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RESEARCH PAPER

Studies on combining ability for yield and it's component traits in maize [*Zea mays* (L.)]

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Abstract: The study was carried out to assess the general combining ability of the lines and specific combining ability of the hybrids, using line x tester mating design. 134 hybrids derived from mating two testers with sixty seven lines in L x T design were evaluated during the *kahrif*, 2018-19. The ratio of σ^2 GCA/σ^2 SCA was less than unity for all the characters indicating preponderance of non-additive gene action. Among female lines GPM-726 was the best combiner for grain yield, and tester CML-451 was found to be the best general combiner for grain yield. Hybrids GH-17232, GH-17212, GH-17173, GH-17108 and GH-17105 recorded higher significant SCA effects in positive direction for grain yield.

Key words: Combining ability, Maize, Progeny, Testers

Introduction

Maize (*Zea mays* L.) is an important cereal crop belonging to the tribe Maydeae of the grass family Poaceae. In maize breeding program, analysis of general combining ability (GCA) and specific combining ability (SCA), would help to identify best inbred lines for hybrid development and hybrid combinations for better specific combining ability. Combining ability is an effective tool which gives useful genetic information for the choice of parents in terms of their performance in series of crosses (Sprague and Tatum 1942). The development of populations with high combining abilities has a fundamental role in the efficient use of heterosis (Parviz *et al.*, 2016 and Francis *et al.*, 2020). It also indicates the nature and magnitude of various types of gene action involved in the expression of quantitative characters. Such information is of potential use in formulating and executing an efficient breeding programme for achieving maximum genetic gain with minimum resources and time. Hence, this study was conducted with the aim to understand the combining ability of the selected lines and testers in maize.

Material and methods

The base material for the experiment included 67 germplasm lines collected from IIMR / CIMMYT and two testers CML-451 (CIMMYT tester) and CM-111 (Indian maize programme) maintained at AICRP on Maize, Dharwad. These 67 germplasm lines were crossed with both the testers (CML-451 and CM-111) during summer, 2017-18 in L x T method (Kempthorne, 1957) to obtain 134 hybrids. These 134 hybrids along with three hybrid checks *viz.*, GH-0727, GPMH-1101 and NK-6240 were grown in 14 x 10 alpha lattice design during *kharif*, 2018-19 at AICRP on maize, Dharwad. The hybrids were grown in two rows of four meter and three replications with spacing of 60 cm x 20 cm and all the recommended agronomic practices are followed to raise the good crop.

Field observations were recorded for twelve characters *viz., i.e.,* days to 50 per cent tasselling, days to 50 per cent silking, days to 75 per cent dry husk, plant height, ear height, number of kernel rows per year, number of kernels per row, ear girth, ear length, hundred grain weight, shelling percentage and grain yield in each replication. The mean values of observations were subjected to statistical analysis to estimate general combining ability (GCA) and specific combining ability (SCA) effects of the lines and crosses respectively (Panse and Sukhatme, 1967).

Results and discussion

The analysis of variance (Table 1) revealed significant mean sum of squares due to lines, lines x testers for all the traits like days to 50 per cent taselling, days to 50 per cent silking, days to 75 per cent dry husk, plant height, ear height, number of kernel rows per ear, number of kernels per row, ear girth, ear length, hundred grain weight, shelling percentage and grain yield and mean sum of squares for testers was found to be significant for all the traits except number of kernel rows per ear and number of kernels per row. The magnitude of SCA variance was higher than GCA variance for all the 12 traits under study indicating the presence of non-additive variance and non-additive gene action indicating preponderance of non-additive gene action. Sali *et al.*, 2016 and Elmyhum *et al.,* 2020 also reported prevalence of non-additive gene action in maize. Parviz *et al.,* 2016 reported that combining ability of parents gives useful information on the choice of parents in terms of expected performance of hybrids and their progenies. The analysis of variance was high and significant among the lines for maturity traits, plant height and ear height characters as compared to testers. Likewise, the analysis of variance was high for cob length, hundred grain weight, shelling % and grain yield among the lines (Table 1). However, when it came to the passing of information to the progeny in the hybrid combinations the percent contribution of lines was high for majority of the traits as compared to testers indicating that even though the testers had shown higher variability for yield component traits, the lines contributed more efficiently the favorable alleles as compared to testers. Hence, the lines should be meticulously chosen in a hybrid breeding programme. The analysis of variance for line x tester interaction was low or on par as compared to lines for most of the yield component traits indicating that the complementation of alleles

Table 1. ANOVA for combining ability for yield and yield components

	1	2	3	4	5	6	
Source of variation	d.f.	Days to 50 per cent tasselling	Days to 50 per cent silking	Days to 75 per cent dry husk	Plant height (cm)	Ear height (cm)	Number of kernel rows per cob
	133	11.38*	10.61*	13.02*	402.88*	238.61*	1.87*
Crosses	66	8.56*	7.79*	10.01*	445.27*	239.14*	2.08*
Lines effect	1	303.35*	342.10*	359.53*	1260.71*	672.31*	0.64
Testers effect	66	9.35*	7.92*	10.52*	329.00*	222.88*	1.71*
Lines × Testers effect	239	1.16	1.31	1.62	18.62	17.62	0.17
Error	505	333.8	369.73	394.7	2456.48	1390.56	6.47
Total		1.41	2.11	1.94	9.62	5.64	0.01
σ^2 GCA		3.21	2.67	3.45	124.93	76.06	0.56
σ^2 SCA		0.43	0.79	0.56	0.07	0.07	0.01
σ^2 GCA/ σ^2 SCA		38.03	37.28	38.54	56.12	50.63	54.76
Contribution of Lines %		20.41	24.80	20.96	2.40	2.15	0.26
Contribution of Testers %		41.54	37.90	40.48	41.46	47.20	44.98
Contribution of Line × Tester %		41.54	37.90	40.48	41.46	47.20	44.98

Source of variation		7	8	9	10	11	12
	d.f.	Number of kernels per row	Cob girth (cm)	Cob length (cm)	Hundred grain weight (g)	Shelling percentage (%)	Grain Yield (q/ha)
Crosses	133	35.59*	0.16*	9.43*	36.85*	5.69*	225.02*
Lines effect	66	42.13*	0.14*	10.08*	33.06*	5.20*	238.67*
Testers effect	1	1.14	2.66*	79.22*	925.41*	102.17*	811.54*
Lines × Testers effect	66	30.05*	0.14*	7.84*	25.26*	4.78*	204.24*
Error	239	2.92	0.02	0.77	0.79	0.74	29.71
Total	505	111.83	3.12	107.34	1021.37	118.58	1509.18
σ^2 GCA		0.20	0.01	0.55	5.10	0.63	5.36
σ^2 SCA		10.16	0.18	2.50	9.10	1.45	239.51
σ^2 GCA/ σ^2 SCA		0.01	0.25	0.22	0.56	0.43	0.02
Contribution of Lines %		58.35	43.84	52.71	45.70	45.13	52.43
Contribution of Testers %		0.02	12.14	6.28	19.38	13.42	2.70
Contribution of Line × Tester %		41.62	44.02	41.01	34.92	41.45	44.87

between lines and testers for the yield contributing traits was low in the present study. This was also similarly reported by Yazachew *et al.,* 2017.

Estimates of GCA effects are listed in Table 2, where the results revealed that none of the lines showed significant GCA effects in the desired direction for all the traits studied. For grain yield /plant GPM-726 was identified as best combiner followed by GPM-225 and GPM-22. These can be used directly as parents for developing high yielding single cross hybrids. GPM-726 was also having significant GCA in desired direction for number of kernels per row, ear girth, ear length, hundred grain weight and shelling percentage. Similarly, Woldu *et al*., 2020 also reported significant gca effects for different traits among the parental lines. High parental gca effects is a strong indicator of hybrid performance (Kanchao *et al.*, 2020) For maturity traits, GPM-695, GPM-29 and GPM-264 were having highly significant GCA effects in desirable negative direction which is essential while developing early maturity hybrids. For morphological traits like plant height and ear height GPM-22 and GPM-592 showed the desirable GCA effects. For kernel rows /ear, GPM-16 was found as best combiner which also depicted highest and desirable combining ability for ear girth. However, among the important yield contributing characters highest gca effects was observed in GPM-28-1 (5.33), GPM 618 (4.83) and GPM-492 (4.66) for number of kernels/row and similarly for hundred grain weight in GPM-725 (6.47), GPM-55 (4.30) and GPM-57 (3.47) indicating that these are the imporatant component traits and these lines can be further intermated among themselves for accumluation of favourable alleles and inturn yield. Kanchao *et al*., 2020 have also opined that number of kernels/ row and number of kernels /ear are two important traits for exploitation of heterosis for grain yield.

Specific combining ability effects estimates for yield and its attributing traits for 134 crosses/hybrids are represented in Table 2. None of the cross combinations possessed high SCA effects for all the quantitative traits. However, among the crosses GH-17209 (GPM-735 x CML-451) recorded highest sca effects in desirable negative direction for maturity traits days to 50% silking and days to 75% dry husk maturity. Similar results were also reported for maturity traits by Sharma *et al.* (2015). For plant height and ear height cross combinations of GPM-13 x CM-111(GH-17110) and GPM-583 x CML-451 (GH-17159), recorded highest SCA effects in desirable positive direction and were found to be the promising. Among the yield contributing traits like number of kernels / row highest SCA effects was observed in GH-1781(8.41) and GH-17110 (6.08) for hundred seed weight in GH-17204 (7.09). However, the test hybrid GH-17155 cross between GPM-378 x CML-451 showed highest and significant

Table 2. Promising parental lines based on GCA effects of inbred lines and hybrids based on mean performance and SCA effects

Sl. No.	Characters	Best general combiner in desired direction	GCA	Best specific combiner in desired direction	SCA
1	Days to 50 per cent taselling	GPM-695	-3.31	GH-17159 (GPM-583 × CML-451)	-3.87
		GPM-264	-2.48	GH-17226 (GPM-763 × CM-111)	-3.12
		GPM-756	-1.81	GH-17117 (GPM-21 × CML-451)	-2.95
2	Days to 50 per cent silking	GPM-264	-3.30	GH-17223 (GPM-761 × CML-451)	-2.86
		GPM-29	-3.13	GH-17209 (GPM-735 × CML-451)	-2.70
		GPM-20	-1.97	GH-17212 (GPM-748 × CM-111)	-2.63
3	Days to 75 per cent dry husk	GPM-264	-2.82	GH-17212 (GPM-748 × CM-111)	-3.17
		GPM-29	-2.32	GH-17209 (GPM-735 × CML-451)	-3.15
		GPM-23	-2.31	GH-17133 (GPM-39 × CML-451)	-3.15
4	Plant height (cm)	GPM-22	20.85	GH-17110 (GPM-13 × CM-111)	29.16
		GPM-592	16.79	GH-17159 (GPM-583 × CML-451)	24.87
		GPM-660	16.79	GH-17223 (GPM-761 × CML-451)	19.34
5	Ear Height (cm)	GPM-668	15.82	GH-17110 (GPM-13 × CM-111)	22.01
		GPM-22	12.85	GH-17159 (GPM-583 × CM-111)	18.78
		GPM-592	12.82	GH-17134 (GPM-39 × CM-111)	14.44
6	Number of kernel rows per cob	GPM-16	1.60	GH-17155 (GPM-378 × CML-451)	1.45
		GPM-628	1.10	GH-17199 (GPM-725 × CML-451)	1.28
		GPM-775	1.10	GH-17189 (GPM-695 × CML-451)	1.12
7	Number of kernels per row	GPM-28-1	5.33	GH-17181 (GPM-678 × CML-451)	8.41
		GPM-618	4.83	GH-17110 (GPM-13 × CM-111)	6.08
		GPM-492	4.66	GH-17173 (GPM-635 × CML-451)	5.45
8	Cob girth (cm)	GPM-16	0.37	GH-17226 (GPM-763 × CM-111)	0.42
		GPM-733	0.29	GH-17125 (GPM-27 × CML-451)	0.39
		GPM-629	0.27	GH-17134 (GPM-39 × CM-111)	0.37
9	Cob length (cm)	GPM-28-1	2.67	GH-17181 (GPM-678 XCML-451)	2.62
		GPM-31	2.65	GH-17173 (GPM-635 × CML-451)	2.23
		GPM-04	2.13	GH-17110 (GPM-13 × CM-111)	2.21
10	Hundred grain weight (g)	GPM-725	6.47	GH-17204 (GPM-731 × CM-111)	7.09
		GPM-55	4.30	GH-17192 (GPM-702 × CM-111)	4.09
		GPM-57	3.47	GH-17137 (GPM-48 × CML-451)	4.07
11	Shelling per cent	GPM-763	2.82	GH-17212 (GPM-748 × CM-111)	2.30
		GPM-23	1.92	GH-17155 (GPM-378 × CML-451)	2.19
		GPM-706	1.48	GH-17225 (GPM-763 × CML-451)	2.01
12	Grain yield (q/ha)	GPM-726	17.26	GH-17105 (GPM-07 × CML-451)	13.53
		GPM-225	17.24	GH-17108 (GPM-10 × CM-111)	13.25
		GPM-22	13.77	GH-17134 (GPM-39 × CM-111)	12.76

SCA effects for both number of kernel rows / cob and shelling percentage. Similarly, GH17181, GH-17110 and GH-17173 recorded highest SCA effects for both number of kernels/ row and cob length indicating that those hybrids with higher number of kernels/ row also were good for cob length. The test hybrid GH-17110(GPM-13 x CM-111) also recorded higher sca effects for plant height and ear eight trait. That shows that GPM-13 combines well with CM-111 in contributing favorable alleles for plant height, ear height, number of kernels/ row and cob length traits. For grain yield among the different hybrids that recorded higher SCA effects the cross between GPM-39 x CM-111 (GH-17134) also recorded higher sca effects for days to 75 % dry husk maturity, plant height, ear height and cob girth. Similar results were also opined by Bello and Olawuyi (2015), Panda *et al.* (2017) and Anilkumar *et al.* (2018).

Conclusion

Analysis of variance in the present study indicated existence significant difference for majority of the traits indicating the genetic material in the present study was genetically divergent. Non-additive gene action was predominant for controlling most of the traits under the present study. Thus, it can be concluded that both inter and intra allelic interactions were involved in the expression of theses quantitative traits. The contribution of lines was higher than that of testers and line x tester interaction to majority of the quantitative traits. The parental lines, GPM-22, GPM-119, GPM-225 and GPM-726 were identified as best general combiners for several traits and are likely to transmit their characteristics to the progeny and these could be utilized for development of elite breeding populations and high parental GCA effects is a strong indicator of hybrid performance. The hybrids GH-17108, GH-17105 and GH-17134 recorded highest significant SCA effects for grain yield in positive direction. And among them GH-17134 also recorded significant SCA effects for days to 75 % dry husk maturity, plant height, ear height and cob girth.

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