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Combining Ability Analysis in Early Maturing Maize Inbred Lines under Temperate Conditions

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ABSTRACT

Genetic analysis of 10 diverse inbred lines (8 from local germplasm and 2 from AICRP Maize) through half diallel mating design during Kharif-2012 and rabi 2012-13 at Dryland (Karewa) Agriculture Research Station, Budgam and AICRP Winter Maize Nursery, Hyderabad, respectively. The parents and their all possible F_1 *crosses and excluding reciprocals, were evaluated in the Randomized Complete Block Design (RCBD) with two replications at two locations viz., Srinagar, (*E_1*) and Budgam (*E_2*) during kharif 2013. Analysis of variance for all twelve traits revealed that significant mean squares for individual and pooled environments indicating environments taken for experimentation were diverse whereas, significant G x E interaction indicated that genotypes behaved differently in these diverse environments. Substantial genetic variability in the crosses was reflected by highly significant differences among the parents and their crosses for all the traits in the individual environments and data pooled over environments. The significance of the variances resulting from gca x environments and sca x environments pointed out that gca and sca effects also exhibited interaction with environments for all the traits. Magnitude of dominance variance was higher in range in the individual environments as well as data pooled over environments for all the traits, indicating preponderance of non-additive gene action. Both additive and dominance components were found present with preponderance of dominance component. None of the parents as well as crosses exhibited significant and desirable combining ability effects for all the traits. However, several crosscombinations were observed to demonstrate significant sca effect for yield and many important yield attributing and maturity traits. Six promising* F_1*cross combinations(KDM-361A x KDM-332A, KDM-361A x CM-128,KDM-343A x KDM-914A,KDM-332A x KDM-340A,KDM-914A x CM-128, andKDM-362Ax CM-502) were identified on the basis of per seperformance and sca will be further tested in different sets of environments for release in coming years.*

Key words: *Diallel, General combining ability, Grain yield, Specific combining ability, Zea mays.*

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INTRODUCTION

Maize statistics of Jammu and Kashmir (India) reveals that the crop is grown on an area of 0.32 million hectares with an annual production of 0.66 million tons and an average productivity of 2.14 tons per hectare which is very low, when compared to national average of 2.6 tons per hectare[1]. The main objective of the maize breeding program in J&K is to develop high yielding, early maturity maize hybrids for commercial use to cover the increasing consumption of maize in animal feeding, poultry industry and human food. One of the most important criteria for identifying high yielding hybrids is the information about parents' genetic structure and their combining ability[4]. Diallel analysis is proved to be a better method of understanding the genetic nature of the traits and to ascertain the prepotency of parents. This is an efficient technique for deriving basic information on parental combinations in terms of their combining ability, besides elucidating the nature and magnitude of gene action. Such basic information is a prelude to any breeding programme aiming at speedy improvement and development of a broad spectrum of superior genotypes. The information on general and specific combining ability can be used to differentially to classify the parents in terms of their ability to nick well when crossed with each other and can generate desirable segregants. It further helps to elucidate information regarding the predominant type of gene action operative for traits of economic importance. Since the quantitative traits are greatly influenced by the environment and the degree of such influence increases with the increase in number of genes governing the expression of a particular trait, the traits which are governed by several loci exhibit greater genotype x environment (G x E) interaction. The removal of G x E variance from the estimates of genetic variance forms an integral part of any attempt to estimate genetic variances without bias. Singh[18,19] proposed methods for diallel analysis of breeding material over environments which are used in present investigation to elicit unbiased information on combining ability, gene action and other important genetic parameters. The information obtained will be utilized in the selection of inbred lines for their ultimate synthesis into hybrids and synthetic varieties. It is proposed to ascertain the best cross combinations for some economic characters amongst some elite inbred lines of maize.

MATERIAL AND METHODS

The experimental material in the present study comprised of the ten diverse inbred lines of maize (*Zea maize* L.) viz., KDM-361A, KDM-343A, KDM-332A, KDM-914A, KDM-895A, KDM-340A, KDM-362A, KDM-916A, CM-128 and CM-502 from the germplasm collection maintained at Dryland (*Karewa*) Agriculture Research Station, SKUAST-Kashmir, Budgam and used as base material for the present study these lines were primarily identified on the basis of genetic variability for yield attributing traits and maturity.Forty five F_1 crosses (excluding reciprocals) were generated through a 10 × 10 diallel mating design during *Kharif* 2012 and *rabi* 2012-13 at experimental farm of Dryland Agriculture Research Station, SKUAST-Kashmir, Budgam and Winter Maize Nursery (DMR,ICAR), Rajendranagar, Hyderabad. The 45 crosses so developed (through controlled hand pollination) were evaluated along with their parents (10 inbred lines) at two different locations i.e., Shalimar (E_1) and Budgam (E_2) during *Kharif*-2013. The field experiment to identify the best crosses was laid out in a Randomized Complete Block Design (RCBD) with two replications each over two environments. Each genotype was represented by 2 rows of four meter length. The intra-and inter-row spacing was maintained at 20 and 75cm, respectively. Standard agronomic practices were followed to raise a good crop at both the locations. Observations were recorded on five randomly selected competitive plants of each parent and F_1 in every replication except for days to 50% taselling, days to 50% silking and 75% husk browning, where recorded data was on the whole plot basis. Mean values for all the characters except maturity traits (where median values were used) were worked out for statistical and biometrical analysis. Analysis of variance was applied to determine the significance of mean differences. The observations were then subjected to combining ability analysis by

Griffing's[12] model I method II, which is a fixed effects model.

RESULTS AND DISCUSSION

Analysis of variance for combining ability (Table-2) revealed significant mean squares for general and specific combining ability for all the traits in the pooled analysis. The mean sum of squares due to environments was also significant for all the traits indicating that the environments were significantly diverse. Patil and Chopde[17] sugested evaluation of breeding materials over environments to obtain reliable estimates of gca effects. Significant gca x environment as well as sca x environment interaction were also reported for all the traits to obtain reliable estimates of gca and sca effects.Hence results of the present investigation were obtained from two locations and the G x E interactions might have been reduced, reinforcing the view presented by Comstock and Moll[6] that comparison of estimates obtained from different locations in the same year were meaningful than data obtained from a single location in different years, though, of course, reliability would increase if data is generated from different locations over different years. Similar results were also reported by Kumar *et al*[15]. The presence of significant combining ability effect x environmental interaction has been reported for grain yield and component traits in maize by various workers like Deitos *et al*[8].,; Xing Ming *et al*[25]., and Sofi *et al*[20].

Estimates of combining ability (tabl-2) further revealed that mean squares due to gca were comparatively higher in magnitude than corresponding mean squares due to sca for all the traits. Estimates of components of variances due to gca (σ^2g) and variance due to sca (σ^2s) revealed that, in the present set of materials the later component of variance was greater in magnitude for all the traits indicating greater importance of non-additive gene effects. There are instances in literature where the relative magnitude of mean squares have been used to assess the relative importance of general and specific combining ability but such a procedure is reported to lead to erroneous conclusion[3]. Therefore, variance due to general combining ability (σ^2g) was used for assessing the relative importance of additive and non-additive components of variance[2]. The estimates of the components of additive genetic variance (σ^2_A) and variance due to dominance deviation (σ^2_D) indicated the later to be higher in magnitude for all the traits indicating the importance of non-additive gene action. The average degree of dominance was in over dominance range for all the traits, indicating that the present set of materials was diverse and contained contrasting alleles in most of the cases in the dispersion phase, which on combination through hybridization increased heterozygosity.In a similar study, Desai and Singh[9] found that both general and specific combining ability (SCA) variances were significant for grain yield and its components, indicating the feasibility of exploiting non-additive genetic variance through heterosis breeding. This higher magnitude of non-additive gene effects resulted in more heterosis for days taken to 50% silking, 100 kernel weight and grain yield. Similar results were obtained by Venkatesh *et al*[24]., and Dubey *et al*[10]. Desai and Singh[9] further reported that both additive and non-additive components of genetic variance were involved in the inheritance of days taken to 50% tasselling, silking, plant height, ear height and grain yield plot^{-1}. Combining ability studies for yield and other important quantitative characters in sweet corn by Dutta *et al*[11]., revealed predominant role of non-additive gene action for grain yield, kernel rows ear^{-1} and ear weight, whereas additive gene action was important for plant height, ear height, ear diameter and kernels row^{-1}. Our results, in conformity with the results of most of the researchers, also indicated importance of both additive and dominance components with preponderance of later for all important traits including maturity yield and yield attributing traits.

The estimates of GCA effects of parents (Table-3), and analysis of the results pooled over environments revealed that none of the parents showed significant GCA effects in the desired direction simultaneously for all the traits. However, estimates of GCA effects of the parents for flowering and maturity traits indicated that among all the parents KDM-332A, KDM-340A and KDM-914A exhibiting highly significant negative desired GCA effects for these traits. KDM-332A was identified as a desirable parent for early maturity and it also showed high combining ability with desirable GCA for rows cob^{-1}, cob length and seed yield plant^{-1}. Zelleka[26] and Khan *et al*[14]., highlighted the importance of negative GCA effect for days to 50% tasselling, days to 50% silking and pollen shedding to develop early maturing maize varieties. The relative magnitude of GCA effects revealed that *per se* performance of all maturity traits was generally related to the general combining ability effects. Similar result have been reported by Choudhary *et al*[5]., for days taken to anthesis and in no case late maturity parents were best general combiners. Estimates of GCA effects for yield and yield attributing traits indicated that KDM-361A, KDM-343A,CM-502 and CM-128 were having significant positive desired GCA effect for 100 seed weight and KDM-332A, KDM-914A, KDM-895A, CM-128 and CM-502 for yield plant^{-1} but CM-502 was a poor combiner for all other traits. High *per se* performance was associated with high general combining ability for these yield traits (Table -3). Poor combiners for these traits was generally associated with low to average performance. Importance of significant positive general combining ability effects for yield contributing traits with high *per se* performance was also reported by Zelleka[26], Srivastava and Singh[21] and Khan *et al*[14].

The estimates of specific combining ability effects of the 45 crosses for various traits (Table-4) revealed that none of the cross combinations possessed high SCA effects for all the traits. However, crosses which exhibited significant and desirable SCA effects included KDM-343 x CM-128, DM-332 x CM-502, KDM-340 x KDM-362, KDM-340 x KDM-916 for plant height. KDM-332 x CM-502, KDM-340 x KDM-362, KDM-340 x KDM-916, KDM-340 x CM-128 for ear height; KDM-361 x KDM-332, KDM-361 x CM-128, KDM-914 x KDM-916, KDM-362 x KDM-916, DM-340 x CM-502, and CM-128 x CM-502 for days to 50% tasseling; KDM-361 x KDM-340, KDM-361 x CM-128, KDM-914 x KDM-916, KDM-362 x KDM-916 days to 50% Silking. KDM-361 x CM-128, KDM-332 x KDM-340, KDM-914 x CM-128, KDM-362 x CM-502 days to 75% husk browning; KDM-914 x KDM-128, KDM-343 x KDM-914, KDM-332 x CM-502, KDM-362 x CM-502, KDM-361 x KDM-916, KDM-361 x CM-128, KDM-361 x CM-502, KDM-343 x KDM-914 for cob length; KDM-914 x KDM-362, KDM-361 x CM-128, KDM-914 x CM-128, KDM-916 x CM-502, KDM-916 x CM-128, Cobs Plant^{-1} ; KDM-361 x KDM-332, KDM-361 x KDM-914, KDM-361 x KDM-895, KDM-361 x KDM-340, KDM-340 x KDM-916, KDM-362 x CM-128, KDM-362 x CM-502. for rows cob^{-1}; KDM-914 x CM-128, KDM-362 x CM-502, KDM-343 x KDM-914, KDM-332 x KDM-502, KDM-36 x KDM-362, KDM-361 x KDM-916, KDM-361 x CM-128, KDM-361 x CM-502, CM-128 x CM-502 for grains row-^{1}; KDM-343 x KDM-914, KDM-361 x CM-128, KDM-343 x KDM-895, KDM-332x KDM-340 for cob diameter; KDM-361 x KDM-332, KDM-361 x CM-128, KDM-361 x CM-502, KDM-343 x KDM-914, KDM-914 x CM-128, KDM-914 x CM-502, KDM-895 x KDM-340 for 100 seed weight ; KDM-361 x CM-128, KDM-332 x KDM-340, KDM-343 x KDM-914, KDM-362 x CM-502, KDM-895 x CM-128, KDM-895 x CM-502 for seed yield plant^{-1}.

Uddin *et al*[22]., and Khan *et al*[14]., in separate studies on combining ability analysis in maize reported that GCA and SCA effects were highly significant in the desired negative direction for maturity traits (days to 50% silking, days to 50% tasselling and days to pollen shedding) and in desired positive direction for yield and yield contributing traits (kernel rows cob^{-1},cob length, kernels row^{-1}, 100 seed weight and yield plant^{-1}). Similar results were also reported from the studies of Ojo *et al*[16]., Vasal *et al*[23]., and Zivanovic *et al*[27]., in maize. The average degree of dominance $(\hat{H}_1/\hat{D})^{0.5}$ was in the range of overdominance for all the traits, indicating the importance of non-additive gene action for the inheritance of thetraits. Similar to our findings studies by Haq *et al*[13]., Kumar *et al*[15]., and Dawod *et al*[7]., reported average degree of dominance in over-dominance range for ear traits and grain yield in maize.

Table 1: Analysis of variance for maturity, yield and yield attributing traits in maize (*Zea mays* L.) [Pooled over environments]

Source of variation	Plant height (cm)	Ear height (cm)	Days to 50% tasseling	Days to 50% silking	Days to 75% husk browning	Cob length (cm)	Cobs plant^{-1}	Rows cob $^{-1}$	Grains row^{-1}	Cob diameter (cm)	100-seed weight (g)	Grain Yield Plant^{-1} (g)
Environments	1781.25**	1272.00**	1310.76**	767.62**	1856.00**	6.35**	0.29**	0.29**	11.82**	0.86**	13.90**	445.31**
Replications within Environments	78.25**	0.44	2.20	2.49	3.18	0.11	0.03**	0.03**	0.48	0.03	0.22	176.25*
Genotypes	6882.98**	1512.84**	11.25**	12.36**	93.56**	32.18**	0.10**	0.10**	123.75**	1.25**	51.82**	9355.72*
Parents	933.67**	138.52**	12.11**	16.34**	62.24**	0.83**	0.007	0.007	4.06**	0.04**	6.56**	143.74**
Crosses	3090.34**	436.47**	10.96**	11.60**	54.32**	8.91**	0.08**	0.08**	12.03**	0.16**	11.80**	1250.89**
Parents vs Crosses	227303.03**	21242.00**	16.42*	9.70*	2101.82**	1338.41**	2.05**	2.05**	6116.70**	59.83**	2219.85**	448876.24**
Genotypes × Environments	4.05**	10.58**	1.37	0.90*	8.56**	0.68**	0.01**	0.01**	2.23**	0.07**	1.36**	63.01**
Parents × Environments	2.48*	16.74**	2.22	1.38**	3.69	0.27	0.007	0.007	1.10**	0.07*	2.42**	26.39
Crosses × Environments	4.23**	9.14**	1.16	1.01*	9.32**	0.73**	0.01**	0.01**	2.33**	0.08**	1.14**	71.94*
Parents × Crosses × Environments	10.10**	18.82*	2.67	0.68	19.37*	2.05**	0.04*	0.04*	7.69**	0.06*	1.65*	60.02*
Error (pooled)	10.32	3.39	1.70	0.37	3.08	0.20	0.006	0.12	0.41	0.03	0.25	22.89

Table 2: Analysis of variance for combining ability and estimates of components of variance for maturity, yield and yield attributing traits in Maize *(Zea mays L.)* [Pooled over environments]

Source of variation	Plant height (cm)	Ear height (cm)	Days to 50% tasseling	Days to 50% silking	Days to 75% husk browning	Cob length (cm)	Cobs plant^{-1}	Rows cob $^{-1}$	Grains row^{-1}	Cob diameter (cm)	100-seed weight (g)	Grain Yield Plant^{-1} (g)
Environments	890.62**	636.00**	655.38**	383.91**	815.45**	3.17**	0.14**	0.08	5.91**	0.43**	6.95**	222.65**
Gca	962.85**	211.04**	8.60**	7.50**	26.31**	3.79**	0.03**	1.10**	3.48**	0.10**	7.02**	271.93**
Sca	3937.21**	865.49**	5.03**	5.91**	24.95**	18.55**	0.05**	4.95**	73.55**	0.73**	29.68**	5559.05**
gca × environments	3.66	5.30**	0.39	0.63	2.41	0.23*	0.05**	0.41**	0.40	0.02**	1.12**	17.75
sca × environments	1.69	5.29**	0.74	0.41	5.18**	0.36**	0.07**	0.35**	1.25**	0.04**	0.59**	134.25**
Error Pooled	5.16	1.69	0.85	0.68	1.29	0.10	0.03	0.06	0.20	0.005	0.12	26.44
$\hat{\sigma}^2 g$	39.90	8.72	0.32	0.28	1.04	0.15	0.001	0.04	0.13	0.003	0.28	10.22
$\hat{\sigma}^2 s$	1966.02	431.89	2.08	2.61	11.82	9.22	0.02	2.44	36.67	0.36	14.77	2766.30
$\hat{\sigma}^2 A$	79.80	17.44	0.64	0.56	2.08	0.30	0.003	0.08	0.27	0.007	0.57	20.45
$\hat{\sigma}^2 D$	1966.02	431.89	2.08	2.61	11.82	9.22	0.002	2.44	36.67	0.36	14.77	2766.30
$\hat{\sigma}^2 A / \hat{\sigma}^2 D$	0.04	0.04	0.30	0.21	0.17	0.03	1.50	0.032	0.007	0.019	0.038	0.007

Table 3: General combining ability effects for maturity, yield and yield attributing traits in Maize ((*Zea mays L.*) [Pooled over environments]

Parents	Plant height (cm)	Ear height (cm)	Days to 50% tasseling	Days to 50% silking	Days to 75% husk browning	Cob length (cm)	Cobs plant^{-1}	Rows cob $^{-1}$	Grains row^{-1}	Cob diameter (cm)	100-seed weight (g)	Grain Yield Plant^{-1} (g)
KDM-361A	6.77**	3.82**	0.80**	0.64**	0.23	0.58**	-0.07**	-0.05	-0.15	-0.03*	0.63**	-1.15
KDM-343A	-6.05**	2.17**	0.20	-0.06	1.79**	0.32**	0.03*	-0.14**	0.18*	0.08*	0.69**	0.49
KDM-332A	-4.62**	-0.90**	-0.81**	-1.14**	-1.35**	0.24**	0.01	0.32**	0.20*	0.09**	-0.76**	2.45**
KDM-914A	-2.39**	-4.36**	-0.72*	-0.43**	-0.89**	-0.03	0.04**	-0.16**	0.02	-0.01	0.02	3.32**
KDM-895A	7.21**	1.45**	0.64**	0.52**	1.23**	-0.79**	-0.04**	-0.10*	-0.50**	-0.10**	-0.27**	7.37**
KDM-340A	-8.91**	-5.50**	-0.62**	-0.02	0.17	-0.03	0.01	0.42**	0.27**	0.09**	-0.81**	0.99
KDM-362A	5.50**	-0.34	-0.10	-0.10	-1.51**	0.02	0.03*	-0.14**	-0.13	-0.07**	-0.38**	0.01
KDM-916A	7.33**	2.53**	0.78**	-0.79**	0.31	-0.49**	-0.06**	0.06	-0.65**	0.01	0.31**	-3.67**
CM-128	-5.89**	0.95**	-0.35*	-0.33*	-0.10	0.29**	-0.01	-0.03	0.64**	-0.03*	0.37**	2.30*
CM-502	1.04	0.17	-0.01	-0.08	0.10	-0.02	0.05**	-0.20**	0.12	0.02	0.19**	3.60**
SE± (g)	0.44	0.25	0.17	0.16	0.24	0.06	0.01	0.04	0.08	0.01	0.06	0.99
Total No. of desirable parents	5	3	4	4	3	4	4	3	4	3	5	5

Table 4: Specific combining ability effects for maturity, yield and yield attributing traits in Maize (*Zea mays* L.) [Pooled over environments]

Parents	Plant height (cm)	Ear height (cm)	Days to 50% tasseling	Days to 50% silking	Days to 75% husk browning	Cob length (cm)	Cobs plant^{-1}	Rows cob $^{-1}$	Grains row^{-1}	Cob diameter (cm)	100-seed weight (g)	Grain Yield Plant^{-1} (g)
KDM-361A x KDM-343A	20.94**	0.32	1.98**	2.18**	-3.00**	-1.44**	0.06	0.11	0.46	-0.12*	3.02**	14.05**
KDM-361A x KDM-332A	1.25	2.41*	-1.49*	-1.29*	-5.10**	0.87**	0.06	1.64**	2.73**	0.46**	4.85**	54.85**
KDM-361A x KDM-914A	-8.97**	-2.13*	2.98**	3.18**	1.68*	-0.84**	-0.11**	1.28**	1.66**	0.21**	1.99**	7.47*
KDM-361A x KDM-895A	3.92*	1.80*	0.54	0.53	3.81**	1.81**	-0.03	0.55**	3.64**	0.09*	-0.33	2.18
KDM-361A x KDM-340A	17.55**	18.01**	-1.43*	-2.17**	3.87**	1.61**	0.08*	1.04**	2.26**	0.27**	-1.13**	16.55**
KDM-361A x KDM-362A	12.38**	7.09**	-0.45	-1.08*	6.06**	2.37**	-0.08*	1.11**	3.58**	0.16**	3.80**	45.03**
KDM-361A x KDM-916A	45.55**	21.22**	-0.35	-0.48	1.22	2.64**	-0.04	0.20	3.79**	0.25**	2.27**	13.97**
KDM-361Ax CM-128	65.28**	21.80**	-1.95**	-3.06**	-6.60**	2.82**	0.26**	0.51**	3.85**	0.62**	4.54**	65.49**
KDM-361Ax CM-502	43.34**	19.57**	-1.08*	-1.12*	-0.56	1.40**	-0.07*	0.27	2.31**	0.02	2.35**	6.45*
KDM-343A x KDM-332A	46.84**	23.80**	0.35	0.47	7.33**	0.04	0.17**	0.23	1.34**	0.20**	-0.26	10.20**
KDM-343A x KDM-914A	41.86**	19.51**	-0.91	-1.79**	-3.37**	3.97**	-0.02	1.47**	4.95**	0.64**	3.70**	56.58**
KDM-343A x KDM-895A	-0.74	-1.29	0.15	0.30	2.49*	2.18**	0.03	1.14**	1.85**	0.57**	1.85**	28.03**
KDM-343A x KDM-340A	7.38**	0.16	-0.58	-1.40*	3.56**	2.28**	-0.22**	-0.11	3.87**	0.35**	2.39**	3.66
KDM-343A x KDM-362A	19.96**	9.24**	-0.85	0.18	3.99**	1.41**	0.03	-0.24	2.74**	0.05	1.21*	11.89**
KDM-343A x KDM-916A	24.88**	6.11**	0.75	0.78	-1.33	0.26	0.19**	-0.12	2.51**	0.10	-0.08	21.58**
KDM-343A x CM-128	-60.13**	12.45**	1.90**	1.45**	0.58	-0.17	-0.11**	1.85**	-0.73	0.48**	0.35	-0.15
KDM-343A x CM-502	20.42**	4.22**	1.02	1.39*	2.37**	1.81**	0.16**	0.01	2.72**	0.20	2.53**	50.80**
KDM-332A x KDM-914A	-1.32	1.34	-0.14	0.22	0.01	0.94**	0.12**	0.55**	1.60**	0.19**	1.35**	12.87**
KDM-332A x KDM-895A	-9.07**	2.78**	-0.83	-0.17	-0.10	1.13**	0.03	0.16	2.83**	0.10*	-1.16**	10.08**
KDM-332A x KDM-340A	25.69**	16.99**	-0.30	-1.87**	-5.79**	2.65**	0.15**	1.01**	3.60**	0.53**	3.22**	59.45**
KDM-332A x KDM-362A	-0.47	0.57	1.67**	2.07**	0.39	1.08**	0.08*	0.53**	2.51**	0.33**	0.69**	18.68**
KDM-332A x KDM-916A	49.94**	26.95**	-1.22*	-1.44*	-1.93*	0.86**	-0.05	1.27**	2.33**	0.40**	2.31**	10.87**
KDM-332A x CM-128	34.67**	8.78**	-0.33	0.47	0.22	0.26	-0.11**	1.15**	1.13**	0.11*	-0.91**	-6.10*
KDM-332A x CM-502	-13.76**	-9.44**	4.04**	4.41**	1.51*	3.78**	0.13**	0.29*	4.65**	0.28**	0.09	30.60**
KDM-914A x KDM-895[a]	-4.15**	4.24**	-0.35	0.05	1.68*	2.30**	-0.12**	0.66**	3.26**	024**	1.77**	12.45**
KDM-914A x KDM-340[a]	2.46	7.70**	-0.33	-0.15	2.49**	0.88**	0.17**	-0.64**	1.18**	0.12*	1.01**	13.58**
KDM-914A x KDM-362[a]	72.55**	14.03**	1.15*	0.43	-2.31**	-1.18**	0.32**	0.72**	-1.10**	0.41**	-0.61**	15.55**
KDM-914A x KDM-916[a]	40.21**	15.16**	-1.99**	-1.96**	1.60*	-0.31	0.14**	0.81**	1.21**	0.24**	1.65**	29.24**
KDM-914A x CM-128	24.94**	12.49**	-1.35*	-0.79	-6.23**	4.14**	0.24**	-0.32**	6.36**	0.03	3.52**	50.26**
KDM-914A x CM-502	11.50**	6.01**	-0.72	-0.60	1.81*	0.54**	-0.08*	1.25**	3.48**	0.38**	2.05**	18.47**
KDM-895A x KDM-340[a]	39.86**	19.14**	0.73	-0.54	-1.37	-0.03	0.20**	1.06**	-0.13	0.37**	2.19**	29.28**
KDM-895A x KDM-362[a]	27.94**	15.22**	0.71	0.78	3.31**	0.10	0.08*	0.09	2.17**	0.10*	3.08**	23.26**

KDM-895A x KDM-916[a]	26.86**	15.84**	0.31	-0.10	2.72**	0.12	0.02	0.43**	3.47**	0.19**	2.63**	27.20**
KDM-895A x CM-128	13.84**	1.68	0.21	0.30	-1.10	-0.54*	0.03	1.03**	0.74*	0.17**	0.92**	13.72**
KDM-895A x CM-502	32.15**	16.70**	0.08	0.49	-1.06	0.72**	0.01	0.39*	2.56**	0.11*	1.50**	15.93**
KDM-340A x KDM-362[a]	-27.17**	-6.81**	2.98**	3.33**	2.62**	0.92**	0.01	0.43**	1.64**	0.11*	1.25**	11.14**
KDM-340A x KDM-916[a]	-30.76**	-12.69**	1.83**	1.93**	1.04	0.22	-0.01	1.95**	1.76**	0.32**	2.42**	50.33**
KDM-340A x CM-128	-9.28**	-6.86*	0.98	2.10**	0.95	1.35**	0.03	-0.07	3.51**	0.04	-0.13	11.10**
KDM-340A x CM-502	39.28**	16.66**	-1.89**	-0.71	-1.75*	0.97**	-0.06	-0.30*	3.08**	0.16**	0.84**	2.55
KDM-362A x KDM-916[a]	-3.42*	5.39**	-2.43**	-2.48**	-1.52*	1.78**	-0.09*	1.10**	3.63**	0.21**	1.44**	17.30**
KDM-362A x CM-128	18.30**	5.97**	2.71**	0.93	0.39	1.31**	-0.01	0.60**	3.78**	0.13**	0.73**	17.33**
KDM-362A x CM-502	5.11**	3.74**	-0.91	-1.62**	-7.06**	3.08**	0.19**	1.31**	5.54**	0.52**	0.57*	56.53**
KDM-916A x CM-128	3.96*	-1.15	1.56*	1.53*	0.56	2.46**	-0.07*	-0.10	3.30**	0.25**	1.10**	13.51**
KDM-916A x CM-502	4.28**	2.61**	1.19*	0.97*	0.85	-0.76**	0.20**	0.75**	-1.73**	0.32**	2.26**	18.97**
CM-128 x CM- 502	6.50**	5.45**	-2.16**	-1.85**	2.76**	-0.58**	0.16**	0.35*	1.81**	0.12*	0.95**	25.24**
S.E ±(S_{ij})	1.32	0.76	0.53	0.48	0.72	0.18	0.03	0.14	0.26	0.04	0.20	3.00

CONCLUSION

The overall information obtained in the present study if practised with care can, in general, go a long way in developing promising synthetics and hybrids of maize. All the parameters, except number of kernel rows per ear, were under the control of over-dominance type of gene action. The number of kernel rows per ear was under the control of additive type of gene action. Over-dominance for most of the parameters reveals that selection in later generations may be more effective and the selection in early generations will be more effective for the trait which is additively controlled.Six promising F_1cross combinations (KDM-361A x KDM-332A, KDM-361A x CM-128, KDM-343A x KDM-914A, KDM-332A x KDM-340A, KDM-914A x CM-128, andKDM-362Ax CM-502) were identified on the basis of *per se* performance and sca will be further tested in different sets of environments for release in coming years.

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