Fundamental and Applied Agriculture
Vol. 5(2), pp. 188–193: 2020
doi: 10.5455/faa.82914

Agronomy
ORIGINAL ARTICLE

Heterosis in maize hybrids at farmer's field in Dang district of Nepal

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ARTICLE INFORMATION

Article History
Submitted: 25 Jan 2020
Accepted: 28 Mar 2020
First online: 30 Apr 2020

Academic Editor
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ABSTRACT

This experiment was conducted at the farmer's field at Bangaun, Dang, Nepal during summer season from 18th May to 21st September 2018 to estimate heterosis in maize hybrids. Seven maize hybrids were evaluated in a randomized complete block design with three replications. The results revealed that all the maize hybrids showed significant positive heterosis over mid parents and better parent for grain yield. High level of heterosis was found for grain yield followed by plant height. The hybrids RH10 and RML86/RML96 produced significantly the highest mid parent heterosis and heterobeltiosis for grain yield. The hybrids RH10 and RH6 produced higher positive heterosis over both check varieties (Rajkumar and Subarna) for grain yield. Hybrid RH10 produced the highest standard heterosis (39.39%) for grain yield over Rajkumar; followed by RH6 (38.45%) and RML86/RML (22.48%), respectively. Mid and better parent heterosis were significantly higher for yield and yield attributes *viz.*, cob length, cob diameter, number of kernel rows per cob and number of kernels per row. The highest positive mid parent heterosis for grain yield was found in RML96/RML86 (466.91%) followed by RH10, RH8 and RH4. For the grain yield, the heterobeltiosis was found to be the highest in RH10 followed by RML96/RML96. These results suggested that maize hybrids RH10 and RML96/RML86 could be exploited for commercial cultivation and their parental lines could be used for hybrid seed production.

Keywords: Heterobeltiosis, hybrid maize, summer season, grain yield, Nepal

Cite this article: Upreti J, Acharya P, Upadhyaya J, Shrestha J. 2020. Heterosis in maize hybrids at farmer's field in Dang district of Nepal. Fundamental and Applied Agriculture 5(2): 188–193. doi: 10.5455/faa.82914

1 Introduction

Maize (*Zea mays* L.) is the second most important crop in terms of area and production in Nepal. It has been grown over an area of 954158 ha in 2017/18 with a production of 2555847 tons and productivity of 2.67 t ha^{-1} (MoALD, 2018). While in Dang district, total maize production was 53043 t and productivity of 2.3 t ha^{-1} (MoALD, 2017). Prime Minister Agriculture Modernization Project of Nepal has chosen Dang district as 'Maize Superzone' (MoALD, 2018).

Heterosis or hybrid vigor describes the improved superior phenotypes observed in hybrids relative to their inbred parents (Shull, 1948; Flint-Garcia et al., 2009). Heterosis can be easily felt by seeing increased crop size, crop growth rate, and other yield parameters in the F1 progeny in crosses between parental inbred lines (Reif et al., 2005; Echarte and Tollenaar, 2006). Plant breeders always want to increase yield of crop by any of the means. Hybrid maize estimating the highest yield heterosis can be recommended to cultivate for commercial purposes in Dang district. Thirty-two hybrids of fourteen seed companies have been registered in National Seed Board, Nepal (Koirala et al., 2013). In this context, as the hybrid maize area has been growing extensively in Terai and partly in mid-hill districts of Nepal, the commercial seed companies are the major source of seed. In Dang, 56% of the total area are used for maize production and among them only 50% of the maize areas are covered by hybrid maize (Timsina et al., 2016). Hallauer and Miranda (1988) manifested that heterosis depends on the genetic divergence of two parental varieties; also genetic divergence of the parents is inferred from the heterotic patterns manifested in a series of cross combination. As compared to existing cultivars the new maize hybrid should be better for grain yield and other economic traits. The determination of heterosis is important for development of superior hybrids (Sharma et al., 2016). Therefore, heterosis in reference to a standard check variety (Standard heterosis) is important for commercialization of maize hybrids (Shrestha et al., 2018). This study was under taken to estimate heterosis among the five different hybrid lines of maize (single cross hybrid) produced by National Maize Research Program (NMRP) Chitwan, Nepal. This information would be useful to know the performance and relationship of single cross hybrids and their parents as well as to select the best hybrid for cultivation in this location.

2 Materials and Methods

2.1 Experimental site

This experiment was conducted at the farmer's field at Bangaun, Lamahi, Dang from May to September during the summer season of 2018. The experimental site was situated geographically at 27°52′13″N, 82°32′36″E with an elevation of 269 m above sea level. The soil pH was 7.4 while organic matter was found to be 2.6%. The available Nitrogen percentage was moderate ranging from 0.17% to 0.19%. Similarly the available phosphorus and potassium were 205.51 and 549.1 kg ha^{-1}, respectively.

2.2 Climatic observation

The total rainfall of 1241.04 mm was received during the entire period of experimentation (from May to September). The highest rainfall was recorded in July (597.85 mm) and minimum rainfall was recorded in September (50.07 mm). The maximum and minimum temperature during the experimental period ranged from 26.12 °C to 40.39 °C and 22.97 °C to 28.09 °C, respectively (TU, 2018).

2.3 Experimental materials

The experimental materials used in this research were received from National Maize Research Program (NMRP), Rampur, Chitwan, Nepal and Local Agrovet. Seven hybrids used in this experiment along with their parental lines except check were given in Table 1.

Table 1. List of hybrids used in the experiment in Lamahi, Dang in 2018

Sl.	Hybrids	Parent 1	Parent 2
1	RML86/RML96	RML-86	RML-95
2	RH4	RML32	RML17
3	RH6	RML4	RML17
4	RH8	ZL126632	CML451
5	RH10	VL101926	CML451
6	RAJKUMAR	–	–
7	SUBARNA	–	

2.4 Experimental procedure

This experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. Each experimental plot was of size 6 m^2 (3 m × 2 m). Crop production package was followed as per recommendation of NMRP, Rampur, Chitwan, Nepal. The spacing was 60 cm × 25 cm for inbred and 75 × 20 cm for hybrid. The dose of chemical fertilizers applied was 120:60:40 kg NPK ha^{-1}. Fertilizer were applied prior to sowing at rate of 60 N kg/ha, 60 kg P and 40 kg K ha^{-1} and additional side dressing of 30 kg N ha^{-1} were applied at six leaves stage and knee high stage of maize. The irrigation was done at three important stages, knee high stage, tasseling stage and milking stage.

2.5 Data recorded

Grain yield (kg ha^{-1}) at 15% moisture content was calculated using fresh ear weight with the help of the formula given by Carangal et al. (1971) and Shrestha (2019) as follows:

$$Y = \frac{FWT \times (100 - HMP) \times SCF \times 10000}{(100 - DMP) \times NPA} \quad (1)$$

where, Y = Grain yield (kg ha^{-1}), FWT = Fresh weight of ear (kg plot^{-1}) at harvest, HMP = Grain moisture percentage at harvest, DMP = Desired moisture percentage, i.e. 15%, NPA = Net harvest plot area (m^{-2}), SCF = Shelling coefficient, i.e. 0.8.

Heterosis expressed as increase or decrease of F1 hybrid value over mid-parent (relative heterosis), better parent (heterobeltiosis) and over the best commercial check (standard heterosis) were calculated for grain yield. Better parent refers to the parent which has higher yield potential. Percent standard heterosis was calculated by using the formula suggested by Falconer et al. (1996) as follows:

$$H_S = \frac{P_{F1} - P_{Cv}}{P_{Cv}} \times 100 \quad (2)$$

where, H_S = Standard heterosis (%), P_{F1} = Mean performance of hybrid (F1), and P_{Cv} = Mean performance of check varieties (i.e. Raj Kumar or Subarna). Mid parent and better parent heterosis was estimated using below formula (Hayes et al., 1955);

$$H_{Mp} = \frac{P_{F1} - P_{Mp}}{P_{Mp}} \times 100 \quad (3)$$

$$H_{Bp} = \frac{P_{F1} - P_{Bp}}{P_{Bp}} \times 100 \quad (4)$$

where, H_{Mp} = Mid parent heterosis or relative heterosis (%), H_{Bp} = Better parent heterosis or Heterobeltiosis (%), P_{F1} = Mean performance of hybrid (F1), P_{Mp} = Average trait value of parent 1 and parent 2, and P_{Bp} = Trait value (mean) of one better parent.

2.6 Statistical analysis

The recorded data were analyzed using MS Excel (Version 2010) and R (Version 3.6.3) (R Core Team, 2020). The significant differences between genotypes were determined using the least significant difference (LSD) test at 1% or 5% level of significance (Gomez and Gomez, 1984; Shrestha et al., 2019).

3 Results and Discussion

3.1 Anthesis silking interval (ASI)

Mid parent heterosis for ASI significantly varied from −42.05 (RH10) to 13.85 (RH4); heterobeltiosis ranged from −23.33 (RH10) to 41.67 (RH6) and commercial heterosis for Check variety 1 (Rajkumar) and Check variety 2 (Subarna) ranged from −34.4 (RH10) to 28.90 (RH4) and −56 (RH10) to −10.0 (RH8), respectively (Table 2). Negative heterosis is a desirable feature for this character as it indicates the lesser gap for male and female flowering of a genotype. The highest negative heterosis over mid parent, better parent and check was observed in the hybrid RH10 (Table 2). The results of significant negative heterosis for this trait were in agreement with those of Reddy et al. (2011) and Rajitha (2013) over mid parent and better parent while over standard check with those of Singh et al. (2010). The hybrid RH10 recorded the highest significant values for all the three types of heterosis in desired direction.

3.2 Days to maturity

Mid parent heterosis for days to maturity varied significantly from −12.48 (RH4) to −20.06 (RH10); heterobeltiosis ranged from −13.08 (RH8) to −23.47 (RH10) and standard heterosis for Check variety 1 (Rajkumar) and Check variety 2 (Subarna) ranged from −2.34 (RH4) to 9.80 (RH10) and −4.24 (RH4) to 25.04 (RH6), respectively (Table 3). Negative heterosis is a desirable feature for this character as it indicates the earliness of a genotype. The highest negative heterosis over mid parent, better parent and check was observed in the hybrid RH10 (−20.06, −23.47 and −9.80, respectively). The results of significant negative heterosis for this trait were in agreement with those of Reddy et al. (2011) and Rajitha (2013) over mid parent and better parent while over standard check with those of Singh et al. (2010), Reddy et al. (2011), Jawaharlal et al. (2012) and Rajesh et al. (2014). The hybrid RH10 produced the highest significant values for all the three types of heterosis in desired direction.

3.3 Plant height

Average heterosis for plant height ranged from -5.81 (RH8) to 39.54 (RH10); heterobeltiosis significantly varied from 5.43 (RH4) to 23.10 (RH10) and standard heterosis for checks Rajkumar and Subarna ranged from −24.54 (RML86/RML96) to 9.38 (RH6) and −26.60 (RML86/RML96) to 1.00 (RH6), respectively (Table 4). The highest positive heterosis over mid parent and better parent was observed in the cross RH10 (39.54 and 23.10, respectively). The hybrid RML86/RML96 exhibited significant negative commercial heterosis over both checks. The significant positive heterosis over mid parent in maize were reported by Reddy et al. (2011); Raghu et al. (2012) and Patwary et al. (2013). Significant better parent heterosis for plant height was reported earlier by several workers (Chattopahdyay and Dhiman, 2005; Singh et al., 2010; Reddy et al., 2011; Raghu et al., 2012; Rajesh et al., 2014).

3.4 Grain yield

Mid parent or average heterosis for grain yield ranged from 134.83 (RH6) to 466.91 (RML86/RML96); heterobeltiosis ranged from 71.25 (RH6) to 371.31 (RML86/RML96) and commercial heterosis for check varieties (hybrids); Rajkumar and Subarna ranged from 9.39 (RH4) to 39.39 (RH10) and −7.73 (RH4) to 20.32 (RH6), respectively (Table 5). The highest positive heterosis over mid parent and better parent was recorded in the cross RML86/RML96 (466.91 and 371.31, respectively). The highest positive heterosis over checks Rajkumar and Subarna was observed in the cross RH10 and RH6 (39.39 and 20.32, respectively) (Table 5). These results were in conformity with the findings of Reddy et al. (2011) and Rajesh et al. (2014) who found positive better parent heterosis in maize.

Table 2. Heterosis for anthesis silking interval (ASI) of maize hybrid genotypes evaluated at farmer field Bangaun, Lamahi Dang in 2018 during summer season

Genotype	H_{Bp} (%)	H_{Mp} (%)	H_S (%)	
			Check var1 (Rajkumar)	Check var2 (Subarna)
RH4	9.17	13.85	28.9	−11.1
RH6	41.67	2.77	6.7	−10.0
RH8	−7.94	−16.75	−16.7	−44.0
RH10	−23.33	−42.05	−34.4	−56.0
RML86/RML96	32.05	12.96	17.8	−19.4
Grand Mean	10.32	−5.84	0.4	−28.1
F-test	ns	*	*	ns
$LSD_{0.05}$	101.91	37.24	25.05	35.1
CV (%)	5.24	13.92	29.93	6.63

H_{Bp} = Heterobeltiosis, H_{Mp} = Mid parent heterosis, H_S = Standard heterosis; * Significant difference at 0.05 level, ns = Non-significant, LSD = Least significant difference at 0.05 level, CV= Coefficient of variation

Table 3. Heterosis for day to maturity of hybrid genotypes evaluated at farmer field Bangaun, Lamahi Dang in 2018 during summer season

Genotype	H_{Bp} (%)	H_{Mp} (%)	H_S (%)	
			Check var1 (Rajkumar)	Check var2 (Subarna)
RH4	−14.06	−12.48	−2.34	−4.24
RH6	−14.58	−14.14	−4.00	25.04
RH8	−13.08	−13.12	−6.39	−10.09
RH10	−23.47	−20.06	−9.80	19.90
RML86/RML96	−17.66	−19.71	−8.12	3.81
Grand Mean	−16.57	−15.9	−6.13	6.88
F-test	ns	**	**	*
$LSD_{0.05}$	6.06	4.27	1.89	17.45
CV (%)	19.44	14.25	16.25	16.24

H_{Bp} = Heterobeltiosis, H_{Mp} = Mid parent heterosis, H_S = Standard heterosis; * Significant difference at 0.05 level, ns = Non-significant, LSD = Least significant difference at 0.05 level, CV= Coefficient of variation

Table 4. Heterosis for plant height of hybrid genotypes evaluated at farmer field Bangaun, Lamahi Dang in 2018 during summer season

Genotype	H_{Bp} (%)	H_{Mp} (%)	H_S (%)	
			Check var1 (Rajkumar)	Check var2 (Subarna)
RH4	5.43	14.97	2.05	−1.32
RH6	14.44	8.61	9.38	1.00
RH8	11.01	5.81	−15.73	−19.26
RH10	23.10	39.54	−6.79	−9.26
RML86/RML96	12.13	16.93	−24.54	−26.6
Grand Mean	13.22	17.17	−7.13	−11.09
F-test	*	ns	*	*
$LSD_{0.05}$	26	19.33	11.88	12.64
CV (%)	10.44	7.68	7.81	6.56

H_{Bp} = Heterobeltiosis, H_{Mp} = Mid parent heterosis, H_S = Standard heterosis; * Significant difference at 0.05 level, ns = Non-significant, LSD = Least significant difference at 0.05 level, CV= Coefficient of variation

Table 5. Heterosis for grain yield of hybrid genotypes evaluated at farmer field Bangaun, Lamahi Dang in 2018 during summer season

Genotype	H_{Bp} (%)	H_{Mp} (%)	H_S (%)	
			Check var1 (Rajkumar)	Check var2 (Subarna)
RH4	371.31	466.91	22.48	2.19
RH6	131.36	221.87	21.23	1.74
RH8	71.25	134.83	38.45	20.32
RH10	123.89	183.31	9.93	−7.73
RML86/RML96	353.28	419.06	39.39	17.23
Grand Mean	210.22	285.2	26.3	6.75
F-test	**	**	ns	ns
$LSD_{0.05}$	83.93	130.79	50.66	40.8
CV (%)	52.44	38.04	102.31	321.1

H_{Bp} = Heterobeltiosis, H_{Mp} = Mid parent heterosis, H_S = Standard heterosis; * Significant difference at 0.05 level, ns = Non-significant, LSD = Least significant difference at 0.05 level, CV= Coefficient of variation

4 Conclusions

Dang district of Nepal is gaining popularity for maize seed production. Maize hybrids RH10 and RML86/96 produced the highest mid parent heterosis and heterobeltiosis for grain yield. Therefore these two hybrids can be utilized for developing high yielding hybrid varieties.

Acknowledgements

The authors express their warmest appreciation with deep sense of gratitude to National Maize Research Program (NMRP), Rampur Chitwan for providing the planting materials. They wish to express their thanks to Institute of Agriculture and Animal Sciences, Prithu Technical College, Deukhuri, Dang for providing necessary facilities, technical and administrative support for conductance of this research.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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The Official Journal of the **Farm to Fork Foundation**
ISSN: 2518–2021 (print)
ISSN: 2415–4474 (electronic)
http://www.f2ffoundation.org/faa