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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(7): 664-666

www.thepharmajournal.com
Received: 03-04-2021
Accepted: 12-05-2021

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

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Abstract
Present investigation was carried out in Kharif 2019 at Experimental Farm, Bhola Paswan Shastri Agricultural College, Purnea, Bihar Agricultural University, Sabour with seven parental inbred lines and their twenty one F_1's generated through half diallel matting scheme during Rabi, 2018-19. The experiment was performed in randomized block design with three replications. Analysis of variance for Randomized Block Design (RBD) revealed the mean squares due to genotypes were highly significant for all the fourteen quantitative characters namely days to anthesis, days to sulk, anthesis-silking interval, days to 50 per cent physiological maturity, plant height, ear height, ear diameter, kernel rows per ear, kernels per row, grains per plant, 1000-kernel weight, shelling per cent and grain yield per plant except ear length. The estimates of standard heterosis over the best check, DMRH-1308 for grain yield per plant and its attributes revealed the only one cross combination among twenty one, namely P5 x P7exhibited highly significant positive standard heterosis was considered as promising experimental hybrids and may be exploited commercially after critical evaluation for their superior and stable performance over environments.

Keywords: General combining ability, specific combining ability and standard heterosis.

Introduction
Maize (*Zea mays* L.,) third major cereal crop that add to food security after rice and wheat. In addition to the human food, it has huge potential toward animal's feed and industrial raw material. Maize offers variety of nutritional benefits and has clinical implications in a range of diseases (Murdia *et al.*, 2016) [8]. According to National Collateral Management service, Special report (2017) [7], nearly 13 per cent of the total maize consumed directly as food, 7 per cent as processed food, 47 per cent as poultry feed, 14 per cent as industrial raw materials, 13 per cent as animal feed and 6 per cent as sell overseas and others. In Bihar, maize is grown under the three crop growing seasons such as kharif, *rabi* and summer. Maize grown under kharif season faced allot of biotic and abiotic stresses such as irregular rain fall, water logging, pest and disease incidence etc which lead to severe decline in grain yield. To boost the increment in grain yield heterosis breeding is one of an important breeding tool. Keeping this point the present study was carried out with the objective, to estimate the standard heterosis of hybrids for grain yield and its attributes.

Materials and Methods
The experimental material comprises seven inbred lines and their twenty one F_1's generated during Rabi 2018-19 using half diallel matting design (Griffing, 1956) [5] and one hybrid (DMRH-1308) as check. All these were evaluated for their agronomic performance during the Kharif, 2019 at Experimental Farm, Bhola Paswan Shastri Agricultural College, Purnea, Bihar Agricultural University, Sabour. The experiment was carried out in randomized block design with three replications and 5m row length having row to row distance 60 cm and plant to plant distance 20cm. The two seeds per hill were sown and after one week of germination thinning operation were performed to maintain single plant per hill.
The recommended package of practices was followed for raising healthy crops. The data were recorded on fourteen quantitative traits on ten competitive plants from each replication *viz.*, days to anthesis, days to silk, anthesis silking interval, days to 50 per cent physiological maturity, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), kernel row per ear, kernels per row, grains per plant, 1000-kernel weight (g), shelling (%) and grain yield per plant.

The mean values on different traits were analysed using INDOSTAT 9.2 software to estimate the heterotic performance of F_1 hybrids.

Results and Discussion

Analysis of variance for Randomized Block Design (RBD) revealed the mean squares due to genotypes were highly significant for all the fourteen quantitative characters, namely days to anthesis, days to sulk, anthesis-silking interval, days to 50 per cent physiological maturity, plant height, ear height, ear diameter, kernel rows per ear, kernels per row, grains per plant, 1000-kernel weight, shelling per cent and grain yield per plant except ear lengths (Table 1). The estimates of standard heterosis over the commercial hybrid as check, DMRH-1308 for fourteen quantitative traits (Table 2) revealed the per cent of standard heterosis for grain yield ranged from -37.27 per cent (P4 x P6) to 25.52 per cent (P5 x P7). The best cross combination, namely P5 x P7 had highest positive significant standard heterosis for grain yield per plant and one or more grain yield contributing traits such as 1000-kernel weight and grains per plant. Hence, this hybrid can be exploited commercially after critical evaluation for their superiority and stability over the locations or years. Dwarf plant type is desirable to overcome the problem of lodging. The cross combinations, namely P2 x P3, P2 x P7, P3 x P4 and P3 x P7 exhibited significant to highly significant negative standard heterosis for plant height which may be commercialized after critical evaluation over environment. Days to 50 per cent anthesis and days to 50 per cent silk regulate the early flowering. Almost all the cross combinations except P4 x P6 had significant to highly significant negative standard heterosis for days to 50 per cent anthesis and days to 50 per cent silk. For days to 50 per cent physiological maturity, the cross combinations, namely, P1 x P2, P1 x P4, P1 x P5, P2 x P6, P3 x P5, P3 x P6, P5 x P6 and P6 x P7 exhibited significant to highly significant negative standard heterosis, while, all the cross combinations had highly significant negative standard heterosis for anthesis-silking interval except P3 x P7. Hence these hybrids can be exploited earliness after critical testing over environments. Similar results were reported by Ambikabathy *et al*. (2019) [6], Kumar and Babu (2016) [1], Kumar *et al*. (2015) [4], Ofori *et al*. (2015) [3], Lahane *et al*. (2014) [2].

Table 1: Analysis of variance for Randomized Block Design (RBD) for fourteen quantitative characters in maize

Source of variation	D. F.	Mean squares						
		DA	DS	ASI	DPM	PH	EH	EL
Replicate	2	37.62366	36.2043	0.032258	55.94624	665.0629	470.0399	1.649588
Genotype	28	18.70108**	28.17706**	3.85233**	33.10824**	924.783**	490.2161**	3.382902
Error	56	2.256989	2.259857	0.021147	7.868459	252.02	99.12811	2.510552

* & **: level of significance at 5% and 1%, respectively. DA: Days to 50 per cent anthesis, DS: days to 50 per cent silk, ASI: anthesis-silking interval, DPM: days to 50 per cent physiological maturity, PH: plant height, EH: ear height, EL: ear length.

Table 1: Contd…..

Source of variation	D. F.	Mean squares						
		ED	KRPE	KPR	GPP	1000-KW	SP	GYP
Replicate	2	0.0052	0.10871	13.01497	228.5485	716.1927	10.35902	153.3001
Genotype	28	0.431308**	8.322616**	68.90751**	15412.78**	5625.806**	179.373**	1252.283**
Error	56	0.05785	1.229821	5.661123	991.1805	875.9331	8.414106	122.0124

* & **: level of significance at 5% and 1%, respectively. ED: ear diameter, KRPE: kernel rows per ear, KPR: kernels per row, GPP: grains per plant, 1000-kw: 1000-kernel weight, SP: shelling per cent and GYP: grain yield per plant.

Table 2: Estimates of standard heterosis over the best check, DMRH-1308 for grain yield and its attributes

Sl. No.	F₁'s	DA	DS	ASI	DPM	PH	EH	EL	ED	KRPE	KPR	GPP	1000-KW	SP	GYP
1	P1 x P2	-15.91 **	-19.57 **	-100.00 **	-10.69 **	-7.51	-14.90	-5.22	9.28	13.29	-7.22	-0.48	-16.78 *	2.38	6.81
2	P1 x P3	-14.20 **	-16.30 **	-66.67 **	-4.83	-10.73	-21.38 *	-6.98	12.46 *	19.08 *	-2.98	2.64	-15.43 *	4.61	3.63
3	P1 x P4	-12.50 **	-17.93 **	-133.33 **	-9.31 **	-9.30	-21.28 *	0.84	4.12	4.05	0.47	-5.51	-19.41 **	1.17	-7.22
4	P1 x P5	-10.80 **	-14.67 **	-100.00 **	-7.24 **	-11.54	-21.83 *	2.18	5.53	13.29	-6.28	-7.16	-21.07 **	-1.24	-7.80
5	P1 x P6	-11.93 **	-16.85 **	-122.22 **	-3.79	-3.67	-13.40	2.02	12.18 *	8.67	-3.69	-13.45	-3.00	2.37	5.76
6	P1 x P7	-9.09 **	-13.04 **	-100.00 **	-4.83	-6.36	-13.76	-0.92	5.81	7.51	17.66	17.74	-26.82 **	5.96	4.75
7	P2 x P3	-4.55 *	-7.07 **	-66.67 **	-2.41	-14.77 *	-33.12 **	-14.14	22.40 **	21.97 **	-18.84	-14.34	-7.1	1.53	-0.72
8	P2 x P4	-6.82 **	-9.24 **	-66.67 **	-1.03	-1.03	-21.81 *	-8.68	17.62 **	10.98	-7.22	-17.39	-10.04	-1.04	-5.35
9	P2 x P5	-5.11 *	-9.24 **	-100.00 **	-4.14	-8.94	-26.57 **	-10.15	11.90	11.56	-2.28	-1.02	-20.37 **	2.76	-5.26
10	P2 x P6	-4.55 *	-7.07 **	-66.67 **	-5.86 *	-1.13	-18.72 *	-14.98	16.31 **	5.20	-13.58	-23.81 *	-5.70	2.16	-11.87
11	P2 x P7	-3.41	-5.98 **	-66.67 **	-0.34	-21.60 **	-30.23 **	-17.86	12.37 *	4.05	-1.57	-6.57	-26.11 **	2.67	-11.34
12	P3 x P4	-7.39 **	-9.78 **	-66.67 **	-2.76	-16.20 *	-32.31 **	-2.83	8.72	5.78	-8.48	-17.13	-7.43	1.08	-7.58
13	P3 x P5	-7.95 **	-10.33 **	-66.67 **	-6.21 *	-11.46	-32.43 **	-5.12	16.49 **	19.08 *	-3.06	-0.10	-8.37	3.37	11.03
14	P3 x P6	-9.66 **	-13.59 **	-100.00 **	-8.97 **	-8.57	-25.25 **	6.72	15.28 *	5.20	-6.36	-12.61	4.29	3.26	11.23
15	P3 x P7	-5.68 **	-4.89 *	0.00	-2.41	-16.82 *	-27.02 **	-13.85	7.12	13.87	-8.79	-6.55	-22.09 **	2.56	-11.74
16	P4 x P5	-7.95 **	-10.33 **	-66.67 **	-4.14	-5.84	-15.90	9.68	9.18	6.94	-2.20	-8.86	-10.06	-0.11	21.90
17	P4 x P6	-0.57	-3.26	-66.67 **	-2.76	-9.14	-26.33 **	-11.94	-4.97	-4.05	-28.26 **	-41.37 **	-13.86	1.85	-37.27 **
18	P4 x P7	-3.4	-4.35 *	-33.33**	-3.79	-4.61	-11.42	-3.17	5.15	-1.73	10.28	-0.58	-18.90 *	4.20	-2.22
19	P5 x P6	-10.23 *	-12.50 **	-66.67 **	-6.21 *	-1.98	-14.44	2.31	13.50 *	9.83	-7.93	-15.30	2.20	0.74	2.75
20	P5 x P7	-8.52**	-10.87 **	-66.67 **	-1.03	2.01	-1.33	6.56	8.06	9.25	19.13	25.61**	20.17**	3.26	25.52*
21	P6 x P7	-8.52**	-10.87 **	-66.67 **	-7.93 **	3.07	2.63	-0.08	8.15	0.58	9.58	1.40	-14.62	5.23	3.11

* & **: level of significance at 5% and 1%, respectively. DA: Days to 50 per cent anthesis, DS: days to 50 per cent silk, ASI: anthesis-silking interval, DPM: days to 50 per cent physiological maturity, PH: plant height, EH: ear height, EL: ear length, ED: ear diameter, KRPE: kernel rows per ear, KPR: kernels per row, GPP: grains per plant, 1000-KW: 1000-kernel weight, SP: shelling per cent and GYP: grain yield per plant.

Conclusion

In the present study for grain yield per and its attributes, the cross combination, P5 x P7 was identified as the best experimental hybrids on the basis of high standard heterosis. Hence, this hybrid may be exploited commercially after critical evaluation for their performance and stability over environments for this trait.

Acknowledgement

Authors thankful to Dean PGS, Bihar Agricultural University, Sabour, Bhagalpur for their financial support for accomplishing research works.

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