

Evaluation of the performance of parental lines and their F₁ 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 F₁'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 (Y₁) and 2021-22 (Y₂) 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 P₁₀ (60.84 g) exhibited highest green pod yield per plant followed by P₅ (55.80 g). The *per se* performance of crosses *i.e.* P₇ x P₁₀ (81.88 g) followed by P₆ x P₁₀ (81.87 g), P₅ x P₁₀ (79.66 g) and P₅ x P₇ (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.

1. INRODUCTION

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].

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.

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 F₁ 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

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 F₁ hybrids with overall mean 47.89 days of parents and F₁'s. Among the parents, P₅ and P₆ (39.00) exhibited minimum days to 50 % flowering while P₄ (56.00) took maximum days to 50 % flowering. Out of 45 crosses, hybrids which exhibited early days to 50% flowering were P₅ x P₆ (32.50) followed by P₅ x P₇ (32.83) while cross P₄ x P₉ (55.00) took maximum days to 50 % flowering. Similar findings were also reported by Sharma *et al.* [12], Kumar *et al.* [8].

Days to first picking varied from 65.17 to 84.67 days for parents and 56.00 to 83.83 days for F₁ hybrids with overall mean 75.63 days of parents and F₁'s. Among the parents P₅ (65.17 days) exhibited early days to first picking and P₄ (84.67) took maximum days for first picking. Out of 45 crosses, hybrids which exhibited minimum days to first picking were P₅ x

P₆ (56.00) followed by P₅ x P₇ (56.33). Cross P₂ x P₄ (83.83) took maximum days to first picking. Above findings were also reported by Kumar *et al.* [8], Suman *et al.* [19].

Plant height ranged from 63.65 cm to 126.26 cm for parents and 68.6 to 126.05 cm for F₁ hybrids with overall mean 82.68 cm of parents and F₁'s. Among the parents P₅ (63.65 cm) exhibited minimum while, parent P₃ (126.26 cm) exhibited maximum plant height. Out of 45 crosses, F₁ hybrids which exhibited minimum plant height were P₅ x P₈ (68.6 cm) and P₆ x P₈ (70.01 cm) while, maximum plant height was exhibited by crosses P₂ x P₃ (126.05 cm) followed by P₂ x P₁₀ (122.76 cm). These findings are in agreement with Suman *et al.* [19], Kumar *et al.* [8].

Node to first pod appearance ranged from 9.93 to 13.88 for parents and 7.72 to 13.95 for F₁ hybrids with overall mean 12.08 of parents and F₁'s. Among the parents P₇ (9.93) recorded minimum value for node to first pod appearance while P₄ (13.88) exhibited maximum mean value. Out of 45 crosses P₅ x P₇ (7.72) followed by P₅ x P₆ (7.97) recorded minimum, P₂ x P₃ (13.95) followed by P₃ x P₆ (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].

Pod length ranged from 6.28 cm to 8.84 cm for parents and 6.22 to 10.32 cm for F₁ hybrids with overall mean 8.03 cm of parents and F₁ hybrids. Among the parents P₇ (8.84 cm) exhibited maximum pod length and P₂ exhibited minimum pod length (6.28 cm). Among F₁ hybrids, cross P₇ x P₁₀ (10.32 cm) followed by P₆ x P₁₀ (10.14 cm) recorded maximum pod length and cross P₂ x P₄ (6.22 cm) recorded minimum pod length. Above findings were also reported by Shubh and Dhar [18], Kumar *et al.* [8].

Number of pods per plant ranged from 8.52 to 11.32 for parent whereas, 8.12 to 13.25 for F₁ hybrids with overall mean 10.62 of parents and F₁ hybrids. Among the parents the maximum number of pods per plant was recorded in P₃ (11.32) and minimum by P₁ (8.52). In case of F₁ hybrids, crosses P₅ x P₇ (13.25) followed by P₅ x P₆ (13.23) exhibited maximum number of pods per plant and cross P₁ x P₉ (8.12) recorded minimum number of pods per plant. Similar findings were also reported by Suman *et al.* [19], Sharma *et al.* [12].

Protein content ranged from 17.96 to 23.24 % for parents while, 17.88 to 26.14 % for F₁ hybrids with overall mean 21.11% of parents and F₁'s hybrid. Among the parents, maximum protein content was recorded in P₅ (23.24 %) while minimum in P₃ (17.96%). Among the 45 F₁ hybrids, crosses P₅ x P₁₀ (26.14 %) followed by P₅ x P₆ (25.61 %) recorded maximum protein content and cross P₃ x P₈ (17.88 %) recorded minimum protein content. Above findings were also reported by Daheriya [6], Singh *et al.* [15].

Total soluble solids ranged from 11.80 to 14.48 °Brix for parents while, 12.17 to 17.30 °Brix for F₁ hybrids with overall mean 13.83 °Brix of parents and F₁'s hybrid. Among the parents, highest total soluble solids were found in P₅ (14.48 °Brix) and lowest in P₁ (11.80 °Brix). Among F₁'s crosses P₅ x P₆ (17.30 °Brix) followed by P₅ x P₁₀ (17.25 °Brix) exhibited maximum total soluble solids and cross P₈ x P₉ (12.17 °Brix) recorded minimum mean value. Similar findings were also reported by Daheriya [6], Bisht and Singh [3].

Total sugars were ranged from 3.28 to 4.62 % for parents while, 3.35 to 6.05% for F₁ hybrids with overall mean 4.2 % of parents and F₁'s hybrid. Among the parents P₁₀ (4.62%) exhibited maximum total sugars and P₉ (3.28 %) recorded minimum mean value for total sugars. In case of F₁ hybrids, crosses P₅ x P₁₀ (6.05%) followed by P₇ x P₁₀ (6.02%) and P₅ x P₆ (5.96%) exhibited higher total sugars than the general mean and cross P₂ x P₉ (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 F₁ hybrids with overall mean 60.52 g of parents and F₁'s hybrid. Among the parents P₁₀ produced highest green pod yield per plant and P₉ produced minimum green pod yield per plant. Among F₁ hybrids, crosses P₇ x P₁₀ (81.88 g) followed by P₆ x P₁₀ (81.87 g) and P₅ x P₁₀ (79.66 g) produced highest green pod yield per plant than the general mean. Cross P₅ x P₆ (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

From present study it may be concluded that based on *per se* performance, Parents P₅, P₆ P₇ and P₁₀ were identified as superior parents while, five crosses *viz.* P₇ x P₁₀, P₆ x P₁₀, P₅ x P₆, P₅ x P₇ and P₅ x P₁₀ 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 it's 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.

| 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

UNDER PEER REVIEW

Table 2: Mean performance, general mean, range, coefficient of variation and critical difference for Eighteen characters of diallel set of 45 F₁'s and their 10 parents in vegetable pea during overseason pooled

| 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 × P ₂ | 49.67 | 79.33 | 108.32 | 12.88 | 22.79 | 8.12 | 4.03 | 7.70 | 8.24 |
| 2 | P ₁ × P ₃ | 50.33 | 79.17 | 109.18 | 13.30 | 22.29 | 8.19 | 4.07 | 7.67 | 8.29 |
| 3 | P ₁ × P ₄ | 51.67 | 80.17 | 92.99 | 13.58 | 24.17 | 8.21 | 4.06 | 8.15 | 8.37 |
| 4 | P ₁ × P ₅ | 45.50 | 73.83 | 81.19 | 11.22 | 21.24 | 9.42 | 4.48 | 9.22 | 11.67 |
| 5 | P ₁ × P ₆ | 45.17 | 73.83 | 82.69 | 11.18 | 22.17 | 9.34 | 4.47 | 9.18 | 12.14 |
| 6 | P ₁ × P ₇ | 45.50 | 73.67 | 85.42 | 11.22 | 21.98 | 9.23 | 4.47 | 9.02 | 11.26 |
| 7 | P ₁ × P ₈ | 49.67 | 78.67 | 80.32 | 13.45 | 22.70 | 8.15 | 4.06 | 8.17 | 8.16 |
| 8 | P ₁ × P ₉ | 50.00 | 79.17 | 81.92 | 12.73 | 22.10 | 8.20 | 4.05 | 8.15 | 8.12 |
| 9 | P ₁ × P ₁₀ | 45.50 | 74.00 | 80.57 | 11.23 | 20.85 | 9.45 | 4.48 | 9.22 | 11.59 |
| 10 | P ₂ × P ₃ | 53.33 | 82.50 | 126.05 | 13.95 | 23.87 | 6.33 | 3.70 | 6.15 | 10.34 |
| 11 | P ₂ × P ₄ | 54.33 | 83.83 | 121.44 | 13.45 | 23.82 | 6.22 | 3.76 | 6.15 | 11.12 |
| 12 | P ₂ × P ₅ | 50.83 | 79.83 | 120.21 | 13.02 | 21.78 | 6.95 | 3.81 | 7.25 | 12.01 |
| 13 | P ₂ × P ₆ | 51.33 | 80.17 | 119.61 | 12.87 | 21.27 | 6.85 | 3.82 | 7.30 | 11.10 |
| 14 | P ₂ × P ₇ | 50.67 | 79.67 | 121.38 | 12.88 | 22.70 | 6.89 | 3.82 | 7.28 | 11.93 |
| 15 | P ₂ × P ₈ | 54.17 | 83.17 | 121.17 | 13.60 | 23.67 | 6.25 | 3.63 | 6.23 | 10.15 |
| 16 | P ₂ × P ₉ | 53.17 | 81.83 | 120.65 | 13.37 | 24.14 | 6.30 | 3.68 | 6.07 | 10.17 |
| 17 | P ₂ × P ₁₀ | 49.33 | 80.33 | 122.76 | 12.93 | 22.40 | 6.87 | 3.76 | 7.30 | 12.02 |
| 18 | P ₃ × P ₄ | 54.33 | 83.50 | 118.60 | 13.38 | 25.40 | 7.08 | 3.58 | 6.38 | 11.68 |
| 19 | P ₃ × P ₅ | 50.17 | 80.17 | 121.23 | 12.93 | 23.14 | 7.66 | 3.81 | 7.27 | 11.99 |
| 20 | P ₃ × P ₆ | 50.33 | 79.83 | 119.00 | 13.80 | 22.67 | 7.74 | 3.82 | 7.20 | 11.38 |
| 21 | P ₃ × P ₇ | 50.17 | 79.17 | 120.05 | 12.87 | 24.24 | 7.84 | 3.82 | 7.12 | 11.97 |
| 22 | P ₃ × P ₈ | 53.67 | 83.00 | 118.89 | 13.35 | 23.87 | 7.16 | 3.67 | 6.08 | 10.48 |
| 23 | P ₃ × P ₉ | 53.50 | 82.50 | 120.30 | 13.27 | 24.54 | 7.18 | 3.68 | 6.12 | 10.73 |
| 24 | P ₃ × P ₁₀ | 50.33 | 78.83 | 118.84 | 12.87 | 23.64 | 7.74 | 3.84 | 7.25 | 11.77 |
| 25 | P ₄ × P ₅ | 53.17 | 82.17 | 91.21 | 12.95 | 23.60 | 7.66 | 3.76 | 7.68 | 12.08 |
| 26 | P ₄ × P ₆ | 52.83 | 82.17 | 89.30 | 13.00 | 23.07 | 7.69 | 3.79 | 7.63 | 12.00 |
| 27 | P ₄ × P ₇ | 52.00 | 82.00 | 93.57 | 12.90 | 24.57 | 7.83 | 3.83 | 7.82 | 11.87 |
| 28 | P ₄ × P ₈ | 54.50 | 83.50 | 86.87 | 13.52 | 24.04 | 7.21 | 3.66 | 6.52 | 11.28 |
| 29 | P ₄ × P ₉ | 55.00 | 83.33 | 88.95 | 13.37 | 23.14 | 7.20 | 3.73 | 6.45 | 11.38 |
| 30 | P ₄ × P ₁₀ | 51.83 | 81.67 | 89.35 | 12.77 | 24.27 | 7.76 | 3.81 | 7.87 | 12.03 |
| 31 | P ₅ × P ₆ | 32.50 | 56.00 | 75.34 | 7.97 | 19.45 | 9.96 | 4.61 | 9.93 | 13.23 |
| 32 | P ₅ × P ₇ | 32.83 | 56.33 | 73.28 | 7.72 | 19.03 | 9.98 | 4.56 | 9.95 | 13.25 |
| 33 | P ₅ × P ₈ | 43.67 | 70.83 | 68.60 | 11.58 | 18.18 | 8.41 | 4.11 | 8.30 | 9.19 |
| 34 | P ₅ × P ₉ | 43.33 | 71.17 | 70.42 | 11.17 | 18.47 | 8.38 | 4.12 | 8.28 | 9.30 |
| 35 | P ₅ × P ₁₀ | 34.83 | 57.17 | 73.61 | 8.07 | 19.17 | 9.99 | 4.59 | 10.02 | 13.16 |
| 36 | P ₆ × P ₇ | 33.67 | 57.00 | 74.02 | 8.05 | 19.04 | 10.13 | 4.58 | 10.18 | 13.15 |
| 37 | P ₆ × P ₈ | 44.50 | 72.00 | 70.01 | 11.88 | 19.40 | 8.38 | 4.08 | 8.38 | 8.77 |
| 38 | P ₆ × P ₉ | 43.67 | 72.00 | 70.82 | 11.77 | 19.54 | 8.43 | 4.03 | 8.26 | 8.57 |
| 39 | P ₆ × P ₁₀ | 34.83 | 57.50 | 73.11 | 8.05 | 20.40 | 10.14 | 4.59 | 10.17 | 12.87 |
| 40 | P ₇ × P ₈ | 44.33 | 72.00 | 70.83 | 11.97 | 19.41 | 8.48 | 4.10 | 8.35 | 8.87 |
| 41 | P ₇ × P ₉ | 44.67 | 72.17 | 72.26 | 11.82 | 18.24 | 8.50 | 4.18 | 8.38 | 8.90 |
| 42 | P ₇ × P ₁₀ | 35.17 | 58.17 | 74.09 | 8.33 | 19.88 | 10.32 | 4.62 | 10.27 | 12.86 |
| 43 | P ₈ × P ₉ | 54.33 | 83.17 | 68.68 | 12.93 | 19.91 | 7.38 | 3.65 | 6.08 | 8.91 |
| 44 | P ₈ × P ₁₀ | 52.00 | 80.67 | 70.57 | 13.00 | 21.70 | 7.56 | 3.62 | 6.55 | 9.01 |
| 45 | P ₉ × P ₁₀ | 50.83 | 79.67 | 71.30 | 12.85 | 21.90 | 8.01 | 3.66 | 7.07 | 9.65 |
| F₁ 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 (^o Brix) | Reducing sugars (%) | Non reducing sugar (%) | Total sugars (%) | Green pod yield/plant (g) |
|----------------------------------|----------------------------------|-------------------------|---------------------|---------------------------|---------------------|---|---------------------|------------------------|------------------|---------------------------|
| 1 | P ₁ × P ₂ | 43.91 | 18.58 | 42.25 | 19.95 | 12.77 | 0.21 | 3.81 | 4.02 | 49.11 |
| 2 | P ₁ × P ₃ | 44.50 | 18.73 | 43.06 | 19.15 | 12.20 | 0.19 | 3.88 | 4.07 | 49.58 |
| 3 | P ₁ × P ₄ | 44.03 | 19.02 | 43.23 | 20.51 | 12.75 | 0.21 | 3.54 | 3.75 | 54.12 |
| 4 | P ₁ × P ₅ | 46.66 | 15.69 | 46.54 | 22.42 | 14.48 | 0.25 | 4.66 | 4.91 | 72.55 |
| 5 | P ₁ × P ₆ | 45.61 | 15.70 | 46.90 | 20.40 | 14.65 | 0.21 | 4.50 | 4.71 | 73.47 |
| 6 | P ₁ × P ₇ | 46.09 | 15.67 | 47.89 | 21.16 | 13.78 | 0.28 | 4.37 | 4.65 | 72.49 |
| 7 | P ₁ × P ₈ | 44.04 | 18.61 | 43.15 | 19.04 | 12.57 | 0.23 | 3.98 | 4.20 | 50.97 |
| 8 | P ₁ × P ₉ | 44.39 | 17.88 | 42.88 | 19.17 | 12.75 | 0.23 | 4.09 | 4.32 | 52.88 |
| 9 | P ₁ × P ₁₀ | 46.42 | 15.86 | 46.85 | 22.38 | 14.95 | 0.27 | 4.33 | 4.60 | 69.82 |
| 10 | P ₂ × P ₃ | 45.01 | 21.53 | 40.75 | 18.87 | 12.58 | 0.20 | 3.39 | 3.59 | 50.73 |
| 11 | P ₂ × P ₄ | 43.62 | 21.43 | 41.29 | 20.46 | 12.57 | 0.21 | 3.20 | 3.41 | 52.73 |
| 12 | P ₂ × P ₅ | 45.87 | 20.11 | 43.54 | 21.57 | 14.05 | 0.23 | 3.50 | 3.73 | 63.62 |
| 13 | P ₂ × P ₆ | 45.73 | 20.05 | 43.91 | 20.22 | 14.57 | 0.21 | 3.52 | 3.72 | 62.15 |
| 14 | P ₂ × P ₇ | 45.92 | 19.99 | 43.72 | 20.74 | 13.65 | 0.24 | 3.87 | 4.11 | 63.23 |
| 15 | P ₂ × P ₈ | 44.90 | 21.56 | 42.69 | 18.66 | 12.22 | 0.21 | 3.33 | 3.54 | 51.98 |
| 16 | P ₂ × P ₉ | 45.62 | 20.78 | 41.90 | 19.11 | 12.68 | 0.22 | 3.13 | 3.35 | 51.99 |
| 17 | P ₂ × P ₁₀ | 45.59 | 20.08 | 43.20 | 21.58 | 13.27 | 0.24 | 3.59 | 3.83 | 63.73 |
| 18 | P ₃ × P ₄ | 43.80 | 20.97 | 40.35 | 19.07 | 12.42 | 0.21 | 3.42 | 3.63 | 59.15 |
| 19 | P ₃ × P ₅ | 44.59 | 20.07 | 42.76 | 19.47 | 14.18 | 0.22 | 3.71 | 3.93 | 63.39 |
| 20 | P ₃ × P ₆ | 44.98 | 20.08 | 43.03 | 19.09 | 13.92 | 0.22 | 3.74 | 3.95 | 60.61 |
| 21 | P ₃ × P ₇ | 45.04 | 20.12 | 43.33 | 20.21 | 13.27 | 0.24 | 3.68 | 3.92 | 63.70 |
| 22 | P ₃ × P ₈ | 44.97 | 21.54 | 42.21 | 17.88 | 12.95 | 0.22 | 3.35 | 3.57 | 51.12 |
| 23 | P ₃ × P ₉ | 44.69 | 21.40 | 42.75 | 18.48 | 13.40 | 0.23 | 3.25 | 3.48 | 53.54 |
| 24 | P ₃ × P ₁₀ | 45.85 | 20.11 | 43.57 | 20.57 | 13.70 | 0.24 | 3.78 | 4.02 | 64.01 |
| 25 | P ₄ × P ₅ | 45.07 | 20.88 | 42.87 | 23.06 | 14.13 | 0.27 | 3.77 | 4.03 | 63.97 |
| 26 | P ₄ × P ₆ | 45.73 | 20.96 | 43.70 | 21.19 | 13.93 | 0.27 | 3.68 | 3.94 | 62.99 |
| 27 | P ₄ × P ₇ | 45.22 | 20.89 | 43.37 | 22.22 | 13.35 | 0.27 | 3.78 | 4.04 | 63.38 |
| 28 | P ₄ × P ₈ | 43.55 | 21.80 | 42.37 | 21.19 | 12.55 | 0.25 | 3.26 | 3.50 | 52.90 |
| 29 | P ₄ × P ₉ | 44.53 | 21.61 | 42.52 | 20.81 | 12.82 | 0.23 | 3.39 | 3.62 | 56.25 |
| 30 | P ₄ × P ₁₀ | 45.43 | 20.86 | 42.92 | 22.37 | 13.27 | 0.28 | 3.77 | 4.05 | 63.52 |
| 31 | P ₅ × P ₆ | 50.63 | 14.37 | 54.87 | 25.61 | 17.30 | 0.33 | 5.63 | 5.96 | 78.71 |
| 32 | P ₅ × P ₇ | 51.88 | 14.08 | 55.72 | 25.13 | 17.03 | 0.35 | 5.56 | 5.90 | 78.89 |
| 33 | P ₅ × P ₈ | 48.68 | 17.41 | 47.21 | 22.99 | 14.38 | 0.27 | 4.19 | 4.46 | 63.61 |
| 34 | P ₅ × P ₉ | 48.33 | 16.91 | 47.65 | 23.23 | 14.42 | 0.25 | 4.19 | 4.44 | 64.23 |
| 35 | P ₅ × P ₁₀ | 52.92 | 14.33 | 56.22 | 26.14 | 17.25 | 0.35 | 5.70 | 6.05 | 79.66 |
| 36 | P ₆ × P ₇ | 52.93 | 14.89 | 55.38 | 24.36 | 17.23 | 0.33 | 5.58 | 5.91 | 78.09 |
| 37 | P ₆ × P ₈ | 48.13 | 18.43 | 47.80 | 20.80 | 14.82 | 0.25 | 4.12 | 4.37 | 64.68 |
| 38 | P ₆ × P ₉ | 47.80 | 17.56 | 48.34 | 20.49 | 15.62 | 0.25 | 4.20 | 4.45 | 63.64 |
| 39 | P ₆ × P ₁₀ | 52.95 | 14.67 | 56.07 | 24.73 | 17.07 | 0.33 | 5.56 | 5.88 | 81.87 |
| 40 | P ₇ × P ₈ | 48.14 | 18.03 | 48.09 | 22.35 | 13.47 | 0.27 | 4.11 | 4.37 | 64.38 |
| 41 | P ₇ × P ₉ | 48.11 | 18.09 | 46.69 | 21.99 | 14.53 | 0.26 | 4.12 | 4.38 | 61.33 |
| 42 | P ₇ × P ₁₀ | 52.71 | 15.03 | 56.08 | 25.37 | 17.03 | 0.34 | 5.68 | 6.02 | 81.88 |
| 43 | P ₈ × P ₉ | 42.12 | 21.19 | 42.86 | 19.00 | 12.17 | 0.23 | 3.33 | 3.62 | 49.60 |
| 44 | P ₈ × P ₁₀ | 42.76 | 20.62 | 44.74 | 20.99 | 13.10 | 0.22 | 3.38 | 3.78 | 51.44 |
| 45 | P ₉ × P ₁₀ | 43.32 | 20.80 | 43.05 | 21.69 | 13.57 | 0.23 | 3.50 | 3.88 | 52.99 |
| F₁ 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 |