Full Length Research Article


Research Journal of Agricultural Sciences
Volume 16; Issue 04 (Jul–Aug 2025); pp 423–426

ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

# Genetic Evaluation Studies in Sprouting Broccoli (*Brassica oleracea* var. *italica* plenck) for Growth, Yield and Quality Parameters

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Received: 10 Jul 2025; Revised accepted: 29 Aug 2025

## Abstract

In the modern era, where health consciousness is rising, broccoli stands out as a nutrient-rich vegetable with potential disease-preventing properties, including cancer. It is an excellent source of dietary carotenoids and essential vitamins like thiamine, niacin, and riboflavin, contributing to overall health and nutrition. Broccoli is yet to achieve widespread popularity in our country. The crop is grown only in specific areas of India which limits its area and production. No systematic efforts have been made to evaluate and commercialize this high-value, nutrient-rich Cole crop. Hence the present investigation was carried out on 28 broccoli genotypes using randomized complete block design at Experimental Vegetable Farm ETC Malangpora, Pulwama during *rabi* 2023, with an objective to identify the promising genotypes in terms of yield and other quality parameters. The genotypes under investigation were SK-B-01, SK-B-02, SK-B-03, SK-B-04, SK-B-05, SK-B-06, SK-B-07, SK-B-08, SK-B-09, SK-B-10, SK-B-11, SK-B-12, SK-B-13, SK-B-14, SK-B-15, SK-B-16, SK-B-17, SK-B-18, SK-B-19, SK-B-20, SK-B-21, SK-B-22, SK-B-23, SK-B-24, SK-B-25, SK-B-26, SK-B-27, and Palam Samridhi (check). The significant result includes that SK-B-24 surpasses the check variety Palam Samridhi in terms of head yield and other genotypes viz. SK-B-15, SK-B-27 and SK-B-05 were also showing comparable results. Some other genotypes viz. SK-B-26, SK-B-10, SK-B-11 and SK-B-24 were identified based on different quality parameters.

***Key words*:** *Brassica oleracea* var. *italica* plenck, Evaluation, Varieties, Quality, Yield

In the period of modernization where people are getting more and more health conscious and realize the importance of taking a great diversity of vegetables in their diet for attaining proper nutrition and prevent themselves from large number of life-threatening diseases as well, Broccoli is nutrient rich vegetable and can prevent our body from various diseases like cancers [1]. Broccoli is an excellent source of dietary carotenoids which are reported to confer health promoting effects on humans when consumed in the diet [2]. Realizing the tremendous potential of sprouting broccoli in domestic and foreign market, the cauliflower growers of terai zone of West Bengal (India) are gradually adopting the broccoli cultivation [3]. India possesses a diverse range of tropical, subtropical, and temperate vegetable crops. However, some vegetables remain lesser-known to many growers and consumers. Farmers can achieve significant profits by cultivating these rare or high-value Cole crops near major cities (peri-urban areas) and towns, where they fetch premium prices in cosmopolitan markets, luxury hotels, and tourist destinations. The adoption of sprouting broccoli cultivation by growers in the Terai region is a strategic shift driven by significant economic potential in both domestic and foreign markets [4]. Faced with the low and fluctuating prices a crop with a low-profit margin farmers are transitioning to broccoli, which commands a higher and more stable market price. This change is spurred by a growing health-conscious consumer base in urban centers across India, which has dramatically increased domestic demand. Additionally, the climate of the Terai zone is ideal for broccoli cultivation, providing a key geographical advantage. Farmers are also tapping into lucrative export opportunities, further diversifying their income. This move not only addresses the economic challenges associated with traditional crops but also positions them to capitalize on a globally recognized superfood, transforming their agricultural practices to be more profitable and sustainable [5].

Additionally, these vegetables have strong export potential, particularly to European countries, where year-round open-field cultivation is not feasible cultivation is not feasible for initial systematic breeding/improvement programme in any crop [6]. It is essential to study variability present in the basic genetic material/germplasm the improvement in any crop is proportional to the magnitude of genetic variability present in the germplasm. Broccoli being an exotic crop, the variability present in India is limited. The crop is less genetic diverse in India and is grown in specific areas only. The farmers are demanding high yielding compact and good quality broccoli

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**Citation:** Fayaz A, Dar RA, Afroza B, Ali G, Nazir N, Baba JA, Gani G, Aezum AM. 2025. Genetic evaluation studies in sprouting broccoli (*Brassica oleracea* var. *italica* plenck) for growth, yield and quality parameters. *Res. Jr. Agril. Sci.* 16(4): 423-426.

varieties [7-8]. Hence the emphasizes are given on identification of the suitable genotypes, with promising horticultural traits viz. head size, curd yield and high ascorbic acid thus genetic evaluation of genotypes has become a necessity. The improvement in major parameters would help in overall crop improvement. The present investigation is attempted to study and generate the information regarding quantitative and qualitative traits of broccoli. Therefore, it is essential to collect the new genotypes with diverse horticultural traits; for this purpose, the evaluation and characterization of the collected germplasm is a pre-requisite.

## MATERIALS AND METHODS

The present investigation was conducted during Rabi season of 2023-2024 at the vegetable experimental farm, at ETC Malangpora, Pulwama J & K in order to estimate the amount of variability present in the genotypes under study and identify the promising genotypes for growth yield and other quality parameters. Randomized complete block design was used as statistical tool to access the variability present in the germplasm. The other investigation details are as follows the above-mentioned genotypes were taken into consideration from the date of sowing (11th July 2023) followed by the transplanting of crop was done on 9th August 2023 with a spacing of 60cm × 45 cm. Fertilizer was applied at an NPK ratio of 100:80:100 kg per hectare**.** Standard cultural practices and crop protection measures were implemented as per the crop's requirements. Observations were recorded for physical, yield, and quality-related parameters. The mean values of randomized data were analyzed using standard statistical methods given by Panse and Sukhtame [9].

## RESULTS AND DISCUSSION

Mean performance of the 28 genotypes of broccoli studied, during the present investigation, with respect to 14 quantitative traits and 6 qualitative traits has been presented in (Table 1). The elaborate discussion on the mean performance of the various genotypes, with respect to various horticultural traits are as follows; plant height, a key factor influencing vegetative growth and yield potential in broccoli, exhibited significant variability among the 28 genotypes evaluated. Heights ranged from 40.30 cm (SK-B-26) to 72.54 cm (SK-B-15), with SK-B-15 showing superior vegetative growth under temperate conditions. SK-B-26, the shortest genotype, was statistically at par with SK-B-02, SK-B-09, SK-B-13, and SK-B-01 [10]. Genetic factors likely contribute to variations in plant height, influencing overall biomass and growth potential. Plant spread ranged from 2913.57 cm² (SK-B-26) to 3951.45 cm² (SK-B-24), influencing light interception and photosynthetic efficiency [11-12]. Leaf number varied from 8.11 (SK-B-26) to 16.93 (SK-B-24), reflecting differences in vegetative vigour, Leaf area, a key indicator of photosynthetic capacity, ranged from 662.91 cm² (SK-B-26) to 959.38 cm² (SK-B-24).

Table 1 Mean performance of various quantitative horticultural traits in different broccoli (*Brassica oleracea* var. *italic* Plenck.) genotypes

| Genotypes | Parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | Plant height (cm) | Plant spread ($cm^2$) | Number of leaves | Leaf area ($cm^2$) | Curd diameter (cm) | Curd depth (cm) | Curd weight (g) |
| SK-B-01 | 45.90 | 3466.77 | 12.69 | 816.72 | 9.58 | 5.07 | 146.80 |
| SK-B-02 | 43.27 | 3451.12 | 11.79 | 810.93 | 9.39 | 4.81 | 131.57 |
| SK-B-03 | 46.88 | 3471.26 | 13.11 | 829.74 | 10.08 | 5.93 | 160.30 |
| SK-B-04 | 54.21 | 3483.14 | 13.05 | 814.66 | 10.38 | 6.08 | 163.65 |
| SK-B-05 | 64.59 | 3520.56 | 14.21 | 842.33 | 9.95 | 8.03 | 238.15 |
| SK-B-06 | 61.82 | 3487.79 | 13.25 | 835.59 | 10.31 | 6.17 | 164.14 |
| SK-B-07 | 56.26 | 3480.40 | 13.17 | 831.61 | 10.24 | 6.09 | 163.08 |
| SK-B-08 | 64.80 | 3517.16 | 13.89 | 838.28 | 9.02 | 7.07 | 194.78 |
| SK-B-09 | 45.29 | 3466.86 | 12.25 | 828.13 | 9.72 | 5.11 | 138.75 |
| SK-B-10 | 54.99 | 3472.28 | 13.09 | 830.33 | 9.41 | 5.80 | 162.82 |
| SK-B-11 | 46.40 | 3458.82 | 12.58 | 812.30 | 9.44 | 5.02 | 132.89 |
| SK-B-12 | 57.58 | 3486.68 | 13.13 | 831.54 | 10.15 | 6.02 | 162.13 |
| SK-B-13 | 45.69 | 3463.99 | 12.71 | 816.48 | 9.53 | 5.07 | 146.96 |
| SK-B-14 | 57.38 | 3489.30 | 14.36 | 832.25 | 10.11 | 7.95 | 234.56 |
| SK-B-15 | 72.54 | 3922.13 | 16.65 | 956.39 | 12.14 | 9.83 | 334.51 |
| SK-B-16 | 57.29 | 3472.10 | 12.56 | 835.98 | 9.77 | 5.25 | 143.63 |
| SK-B-17 | 67.02 | 3481.34 | 13.07 | 832.87 | 10.17 | 5.96 | 162.39 |
| SK-B-18 | 63.39 | 3553.28 | 13.04 | 835.74 | 9.43 | 5.96 | 162.57 |
| SK-B-19 | 55.59 | 3542.54 | 12.89 | 814.79 | 10.13 | 5.53 | 157.86 |
| SK-B-20 | 51.39 | 3481.89 | 13.13 | 817.28 | 10.05 | 5.81 | 162.52 |
| SK-B-21 | 59.57 | 3548.22 | 14.31 | 832.91 | 11.17 | 7.78 | 231.12 |
| SK-B-22 | 47.28 | 3484.04 | 13.79 | 829.66 | 11.03 | 7.05 | 192.00 |
| SK-B-23 | 57.55 | 3484.84 | 13.68 | 835.92 | 11.00 | 7.03 | 190.93 |
| SK-B-24 | 56.47 | 3951.45 | 16.93 | 959.38 | 13.29 | 10.17 | 385.86 |
| SK-B-25 | 62.64 | 3477.44 | 13.12 | 836.12 | 9.83 | 5.79 | 160.30 |
| SK-B-26 | 40.30 | 2913.57 | 8.11 | 662.91 | 9.37 | 3.64 | 60.38 |
| SK-B-27 | 58.35 | 3780.56 | 16.31 | 836.07 | 11.12 | 9.44 | 302.97 |
| Palam Samridhi (Check) | 55.68 | 3900.15 | 16.89 | 842.44 | 13.31 | 10.19 | 377.51 |
| Mean | 55.36 | 3525.34 | 13.51 | 832.12 | 10.34 | 6.58 | 192.08 |
| SE (m) | 0.55 | 1.53 | 0.58 | 0.85 | 0.36 | 0.41 | 6.99 |
| CD ($P \leq 0.05$) | 1.579 | 4.33 | 1.65 | 2.41 | 1.03 | 1.16 | 19.82 |

*……… Continued Table 1 ………*

| Genotypes | Parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | Days to curd initiation | Days to first harvest | Curd compactness | Number of lateral heads | Whole plant weight (g) | Harvest index (%) | Curd yield (q/h) |
| SK-B-01 | 55.48 | 96.35 | 4.72 | 3.75 | 538.35 | 30.07 | 63.62 |
| SK-B-02 | 56.78 | 96.52 | 4.70 | 4.37 | 568.20 | 25.38 | 54.01 |
| SK-B-03 | 54.49 | 95.18 | 3.92 | 4.40 | 642.91 | 27.81 | 66.11 |
| SK-B-04 | 54.37 | 95.14 | 3.63 | 4.41 | 680.02 | 27.18 | 68.44 |
| SK-B-05 | 50.63 | 88.19 | 4.10 | 7.21 | 840.26 | 31.58 | 98.27 |
| SK-B-06 | 54.55 | 95.19 | 3.71 | 4.40 | 792.69 | 23.54 | 69.03 |
| SK-B-07 | 54.95 | 95.20 | 3.75 | 4.39 | 759.54 | 24.26 | 68.23 |
| SK-B-08 | 52.62 | 93.61 | 4.63 | 4.45 | 770.85 | 28.49 | 81.25 |
| SK-B-09 | 55.61 | 96.38 | 4.30 | 3.73 | 600.69 | 25.34 | 56.31 |
| SK-B-10 | 54.39 | 95.05 | 4.70 | 4.29 | 700.11 | 25.72 | 66.68 |
| SK-B-11 | 56.69 | 96.62 | 4.47 | 3.73 | 650.43 | 22.69 | 54.60 |
| SK-B-12 | 54.40 | 94.95 | 3.90 | 4.31 | 750.42 | 24.32 | 67.57 |
| SK-B-13 | 55.37 | 96.31 | 4.73 | 3.75 | 750.13 | 22.54 | 62.50 |
| SK-B-14 | 50.57 | 88.24 | 3.98 | 7.13 | 800.86 | 32.79 | 96.92 |
| SK-B-15 | 49.03 | 87.12 | 3.20 | 7.28 | 920.04 | 40.81 | 138.69 |
| SK-B-16 | 55.27 | 96.42 | 2.92 | 3.81 | 350.08 | 19.67 | 59.66 |
| SK-B-17 | 54.45 | 95.27 | 3.87 | 4.38 | 627.17 | 26.83 | 68.53 |
| SK-B-18 | 54.51 | 94.89 | 3.05 | 4.32 | 602.77 | 27.15 | 68.09 |
| SK-B-19 | 54.67 | 96.02 | 4.13 | 3.88 | 634.52 | 25.82 | 65.41 |
| SK-B-20 | 54.42 | 94.72 | 4.08 | 4.34 | 649.66 | 25.83 | 67.91 |
| SK-B-21 | 50.47 | 87.61 | 3.38 | 7.20 | 796.96 | 29.45 | 97.45 |
| SK-B-22 | 52.70 | 93.68 | 3.27 | 4.43 | 714.25 | 27.14 | 80.31 |
| SK-B-23 | 52.72 | 93.79 | 3.27 | 4.42 | 734.34 | 26.75 | 79.23 |
| SK-B-24 | 48.75 | 86.48 | 4.47 | 7.61 | 964.65 | 40.46 | 160.31 |
| SK-B-25 | 54.45 | 95.44 | 4.28 | 4.36 | 642.12 | 25.73 | 66.86 |
| SK-B-26 | 59.82 | 103.21 | 4.92 | 1.34 | 424.03 | 18.38 | 28.30 |
| SK-B-27 | 49.17 | 88.87 | 3.92 | 7.09 | 867.28 | 35.74 | 123.66 |
| Palam Samridhi (Check) | 48.88 | 84.12 | 4.24 | 7.58 | 898.59 | 42.12 | 156.18 |
| Mean | 53.58 | 93.60 | 4.00 | 4.93 | 702.62 | 28.03 | 79.80 |
| SE (m) | 0.54 | 1.10 | 0.642 | 0.54 | 6.35 | 1.09 | 1.10 |
| CD (P≤ 0.05) | 1.54 | 3.12 | 1.6921 | 1.54 | 18.01 | 3.10 | 3.12 |

Leaf number varied from 8.11 (SK-B-26) to 16.93 (SK-B-24), reflecting differences in vegetative vigor, Leaf area, a key indicator of photosynthetic capacity, ranged from 662.91 cm² (SK-B-26) to 959.38 cm² (SK-B-24). Among yield-related traits, curd diameter varied from 9.37 cm (SK-B-26) to 13.31 cm (Palam Samridhi), with the largest curds recorded in Palam Samridhi and SK-B-24. Similarly, curd depth ranged from 3.64 cm (SK-B-26) to 10.19 cm (Palam Samridhi), with SK-B-24 and SK-B-15 also showing considerable depth. Curd weight, a crucial breeding trait, ranged from 60.38 g (SK-B-26) to 385.86 g (SK-B-24), with SK-B-24 surpassing the check variety Palam Samridhi, followed by SK-B-15 and SK-B-27. Days to curd initiation, influencing early yield, varied from 48.75 days (SK-B-24) to 59.82 days (SK-B-26), with early initiation observed in SK-B-24 and Palam Samridhi, Days to first harvest, a key market trait, ranged from 84.12 days (Palam Samridhi) to 103.21 days (SK-B-26), reflecting differences in crop maturity. Curd compactness, an indicator of structural integrity, ranged from 2.92 to 4.92, with SK-B-26 exhibiting the highest compactness. Number of lateral heads, which impact yield potential, varied from 1.34 (SK-B-26) to 7.61 (SK-B-24). Whole plant weight, essential for assessing biomass and resource efficiency, varied from 350.08 g (SK-B-16) to 964.65 g (SK-B-24), with Palam Samridhi also showing high values. These variations highlight the genetic potential for selecting high-yielding genotypes with superior agronomic traits. Harvest index, which measures the efficiency of biomass conversion into yield, varied significantly among genotypes, ranging from 18.38% (SK-B-26) to 42.12% (Palam Samridhi), followed by SK-B-15 (40.81%), SK-B-24 (40.46%), and SK-B-27 (35.74%), with a mean of 28.03%. Similarly, curd yield, a key indicator of broccoli productivity, ranged from 28.30 q/ha (SK-B-26) to 160.31 q/ha (SK-B-24), surpassing the check variety Palam Samridhi (156.18 q/ha). Other high-yielding genotypes included SK-B-15 (138.69 q/ha) and SK-B-27 (123.66 q/ha), with an overall mean of 79.80 q/ha, reflecting substantial variation in curd productivity highlighting the potential for selecting high-yielding genotypes for improved broccoli production. Significant variation was observed among the broccoli genotypes for key quality parameters, highlighting their nutritional potential.

Dry matter content, influencing texture and shelf life, ranged from 12.29% (SK-B-24) to 17.84% (SK-B-26), with an average of 15.61%, indicating broad variability across genotypes. Acidity, a key determinant of flavour and storage quality, varied from 0.38% (SK-B-10) to 0.96% (SK-B-11), with a mean of 0.70%, reflecting notable differences in taste profiles. Ascorbic acid, essential for antioxidant properties, ranged from 51.02 mg/100g (SK-B-26) to 82.61 mg/100g (SK-B-24). Total Soluble Solids (TSS), influencing flavour balance, varied from 7.11° Brix (SK-B-11) to 11.98° Brix (SK-B-10), averaging 9.10° Brix, consistent with Thapa and Rai [13]. Chlorophyll content, a key indicator of photosynthetic efficiency and freshness, ranged from 0.275 mg/100g (SK-B-26) to 0.554 mg/100g (Palam Samridhi), supporting the study by Murcia *et al*. [14]. Carotenoids, vital for antioxidant properties, showed a wide range from 0.22 µg/100mg (SK-B-24) to 3.12 µg/100mg (SK-B-26), with a mean of 2.17 µg/100mg, in agreement with Bagale *et al*. [15]. Significant differences in leaf area, curd traits, harvest index, and biochemical parameters (ascorbic acid, TSS, chlorophyll, and carotenoids) highlight the potential of these genotypes for both yield and nutritional enhancement. Overall, the wide genetic diversity observed provides a valuable resource for breeding high-yielding, nutritionally superior, and early-maturing broccoli varieties suited to diverse agro-climatic conditions. The observed variability highlights the genetic potential of different genotypes for breeding programs aimed at enhancing broccoli's nutritional and market value [16-18].

## CONCLUSION

Based on the findings from this study, it can be concluded that the genotype SK-B-24, with a Curd yield of 160(q/h), was the highest-performing genotype in terms of curd yield. The curd yield(q/h) followed by the check Palam Samridhi (156.18), SK-B-15 (138.69), and SK-B-27 (123.66). These genotypes demonstrated significantly better performance compared to others for curd yield as well as for several other traits, including the curd weight(g), leaf area($cm^2$), number of leaves, whole plant weight (g), curd depth (cm), and plant spread ($cm^2$), and harvest index (%). Therefore, it is advisable to recommend these superior genotypes for cultivation. Some other genotypes showing peak values in quality parameters were also identified as SK-B-26, SK-B-10, SK-B-11 and SK-B-24.

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