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RESEARCH ARTICLE

Mean performance and *per se* evaluation of biparental progenies of dolichos bean (*Lablab purpureus* (L.)) for quantitative, yield and yield-related traits

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Abstract

The study was conducted collaboratively by the Indian Institute of Horticultural Research (ICAR-CHES) and the Department of Vegetable Science at Odisha University of Agriculture and Technology (OUAT), Bhubaneswar, with the objective of enhancing yield in lablab bean (*Lablab purpureus* L.), an important legume vegetable. A total of 32 biparental progenies were evaluated in randomized block design with 3 replications for a comprehensive set of traits directly influencing pod and seed production. The results revealed significant variation among the progeny lines across all measured characteristics. Key growth phases, such as days to first germination (2–5 days) and days to first harvest (64–112 days), varied widely, identifying lines suitable for shorter cropping cycles. Important structural components like stem diameter, branch number and inflorescence count also showed considerable variation, indicating differences in plant architecture. Crucially, yield-related traits exhibited a broad range: pod number per plant (36–185), individual pod weight and seed characteristics like size and 100-seed weight (19.36–43.31 g). This directly translated to a wide spectrum of pod yield per plant, with the top-performing line, BP-12, yielding 1120.00 g. The extensive genetic variability observed confirms that the breeding process successfully generated a valuable pool of diverse genetic material. Promising lines, including BP-1, BP-12, BP-21 and BP-18, which excelled in multiple yield attributes, have been identified for further evaluation. The selection of these superior biparental progenies is expected to produce individuals with yields in the subsequent generations.

Keywords: biparental progenies; dolichos beans; lablab bean; mean performance

Introduction

Legumes occupy a unique position in global agriculture due to their dual role in human nutrition and soil fertility. They are characterised by a high protein content (18–40 %), a substantial starch component (60–67 %) and the ability to biologically fix atmospheric nitrogen, with reported rates of up to 200 kg per hectare (1). In many developing regions, including South Asia, sub-Saharan Africa, Latin America and Central Asia, legumes serve as a primary source of dietary protein (2). Their amino acid profile is particularly valuable, being rich in lysine-an essential amino acid that is typically limiting in cereal-based diets. This complementary relationship makes legumes crucial for achieving balanced nutrition. Despite their well-documented benefits for dietary health and sustainable soil management through nitrogen fixation, significant improvements in the production and productivity of legume crops, particularly in India, remain a persistent challenge.

Among leguminous crops, the lablab bean (*Lablab purpureus* (L.), 2n=2x=22) is a prominent vegetable of economic and nutritional importance. Known variously as Indian bean, hyacinth bean, sem or avarai, belongs to the family Fabaceae. While its origin is often attributed to the Indian subcontinent (3), some studies propose Ethiopia and broader Africa as primary centres of diversity (4). In India, it is cultivated extensively in the eastern, north-eastern and southern regions. The crop is versatile, grown for its tender pods and green seeds as vegetables and for its dry seeds as a pulse.

It is considered a multipurpose crop, serving as forage, a cover crop for weed control and soil protection and a key component in soil improvement strategies due to its nitrogen-fixing ability (5). Consumption patterns exhibit strong regional preferences; in Southern India, the seeds are preferred, whereas in Eastern and Northeastern states like Odisha, West Bengal and Bihar, tender pods are consumed as a vegetable.

In the context of climate change, lablab bean offers considerable agronomic promise due to its inherent drought tolerance and capacity to enhance soil fertility. However, its full genetic potential as a dual-purpose vegetable and pulse crop remains largely untapped. A critical step towards its improvement is the expansion of its genetic base through the inclusion of diverse genotypes with economically valuable traits. Consequently, focused breeding efforts are essential. Priority must be given to developing high-yielding, short-duration and early-maturing cultivars. For vegetable purposes, selections should emphasise prolific bearing, fleshy pods with less bold seeds. Additionally, the development of photo-insensitive varieties would allow for wider adaptability and extended growing seasons.

Mean performance studies in biparental progenies provide valuable insights into variability among the biparental progenies. Therefore, strategic research and breeding initiatives aimed at harnessing the genetic diversity of lablab bean are imperative. The development of improved varieties with these targeted traits will enhance crop productivity, increase farm profitability and contribute to sustainable agricultural systems, ultimately augmenting the income of farmers and strengthening food security.

The biparental mating approach has therefore been followed in the present investigation to evaluate the biparental progenies for yield and other quantitative traits and selection of superior progenies based on their *per se* performance.

Materials and Methods

A brief description of the materials and methods employed to study mean performance, *per se* performance, yield and yield-attributing traits in dolichos bean is presented.

Location of the experiment

The experiment was carried out at Central Horticultural Experiment Station (CHES), ICAR-IIHR, Aiginia, Bhubaneswar, Odisha, India. The soils of the experimental site were of a red laterite type, slightly acidic, with a low water-holding capacity and poor nutrient status.

Experimental material and mating design

In the F_3 generation, biparental mating was carried out using 2 sets of 4 male and 4 female parents. The crosses were performed with 4 randomly selected males and females in 2 sets. In each set, each female was crossed with all the males. The evaluation of the 32 biparental progenies was carried out for quantitative characters in randomized block design with 3 replications.

Season and year of the experiment

The crosses for the bi parental progenies were made during rabi 2023–24. The biparental progenies were grown during rabi 2024–25. The seeds were sown in the last week of September to the first week of October in 2024–25.

Experimental design

The 32 biparental progenies were laid out in a randomized block design with 3 replications. The seeds were sown at 90 x 60 cm spacing. The spacing between 2 plants was more than the recommended spacing to facilitate the easy observation of individual progeny plants. Otherwise, the closer spacing leads to the twining of the vines of adjacent plants and obstructs the observations on each plant. The soil was red laterite soil where irrigation was given in alternate days.

Statistical analyses

Smith and Hazel selection index was performed to find out the superior biparental progenies based on the *per se* performance of characters exhibiting significant variation (6). The analysis was carried out using R-open source statistical software.

Observations recorded

1. **Days to germination:** The days to germination were measured by the number of days seeds took to germinate from the date of sowing.
2. **Stem diameter (mm):** Stem diameter was measured as the diameter of the main stem at the time of final harvest above or near the collar region of the stem, where the stem girth was maximum. It was measured by using a vernier calliper and the measurement was expressed in millimetre (mm).
3. **Primary branches per plant:** The total number of primary branches arising from the main axis was recorded at the time of final harvest.
4. **Number of inflorescences per plant:** The number of racemes/ inflorescences produced was counted from the start till the last harvest.
5. **Number of flowers in per florescence:** The number of individual florets present in individual inflorescences or racemes was counted.
6. **Days to first flowering:** Days to first flowering were calculated from the date of sowing to the first inflorescence/ racemes that appeared in the vine.
7. **Days to first harvest:** The number of days taken from the date of sowing to the date of first picking of the marketable pods was counted**.**
8. **Pod length (cm):** The length of 10 random pods was measured, average was computed and expressed in centimetres (cm).
9. **Pod width (cm):** The width of 10 random pods was measured, average was computed and expressed in centimetres (cm).
10. **Pod girth (cm):** The girth of 10 randomly selected pods was measured at full maturity stage and expressed in centimetres (cm).
11. **Number of pods per plant:** The total number of green pods from each plant at each harvesting was counted and summed up to obtain the total number of pods per plant.
12. **Pod yield per plant:** The weight of the edible mature green tender pods was measured at every harvest and summed up to get the total yield per plant.
13. **Number of seeds per pod:** The number of seeds from 10 pods from each plant was counted and the average seeds per pod was calculated.

14. **Seed length (mm):** The length of the 10 seeds was measured in millimetre with the help of a vernier-calipers.
15. **Seed width (mm):** The width of the 10 seeds was measured in millimetre with the help of a vernier-calipers.
16. **Seed thickness (mm):** The width of the 10 seeds was measured in millimetres with the help of a vernier-calipers.
17. **Hundred seed weight (g):** One hundred seeds were collected at random from each plant and weighed on a digital balance. The average of seed weight was noted as the test weight or the weight of 100 seeds in grams.
18. **Shelling percentage:** Shelling percentage was calculated by taking the total weight of dry pods per plant and the total weight of seed from these pods by following the formula:

$$\text{Shelling percentage} = \frac{\text{Weight of dry seeds}}{\text{Total weight of dry pods}} \times 100 \qquad \text{(Eqn. 1)}$$

19. **Pod fresh weight (g):** The fresh pods were weighed by physical balance and the average pod weight was measured for each progeny and expressed in grams.
20. **Pod dry weight (g):** Ten random pods from each plant from each replication were taken for evaluation. The oven-dry pods were weighed by a physical balance and average dry pod weight was expressed in grams.

Results

Mean performance of BPM progenies for various quantitative characters

Mean performance of 32 biparental progenies developed through NCD-II was evaluated. The mean performance with standard error (S.E.) for different biparental progenies are given herein bar graph for individual parameters.

Days to germination (DG)

The data presented in Fig. 1. showed a distinct variation for the days taken for germination among the progenies. A wide range of variation was observed from 2–5 days for germination. Early germination (2 days) was observed in BP-15 and BP-30, whereas late germination (5 days) was observed for BP-19, BP-25 and BP-27.

Stem diameter (SD)

The thickness of the stem diameter was measured by digital vernier calliper, where the highest value (14.78 mm) was observed for BP-5, followed by BP-31 and BP-3. Lower value was observed for BP-12 (8.33 mm) followed by BP-27 and BP-1 (Fig. 2).

Number of primary branches plant^{-1}

The biparental progenies had 5 primary branches being highest were BP-10, BP-21 and BP- 29 whereas, BP-2, BP-5, BP-9, BP-12, BP-16, BP-18 and BP-27 had 2 primary branches being lowest among the 32 biparental progenies (Fig. 3).

Number of inflorescences plant^{-1}

Three biparental progenies showed the highest value (43 inflorescences per plant) for the number of inflorescences per plant, viz. BP-3, BP-24 and BP-26 whereas the lowest values (18 numbers) were observed for 2 progenies, i.e. BP-9 and BP-31 (Fig. 4).

Number of flowers per inflorescence

Among 32 biparental progenies, the highest and lowest values were observed for 2 progenies (Fig. 5), each with a wide range of variation, with values ranging from 3–12 flowers per inflorescences. BP-6 and BP-31 showed the lowest number of flowers per inflorescence, i.e. 3 flowers, whereas, highest number of flowers per inflorescence was observed for BP-9 and BP-15.

Days to first flowering

A wide range of variation was recorded for days to first flowering (Fig. 6), where BP-7 showed the highest value, i.e. 84 days, being a late flowering type followed by BP-24 and BP-26 (64 days each) and the lowest value being and early flowering type with 37 days taken for first flowering was recorded for BP-10 followed by BP-6 and BP-14 (38 days).

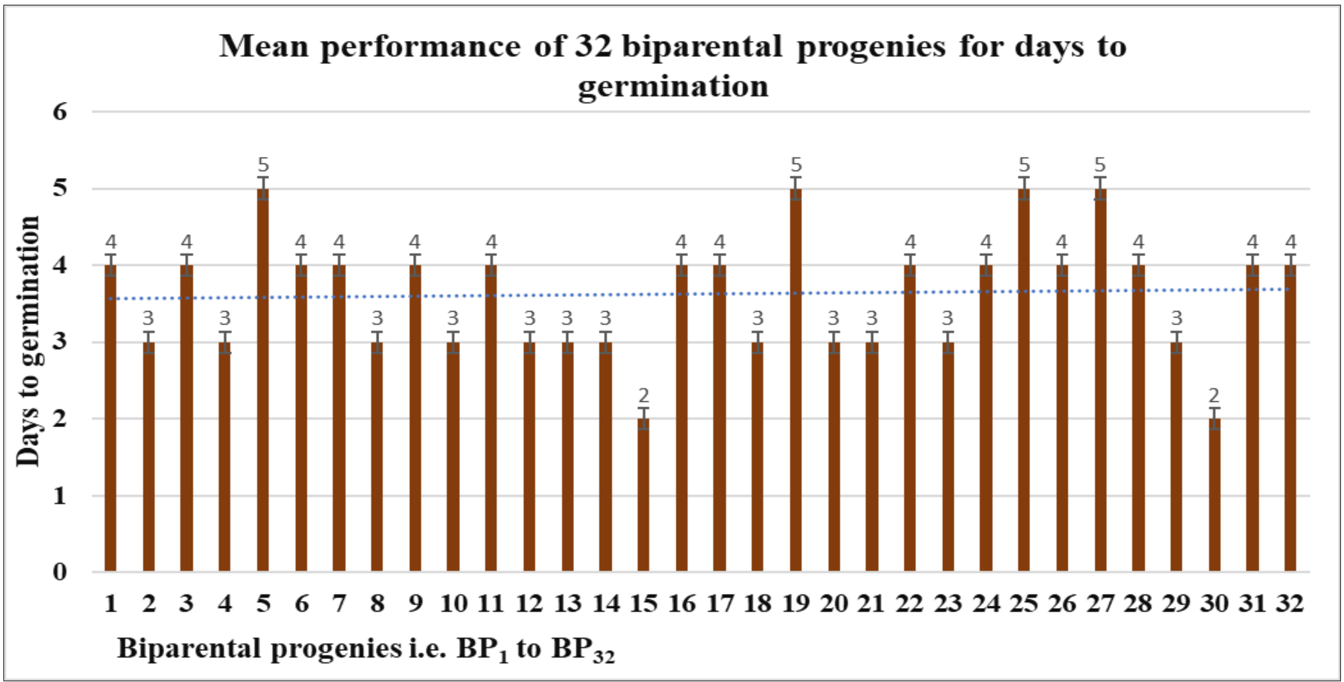

Fig. 1. Mean performance of biparental progenies for days to germination.

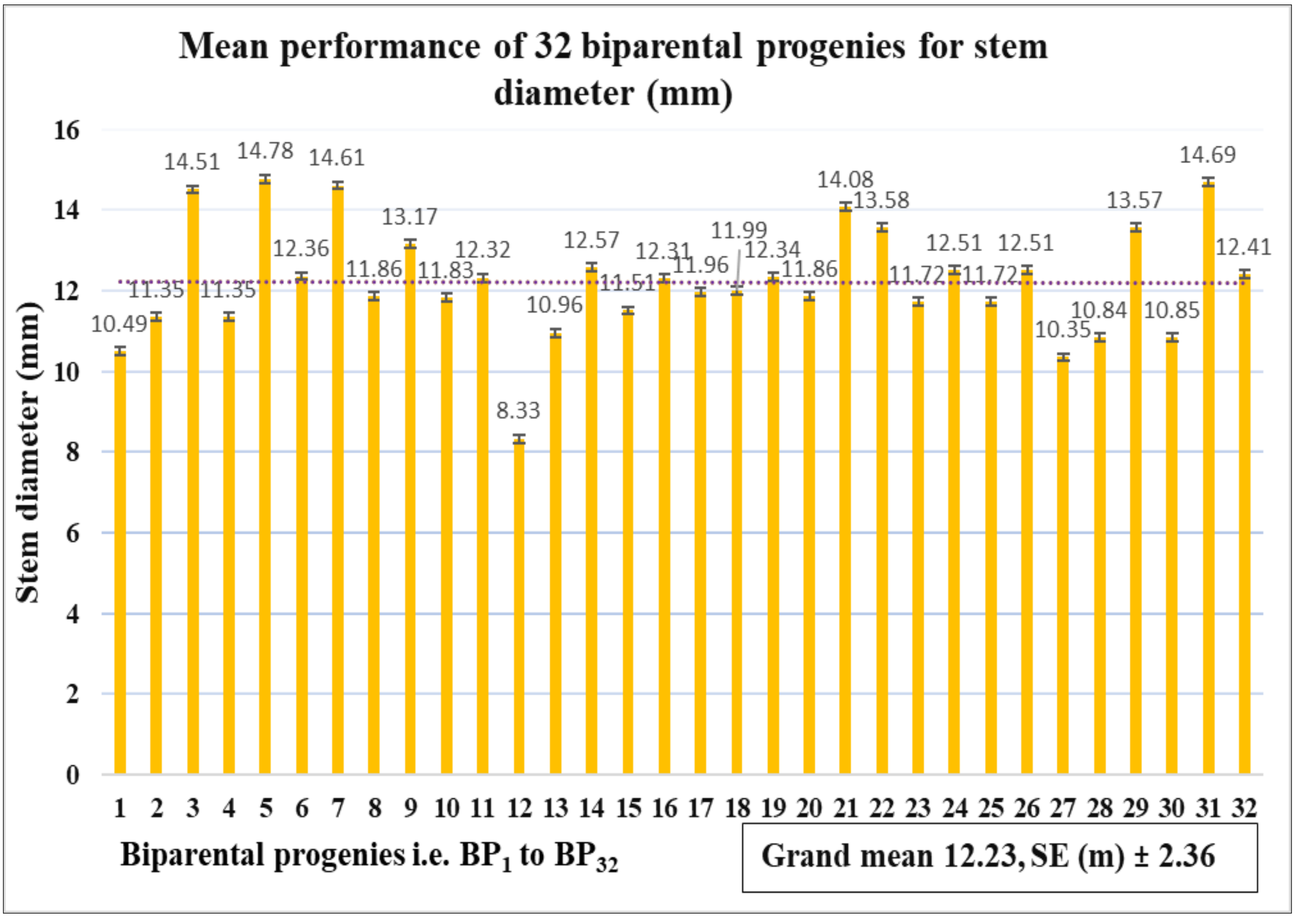

Fig. 2. Mean performance of biparental progenies for stem diameter (mm).

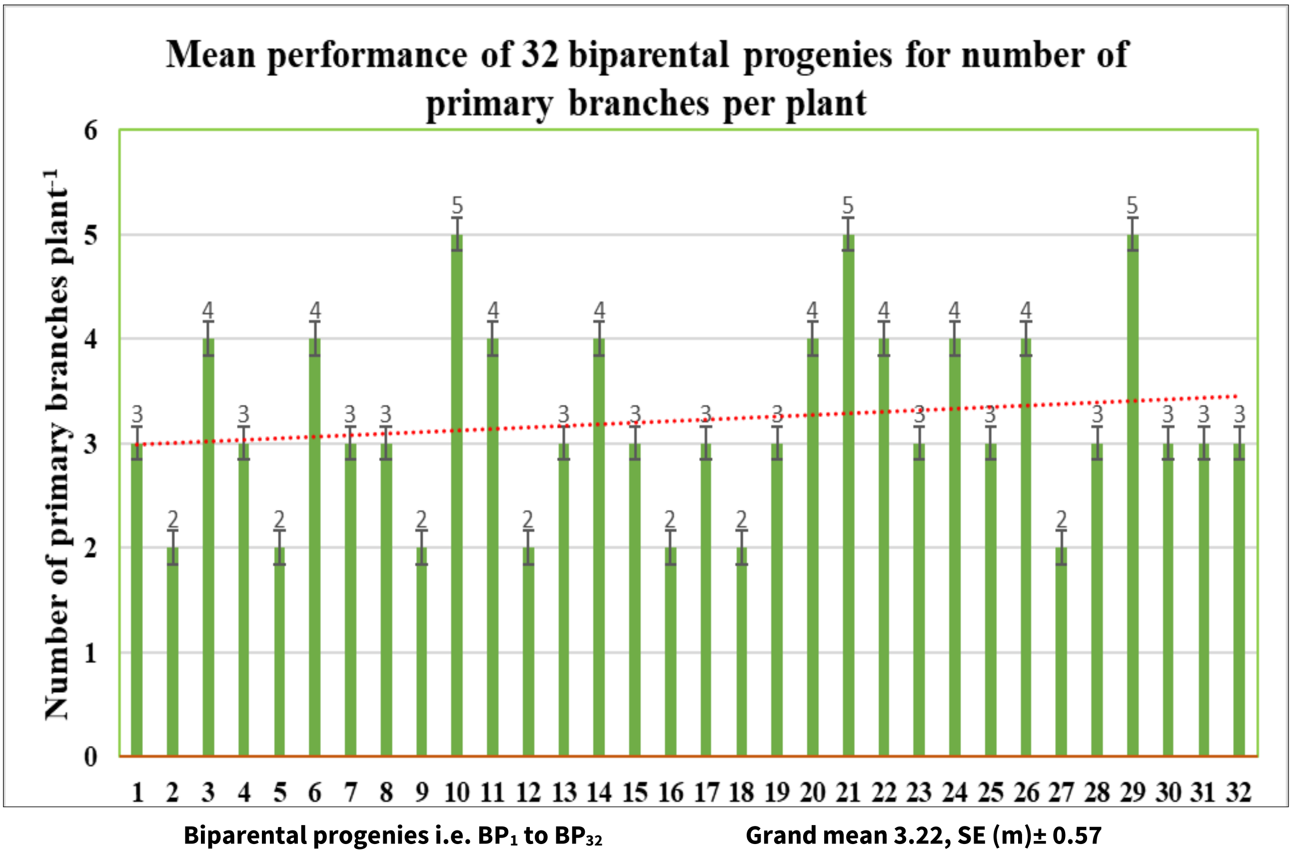

Fig. 3. Mean performance of biparental progenies for number of primary branches per plant.

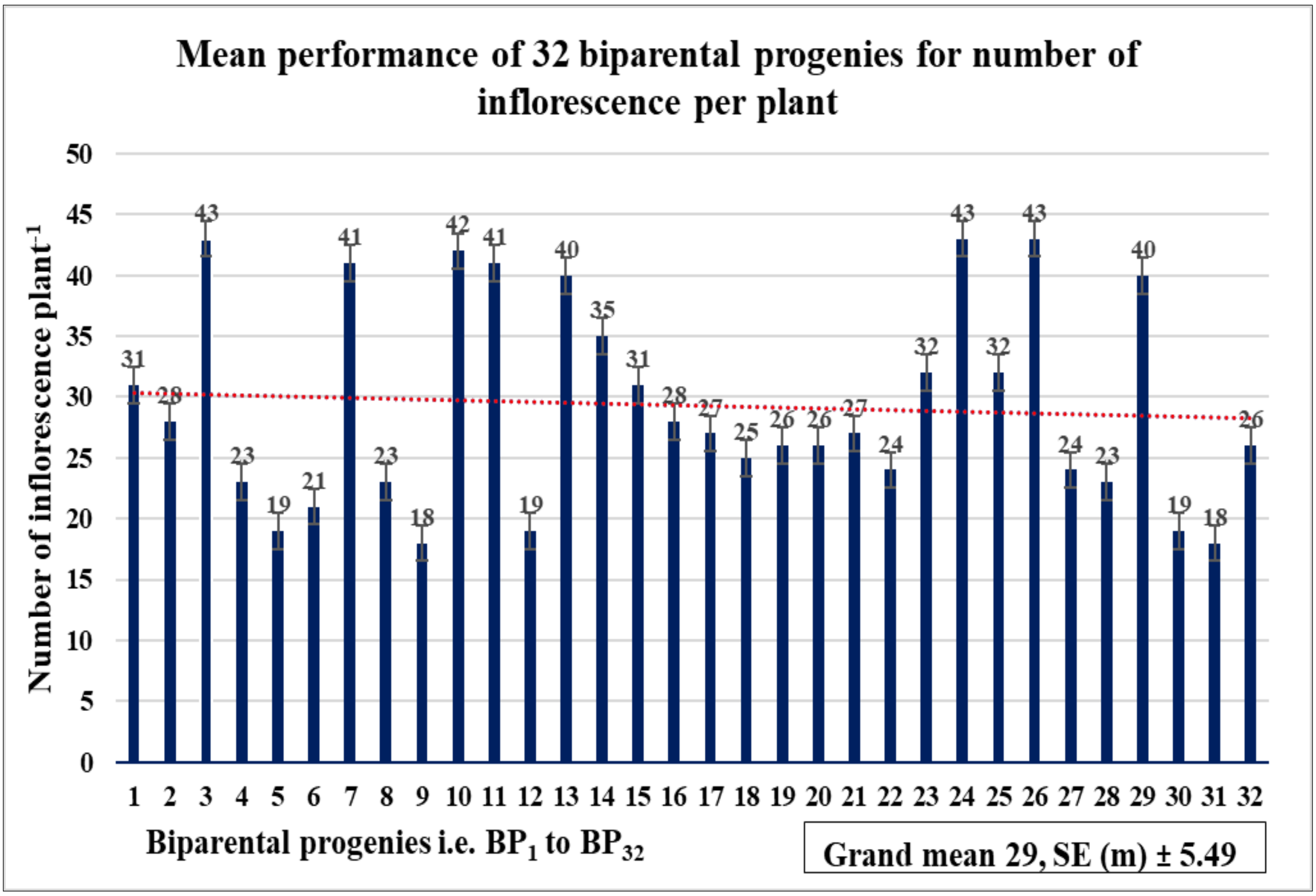

Fig. 4. Mean performance of biparental progenies for number of inflorescences per plant.

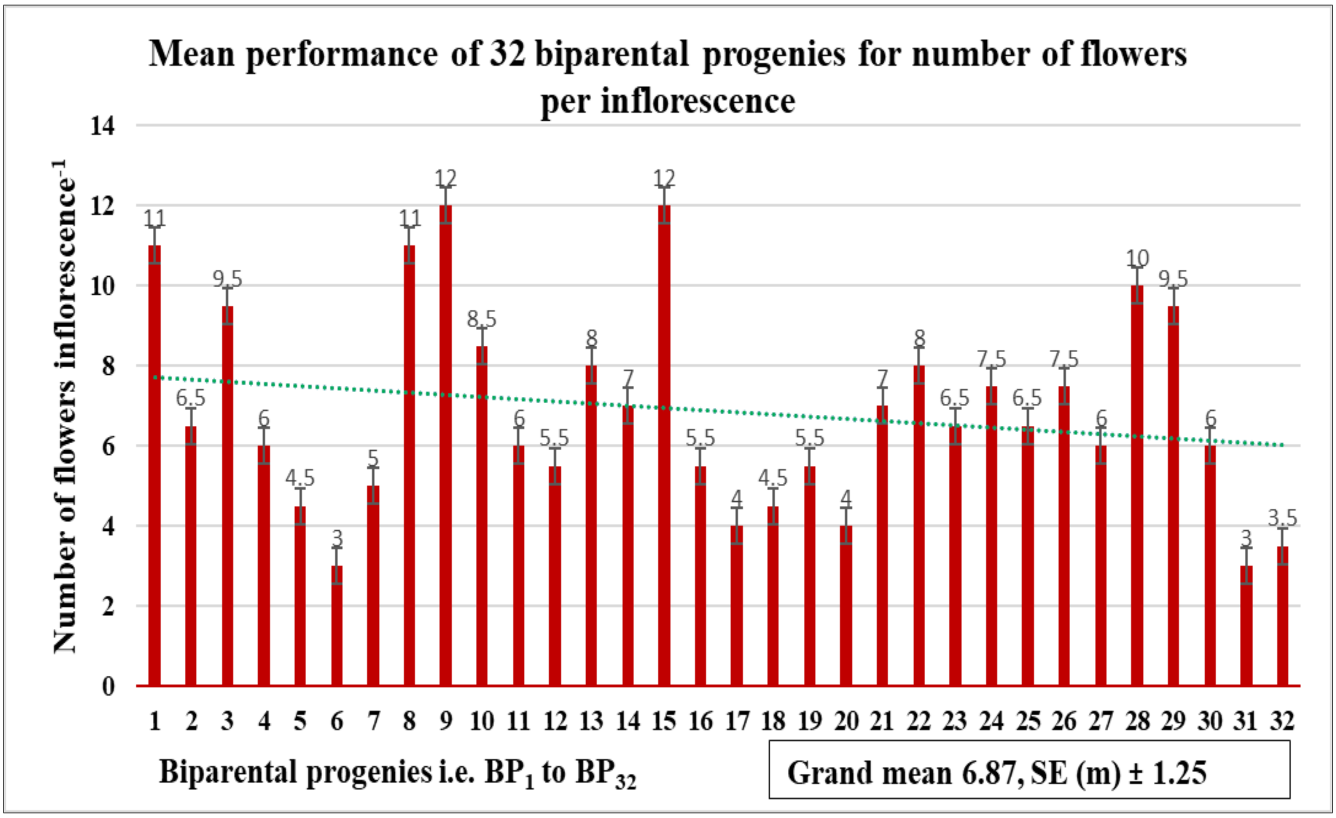

Fig. 5. Mean performance of biparental progenies for number of flowers per inflorescence.

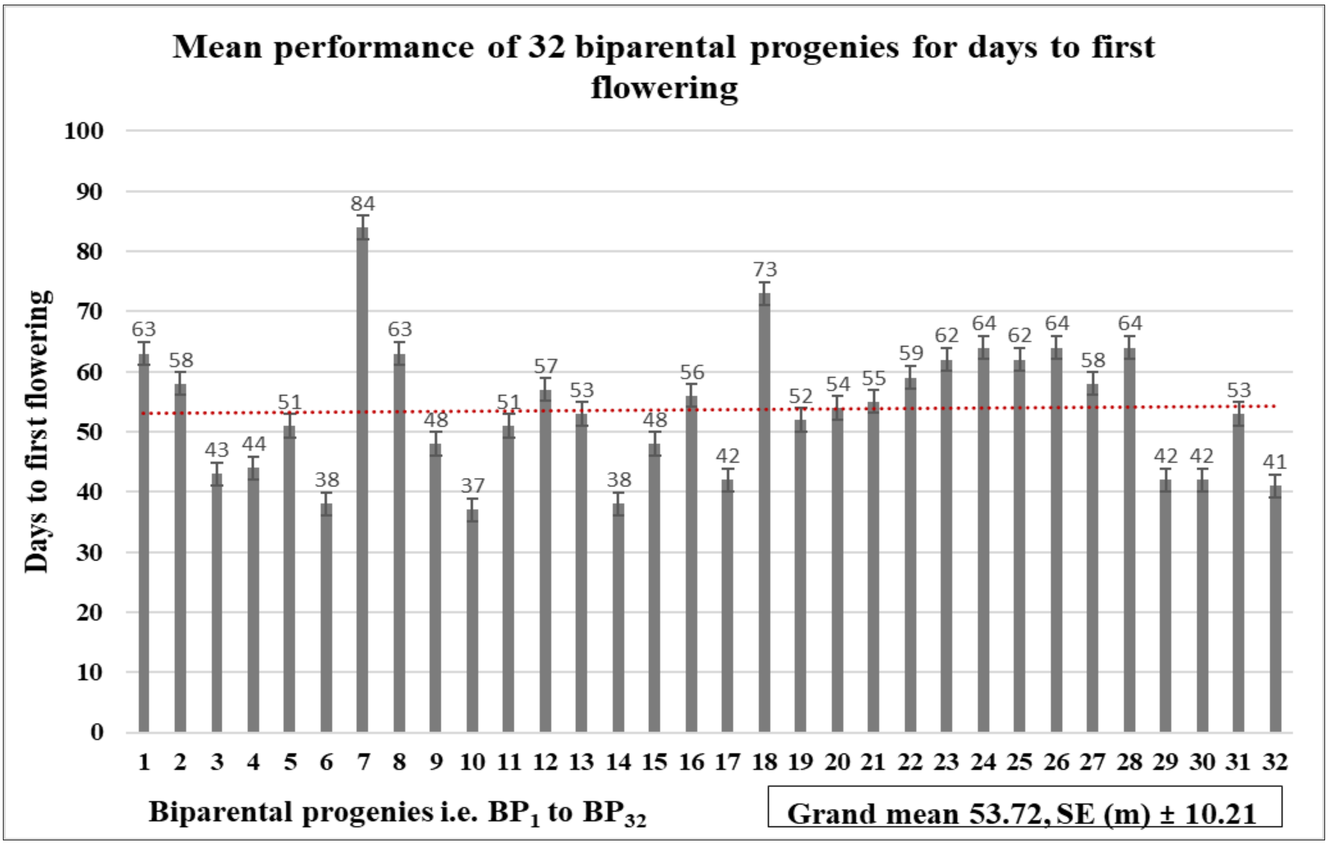

Fig. 6. Mean performance of biparental progenies for days to first flowering.

Days to first harvest

The biparental progeny showed the same result as that of days to first flowering (Fig. 7), where BP-10 and BP-30 flowered early (64 days) and the highest days taken for flowering was recorded in BP-7 (112 days) followed by BP-18 (111 days) and BP-28 (90 days) among the 32 biparental progenies.

Pod length

A wide variation was seen for the pod length (Fig. 8), where BP-14 recorded long pod (12.60 cm) followed by 2 biparental progenies viz. BP-5 and BP-31 with 12.40 cm long pod each, whereas lowest value (8.00 cm) was noted for BP-8 and BP-28, being the shortest.

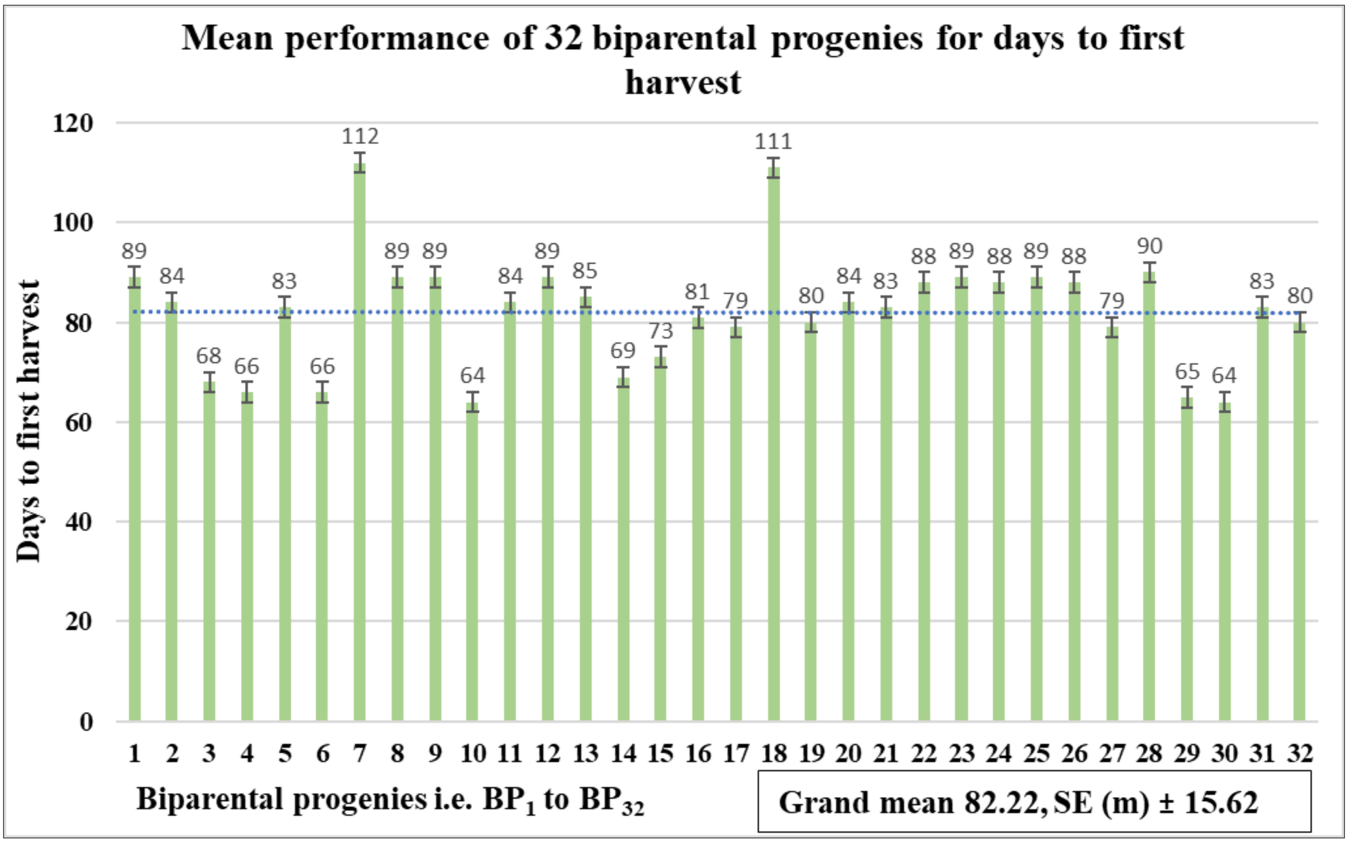

Fig. 7. Mean performance of biparental progenies for days to first harvest.

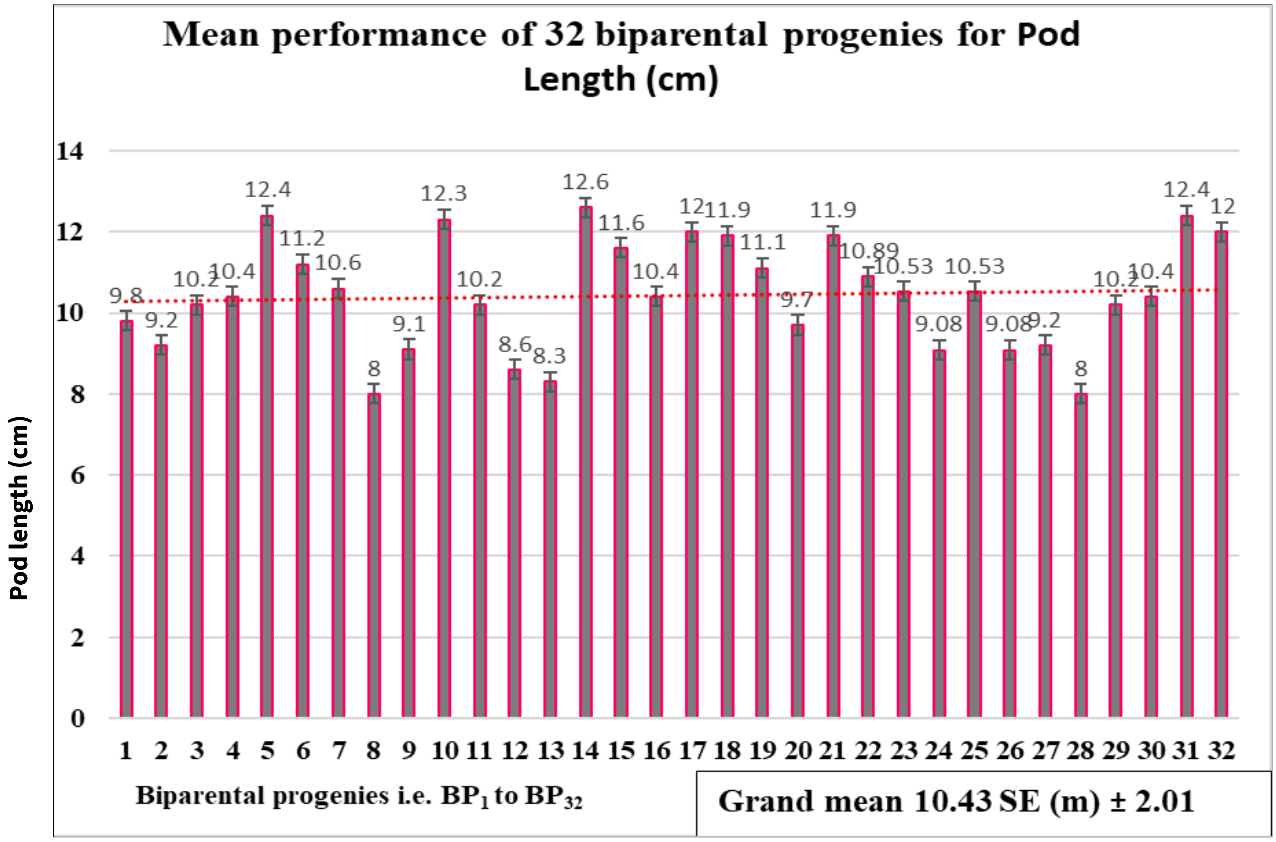

Fig. 8. Mean performance of biparental progenies for pod length (cm).

Pod width

Wide range of variability was observed for pod width (Fig. 9) Lowest value for the pod width was recorded for BP-12 (0.8 cm) followed by BP-13 and BP-24, whereas highest value (3.10 cm) was observed for BP-23 and BP-25 both followed by BP-1 and BP-22.

Average number of pods per plant

A wide range of variability was observed for the trait (Fig. 10). The highest average number of pods per plant was noted for BP-2 (185) followed by BP-8 and BP-11 whereas, the lowest number of pods was recorded for BP- 13 (24) followed by BP-9 and BP-31.

Number of seeds per pod

BP-12 recorded the highest number of seeds per pod (4.78), followed by BP-1 and BP-7, whereas the lowest number was noted for BP-18 with 1.24 seeds followed by BP-6 and BP-16 among the 32 biparental progenies (Fig. 11).

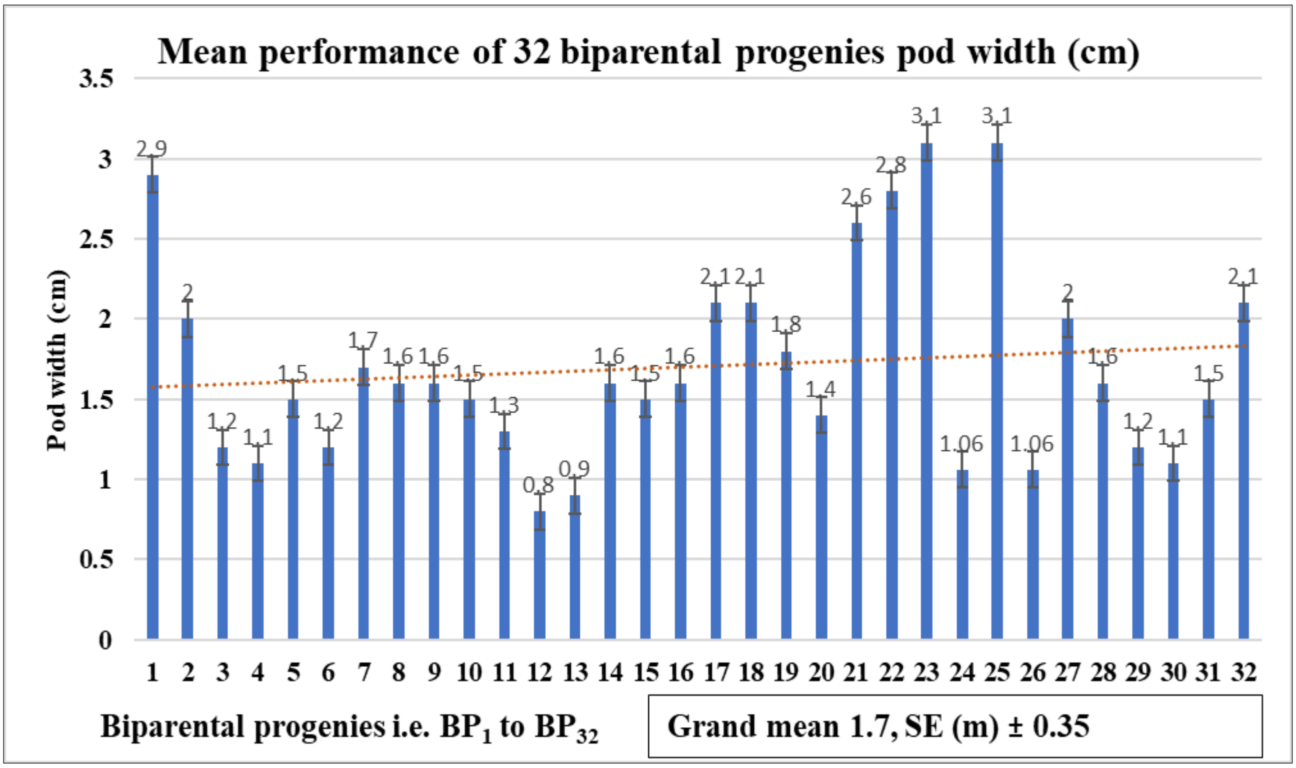

Fig. 9. Mean performance of biparental progenies for pod width (cm).

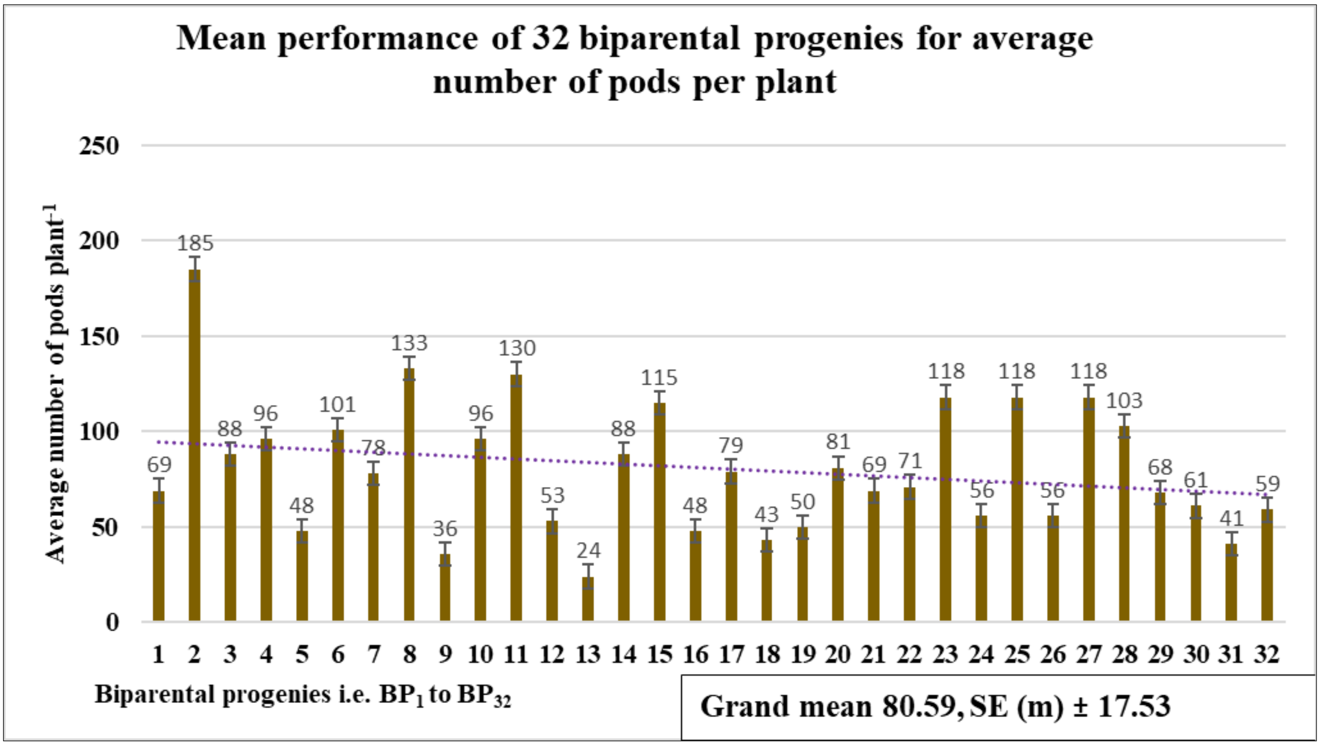

Fig. 10. Mean performance of biparental progenies for average number of pods per plant.

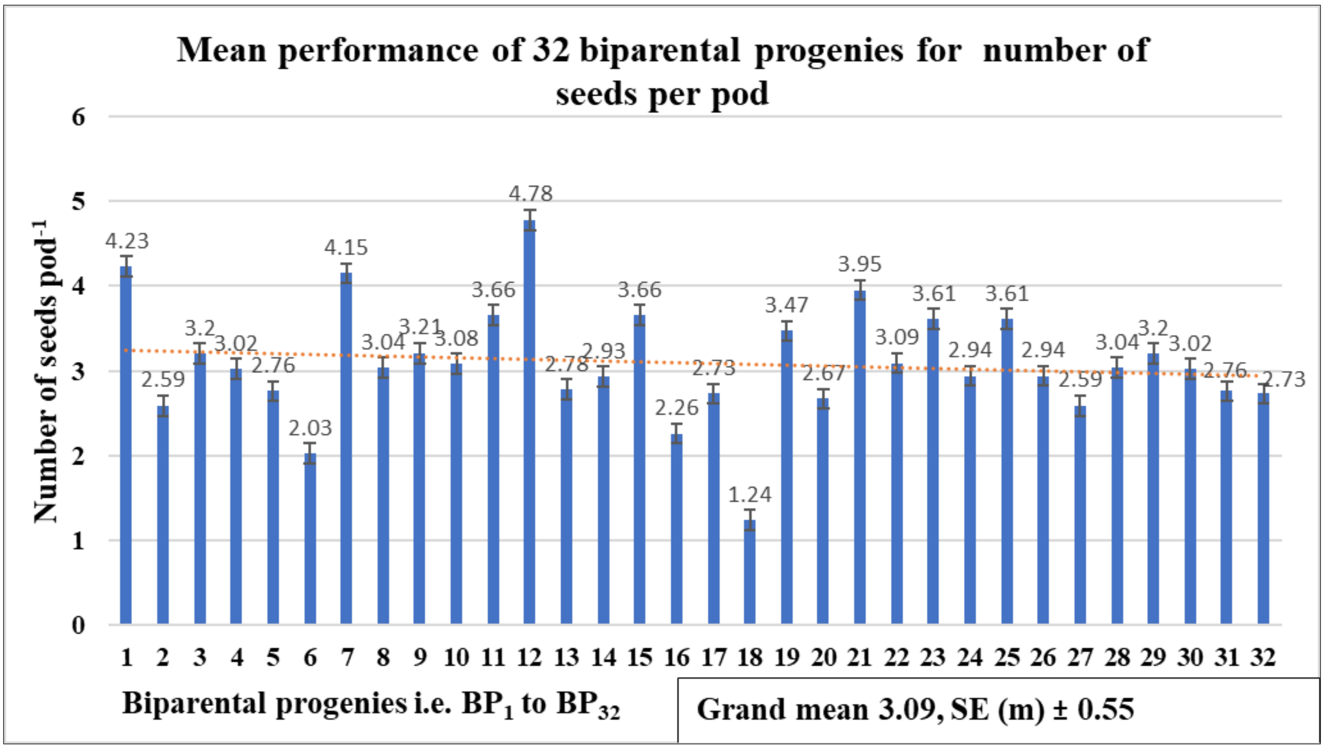

Fig. 11. Mean performance of biparental progenies for number of seeds per pod.

Seed length

Among the 32 biparental progenies, a wide range of variation was observed (Fig. 12) where the progeny BP-16 with 13.81 mm has maximum seed length followed by BP-18 and BP-21 with values 12.89 mm and 12.56 mm and whereas, BP-13 recorded the lowest value (9.56 mm) followed by BP-29 and BP-3.

Seed width

Seed width variability has been recorded from Fig. 13, where, BP-3 being the shortest width seed among the 32 biparental progenies with value 6.21 mm followed by BP-22 and BP-29 and the highest value was noted for BP-18 (9.95 mm) followed by BP-16 and BP-7.

Seed thickness

The Fig. 14, showed significant variation among the progenies where progeny BP-7 with 6.75 mm had the maximum seed thickness, followed by BP-18 and BP-2 whereas, lowest value was observed for BP-20 (4.75 mm) among the 32 biparental progenies.

Hundred seed weight

The hundred seed weight being an important parameter of any crop. A wide variation was observed in the 100-seed weight (Fig. 15), where the highest was noted for BP- 14 (43.31 g) followed by BP-1 and BP-17 while the lowest value was recorded for BP-13 (19.36 g) followed by BP-28 and BP-11.

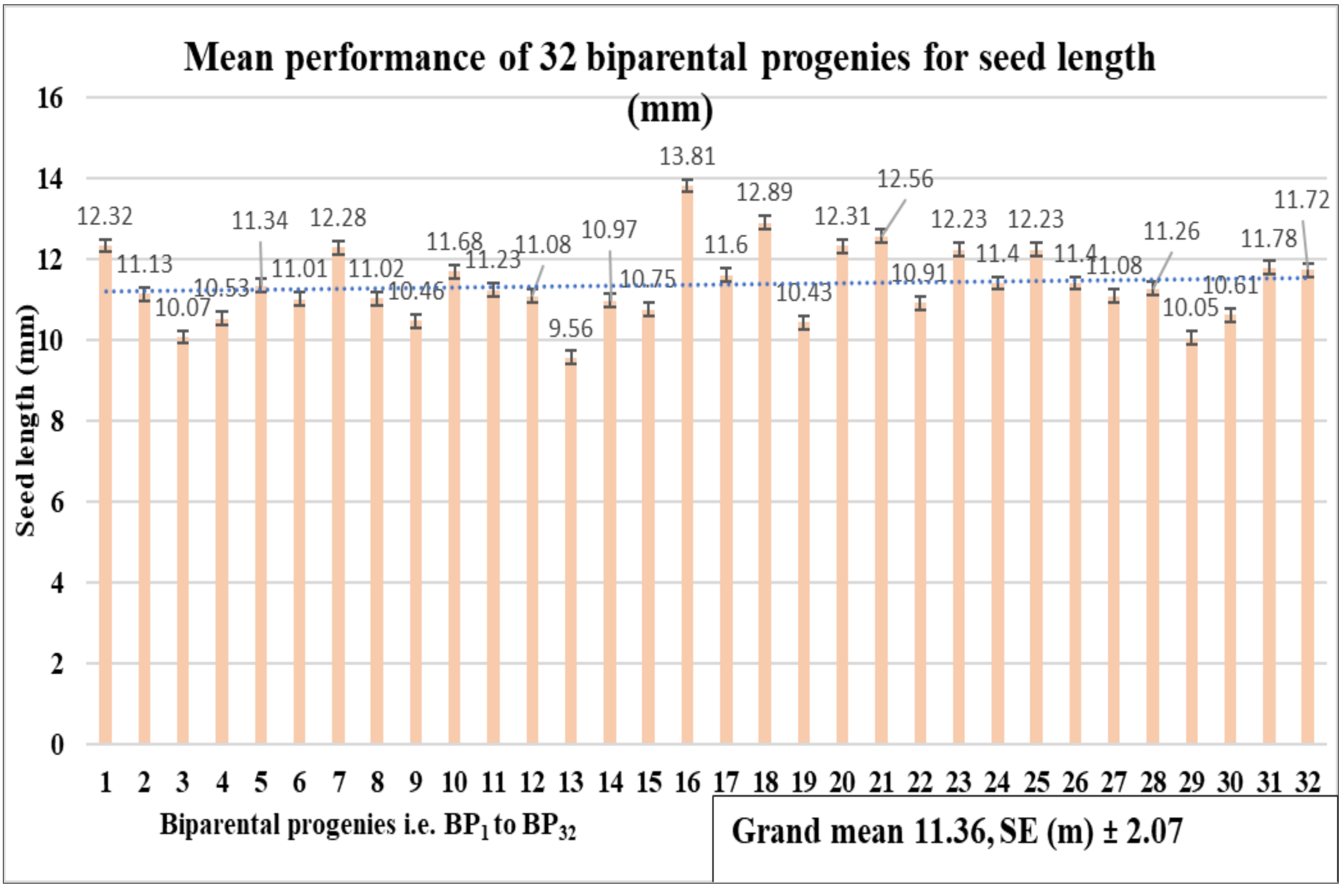

Fig. 12. Mean performance of biparental progenies for seed length (mm).

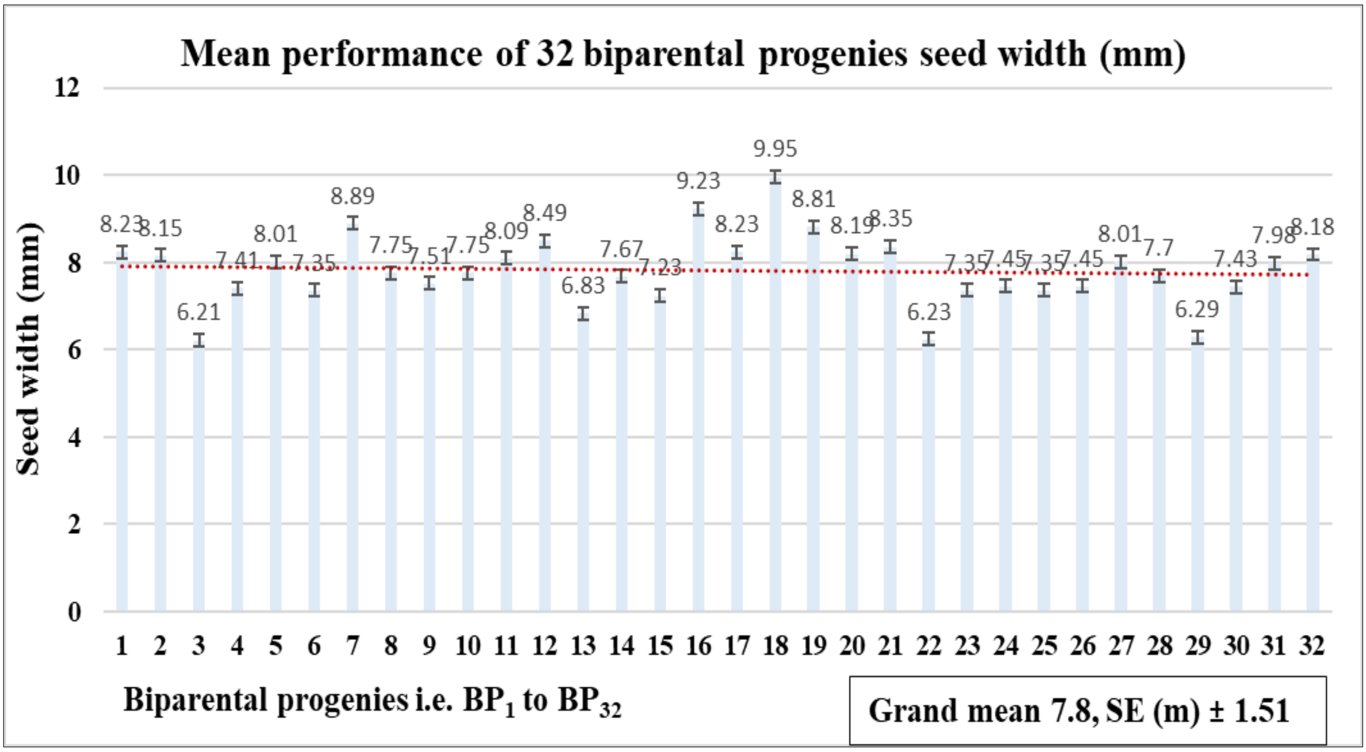

Fig. 13. Mean performance of biparental progenies for seed width (mm).

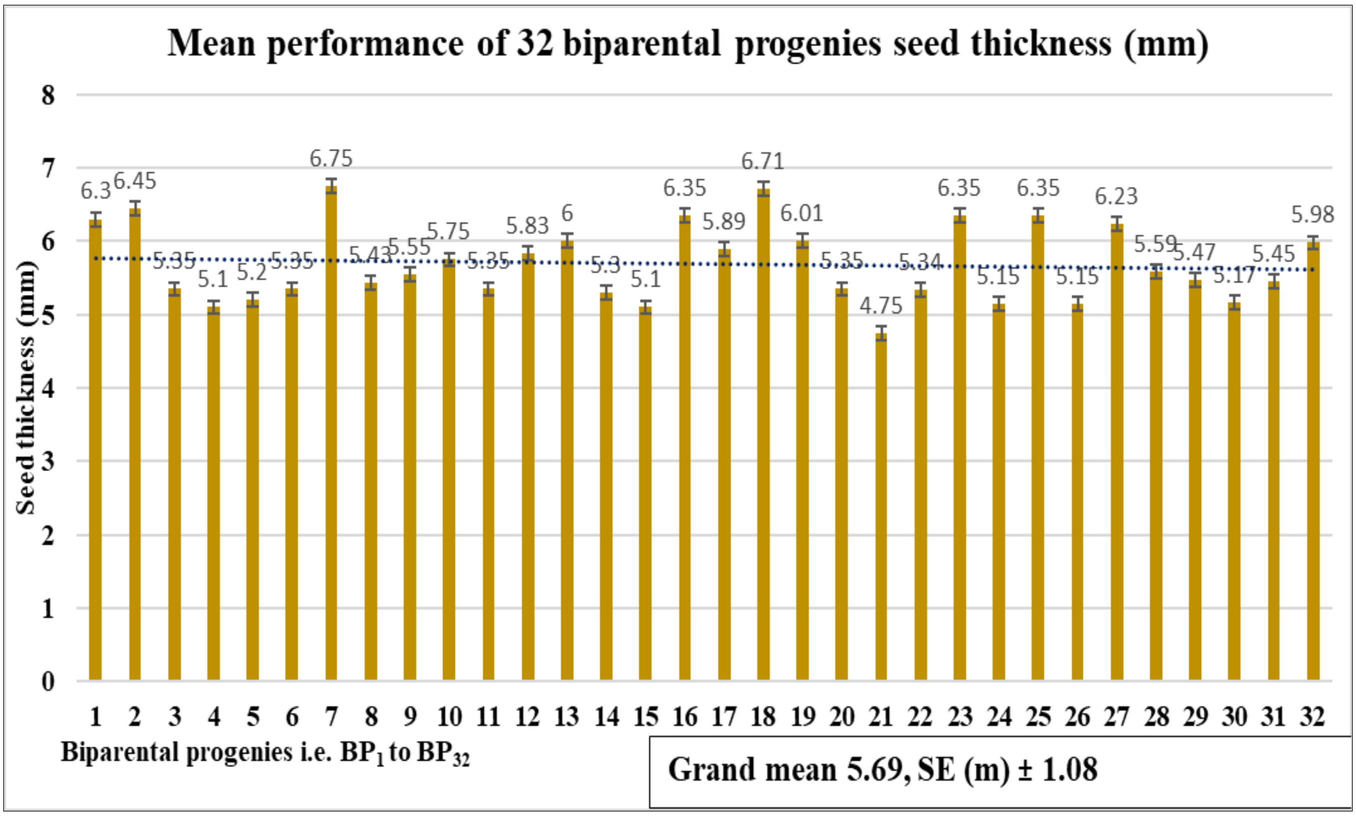

Fig. 14. Mean performance of biparental progenies for seed thickness (mm).

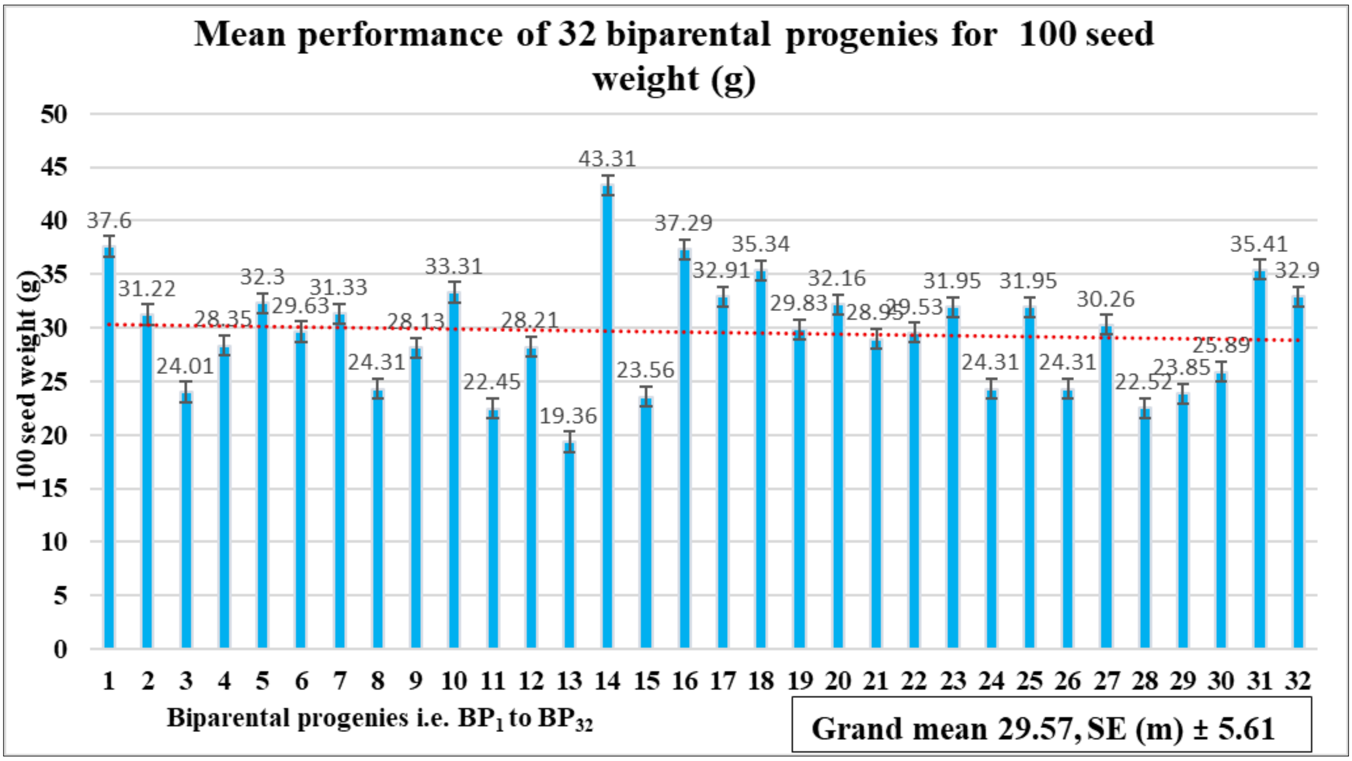

Fig. 15. Mean performance of biparental progenies for 100 seed weight (g).

Shelling percentage

A wide range of variability was observed for shelling percentage which is presented in Fig. 16. The minimum shelling percent (15.93 %) was recorded for BP-18 and the maximum was noted for BP-12 (86.44 %), indicating a higher range of variability among the 32 biparental progenies.

Pod fresh weight

The highest pod fresh weight was observed for BP-21 (10.11 g), followed by BP-23 and BP-25 with 8.77 g each and the lowest value for the pod weight was recorded for BP-3 (4.15 g) followed by BP-29 (4.18 g) and BP-12 (4.43 g) among the 32 biparental progenies (Fig. 17).

Pod dry weight

A wide variability has been recorded for pod dry weight evident by Fig. 18, where, BP-21 recorded maximum pod dry weight (3.38 g), whereas the lowest value was recorded for BP-30 (1.02 g) among the 32 biparental progenies.

Pod yield per plant

Among the 32 biparental progeny a wide range of variation was observed (Fig. 19) The highest pod yield was recorded for progeny BP-2 (1120.00 g), followed by BP-23 and BP-25 whereas, lowest was noted for BP-13 (180 g). Moderate to high values were observed for BP-11 and BP-8.

Identification of superior progenies on *per se* performance from 32 biparental progenies

Smith-Hazel simultaneous selection index of different BPM progenies

The complete ranking of crosses based on the index values is presented in Fig. 20. Based on the selection index values, BP-1(19.00) ranked highest among the 32 crosses, followed closely by BP-21 (18.00), BP-12 (17.00), BP-23 and BP-25 (15.50 each). Other top-performing crosses included BP-19 (15.00), BP-10 (14.75), BP-16 (14.50) and BP-8 (14.00). The lowest index values were recorded for BP-28 (6.00), BP-27 (8.00), BP-32 (8.698) and BP- 14 (9.336), indicating relatively poorer performance.

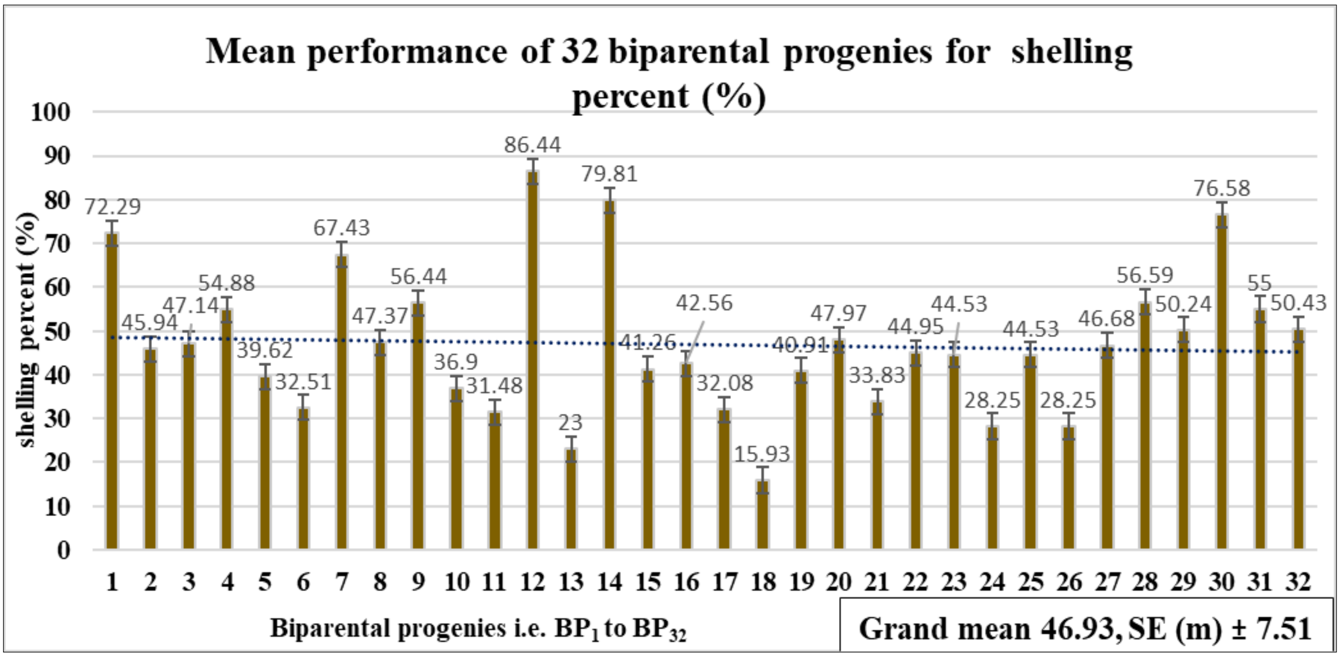

Fig. 16. Mean performance of biparental progenies for shelling percent (%).

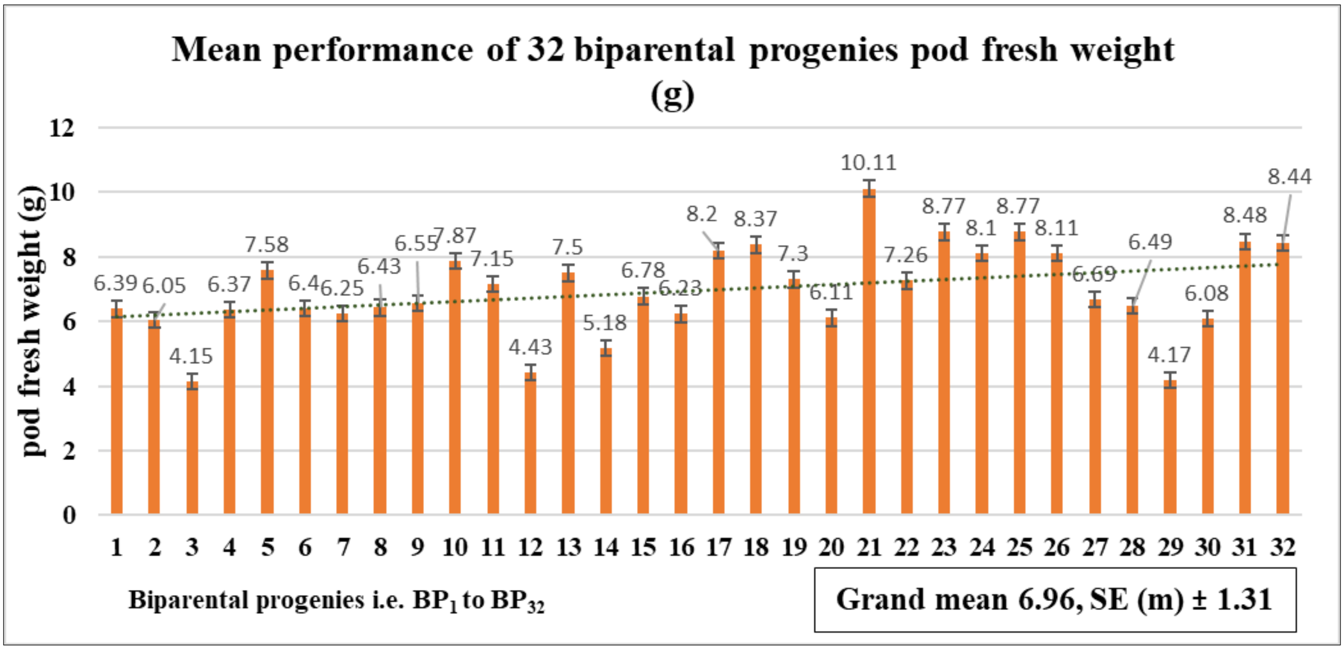

Fig. 17. Mean performance of biparental progenies for fresh pod weight (g).

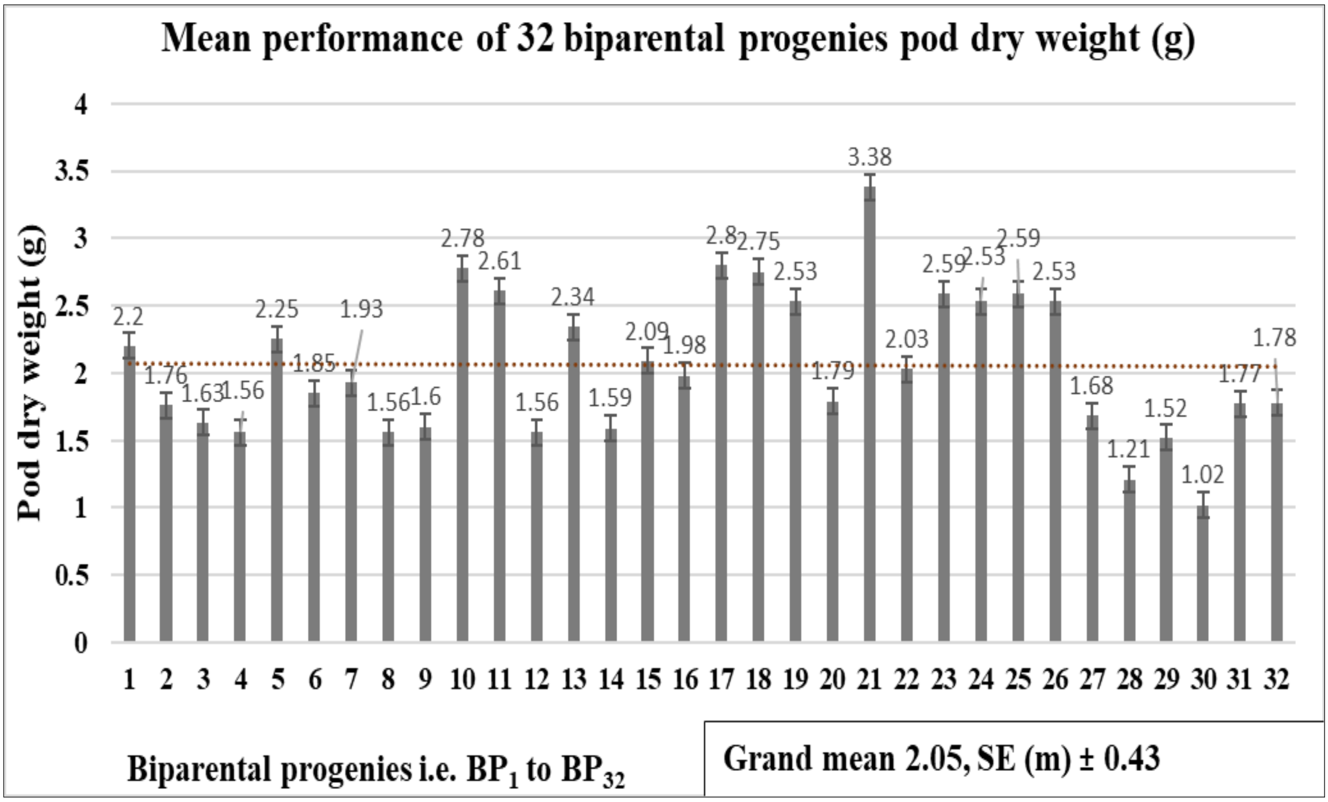

Fig. 18. Mean performance of biparental progenies for pod dry weight (g).

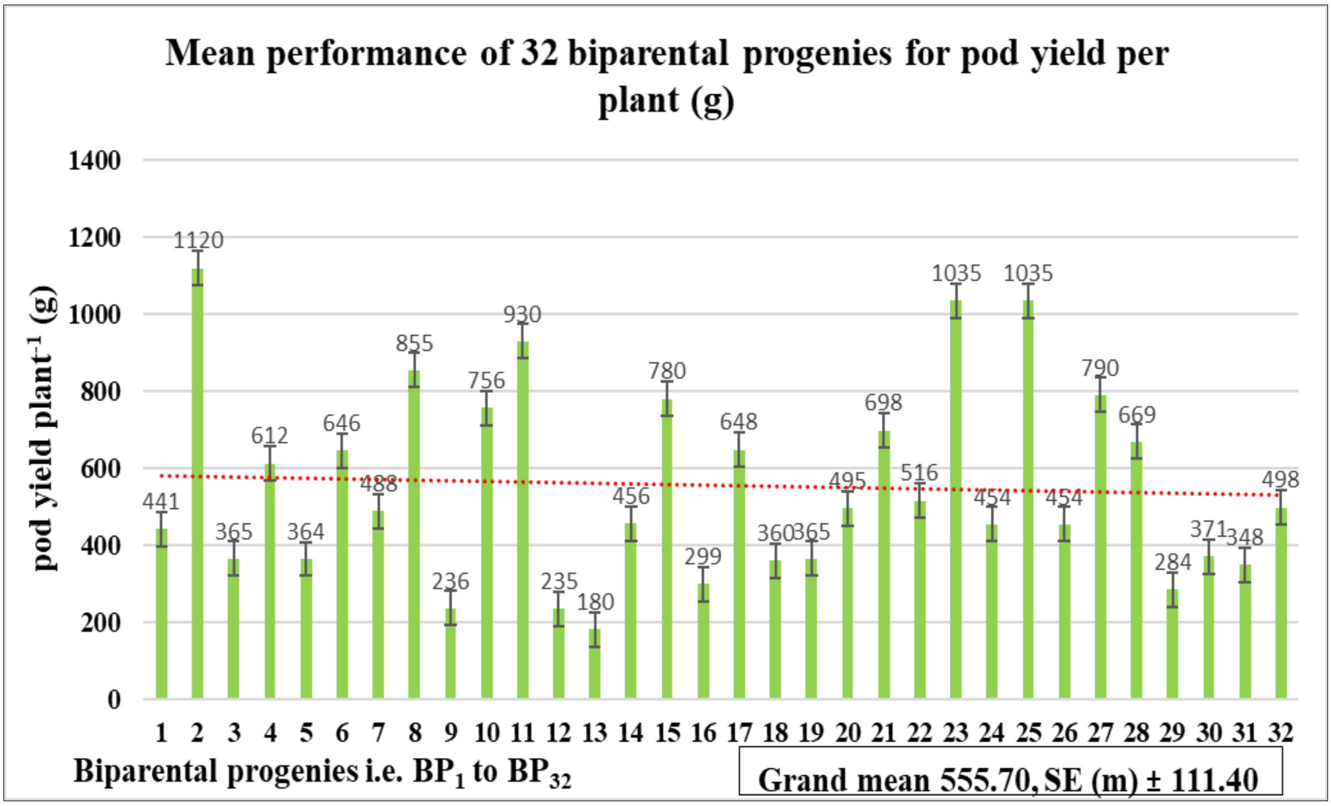

Fig. 19. Mean performance of biparental progenies for pod yield per plant (g).

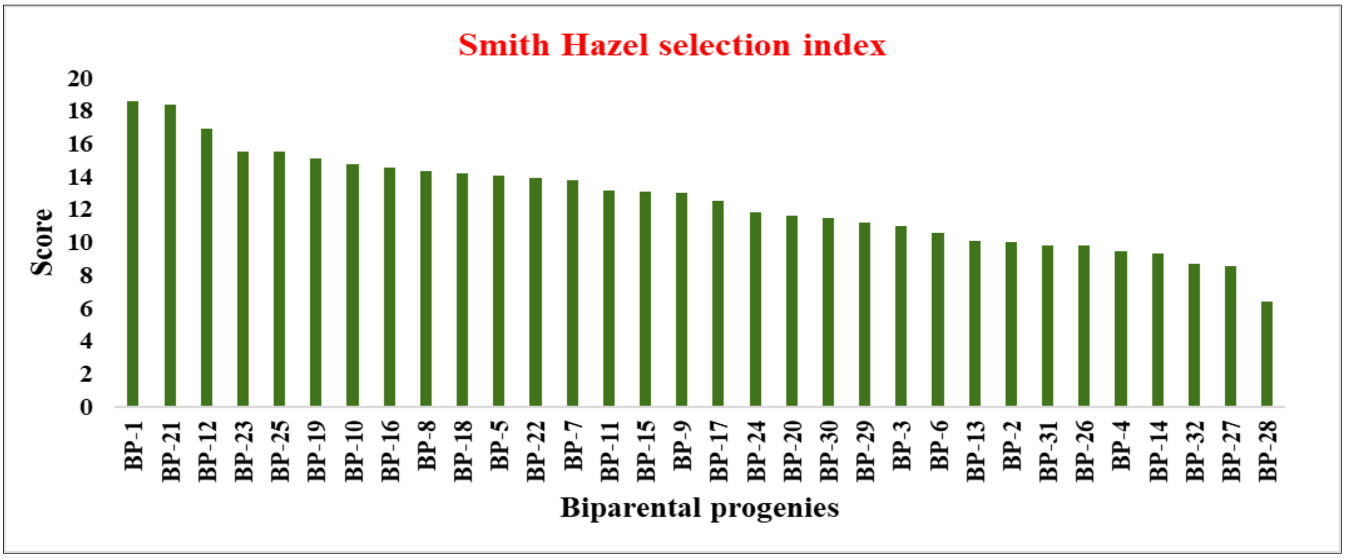

Fig. 20. Smith-Hazel selection index of 32 biparental progenies.

Discussion

The biparental progenies of the dolichos bean developed through NCD II mating design exhibited wide genetic variability for a range of quantitative traits, suggesting the presence of considerable genetic diversity in the segregating population.

The days to germination ranged from 2–5 days, indicating variability in early seed vigour. Early germinating progenies, such as BP -15 and BP-30, could be advantageous for rapid establishment, while late germinating ones may be more sensitive to environmental cues.

Substantial variation was observed in stem diameter, with thicker stems (up to 14.78 mm) in progenies like BP-5, followed by BP-31 and BP-3, indicating their robustness and potential for better support of vegetative and reproductive structures. In contrast, thinner stems were recorded in BP-12 followed by BP-27 and BP-1, suggesting reduced mechanical strength.

The number of primary branches per plant varied from 2–5, with branching being maximum in progenies such as BP-10, BP-21 and BP- 29 and minimum in several crosses, suggesting differences in architectural growth patterns, which could influence yield components like inflorescence and pod number. Similar results reported his studies in dolichos beans (7–9).

Variation in inflorescence number per plant (18–43) further emphasised this structural diversity. High values in progenies such as BP-3, BP-24 and BP-26 suggest potential for higher reproductive output. The number of flowers per inflorescence ranged from 3–12, with high values observed in BP-9 and BP-15, which may translate to higher pod set, although this depends on the efficiency of flower-to-pod conversion. The findings are in line with the findings of (7, 10–12) in dolichos beans.

Significant variation in days to first flowering (37–84 days) and days to first harvest (64–112 days) highlights diversity in maturity. Early flowering and early harvesting progenies like BP-10 are desirable for short-duration cropping systems or offseason production (7–11) revealed similar trends of results in their studies in dolichos beans. The pod length varied between 8.00 and 12.60 cm, while pod width ranged from 0.8–3.1 cm, suggesting ample variability for market-preferred pod types. BP-14 followed by BP-5 and BP-31 respectively, were superior for the trait like pod length. The findings are following the similar trend with (13–15) in lab beans for the pod length and width. High variability was noted in the number of pods per plant, with a range of 36–185 pods. Progeny BP-12, which exhibited the highest pod number, also recorded the highest pod yield per plant (1120.00 g), indicating its potential for yield improvement which has been evidenced by other scientists like (12, 16–20) in their study with similar trends.

The number of seeds per pod ranged from 1.24–4.78, while seed size traits like length, width and thickness also varied widely among progenies. These traits contribute to seed quality and market value. BP-21 and BP-18 were notable for larger seeds. The studies are following the findings of (7, 20) in dolichos beans.

The 100-seed weight showed nearly twofold variation (19.36–43.31 g), reflecting differences in seed filling ability and genetic potential for larger seeds. Similar trends were observed for number of seeds per pod and 100 seed weight in dolichos beans (11, 21, 22) and in cowpea (23). Shelling percentage varied from 15.94–86.44 %, an important trait for edible-seed types, with BP-12 being highly desirable. Pod biomass, as reflected by pod fresh weight and pod dry weight, was highest in BP-21, suggesting suitability for fresh market produce. The result is similar to early findings for the pod biomass and pod pericarp thickness in dolichos beans (11). Moisture percentage varied widely (60.70 – 79.06 %), influencing storage and post-harvest quality.

Overall, the observed variability across qualitative traits including yield and yield-related, parameters demonstrated that the biparental progenies possessed a rich pool of recombinants. This diversity can be effectively utilised in the selection and advancement of dolichos bean lines suited for specific markets, agro-climatic, or nutritional needs. Progenies such as BP-2, BP-21 and BP-18 emerged as promising lines for multiple traits and warrant further evaluation in subsequent generations (11, 12, 14, 22).

Previously recorded a range from 25.80–63.30 pods per plant and 79.40–272.90 g pod yield per plant in biparental progenies in dolichos bean (24). They further observed that biparental progenies had 0.84 higher mean pods per plant and 5.76 g higher mean pod yield per plant, which were on par with F_3 progenies. Similarly, higher mean values of biparental progenies than the pedigree progenies for all the characters were observed (14, 25, 26), in dolichos bean and in black grams (27). They attributed the superior mean and wider ranges of variation in biparental progenies to releasing of hidden genetic variability.

Identification of superior progenies on selection index

The ranking of crosses based on selection index values revealed considerable variation in performance among the 32 biparental progenies of lablab bean. The cross BP-1emerged as the best-performing combination, followed closely by BP-21, BP-12, BP-23 and BP-25 also registered high index values, suggesting their superiority for yield-related traits. Conversely, crosses such as BP-28, BP-27, BP-32 and BP- 14 showed the lowest index values, reflecting relatively poor performance. Similar trends were observed in dolichos beans (11, 14, 28) and in chick pea (29).

Conclusion

The extensive phenotypic variation observed across vegetative, reproductive and yield-related traits in the dolichos bean biparental population confirms a rich resource of genetic recombinants. This diversity is directly applicable for targeted selection. Notably, progeny BP-2 demonstrated exceptional pod yield followed by BP-23 and BP-25, while BP-21 excelled in multiple seed and biomass traits. The selection index rankings further validated these findings, identifying BP-1 and BP-21 as superior, high-performing crosses. These elite progenies constitute valuable genetic material and can be advanced in subsequent generations for the development of improved dolichos bean varieties with enhanced yield potential and desirable agronomic traits. At the end of breeding cycle, the selected superior progenies will be subjected to multi-location trails to study their performance across various agro-climatic zones.

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Authors' contributions

The conceptualisation of the research was carried out by KKM, SKD and AVVK. The experiments were designed by KKM, SKD and AVVK. The experimental materials were contributed by AVVK and KKM. The execution of field and laboratory experiments and data collection were performed by KKM, AVVK and SKD. Data analysis and technical guidance were provided by KKM, AVVK, MD and PT. The manuscript was prepared by KKM, AVVK, SKD, PKT, GSS and SS. Modifications and coordination were carried out by KKM, AVVK, MD, PT and SKD. All the authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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