environments were similar. Similarly, in earlier studieswere recorded significant mean square of GCA and SCA effects of yield components in maize[2,3 ,6, 11, 15,17, 22, 24,26].

Table 1. Combined analysis of days to silking, plant height, yield components and kernel yield of maize based on Griffing's method 2.

S.O.V	DF	DS	PH	KW	EL	NR	NB	EH	KY
Environments (E)	1	3003**	33073.7**	21013**	0.06 ^{ns}	0.011 ^{ns}	51.7**	1719**	37.2**
E (REP)	6	228**	3634.12**	2767*	18.3**	3.18 ^{ns}	6.8**	1124**	11.6**
Genotypes(G)	35	65.5^{ns}	3633.30**	2892**	38.96**	19.2 ^{ns}	1.77**	1442**	25.9**
E*G	35	5.7**	384.83^{ns}	1384^{ns}	6.7**	3.45**	0.795**	138 ^{ns}	4.67**
GCA	7	162.5**	1431.28**	6582**	52.4**	52.14**	3.15 **	946.8**	13.5**
SCA	28	33.4**	4075.6**	2278**	36.1**	10.6**	1.16 **	1544**	29.15**
GCA*E	7	13.6**	762.6^{ns}	1687 ^{ns}	6.97 ^{ns}	3.07 ^{ns}	1.38**	168 ^{ns}	3.84*
SCA*E	28	3.6 ^{ns}	320.1 *	1375 ^{ns}	5.58 ^{ns}	3.35**	0.53 ^{ns}	131 ^{ns}	4.43**
Error	210	4	359.35	1171.7	3.76	1.68	0.367	165.8	1.48
MSGCA/MSSCA		4.86**	0.35^{ns}	2.89*	4.86**	4.9**	2.72*	0.61**	0.46 ^{ns}
D		1.43	5.89	1.43	1.36	1.33	1.68	4.2	4.79
H^2		0.32	0.05	0.32	0.487	0.488	0.325	0.092	0.076

PH: plant height, EH: ear height, KW: 1000-kernel weight, DS: Days to ear silking, EL: Ear length,NR: number of row in ear, , NB: number of Leaf, KY: kernel yield.
ns,* and **: Non significant , significant at 5% and 1% levels , respectively.

General combining ability of the parents

The mean of combining ability effects of parents for all the traits across the environments is presented in Table 2. Due to importance of early maturity and lower values of DS; L36,L12 and L33 which had significant negative GCA effects were considered as good combiners for this trait. The parents; L33 , L12 and L36 with mean of 61.5,62.5 and 63.25 for DS are more profitable for improving this trait (Table 3). Due to lower plant height makes more tolerant to lodging, therefore the parents L12, MO17 and L21 with means of 151.8 ,161.9 and 173.7 cm of PH, respectively ,were suitable parents for this trait. The mean of KW ranged from 234.8 to 263.1g and the parents L21 and MO17 with 263.1 and 262.3g mean of KW had high mean values for this trait. Parents MO17 had significant positive GCA effects for KW and thus are considered to be good combiner for improving this trait .The mean value for NR varied from 11.5 to 16.25,. Parents L8,L12 and L33 had significant positive GCA effects for NR, hence were good combiners for increasing this trait. Parents MO17, L8 and L10 had significant positive GCA effects for EL making them good combiners for improving the trait. In addition, L8 and L10 parents had high mean values for EL (Table 3). The parent L8 had significant GCA effects for NB and were , therefore, good combiner for this trait. The highest mean of NB also was observed for L8. The Lowest means of EH also were observed for L12 and MO17. The parent L12 and L36 had negative significant GCA effects for EH and were , therefore, good combiner for this trait. Due to lower ear height makes more tolerant to lodging, therefore the parents L12 and L36 were suitable parents for this trait . The parents L8 and MO17 which had significant positive GCA effects for KY were good combiners for improving the trait. Inbred lines L8 and L10 had high means for KY (Table 3). Ojo et al reported significant GCA effects for grain yield and yield components in a diallel crosses of seven white maize inbred lines[20].

Table 2. General combining effects of eight maize lines for kernel yield and related traits across two environments using Griffing's method 2.

Traits Lines	PH	EH	KW	DS	EL	NR	NB	KY
L8	5.1*	5.48**	1.83 ^{ns}	1.06*	0.74**	1.1**	0.23*	0.66**
L10	4.27 ^{ns}	0.7 ^{ns}	4.63 ^{ns}	0.16 ^{ns}	0.92**	0.07 ^{ns}	0.008 ^{ns}	0.23 ^{ns}
L12	-5.75 ^{ns}	-3.82*	-2.05 ^{ns}	-1.39**	-0.79**	0.6**	0.16 ^{ns}	0.19 ^{ns}
L21	-2.39^{ns}	-0.03 ^{ns}	-4.45 ^{ns}	-0.34 ^{ns}	-0.63 **	0.27 ^{ns}	0.054 ^{ns}	-0.37*
L24	3.3 ^{ns}	2.5 ^{ns}	-3.6 ^{ns}	0.56 ^{ns}	-0.79**	0.02 ^{ns}	0.16 ^{ns}	-0.29 ^{ns}
L33	3.39 ^{ns}	2.2 ^{ns}	-6.24 ^{ns}	-1.18*	0.08 ^{ns}	0.4**	-0.008 ^{ns}	-0.26 ^{ns}
L36	-3.89 ^{ns}	-5.67**	-10.53**	-1.67**	-.073**	-.097**	-0.24**	-0.56**
MO17	-4.03 ^{ns}	-1.41 ^{ns}	20. 4**	2.8**	1.19**	-1.49**	-0.37**	0.39*

DS: Days to ear silking, PH: plant height, KW: 1000-kernel weight, EL: Ear length,NR: number of row in ear, , NB: number of Leaf, EH: ear height, KY: kernel yield.
ns,* and **: Non significant , significant at 5% and 1% levels , respectively.

Table 3. Means of eight maize lines for days to silking, plant height, yield components and kernel yield across two environments.

Traits Lines	PH(Cm)	EH(Cm)	KW(Gr)	DS(Day)	EL(Cm)	NR	NB	KY (T/Ha)
L8	179.2	87.29	239.1	67.5	16.09	16.25	11.38	5.1
L10	190.1	86.26	252.9	66.13	17.49	15.5	10.63	6.09
L12	151.8	66.78	244.8	62.5	13.27	15.5	11.25	4.27
L21	173.7	84.75	263.1	63.5	15.15	14.75	11.13	4.8
L24	178.6	84.53	234.8	68.38	13.00	12.75	11.25	3.0
L33	203.7	96.18	246.9	61.5	16.01	14.5	10.88	4.35
L36	181.0	78.49	241.9	63.25	12.89	13.25	9.5	2.68
MO17	161.9	70.56	262.3	72.88	13.82	11.5	10.0	2.2
LSD5%	18.69	12.57	33.53	1.96	1.89	1.27	0.58	1.23

PH: plant height, EH: ear height, KW: 1000-kernel weight, DS: Days to ear silking, EL: Ear length,NR: number of row in ear, , NB: number of Leaf, KY: kernel yield.

Specific combining ability of the crosses

The result of SCA effects of crosses across the two environments for the different traits are presented in Table 4. Across the environments, only a few crosses had significant SCA effects for some of the traits. Only MO17X L21of the crosses had significant SCA effects for DS. This could be, an indication that additive genetic effects were more important. The DS means varied from 58.63 to 65.75 for L12 x L36 and MO17 x L10, respectively (Table 5). The crosses with low value for DS had at least one parent with significant negative GCA effect for this trait. The parents can, therefore be used in breeding for early maturity. Out of 28 crosses, 4 crosses had significant positive SCA effects for PH. The cross MO17 x L21 with significant negative SCA effects for PH was the best cross combination for this trait. Low values for plant height were observed for MO17 x L21 (190.7 cm), L12 x L36 (198 cm) and L21 x L36 (209.4 cm) .

Significant, positive correlations were observed for NR with EL and KY (Table 6), implying that crosses with high means value of these traits can be used for NR improving.NR is one of the most important trait in order to increasing kernel yield. Among the crosses, L8 x L33, L10 x L33, L12 x L24 and L21 x L24 had significant positive SCA effect for NR and these crosses had high mean for NR. Significant positive correlations were detected for EL with KY NR and NB. Therefore, the genotypes with high value for EL will result in more NR and high KY. The crosses MO17 x L8, MO17 x L10, MO17 x L12 , L21 x L36, L24 x L33 ,L24 x L36 and L33 x L36 had significant positive SCA effect for EL were considered good cross combinations for EL. Significant positive correlation was determined between NB and KY, therefore this trait can also be used as indirect selection criterion for improving KY. Out of 28 crosses, one cross had significant SCA effects for NB. The cross MO17 x L21 which had significant negative SCA effects for PH makes lower value for the trait, therefore, it was the best cross combination for PH. The crosses including MO17 x L8, MO17 x L10, MO17 x L12 and L8 x L10 had the highest means for EL. Only one of the cross had significant SCA effects for NB. This could be explained by the fact that additive genetic effects were predominant. Out of 28 crosses, 5 crosses had significant SCA effects for KY. The crosses MO17 x L8, MO17 x L12 and L8 x L10 with 11.08 , 9.847 and 8.65 t/ha kernel yield had high KY and were considered as good combinations for improving the trait .Most of the crosses with high mean of kernel yield had at least one parent (MO18 and L8) with significant GCA effect for this trait.SC704 (Check) had 9.386 t/ha kernel yield.Significant SCA effects were reported for kernel yield and yield components in diallel crosses of maize breeding lines[8, 11,22].MO17 x L8 was the best hybrid in order to kernel yield in two locations therefore it can more investigate for using in the same conditions.L8 had the highest combining ability in more traits, therefore it can use in maize breeding program.

Table 4. Specific combining effects of maize lines for kernel yield and related traits across two environments using Griffing's method 2.

Crosses	PH	EH	KW	DS	EL	NR	NB	KY
L8X L10	11.9^{ns}	2.24^{ns}	0.92^{ns}	1.11^{ns}	0.49^{ns}	0.18^{ns}	-0.04^{ns}	0.76^{ns}
L8X L12	-2.9^{ns}	5.92^{ns}	24**	1.15^{ns}	0.22^{ns}	0.65^{ns}	0.05^{ns}	-0.10^{ns}
L8X L21	16.26*	6.56^{ns}	-1.39^{ns}	1.48^{ns}	0.75^{ns}	-0.78^{ns}	-0.08^{ns}	0.43^{ns}
L8X L24	2.11^{ns}	7.64^{ns}	-18.9^{ns}	-1.55^{ns}	-0.37^{ns}	0. 23^{ns}	-0.07^{ns}	-0.47^{ns}
L8X L33	3.83^{ns}	-2.92^{ns}	-17.08^{ns}	-0.92^{ns}	-1.42*	1.35**	0.22^{ns}	-0.77^{ns}
L8X L36	13.48^{ns}	-6.9^{ns}	0.52^{ns}	-2.31^{ns}	0.39^{ns}	0.72^{ns}	0.46*	0.35^{ns}
L10X L12	7.47^{ns}	4.26^{ns}	-12.29^{ns}	-1.3^{ns}	0.45^{ns}	-1.07*	0.02^{ns}	-0.47^{ns}
L10X L21	1.63^{ns}	0.91^{ns}	-1.8^{ns}	-0.24^{ns}	-0.19^{ns}	0.25^{ns}	-0.11^{ns}	-0.13^{ns}
L10X L24	8.61^{ns}	5.2^{ns}	9.17^{ns}	-1.39^{ns}	1.34*	-0.24^{ns}	0.15^{ns}	0.4^{ns}
L10X L33	5.77^{ns}	4.1^{ns}	-6.6^{ns}	-0.27^{ns}	-0.59^{ns}	1.1**	0.19^{ns}	0.55^{ns}
L10X L 36	-4.12^{ns}	-1.07^{ns}	-16.2^{ns}	-1.16^{ns}	-1.23^{ns}	-0.24^{ns}	0.43^{ns}	-0.4^{ns}
L12X L21	9.38^{ns}	7.5^{ns}	-3.8^{ns}	1.3^{ns}	-2.77**	0.22^{ns}	0.23^{ns}	0.24^{ns}
L12X L24	9.27^{ns}	-1.18^{ns}	3.6^{ns}	-0.97^{ns}	-0.45^{ns}	1.6**	0.12^{ns}	0.53^{ns}
L12X L33	10.36^{ns}	7.99^{ns}	23.1*	-1.09^{ns}	-0.25^{ns}	0.23^{ns}	-0.04^{ns}	0.79^{ns}
L12X L36	-6.77^{ns}	-7.85^{ns}	-7.2^{ns}	-0.99^{ns}	0.5^{ns}	-0.53^{ns}	-0.1^{ns}	-0.17^{ns}
L21X L24	20.6**	10.46*	8.8^{ns}	-0.14^{ns}	-0.53^{ns}	0.93*	-0.11^{ns}	0.9*
L21X L33	4.16^{ns}	-0.03^{ns}	-7.4^{ns}	-0.89^{ns}	0.77^{ns}	-0.19^{ns}	0.15^{ns}	0.15^{ns}
L21X L36	1.24^{ns}	2.4^{ns}	6.64^{ns}	-0.41^{ns}	1.84*	0.45^{ns}	0.008^{ns}	0.83^{ns}
L24X L33	-7.58^{ns}	-1.9^{ns}	9.4^{ns}	-0.45^{ns}	1.27*	-0.19^{ns}	-0.34^{ns}	0.99*
L24X L36	2.088^{ns}	3.07^{ns}	2.76^{ns}	-0.06^{ns}	1.75**	0.3^{ns}	0.27^{ns}	1.59**
L33X L36	--3.47^{ns}	-0.82^{ns}	-3.05^{ns}	0.69^{ns}	1.54*	0.18^{ns}	-0.05^{ns}	0.16^{ns}
MO17X L8	0.82^{ns}	3.13^{ns}	31.4**	-1.65^{ns}	2.9**	-0.51^{ns}	-0.16^{ns}	3.02**
MO17X L10	1.62^{ns}	4.66^{ns}	38.1**	0.12^{ns}	1.7**	0.52^{ns}	0.05^{ns}	0.71^{ns}
MO17X L12	24.3**	13.7**	-21.4^{ns}	-0.71^{ns}	2.8**	0.49^{ns}	0.02^{ns}	2.27**
MO17X L21	-17.3*	-7.5^{ns}	-18.1^{ns}	-2.63*	-2.77**	0.81^{ns}	0.008^{ns}	-0.98*
MO17X L24	7.4^{ns}	1.4^{ns}	-2.1^{ns}	-0.91^{ns}	0.64^{ns}	0.57^{ns}	0.15^{ns}	-0.54^{ns}
MO17X L33	4.48^{ns}	5.34^{ns}	-2.8^{ns}	0.84^{ns}	0.74^{ns}	-0.3^{ns}	0.19^{ns}	0.24^{ns}
MO17X L36	23.19**	11.02**	8.4^{ns}	0.33^{ns}	0.089^{ns}	-0.18^{ns}	0.3^{ns}	0.87^{ns}

PH: plant height, EH: ear height, KW: 1000-kernel weight, DS: Days to ear silking, EL: Ear length,NR: number of row in ear, , NB: number of Leaf, KY: kernel yield.

ns,* and **: Non significant , significant at 5% and 1% levels , respectively.

Table 5. Means of half diallel crosses of eight maize lines across two environments for days to silking, plant height, yield components and grain yield.

Crosses	PH(Cm)	EH(Cm)	KW(Gr)	DS(Day)	EL(Cm)	NR	NB	KY (T/Ha)
L8X L10	235.7	113.6	262.3	65.0	19.78	17.25	11.5	8.650
L8X L12	210.9	112.1	278.7	63.5	17.8	18.25	11.75	7.740
L8X L21	233.4	117.2	250.9	64.88	18.5	16.5	11.5	7.719
L8X L24	225.0	120.8	234.2	62.75	17.21	17.25	11.63	6.898
L8X L33	226.8	109.9	233.4	61.63	17.03	18.75	11.75	6.619
L8X L 36	229.1	111.8	246.7	59.75	18.03	16.75	11.75	7.448
L10X L12	220.4	106.3	245.2	60.13	18.2	15.5	11.5	6.950
L10X L21	217.9	106.7	253.2	62.25	17.73	16.5	11.25	6.731
L10X L24	230.6	113.6	265.0	62.0	19.11	15.75	11.63	7.350
L10X L33	227.9	112.2	246.6	61.38	18.03	17.5	11.5	7.519

L10X L36	210.7	99.11	232.8	60.0	16.59	14.75	11.5	6.216
L12X L21	215.7	108.8	244.6	62.25	15.76	17.0	11.75	7.061
L12X L24	221.3	103.7	252.8	60.88	15.79	18.13	11.75	7.429
L12X L33	222.4	111.5	269.7	59.0	17.42	17.13	11.5	7.711
L12X L36	198.0	87.8	235.1	58.63	15.57	15.0	11.13	6.448
L21X L24	235.9	118.1	255.6	62.75	16.98	17.13	11.63	7.245
L21X L33	219.6	107.3	236.8	60.25	18.91	16.38	11.5	6.516
L21X L36	209.4	101.9	246.6	60.25	17.54	15.65	11.13	6.900
L24X L33	213.6	108.0	254.4	62.5	16.08	16.13	11.13	7.439
L24X L36	215.9	105.1	243.5	61.5	17.86	15.25	11.5	7.733
L33X L36	210.5	102.5	235.1	60.5	18.52	15.5	11.0	6.321
MO17X L8	216.3	112.3	308.5	64.88	22.52	15.0	11.0	11.08
MO17X L10	216.3	109.1	318.1	65.75	21.45	15.0	11.0	8.333
MO17X L12	229.0	113.6	251.9	63.38	20.86	15.5	11.13	9.847
MO17X L21	190.7	96.2	252.8	62.5	15.42	15.5	11.0	6.041
MO17X L24	221.1	107.7	269.6	65.13	18.68	15.0	11.25	6.560
MO17X L33	218.3	111.3	266.3	65.13	19.64	14.5	11.13	7.364
MO17X L36	229.7	109.1	273.2	64.13	18.18	13.25	11.0	7.693
SC704CHEK	220.7	113.0	279.6	67.63	21.13	15.5	11.63	9.386
LSD5%	18.69	12.57	33.53	1.96	1.89	1.27	0.58	1.23

PH: plant height, EH: ear height, KW: 1000-kernel weight, DS: Days to ear silking, EL: Ear length,NR: number of row in ear, , NB: number of Leaf, KY: kernel yield.

Table 6. Correlation between the traits from a half diallel crosses of 8 parents of maize.

Traits	PH	EH	KW	DS	EL	NR	NB	KY
PH	1							
EH	0.96**	1						
KW	0.08 ns	0.15ns	1					
DS	-0. 51**	-0.45*	0.18 ns	1				
EL	0.80 **	0.80**	0.23ns	-0.37ns	1			
NR	0.69**	0.74**	0.15 ns	-0.47*	0.61**	1		
NB	0.63**	0.70*	-0.001ns	-0.45*	0.58**	0.75**	1	
KY	0.85**	0.85**	0.23 ns	-0.56**	0.84**	0.81**	0.75**	1

PH: plant height, EH: ear height, KW: 1000-kernel weight, DS: Days to ear silking, EL: Ear length,NR: number of row in ear, , NB: number of Leaf, KY: kernel yield.

ns,* and **: Non significant , significant at 5% and 1% levels , respectively.

CONCLUSION

The non significant interaction effects of GCA and SCA with the environments in KW,EL and EH revealed that the trend of GCA effects of parents and SCA effects of the crosses over the environments were similar. Among the yield components, NR, EL,NB and DS had high narrow-sense heritability estimates, therefore these traits were affected more by additive genetic effects. A significant positive correlation was detected between NR and EL with KY implying that genotypes with high NR and EL will have high KY. Cross of MO17 x L8 had the highest kernel yield.This cross with positive SCA effects for EL and KY had parents with significant GCA effect for same trait.

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