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COMBINING ABILITY AND GENETIC ADVANCE IN DIFFERENT PARENTS' PERFORMANCE IN MAIZE

D. P. Divya Vani*, Bijendra Kumar, P. Baveesh, Amandeep Kaur, Dattesh Tamatam and Akshay Kumar

Department of Genetics and Plant Breeding, School of Agriculture, Lovely Professional University, Phagwara - 144 411 (Punjab), India.

Abstract

The investigation was conducted in Randomized block design in 3 replications at Experimental Farm during 2015-16, Lovely Professional University, Jalandhar, Punjab, India. The estimates of general combining ability revealed that the line CM 149 and BML15 and the tester BH19 are good general combiners for all the traits. The hybrids KMH 408710 × CM201, KMH408710 × BML15, KMH408710 × CM201, BH19 × BML7 and BH19 × CML440 showed best performance for all the characters under study based on specific combining ability. The high heritability (narrow sense) was observed for plant height (78.1555%), 100 grain weight (65.1828%). High value of genetic advance was observed to be highest for plant height (42.0433) followed by number of seeds per cob (32.256). The hybrids that exhibited heterobeltiosis and standard heterosis for the grain yield and its contributing characters like plant height, days to 50% tasselling, days to 50% silking, ear length, ear girth, number of rows per cob, number of kernals per row, number of cobs per plant, number of seeds per cob, grain yield per plant and 100 grain weight are BML15 × KMH408710, CML440 × BH19 and CM149 × BH19. Thus, these hybrids can be utilized further in crop improvement programmes.

Key words : Combining ability, genetic advance, maize, cereal crops.

Introduction

Maize (*Zea mays* L. 2n = 20) is one of the most important cereal crops grown all over the world, that belong to the family Poaceae. It is known as the queen of cereals because of its highest yield potential among the cereals. This is due to wide genetic variability. The present study was entitled as "Genetic studies of yield and its contributing characters in Maize (*Zea mays* L.)". It includes 16 hybrids produced from 10 genotypes in which 8 are considered as lines (females) and 2 are considered as testers (males) and 1 as check *i.e.*, GK3101. The investigation was conducted in Randomized block design in 3 replications at Experimental Farm, Lovely Professional University, Jalandhar, Punjab, India. In this study, analysis of variance, heterosis, combining ability, proportional contribution of line, testers and their interaction to total variance, heritability and genetic advance for 11 characters namely, plant height, days to 50% tasselling, days to 50% silking, ear length, ear girth, number of rows per cob, number of kernals per row, number of cobs per plant, number of seeds per cob, grain yield per plant and 100 grain weight. In this study, in order to evaluate the varieties, line × tester technique was used.

***Author for correspondence :** E-mail: divya0706@gmail.com

Materials and Methods

The experimented material for this genetic study comprised of ten genotypes in which two were used as testers (male) and the other eight were used as the lines (female). **Testers :** KMH 408710, BH 19. **Lines :** CM 201, CM 149, BML 15, BML 6, CML 440, KML 461, KML 226, BML 7. **F_1 Hybrids :** The above 2 testers were crossed with the 8 lines and a total of 16 hybrids were obtained during the *Kharif* 2015. Enough seeds were produced for the investigation. These F_1 hybrid seeds were sown in the same experimental farm, Lovely Professional University, Phagwara for further experimentation.

The corporeal consisting of 10 parents and 16 F_1 hybrids were laid in randomized block design for the experiment with three replications. Each plot was of 2×2m for the lines and 3×3m for the testers. Two rows of plants

were planted in each plot. A spacing of 60cm between the rows and 30cm between the plants was maintained. First sowing was done on 18 April 2015 manually in the ridges at the rate of two seeds per hole. Later thinning was done. Standard agricultural practices were followed regularly. Crossing program was done by following two major steps that is bagging and pollination. The observations like plant height, days to 50% tasselling, days to 50 % silking, ear length, ear girth, number of rows per cob, number of kernals per row, number of cobs per plant, number of seeds per cob, grain yield per plant and 100 grain weight were recorded in randomly selected 5 plants in each plot and each replication.

Results and Discussion

The data was analyzed following standard statistical procedures and statistical software Windostat 8.1 to study the genetic architecture (nature and magnitude of genetic variance and genetic components), combining ability, generation mean analysis for yield and its related traits as well as per cent heterosis.

General combining ability effects (GCA)

The estimates of general combining ability effects for ten diverse parents (eight lines and two testers) for eleven characters of maize are presented in table 1. The positive and significant GCA effects were considered desirable for ear length, ear girth, cobs per plant, kernals per row, rows per cob, seeds per cob, seeds per plant and 100 grain weight. The negative values of general combining ability effects for some of the traits such as days to 50% tasselling, days to 50% silking, and plant height are considered as desirable. The estimates of general combining ability (*gca*) effects of parents in the present study have been particularized trait wise in the following paragraphs.

Negative and significant GCA effect is considered desirable for plant height. The lines BML6 (-12.440), KML461 (-24.578), BML7 (-8.608) and BML15 (-0.541) have shown negative significant effect. Among the testers KMH408710 (-11.779) showed negative significant *gca* effect.

For the characters days to 50% tasselling, negative and significant general combining ability is to considered desirable. The lines CM149 (-1.479), CML440 (-4.979) and BML15 (-0.146) where found to be negative and significant in respect to general combining ability effect. The tester BH19 (-0.604) has shown the negative significant effect.

Negative significant effect is desirable for days to 50% silking. The lines CM440 (-4.979) has shown the most significant effect. The other lines CM201 (-0.625), CM149 (-0.292), BML15 (-0.458) and KML461 (-0.792) have shown negative effect.

The *gca* effects of parents ranged from -1.009 to 1.624 for length of ear. The lines, CM149 (1.458), BML15 (1.624), KML461 (1.041) exhibited positive significant gca effects that suggests to be good general combiner. Whereas, CML440 (0.958) manifested non significant GCA effects, which are to be average general combiner. The lines CML201 (-0.162), BML6(-1.009), KML226(-0.909) and BML7 (-0.918) manifested negative significant gca effects indicating to be poor general combiner for length of ear. Among the testers BH19 (0.255) has manifested positive and significant GCA effect, which proves to be a good general combiner.

The *gca* effects of parents ranged from -0.844 to 1.708 for ear girth. The line CM201 (1.708) showed positive significant GCA effects indicating to be good general combiner, while CM149 (0.176), BMl15 (0.306) and CML440 (0.159) manifested non significant GCA effects that suggests to be average general combiner. The lines KML461 (-0.169), KML226 (-0.687) and BML7 (-0.844) exhibited negative significant GCA effects and are poor general combiner for this character. The tester BH19 (0.091) has exhibited non significant effects indicating to be an average general combiner for this trait.

The GCA effects of cobs per plant ranged from -0.383 to 0.417. Among the lines CM149 (0.417) and CM201 (0.117) has shown positive significant GCA effect reflecting to be a good general combiner. The lines BML15 (0.050), CML440 (0.083), KML226 (0.083) manifested non significant GCA effects that suggest being average combiners. The lines BML6, KML461 and BML7 exhibited negative significant GCA effects and are poor general combiners for this trait. The tester BH19 (0.067) has exhibited significant effects indicating to be a good combiner for this trait.

The GCA effects of parents ranged from -8.959 to 8.627 for number of kernels per row. A lines, CM149 (5.329) and BML15 (8.627) exhibited positive and significant GCA effects which is to be good general combiner. The lines KML226 (0.303) and BML7 (0.811) manifested non significant GCA effects indicating to be average general combiner. The lines, KML461 (-8.959), BML6 (-4.056) and CML440 (-1.824) manifested negative and significant GCA effects that suggests to be poor general combiner for number of kernels per row. The tester, KMH408710 (0.338), has shown non significant GCA effects that concludes to be average general combiner.

Table 1 : Estimation of general combining ability in the parents for the characters under study.

Parents	Plant height	Days to 50% tasselling	Days to 50% silking	Ear length	Ear girth	Cobs/plant	Kernals/row	Rows/cob	Seeds/cob	Grain yield/ plant	100 grain weight
Testers											
KMH408710	-11.779***	0.604**	0.417	-0.255	-0.091	-0.067*	0.338	-0.091	0.892	-14.222	-2.931***
BH19	11.779***	-0.604**	-0.417	0.255	0.091	0.067*	-0.338	0.091	-0.892	14.222	2.931***
Lines											
CM201	22.404***	0.688	-0.625	-0.162	1.708***	0.117*	-0.228	0.02	-6.256	11.339	2.080***
CM149	16.795***	-1.479**	-0.292	1.458**	0.176	0.417***	5.329***	0.750*	88.991***	284.395***	-1.407*
BML15	-0.541	-0.146	-0.458	1.624**	0.306	0.050	8.624***	-0.671	76.625***	127.393***	5.221***
BML6	-12.440***	1.854***	1.875**	-1.009*	-0.649	-0.217***	-4.056***	-0.271	-52.546***	-148.354***	0.576
CML440	-0.380	-4.979***	-4.732***	0.958*	0.159	0.083	-1.824*	0.654	-7.468	11.138	-2.099**
KML461	-24.578***	0.021	-0.792	1.041*	-0.169	-0.383***	-8.959***	-0.328	-110.970	-260522***	-1.112
KML226	7.347	0.188	1.042	-0.909	-0.1687*	0.083	0.303	0.009	4.904	26.993	-5.187***
BML7	-8.608**	3.854	4.042***	-0.918	-0.844*	-0.150**	0.811	-0.145	6.719	-52.383	1.928**

The GCA effects of parents ranged from -0.671 to 0.750 for number of rows per ear. The line CM149 (0.750) exhibited positive and significant GCA effects which suggests to be good general combiner. Whereas, CM201 (0.002) and CML440 (0.654) manifested non significant GCA effects indicating to be average general combiner. Besides this, BML15 (-0.671), BML6 (-0.271), KML461 (-0.328) and BML7 (-0.145) showed negative significant GCA effects leading to be a poor general combiner. The tester BH19 (0.091) recorded highest, positive and significant GCA effects that concludes to be good general combiner.

The GCA effects of parents ranged from -110.970 to 88.991 for number of seeds per cob. Among lines, CM149 (88.991) and BML15 (76.625) exhibited positive significant GCA effects that can be selected as good general combiner, whereas, KML226 (4.904) and BML7 (6.719) manifested non significant GCA effects, which identifies to be average general combiner. In addition to this, CM201 (-6.256), BML6 (-52.546), CML440 (-7.468) and KML461 (-110.970) exhibited negative significant GCA effects. This indicates to be poor general combiner for number of seeds per cob. Among the testers, KMH408710 (0.892) exhibited, positive and significant GCA effects that to be good general combiner.

The GCA effects of parents ranged from -27.123 to 32.159 for grain yield per plant. Out of all lines, CM149 (23.487), BML15 (32.159) and CML440 (30.204) exhibited positive significant GCA effects that identifies to be good general combiner. Besides this, BML6 (-27.123), KML461 (-25.101), KML226 (-18.798), BML7 (-9.032) and CM201 (-5.796) exhibited negative significant GCA effects that are to be poor general combiner for grain yield per plant. Among testers, KMH408710 (6.470) manifested positive significant GCA effects which is to be good general combiner.

The GCA effects of the parents ranged from -5.187 to 2.931 for 100 grain weight. Among all the lines CM201 (2.08) and BML15 (5.221) have shown positive significant GCA effects proving to be good general combiners. Whereas the lines CM149 (-1.407), KML226 (5.187), KML461 (-1.112) and CML440 (-2.099) have shown negative significant GCA effects manifesting to be poor general combiners for this trait. Among the testers BH19 (2.931) has shown the positive significant GCA effects being good general combiner for this trait of 100 grain weight. The significant GCA effects were also reported by Alam *et al*. (2008) and Kumar and Reddy (2013) in maize.

Table 2 : Estimation of Specific combining Ability in the parents for the characters under study.

Crosses	Plant height (cm)	Days to 50% tasselling	Days to 50% silking	Ear length (cm)	Ear girth (cm)	Cobs/ plant	Kernals per row	Rows/cob	Seeds/cob	Grain yield/ plant	100 grain weight (gm)
CM201 X KMH408710	10.924*	-4.938	-4.083***	2.868***	1.342**	0.100	6.343***	-0.585	58.144**	115.311**	4.038***
CM201 X BH19	-10.924*	4.938	4.083***	-2.868***	-1.342**	-0.100	-6.343***	0.585	-58.144**	-115.311**	-4.038***
CM149 X KMH408710	-3.298	-0.771	-0.417	-0.075	0.071	0.133	1.463	0.740	42.261*	123.080**	0.558
CM149 XBH19	3.298	0.771	0.417	0.075	-0.071	-0.133	-1.463	-0.740	-42.261*	-123.080**	-0.558
BML 15 X KMH408710	5.002	2.896***	3.417***	1.758**	-0.549	0.233**	8.795***	0.081	99.240***	231.515***	0.790
BML 15 XBH19	-5.002	-2.896***	-3.417***	-1.758**	0.549	-0.233**	-8.795***	-0.081	-99.240***	-231.515***	-0.790
BML 6 X KMH408710	-1.756	2.563***	2.417*	-1.215	-0.431	-0.100	-3.788***	-0.202	-47.318**	-86.837*	-1.095
BML 6 XBH19	1.756	-2.563***	-2.417*	1.215	0.431	0.100	3.788***	0.202	47.318**	86.837*	1.095
CML 440 X KMH408710	4.244	-0.271	-1.250	-1.588*	0.431	-0.133	-8.297***	0.546	-87.517***	-180.744***	-3.587***
CML 440 XBH19	-4.244	0.271	1.250	1.588*	-0.431	0.133	8.297***	-0.546	87.517***	180.744***	3.587***
KML 461 X KMH408710	-1.401	1.729**	1.417	0.757	-0.238	0.0133	2.038	-0.245	19.532	49.314	0.293
KML 461 XBH19	1.401	-1.729**	-1.417	-0.757	0.238	-0.0133	-2.038	0.245	-19.532	-49.314	-0.293
KML 226 X KMH408710	-18.016***	-0.104	-0.417	-0.992	-0.373	-0.267**	-2.860**	-0.249	-39.910*	-155.786***	3.131**
KML 226 XBH19	18.016***	0.104	0.417	0.992	0.373	0.267**	2.860**	0.249	39.910*	155.786***	-3.131**
BML 7 X KMH408710	4.302	-1.104	-1.083	-1.513*	-0.253	-0.100	-3.695***	-0.085	-44.431*	-95.853*	-4.127***
BML 7 XBH19	-4.302	1.104	1.083	1.513*	0.253	0.100	3.695***	0.085	44.431*	95.853*	4.127***

Specific combining ability (SCA)

The SCA effects of 16 F_1s derived from the crosses between 2 testers and 8 lines were estimated are presented in table 2. The criteria for sorting out the desirable and significant specific combiners were the same as described for GCA effects.

The negative values of SCA effects were considered as desirable if genotypes are tall. The differences between the estimates of *sca* effects for plant height varied considerably. KML226 × KMH408710 (-18.016) showed highest negative significant SCA effects followed by CM201 × BH 19, BML15 × BH19 (-5.002), BML7 × BH19 (-4.302), CM149 × KMH408710 (-3.298), BML6 × KMH408710 (-1.756) and KML461 × KMH408710 (-1.401).

Among all the hybrids CM201 × KMH408710 (-4.983), CM149 × KMH408710 (0.771), CML440 × KMH408710 (-0.271), KML226 × KMH408710 (-0.104), BML7 × KMH408710 (-1.104) and KML461 × BH19 (-1.729) reported negative estimates of *sca* effects and appeared to be good specific combiners. Whereas, CM201 × BH19 (4.98), BML15 × BH19 (2.896), BML6 × BH19 (2.563) exhibited positive highest significant estimates, which could not be desirable.

Hybrids, CM201 × KMH408710 (-4.083), CM149 × KMH408710 (0.417), CML440 × KMH408710 (-1.250), KML226 × KMH408710 (-0.417), BML7 × KMH408710 (-1.083) and KML461 × BH19 (-1.417), reported negative estimates of *sca* effects and appeared to be good specific combiner. Whereas, crosses CM201 × BH19 (4.083), BML15 × BH19 (3.417), BML6 × BH19 (2.417) found highest significant and positive estimates, that indicates unfavorable to earliness for silking.

Among all, 8 hybrids exhibited significant SCA effects, out of which 4 hybrids showed significant positive estimates. The hybrids, CM201 × KMH408710 (2.868), BML15 × KMH408710 (1.758), BML7× BH19 (1.513) and CML440 × BH19 (1.588) recorded positive estimates of SCA effects that indicates to be good specific combiner. The crosses, BML15 × BH19 (-1.758), CM201 × BH19 (-2.868) have shown significant negative values of SCA effect which is unfavorable for length of ear.

The crosses, CM201 × KMH408710 (1.342),

Table 7 : General mean, heritability (narrow sense) and genetic advance.

S. no.	Traits	General mean	Heritability (Narrow sense)	Genetic advance (5%)
1.	**Plant height**	157.8413	78.1555	52.0433
2.	**Days to 50% tasselling**	54.0513	22.3495	1.8571
3.	**Days to 50% silking**	57.5128	20.1300	1.5544
4.	**Ear length**	13.7751	9.6859	0.4914
5.	**Ear girth**	11.5785	20.9368	0.4291
6.	**Cobs/plant**	1.4872	37.5468	0.2391
7.	**Kernals/row**	26.1604	15.0545	2.7212
8.	**Rows/cob**	11.8792	5.9116	0.0784
9.	**Seeds/cob**	313.0232	15.8205	32.2562
10.	**Grain yield/plant**	487.3447	19.5965	95.6971
11.	**100 grain weight**	17.4645	65.1828	9.2820

CM149 × KMH408710 (0.071), CML440 × KMH408710 (0.431), KML461 × BH19 (0.238), KML226 × BH19 (0.373), BML7× BH19 (0.253), BML15 × BH19 (0.549) and BML6 × BH19 (0.431) found positive estimates of SCA effects indicating good specific combiners. A cross, CM201 × BH19 (-1.34) had highest significant and negative estimates, which is undesirable for ear girth.

The hybrids that exhibited positive SCA effects, are CM201 × KMH408710 (0.100), CM149 × KMH408710 (0.133), BML15 × KMH408710 (0.233). BML7 × KMH408710 (-0.267) has sown negative significant which is undesirable for number of cobs per plant.

A total of 12 crosses exhibited significant sca effects, out of which, CM201 × KMH408710 (6.343), BML15 × KMH408710 (8.795), KML226 × BH19 (2.860), BML7× BH19 (3.695), BML6 × BH19 (3.788), CML440 × BH19 (8.297) are significant positive which is desirable for the trait. A cross, CML440 × KMH408710 (-8.297) showed highest significant and negative estimates, indicating undesirable to this character.

The crosses, CM149 × KMH408710 (0.740), BML15 × KMH408710 (0.081), CML440 × KMH408710 (0.546), CM201 × BH19 (0.585), BML6 × BH19 (0.202), KML461 × BH19 (0.245), KML226 × BH19 (0.249) and BML7× BH19 (0.085) have exhibited positive estimates of SCA effects influencing to be good specific combiner. A cross, CM201 × KMH408710 (-0.585) have shown negative estimate of SCA effects for this character.

Among all hybrids 14 exhibited significant SCA effects, out of which 7 hybrids were significant positive estimates. The hybrids, CM201 × KMH408710 (58.144), CM149 × KMH408710 (42.261), BML15 × KMH408710 (99.240), KML226 × BH19 (39.910), BML7× BH19 (44.431), BML6 × BH19 (47.318) and CML440 × BH19 (87.517) reported positive estimates of SCA effects which may be good specific combiner. A cross, BML15 × BH19 (99.240) showed highest significant and negative estimate of SCA effect which is undesirable for this trait.

Among all crosses 8 crosses exhibited significant SCA effects, out of which, CM149 × KMH408710 (26.067), BML15 × KMH408710 (60.386), CML440 × BH19 (51.069), BML7× BH19 (20.243) showed significant positive estimates which is desirable for the trait. A cross, BML15 × BH19 (-60.386) showed significant and negative estimate of SCA effect which may be undesirable for this trait.

Total 8 crosses exhibited significant SCA effects, out of which CM201 × KMH408710 (4.038), KML226 × KMH408710 (3.131), BML7× BH19 (4.127) and CML440 × BH19 (3.587) were significant positive estimates, which is desirable for this trait. A cross BML7 × KMH408710 (-4.038) showed highest significant negative estimates, which is undesirable. Similar to the above result Alam *et al*. (2008) and Kumar and Reddy (2013) also reported significant SCA effects in maize.

Heritability and genetic advance

The high heritability (narrow sense) was observed for plant height (78.1555%), 100 grain weight (65.1828%). Moderate values of heritability were observed for number of cob per plant (37.5468%). Low heritability value was observed in days to 50% tasselling (22.349), days to 50% silking (20.13), ear length (9.686), ear girth (20.9368), kernals per row (15.0545), rows per cob (5.9116), number of seeds per cob (15.8205) and grain yield per plant (14.90). The genetic advance in percent over mean was estimated for all the 10 traits which ranged from 0.0784 for rows per cob to 42.0433 for plant height. High value of genetic advance was observed to be highest for plant height (42.0433) followed by number of seeds per cob (32.256), grain yield per plant (15.393) and there follows

the traits, 100 grain weight (9.282), number of kernals per row (2.721), days to 50% tasselling (1.857), days to 50% silking (1.554), ear length (0.4914), ear girth (0.429), number of cobs per plant (0.2391) and at the minimal rows per cob (0.0784) (table 3). Similar findings were reported by Bello *et al*. (2012), Jyoti Kaul *et al*. (2012), Mohammed and Zakiya (2014), Ram Reddy *et al*. (2012) and Sumalini and Manjulatha (2012).

Summary and Conclusion

The estimates of general combining ability revealed that the line CM 149 and BML15 and the tester BH19 are good general combiners for all the traits. The hybrids KMH 408710 × CM201, KMH408710 × BML15, KMH408710 × CM201, BH19 x BML7 and BH19 × CML440 showed best performance for all the characters under study based on specific combining ability.

The high heritability (narrow sense) was observed for plant height (78.1555%), 100 grain weight (65.1828%). High value of genetic advance was observed to be highest for plant height (42.0433) followed by number of seeds per cob (32.256).

Thus, these hybrids can be utilized further in crop improvement programmes and can be modified in such a way that it helps in the improvement of the crop and meets the demand of the agricultural world.

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