Heterosis and yield potentialities of promising maize hybrids suitable for Terai and inner Terai environments of Nepal

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Abstract

Heterosis has made a dramatic impact on the developing of breeding methods and high yields in many field crops during the 20th century. In general, heterosis is greatest in cross pollinated compared to self pollinated crops and thus widely exploited for hybrid cultivar development. Standard heterosis is one of the most important parameters in commercialization of maize hybrids. A new hybrid must be superior to the standard hybrids in terms of grain yield and other economic traits. We have analyzed four coordinated varietal trials of hybrids, 3 of which were conducted at NMRP, Rampur and another was tested at NMRP, Rampur and at ARS, Belachapi, Janakpur from 2006 to 2008 in order to determine the standard heterosis of the promising hybrids. The objective of this study was to evaluate hybrids under different production domains and to select superior hybrids for commercialization. Standard heterosis was calculated based on the best check hybrids and Indian commercial hybrids. The hybrids showed significant differences for grain yields and days to silking in all the trials. Standard heterosis of the tested hybrids ranged from -39.4 to 47.8%. Most of the hybrids showed positive standard heterosis for grain yield. Hybrids namely; RML-4/NML-2, RML-6/RML-8, NML-1/RML-8 in 2006 and RML-57/RL-174, NML-1/RML-6 and RL-197/NML-2 in 2008 had more than15% standard heterosis for grain yield evaluated at NMRP, Rampur. Hybrid between RML-4/NML-2 had only shown positive standard heterosis in 2007 at NMRP, Rampur. RML-4/NML-2, NML-1/RL-17 and RL-111/RL-189 were superior hybrids, which had >15% standard heterosis across NMRP, Rampur and at ARS, Belachapi, Janakpur in 2008. Seed production aspect of these selected hybrids should be studied to develop a complete package of practices for F1 hybrid seed production.

Key words: Siingle cross, top cross, heterosis, economic seed production, and commercialization

Introduction

It is well known fact that one of the top breakthroughs in modern agriculture came with discovery of heterosis in plant crosses, which has been recognized for nearly 250 years (Malik et al, 2004). Heterosis has made a dramatic impact on the developing of breeding methods and high yields in many field crops during the 20th century. In general, heterosis is greatest in cross pollinated as compared to self pollinated crops and thus widely exploited for hybrid cultivar development. Greater heterosis is associated with greater parental diversity. Inbred lines are generally developed from the diverse parent groups and then selected on the basis of heterosis as well as general and specific combining ability. Therefore, choices of heterotic groups and patterns are fundamentally important in hybrid breeding of maize (Melchinger and Gumber, 1998). Heterosis is responsible for much of the annual yield gains in maize, sorghum and sunflower (Duvick, 1997). Heterosis is a phenomenon in which an F1 hybrid of two genetically dissimilar parents show superiority over the mid parent value in a measurable character (Shull, 1908).A new maize hybrid must be superior to existing cultivars for grain yield and other economic traits. Therefore, heterosis in reference to a standard check (standard heterosis) is important for commercialization.

In Terai, farmers have earned relatively more income from hybrids grown in winter season due to higher yields. Farmers are growing maize hybrids imported from India, Thailand and other countries. NMRP has not released new hybrids after Gaurav, which was released in 2003 for Terai. A series of experiments were conducted at NMRP Rampur and at ARS Belachapi, Janakpur to determine standard heterosis of the hybrids developed at NMRP Rampur and to select best hybrids for commercialization.

Methodology

Hybrids were evaluated in Coordinated Varietal Trials (CVT) at NMRP Rampur and ARS Belachapi, Janakpur. CVTs were conducted at Rampur for 3 years (from 2006/07 to 2008/09). The same set was conducted at Rampur and Belachapi in 2008/09. The hybrids and popular commercial and standard checks were planted in a RCB design during winter season at both the locations. The experimental plots were fertilized with 120:60:40 kg NPK/ha. The plant spacing was 75 cm between rows 25 cm between plants. Cultural practices were followed as per recommendation. Variances were analyzed for days to mid-silking and grain yield. Grain yields were adjusted to 80% shelling percent and 15% grain moisture content. Standard heterosis was calculated as a percent increased grain yield of a hybrid compared to the best check (Gaurav). Detail of the experiments is given in Table-1.

Table 1. Details of experiments conducted on hybrid maize from 2006/07 to 2008/09.

SN	Experiment	Design	No. of genotypes	Location
1	CVT 2006/07 winter	RCBD, 3 replications	16	Rampur
2	CVT 2007/08 winter	RCBD, 3 replications	16	Rampur
3	CVT 2008/09 winter	RCBD, 3 replications	12	Rampur & Belachapi
4	CVT 2008/09 winter	RCBD, 3 replications	30	Rampur

Results and discussion

Coordinated varietal trial at Rampur in 2006/07 winter

The variances for days to silking and grain yields were highly significant ($p<0.01$) and significant ($p<0.05$), respectively. Grain yield from the tested hybrids ranged from 4049 to 7639kg/ha (Table 2). Gaurav, a standard check had higher grain yield than the commercial checks and significantly higher than Bioseed 9681. Gurung (2006) has reported the range of heterosis from -22 to 63.1% in 10 Nepalese yellow maize populations. Similar findings were reported (Sonegas *et al.*2003; Revilla *et al*.1997; Malik *et al.* 2004 and Melani *et al.* 2005) for open pollinated flint cultivars, sweet corn varieties and in temperate, subtropical and tropical germplasms.

Seven hybrids out yielded Gaurav but the differences were not significant ($p>0.05$). The standard heterosis of the hybrids under testing ranged from -14.2 in NML-1/RML-6 to 24.5% in RML-4/NML-2. Hybrids namely; RML-4/NML-2, RML-6/RML-8, NML-1/RML-8, RML-18/RML-17, RL-17/RL30-1, RML4/RML-5 and NML-1/RML-8 showed positive standard heterosis. Most of the hybrids had similar maturity with checks except for Bioseed-9681, which matured earlier than the other tested hybrids. The results showed a greater variability in grain yield indicating the superiority of NMRP bred hybrids over the imported commercial hybrids.

Table 2. Days to mid-silking, grain yield and standard heterosis of hybrids tested in CVT at NMRP, Rampur in 2006/07

SN	Pedigree	Days to mid-silking	Grain ield (kg/ha)	Standard Heterosis (%)
1	RML-4/NML-2	68	7639	24.5
2	RML-6/RML-8	71	7471	21.8
3	NML-1/RML-8	72	7057	15.0
4	RML-18/RML-17	74	6731	9.7
5	RL-17/RL30-1	70	6641	8.2
6	RML-4/RML-5	71	6567	7.0
7	NML-1/RML-8	67	6553	6.8
8	RML-8/RL30-1	68	6043	-1.5
9	RML-41/RL30-1	66	5803	-5.4
10	RL-12/RML-8	66	5671	-7.6
11	RL-29/RL30-1	64	5359	-12.7
12	NML-1/RML-6	74	5265	-14.2
13	Gaurav	70	6136	0.0
14	Bioseed 9681	65	4049	-34.0
15	Pioneer 30G10	70	5069	-17.4
16	Rampur Composite	62	5497	-10.4
	Grand mean	69	6097	
	F-test	**	*	
	CV%	3.8	17.4	
	LSD (P<0.05)	4.4	1841	

F test, * and ** indicate significant at P<0.05 and 0.01 level of sinnificant, respectively

Coordinated varietal trial at Rampur in 2007/08 winter

Differences among genotypes were highly significant (p<0.01) for days to mid-silking and grain yield. Genotypes for grain yields were recorded 4169 to 8694 kg/ha (Table 3). RML-4/NML-2 which gave higher grain yield than Gaurav (standard check), however, RML-18/RML-17, Rampur Composite/RML-4, NML-1/RML-17, Rampur Composite/NML-1 and RML-4/Arun-2 gave grain yields statistically at par with Gaurav. Rampur Composite was the earliest for midsilking (68.7 days). RML-4/NML-2 has only shown positive standard heterosis for grain yield. Top cross hybrids; Rampur Composite/RML-4, Rampur Composite /NML-1, Rampur Composite /RML-17, Rampur Composite /RML-5 and RL30-1/ Rampur Composite were early in maturity than single-cross hybrids.

Table 3 Grain yield, days to mid-silking and standard heterosis of hybrids in CVT 2007/08 at Rampur

SN	Pedigree	Days to mid-silking	Grain yield kg/ha	Standard heterosis %
1	RML-4/NML-2	77.6	8694	1.4
2	RML-18/RML-17	82.3	8548	-0.3
3	Rampur Composite /RML-4	71.3	8097	-5.6
4	NML-1/RML-17	74.3	7551	-12.0
5	Rampur Composite /NML-1	70.7	7461	-13.0
6	RML-4/Arun-2	73.3	7388	-13.9
7	NML-1/RML-8	74.7	6863	-20.0
8	RML-4/RML-3	80.3	6774	-21.0
9	Rampur Composite /RML-17	80.0	6538	-23.8
10	Rampur Composite /RML-5	70.7	6318	-26.3
11	RL30-1/ Rampur Composite	71.3	6002	-30.0
12	RL-125/RL-169	69.7	5838	-31.9
13	Gaurav	78.0	8577	0.0
14	Pioneer 30G10	82.7	6630	-22.7
15	Bioseed 9681	70.0	4169	-51.4

16	Rampur Composite	68.7	6256	-27.1
	Grand mean	74.8	6982	
	F-test	**	**	
	CV%	4.7	11	
	LSD (P<0.05)	5.8	1320	

F test, * and ** indicate significant at P<0.05 and 0.01 level of sinnificant, respectively

Coordinated varietal trial at Rampur and Belachapi in 2008/09 winter

Combined analysis was done for CVT conducted in 2008/09 at Rampur and Belachapi, Janakpur. The significant (p<0.05) effects of locations, genotypes and their interaction for grain yield indicated that hybrids responded differently with the environments at Rampur and Belachapi. Grain yields ranged from 4480 to 5933 kg/ha. Seven genotypes gave positive standard heterosis for grain yield. Hybrids namely; RML-4/RML-3, NML-1/RL-17, RL-111/RL-189 and RL-193/RL111 had significantly higher grain yield over Gaurav (Table 4).

Table 4. Days to midsilking, grain yields and standard heterosis for grain yield of genotypes tested in CVT 2008/09 over Rampur and Belachapi

SN	Pedigree	Days to Mid-silking	Grain yield kg/ha	Standard heterosis, %
1	RML-4/RML-3	85.6	5933	20.5
2	NML-1/RL-17	82.0	5763	17.0
3	RL-111/RL-189	86.4	5726	16.3
4	RL-193/RL-111	85.0	5346	8.6
5	RL-47/RML-5	83.0	5249	6.6
6	RML-18/RML-17	88.2	5103	3.6
7	RL-12/RML-8	85.4	4965	0.8
8	RML-73/RML-72	87.6	4830	-1.9
9	RL-125/RL-169	78.4	4741	-3.7
10	RML-6/RML-8	82.2	4645	-5.7
11	RL-83/RL-105	84.6	4480	-9.0
12	Gaurav	87.4	4924	
	Grand mean	84.7	5142	
	F-test location.	-	*	-
	Genotype		*	
	Genotype x Location		*	
	LSD (P<0.05)	24.37	1040	
	CV%	22.6	15.4	

F test, * and ** indicate significant at P<0.05 and 0.01 level of sinnificant, respectively

Coordinated varietal trial at Rampur in 2008/09 winter

Another set of CVT was conducted at Rampur in 2008/09 winter. Hybrids were highly significant ($p<0.01$) for days to mid-silking and grain yield. Grain yield of hybrids ranged from 5238 to 10062 kg/ha. Open pollinated varieties gave lowest grain yields. Eight out of thirty genotypes gave positive standard heterosis for grain yield. Only two hybrids (RML-57/RL-174 and NML-1/RML-6) had significantly higher grain yields than Gaurav (standard check). These hybrids showed 47.8 and 40.2% standard heterosis, respectively (Table 5). RML-8/ Rampur Composite recorded the lowest days for mid-silking.

Table 5. Performance of maize hybrids in CVT 2008/09 at Rampur

SN	Pedigree	Days to mid silking	Grain yield Kg/ha	Standard heterosis %
1	RML-57/RL-174	73.5	10062	47.8
2	NML-1/RML-6	70.5	9546	40.2
3	RL-197/NML-2	65.5	9259	36.0
4	Rampur Composite/NML-1	65.0	7765	14.1
5	RL-174/RML-36	67.5	7543	10.8
6	RML-8/ Rampur Composite	65.5	7469	9.7
7	NML-1/RML-5	68.5	7434	9.2
8	RML-6/RML-72	74.5	7193	5.7
9	RL-41/ Rampur Composite	64.5	6690	-1.7
10	RML-68/RML-36	65.0	6451	-5.2
11	RML-19/ Rampur Composite	66.0	6447	-5.3
12	RL-180/RL-175	63.0	6200	-8.9
13	A-2/RML-8	73.0	6060	-11.0
14	RML-8/ Rampur Composite	60.0	6014	-11.7
15	RML-8/RL30-1	65.5	5851	-14.1
16	RL-5-2/ Rampur Composite	65.0	5823	-14.5
17	NML-1/ Rampur Composite	68.0	5447	-20.0
18	NML-4/(RL-29/RL-30-1)	86.5	5387	-20.9
19	RML-18/ Rampur Composite	68.5	5122	-24.8
20	RL-105/ Rampur Composite	67.5	5009	-26.4
21	Rampur Composite /RML-8	75.0	4954	-27.2
22	Pio.30G10/RML-8	76.5	4745	-30.3
23	RML-57/RML-6	81.0	4660	-31.6
24	RL-174/RML-6	67.5	4544	-33.3
25	A-2/RL-30-1	71.5	4127	-39.4
26	Gaurav St. Check	70.0	6808	0.0
27	Pio.30G10	70.0	5266	-22.6
28	Rajkumar	66.5	5238	-23.1
29	Rampur composite	62.0	5486	-19.4
30	Pop45C10	65.0	4940	-27.4
	Grand mean	68.9	6251	
	F-test	**	**	
	CV %	6.4	20.8	
	$LSD_{0.05}$	8.9	2728	

F test, * and ** indicate significant at P<0.05 and 0.01 level of sinnificant, respectively

A total of 9 superior hybrids are selected from different the experiment conducted in different years (Table 6). The basis of selecting these hybrids was grain yield and standard heterosis shown by these hybrids. These hybrids are being tested in coordinated farmers' field trials in outreach research sites of Chitwan, Makaanpur and Nawalparasi districts.

Table 6 List of promising hybrids selected from different experiments

SN	Hybrid	Experiment	Standard heterosis %
1	RML-4/NML-2	CVT 2006/07 Rampur	24.5
2	RML-6/RML-8	CVT 2006/07 Rampur	21.8
3	NML-1/RML-8	CVT 2006/07 Rampur	15.0
4	RML-4/RML-3	CVT 2008/09 Rampur and Belachapi	20.5
5	NML-1/RML-17	CVT 2008/09 Rampur and Belachapi	17.0
6	RL-111/RL-189	CVT 2008/09 Rampur and Belachapi	16.3
7	RML-57/RL-174	CVT 2008/09 Rampur	47.8
8	NML-1/RML-6	CVT 2008/09 Rampur	40.2
9	RL-197/NML-2	CVT 2008/09 Rampur	36.0

Conclusion

Many hybrids developed at NMRP were found superior to imported ones. Hybrids showing more than 15% standard heterosis for grain yield and selected from different experiments should be advanced to increase their seed production potentiality and commercialization. Among the selected genotypes, the genotypes tested over locations were likely more stable than those tested only at a location. RML-4/NML-2 had repeatedly shown superiority in CVT 2007/08 at Rampur. However, it did not show >15% standard heterosis for grain yield in CVT 2007/08, it was only the genotype, which gave higher grain yield over the Standard Check being the stable genotype over years. Hybrids performing well in a specific location should be recommended for that particular area. Some top crosses were similar to promising hybrids for grain yield. Top crosses of Rampur Composite with RML-4 and NML-1 and RML-4/Arun-2 gave statistically comparable grain yield to Gaurav. Hence, these OPVs could be used in developing high-yielding hybrids. Out of 9 selected hybrids, two hybrids namely; RML-4/NML-2 and RL-111/RL-189 are in the process of release.

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