Evaluation of the performance of parental lines and their F_1 hybrids for yield and attributing traits in vegetable pea [*Pisum sativum* (L.) var. *hortense*]

Abstract

The present investigation was carried out to obtain information based on *per se* performances of parents and their combinations for genetic improvement in vegetable pea. Ten promising genotypes were crossed in diallel manner (excluding reciprocals). Half diallel set of 45 F_1's in vegetable pea was evaluated in Randomized Complete Block Design (RBD) with three replications for eighteen yield and yield attributing traits during *Rabi* 2020-21 (Y_1) and 2021-22 (Y_2) at the Main Experimental Station (MES), Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.) India. The study evident that highly significant differences were observed for most of the traits under study. Based on *per se* performance, parent P_{10} (60.84 g) exhibited highest green pod yield per plant followed by P_5 (55.80 g). The *per se* performance of crosses *i.e.* P_7 x P_{10} (81.88 g) followed by P_6 x P_{10} (81.87 g), P_5 x P_{10} (79.66 g) and P_5 x P_7 (78.89 g) were produced significantly higher green pod yield per plant than the general mean. These hybrids may be exploited as new variety after selection and subjected to multi-locational trials for their release as cultivation on commercial scale.

Key word: evident, reciprocals, yield, hybrids.

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1. INRODUCTION

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Garden pea [*Pisum sativum* (L.) var. *hortense*] is an important legume vegetable crop grown in temperate and subtropical regions of the world. After *Phaseolus vulgaris*, it is the second-most important legume crop globally [7]. Near East and Ethiopia are regarded as secondary habitats, with the Mediterranean serving as the garden pea's primary source of origin [4].

Comment [kv3]: It should start from 1,2....... Rearrange the reference

India is second in the world for vegetable production behind China, and it contributes 10.80 million hectares and 196.26 million tonnes of vegetables to the world's production overall. Vegetable peas are grown on an average productivity of 10.04 tonnes per hectare in India, where they cover 0.573 million hectares and produce 5.823 million tonnes **[2].** In India, it is grown extensively in Uttar Pradesh, Madhya Pradesh, Himachal Pradesh, Jharkhand, Punjab, Haryana, Rajasthan, Maharashtra, Bihar, and Karnataka, contributing to 67% of the total production. Uttar Pradesh is the highest-producing state in India. This crop is grown on

0.218 million hectares in Uttar Pradesh, producing 2.481 million tonnes and productivity was 11.360 tonnes per hectare [1].

Vegetable pea seeds are consumed fresh, frozen, canned or dehydrated and are highly tasty and nourishing for human nutrition. There is growing interest in this crop as a cheap source of protein because to its high protein content (20-30 per cent) and the increased demand for protein-rich raw materials for animal feed or intermediate products for human nutrition [5]. The anti-oxidant flavonoids carotenes, lutein, and zeaxanthin, which assist to prevent lung and oral cavity malignancies, are present in sufficient amounts [10].

Hybridization is a crucial breeding strategy for overcoming yield limitations. Crosses between the parents having good per se performance, are expected to yield desirable recombinants in further segregating generations and the potentialities of such genotypes could be seen in the performance of the hybrids. Utilizing natural sources of germplasm through selection or hybridization followed by selection is the basic foundation for development of varieties [13]. The only feasible option to integrate the favourable horticultural qualities of two or more types, hybridization offers more chances for crop development than any other breeding technique [18]. The important factor that reduces the vegetable pea production is low yielding potential of old varieties and lack of stability for yield. Keeping this objective in view, ten parents and their resultant hybrids were evaluated based on mean per se performance for yield and its attributing traits.

Comment [kv4]: Italics

2. MATERIALS AND METHODS

The present investigation was carried out 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). The experimental farm falls under humid subtropical climate and is located between 24.47° and 26.54°N latitude and 81.84° and 83.58°E longitude at an altitude of 98 m above mean sea level.

The experimental materials comprised of ten promising varieties of pea selected on the basis of genetic variability from the germplasm stock maintained in the Department of Vegetable Science. The selected parental lines *i.e.*; Azad Pea-1 (P_1), Azad Pea-2 (P_2), Azad Pea-4 (P_3), Kashi Samridhi (P_4), Kashi Nandini (P_5), Kashi Mukti (P_6), Kashi Udai (P_7), NDVP-2 (P_8), NDVP-4 (P_9) and Azad Pea-3 (P_{10}) were crossed in all possible cross combinations (excluding reciprocal) during *Rabi* season of 2019-20 to get 45 F_1's for the study of study of mean performance of parental line and their resultant F_1.

The experiments were grown in a Randomized Complete Block Design (RBD) with three replications to evaluate the performance of 45 F_1 hybrids and their 10 parental lines of vegetable pea. The crop was sown in single row spaced at 30 cm apart with a plant to plant spacing of 10 cm.

Observations were recorded for eighteen economic and quality traits, *viz.* days to 50% flowering, days to first picking, plant height (cm), node to first pod appearance, nodes per plant, pod length (cm), pod girth (cm), number of seed per pod, number of pods per plant, shelling percentage, number of pods per 100 g, 100 green seed weight (g), protein content (%), total soluble solids, reducing sugars (%), non-reducing sugar (%), total sugars (%) and green pod yield per plant (g). *Per se* performance were evaluated for parents and hybrids following method suggested by Panse and Sukhatme [11] for analysis of variance of experimental for eighteen yield and yield contributing traits.

3. RESULTS AND DISCUSSION

Comment [kv5]: Discuss the results with proper reason

Selection of suitable parents and proper breeding methodology are basic steps for the improvement of yield and attributing traits. The selection of parents having high *per se* performance would be of merit in producing better hybrids and hence the parents selected for crossing programme were evaluated based on their *per se* performances. The most important trait green pod yield per plant and other quality traits result for pooled data are discussed below.

Perusal of Table-1 revealed that the mean squares due to genotypes, parents and hybrids were found highly significant for all the traits. The mean squares due to parents *vs.* hybrids also found significant for all the traits studied except for days to 50% flowering, days to first picking and number of pods per 100g.

Perusal of Table-2 revealed that days to 50% flowering varied from 39.00 to 56.00 days for parents and 32.50 to 55 days for F_1 hybrids with overall mean 47.89 days of parents and F_1's. Among the parents, P_5 and P_6 (39.00) exhibited minimum days to 50 % flowering while P_4 (56.00) took maximum days to 50 % flowering. Out of 45 crosses, hybrids which exhibited early days to 50% flowering were P_5 x P_6 (32.50) followed by P_5 x P_7 (32.83) while cross P_4 x P_9 (55.00) took maximum days to 50 % flowering. Similar findings were also reported by Sharma *et al.* [12], Kumar *et al.* [8].

Comment [kv6]: Discussion with proper reason

Days to first picking varied from 65.17 to 84.67 days for parents and 56.00 to 83.83 days for F_1 hybrids with overall mean 75.63 days of parents and F_1's. Among the parents P_5 (65.17 days) exhibited early days to first picking and P_4 (56.00) took maximum days for first picking. Out of 45 crosses, hybrids which exhibited minimum days to first picking were P_5 x

P_6 (56.00) followed by P_5 x P_7 (56.33). Cross P_2 x P_4 (83.83) took maximum days to first picking. Above findings were also reported by Kumar *et al.* [8], Suman *et al*. [19].

Comment [kv7]: Discussion with proper reason

Plant height ranged from 63.65 cm to 126.26 cm for parents and 68.6 to 126.05 cm for F_1 hybrids with overall mean 82.68 cm of parents and F_1's. Among the parents P_5 (63.65 cm) exhibited minimum while, parent P_3 (126.26 cm) exhibited maximum plant height. Out of 45 crosses, F_1 hybrids which exhibited minimum plant height were P_5 x P_8 (68.6 cm) and P_6 x P_8 (70.01 cm) while, maximum plant height was exhibited by crosses P_2 x P_3 (126.05 cm) followed by P_2 x P_{10} (122.76 cm). These findings are in agreement with Suman *et al.* [19], Kumar *et al.* [8].

Comment [kv8]: Discussion with proper reason

Node to first pod appearance ranged from 9.93 to 13.88 for parents and 7.72 to 13.95 for F_1 hybrids with overall mean 12.08 of parents and F_1's. Among the parents P_7 (9.93) recorded minimum value for node to first pod appearance while P_4 (13.88) exhibited maximum mean value. Out of 45 crosses P_5 x P_7 (7.72) followed by P_5 x P_6 (7.97) recorded minimum, P_2 x P_3 (13.95) followed by P_3 x P_6 (13.80) recorded maximum mean value for node to first pod appearance. Similar findings were also reported by Shubh and Dhar [18], Ceyhan *et al*. [5].

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Pod length ranged from 6.28 cm to 8.84 cm for parents and 6.22 to 10.32 cm for F_1 hybrids with overall mean 8.03 cm of parents and F_1 hybrids. Among the parents P_7 (8.84 cm) exhibited maximum pod length and P_2 exhibited minimum pod length (6.28 cm). Among F_1 hybrids, cross P_7 x P_{10} (10.32 cm) followed by P_6 x P_{10} (10.14 cm) recorded maximum pod length and cross P_2 x P_4 (6.22 cm) recorded minimum pod length. Above findings were also reported by Shubh and Dhar [18], Kumar *et al.* [8].

Comment [kv10]: Discussion with proper reason

Number of pods per plant ranged from 8.52 to 11.32 for parent whereas, 8.12 to 13.25 for F_1 hybrids with overall mean 10.62 of parents and F_1 hybrids. Among the parents the maximum number of pods per plant was recorded in P_3 (11.32) and minimum by P_1 (8.52). In case of F_1 hybrids, crosses P_5 x P_7 (13.25) followed by P_5 x P_6 (13.23) exhibited maximum number of pods per plant and cross P_1 x P_9 (8.12) recorded minimum number of pods per plant. Similar findings were also reported by Suman *et al.* [19], Sharma *et al.* [12].

Comment [kv11]: Discussion with proper reason

Protein content ranged from 17.96 to 23.24 % for parents while, 17.88 to 26.14 % for F_1 hybrids with overall mean 21.11% of parents and F_1's hybrid. Among the parents, maximum protein content was recorded in P_5 (23.24 %) while minimum in P_3 (17.96%). Among the 45 F_1 hybrids, crosses P_5 x P_{10} (26.14 %) followed by P_5 x P_6 (25.61 %) recorded maximum protein content and cross P_3 x P_8 (17.88 %) recorded minimum protein content. Above findings were also reported by Daheriya [6], Singh *et al*. [15].

Comment [kv12]: Discussion with proper reason

Total soluble solids ranged from 11.80 to 14.48 ^{0}Brix for parents while, 12.17 to 17.30 ^{0}Brix for F_1 hybrids with overall mean 13.83 ^{0}Brix of parents and F_1's hybrid. Among the parents, highest total soluble solids were found in P_5 (14.48 ^{0}Brix) and lowest in P_1 (11.80 ^{0}Brix). Among F_1's crosses P_5 x P_6 (17.30 ^{0}Brix) followed by P_5 x P_{10} (17.25 ^{0}Brix) exhibited maximum total soluble solids and cross P_8 x P_9 (12.17 ^{0}Brix) recorded minimum mean value. Similar findings were also reported by Daheriya [6], Bisht and Singh [3].

Comment [kv13]: Discussion with proper reason

Total sugars were ranged from 3.28 to 4.62 % for parents while, 3.35 to 6.05% for F_1 hybrids with overall mean 4.2 % of parents and F_1's hybrid. Among the parents P_{10} (4.62%) exhibited maximum total sugars and P_9 (3.28 %) recorded minimum mean value for total sugars. In case of F_1 hybrids, crosses P_5 x P_{10} (6.05%) followed by P_7 x P_{10} (6.02%) and P_5 x P_6 (5.96%) exhibited higher total sugars than the general mean and cross P_2 x P_9 (3.35 %) recorded minimum total sugars. Similar findings were also reported by Singh and Dhillon [16], Kumari and sharma [9].

Green pod yield per plant is the most important traits for vegetable pea the range of parent was 46.78 to 60.84 g while, 49.11 to 81.88 g for F_1 hybrids with overall mean 60.52 g of parents and F_1's hybrid. Among the parents P_{10} produced highest green pod yield per plant ans P_9 produced minimum green pod yield per plant. Among F_1 hybrids, crosses P_7 x P_{10} (81.88 g) followed by P_6 x P_{10} (81.87 g) and P_5 x P_{10} (79.66 g) produced highest green pod yield per plant than the general mean. Cross P_5 x P_6 (49.11 g) recorded minimum green pod yield per plant. These findings are in agreement with Kumar *et al.* [8], Shubha and dhar [18].

CONCLUSION

Comment [kv14]: Re-Write, Add little more result finding

From present study it may be concluded that based on *per se* performance, Parents P_5, P_6 P_7 and P_{10} were identified as superior parents while, five crosses *viz*. P_7 x P_{10}, P_6 x P_{10}, P_5 x P_6, P_5 x P_7 and P_5 x P_{10} were identified as superior crosses for green pod yield per plant as well as for earliness also. The best performing crosses may be utilized for multi-locational trials for selection and utilization as variety. Best performing parents may be used in future breeding programs for improvement of yield and its attributing traits.

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Table 1: ANOVA (mean squares) for a set of 10 x 10 diallel crosses for different traits in vegetable pea during over season pooled.

Comment [kv15]: Separate into two tables

Source of variation	d.f	Days to 50% flowering	Days to first picking	Plant height	Node to first pod appearance	Nodes per plant	Pod length	Pod girth	Number of seeds/pod	Number of pods/plant	Shelling percentage
Replications	2	0.26	9.15*	34.39*	0.053	5.59**	0.31 **	0.003	0.25 *	1.31*	3.62*
Genotypes	54	129.62**	205.41**	1422.38**	9.33 **	16.89**	3.55 **	0.31 **	4.69 **	7.46 **	35.30 **
Parents	9	158.10**	184.88**	1611.93**	9.23 **	33.02**	2.53 **	0.24 **	4.33 **	3.19 **	8.21 **
Hybrids	44	126.17 **	214.20**	1345.38**	9.54 **	12.41**	3.83 **	0.33 **	4.81 **	7.76 **	39.38 **
Parents *vs.* Hybrids	1	1.37	3.64	3104.28**	0.82 *	68.79**	0.72 **	0.37 **	2.85 **	32.75 **	99.31 **
Error	108	1.64	2.85	7.58	0.16	0.90	0.03	0.012	0.070	0.39	0.97

Source of variation	d.f	Number of pods/100 g	100 green seed weight	Protein content	Total soluble solids	Reducing sugars	Non reducing sugar	Total sugars	Green pod yield per plant
Replications	2	0.46	11.48 *	0.023	0.141	0.001 *	0.021	0.03	8.22
Genotypes	54	17.69**	54.27 **	12.16**	6.33**	0.005 **	1.47 **	1.62 **	290.47 **
Parents	9	19.21**	23.54 **	8.71 **	3.26 **	0.002 **	0.85 **	0.92 **	53.74 **
Hybrids	44	17.76 **	61.26 **	12.86 **	6.74 **	0.005 **	1.60 **	1.76 **	296.32 **
Parents *vs.* Hybrids	1	0.92	23.02 **	12.71 **	16.06 **	0.042 **	1.68 **	2.26 **	2163.72 **
Error	108	0.44	2.43	0.069	0.135	0.0001	0.013	0.012	7.27

*, ** significant at 5% and 1% level, respectively

Table 2: Mean performance, general mean, range, coefficient of variation and critical difference for Eighteen characters of diallel set of 45 F_1's and their 10 parents in vegetable pea during overseason pooled

Comment [kv16]: Separate into two tables

Sr. No.	Genotypes	Days to 50% flowering	Days to first picking	Plant height (cm)	Node to first pod appearance	Nodes per plant	Pod length (cm)	Pod girth (cm)	Number of seeds/pod	Number pods/plant
1	$P_1 \times P_2$	49.67	79.33	108.32	12.88	22.79	8.12	4.03	7.70	8.24
2	$P_1 \times P_3$	50.33	79.17	109.18	13.30	22.29	8.19	4.07	7.67	8.29
3	$P_1 \times P_4$	51.67	80.17	92.99	13.58	24.17	8.21	4.06	8.15	8.37
4	$P_1 \times P_5$	45.50	73.83	81.19	11.22	21.24	9.42	4.48	9.22	11.67
5	$P_1 \times P_6$	45.17	73.83	82.69	11.18	22.17	9.34	4.47	9.18	12.14
6	$P_1 \times P_7$	45.50	73.67	85.42	11.22	21.98	9.23	4.47	9.02	11.26
7	$P_1 \times P_8$	49.67	78.67	80.32	13.45	22.70	8.15	4.06	8.17	8.16
8	$P_1 \times P_9$	50.00	79.17	81.92	12.73	22.10	8.20	4.05	8.15	8.12
9	$P_1 \times P_{10}$	45.50	74.00	80.57	11.23	20.85	9.45	4.48	9.22	11.59
10	$P_2 \times P_3$	53.33	82.50	126.05	13.95	23.87	6.33	3.70	6.15	10.34
11	$P_2 \times P_4$	54.33	83.83	121.44	13.45	23.82	6.22	3.76	6.15	11.12
12	$P_2 \times P_5$	50.83	79.83	120.21	13.02	21.78	6.95	3.81	7.25	12.01
13	$P_2 \times P_6$	51.33	80.17	119.61	12.87	21.27	6.85	3.82	7.30	11.10
14	$P_2 \times P_7$	50.67	79.67	121.38	12.88	22.70	6.89	3.82	7.28	11.93
15	$P_2 \times P_8$	54.17	83.17	121.17	13.60	23.67	6.25	3.63	6.23	10.15
16	$P_2 \times P_9$	53.17	81.83	120.65	13.37	24.14	6.30	3.68	6.07	10.17
17	$P_2 \times P_{10}$	49.33	80.33	122.76	12.93	22.40	6.87	3.76	7.30	12.02
18	$P_3 \times P_4$	54.33	83.50	118.60	13.38	25.40	7.08	3.58	6.38	11.68
19	$P_3 \times P_5$	50.17	80.17	121.23	12.93	23.14	7.66	3.81	7.27	11.99
20	$P_3 \times P_6$	50.33	79.83	119.00	13.80	22.67	7.74	3.82	7.20	11.38
21	$P_3 \times P_7$	50.17	79.17	120.05	12.87	24.24	7.84	3.82	7.12	11.97
22	$P_3 \times P_8$	53.67	83.00	118.89	13.35	23.87	7.16	3.67	6.08	10.48
23	$P_3 \times P_9$	53.50	82.50	120.30	13.27	24.54	7.18	3.68	6.12	10.73
24	$P_3 \times P_{10}$	50.33	78.83	118.84	12.87	23.64	7.74	3.84	7.25	11.77
25	$P_4 \times P_5$	53.17	82.17	91.21	12.95	23.60	7.66	3.76	7.68	12.08
26	$P_4 \times P_6$	52.83	82.17	89.30	13.00	23.07	7.69	3.79	7.63	12.00
27	$P_4 \times P_7$	52.00	82.00	93.57	12.90	24.57	7.83	3.83	7.82	11.87
28	$P_4 \times P_8$	54.50	83.50	86.87	13.52	24.04	7.21	3.66	6.52	11.28
29	$P_4 \times P_9$	55.00	83.33	88.95	13.37	23.14	7.20	3.73	6.45	11.38
30	$P_4 \times P_{10}$	51.83	81.67	89.35	12.77	24.27	7.76	3.81	7.87	12.03
31	$P_5 \times P_6$	32.50	56.00	75.34	7.97	19.45	9.96	4.61	9.93	13.23
32	$P_5 \times P_7$	32.83	56.33	73.28	7.72	19.03	9.98	4.56	9.95	13.25
33	$P_5 \times P_8$	43.67	70.83	68.60	11.58	18.18	8.41	4.11	8.30	9.19
34	$P_5 \times P_9$	43.33	71.17	70.42	11.17	18.47	8.38	4.12	8.28	9.30
35	$P_5 \times P_{10}$	34.83	57.17	73.61	8.07	19.17	9.99	4.59	10.02	13.16
36	$P_6 \times P_7$	33.67	57.00	74.02	8.05	19.04	10.13	4.58	10.18	13.15
37	$P_6 \times P_8$	44.50	72.00	70.01	11.88	19.40	8.38	4.08	8.38	8.77
38	$P_6 \times P_9$	43.67	72.00	70.82	11.77	19.54	8.43	4.03	8.26	8.57
39	$P_6 \times P_{10}$	34.83	57.50	73.11	8.05	20.40	10.14	4.59	10.17	12.87
40	$P_7 \times P_8$	44.33	72.00	70.83	11.97	19.41	8.48	4.10	8.35	8.87
41	$P_7 \times P_9$	44.67	72.17	72.26	11.82	18.24	8.50	4.18	8.38	8.90
42	$P_7 \times P_{10}$	35.17	58.17	74.09	8.33	19.88	10.32	4.62	10.27	12.86
43	$P_8 \times P_9$	54.33	83.17	68.68	12.93	19.91	7.38	3.65	6.08	8.91
44	$P_8 \times P_{10}$	52.00	80.67	70.57	13.00	21.70	7.56	3.62	6.55	9.01
45	$P_9 \times P_{10}$	50.83	79.67	71.30	12.85	21.90	8.01	3.66	7.07	9.65
F_1 Hybrid mean		**47.94**	**76.02**	**93.93**	**12.11**	**21.95**	**8.06**	**4.00**	**7.82**	**10.82**
Parents										
1	P_1	47.00	76.00	82.32	11.94	20.72	8.50	4.17	8.55	8.52
2	P_2	53.50	81.67	119.54	13.74	23.23	6.28	3.62	6.03	10.24
3	P_3	54.17	82.67	126.26	13.68	24.00	7.11	3.70	6.07	11.32
4	P_4	56.00	84.67	93.63	13.88	22.97	7.21	3.58	7.10	11.08
5	P_5	39.00	65.17	63.65	10.02	16.70	8.66	4.11	8.28	9.14
6	P_6	39.00	66.33	64.93	10.10	15.53	8.73	4.16	8.53	8.99
7	P_7	39.33	66.17	64.77	9.93	16.80	8.84	4.16	8.73	9.20
8	P_8	54.17	82.17	67.29	12.67	21.45	7.12	3.58	6.00	8.57
9	P_9	53.17	81.17	73.72	13.37	23.78	7.71	3.57	6.72	9.10
10	P_{10}	41.67	70.33	70.72	9.95	17.45	8.73	4.12	8.72	10.52
Parental mean		**47.70**	**75.63**	**82.68**	**11.93**	**20.26**	**7.89**	**3.88**	**7.47**	**9.67**
Grand mean		47.89	75.95	91.88	12.08	21.65	8.03	3.98	7.75	10.62
CV		2.67	2.22	3.01	3.39	4.39	2.40	2.17	3.41	5.95
CD 5%		2.05	2.70	4.40	0.65	1.51	0.30	0.17	0.42	1.01
Range	**Lowest**	**32.50**	**56.00**	**63.65**	**7.72**	**15.53**	**6.22**	**3.58**	**6.00**	**8.24**
	Highest	**56.00**	**84.67**	**126.26**	**13.95**	**25.40**	**10.32**	**4.62**	**10.27**	**13.25**

Table 2: Contd…

Sr. No.	Genotypes	Shelling percentage (%)	Number of pods/100g	100 green seed weight (g)	Protein content (%)	Total soluble solids (^{0}Brix)	Reducing sugars (%)	Non reducing sugar (%)	Total sugars (%)	Green pod yield/plant (g)
1	$P_1 \times P_2$	43.91	18.58	42.25	19.95	12.77	0.21	3.81	4.02	49.11
2	$P_1 \times P_3$	44.50	18.73	43.06	19.15	12.20	0.19	3.88	4.07	49.58
3	$P_1 \times P_4$	44.03	19.02	43.23	20.51	12.75	0.21	3.54	3.75	54.12
4	$P_1 \times P_5$	46.66	15.69	46.54	22.42	14.48	0.25	4.66	4.91	72.55
5	$P_1 \times P_6$	45.61	15.70	46.90	20.40	14.65	0.21	4.50	4.71	73.47
6	$P_1 \times P_7$	46.09	15.67	47.89	21.16	13.78	0.28	4.37	4.65	72.49
7	$P_1 \times P_8$	44.04	18.61	43.15	19.04	12.57	0.23	3.98	4.20	50.97
8	$P_1 \times P_9$	44.39	17.88	42.88	19.17	12.75	0.23	4.09	4.32	52.88
9	$P_1 \times P_{10}$	46.42	15.86	46.85	22.38	14.95	0.27	4.33	4.60	69.82
10	$P_2 \times P_3$	45.01	21.53	40.75	18.87	12.58	0.20	3.39	3.59	50.73
11	$P_2 \times P_4$	43.62	21.43	41.29	20.46	12.57	0.21	3.20	3.41	52.73
12	$P_2 \times P_5$	45.87	20.11	43.54	21.57	14.05	0.23	3.50	3.73	63.62
13	$P_2 \times P_6$	45.73	20.05	43.91	20.22	14.57	0.21	3.52	3.72	62.15
14	$P_2 \times P_7$	45.92	19.99	43.72	20.74	13.65	0.24	3.87	4.11	63.23
15	$P_2 \times P_8$	44.90	21.56	42.69	18.66	12.22	0.21	3.33	3.54	51.98
16	$P_2 \times P_9$	45.62	20.78	41.90	19.11	12.68	0.22	3.13	3.35	51.99
17	$P_2 \times P_{10}$	45.59	20.08	43.20	21.58	13.27	0.24	3.59	3.83	63.73
18	$P_3 \times P_4$	43.80	20.97	40.35	19.07	12.42	0.21	3.42	3.63	59.15
19	$P_3 \times P_5$	44.59	20.07	42.76	19.47	14.18	0.22	3.71	3.93	63.39
20	$P_3 \times P_6$	44.98	20.08	43.03	19.09	13.92	0.22	3.74	3.95	60.61
21	$P_3 \times P_7$	45.04	20.12	43.33	20.21	13.27	0.24	3.68	3.92	63.70
22	$P_3 \times P_8$	44.97	21.54	42.21	17.88	12.95	0.22	3.35	3.57	51.12
23	$P_3 \times P_9$	44.69	21.40	42.75	18.48	13.40	0.23	3.25	3.48	53.54
24	$P_3 \times P_{10}$	45.85	20.11	43.57	20.57	13.70	0.24	3.78	4.02	64.01
25	$P_4 \times P_5$	45.07	20.88	42.87	23.06	14.13	0.27	3.77	4.03	63.97
26	$P_4 \times P_6$	45.73	20.96	43.70	21.19	13.93	0.27	3.68	3.94	62.99
27	$P_4 \times P_7$	45.22	20.89	43.37	22.22	13.35	0.27	3.78	4.04	63.38
28	$P_4 \times P_8$	43.55	21.80	42.37	21.19	12.55	0.25	3.26	3.50	52.90
29	$P_4 \times P_9$	44.53	21.61	42.52	20.81	12.82	0.23	3.39	3.62	56.25
30	$P_4 \times P_{10}$	45.43	20.86	42.92	22.37	13.27	0.28	3.77	4.05	63.52
31	$P_5 \times P_6$	50.63	14.37	54.87	25.61	17.30	0.33	5.63	5.96	78.71
32	$P_5 \times P_7$	51.88	14.08	55.72	25.13	17.03	0.35	5.56	5.90	78.89
33	$P_5 \times P_8$	48.68	17.41	47.21	22.99	14.38	0.27	4.19	4.46	63.61
34	$P_5 \times P_9$	48.33	16.91	47.65	23.23	14.42	0.25	4.19	4.44	64.23
35	$P_5 \times P_{10}$	52.92	14.33	56.22	26.14	17.25	0.35	5.70	6.05	79.66
36	$P_6 \times P_7$	52.93	14.89	55.38	24.36	17.23	0.33	5.58	5.91	78.09
37	$P_6 \times P_8$	48.13	18.43	47.80	20.80	14.82	0.25	4.12	4.37	64.68
38	$P_6 \times P_9$	47.80	17.56	48.34	20.49	15.62	0.25	4.20	4.45	63.64
39	$P_6 \times P_{10}$	52.95	14.67	56.07	24.73	17.07	0.33	5.56	5.88	81.87
40	$P_7 \times P_8$	48.14	18.03	48.09	22.35	13.47	0.27	4.11	4.37	64.38
41	$P_7 \times P_9$	48.11	18.09	46.69	21.99	14.53	0.26	4.12	4.38	61.33
42	$P_7 \times P_{10}$	52.71	15.03	56.08	25.37	17.03	0.34	5.68	6.02	81.88
43	$P_8 \times P_9$	42.12	21.19	42.86	19.00	12.17	0.23	3.33	3.62	49.60
44	$P_8 \times P_{10}$	42.76	20.62	44.74	20.99	13.10	0.22	3.38	3.78	51.44
45	$P_9 \times P_{10}$	43.32	20.80	43.05	21.69	13.57	0.23	3.50	3.88	52.99
F_1 Hybrid mean		**46.28**	**18.87**	**45.56**	**21.24**	**13.99**	**0.25**	**4.00**	**4.26**	**62.19**
Parents										
1	P_1	43.29	16.95	45.38	20.18	11.80	0.20	4.08	4.28	52.59
2	P_2	44.62	21.20	42.01	19.09	12.93	0.18	3.30	3.48	50.73
3	P_3	43.47	21.28	41.00	17.96	12.38	0.17	3.28	3.45	52.32
4	P_4	42.82	21.93	40.93	21.43	12.30	0.19	3.37	3.55	53.30
5	P_5	45.88	16.65	47.88	23.24	14.48	0.24	4.31	4.55	55.80
6	P_6	45.61	16.74	47.06	20.95	14.42	0.22	4.28	4.49	55.04
7	P_7	47.15	16.34	47.12	22.01	14.12	0.24	4.17	4.41	55.55
8	P_8	43.12	21.63	43.73	18.90	11.97	0.20	3.25	3.44	46.94
9	P_9	43.36	21.21	43.00	19.30	13.27	0.22	3.06	3.28	46.78
10	P_{10}	46.97	16.67	47.82	22.15	14.10	0.23	4.39	4.62	60.84
Parental mean		**44.63**	**19.06**	**44.59**	**20.52**	**13.18**	**0.21**	**3.75**	**3.95**	**52.99**
Grand mean		45.98	18.91	45.39	21.11	13.83	0..24	3.96	4.20	60.52
CV		2.13	3.52	3.43	1.24	2.66	5.35	2.82	2.65	4.44
CD 5%		1.58	1.06	2.49	0.42	0.58	0.02	0.17	0.17	4.31
Range	**Lowest**	**42.12**	**40.35**	**40.35**	**17.96**	**11.80**	**0.17**	**3.06**	**3.28**	**46.94**
	Highest	**52.95**	**56.22**	**56.22**	**26.14**	**17.30**	**0.35**	**5.70**	**6.05**	**81.88**