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GENETICS AND PLANT BREEDING

Heterosis Studies for Yield and Yield Component Characters in Maize (*Zea mays* L.)

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ABSTRACT

21 F_1s obtained by crossing seven inbred lines in diallel fashion (without reciprocals) over parents and standard check were evaluated for grain yield and its component characters to study the heterosis over better parent and standard check. Thirteen crosses registered significant positive heterosis over both mid and better parents for grain yield per plant. The crosses, DHK-12-2002 × DHK-12-2036, DHK-12-2002 × DHK-12-2035 and DHK-12-2003 × DHK-12-2068, recorded highest significant relative heterosis and heterobeltiosis for grain yield per plant. The cross, DHK-12-2003 × DHK-12-2068, registered significant positive heterosis over standard check (DHM 117) for grain yield per plant indicating that the cross may be exploited for commercial release.

Highlights

- All crosses showed high levels of average and heterobeltiosis for yield and yield components.
- The Cross, DHK-12-2003 × DHK-12-2068, showed maximum heterosis over standard check for yield and yield components indicating its worth for further studies before it is being exploited for commercial cultivation.

Keywords: Heterosis, relative heterosis, heterobeltiosis, standard heterosis, maize

Maize (*Zea mays* L.; 2n=20) is a highly cross pollinated crop and also the model crop for the cross pollinated crop systems for exploitation of the heterosis. The exploitation of heterosis depends on the magnitude and direction of heterosis and the type of gene action involved. The magnitude of heterosis provides information on the extent of genetic diversity of parents and has direct bearing on the breeding methodology to be adapted for varietal improvement. Shete *et al.* (2011), Avinashe *et al*. (2012), Raghu *et al.* (2012) Soni and Khanorkara (2013) and Rajeev Kumar *et al*. (2013) and reported heterosis for yield and yield components in maize in different lines. Breeding for higher yield is the main objective in maize, hence generation of new lines and testing their superiority is a continuous process. Therefore, the present investigation was carried out to know the direction and magnitude of heterosis in 21 hybrids of maize developed by crossing seven inbred lines in diallel fashion without reciprocals for yield and yield components hypothesizing that better performing hybrids for yield and yield components can be exploited commercial purpose. The main objective of the experiment was to identify the hybrids performing better over the standard check (Standard heterosis).

MATERIALS AND METHODS

Crossing programme with seven inbred lines in diallel fashion as suggested by Griffing (1956) without reciprocals (Method-2) was planned during *kharif* 2013 to generate twenty one hybrids and the evaluation of twenty one hybrids, seven inbred lines along with standard check (DHM-117) for different traits was carried out at Agricultural College Farm, Bapatla during *rabi* 2013-14 in Randomized Complete Block Design (RCBD) with three replications, wherein each replication was represented by three rows of 3 m length for each entry. A spacing of 60cm between rows and 20 cm within a row was adopted and recommended agronomic practices were followed to raise successful experimental crop. Observations were recorded on plot basis for days to 50% tasseling, days to 50% silking, days to maturity and 100-seed weight while the traits plant height, ear height, cob length, kernel rows per cob, number of kernels per row, leaf number and grain yield per plant were taken over ten randomly selected competitive plants in each replication for all the genotypes. Heterosis, expressed as per cent increase or decrease in the performance of F_1 hybrid over the mid-parent (average or relative heterosis), better parent (heterobeltiosis) and standard check(standard heterosis) was computed for each character using the following formulae given by Liang *et al.* (1971).

(i) Relative heterosis = $\frac{\overline{F}_1 - \overline{MP}}{\overline{BP}} \times 100$

Where,

$\overline{MP} = \frac{\overline{P}_1 - \overline{P}_2}{2}$

(ii) Heterobeltiosis = $\frac{\overline{F}_1 - \overline{BP}}{\overline{BP}} \times 100$

Where,

$\overline{F}_1$ = Mean value of F_1

$\overline{MP}$ = Mean value of mid parent

$\overline{BP}$ = Mean value of better parent

$\overline{P}_1$ = Mean value of first parent

$\overline{P}_2$ = Mean value of second parent

(iii) Standard heterosis = $\frac{\overline{F}_1 - \overline{SP}}{\overline{SP}} \times 100$

Where,

$\overline{F}_1$ = Mean value of F_1

$\overline{SP}$ = Mean value of standard check

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among all the 30 genotypes for all the characters studied indicating a high degree of variability in the material. The estimates of heterosis for yield and yield components over mid parent, better parent and standard check for 21 cross combinations are presented in the Table 1.

Days to 50% tasseling

Negative heterosis is a desirable feature for this character as it indicates the earliness of a genotype. Highest negative heterosis over mid parent was observed in the cross, DHK-12-2002 × DHK-12-2036 (-12.64**) and highest negative heterosis over better parent was observed in the cross, DHK-12-2002 × DHK-12-2082 (-18.50**). Highest negative standard heterosis over check, DHM-117, was observed in the cross DHK-12-2002 × DHK-12-2082 (-14.02**). Similar results of significant negative heterosis over mid parent for this trait were reported by Shete *et al.* (2011) and Raghu *et al.* (2012), while over better parent were reported by Shete *et al.* (2011) Jawaharlal *et al.* (2012) and Rajesh *et al*. (2014) and over standard check was reported by Reddy *et al.* (2011) and Sumalini *et al*. (2012) indicating the usefulness of the hybrids for commercial exploitation for earliness.

Days to 50% silking

Negative heterosis is a desirable feature for days to 50% silking as it indicates the earliness of a genotype. Highest negative heterosis over mid parent was observed in the cross, DHK-12-2002 × DHK-12-2036 (-17.46**) and highest negative heterosis over better parent was observed in the cross, DHK-12-2002 × DHK-12-2082 (-21.28**). Highest negative standard heterosis over check, DHM-117, was observed in the cross DHK-12-2002 × DHK-12-2082 (-14.45**). Similar results of significant negative heterosis over mid parent for this trait were reported by Shete *et al.* (2011) and Avinashe *et al*. (2012). While over better parent was reported by Reddy *et al.* (2011) and over standard check were reported by Reddy *et al.* (2011), Shete *et al.* (2011) and Xiaocong *et al*. (2017).

Days to maturity

Negative heterosis is a desirable feature for this character indicating earliness of a genotype. Highest negative heterosis over mid parent, better parent and check, DHM-117, was observed in the cross, DHK-12-2002 × DHK-12-2035 (-8.19**, -8.37** and -10.07**, respectively). The result of significant negative heterosis for this trait was in agreement with those of Reddy *et al.* (2011) over mid parent and better parent while over standard check with those of Reddy *et al.* (2011) and Jawaharlal *et al.*

Table 1: Analysis of variance for yield and yield component characters in maize (*Zea mays* L.)

Source of variations	d.f.	Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height	Ear height	Cob length	Kernel rows per cob	Number of kernels per row	Leaf number	100-seed weight	Grain yield per plant
		Mean sum of squares										
Replications	2	0.211	0.011	2.344	69.287	5.381	3.244	0.009	11.417	0.131	0.585	120.213
Entries	29	35.381**	44.613**	17.700**	6037.835**	2074.713**	19.349**	4.816**	164.774**	8.586**	55.954**	3589.756**
Error	58	0.751	0.965	3.965	243.252	33.543	1.530	0.599	4.555	1.138	0.605	106.220
Total	89	12.023	15.166	8.404	2127.465	698.011	7.375	1.960	56.915	3.542	18.640	1241.619

*** Significant at 1% level*

(2012). Thus, this genotype can be exploited as short duration hybrid in different cropping systems.

Plant height

Highest positive heterosis over mid parent and better parent was observed in the cross, DHK-12-2002 × DHK-12-2034 (87.34** and 83.36**, respectively). None of the crosses exhibited significant positive standard heterosis. Similar results for significant positive heterosis over mid parent and better parent were reported by Reddy *et al.* (2011) and Raghu *et al.* (2012) indicating the non-availability of the variability for plant height in the present lines.

Ear height

Highest positive heterosis over mid parent and better parent was observed in the cross, DHK-12-2002 × DHK-12-2034 (142.06** and 126.84**, respectively). None of the crosses exhibited significant positive standard heterosis. Similar results for significant positive heterosis over mid parent and better parent were reported by Alam *et al.* (2008), Reddy *et al.* (2011) and Xiaocong *et al.* (2017).

Cob length

Highest positive heterosis over mid parent and better parent was observed in the cross, DHK-12-2003 × DHK-12-2034 (47.21** and 38.76**, respectively). None of the crosses exhibited significant positive standard heterosis. Similar results over mid and better parent were reported by Shete *et al.* (2011) and Raghu *et al.* (2012).

Kernel rows per cob

Highest positive heterosis over mid parent, better parent and check, DHM-117, was observed in the cross, DHK-12-2002 × DHK-12-2034 (32.28**, 30.57**and 11.01*, respectively). These results were in conformity with the findings of Reddy *et al.* (2011) and Shete *et al.* (2011) for relative heterosis, heterobeltiosis and standard heterosis. Thus, this hybrid can be exploited for the commercial purpose as it is having more kernel rows per cob.

Number of kernels per row

Highest positive heterosis over mid parent and better parent was observed in the cross, DHK-12-2003 × DHK-12-2034 (133.79** and 97.05**, respectively). Highest positive standard heterosis over check DHM-117 was observed in the cross, DHK-12-2003 × DHK-12-2082 (23.50**). These results were in conformity with the findings of Reddy *et al.* (2011) for relative heterosis, heterobeltiosis and standard heterosis indicating the possibility of exploitation of the cross for commercial release.

Leaf number

Highest positive heterosis over mid parent and better parent was observed in the cross, DHK-12-2002 × DHK-12-2034 (50.10** and 45.70**, respectively). None of the crosses exhibited significant positive standard heterosis for leaf number indicating the absence of variability for this trait in the present material.

100-seed weight

Highest positive heterosis over mid parent was recorded in the cross, DHK-12-2002 × DHK-12-2035 (67.53**). Highest positive heterosis over better parent and check, DHM-117, was observed in the cross, DHK-12-2003 × DHK-12-2082 (58.66** and 64.15**, respectively). These results were in

Table 2: Relative heterosis, heterobeltiosis and standard hetrosis for yield and yield contributing characters in maize (*Zea mays* L.)

Crosses	Days to 50% tasseling			Days to 50% silking			Days to maturity		
	Relative heterosis	Hetero beltiosis	Standard heterosis[a]	Relative heterosis	Hetero beltiosis	Standard heterosis[a]	Relative heterosis	Hetero Beltiosis	Standard heterosis[a]
DHK-12-2002 × DHK-12-2003	-6.63**	-10.40**	-5.49**	-3.70**	-10.11**	-2.31	-5.52**	-5.70**	-7.46**
DHK-12-2002 × DHK-12-2036	-12.64**	-13.14**	-7.32**	-17.46**	-17.89**	-9.83**	-3.38*	-4.46*	-4.10*
DHK-12-2002 × DHK-12-2082	-11.60**	-18.50**	-14.02**	-12.68**	-21.28**	-14.45**	-3.33	-6.08**	-7.84**
DHK-12-2002 × DHK-12-2068	-7.83**	-8.09**	-3.05*	-7.86**	-9.57**	-1.73	-5.30**	-5.66**	-6.72**
DHK-12-2002 × DHK-12-2035	-10.12**	-12.72**	-7.93**	-11.29**	-12.23**	-4.62**	-8.19**	-8.37**	-10.07**
DHK-12-2002 × DHK-12-2034	-11.49**	-12.00**	-6.10**	-12.81**	-14.89**	-7.51**	-2.65	-3.02	-4.10*
DHK-12-2003 × DHK-12-2036	2.99*	-1.71	4.88**	3.12*	-4.21**	5.20**	-0.19	-1.49	-1.12
DHK-12-2003 × DHK-12-2082	-6.89**	-10.69**	-13.41**	0.00	-3.68*	-9.25**	-1.57	-4.20*	-6.34**
DHK-12-2003 × DHK-12-2068	-8.76**	-12.21**	-7.93**	-4.65**	-9.39**	-5.20**	-2.47	-3.02	-4.10*
DHK-12-2003 × DHK-12-2035	-4.97**	-6.13**	-6.71**	-9.51**	-14.67**	-9.25**	-2.29	-2.29	-4.48*
DHK-12-2003 × DHK-12-2034	-9.58**	-13.71**	-7.93**	-8.77**	-12.85**	-9.83**	-3.23	-3.77	-4.85*
DHK-12-2036 × DHK-12-2082	-7.17**	-14.86**	-9.15**	-3.23*	-13.16**	-4.62**	0.58	-3.35	-2.99
DHK-12-2036 × DHK-12-2068	-0.29	-1.14	5.49**	-0.81	-3.16*	6.36**	0.37	-0.37	0.00
DHK-12-2036 × DHK-12-2035	-3.55**	-6.86**	-0.61	-9.63**	-11.05**	-2.31	-0.94	-2.23	-1.87
DHK-12-2036 × DHK-12-2034	-2.86*	-2.86*	3.66**	1.36	-1.58	8.09**	-0.37	-1.12	-0.75
DHK-12-2082 × DHK-12-2068	-5.66**	-12.79**	-8.54**	0.00	-8.29**	-4.05**	-0.97	-4.15*	-5.22**
DHK-12-2082 × DHK-12-2035	-2.27	-7.36**	-7.93**	-6.87**	-15.22**	-9.83**	-1.96	-4.58*	-6.72**
DHK-12-2082 × DHK-12-2034	-9.66**	-17.14**	-11.59**	0.00	-7.82**	-4.62**	-1.36	-4.53*	-5.60**
DHK-12-2068 × DHK-12-2035	-6.87**	-9.30**	-4.88**	-4.11**	-4.89**	1.16	-0.57	-1.13	-2.24
DHK-12-2068 × DHK-12-2034	-11.24**	-12.00**	-6.10**	-5.56**	-6.08**	-1.73	-2.26	-2.26	-3.36
DHK-12-2035 × DHK-12-2034	-7.10**	-10.29**	-4.27**	-6.89**	-8.15**	-2.31	-3.98*	-4.53*	-5.60**
Range	-12.64 to 2.99	-18.50 to -1.14	-14.02 to 5.49	-17.46 to 3.12	-21.28 to -1.58	-14.45 to 8.09	-8.19 to 0.58	-8.37 to -0.37	-10.07 to 0.00

Table 2 (cont.)

Crosses	Plant height			Ear height			Cob length		
	Relative heterosis	Hetero beltiosis	Standard heterosis[a]	Relative heterosis	Hetero beltiosis	Standard heterosis[a]	Relative heterosis	Hetero beltiosis	Standard heterosis[a]
DHK-12-2002 × DHK-12-2003	80.76**	60.44**	-1.87	131.07**	106.48**	-3.12	38.36**	22.97**	-12.44*
DHK-12-2002 × DHK-12-2036	85.18**	75.50**	-7.08	122.97**	94.93**	-3.81	18.72**	-7.27	-8.69
DHK-12-2002 × DHK-12-2082	64.53**	47.65**	-11.93*	46.21**	26.74**	-36.19**	19.23**	-2.17**	-15.50**
DHK-12-2002 × DHK-12-2068	50.29**	36.32**	-20.62**	120.26**	106.47**	-12.82**	11.28	-6.85	-23.51**
DHK-12-2002 × DHK-12-2035	76.57**	60.89**	-7.25	130.54**	126.84**	-13.44**	10.79	-9.85	-20.44**
DHK-12-2002 × DHK-12-2034	87.34**	83.36**	-13.07**	142.06**	126.84**	-4.16	34.39**	26.22**	-20.44**
DHK-12-2003 × DHK-12-2036	-12.82	-18.68*	-50.26**	-29.90**	-31.63**	-66.26**	-13.86*	-25.78**	-26.92**
DHK-12-2003 × DHK-12-2082	45.39**	43.59**	-12.18*	28.94**	24.56**	-37.29**	38.16**	26.04**	8.86
DHK-12-2003 × DHK-12-2068	1.57	-0.86	-39.37**	48.88**	41.43**	-33.64**	37.78**	28.63**	5.62
DHK-12-2003 × DHK-12-2035	33.37**	29.54**	-20.77**	63.25**	48.01**	-30.55**	2.14	-7.72	-18.57**
DHK-12-2003 × DHK-12-2034	62.38**	41.45**	-13.49**	78.52**	69.62**	-20.41**	47.21**	38.76**	-1.19
DHK-12-2036 × DHK-12-2082	53.58**	44.95**	-13.54**	65.62**	63.98**	-17.45**	3.41	-2.94	-4.43
DHK-12-2036 × DHK-12-2068	29.63**	23.75**	-27.94**	25.41**	16.36*	-42.58**	-25.09**	-31.31**	-32.37**
DHK-12-2036 × DHK-12-2035	9.69	5.22	-39.34**	47.69**	30.95**	-35.38**	-10.58*	-15.22**	-16.52**

DHK-12-2036 × DHK-12-2034	42.07**	31.94**	-30.15**	52.43**	41.46**	-30.19**	-13.92*	-29.41**	-30.49**
DHK-12-2082 × DHK-12-2068	47.38**	45.62**	-13.14**	82.40**	67.68**	-15.58**	4.75	2.17	-11.75*
DHK-12-2082 × DHK-12-2035	26.29**	24.17**	-25.93**	30.51**	14.71*	-42.25**	-6.73	-7.72	-18.57**
DHK-12-2082 × DHK-12-2034	68.40**	48.28**	-11.55*	88.58**	73.41**	-12.69**	24.74**	7.89	-6.81
DHK-12-2068 × DHK-12-2035	69.73**	68.89**	-1.66	125.10**	114.28**	-9.53*	4.20	0.58	-11.24*
DHK-12-2068 × DHK-12-2034	73.99**	54.82**	-9.85*	82.52**	82.47**	-22.91**	23.71**	9.34	-10.22
DHK-12-2035 × DHK-12-2034	43.52**	28.26**	-26.06**	98.48**	88.88**	-20.20**	17.34**	0.58	-11.24*
Range	-12.82 to 87.34	-18.68 to 83.36	-50.26 to -1.66	-29.90 to 142.06	-31.63 to 126.84	-66.26 to -3.12	-25.09 to 47.21	-31.31 to 38.76	-32.37 to 8.86

Table 2 (cont.)

Crosses	Kernel rows per cob			Number of kernels per row			Leaf number		
	Relative heterosis	Hetero beltiosis	Standard heterosis[a]	Relative heterosis	Hetero beltiosis	Standard heterosis[a]	Relative heterosis	Hetero beltiosis	Standard heterosis[a]
DHK-12-2002 × DHK-12-2003	11.71**	5.53	0.88	66.81**	65.08**	-16.16**	18.31**	-3.46	-7.13
DHK-12-2002 × DHK-12-2036	23.37**	17.62**	0.00	48.63**	26.60**	-8.60	30.10**	11.05	-4.51
DHK-12-2002 × DHK-12-2082	15.66**	12.81**	0.88	55.44**	36.68**	-8.50	19.81**	0.26	-9.50
DHK-12-2002 × DHK-12-2068	23.81**	21.24**	3.08	29.88**	14.29	-23.61**	22.30**	10.38	-16.63**
DHK-12-2002 × DHK-12-2035	3.72	-0.48	-7.93	41.11**	21.22*	-14.27*	37.31**	21.75**	-4.28
DHK-12-2002 × DHK-12-2034	32.28**	30.57**	11.01*	94.81**	62.81**	-17.31**	50.10**	45.70**	-11.40
DHK-12-2003 × DHK-12-2036	13.78**	2.76	-1.76	10.50	-6.69	-32.63**	-26.47**	-30.37**	-33.02**
DHK-12-2003 × DHK-12-2082	-0.48	-3.69	-7.93	111.69**	84.48**	23.50**	0.38	-2.72	-6.41
DHK-12-2003 × DHK-12-2068	18.91**	10.14*	5.29	77.14**	54.47**	3.25	7.33	-4.20	-7.84
DHK-12-2003 × DHK-12-2035	-15.69**	-17.05**	-20.70**	53.31**	30.56**	-7.66	-5.71	-14.32*	-17.58**
DHK-12-2003 × DHK-12-2034	16.05**	8.29	3.52	133.79**	97.05**	-1.99	22.60**	-2.22	-5.94
DHK-12-2036 × DHK-12-2082	17.99**	9.85*	-1.76	67.42**	61.34**	16.47**	14.56*	11.84	0.95
DHK-12-2036 × DHK-12-2068	7.78	4.86	-14.54**	-13.36	-16.57*	-39.77**	9.12	2.49	-11.88
DHK-12-2036 × DHK-12-2035	19.48**	9.52*	1.32	31.57**	30.23**	-5.98	-6.20	-10.22	-22.80**
DHK-12-2036 × DHK-12-2034	22.31**	18.09**	-2.20	32.87**	-2.18	-29.38**	-11.44	-26.24**	-36.58**
DHK-12-2082 × DHK-12-2068	8.25	3.45	-7.49	67.53**	67.40**	12.07*	18.05**	8.42	-2.14
DHK-12-2082 × DHK-12-2035	-1.21	-2.86	-10.13*	66.46**	62.02**	14.59*	-3.80	-10.00	-18.76**
DHK-12-2082 × DHK-12-2034	14.58**	10.34*	-1.32	122.22**	67.71**	12.28*	19.81**	-2.11	-11.64
DHK-12-2068 × DHK-12-2035	17.97**	10.95*	2.64	47.37**	43.32**	1.36	35.29**	32.63**	4.28
DHK-12-2068 × DHK-12-2034	21.72**	20.74**	0.00	129.94**	73.63**	16.05**	21.65**	6.92	-19.24**
DHK-12-2035 × DHK-12-2034	9.05*	3.33	-4.41	105.41**	52.23**	7.66	28.67**	11.18	-12.59*
Range	-15.69 to 32.28	-17.05 to 30.57	-20.70 to 11.01	-13.36 to 133.79	-16.57 to 97.05	-39.77 to 23.50	-26.47 to 50.10	-30.37 to 45.70	-36.58 to 4.28

Table 2 (cont.)

Crosses	100-seed weight			Grain yield per plant		
	Relative heterosis	Hetero beltiosis	Standard heterosis[a]	Relative heterosis	Hetero beltiosis	Standard heterosis[a]
DHK-12-2002 × DHK-12-2003	22.66**	19.21**	23.33**	117.11**	74.40**	-9.67
DHK-12-2002 × DHK-12-2036	49.42**	41.81**	38.44**	269.58**	213.20**	-1.60
DHK-12-2002 × DHK-12-2082	9.05*	8.81*	6.70	85.83**	50.75**	-23.91**
DHK-12-2002 × DHK-12-2068	14.42**	7.96	5.40	36.72*	21.61	-50.95**
DHK-12-2002 × DHK-12-2035	67.53**	35.84**	32.61**	192.31**	183.32**	-10.99
DHK-12-2002 × DHK-12-2034	28.34**	-5.31	-7.56	79.45**	76.81**	-44.45**
DHK-12-2003 × DHK-12-2036	25.20**	15.66**	19.65**	31.02	-6.87	-51.77**

DHK-12-2003 × DHK-12-2082	62.92**	58.66**	64.15**	121.10**	118.29**	13.06
DHK-12-2003 × DHK-12-2068	61.82**	48.64**	53.78**	181.96**	150.76**	29.88**
DHK-12-2003 × DHK-12-2035	60.79**	27.56**	31.97**	50.76**	18.29	-38.73**
DHK-12-2003 × DHK-12-2034	43.80**	4.18	7.78	110.49**	67.21**	-13.40
DHK-12-2036 × DHK-12-2082	44.88**	37.22**	34.56**	165.19**	89.95**	-4.12
DHK-12-2036 × DHK-12-2068	13.01**	12.32**	-1.51	15.69	-10.84	-64.04**
DHK-12-2036 × DHK-12-2035	50.80**	27.59**	11.88**	86.78**	62.55*	-52.07**
DHK-12-2036 × DHK-12-2034	4.03	-20.44**	-30.24**	10.77	-4.96	-71.02**
DHK-12-2082 × DHK-12-2068	7.60*	1.32	-0.65	41.98**	27.71	-35.54**
DHK-12-2082 × DHK-12-2035	-0.14	-19.16**	-20.73**	11.95	-11.33	-55.24**
DHK-12-2082 × DHK-12-2034	22.87**	-9.47*	-11.23**	56.59**	25.60	-36.60**
DHK-12-2068 × DHK-12-2035	45.45**	23.69**	7.13	133.08**	101.74**	-18.64*
DHK-12-2068 × DHK-12-2034	52.92**	17.46**	1.73	125.64**	98.12**	-20.10**
DHK-12-2035 × DHK-12-2034	42.74**	25.98**	-23.54**	61.50**	58.82*	-51.57**
Range	-0.14 to 67.53	-20.44 to 58.66	-30.24 to 64.15	10.77 to 269.58	-11.33 to 213.20	-71.02 to 29.88

** Significant at 5% level; ** Significant at 1% level; a – standard check considered was DHM-117*

Table 3: The best heterotic combinations identified for yield and yield contributing characters in maize (*Zea mays* L.) based on overall performance.

Sl. No.	Characters	Cross combinations	*Per se* performance	Standard heterosis (DHM-117)
1	Days to 50% tasseling	DHK-12-2002 × DHK-12-2082	47.00	-14.02**
		DHK-12-2003 × DHK-12-2082	47.33	-13.41**
		DHK-12-2082 × DHK-12-2034	48.33	-11.59**
2	Days to 50% silking	DHK-12-2002 × DHK-12-2082	49.33	-14.45**
		DHK-12-2082 × DHK-12-2035	52.00	-9.83**
		DHK-12-2002 × DHK-12-2036	52.00	-9.83**
3	Days to maturity	DHK-12-2002 × DHK-12-2035	80.33	-10.07**
		DHK-12-2002 × DHK-12-2082	82.33	-7.84**
		DHK-12-2002 × DHK-12-2003	82.67	-7.46**
4	Kernel rows per cob	DHK-12-2002 × DHK-12-2034	16.80	11.01*
5	Number of kernels per row	DHK-12-2003 × DHK-12-2082	39.23	23.50**
		DHK-12-2036 × DHK-12-2082	37.00	16.47**
		DHK-12-2068 × DHK-12-2034	36.87	16.05**
6	100-seed weight (g)	DHK-12-2003 × DHK-12-2082	25.33	64.15**
		DHK-12-2003 × DHK-12-2068	23.73	53.78**
		DHK-12-2002 × DHK-12-2036	21.37	38.44**
7	Grain yield per plant (g)	DHK-12-2003 × DHK-12-2068	154.47	29.88**

** Significant at 5% level; ** Significant at 1% level* conformity with the findings of Reddy *et al.* (2011), Shete *et al.* (2011) and Raghu *et al.* (2012) for relative heterosis, heterobeltiosis and standard heterosis denoting the importance of the cross for commercial release and the use of the material for exploitation of this trait in the breeding programmes.

Grain yield per plant

Highest positive heterosis over mid parent and better parent was recorded in the cross, DHK-12-2002 × DHK-12-2036 (269.58** and 213.20**, respectively). Highest positive heterosis over check, DHM-117, was observed in the cross, DHK-12-2003 **×** DHK-12-2068 (29.88**). These results were in conformity with the findings of Reddy *et al.* (2011) and Meenakshi *et al*. (2017) for relative heterosis, heterobeltiosis and standard heterosis indicating the importance of the cross for commercial release for yield increase.

Based on overall performance (*per se* performance and standard heterosis over check, DHM-117), the best heterotic combinations identified for yield and yield components are presented in Table 2. The best heterotic combination identified were DHK-12-2002 × DHK-12-2082 for days to 50% tasseling and days to 50% silking; DHK-12-2002 **×** DHK-12-2035 for days to maturity; DHK-12-2002 × DHK-12-2034 for kernel rows per cob; DHK-12-2003 × DHK-12-2082 for number of kernels per row and 100-seed weight and DHK-12-2003 × DHK-12-2068 for grain yield per plant.

CONCLUSION

Thus, the results revealed the superiority of crosses over standard check (DHM-117) for majority of the traits except for plant height, ear height, cob length and leaf number. The present study also identified the cross, DHK-12-2003 × DHK-12-2068, which had significant standard heterosis over better check for yield and yield components. This cross may be further evaluated over large number of environments in different seasons for further confirmation of its superiority before it is being exploited commercially.

The results also suggested that the cross, DHK-12-2003 × DHK-12-2068, did not express high heterosis for all the yield component traits studied except for 100-seed weight which had strong association with yield might have contributed towards the significant yield heterosis in this cross.

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