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Varietal evaluation of broccoli (*Brassica oleracea* var. italica) under Prayagraj agroclimatic conditions

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Abstract
The present study, titled "Varietal Evaluation of Broccoli (*Brassica oleracea* var. italica) under Prayagraj Agroclimatic Conditions," was conducted during the Rabi season of 2024-2025 at the Horticulture Research Farm**,** Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The objective was to assess the performance of various broccoli varieties in terms of growth, yield, and quality under the specific climatic conditions of Prayagraj. A total of ten varieties—Saki, Anastya, Romanesco, Matsuri, Hari, Star, Green Magic, Palam Samridhi, Shishir, and Palam Vichitra—were evaluated using a Randomized Block Design (RBD) with three replications. Data was collected on key parameters such as plant growth, curd development, yield, and nutritional quality. Among all the varieties, Palam Vichitra (V10) showed the most promising results. It recorded the maximum plant height (56.42 cm)**,** highest number of leaves per plant (35.00)**,** longest and widest leaves (49.48 cm and 25.57 cm, respectively)**,** thickest stem diameter (5.34 cm)**,** and widest plant spread (75.75 cm)**.** It also showed early curd formation (50.05 days) and reached harvest in 70.34 days**,** with the largest curd diameter (15.46 cm)**.** In terms of biomass and yield, Palam Vichitra achieved the highest plant weight without roots (983.14 g)**,** curd weight (631.41 g)**,** curd yield per plot (7.58 kg)**,** and overall yield of 21.05 tonnes per hectare**.** Nutritionally, it also had the highest ascorbic acid content (118.52 mg/100g) and total soluble solids (4.28 °Brix)**.** However, when considering profitability, Shishir emerged as the most economically viable variety, recording the highest benefit-cost ratio of 6.07**.**

Keywords: Broccoli, growth, yield, quality, varieties

Introduction
India has long been recognized as an agriculturally driven nation, supported by a dynamic and resourceful farming community. The country's vast range of agro-climatic zones provides favorable conditions for cultivating an impressive diversity of horticultural crops. Thanks to its varied natural environments and multiple growing seasons, India has the unique advantage of being able to produce over a hundred different types of vegetables throughout the year (Thakor, 2008; Tejaswini *et al*., 2018) [13, 12]. Agriculture remains the largest private-sector industry in the country, contributing over 25% to the national GDP. It continues to be the main source of livelihood for nearly two-thirds of the population and forms the backbone of many agro-based industries.

One crop that has recently gained traction in Indian agriculture is broccoli (*Brassica oleracea* L. var. *italica*), a cool-season vegetable that belongs to the Brassicaceae family. Commonly referred to in Hindi as Hari Gobi, broccoli was once considered an uncommon cole crop in India. However, its popularity has been steadily rising in recent years, both among farmers and health-conscious consumers (Singh *et al*., 2023; Yadav *et al*., 2013) [11, 15]. In international markets, around 40% of broccoli is sold fresh, while the remaining 60% is distributed in frozen form. The word "broccoli" originates from the Italian *broccolo*, meaning "the flowering crest of a cabbage," derived from *brocco*, which means "sprout" or "small shoot."

Botanically, broccoli falls under the Cruciferae family and the Papaverales order, with a chromosome number of 2n = 2x = 18**.** It is widely appreciated for its exceptional nutritional value, being rich in vitamins, minerals, proteins, and dietary fiber. Notably, broccoli contains approximately 130 times more Vitamin A than cauliflower and 22 times more than cabbage. According to Prashanthi *et al*. (2022) [9], the nutritional composition of broccoli per 100 grams

includes 89.3 g moisture, 141 kcal energy, 6.64 g carbohydrates, 1.7 g sugar, 2.6 g dietary fiber, 0.37 g fat, and 2.82 g protein. It also provides 47 mg calcium, 0.73 mg iron, 66 mg phosphorus, along with essential vitamins such as thiamine (0.071 mg), riboflavin (0.117 mg), niacin (0.639 mg), and Vitamin C (89.2 mg).

The cultivation of broccoli has seen notable growth in India in recent years. As reported by Singh and Deepanshu (2023) [11], it is now cultivated over an area of approximately 3,776 acres, producing an annual yield of around 26.6 million pounds, with an average productivity of 7.04 thousand pounds per acre. This growth reflects the crop's increasing acceptance in Indian agriculture due to its high market value and significant health benefits.

Materials and Methods

The present study, titled "Varietal Evaluation of Broccoli (*Brassica oleracea* var. italica) under Prayagraj Agroclimatic Conditions," was conducted during the *Rabi* season of 2024-2025 at the Horticulture Research Farm, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. Located in the southeastern part of Uttar Pradesh, the Prayagraj district falls under the subtropical climatic zone, characterized by extremely hot summers and moderately cold winters. During the growing season, maximum temperatures in the region ranged between 32°C and 34°C, while the lowest temperatures dipped to around 4°C to 5°C. The relative humidity varied from 20% to 94%, and the area receives an average annual rainfall of approximately 1013.4 mm.

In this experiment, seeds were sown in nursery beds on 23rd October 2024, and transplanting was done on 1st December 2024. The trial was laid out in a Randomized Block Design (RBD) with three replications to ensure statistical reliability. The total experimental area was divided into plots, each measuring 2.4 m × 1.5 m (3.6 m²). The plant spacing maintained was 60 cm between rows and 45 cm between plants, accommodating 12 plants per plot.

The experiment evaluated ten broccoli varieties

- V1: Saki
- V2: Anastya
- V3: Romanesco
- V4: Matsuri
- V5: Hari
- V6: Star
- V7: Green Magic
- V8: Palam Samridhi
- V9: Shishir
- V10: Palam Vichitra

To assess varietal performance, data was recorded on various growth, yield, and quality traits. These included plant height (cm), number of leaves per plant, leaf length and width (cm), stem diameter (cm), plant spread (cm), days to first curd formation, total duration from planting to harvest, curd diameter (cm), total plant weight without roots (g), fresh curd weight (g), curd yield per plot (kg), total yield (t/ha), ascorbic acid content (mg/100g of edible portion), and total soluble solids (%).

All the recorded data were statistically analyzed using Analysis of Variance (ANOVA) under the two-way classification system as per the methodology described by Panse and Sukhatme (1985), to determine the significance of treatment effects.

Results and Discussion

The evaluation of different broccoli varieties revealed significant differences in terms of growth, yield, and quality parameters. The detailed results are presented in Table 1 and 2 and illustrated in Figures 1 and 2. Among the ten varieties tested, the tallest plants were observed in V10 (Palam Vichitra), which recorded a plant height of 56.42 cm. This was followed closely by Shishir and Green Magic, which also showed comparatively greater plant height. In contrast, the shortest plants were recorded in V3 (Romanesco), with an average height of 42.26 cm.

The variation in plant height across varieties can likely be attributed to differences in genetic potential, as well as longer crop duration in Palam Vichitra, which allowed for extended vegetative growth before curd formation. These results are consistent with earlier studies conducted by Nooprom *et al.* (2013) [8], El-Bassiony *et al.* (2014) [2], Singh *et al.* (2014) [10], Hafiz *et al.* (2015) [6], and Thakur *et al.* (2016) [14], who reported similar varietal effects on plant height in broccoli.

The maximum number of leaves per plant have been recorded with the treatment V_{10} (Palam Vichitra) was 35.00. Followed by Shishir and Green magic. Whereas the minimum recorded number of leaves per plant was (19.97) with the treatment V_3 (Romanesco). In this study, the variation observed in the number of leaves per plant among different broccoli varieties can be attributed primarily to their inherent genetic potential and adaptability to the prevailing climatic conditions of the region. Varieties producing fewer leaves may have exhibited a slower rate of leaf initiation, which could explain their lower leaf count. These results are in close agreement with earlier research conducted by El-Magd *et al.* (2006) [3], El-Magd *et al.* (2013) [4] and Thapa and Rai (2012) [15], who also reported similar varietal differences in broccoli. The maximum leaf length (cm) have been recorded with the treatment V_{10} (Palam Vichitra) was 49.48. Followed by Shishir and Green magic. Where as the minimum recorded leaf length (cm) was (31.33) with the treatment V_3 (Romanesco). The variation in leaf length observed among the broccoli varieties is likely influenced by their genetic makeup as well as the local agro-climatic conditions during the growing season. Varieties with longer leaves may possess genotypic traits that promote enhanced vegetative growth under favorable conditions. These results are consistent with the findings reported by Hafiz *et al.* (2015) [6] and further supported by the observations of Changkiri *et al.* (2022) [1] in similar studies on broccoli.The maximum leaf width (cm) have been recorded with the treatment V_{10} (Palam Vichitra) was 25.57. Followed by Shishir and Green magic. Where as the minimum recorded leaf width (cm)was (17.39) with the treatment V_3 (Romanesco). The differences in leaf width among the broccoli varieties could be attributed to their genetic traits and how well they respond to the prevailing agro-climatic conditions. Varieties that showed broader leaves may have had a better genetic predisposition for vegetative growth under these specific environmental factors. These observations are in line with the results reported by Hafiz *et al.* (2015) [6] and are further supported by the findings of Changkiri *et al.* (2022) [1] in their studies on broccoli. The maximum stem diameter (cm)have been recorded with the treatment V_{10} (Palam Vichitra) was 5.34. Followed by Shishir and Green magic. Where as the minimum recorded stem diameter (cm) was (3.07) with the treatment V_3 (Romanesco). the maximum plant spread (cm) have been recorded with the treatment V_{10} (Palam Vichitra) was 75.75. Followed by Shishir and Green magic. Where as the minimum recorded plant spread (cm) was (55.74) with the treatment V_3

(Romanesco). The observed variation in plant spread (both East-West and North-South directions) among the different broccoli varieties is likely influenced by their genetic characteristics**,** the duration taken to reach head maturity**,** and their adaptability to local climatic conditions. Varieties that took longer to mature or had more vigorous vegetative growth tended to exhibit a wider plant spread. These results are consistent with the findings of El-Bassiony *et al*. (2014) [2]**,** Singh *et al*. (2014) [10]**,** Hafiz *et al*. (2015) [6]**,** Thakur *et al*. (2016) [14]**,** and are further supported by the observations of Changkiri *et al*. (2022) [1] in similar broccoli evaluations. The minimum days of first curd formation was recorded (50.05days) in V_{10} (Palam Vichitra). Followed by Shishir and Green magic. Whereas the maximum days of first curd formation was found (61.70) in V_3 (Romanesco).The variation in earliness to edible maturity among the broccoli varieties can likely be attributed to genetic differences inherent to each cultivar. These findings are in agreement with earlier studies conducted by Gogoi *et al.* (2016) [5], and Thakur *et al*. (2016) [14]**,** who reported similar trends in broccoli. These findings are in accordance with the findings reported by Changkiri *et al*. (2022) [1]. The minimum total duration from planting to harvesting was recorded (70.34days) in V_{10} (Palam Vichitra). Followed by Shishir and Green magic. Whereas the maximum total duration from planting to harvesting was found (97.54) in V_3 (Romanesco). The significant differences observed in fresh head weight**,** head yield per plot**,** and head yield per hectare across the broccoli varieties are likely due to their distinct genetic traits and how well each variety adapted to the prevailing agro-climatic conditions of the region. Some varieties demonstrated better performance because they were more suited to the environmental conditions, which positively influenced their yield potential. These findings are in line with the results reported by El-Bassiony *et al.* (2014) [2] in cabbage, and by Thapa and Rai (2012) [15]**,** El-Magd (2013) [4]**,** Nguille *et al.* (2014)**,** Singh *et al.* (2014) [10], and Thakur *et al.* (2016) [14] in broccoli. Similar outcomes were also observed in the study by Changkiri *et al.* (2022) [1]**.**

The maximum curd diameter (cm) was recorded (15.46) in V_{10} (Palam Vichitra). Whereas the minimum curd diameter (cm) was found (11.30) in V_3 (Romanesco). However, Shishir and green magic are found statistically at par to V_{10} (Palam Vichitra).

The noticeable variation in fresh head weight**,** yield per plot**,** and overall yield per hectare among the different broccoli varieties is likely due to a combination of their inherent genetic potential and how well each variety adapted to the specific agro-climatic conditions of the region. Some varieties demonstrated superior performance, suggesting they were more suited to the local environment in terms of growth and productivity. These results are consistent with previous research findings by El-Bassiony *et al*. (2014) [2] in cabbage, and by Thapa and Rai (2012) [15], El-Magd (2013) [4], Nguille *et al*. (2014), Singh *et al*. (2014) [10], and Thakur *et al*. (2016) [14] in broccoli. Similar outcomes were also reported by Changkiri *et al*. (2022) [1], further supporting these observations.

The maximum total weight of plant without roots (g) was recorded (983.14) in V_{10} (Palam Vichitra). Followed by Shishir and Green magic. Whereas the minimum total weight of plant without roots (g) was found (673.86) in V_3 (Romanesco).

The significant differences observed in fresh head weight, head yield per plot, and yield per hectare across the various broccoli varieties can be attributed to their distinct genetic characteristics and how well each variety responded to the climatic conditions of the region**.** Some varieties were naturally better adapted, resulting in improved growth and yield performance. These results are consistent with earlier research by El-Bassiony *et al*. (2014) [2] in cabbage, as well as studies by Thapa and Rai (2012) [15]**,** El-Magd (2013) [4]**,** Nguille *et al*. (2014)**,** Singh *et al*. (2014) [10]**,** and Thakur *et al*. (2016) [14] in broccoli. The findings also align with the observations made by Changkiri *et al*. (2022) [1]**.** The maximum curd weight (g) was recorded (631.41) in V_{10} (Palam Vichitra). Followed by Shishir and Green magic. Whereas the minimum curd weight (g) was found (331.27) in V_3 (Romanesco). The notable variation in fresh head weight**,** yield per plot, and yield per hectare across the different broccoli varieties can largely be attributed to their genetic diversity and how well each variety was able to adapt to the prevailing climatic conditions of the region. Certain varieties performed better, likely due to a natural compatibility with the environmental factors of this zone. These results are in line with the findings of El-Bassiony *et al.* (2014) [2] in cabbage, and similar studies conducted by Thapa and Rai (2012) [15], El-Magd (2013) [4], Nguille *et al*. (2014), Singh *et al*. (2014) [10], and Thakur *et al*. (2016) [14] in broccoli. Comparable outcomes were also reported by Changkiri *et al*. (2022) [1], reinforcing the observed trends.

The maximum Curd yield plot (Kg) was recorded (7.58) in V_{10} (Palam Vichitra). Followed by Shishir and Green magic. Whereas the minimum Curd yield plot (Kg) was found (3.98) in V_3 (Romanesco). The observed variation in fresh head weight**,** yield per plot**,** and yield per hectare among the broccoli varieties is likely a result of their distinct genetic traits and their adaptability to the local climatic conditions**.** Some varieties showed better yield performance due to a more favorable response to the agro-environmental factors of the region. These outcomes are supported by earlier studies conducted by El-Bassiony *et al.* (2014) [2] in cabbage and by Thapa and Rai (2012) [15]**,** El-Magd (2013) [4]**,** Nguille *et al*. (2014)**,** Singh *et al*. (2014) [10], and Thakur *et al*. (2016) [14] in broccoli. Similar results were also reported by Changkiri *et al.* (2022) [1]**,** confirming the consistency of these findings across different studies.

The maximum curd yield (t ha^{-1}) was recorded (21.05) in V_{10} (Palam Vichitra). Followed by Shishir and Green magic. Whereas the minimum curd yield (t ha^{-1}) was found (11.04) in V_3 (Romanesco). The notable differences observed in fresh head weight**,** yield per plot, and yield per hectare among the broccoli varieties can be attributed to their unique genetic makeup and how well each variety adapted to the local climatic conditions. Some cultivars naturally performed better due to their compatibility with the environment in this particular agro-climatic zone. These results are consistent with previous research conducted by El-Bassiony *et al.* (2014) [2] in cabbage, and by Thapa and Rai (2012) [15], El-Magd (2013) [4], Nguille *et al*. (2014), Singh *et al*. (2014) [10], and Thakur *et al*. (2016) [14] in broccoli. Similar patterns were also noted in the findings of Changkiri *et al*. (2022) [1].

The maximum Ascorbic acid (mg/100g of edible portion) was recorded (118.52) in V_{10} (Palam Vichitra). Followed by Shishir and Green magric. Whereas the minimum Ascorbic acid (mg/100g of edible portion) was found (107.12) in V_3 (Romanesco). These results align with the observations made by Changkiri *et al*. (2022) [1]. Among the varieties tested, the highest total soluble solids content (measured in °Brix) was recorded in V_{10} (Palam Vichitra) with a value of 4.28, followed by the varieties Shishir and Green Magic. On the other hand, the lowest total soluble solids content of 3.16 °Brix was observed in V_3 (Romanesco). These patterns are consistent with previous findings reported by Changkiri *et al*. (2022) [1].

Table 1: Effect of different varieties of Broccoli (*Brassica oleraceae* var. *Italica*) on growth, yield and quality.

Notation	Varieties	Plant height (cm)	Number of leaves per plant	Leaf length (cm)	Leaf width (cm)	Stem diameter (cm)	Plant spread (cm)	Days of first curd formation	Total duration from planting to harvesting	Diameter of curd (cm)
V_1	Saki	44.14	23.59	36.33	21.49	4.67	63.14	58.10	71.83	11.77
V_2	Anastya	46.67	26.66	39.49	22.43	4.49	61.16	54.49	71.95	13.06
V_3	Romanesco	42.26	19.97	31.33	17.39	3.07	55.74	61.70	75.45	11.30
V_4	Matsuri	49.28	23.49	42.39	23.09	4.28	68.16	57.00	72.75	13.38
V_5	Hari	50.73	28.16	45.95	20.76	4.40	63.92	54.64	73.10	12.76
V_6	Star	50.27	26.62	42.10	23.09	4.12	60.94	54.76	72.96	13.19
V_7	Green magic	54.05	31.21	46.37	23.79	5.15	70.66	52.16	72.10	14.09
V_8	Palam Samridhi	52.60	30.33	45.02	23.30	4.19	69.15	55.67	72.91	12.07
V_9	Shishir	54.33	32.53	47.49	25.17	5.26	73.92	51.39	71.16	14.49
V_{10}	Palam Vichitra	56.42	35.00	49.48	25.57	5.34	75.75	50.05	70.34	15.46
	F-Test	S	S	S	S	S	S	S	S	S
	S.Ed. (±)	0.446	0.490	0.773	0.108	0.092	0.712	0.604	0.219	0.097
	C.D. at 5%	0.937	1.030	1.624	0.227	0.193	1.496	1.268	0.460	0.204
	CV	1.091	2.163	2.223	0.585	2.499	1.316	1.344	0.370	0.903

Table 2: Effect of different varieties of Broccoli (*Brassica oleraceae* var. *Italica*) on growth, yield and quality.

Notation	Varieties	Total weight of plant without roots (g)	Fresh weight of curd (g)	Curd yield per plot (kg)	Curd yield (t ha-1)	Ascorbic acid (mg/100g of edible portion)	Total soluble solid (°Brix)
V_1	Saki	874.21	511.90	6.14	17.06	113.42	3.90
V_2	Anastya	844.68	479.90	5.76	16.00	112.50	3.75
V_3	Romanesco	673.86	331.27	3.98	11.04	107.12	3.16
V_4	Matsuri	832.70	465.73	5.59	15.52	110.19	3.58
V_5	Hari	903.31	521.85	6.26	17.40	108.63	3.41
V_6	Star	812.44	428.62	5.14	14.29	112.03	3.46
V_7	Green magic	973.21	581.07	6.97	19.37	113.14	4.08
V_8	Palam Samridhi	912.08	509.16	6.11	16.97	113.33	3.80
V_9	Shishir	980.90	626.64	7.52	20.89	114.77	4.20
V_{10}	Palam Vichitra	983.14	631.41	7.58	21.05	118.52	4.28
	F-Test	S	S	S	S	S	S
	S.Ed. (±)	2.099	2.896	0.210	0.087	0.422	0.069
	C.D. at 5%	4.410	6.084	0.441	0.184	0.887	0.144
	CV	0.292	0.697	4.206	0.0631	0.460	2.235

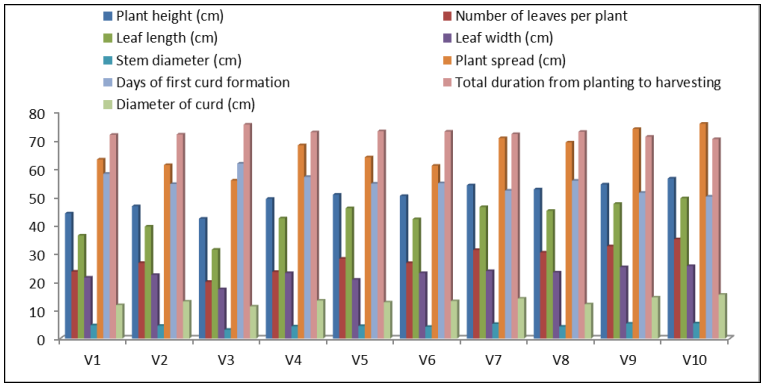

Fig 1: Effect of different varieties of Broccoli (*Brassica oleraceae* var. *Italica*) on growth, yield and quality.

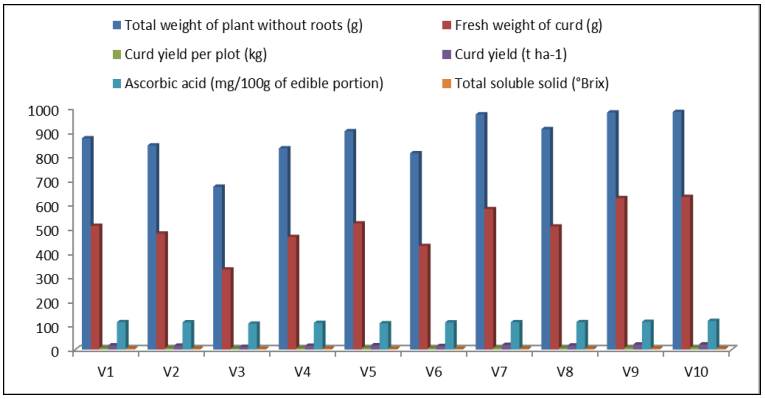

Fig 2: Effect of different varieties of Broccoli (*Brassica oleraceae* var. *Italica*) on growth, yield and quality

Conclusion

Based on the findings of this study, the variety V_{10} (Palam Vichitra) emerged as the best performer among all the tested broccoli varieties in terms of growth, yield, and quality. This variety showed the greatest plant height (56.42 cm), number of leaves per plant (35), leaf length (49.48 cm), leaf width (25.57 cm), stem diameter (5.34 cm), and overall plant spread (75.75 cm). It also had the earliest curd formation at around 50 days and a total growing period of about 70 days from planting to harvest. Additionally, Palam Vichitra produced the largest curd diameter (15.46 cm), highest total plant weight excluding roots (983.14 g), heaviest curd weight (631.41 g), and greatest yield per plot (7.58 kg), translating to 21.05 tons per hectare. This variety also had the highest ascorbic acid content (118.52 mg/100g edible portion) and total soluble solids (4.28 °Brix). Meanwhile, the variety Shishir recorded the highest benefit-cost ratio of 6.07. However, since this study was conducted over a single season, additional trials across different seasons and locations are recommended to confirm these results.

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