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RESEARCH PAPER

Heterosis for grain yield and yield attributes in maize (*Zea mays* L.)

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Abstract: An investigation was undertaken to understand the better parent heterosis for grain yield and its attributes among 60 testcross hybrids developed by crossing 20 inbreds with three testers in line × tester design during *kharif* 2024. The hybrids in 8×8 alpha lattice and parents in randomized complete block design were evaluated with two replications at Main agricultural research station, Dharwad during *rabi* 2024-25.The better parent heterosis for grain yield was higher in the hybrids GH 24716 (385.09%), GH 24722 (360.36%) and GH 24713(320.33%) and among those GH 24713 also exhibited greater ear length. The hybrid GH 24720 was best for both number of kernels per row and shelling per cent. For hundred kernel weight, GH 24724 (61.22%) was found to be superior. Similarly for ear length, ear girth and number of kernel rows per ear, the hybrid GH 24710 was promising. The hybrid GH 24716 (GI 2210×KL141702) was significantly superior in terms of better parent heterosis for grain yield and can be utilized to maximize the yield in maize.

Key words: Better parent heterosis, Maize

Introduction

Maize (*Zea mays* L., 2n=20) is one of the most widely cultivated crops globally due to its remarkable adaptability to diverse climates, ecosystems and environments (Hugar *et al*., 2022). Maize is expected to overtake rice as the world's most important grain by 2030, owing to rising demand for dairy and meat products in developing countries and declining rice production in China and India (Salvi *et al*., 2007). Often referred to as the "Queen of Cereals" or the "Miracle Crop", maize stands out among cereals for its high genetic potential (Vanipraveena *et al*., 2021). Maize belongs to the *Poaceae* family and is classified under the genus *Zea*, one of the seven genera within the *Maydeae* tribe (Hombaradi *et al*., 2019).

Maize has several types, including normal maize, baby corn, high-amylase corn, high-oil corn, sweet corn, popcorn, waxy corn, and high-protein maize. It is primarily cultivated for feed, fodder and industrial applications. Nutritionally, maize consists of approximately 72 per cent carbohydrates, 10 per cent protein, 4.8 per cent oil, 5.8 per cent fiber, 3.0 per cent sugar and 1.7 per cent ash (Ranum *et al*., 2014).

Maize, being a highly cross-pollinated crop, offers great potential for the exploitation of hybrid vigour, which largely depends on the direction and magnitude of heterosis, the type of gene action involved, and biological feasibility. The first and most crucial step in hybrid development is the creation and evaluation of inbred lines for *per se* and test cross performance, which helps in assessing the nature and extent of heterosis for grain yield and its component traits. Crosses between genetically diverse parents are more likely to exhibit higher heterosis, as the magnitude of heterosis reflects the degree of genetic divergence. This knowledge is vital for identifying superior F_1 hybrids and maximizing the efficiency of hybrid breeding programs (Sharma *et al*., 2017). Hence, the present study was carried out to estimate the better parent heterosis among the experimental hybrids.

Material and methods

The present experiment was conducted at All India Coordinated Research Project (AICRP) on Maize, Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad, Karnataka. The experimental material for this study includes 20 elite inbred lines and 3 testers VL1010930, VL1010936 and KL141702 from AICRP on Maize, Dharwad. Twenty selected elite inbred lines and three testers (Table 1) were grown during *kharif* 2024 three rows each to facilitate easy effecting of pollination of lines with testers in line × tester mating design, to generate a total of 60 new experimental hybrids.

During *rabi* 2024-25, 60 F_1 hybrids were evaluated in 8×8 alpha lattice design along with two check hybrids *viz*., GH 150125 (Local check) and NK 6240 (National check). Two hybrids were used as filler entries to fit the 8×8 alpha lattice design making the total entries in the experiment to sixty four.

Data was recorded on 11 quantitative traits *viz*., days to 50% tasseling, days to 50% silking, plant height, ear height, ear length, ear girth, number of kernel rows per ear, number of kernels per row, hundred grain weight, shelling per cent and grain yield in both the replications.

The statistical analysis *viz*., Analysis of variance (ANOVA) and heterosis was carried out using R software version 4.5.2 package agricolae.

Results and discussion

The analysis of variance for all the eleven yield and yield attributing traits for all the genotypes (hybrids) indicated that

Table 1. List of inbred lines and testers used in the pollination program for developing new experimental test cross hybrids

Inbred line	Pedigree
GI 743	VH 1666-1-1-1-#-B-B-B
GI 755	VH 16105-1-2-2-#-B-B-B
GI 2111	CML-579-2
GI 2203	DCH-1-11-#-B-B-B
GI 2204	DCH-1-30-#-B-B-B
GI 2210	DCH-1-69-#-B-B-B
GI 2281	DCH-1-11-2-#-B-B-B
GI 2282	DCH-1-11-3-#-B-B-B
GI 2283	DCH-1-11-4-#-B-B-B
GI 2284	DCH-1-157-1-#-B-B-B
GI 2285	DCH-2-36-1-#-B-B-B
GI 2286	DCH-2-36-2-#-B-B-B
D 1013	D 1013
DIM 204	DIM 204
PML 93	PML 93
PDM 4641	PDM 4641
VL192008	(DTPYSyn16HG(B))-6-2-1-2-B1
VL183150	(CLQG2508-B*8/(DT/LN/EM-46-3-1xCML311-2-1-3)-B-F50-1-1-1-B1-B*6)-B-3-2-1-B1
VL184811	((CML581/CML161X165-16-2-1-B*8)-B)DH164-B
CML 580	CML 580
Testers	
1 VL1010930	VL1010930
2 VL1010936	VL1010936
3 KL141702	KL141702

treatment variance was significant for all the characters except for plant height under investigation. This revealed the presence of sufficient variability among the experimental hybrids. Mean sum of squares due to blocks within replication was non-significant (Table 2) for most of the traits except ear height and shelling percentage indicating the absence of heterogeneity between blocks in each replication. These findings were in parallel with the findings of Ejigu *et al*. (2017), Hundera *et al*. (2017) and Suresh *et al*. (2021).

Better parent heterosis

Better parent heterosis (Heterobeltiosis) for days to 50% tasselling among the 60 experimental hybrids ranged from -17.76% to 1.36% (Table 3). The hybrids, GH 24732 (-17.76%) and GH 24720 (-17.76%) were desirable as they were earliest in tasselling.Heterosis in desirable direction(negative) was manifested by 53 out of 60 test hybrids for days to 50% silking and it ranged from -20.25% to -2.16%. The hybrids GH 24732 (-20.25%), GH 24733 (-18.99%) and GH 24711 (-17.65%) exhibited more than 15% negative heterosis and were earliest in days to 50 per cent silking (Table 4). Similar results were reported by Agarwal *et al*. (2021), Tulu *et al*. (2021) and Karim *et al*. (2022).

Table 3. Range and frequency (significant) of better parent heterosis of experimental hybrids in respect of different quantitative characters in maize

Characters	Better parent heterosis (%)			
	Range	Positive	Negative	Total
Days to 50 per cent tasselling	-17.76 to 1.36	0	54	54
Days to 50 per cent silking	-20.25 to 8.75	3	53	56
Plant height (cm)	-14.82 to 77.44	39	0	39
Ear height (cm)	-24.32 to 86.02	27	1	28
Ear length (cm)	-8.58 to 90.43	57	0	57
Ear girth (cm)	-8.04 to 35.52	52	1	53
Number of kernel rows per ear	-13.67 to 28.05	22	2	24
Number of kernels per row	-2.12 to 90.68	58	0	58
Hundred kernel weight (g)	-33.78 to 61.22	35	4	39
Shelling per cent	-8.36 to 9.31	9	9	18
Grain yield (q/ha)	-4.75 to 385.09	55	0	55

Heterobeltiosis for plant height varied from -14.82% to 77.44%. Thirty-nine out of sixty hybrids showed positive significant heterosis for the trait. Hybrids, GH 24755 (77.72%), GH 24701 (77.44%), GH 24746 (67.88%) and GH 24719 (65.80%) exhibited highest positive significant heterosis. While none of the hybrids manifested significant heterosis in desirable negative direction. Out of 60 hybrids, twenty-seven test hybrids showed significant heterosis for ear height in positive direction and one hybrid recorded significant negative heterosis. The hybrid, GH 24746 (86.02%) manifested highest desirable heterosis followed by GH 24701 (69.70%) and GH 24755 (65.63%).These findings are in accordance with the earlier works by Suresh *et al*. (2021) and Tejaswini *et al*. (2023) for the trait clearly indicating the possibility of exploiting heterosis for plant growth characters such as plant and ear height.

Heterobeltiosis for ear length among 60 hybrids ranged from -8.58% (GH 24738) to 90.43% (GH 24713), and fifty-seven hybrids showed positive significant heterosis over better parent. The test hybrids *viz*., GH 24713 (90.43%), GH 24719 (89.31%)

Table 2. Analysis of variance for grain yield and yield attributes in hybrids of maize

Sources of variation	d.f.	DFT	DFS	PH	EH	EL	EG	KRN	KNPR	GW	SP	GY
Replications	1	0.28	0.28	2.85	29.30	3.56	0.04	2.12	1.52	2.25	0.18	207.25
Genotypes	63	22.17**	30.04**	504.58	237.72**	4.97**	0.18**	4.69**	25.76**	32.40**	12.62**	858.22**
Blocks within replication	14	0.88	1.87	351.70	174.82**	0.47	0.02	0.51	0.85	2.95	3.77*	53.43
Error	49	1.16	1.27	120.14	58.00	0.35	0.01	0.37	0.70	2.42	1.60	79.07
Total	127	24.49	33.46	979.27	499.84	9.35	0.26	7.69	28.83	40.02	18.17	1197.97

*- Significant at 5% and **- Significant at 1% level of probability, d.f. - degrees of freedom

DFT - Days to 50% tasselling, DFS - Days to 50% silking, PH- Plant height (cm), EH- Ear height (cm), EL- Ear length (cm), EG- Ear girth (cm), KRN- Number of kernel rows per ear, KNPR- Number of kernels per row, GW- 100 kernel weight, SP- Shelling per cent and GY- Grain yield (q/ha)

Table 4. Promising hybrids based on significant better parent heterosis in desirable direction

Sl.No	Characters	Hybrids (*)	Sl.No	Characters	Hybrids (*)
1.	Days to 50 per cent tasselling	GH 24732 (-17.76)GH 24720 (-17.76)GH 24733 (-17.11)	7	Number of kernel rows per ear	GH 24734 (28.05) GH24735 (23.02) GH 24710 (21.45)
2.	Days to 50 per cent	GH 24732 (-20.25)GH 24733 (-18.99)GH 24711 (-17.65)	8	Number of kernels per silking row	GH 24719 (90.68)GH 24720 (85.59)GH 24755 (80.69)
3.	Plant height (cm)	GH 24755 (77.72)GH 24701 (77.44)GH 24746 (67.88)	9	Hundred kernel weight (g)	GH 24724 (61.22)GH 24733 (60.42)GH 24731 (52.00)
4.	Ear height (cm)	GH 24746 (86.02)GH 24701 (69.70)GH 24755 (65.63)	10	Shelling per cent	GH 24718 (9.31)GH 24721 (7.79)GH 24720 (7.56)
5.	Ear length (cm)	GH 24713 (90.43)GH 24719 (89.31)GH 24710 (87.43)	11	Grain yield (q/ha)	GH24716(385.09)GH 24722 (360.36)GH 24713 (320.33)
6.	Ear girth (cm)	GH 24710 (35.52)GH 24707 (33.77)GH 24743 (33.70)			

* Values in parenthesis indicates better parent heterosis %

and GH 24710 (87.43%) manifested more than 80 per cent better parent heterosis. Significant better parent heterosis for ear girth was recorded by 52 hybrids in desirable direction. The hybrid, GH 24710 (35.52%) showed highest significant positive heterosis over better parent followed by GH 24707 (33.77%) and GH 24743 (33.70%). Heterosis of sixty hybrids for number of kernel rows per ear varied from -13.67% to 28.05%. The hybrid GH 24734 (28.05%) showed maximum significant heterosis in desirable positive direction followed by GH 24735 (23.02%), GH 24710 (21.45%), GH 24702 (20.86%) and GH 24708 (20.86%). Among 60 test hybrids, 58 hybrids recorded significant heterosis for number of kernels per row in desired direction over better parent. The heterosis ranged from -2.12% to 90.68%. The hybrid, GH 24719 (90.68%) documented highest significant positive heterosis followed by GH 24720 (85.59%) and GH 24755 (80.65%).

Better parent heterosis for hundred kernel weight ranged from -33.78% to 61.22%. Thirty-five out of sixty hybrids exhibited significant positive heterosis for this trait. The hybrid, GH 24724 (61.22%) manifested maximum significant heterosis in desirable direction followed by GH 24733 (60.42%). Heterobeltiosis for shelling per cent ranged from -8.36% to 9.31%. The hybrid, GH 24718 (9.31%) recorded highest positive significant heterosis. Heterobeltiosis for grain yield ranged from -4.75% to 385.09%. Fifty-five out of 60 hybrids exhibited positive significant heterosis for grain yield. The hybrid, GH 24716 (385.09%) showed maximum significant heterosis in desirable direction.Similar desirable heterobeltiosis for these traits in maize has been reported in the studies by Patil *et al*. (2017), Brahmbhatt *et al*. (2018), Tafa *et al*. (2020), Upreti *et al*. (2020), Agarwal *et al*. (2021), Tejaswini *et al*. (2023) and Reddy *et al*. (2024).

Conclusion

The analysis of variance for all 11 traits under study revealed the presence of significant treatment variance for all the traits except for plant height indicating that the experimental material was genetically diverse.

The hybrid GH 24732 was earliest to both days to 50% tasselling and days to 50% silking. The hybrids, GH 24724 (61.22%) and GH 24733 (60.42%) manifested maximum significant heterosis in desirable direction for hundred kernel weight. The hybrid, GH 24716 (385.09%) exhibited maximum significant positive heterosis over better parent for grain yield. These hybrids need to be tested across environments for their stability.

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