Genetic analysis of heterosis for seed yield and quality attributes in fenugreek (*Trigonella foenum graecum* L.)

Abstract

As heterosis is widely utilized for the selection of superior cross combinations, this study was conducted to estimate the magnitude of heterosis for green pod yield and yield attributing characters. A diallel analysis (excluding reciprocal) was designed aiming towards the identification of best heterotic crosses for green pod yield per plant and quality traits in vegetable pea. The present study was conducted at Main Experimental Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya (UP), India, during *Rabi*, 2020-21 (Y_1) and 2021–22 (Y_2). Forty-five hybrids were developed through diallel mating design by using ten parental lines excluding reciprocals. Appreciable heterosis was found over better parent and standard variety for all the traits under study in desirable direction. For early maturity traits *i.e.,* days to 50% flowering, days to maturity negative heterosis is desirable, for this the cross combinations P_1X P_2 $P_2 \times P_5$, $P_1 \times P_{10}$ and $P_5 \times P_9$ exhibited highest significant heterosis over better parent and standard variety. Crosses $P_1 \times P_3$, P_3 x P_8, P_4 x P_7 may be exploited commercially after evaluation for profitable yield in fenugreek. Significant heterobeltiosis and economic heterosis indicates the importance of heterosis breeding for developing high yielding hybrids/varieties.

Keywords: Diallel mating, heterosis, magnitude, economic heterosis.

INTRODUCTION

Fenugreek is an annual herb reaching to a height of about 0.9 meters. Leaves are light-green and are pinnately trifoliate. The flowers are papilionaceous. Fruits are legumes, long, narrow curved and are tapering with a slender point which contain small deeply furrowed seeds. The flowers are white are yellow in color. Anthesis takes place between 9 AM and 6 PM with peak at 11.30 AM. The anthers dehisce between 10.30 AM and 5.30 PM with peak between 11.30 AM and 12.30. Noon. Lower in Stigma becomes receptive 12 before flower opening and remain receptive for about 10 hours after the opening of flowers. The plants flower in about 30 to 37 days after sowing and the duration of flowering phase is 7 to 18 days. The species is typically self-pollinated. Pollen fertility ranges from 95 to 98 per cent in the unopened flower bud and 67 to 80 percent in the open flowers. The pods mature within 60 to 70 days after sowing. The cultivated forms are diploids with 2n=16. A sterile hexaploidy (2n=44) has been recorded. A mixoploid plant with chromosomes number between 24 and 44 has been detected among tetraploids. Aberrational frequency is higher in tetraploids.

Fenugreek (*Trigonella foenum-graecum* L.) is widely distributed throughout the world. It is an annual herb indigenous to the countries bordering on the Eastern shores of the Mediterranean.

It is a self-pollinating dicotyledonous plant with branches stems, trifoliate leaves, which bears white flowers and producer golden yellow seeds. Fenugreek is primarily used as a spice in countries where it is grown (Acharya *et al*. 2007). Specially in India and countries in the Mediterranean regions both seeds and leaves of fenugreek are widely used as a culinary spice to enhance the test of many meats, poultry and vegetable dishes.

Although fenugreek cultivation is mostly concentrated in Asia and the Mediterranean region, it is now widely cultivated in Northern Africa, central Europe, North America and Australia. Fenugreek is used as whole seed and in powdered form and often roasted to reduce its bitterness and enhances the flavor. Bitter taste of seeds due to presence of an alkaloid "*Trigonellin*e". The importance of fenugreek has been increased due to presence of asteroid called "*Diosgenin*". And it is used in the synthesis of sex hormones and contraceptives (Meena *et al*. 2017).

India occupies a topmost among the fenugreek growing counties in the world. India is one of the dominant producers and exporters of fenugreek. The value-added products of fenugreek such as its seeds, powder and oleoresins are exported to Europe, North America, South Africa and other Asian countries (Malhotra and Vashishtha, 2008).

In India, it occupies an area of about 133 thousand hectares with 203 MT productions with productivity 1.526. Million tonnes (NHB 2020-21) Fenugreek is mainly grown in the states of Rajasthan, Gujarat, Punjab, Haryana, U.P., M.P. Maharashtra and Tamil Nadu. Rajasthan alone contributes nearly 60 % of total area and 80% of total production of the crop in the country.

It is growing in Argentina, Southern France, Spain, Morocco, Egypt, North Western India, Turkey, Pakistan, China and Lebanon are the leading countries for fenugreek production. Through, in India fenugreek is mainly grown in Rajasthan, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh, Gujarat and Punjab. Rajasthan state accounting highest production and contributed about 80% of total production in the country (Kumar *et al*. 2018).

MATERIALS AND METHODS

The experiment was conducted on fenugreek (*Trigonella foenum-graecum* L.) at Main Experiment Station (Vegetable Research Farm), ANDUAT (Kumarganj), Ayodhya (U.P.) India, during season of 2020-21 (Y_1) and 2021-22(Y_2). The experiment was conducted in a Randomized Complete Block Design (R.B.D.) with three replications and 55 genotypes (45 F_1 + 10 parents). The crop was planted in row length spaced 30 cm. apart where, 10 cm plant to plant spacing was maintained. The experimental plant material for present investigation was comprised of 45 hybrids developed by crossing 10 lines *viz*, NDM-3, NDM-4, NDM-6, NDM-

12, NDM-13, NDM-33, NDM-35, Azad Methi-1with 2 testers Hisar Sonali (check) and Pusa Early Bunching (PEB) including in parent reported by Patel *et al.* (2014)

The observations were recorded on five plants randomly selected from each genotype in each replication on eleven characters, *viz*., days to 50% flowering, plant height (cm), number of branches per plant, number of pods per plant, pods length (cm), days to maturity, number of seeds per pods, biological yield per plant (g), harvest-index (%), number of pods per plant, 1000-seed weight (g) and seed yield per plant (g). The data were recorded from 45 F1's and 10 parental lines with 2 checks on eleven characters were subjected to estimate nature and magnitude of heterosis. Heterosis expressed as per cent increase or decrease in the mean values of F_1's (hybrid) over better-parent (heterobeltiosis) and standard variety (standard heterosis) was calculated according to suggested method.

The formulas used for estimation of heterosis are as follows:

(a) Heterobeltiosis (%) $= \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$

(b) Standard heterosis (%) $= \frac{\overline{F_1} - \overline{SV}}{\overline{SV}} \times 100$

Where, $\overline{F_1}$ is the mean value of F_1, $\overline{BP}$ is the mean value of better-parent and $\overline{SV}$ is the mean value of standard variety.

The significance of heterosis was tested by 't' tests as given below:

't' (Heterobeltiosis) $= \frac{\overline{F_1} - \overline{BP}}{SE}$

't' (Standard heterosis) $= \frac{\overline{F_1} - \overline{SV}}{SE}$

SE of heterosis over better-parent and standard variety = $\sqrt{Me/r}$

Where, Me is the error mean square, r is the number of replications, SE is the standard error of the treatments mean and (t) is the table value of (t) at 5% or 1% level of significance at error degree of freedom. The calculated 't' value was compared with table value 't' at error *d. f.* at 5% and 1% level of probability for testing the significance of heterosis.

RESULTS AND DISCUSSION

Significantly negative heterosis over better parent and standard variety were observed in respect to days to 50% flowering. The maximum and significant negative heterosis over better parent (-

21.24 %) followed by (-10.27 %) and standard variety (-22.52 %) followed by (-9.56 %) were observed in cross. Out of 45 crosses, fourteen crosses over better parent and twelve crosses over standard variety showed significant negative heterosis in over season (pooled) reported that Nautiyal et al. (2013).

The maximum and significant positive heterosis over better parent (18.15 %) followed by (14.06 %) and standard variety (25.60 %) followed by (25.28 %) were observed in cross $P_1 \times P_9$ and $P_3 \times P_9$. Out of 45 crosses, eleven crosses over better parent and thirty-three crosses over standard variety showed significant positive heterosis in over season (pooled) reported that Bhatt *et al.* (2013)

For number of branches per plant, the highest heterosis over better parent was recorded in cross $P_3 \times P_5$ (26.87 %) followed by $P_3 \times P_6$ (25.38 %) while, maximum heterosis over standard variety was recorded in cross $P_6 \times P_9$ (21.69 %) followed by $P_8 \times P_9$ (20.70 %). Out of 45 crosses, eleven crosses over better parent and six crosses over standard variety showed significant positive heterosis in over season (pooled) reported by Kadam (2013).

The best cross showing highest positive heterosis over better parent for character number of pods per plant were $P_1 \times P_9$ (17.52 %) followed $P_2 \times P_9$ (13.35 %) while, maximum heterosis over standard variety was recorded in cross $P_2 \times P_9$ (19.34 %) followed by $P_3 \times P_9$ (18.65 %). Out of 45 crosses, sixteen crosses over better parent and forty-five crosses over standard variety showed significant positive heterosis in over season (pooled).

For pod length, the highest heterosis over better parent was recorded in cross $P_4 \times P_9$ (19.56 %) followed by $P_2 \times P_9$ (18.40 %) while, maximum heterosis over standard variety was recorded in cross $P_4 \times P_9$ (20.02 %) followed by $P_5 \times P_9$ (18.48 %). Out of 45 crosses, ten crosses over better parent and twenty-four crosses over standard variety showed significant positive heterosis in over season (pooled) Das *et al.* (2014).

The crosses with negative significant heterosis were considered as desirable for the trait days to maturity. The maximum and significant negative heterosis over better parent was recorded in cross $P_3 \times P_8$ (-8.32 %) followed by $P_4 \times P_7$ (-7.30 %) while, maximum negative heterosis over standard variety was recorded in cross $P_3 \times P_8$ (-6.79 %) and $P_4 \times P_7$ (-6.79 %) followed by $P_5 \times P_{10}$ (-6.34 %). Out of 45 crosses, thirty-eight crosses over better parent and forty-four crosses over standard variety showed significant negative heterosis in over season (pooled).

For number of seeds per pod, the highest heterosis over better parent was recorded in cross $P_1 \times P_9$ (13.95 %) followed by $P_4 \times P_9$ (13.83 %) while, maximum heterosis over standard variety was recorded in cross $P_3 \times P_9$ (14.05 %) followed by $P_1 \times P_9$ (13.95 %) and $P_3 \times P_9$ (13.95 %). Out of 45 crosses, eight crosses over better parent and eight crosses over standard variety showed significant positive heterosis in over season (pooled).

The crosses with positive significant heterosis were considered as desirable for the trait biological yield. The maximum and significant positive heterosis over better parent was recorded in cross $P_3 \times P_9$ (15.06 %) followed by $P_1 \times P_9$ (14.60 %) while, maximum heterosis over standard variety was recorded in cross $P_6 \times P_9$ (17.79 %) followed by $P_7 \times P_9$ (17.35 %). Out of 45 crosses, thirty-seven crosses over better parent and forty-five crosses over standard variety showed significant positive heterosis in over season (pooled).

For harvest index, the highest heterosis over better parent was recorded in cross $P_5 \times P_8$ (10.63 %) followed by $P_1 \times P_4$ (10.51 %) while, none of the cross showed significant heterosis over standard variety. Out of 45 crosses, two crosses over better parent showed significant positive heterosis in over season (pooled).

The best crosses with positive significant heterosis for test weight over better parent was recorded in cross $P_4 \times P_9$ (15.40 %) followed by $P_7 \times P_9$ (14.95 %) while, maximum heterosis over standard variety was recorded in cross $P_4 \times P_9$ (18.88 %) followed by $P_5 \times P_9$ (15.86 %). Out of 45 crosses, ten crosses over better parent and nineteen crosses over standard variety showed significant positive heterosis in over season (pooled).

For the trait seed yield per plant, the cross $P_5 \times P_9$ (26.79 %) showed highest positive significant heterosis followed by $P_7 \times P_{10}$ (25.87 %) while, maximum heterosis over standard variety was recorded in cross $P_5 \times P_9$ (26.79 %) followed by $P_7 \times P_9$ (25.87 %). Out of 45 crosses, twenty-nine crosses over better parent and twenty-six over standard variety showed significant positive heterosis in over season (pooled) reported that Ceyhan *et al.* (2014)

CONCLUSION

On the basis of heterosis analysis, among the cross combination $P_2 \times P_5$ and $P_1 \times P_3$ exhibited significant negative heterosis over better parent as well as standard variety for days to 50% flowering. $P_8 \times P_9$ (20.70 %). Out of 45 crosses, eleven crosses over better parent and six crosses over standard variety showed significant positive (positive) heterosis in over season (pooled).

For the trait seed yield per plant, the cross $P_5 \times P_9$ showed highest positive significant heterosis followed by $P_7 \times P_{10}$ while, maximum heterosis over standard variety was recorded in cross $P_5 \times P_9$ followed by $P_7 \times P_9$ The best crosses with positive significant heterosis for test weight over better parent was recorded in cross $P_4 \times P_9$ followed by $P_7 \times P_9$ while, maximum heterosis over standard variety was recorded in cross $P_4 \times P_9$ followed by $P_5 \times P_9$. Out of 45 crosses, ten crosses over better parent and nineteen crosses over standard variety showed significant positive heterosis in over season (pooled).

Table-1. Estimates of heterosis (%) over better parent (BP) and standard variety (SV) Hisar Sonali during two season (Y_1, Y_2) and pooled.

Crosses	Days to 50 percent flowering						Plant height (cm)					
	Y_1		Y_2		Pooled		Y_1		Y_2		Pooled	
	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV
$P_1 \times P_2$	-9.72 **	-8.79 *	-9.99 *	-9.50 *	-9.85 **	-9.14**	0.45	7.96	3.01	11.79 *	1.78	9.50
$P_1 \times P_3$	-8.48 *	-7.54 *	-12.12**	-11.64 **	-10.27 **	-9.56**	0.08	10.58 *	4.1	13.55 **	1.87	11.89 *
$P_1 \times P_4$	-8.13 *	-7.19	-7.16	-6.65	-7.65 *	-6.92 *	6.79	12.84 **	6.99	16.11 **	7.13	13.89 **
$P_1 \times P_5$	-6.06	-5.1	-8.58 *	-8.07 *	-7.30 *	-6.57	4.61	12.01 *	6.68	15.78 **	5.20	13.31 **
$P_1 \times P_6$	-6.96	-6.01	-8.10 *	-7.6	-7.52 *	-6.79	5.92	15.39 **	8.74	18.27 **	7.09	16.54 **
$P_1 \times P_7$	-10.49 **	-6.7	-7.87 *	-7.36	-7.82 *	-7.03 *	3.46	11.55 *	1.74	13.30 **	2.76	12.04 *
$P_1 \times P_8$	-8.60 *	-7.45 *	-6.45	-5.94	-7.44 *	-6.71	-0.44	10.56 *	2.44	13.54 **	1.39	11.29 *
$P_1 \times P_9$	-9.94 **	-9.02 *	-9.28 *	-8.79 *	-9.62 **	-8.91 *	19.17**	24.41 **	17.12**	27.11 **	18.15 **	25.60 **
$P_1 \times P_{10}$	-6.75	-5.8	-7.18	-6.67	-6.96 *	-6.23	3.88	12.36 **	6.24	15.30 **	5.31	13.59 **
$P_2 \times P_3$	-7.16	-6.7	-6.78	-8.55 *	-6.09	-7.62 *	-1.25	9.1	2.78	12.11 *	0.36	10.23 *
$P_2 \times P_4$	-7.24	-7	-3.39	-5.22	-4.57	-6.12	7.87	15.93 **	10.69 *	18.80 **	8.65	16.88 **
$P_2 \times P_5$	-5.57	-6.01	-38.26**	-39.43 **	-21.24 **	-22.52**	10.21*	18.45 **	12.16 **	21.27 **	10.86 *	19.40 **
$P_2 \times P_6$	-5.15	-6.31	-3.81	-5.63	-4.42	-5.97	0.9	9.92 *	3.81	12.91 *	1.95	10.95 *
$P_2 \times P_7$	-8.60 *	-4.73	-1.94	-3.8	-5.09	-4.28	-1.73	5.95	-2.1	9.02	-1.30	7.61
$P_2 \times P_8$	-9.23 *	-8.10 *	-7.02	-8.79 *	-6.92	-8.44 *	-6.64	3.68	-3.65	6.79	-4.17	5.19
$P_2 \times P_9$	-11.58 **	-11.58**	-6.41	-6.41	-9.02 *	-9.02 *	11.65**	20.00 **	14.41**	22.79 **	12.69 **	21.24 **
$P_2 \times P_{10}$	-9.63 *	-9.40 *	-9.26 *	-10.12 *	-9.45 **	-9.75 **	1.19	9.45 *	4.12	12.45 *	2.77	10.84 *
$P_3 \times P_4$	-5.63	-5.17	2.48	-5.79	-1.80	-5.48	-3.22	6.93	0.82	9.98	-1.40	8.30
$P_3 \times P_5$	-2.08	-1.6	5.91	-2.14	1.95	-1.87	0.76	11.32 *	4.77	14.28 **	2.32	12.39 *
$P_3 \times P_6$	-5.54	-5.08	-1.39	-5.7	-2.69	-5.39	-5.57	4.34	-1.51	7.44	-3.22	6.30
$P_3 \times P_7$	-7.88 *	-3.99	-3.27	-5.77	-5.68	-4.87	-5.13	4.82	-3.1	7.91	-8.81 *	0.16
$P_3 \times P_8$	-7.86 *	-6.7	8.73 *	2.97	0.06	-1.92	6.53	18.31 **	9.29 *	21.13 **	8.91 *	19.62 **
$P_3 \times P_9$	-7.85 *	-7.4	-1.66	-1.66	-4.56	-4.56	13.01**	24.86 **	16.43 **	27.01 **	14.06 **	25.28 **
$P_3 \times P_{10}$	-4.39	-3.92	2.16	1.19	-1.06	-1.39	-3.88	6.2	0.16	9.26	-2.10	7.53
$P_4 \times P_5$	-3.47	-3.22	12.80 **	4.23	4.62	0.46	-1.42	5.55	0.46	8.62	-0.79	6.86
$P_4 \times P_6$	-9.72 *	-9.49 *	1.34	-3.09	-3.65	-6.32	-0.5	8.39	2.44	11.41 *	0.83	9.74 *
$P_4 \times P_7$	-7.82 *	-3.92	7.17	4.4	-0.66	0.19	2.63	10.65 *	2.03	13.63**	2.99	12.29 *

Contd..

Crosses	Days to 50 percent flowering						Plant height (cm)					
	Y1		Y2		Pooled		Y1		Y2		Pooled	
	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV
$P_4 \times P_8$	-7.17	-6.01	5.47	-0.11	-1.14	-3.10	-0.96	9.99 *	1.94	12.98 *	1.62	11.55 *
$P_4 \times P_9$	-8.33 *	-8.10 *	-3.8	-3.8	-5.97	-5.97	14.80**	21.30**	15.98**	24.07 **	14.06 **	20.64 **
$P_4 \times P_{10}$	-4.86	-4.62	4.53	3.54	-0.25	-0.58	6.61	15.31**	9.44 *	18.20 **	8.11	16.60 **
$P_5 \times P_6$	0.37	-0.09	3.95	-0.59	2.51	-0.34	2.47	11.63 *	5.35	14.58 **	3.81	12.98 **
$P_5 \times P_7$	-15.36**	-11.79**	7.02	4.25	-4.68	-3.86	-0.84	6.91	-2.34	8.76	-0.98	7.96
$P_5 \times P_8$	-2.36	-1.13	11.06**	5.18	4.05	1.99	-3	7.73	-0.07	10.76 *	-0.63	9.07
$P_5 \times P_9$	-7.87 *	-7.87 *	-4.51	-4.51	-6.21	-6.21	11.21 *	19.07**	12.72**	21.88 **	11.67 *	20.27 **
$P_5 \times P_{10}$	-1.74	-1.48	0.72	-0.24	-0.53	-0.87	4.14	12.64 **	6.89	15.57 **	5.87	14.19 **
$P_6 \times P_7$	-4.01	0.05	5.34	2.62	0.45	1.32	2.53	11.70 *	2.95	14.65 **	3.66	13.01 **
$P_6 \times P_8$	-4.88	-3.69	4.32	-0.24	-0.01	-1.99	-5.19	5.29	-2.22	8.37	-2.63	6.88
$P_6 \times P_9$	-12.27**	-12.27**	-1.85	-1.85	-7.12 *	-7.12 *	11.17 *	21.11**	14.26**	24.28 **	12.50 **	22.44 **
$P_6 \times P_{10}$	-3.47	-3.22	-4.55	-5.46	-4.00	-4.32	0.68	9.68 *	8.83	18.37 **	4.25	13.46 **
$P_7 \times P_8$	-5.34	-1.34	0.22	-2.37	-2.69	-1.85	-0.52	10.48 *	1.88	13.46 **	1.93	11.88 *
$P_7 \times P_9$	-10.49**	-6.7	-5.22	-5.22	-6.77	-5.97	13.46**	22.33**	12.31**	25.07 **	13.30 **	23.53 **
$P_7 \times P_{10}$	-7.82 *	-3.92	1.44	0.48	-2.58	-1.75	7.56	16.33 **	7.03	19.20 **	8.29	18.07 **
$P_8 \times$ P9	-10.15**	-9.02 *	-4.75	-4.75	-6.91 *	-6.91 *	8.94 *	20.98**	11.65 *	23.75 **	11.23 *	22.10 **
$P_8 \times P_{10}$	-3.05	-1.83	2.16	1.19	0.00	-0.34	-3.08	7.64	-0.15	10.67 *	-0.44	9.28
$P_9 \times P_{10}$	-0.69	-0.44	6.89	6.89	3.18	3.18	5.2	13.79**	8.06	16.70 **	7.28	15.70 **
No. of crosses with significant (+) heterosis	**0**	0		0	0	0	9	31	12	36	11	33
No. of crosses with significant (-) 'heterosis	22	13	11	8	14	12	0	0	0	0	1	0
Range of heterosis	-15.36 to 0.37	-12.27 to 0.05	-38.26 to 12.80	-39.43 to 6.69	-21.24 to 4.62	-22.52 to 3.18	-6.64 to 19.17	3.68 to 24.86	-3.65 to 17.12	6.79 to 27.11	-8.81 to 18.15	0.19 to 25.60

Crosses	No. of branches /plant						Number of pods per plant					
	Y_1		Y_2		Pooled		Y_1		Y_2		Pooled	
	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV
$P_1 \times P_2$	-4.13	-1.59	-3.11	-3.24	-2.96	-2.45	3.54	7.57 *	8.76 *	16.06 **	6.15	11.75 **
$P_1 \times P_3$	21.71 *	7.28	4.04	3.9	21.46 **	5.56	2.93	12.27 **	8.88 *	18.30 **	5.85	15.24 **
$P_1 \times P_4$	-3.06	-1.46	-4.79	-0.13	-3.91	-0.79	-0.88	8.86 *	6.17	17.50 **	2.61	13.12 **
$P_1 \times P_5$	42.88 **	5.7	1.79	1.65	19.25 *	3.64	5.52	10.49 **	8.06 *	16.19 **	6.79 *	13.30 **
$P_1 \times P_6$	5.43	-3.64	1.32	1.19	13.62	-1.26	-1.26	8.19 *	5.97	16.70**	2.31	12.38 **
$P_1 \times P_7$	-18.33 *	-21.52 *	-2.37	-1.79	-10.22	-11.71	4.87	10.63 **	11.95**	19.97**	8.39 *	15.23 **
$P_1 \times P_8$	9.23	2.65	-0.07	-0.2	8.98	1.12	1.85	7.55 *	7.02 *	16.04**	4.43	11.73 **
$P_1 \times P_9$	19.21 *	19.21 *	19.11 *	19.11 *	19.11 **	19.11 **	13.93**	13.93 **	20.86**	21.22**	17.52 **	17.52 **
$P_1 \times P_{10}$	7.3	-2.65	5.36	5.22	11.67	1.26	3.5	4.12	12.77**	14.00**	8.07 *	8.99 *
$P_2 \times P_3$	-24.19 **	-22.19**	-0.2	-1.65	-12.37	-11.90	-3.5	5.25	5.78	14.93**	1.06	10.02 **
$P_2 \times P_4$	-3.23	-0.66	-9.84	-5.42	-6.15	-3.11	-2.13	7.49 *	4.79	15.98**	1.30	11.67 **
$P_2 \times P_5$	-6.45	-3.97	5.17	3.64	-0.79	-0.26	4.53	9.46 *	9.75 **	18.01**	7.13 *	13.67 **
$P_2 \times P_6$	-25.16 **	-23.18**	-2.48	-3.9	-14.01 *	-13.56 *	-1.32	8.13 *	4.41	14.98**	1.51	11.50 **
$P_2 \times P_7$	-2.58	0.01	0.02	0.6	-0.26	0.26	4.2	9.92 **	10.32**	18.22**	7.24 *	14.01 **
$P_2 \times P_8$	-10.32	-7.95	-6.04	-7.41	-8.22	-7.74	0.96	6.61	7.66 *	16.74**	4.31	11.60 **
$P_2 \times P_9$	7.1	9.93	17.13	17.13	12.89	13.49 *	11.68**	16.03 **	15.02**	22.74**	13.35 **	19.34 **
$P_2 \times P_{10}$	-11.61	-9.27	-2.01	-3.44	-6.91	-6.42	6.31	10.45 **	9.79 **	17.16**	8.05 *	13.75 **
$P_3 \times P_4$	-2.08	-0.46	-3.85	0.86	-2.95	0.20	-1.95	7.69 *	3.45	14.50**	0.73	11.05 **
$P_3 \times P_5$	3.76	-8.54	23.21 *	19.71 *	26.87 **	5.56	-2.47	6.37	6.35	15.55**	1.86	10.89 **
$P_3 \times P_6$	11.01	1.46	37.25 **	6.48	25.38 **	3.90	0.26	9.86 **	8.41 *	19.39**	4.29	14.55 **
$P_3 \times P_7$	16.33	11.79	-2.04	-1.46	6.86	5.09	-0.59	8.43 *	7.81 *	17.14**	3.54	12.72 **
$P_3 \times P_8$	3.59	-2.65	11.69	2.38	7.56	-0.20	-1	7.98 *	7.21 *	16.49**	3.04	12.17 **
$P_3 \times P_9$	12.32	12.32	19.25 *	19.25 *	15.67 *	15.67 *	5.93	15.54 **	12.16 **	21.86**	8.99 **	18.65 **
$P_3 \times P_{10}$	5.91	-3.91	12.47	1.98	9.12	-1.06	2.04	11.29 **	11.28**	20.90**	6.58 *	16.02 **
$P_4 \times P_5$	-25.73 **	-24.50**	-8.32	-3.84	-16.85 *	-14.15 *	3.14	13.28 **	7.58 *	19.07**	5.34	16.13 **
$P_4 \times P_6$	-6.84	-5.3	1.64	6.61	-2.56	0.60	0.59	10.48 **	5.45	16.71**	3.00	13.55 **
$P_4 \times P_7$	-0.33	1.32	-6.56	-1.98	-3.52	-0.40	-2.81	6.75	4.02	15.13**	0.58	10.88 **

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Crosses	No. of branches /plant						Number of pods per plant					
	Y_1		Y_2		Pooled		Y_1		Y_2		Pooled	
	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV
$P_4 \times P_8$	-5.54	-3.97	-25.28 **	-21.63 *	-15.57*	-12.83	-2.18	7.44 *	4.75	15.93**	1.25	11.62 **
$P_4 \times P_9$	8.79	10.6	5.23	10.38	6.98	10.45	3.94	14.15 **	9.91 **	21.65**	6.90 *	17.84 **
$P_4 \times P_{10}$	-9.45	-7.95	-6.24	-1.65	-7.88	-4.89	1.14	11.08 **	8.14 *	19.68**	4.60	15.32 **
$P_5 \times P_6$	-13.7	-21.13 *	8.58	5.49	10.73	-7.87	-0.6	8.91 *	7.31 *	18.18**	3.31	13.48 **
$P_5 \times P_7$	8.27	4.04	-3.68	-3.11	2.02	0.33	2.1	7.70 *	10.53 **	18.85**	6.47	13.19 **
$P_5 \times P_8$	-1.69	-7.62	8.24	5.16	6.41	-1.26	3.4	9.19 *	7.50 *	16.56**	5.45	12.82 **
$P_5 \times P_9$	19.54 *	19.54 *	21.63 *	21.63 *	20.57**	20.57**	8.40 *	13.51 **	14.45 **	23.06**	11.42 **	18.22 **
$P_5 \times P_{10}$	10.29	0.07	10.01	6.88	14.00	3.37	3.69	8.58 *	8.91 *	17.11**	6.30	12.78 **
$P_6 \times P_7$	-18.47 *	-21.66 *	-6.84	-6.28	-12.58	-14.02 *	-3.99	5.2	8.25 *	19.21**	2.06	12.10 **
$P_6 \times P_8$	2.18	-3.97	13.28	3.84	7.63	-0.13	0.92	10.59 **	7.54 *	18.42**	4.19	14.44 **
$P_6 \times P_9$	23.44 **	23.44 **	19.97 *	19.97 *	21.69 **	21.69 **	1.84	11.59 **	8.77 *	19.78 **	5.27	15.63 **
$P_6 \times P_{10}$	6.3	-2.85	11.52	1.12	9.34	-0.86	1.09	10.77 **	8.39 *	19.36**	4.69	15.00 **
$P_7 \times P_8$	-19.85 *	-22.98**	-4.01	-3.44	-11.77	-13.23	2.97	8.73 *	9.18 **	18.38**	6.07	13.48 **
$P_7 \times P_9$	16.89 *	16.89 *	12.1	12.76	14.75 *	14.75 *	8.05 *	13.98 **	13.21 **	21.32**	10.61 **	17.59 **
$P_7 \times P_{10}$	2.62	-1.39	-4.93	-4.37	-1.28	-2.91	3.11	8.77 *	9.46 **	17.30**	6.27	12.97 **
$P_8 \times P_9$	17.95 *	17.95 *	23.68 **	23.68**	20.70**	20.70**	6.92 *	12.90 **	13.10 **	22.63**	10.01 **	17.70 **
$P_8 \times P_{10}$	7.54	1.06	12.41	3.04	9.91	1.98	4.85	10.72 **	10.03 **	19.30**	7.43 *	14.94 **
$P_9 \times P_{10}$	-5.89	-5.89	-3.84	-3.84	-4.89	-4.89	7.82 *	8.47 *	15.74 **	16.99 **	11.73 **	12.67 **

No. of crosses with significant (+) heterosis	7	5	7	6	11	6	6	39	35	45	16	45
No. of crosses with significant (-) ‘heterosis	4	7	1	1	3	3	0	0	0	0	0	0
Range of heterosis	-25.71 to 23.44	-24.50 to 23.44	-25.28 to 37.25	-7.71 to 23.68	-16.85 to 26.87	-14.15 to 21.69	-3.05 to 13.93	4.12 to 16.03	3.45 to 20.86	14.00 to 23.06	0.58 to 17.52	10.02 to 19. 34

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Crosses	**Pod length (cm)**						**Days to maturity**					
	Y_1		**Y_2**		**Pooled**		**Y_1**		**Y_2**		**Pooled**	
	BP	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**
$P_1 \times P_2$	2.88	3.26	4.43	14.59**	3.68	8.76	-2.46	-3.53 *	-8.70 **	-7.28 **	-2.70	-3.67 **
$P_1 \times P_3$	-1.57	-1.2	-3.75	9.12	-1.65	3.80	-5.22 **	-3.75 *	-6.52 **	-5.08 **	-6.35 **	-4.78 **
$P_1 \times P_4$	-7.13	-6.78	3.32	13.37 *	-1.83	2.98	-0.67	-1.77	-5.65 **	-4.19 *	-1.46	-2.45
$P_1 \times P_5$	-5.22	-4.87	7.38	19.45**	1.23	6.93	-2.01	-3.09	-3.36 *	-4.64 **	-2.46	-2.89 *
$P_1 \times P_6$	1.08	4.95	1.94	11.85 *	3.23	8.28	-0.22	-1.32	-0.45	-1.77	-2.02	-3.00 *
$P_1 \times P_7$	1.43	1.8	6.81	19.15**	5.06	10.20 *	-6.15 **	-5.74**	-7.91 **	-7.51 **	-5.42 **	-4.89 **
$P_1 \times P_8$	10.75	11.17	2.22	12.16 *	6.44	11.65 *	-5.26 **	-4.64**	-5.48 **	-4.86 **	-5.08 **	-4.34 **
$P_1 \times P_9$	13.32	13.74	11.36 *	22.19**	12.31 **	17.81**	-5.52 **	-5.52**	-5.52 **	-5.52 **	-4.34 **	-4.34 **
$P_1 \times P_{10}$	-2.66	3.75	-1.1	9.12	-1.90	6.34	-3.34 *	-4.19 *	-2.45	-3.31 *	-3.48 *	-4.23 **
$P_2 \times P_3$	-0.85	-2.69	-1.61	11.55 *	-1.26	4.22	-3.70 *	-2.21	-2.24	-3.75 *	-5.03 **	-3.45 *
$P_2 \times P_4$	18.15 *	9.59	10.36 *	19.76**	14.07 **	14.50**	-0.22	-1.55	-2.42	-1.99	-1.80	-3.00 *
$P_2 \times P_5$	12.33	12.71	2.73	14.29**	7.42	13.47**	-1.35	-2.87	-4.17 *	-3.53 *	-2.79 *	-3.23 *
$P_2 \times P_6$	-2.18	1.57	12.39 *	18.54**	5.23	9.79 *	-0.9	-2.65	-6.84 **	-6.84 **	-1.69	-3.11 *
$P_2 \times P_7$	14.58	9.79	-2.45	8.81	5.67	9.32	-5.71 **	-5.30**	-6.24 **	-7.06 **	-5.09 **	-4.56 **
$P_2 \times P_8$	10.22	0.63	6.41	16.11**	9.23	8.11	-3.07	-2.43	-3.52 *	-3.09	-3.86 **	-3.11 *
$P_2 \times P_9$	16.58 *	16.58 *	14.12**	20.36**	18.40 **	18.40**	-6.62 **	-6.62**	-3.95 *	-3.31 *	-5.01 **	-5.01 **
$P_2 \times P_{10}$	0.62	7.24	-1.93	8.21	-0.63	7.72	-3.56 *	-4.42**	-5.30 **	-5.30 **	-3.14 *	-3.89 **
$P_3 \times P_4$	0.55	-1.32	4.02	17.93**	2.35	8.02	-3.26 *	-1.77	-1.78	-2.65	-4.81 **	-3.23 *
$P_3 \times P_5$	1.43	1.77	-7.24	5.17	-2.09	3.42	-5.43 **	-3.97 *	-5.70 **	-5.08 **	-5.80 **	-4.23 **
$P_3 \times P_6$	5.24	9.28	-2.68	10.33 *	4.02	9.79 *	-6.74 **	-5.30**	-5.93 **	-5.52 **	-6.24 **	-4.67 **

$P_3 \times P_7$	3.65	1.72	-6.17	6.38	-1.48	3.98	-5.22 **	-3.75 *	-5.27 **	-4.86 **	-5.58 **	-4.00 **

Crosses	**Pod length (cm)**						**Days to maturity**					
	Y1		**Y2**		**Pooled**		**Y1**		**Y2**		**Pooled**	
	BP	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**
$P_3 \times P_8$	10.47	8.42	5.36	19.45 **	7.77	13.74 **	-8.70 **	-7.28 **	-7.93 **	-6.28 **	-8.32 **	-6.79 **
$P_3 \times P_9$	16.32 *	16.32 *	1.61	15.20 **	9.69 *	15.77 **	-6.52 **	-5.08 **	-5.73 **	-4.04 *	-6.13 **	-4.56 **
$P_3 \times P_{10}$	-0.89	5.64	1.88	15.50 **	1.85	10.41 *	-5.65 **	-4.19 *	-5.29 **	-3.59 *	-5.47 **	-3.89 **
$P_4 \times P_5$	1.14	1.49	7.38	19.45 **	4.33	10.20 *	-3.36 *	-4.64 **	-4.23 **	-3.59 *	-3.69 **	-4.12 **
$P_4 \times P_6$	4.71	8.73	8.68	17.93 **	8.48	13.18 **	-0.45	-1.77	-3.40 *	-4.48 **	-1.91	-3.11 *
$P_4 \times P_7$	4.18	-0.17	8.17	20.67 **	6.24	9.91 *	-7.91 **	-7.51 **	-6.68 **	-6.05 **	-7.30 **	-6.79 **
$P_4 \times P_8$	19.20 *	10.56	2.79	12.16 *	10.90 *	11.32 *	-5.48 **	-4.86 **	-4.89 **	-4.04 *	-5.19 **	-4.45 **
$P_4 \times P_9$	18.01 *	18.01 *	12.61 **	22.19 **	19.56 **	20.02 **	-5.52 **	-5.52 **	-4.48 **	-4.48 **	-5.01 **	-5.01 **
$P_4 \times P_{10}$	-5.29	0.94	6.61	17.63 **	0.60	9.05	-2.45	-3.31 *	-5.19 **	-5.83 **	-3.81 **	-4.56 **
$P_5 \times P_6$	10.84	15.09 *	-2.46	8.51	5.94	11.91 *	-2.24	-3.75 *	-4.68 **	-4.04 *	-3.46 *	-3.89 **
$P_5 \times P_7$	0.86	1.2	6.54	18.84 **	3.91	9.76	-2.42	-1.99	-4.23 **	-3.59 *	-3.32 *	-2.78 *
$P_5 \times P_8$	7.33	7.7	-1.64	9.42	2.74	8.52	-4.17 *	-3.53 *	-4.67 **	-3.81 *	-4.42 **	-3.67 **
$P_5 \times P_9$	17.49 *	17.89 *	7.1	19.15 **	12.17 **	18.48 **	-6.84 **	-6.84 **	-4.68 **	-4.04 *	-5.45 **	-5.45 **
$P_5 \times P_{10}$	-0.27	6.3	5.19	17.02 **	2.86	11.50 *	-6.24 **	-7.06 **	-6.24 **	-5.61 **	-5.92 **	-6.34 **
$P_6 \times P_7$	7.97	12.11	-4.09	6.99	5.09	9.64	-3.52 *	-3.09	-4.45 **	-3.81 *	-3.98 **	-3.45 *
$P_6 \times P_8$	5.4	9.45	4.74	14.29 **	7.15	11.79 *	-3.95 *	-3.31 *	-6.67 **	-5.83 **	-5.30 **	-4.56 **
$P_6 \times P_9$	6.26	10.33	14.49 **	20.06 **	10.29 *	15.06 **	-5.30 **	-5.30 **	-4.48 **	-4.48 **	-4.89 **	-4.89 **
$P_6 \times P_{10}$	-8.43	-2.4	1.38	11.85 *	-3.59	4.51	-1.78	-2.65	-3.84 *	-4.48 **	-2.80 *	-3.56 *
$P_7 \times P_8$	10.07	5.47	-5.72	5.17	1.80	5.31	-5.70 **	-5.08 **	-4.44 **	-3.59 *	-5.08 **	-4.34 **
$P_7 \times P_9$	19.50 **	19.50 **	4.36	16.41 **	14.05 **	17.98 **	-5.93 **	-5.52 **	-4.45 **	-3.81 *	-5.20 **	-4.67 **
$P_7 \times P_{10}$	-0.19	6.38	6.27	18.54 **	3.56	12.26 *	-5.27 **	-4.86 **	-4.90 **	-4.26 **	-5.09 **	-4.56 **
$P_8 \times P_9$	18.32 *	18.32 *	-1.67	7.29	12.97 **	12.97 **	-6.36 **	-5.74 **	-5.78 **	-4.93 **	-6.07 **	-5.34 **
$P_8 \times P_{10}$	-5.37	0.86	6.61	17.63 **	0.54	8.99	-6.58 **	-5.96 **	-5.78 **	-4.93 **	-6.18 **	-5.45 **
$P_9 \times P_{10}$	-1.1	5.41	-6.34	3.34	-3.67	4.42	-3.97 *	-3.97 *	-3.81 *	-3.81 *	-3.89 **	-3.89 **
No. of crosses with significant (+) heterosis	8	7	6	33	10	24	0	0	0	0	0	0
No. of crosses with significant (-) 'heterosis	0	0	0	0	0	0	32	32	40	41	38	44
Range of heterosis	-7.22 to	-6.78 to	-6.34 to	3.34 to	-3.67 to	2.98 to	-8.70 to -	-7.51 to -	-8.70 to -	-7.51 to -	-8.32 to -	-5.45 to -

	19.50	19.50	14.49	22.19	19.56	20.02	0.9	1.55	0.45	1.77	1.69	2.45

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Crosses	No. of seeds/pod						Biological yield (g)					
	Y_1		Y_2		Pooled		Y_1		Y_2		Pooled	
	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV
$P_1 \times P_2$	0.58	6.3	-0.77	2.4	-0.10	2.47	2.15	6.23	9.42 **	11.36 **	6.53 *	8.90 **
$P_1 \times P_3$	0.09	9.86	-2.96	-1.8	0.74	2.14	5.84	10.06 **	14.22 **	14.90 **	10.13 **	12.58 **
$P_1 \times P_4$	-5.9	2.13	2.76	3.99	1.15	1.25	3.53	7.67 *	9.38 *	10.03 **	6.53 *	8.90 **
$P_1 \times P_5$	-5	-3.46	5.14	10.18	0.20	1.58	2.73	8.31 **	10.85 **	11.50 **	7.17 *	9.97 **
$P_1 \times P_6$	-3.31	1.02	3.43	4.67	4.12	1.03	0.15	4.15	5.25	9.44 *	3.11	6.90 *
$P_1 \times P_7$	2.99	6.34	0.92	8.98	1.93	5.76	2.6	7.19 *	10.66 **	13.27 **	6.75 *	10.35 **
$P_1 \times P_8$	-7.62	1.02	3.33	5.19	-2.29	1.29	3.26	8.87 **	13.86 **	14.53 **	9.38 **	11.81 **
$P_1 \times P_9$	17.28 **	17.28 **	13.41 *	14.77 *	13.95 **	13.95 **	9.22 **	13.58 **	19.73 **	20.44 **	14.60 **	17.15 **
$P_1 \times P_{10}$	6.51	3.05	3.14	4.99	4.77	2.18	3.38	7.51 *	11.44 **	12.09 **	7.50 *	9.89 **
$P_2 \times P_3$	-2.41	7.11	4.45	7.78	2.89	5.54	0.77	4.63	7.97 *	9.88 **	5.34	7.36 *
$P_2 \times P_4$	-7.3	0.61	2.13	5.39	-1.35	1.19	4.98	7.83 *	8.99 *	10.91 **	7.37 *	9.43 **
$P_2 \times P_5$	0.77	6.5	-5.33	-0.8	-1.54	0.99	0.83	6.31 *	7.83 *	9.73 **	5.34	8.09 *
$P_2 \times P_6$	-7.31	-2.03	2.9	6.19	-2.22	0.30	4.64	8.15 *	8.79 *	13.13 **	6.80 *	10.74 **
$P_2 \times P_7$	-9.23	-4.07	0.18	8.18	-3.34	0.30	0.92	5.43	8.79 *	11.36 **	4.97	8.51 **
$P_2 \times P_8$	-3.72	5.28	6.96	10.38	2.19	5.93	-0.76	4.63	7.61 *	9.51 *	4.84	7.17 *
$P_2 \times P_9$	10.19 *	16.46 **	10.83	14.37 *	10.51 **	13.35 **	9.47 **	11.74 **	17.46 **	19.54 **	13.62 **	15.80 **
$P_2 \times P_{10}$	1.73	7.52	6.38	9.78	4.05	6.73	7.04 *	9.27 **	11.45 **	13.42 **	9.33 **	11.43 **
$P_3 \times P_4$	-8.7	0.2	10.1	6.59	0.20	1.58	7.08 *	11.18 **	11.95 **	11.95 **	9.56 **	11.58 **
$P_3 \times P_5$	-1.3	8.33	4	8.98	5.27	6.73	2.8	8.39 **	13.35 **	13.35 **	8.15 **	10.97 **
$P_3 \times P_6$	-6.48	2.64	9.28	5.79	0.98	2.37	1.55	5.44	6.39	10.63 **	4.30	8.14 *
$P_3 \times P_7$	-0.93	8.74	-6.1	1.4	-0.57	3.17	4.89	9.58 **	11.82 **	14.45 **	8.46 **	12.12 **
$P_3 \times P_8$	-8.33	0.61	8.63	10.58	0.10	3.76	4.92	10.62 **	15.41 **	15.41 **	10.65 **	13.11 **
$P_3 \times P_9$	7.22	17.68 **	14.57 *	14.57 *	12.49 **	14.05 **	10.62 **	14.86 **	19.32 **	19.32 **	15.06 **	17.18 **
$P_3 \times P_{10}$	-0.93	8.74	-1.76	0	1.07	2.47	3.15	7.11 *	12.17 **	12.17 **	7.76 *	9.74 **
$P_4 \times P_5$	-7.49	0.41	-2.48	2.2	-1.85	-0.49	3.71	9.35 **	14.23 **	14.23 **	9.04 **	11.89 **

$P_4 \times P_6$	-2.43	5.89	13.60 *	8.38	5.14	5.24	3.71	7.19 *	9.57 **	13.94 **	6.77 *	10.70 **
$P_4 \times P_7$	-4.87	3.25	-1.48	6.39	-0.76	2.97	0.46	4.95	7.64 *	10.18 **	4.15	7.67 *
$P_4 \times P_8$	-12.83 **	-4.67	5.88	7.78	-3.72	-0.20	1.21	6.71 *	12.63 **	11.80 **	6.98 *	9.36 **
$P_4 \times P_9$	7.3	16.46 **	15.57 **	15.57 **	13.83 **	13.95 **	9.33 **	12.30 **	16.96 **	16.96 **	13.85 **	14.72 **
$P_4 \times P_{10}$	-1.69	6.71	1.96	3.79	3.26	3.36	2.33	5.11	8.64 *	7.52 *	5.56	6.37 *
$P_5 \times P_6$	-1.75	2.64	-4.95	-0.4	-2.05	-0.69	4.17	9.82 **	8.37 *	12.68 **	7.36 *	11.31 **
$P_5 \times P_7$	-0.2	3.05	-14.79 **	-7.98	-7.72 *	-4.25	4.32	9.98 **	12.18 **	14.82 **	8.83 **	12.50 **
$P_5 \times P_8$	-3.9	5.08	-3.05	1.6	-2.10	1.48	0.91	6.39 *	14.90 **	14.90 **	8.00 *	10.81 **
$P_5 \times P_9$	14.60 **	16.46 **	5.9	10.98	10.15 **	11.67 **	7.58 *	13.42 **	17.99 **	17.99 **	12.85 **	15.80 **
$P_5 \times P_{10}$	-2.8	-1.22	-1.9	2.79	-2.34	-0.99	3.33	8.95 **	15.34 **	15.34 **	9.42 **	12.27 **
$P_6 \times P_7$	3.31	7.93	1.85	9.98	3.15	7.02	3.06	7.67 *	8.26 *	12.57 **	6.31 *	10.22 **
$P_6 \times P_8$	-8.36	0.2	-0.2	1.6	-4.39	-0.89	2.95	8.55 **	9.15 *	13.50 **	7.17 *	11.12 **
$P_6 \times P_9$	14.01 **	19.11 **	8.58	8.58	11.77 **	11.77 **	11.75 **	15.50 **	15.32 **	19.91 **	13.61 **	17.79 **
$P_6 \times P_{10}$	-0.97	3.46	2.35	4.19	4.56	1.98	4.64	8.15 *	8.79 *	13.13 **	6.80 *	10.74 **
$P_7 \times P_8$	-3.9	5.08	-8.5	-1.2	-3.53	0.10	0.68	6.15	8.72 *	11.28 **	5.27	8.82 **
$P_7 \times P_9$	12.01 *	15.65 **	4.25	12.57 *	8.01 *	12.07 **	9.33 **	14.22 **	17.46 **	20.24 **	13.52 **	17.35 **
$P_7 \times P_{10}$	1.38	4.67	-2.59	5.19	-0.67	3.07	2.6	7.19 *	9.65 **	12.24 **	6.23 *	9.82 **
$P_8 \times P_9$	8.55	18.70 **	8.82	10.78	8.68 *	12.66 **	8.48 **	14.38 **	18.88 **	18.88 **	14.18 **	16.72 **
$P_8 \times P_{10}$	-2.79	6.3	2.94	4.79	0.00	3.66	1.97	7.51 *	13.37 **	12.54 **	7.73 *	10.12 **
$P_9 \times P_{10}$	1.42	1.42	-6.47	-4.79	-3.46	-3.46	5.27	7.45 *	10.27 **	10.27 **	8.59 **	8.92 **
No. of crosses with significant (+) heterosis	5	8	4	5	8	8	10	36	43	45	37	45
No. of crosses with significant (-) ‘heterosis	1	0	1	0	1	0	0	0	0	0	0	0
Range of heterosis	-12.83 to 17.28	-4.67 to 19.11	-14.79 to15.57	-7.98 to 15.57	-7.72 to 13.95	-4.25 to 14.05	0.15 to 11.75	4.15 to 15.50	5.25 to 19.37	7.52to20.44	3.11 to 14.60	6.37 to 17.18

Contd….

Crosses	Harvest index (%)						Test Weight (g)					
	Y_1		Y_2		Pooled		Y_1		Y_2		Pooled	
	BP	SV	BP	SV	SV	SV	SV	SV	BP	SV	BP	SV
$P_1 \times P_2$	2.83	-0.12	-6.17	-2.59	2.15	-1.44	0.85	11.64 *	1.16	1.16	3.69	6.19
$P_1 \times P_3$	15.54 *	3.26	-10.41	-6.88	0.60	-2.20	5.23	13.84 **	3.49	3.49	4.51	8.46 *
$P_1 \times P_4$	21.56 **	10.97	-0.87	2.91	10.51 *	6.63	8.07	9.43	-9.72	-5.52	-1.32	1.66
$P_1 \times P_5$	14.16 *	8.8	-9.99	-6.56	4.19	0.53	4.05	13.21 *	-1.45	-1.45	1.45	5.59
$P_1 \times P_6$	25.49 **	16.64 **	-9.08	-5.61	8.47	4.66	-4.37	10.06	4.65	4.65	2.60	7.25 *
$P_1 \times P_7$	4.9	1.92	-16.92 **	-13.75 *	-4.42	-6.52	1.86	3.14	-2.62	-2.62	-0.45	0.15
$P_1 \times P_8$	26.80 **	13.77 *	-10.87	-7.48	6.05	2.33	5.23	13.84 **	5.2	5.81	5.22	9.67 **
$P_1 \times P_9$	12.48 *	12.48 *	-2.16	1.57	6.60	6.60	13.04 *	14.47 **	14.24 **	14.24 **	13.66 **	14.35 **
$P_1 \times P_{10}$	11.15	2.04	-8.16	-2.68	0.06	-0.50	4.22	8.81	-4.97	0.00	-0.58	4.23
$P_2 \times P_3$	11.01	7.82	-10.77	-7.26	2.55	-0.30	-7.39	2.52	6.71	6.4	0.73	4.53
$P_2 \times P_4$	5.62	2.59	-6.9	-6.74	1.54	-2.44	3.41	14.47 **	-2.78	1.74	4.69	7.85 *
$P_2 \times P_5$	10.58	7.41	-5.53	-10.24	2.90	-2.10	0.00	10.69 *	6.12	5.81	3.92	8.16 *
$P_2 \times P_6$	4.36	1.37	15.49 *	-0.83	10.00	0.18	-10.93 *	2.52	-1.23	-6.4	-6.36	-2.11
$P_2 \times P_7$	13.03 *	9.83	-2.34	-3.94	4.70	2.41	1.7	12.58 *	13.80 *	7.85	7.52 *	10.12 **
$P_2 \times P_8$	7.25	4.18	-3.67	-5.87	5.03	-1.23	9.66 *	21.38 **	1.16	1.74	6.67	11.18 **
$P_2 \times P_9$	17.39 **	17.39 **	-1.64	-1.64	7.14	7.14	10.80 *	22.64 **	10.17	10.17	13.42 **	16.16 **
$P_2 \times P_{10}$	3.6	0.63	-4.96	0.71	1.24	0.66	-7.95	1.89	-3.59	1.45	-3.03	1.66
$P_3 \times P_4$	13.32 *	3.45	-5.92	-2.22	3.27	0.40	-1.16	6.92	0.83	5.52	2.33	6.19
$P_3 \times P_5$	4.28	-0.62	-17.13 **	-13.87 *	-5.13	-7.77	-5.2	3.14	0.58	0.29	-2.32	1.66
$P_3 \times P_6$	10.46	2.67	-13.97 *	-10.58	-1.73	-4.46	-0.55	14.47 **	-4.96	-5.23	-0.29	4.23
$P_3 \times P_7$	-3.57	-6.3	-11.97	-8.51	-5.40	-7.48	-5.23	2.52	-1.46	-1.74	-3.35	0.30
$P_3 \times P_8$	9.47	-1.78	-13.74 *	-10.35	-3.71	-6.39	1.16	9.43	5.78	6.4	3.48	7.85 *
$P_3 \times P_9$	11.98	11.98	-3.61	0.19	5.62	5.62	9.88 *	18.87 **	8.14	8.14	9.17 **	13.29 **
$P_3 \times P_{10}$	17.25 *	7.63	-5.66	-0.04	4.09	3.50	-2.33	5.66	-2.76	2.33	-0.86	3.93
$P_4 \times P_5$	17.54 **	12.02	-10.09	-9.93	4.28	0.19	-6.94	1.26	0.56	5.23	-0.73	3.32
$P_4 \times P_6$	7.86	0.25	0.27	0.45	4.45	0.36	-3.83	10.69 *	-3.33	1.16	1.16	5.74
$P_4 \times P_7$	11.69	8.53	-6.5	-6.34	2.78	0.53	16.15 **	17.61 **	-9.17	-4.94	2.79	5.89

Contd….

Crosses	Harvest index						Test Weight					
	Y_1		Y_2		Pooled		Y_1		Y_2		Pooled	
	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV
$P_4 \times P_8$	9.25	-0.27	-1.93	-1.77	2.96	-1.07	-4.65	3.14	1.67	6.4	0.58	4.83
$P_4 \times P_9$	11.27	11.27	2.9	3.07	6.85	6.85	22.98**	24.53**	8.61	13.66 **	15.40 **	18.88**
$P_4 \times P_{10}$	11.23	2.11	-0.54	5.39	4.48	3.89	8.43	13.21 *	-11.05 *	-6.4	-1.73	3.02
$P_5 \times P_6$	7.77	2.7	-4.02	-8.81	1.44	-3.49	-5.46	8.81	0.87	0.58	0.00	4.53
$P_5 \times P_7$	0.18	-2.66	0.55	-1.1	0.38	-1.82	10.98 *	20.75**	9.33	9.01	10.16 **	14.65**
$P_5 \times P_8$	20.29 **	14.64 *	-0.52	-2.79	10.63 *	5.25	-2.31	6.29	2.89	3.49	0.58	4.83
$P_5 \times P_9$	12.69 *	12.69 *	7.1	7.1	9.68	9.68	13.29**	23.27**	9.01	9.01	11.32 **	15.86**
$P_5 \times P_{10}$	5.73	0.76	-5.89	-0.27	0.77	0.20	-2.89	5.66	-11.88 *	-7.27	-5.62	-1.06
$P_6 \times P_7$	9.76	6.65	-7.65	-9.16	0.34	-1.86	0.07	15.09**	1.84	-3.49	0.87	5.44
$P_6 \times P_8$	9.04	1.35	0	-2.28	5.71	-0.60	-5.46	8.81	4.34	4.94	2.17	6.80
$P_6 \times P_9$	-2.06	-2.06	13.49 *	13.49 *	6.31	6.31	-2.73	11.95 *	12.79 *	12.79 *	7.51 *	12.39**
$P_6 \times P_{10}$	8.35	0.71	-13.00 *	-7.81	-3.33	-3.88	-4.37	10.06	1.66	6.98	3.46	8.46 *
$P_7 \times P_8$	-1.83	-4.61	-7.2	-8.72	-4.74	-6.83	5.81	14.47**	-5.2	-4.65	0.29	4.53
$P_7 \times P_9$	1.7	1.7	9.74	9.74	6.03	6.03	22.64**	22.64**	7.85	7.85	14.95 **	14.95**
$P_7 \times P_{10}$	5.07	2.1	-13.30 *	-8.13	-2.86	-3.41	3.61	8.18	-3.59	1.45	-0.14	4.68
$P_8 \times P_9$	10.47	10.47	5.29	5.29	7.68	7.68	8.72	17.61**	6.94	7.56	7.83 *	12.39**
$P_8 \times P_{10}$	6.57	-2.17	-10.86	-5.55	-3.43	-3.98	7.56	16.35 **	-1.93	3.2	4.47	9.52 **
$P_9 \times P_{10}$	-0.08	-0.08	-13.76 *	-8.62	-4.68	-4.68	3.61	8.18	-10.22 *	-5.52	-3.60	1.06
No. of crosses with significant (+) heterosis	13	6	2	1	2	0	9	24	3	3	10	19
No. of crosses with significant (-) 'heterosis	0	0	6	2	0	0	1	0	3	0	0	0
Range of heterosis	-3.57 to 26.80	-6.3 to 17.39	-.17.13 to 15.49	-13.87 to 13.49	-4.74to 10.63	-7.77 to 9.68	-10.93 to 22.98	1.26 to 24.53	-11.88 to 14.24	-7.27 to 14.24	-6.36 to 15.40	-1.06 to 18.88

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Crosses	Seed yield/plant (g)					
	Y_1		Y_2		Pooled	
	BP	SV	BP	SV	BP	SV
$P_1 \times P_2$	6.69	5.81	3.77	8.55	8.53	7.34
$P_1 \times P_3$	22.42 **	13.28 *	2.2	6.91	10.95 *	9.72 *
$P_1 \times P_4$	26.99 **	19.09 **	7.23	12.17	16.51 **	15.23 **
$P_1 \times P_5$	17.36 **	17.84 **	-0.31	4.28	11.50 *	10.28 *
$P_1 \times P_6$	26.41 **	21.16 **	-1.57	2.96	12.24 **	11.01 *
$P_1 \times P_7$	7.35	9.13	-6.6	-2.3	1.63	2.75
$P_1 \times P_8$	30.70 **	23.65 **	0.79	5.43	14.75 **	13.49 **
$P_1 \times P_9$	27.39 **	27.39 **	16.98 **	22.37 **	24.59 **	24.59 **
$P_1 \times P_{10}$	17.33 **	9.54	4.4	9.21	9.76 *	9.36 *
$P_2 \times P_3$	12.97 *	12.03 *	-2.53	1.32	7.24	6.06
$P_2 \times P_4$	11.30 *	10.37	4.65	3.62	10.25 *	6.61
$P_2 \times P_5$	13.22 *	13.69 *	3.46	-1.64	7.91	5.14
$P_2 \times P_6$	10.46	9.54	25.83 **	12.17	19.80 **	11.01 *
$P_2 \times P_7$	13.47 *	15.35 **	6.21	6.91	9.44 *	10.64 *
$P_2 \times P_8$	9.62	8.71	6.44	3.29	10.13 *	5.69
$P_2 \times P_9$	30.71 **	30.71 **	17.76 **	17.76 **	23.49 **	23.49 **
$P_2 \times P_{10}$	10.46	9.54	9.43	14.47 *	12.71 **	12.29 **
$P_3 \times P_4$	22.57 **	14.94 **	5.38	9.54	13.17 **	11.93 *

$P_3 \times P_5$	17.77 **	18.26 **	-6.33	-2.63	7.79	6.61
$P_3 \times P_6$	12.55 *	7.88	-4.75	-0.99	4.08	2.94
$P_3 \times P_7$	12.65 *	14.52 **	0.95	4.93	7.99	9.17 *
$P_3 \times P_8$	14.47 *	8.3	-0.63	3.29	6.68	5.50
$P_3 \times P_9$	31.95 **	31.95 **	14.87 *	19.41 **	24.95 **	24.95 **
$P_3 \times P_{10}$	22.22 **	14.11 *	6.92	11.84	13.26 **	12.84 **
$P_4 \times P_5$	21.90 **	22.41 **	3.99	2.96	14.50 **	11.56 *
$P_4 \times P_6$	11.69 *	5.81	15.61 *	14.47 *	14.99 **	11.19 *
$P_4 \times P_7$	11.02 *	24.90 **	2.29	2.96	6.17	7.34
$P_4 \times P_8$	11.84 *	7.05	10.96	9.87	11.76 *	8.07
$P_4 \times P_9$	24.90 **	12.45 *	20.39 **	20.39 **	22.39 **	22.39 **
$P_4 \times P_{10}$	14.16 *	6.64	8.18	13.16 *	10.87 *	10.46 *
$P_5 \times P_6$	11.98 *	21.58 **	7.96	2.63	9.79 *	6.97
$P_5 \times P_7$	4.9	27.39 **	12.75	13.49 *	9.26 *	10.46 *
$P_5 \times P_8$	21.07 **	9.54	14.92 *	11.51	19.02 **	15.96 **
$P_5 \times P_9$	26.86 **	14.11 *	26.32 **	26.32 **	26.79 **	26.79 **
$P_5 \times P_{10}$	9.09	9.54	9.12	14.14 *	12.52 **	12.11 **
$P_7 \times P_8$	12.24 *	12.86 *	1.63	2.3	6.35	7.52
$P_7 \times P_9$	14.29 *	7.88	14.24 *	10.86	14.91 **	10.28 *
$P_7 \times P_{10}$	12.86 *	0.83	36.18 **	36.18 **	25.87 **	25.87 **
$P_8 \times P_9$	12.55 *	15.77 **	-0.94	3.62	5.89	5.50

$P_8 \times P_{10}$	-0.82	9.13	0.33	0.99	-0.18	0.92
$P_9 \times P_{10}$	13.88 *	26.14 **	31.05 **	31.91 **	23.41 **	24.77 **
No. of crosses with significant (+) heterosis	**33**	**24**	**11**	**12**	**29**	**26**
No. of crosses with significant (-) ‘heterosis	**0**	**0**	**0**	**0**	**0**	**0**
Range of heterosis	**-0.82 to 31.95**	**5.81 to 31.71**	**2.53 to 36.18**	**-2.63 to 36.18**	**-0.18 to 26.79**	**2.75 to 26.79**

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