Electronic Journal of Plant Breeding, 5(4): 716-721 (Sep 2014)
ISSN 0975-928X

Research Article

Combining ability and heterosis studies for grain yield and its component traits in maize (*Zea mays* L.)

C. Kapoor[1*], S. Lata[2] and J.K. Sharma [2]
[1]ICAR Research Complex for North Eastern Hill Region, Sikkim Centre, Tadong, Gangtok, Sikkim -737102
[2] CSKHPKV, Palampur, Himachal Pradesh 176 062
Email: chandannaarm@gmail.com

(Received: 18 July 2014; Accepted: 06 Aug 2014)

Abstract
Combining ability analysis was conducted using line x tester design with twelve diverse inbred lines of maize for yield and its contributing traits. Five inbred lines viz. V348, V356, V360, KI-16 and KI-18 were good general combiners for grain yield and majority of its component traits. Six cross combinations KI-16 x CM200, V24 x CM212, V356 x CM126, V354 x CM200, V356 x CM200 and V348 x CM212 exhibited high heterosis as well as high SCA effects and *per se* performance for grain yield and its component traits. The cross KI-16 x CM200 performed best out of these six crosses on the basis of high SCA effect, economic heterosis and *per se* performance for grain yield, cob placement height, cob length, cob girth and harvest index.
Key words
Maize, line x tester, combining ability, heterosis, yield

Introduction

Growing demand for maize has been mainly attributed to its multipurpose use and its importance in today's agricultural scenario. Much of the demand of maize is met through hybrids which are mainly grown for higher productivity. It is one of the most important crop of India having area, production and productivity of 8782 (000'ha), 21759 (000't) and 2478 kg/ha respectively (Anonymous, 2014). Hilly regions are gifted with climate most suitable for successful maize production but limited by unavailability of suitable hybrids adapted to the region. The success of any hybrid breeding programme depends upon the choice of parents and clear knowledge of gene action for specific traits (Venkatesh *et al.,* 2001). Combining ability is one of the most effective tool in deciding the appropriate parents for hybridization especially when a large number of parental lines are available and most promising ones are to be identified on the basis of their ability to give superior hybrids Adelardo *et al.* (2006). The exploitation of heterosis in maize can be accomplished through the development and identification of high *per se* performing parental lines and their subsequent evaluation for combining ability in cross combinations to identify the hybrids with high heterotic effects Kabdal *et al.* (2003). The information about the heterotic patterns and the combining ability of the parents and the crosses both, facilitate the breeders in the selection and the development of the single cross hybrids (Beal, 1880; Shull, 1908; Jones, 1918). Therefore the present study is an attempt to identify the maize inbred lines having high combining ability and crosses showing high heterotic effect which will further be used for hybrid maize breeding programme.

Material and Methods

Twelve diverse inbred lines of maize viz. V13, V24, V340, V348, V354, V356, V360, KI-16, KI-18, KI-24, KI-29 and KI-30 were crossed with three diverse inbred testers CM 126, CM 200 and CM 212 in line x tester fashion to produce 36 hybrids during *kharif*, 2008. The F_1 seed of all the 36 hybrids, their parents along with one standard check hybrid Vivek-23 were grown in randomized block design with three replications during *kharif,* 2008 in the Experimental Farm, HP Agricultural University, Palampur. Each entry comprised of two rows having 15 plants per row in each replication in a plot size of 3.6 m^2. Ten randomly competitive plants were taken for recording data on plant height, cob height, leaves per plant, flag leaf area, internodal length, days to 50% tasseling, days to 50% silking, days to 75% maturity, cob length, cob girth, kernel rows per cob, grains per cob, grain yield per plant and harvest index. Analysis of variance of the data was done using model suggested by Panse and Sukhatme (1984). Line x Tester analysis was carried out as per the procedure described by Kempthorne (Kempthorne (1957). The heterosis was estimated over the check (Hybrid Vivek-23) as per standard procedure.

Results and Discussion

The analysis of variance revealed significant differences among the parents (lines and testers), lines vs testers, parents vs crosses and crosses for all the traits studied except for kernel rows per cob in testers; cob height, leaves per plant and flag leaf area for lines vs testers and cob height and leaves per plant for parents vs crosses (Table1). Likewise the analysis of variance for combining ability exhibited significant differences among line x testers for all the traits studied thereby suggesting that the experimental material possessed considerable variability (Table 2). In our study, lines revealed significant differences for plant height, flag leaf area, internodal length, days to 50% silking, 75% maturity, cob length, kernel rows per cob and grain yield per plant while testers were significantly different for flag leaf area, days to 50% tasseling, silking, 75% maturity, cob girth, cob length, kernel rows per cob and grains per cob. The estimates of components of genetic variances revealed the importance of both additive and dominant gene action with predominance of dominant and over dominance gene action for plant height, cob height, leaves per plant, flag leaf area, internodal length, days to tasseling, silking, maturity, grains per cob, grain yield per plant and harvest index. Predominance of additive gene action coupled with high heritability were observed for cob length, cob girth and kernel rows per cob.

The estimates of GCA effects revealed that five lines viz. V348, V356, V360, KI-16 and KI-18 were good general combiners for grain yield/plant (Table 3). *Per se* performance was also high for the lines V356, V360 and V348 for grain yield and majority of its component traits (Table 4). KI-18 was good general combiner for cob length, grain rows per cob, grains per cob, harvest index, internodal length, days to 50% tasseling and silking. Similarly KI-16 was also good general combiner for grains per cob, cob placement height, leaves per plant, internodal length and harvest index. The results obtained are in conformity with the findings of Tarakanov *et al.* (1980), Debnath *et al.* (1990), Vasal *et al.* (1992), Nagda *et al.* (1995) and Dadheech *et al.* (2007). A perusal of the first best six hybrids revealed that the cross KI-16 x CM200 performed best on the basis of high SCA effects, economic heterosis and *per se* performance for grain yield (Table 5). The cross was also desirable for cob placement height, cob length, grains per cob and harvest index. Another cross V24 x CM212 performed best with respect to SCA, heterosis and *per se* performance for days to silking, cob length, grains per cob and harvest index. Likewise other best performing crosses were V356 x CM126, V354 x CM200, V356 x CM200 and V348 x CM212. Among these, three crosses V356 x CM126, V354 x CM200 and V356 x CM200 were desirable for grain yield, plant height, cob placement height, days to silking, grains per cob and harvest index. Earlier workers (Nagda *et al.*, 1995; Dubey *et al.*, 2001; Srivastava and Singh, 2003; Apunnu *et al.*, 2007) while using different inbred lines of maize and hybrids among them, reported the similar findings.

Presence of wide allelic differences in the parental material is a prerequisite for getting desirable heterotic progenies. The analysis of variance signifies the presence of genetic diversity among the parental material for majority of the traits studied. Significant differences for combining ability indicates that the cross combinations of the parental material exhibited significant differences for economic traits and helpful for the breeders to identify the most suitable inbred lines and the best crossing combinations among them. Gene action reveals the mode of inheritance of the trait thereby facilitate the breeder to employ appropriate breeding methodology for its improvement. The characters showing dominance mode of inheritance like plant height, cob height, leaves per plant, flag leaf area, internodal length, days to tasseling, silking, maturity, grains per cob, grain yield per plant and harvest index can be improved by employing heterosis breeding. Thus desirable hybrids can be obtained in F_1 generation.

Liao *et al.* (1987) and Wu (1987) reported non-additive gene action for grain yield/plant. Jha and Khera (1992) reported predominance of non-additive gene action for grain yield. In contrast to it, Turgut *et al.* (1995) reported dominance as well as additive gene effects for grain yield, ear diameter, ear length, number of grain rows and 100 grain weight. Characters inherited through additive mode of inheritance can be improved by selection method. These characters could be utilized for the development of inbred lines and for the maintenance of composites through mass selection. Mahajan *et al.* (1991), Mathur *et al.* (1998) and Alamnie *et al.* (2006) reported the preponderance of additive gene action for days to silking, tasseling and maturity. The lines showing desirable GCA effects alongwith high *per se* performance for grain yield and its component traits can be effectively utilized in future for the hybridization programme and development of composite varieties. The cross KI-16 x CM200 showed high *per se* performance, SCA effects and heterosis for grain yield and thus as such can be tested for its performance over the locations. Other three hybrids V356 x CM126, V354 x CM200 and V356 x CM200 being superior in *per se* performance, SCA effects and heterosis for grain yield, dwarf stature and early silking were identified for further multilocation evaluation.

Acknowledgement

The authors expressed sincere thanks to Head, Department of Crop Improvement, VPKAS, Almora for supplying the inbred lines for carrying out this study.

References

Adelardo, J., De la Vega. and Scott, C.C. 2006. Multivariate analysis to display interactions between environment and general or specific combining ability in hybrid crops. *Crop Sci.*, **46**: 957-967.

Alamnie, A. 2001. Gene action and heterosis with particular reference to single cross hybrids of maize (*Zea mays* L.) University of Agricultural Sciences, Dharwad, Ph D Thesis, 142.

Alamnie, A., Wali, M. C., Salimath, P. M. and Jagadeesha, R C. 2006. Combining ability, heterosis and *per se* performance in maize maturity components. *Karnataka J. Agri. Sci*., **19**(2): 268–271.

Anonymous, 2008. Vision 2025, Directorate of Maize Research, ICAR, New Delhi.

Anonymous, 2014. Project Director Review. All India Coordinated Research Project on Maize, Directorate of Maize Research, New Delhi.

Apunnu, C., Satyanarayana, E. and Rao, T. N. 2007. Heterosis for grain yield and its components in maize. *J. Res. ANGRAU*, **35**(1): 124–126.

Beal, W.J. 1880. Indian corn Report Michigan State Board Agriculture, **19**:279-289.

Dadheech, A and Joshi, V.N. 2007. Heterosis and combining ability for quality and yield in early maturing single crosses of maize. *Indian J. Agric. Res*., **41**(3): 210-214.

Debnath, S.C. and Sarkar, K.R. 1990. Combining ability analysis of grain yield and some of its attributes in maize (*Zea mays* L.). *Indian J. Genet.*, **50**: 57-61.

Dhillon, B.S. 1975. The application of partial diallel crosses in plant breeding-a review. *Crop Improv.,* **2**: 1-8.

Dubey, R. B., Joshi, V. N. and Pandiya, N.K. 2001. Heterosis and combining ability for quality, yield and maturity traits in conventional and non conventional hybrids of maize. *Indian J. Genet.*, **61**: 353-55.

Jha, P.B. and Khehra, A.S. 1992. Evaluation of maize inbred lines derived from two heterotic populations. *Indian J. Genet.*,**52** (2): 126-131.

Jones, D.F. 1918. The effects of inbreeding and cross breeding upon development. *Conn. Agri. Exp. Stn. Bull*., **200**: 5-100.

Joshi, V. N., Dubey, B. and Marker, S. 2002. Combining ability for polygenic traits in early maturing hybrids of maize. *Indian J. Genet.,* **62**: 312-15.

Kabdal, M.K., Verma, S.S., Kumar, A., Panwar, U.B.S. 2003. Combining ability and heterosis analysis for grain yield and its components in maize (*Zea mays* L.) *Indian J. Agr. Res.,* **37**(1): 39-43.

Kempthorne, O. 1957. An introduction to genetic statistics. Johan Wiley and Sons, New York, 458.

Lata, S., Sharma J. K., Katana, G. and Guleria, S. K. 2008. Heterosis and combining ability for polygenic traits in medium maturity hybrids of maize. *Crop Improv.,* **35**: 135-38.

Liao, S.J. Xu, Z.B. and Wen, S.P. 1987. Analysis of combining ability for major quantitative characters in some maize inbred lines. *Ningxia Agri. Forest Sci. Tech.*, **5**: 10-12.

Mahajan, V., Khehra, A.S. and Malhotra, V.V. 1991. Combining ability studies for silking and maturity in diverse seasons in maize. *J. Res. PAU*, **28**: 315-319.

Mathur, R.K., Chuni, L., Bhatnagar, S. K. and Singh, V. 1998. Combining ability for yield, phenological and ear characters in white seeded maize. *Indian J. Genet.*, **58**(2): 177–182.

Nagda, A. K., Vyas, M. C., Dubey, R. B. and Pandiya, N. K. 1995. Heterosis and combining ability analysis for grain yield and its components in maize *Crop Res.*, **10** (3): 297–301.

Panse, V.G. and Sukhatme, P.V. (1984) Statistical methods for Agricultural workers. Indian Council of Agricultural Research, New Delhi. 145-152.

Shull, G.H. 1908. The composition of field of maize. *Amer. Breed. Asso. Rept.,* **4**: 296-301.

Srdic, J., Pajic, Z., Drinic, S. and Mladenovic, S. 2007. Inheritance of maize grain yield components. *Maydica,* **52**(3): 261–264.

Srivastava, A. and Singh, I. S. 2003. Heterosis and combining ability for yield and maturity involving exotic and indigenous inbred lines of maize. *Indian J. Genet.,* **64**: 345-46.

Tarakanov, P.S. 1980. Evaluation of general combining ability in some races of maize from latin America Trudy Po prik Bnot Genet i Selek, **69** (1): 120-122.

Turgut, I., Yuce, S. and Altinbas, M. 1995. Inheritance of some agronomic traits in a diallel cross of maize inbreds. *Anadolu*, **5**: 74-92.

Vasal, S.K., Spreinivasion, G., Crossa, J. and Beck, D.L. 1992. Heterosis and combining ability of CIMMYT's subtropical and temperate early, maturity maize germplasm. *Crop Sci*., **32**: 884-890.

Venkatesh, S., Singh, N.N. and Gupta, N. P. 2000. Use of inbred tester for evaluating combining ability in modified single cross hybrids of maize. *Indian J. Genet.*,**61**: 309-13.

Venkatesh, S., Singh, N.N. and Gupta, N.P. 2001. Early generation identification and utilization of potential inbred lines in modified single cross hybrids of maize (*Zea mays* L.). *Indian J. Genet.*, **61**(3): 213-217.

Wu, CH. 1987. Analysis of gene effects for three quantitative characters at developmental stages in maize. *Acta Genet. Sinica,* **14**: 363-369.

Electronic Journal of Plant Breeding, 5(4): 716-721 (Sep 2014)
ISSN 0975-928X

Table 1. Analysis of variance for lines, testers and their crosses for different characters in maize

Sources of Variation	df	Plant Height (cm)	Cob placement height (cm)	Leaves /plant	Flag leaf Area (cm^2)	Inter nodal length (cm)	Days to 50% tasseling	Days to 50% silking	Days to 75% Maturity	Cob Length (cm)	Cob Girth (cm)	Kernel rows /cob	Grains/ cob	Grain yield/plant (gm)	Harvest Index (%)
Replication	2	22.03	8.74	0.05	24.31	1.28	0.18	0.32	1.18	0.33	0.91	0.98	7.02	2.68	1.14
Treatments	50	2353.53*	588.04*	1.81*	2212.48*	102.52*	22.38*	28.95*	66.76*	20.67*	5.17*	6.72*	39524.03*	2605.66*	254.50*
Parents	14	2878.45*	592.00*	1.97*	1496.69*	64.29*	11.36*	17.08*	89.07*	22.80*	4.61*	5.29*	26079.92*	526.59*	351.60*
Lines	11	3217.14*	726.56*	1.76*	1028.54*	65.41*	6.21*	10.59*	78.07*	22.15*	5.16*	4.51*	10570.12*	392.86*	355.30*
Testers	2	1052.69*	143.92*	4.11*	4774.22*	13.45*	44.11*	56.44*	187.44*	25.49*	1.24*	2.48	66497.19*	662.89*	463.70*
Lines vs Testers	1	2804.42*	7.92	0.09	91.39	153.69*	2.45*	9.80*	13.33*	24.66*	5.27*	19.42*	115853.13*	1725.03*	87.30*
Parents vs Crosses	1	44997.38*	11053.75	0.04	31081.17*	1166.24*	668.89*	780.06*	143.56*	341.99*	73.61*	20.52*	351358.62*	63154.44*	2081.80*
Crosses	35	925.16*	287.43*	1.80*	1673.98*	87.42*	8.26*	12.22*	55.65*	10.63*	3.44*	6.89*	35992.11*	1707.32*	163.30*
Error	100	10.39	5.31	0.61	25.17	1.24	0.30	0.38	0.78	1.11	0.65	4.48	7.27	0.49	0.0001

*** Significant at 1% level**

Table 2. Analysis of variance for combining ability for lines, testers and their crosses

Sources of Variation	**df**	Plant Height (cm)	Cob placement height (cm)	Leaves /plant	Flag leaf Area (cm^2)	Inter nodal length (cm)	Days to 50% tasseling	Days to 50% silking	Days to 75% Maturity	Cob Length (cm)	Cob Girth (cm)	Kernel rows /cob	Grains/ cob	Grain yield/plant (gm)	Harvest Index (%)
		11.58	21.09	0.44	37.99	7.27	2.78	3.25	4.93	0.82	3.22	1.03	171.34	2.76	0.86
Lines	11	1692.76*	395.64	1.75	3038.78*	150.46*	6.01	15.99*	69.94*	13.54*	2.37	5.56*	18096.89	3665.80*	320.30*
Tester	2	403.65	80.26	0.44	2539.05*	43.57	50.36*	78.78*	249.06*	65.53*	29.11*	69.54*	233727.67*	1125.13	11.52
L x T	22	761.93*	252.15*	1.95*	912.93*	67.38*	5.55*	6.77*	31.42*	4.18*	1.65*	1.87*	26963.76*	1650.83*	143.32*
Error	70	11.46	5.11	0.68	29.25	1.25	0.33	0.37	0.66	1.33	0.44	0.69	4.99	0.63	0.27

*** Significant at 1% level**

Table 3. Estimates of GCA effects of lines and testers for different characters

Lines	Plant Height (cm)	Cob placement height (cm)	Leaves /plant	Flag leaf Area (cm^2)	Inter nodal length (cm)	Days to 50% tasseling	Days to 50% silking	Days to 75% Maturity	Cob Length (cm)	Cob Girth (cm)	Kernel rows /cob	Grains/ cob	Grain yield/plant (gm)	Harvest Index (%)
V13	-10.83*	-5.57*	0.06	-34.98*	-3.02*	-1.28*	-1.22*	-5.07*	-0.89*	-0.08*	-0.30*	-54.39*	-6.47*	1.38*
V24	-19.06*	4.50*	-0.61*	-18.34*	2.79*	-0.50*	-1.00*	-3.19*	-0.86*	0.59*	-0.09*	-25.21*	-2.59*	5.15*
V340	2.54	-5.89*	-0.28*	-5.61*	-0.37*	-0.83*	-1.67*	1.15*	-0.69*	0.51*	0.75*	17.06*	-1.02*	2.98*
V348	4.07	2.41*	0.28*	-0.94*	6.24*	-0.17*	-0.22*	0.93	2.15*	0.33*	-0.56*	2.34*	13.17*	-4.09*
V354	-11.68*	8.22*	-0.06*	24.46*	6.55*	-0.06*	-0.22*	-2.74*	-0.47*	0.47*	1.39*	15.99	-2.06*	-3.06*
V356	-5.59*	5.64*	-0.39*	26.07*	1.43*	-0.06*	1.00*	4.38*	2.02*	0.39*	0.66*	51.03*	22.56*	8.08*
V360	1.17	3.24*	0.50*	21.46*	-3.93*	0.17*	-0.22*	-0.52*	-0.15*	0.34*	-0.25*	5.21*	1.38*	-8.27*
KI 16	12.51*	-7.22*	0.83*	-0.01*	-5.34*	1.17*	1.33*	1.37*	0.41	-0.13*	0.04	78.26*	22.51*	5.75*
KI 18	15.78*	3.97*	-0.28*	5.14	-0.18*	-0.83*	-0.89*	1.04*	0.49*	-0.35*	0.48*	17.59*	1.78*	1.79*
KI 24	22.25*	6.80*	0.50*	-0.82*	0.63*	0.83*	1.56*	-1.96	0.91*	-0.39*	-1.68*	-10.88*	-2.47*	-6.25*
KI 29	-7.85*	-12.42*	-0.39*	2.3	-4.48*	0.17*	0.11	1.37*	-1.22*	-0.84*	-0.58*	-93.69*	-25.18*	-3.15*
KI 30	-3.30*	-3.68*	-0.17*	-18.74*	-0.32*	1.39*	1.44*	3.26*	-1.68*	-0.82	0.13	-3.31*	-21.59*	-0.32*
CM 126	3.32	1.72*	0.11*	2.99*	0.96*	-1.31*	-1.56*	-2.99*	1.42*	-0.95	-1.50*	-91.53	-5.38*	-0.57*
CM 200	-3.38	-0.75*	-0.11*	6.49*	0.24*	1.00*	1.39*	1.04*	-0.16*	0.10*	0.26*	60.21	5.78*	0.02
CM 212	0.06	-0.97*	0.00	-9.49*	-1.19*	0.31*	0.17*	1.95*	-1.26*	0.84	1.24*	31.33	-0.39*	0.56*
SE± (Line)	1.07	0.77	0.26	1.67	0.37	0.18	0.21	0.29	0.35	0.27	0.29	0.71	0.41	0.23
SE ±Tester)	0.54	0.38	0.13	0.84	0.19	0.09	0.1	0.15	0.18	0.13	0.15	0.35	0.21	0.12

Table 4. Mean performance of lines and testers for different characters

Lines	Plant Height (cm)	Cob placement height (cm)	Leaves /plant	Flag leaf Area (cm^2)	Inter nodal length (cm)	Days to 50% tasseling	Days to 50% silking	Days to 75% Maturity	Cob Length (cm)	Cob Girth (cm)	Kernel rows /cob	Grains/ cob	Grain yield/plant (gm)	Harvest Index (%)
V13	102.39	40.67	8.00	54.07	13.55	57.33	59.00	100.33	9.21	9.96	11.61	267.12	50.38	0.43
V24	132.98	66.13	10.67	74.20	15.70	55.67	56.67	93.67	17.18	13.03	13.37	268.51	61.80	0.26
V340	146.59	73.44	9.67	90.67	18.36	55.67	56.67	103.67	9.45	11.88	14.39	270.88	62.19	0.27
V348	155.77	69.43	9.00	91.47	22.92	56.33	58.00	106.00	13.49	11.48	11.37	172.93	42.82	0.12
V354	111.36	60.52	9.00	82.46	19.04	56.67	58.33	95.67	14.20	12.31	14.70	276.70	46.56	0.41
V356	116.70	58.77	9.67	95.83	14.42	56.67	58.33	101.00	14.77	12.12	13.50	253.22	62.15	0.26
V360	136.61	63.95	9.67	101.67	15.99	55.33	58.00	93.33	11.97	12.83	13.59	291.61	59.13	0.22
KI 16	205.32	85.86	9.33	84.09	17.17	57.33	58.00	97.00	16.93	12.97	13.60	155.81	33.67	0.09
KI 18	201.19	97.68	9.67	132.76	24.58	55.33	57.67	95.00	17.49	15.48	15.84	149.40	38.91	0.11
KI 24	161.79	83.05	9.33	86.27	28.01	60.33	63.00	103.00	14.31	12.89	13.80	188.01	45.25	0.19
KI 29	129.75	51.04	8.00	93.71	12.59	57.33	59.33	94.33	13.25	13.57	13.98	143.67	50.52	0.31
KI 30	166.59	71.71	10.00	100.73	17.51	58.33	61.67	108.00	15.00	13.07	12.87	337.78	72.39	0.34
CM 126	105.89	64.29	8.33	84.53	21.43	53.67	55.67	91.33	11.13	11.63	11.39	270.26	54.47	0.20
CM 200	138.40	77.41	10.67	138.07	25.36	61.33	64.33	106.67	15.36	12.48	11.38	291.23	64.66	0.22
CM 212	138.26	67.01	9.33	60.07	22.03	57.33	59.67	95.67	9.77	11.22	12.96	537.97	83.75	0.43
Mean	143.31	68.73	9.36	91.37	19.24	56.98	58.96	98.98	13.57	12.46	13.22	258.34	55.24	0.257

Table 5. Specific combining ability, relative heterosis and *per se* performance of best performing crosses

Character	Effect	Cross combinations					
		KI 16 x CM 200	V24 x CM 212	V356 x CM 126	V354 x CM 200	V356 x CM 200	V348 x CM 212
Grain yield /plant	SCA	39.44*	28.19*	7.54*	33.81*	5.13*	17.09*
	Heterosis	42.93*	6.67*	6.24*	17.18*	13.17*	10.64*
	per se	167.55	146.05	144.55	137.37	133.29	129.70
Cob height (cm)	SCA	-3.43*	6.38*	-4.47*	-4.69*	-6.39*	9.32*
	Heterosis	-4.96*	11.64*	-4.83*	-5.44*	-4.48*	12.60*
	per se	82.84	97.30	84.21	88.16	81.87	98.14
Plant height (cm)	SCA	10.43*	14.55*	-3.94*	-3.98*	-4.08*	4.58*
	Heterosis	24.46*	10.27*	-3.31*	-5.24*	-4.73*	12.13*
	per se	210.50	186.49	164.72	170.80	166.05	189.45
Days to 50% silking	SCA	1.61*	-0.83*	-1.78*	0.50	0.28	-1.72*
	Heterosis	6.06*	-4.85*	-6.06*	-1.21	-4.03*	-4.21*
	per se	58.33	52.33	51.67	55.85	52.67	52.67
Cob length (cm)	SCA	3.43*	6.38*	4.47*	4.69*	-2.39	9.32*
	Heterosis	4.96*	11.64*	13.83*	3.44	-1.48	12.60*
	per se	18.53	17.67	19.20	16.0	15.68	18.40
Grains /cob	SCA	167.83*	110.07*	29.99*	136.02*	19.11*	17.88*
	Heterosis	58.50*	13.95*	15.73*	36.45*	17.29*	13.10*
	per se	439.68	450.6	340.23	517.36	511.23	491.76
Harvest index (%)	SCA	7.74*	1.64*	2.44*	6.36*	1.25*	0.52
	Heterosis	27.90*	11.29*	18.31*	10.41*	16.69*	-19.46*
	per se	0.35	0.34	0.39	0.34	0.40	0.34