International Journal of Plant & Soil Science

Volume 36, Issue 4, Page 386-395, 2024; Article no.IJPSS.113508
ISSN: 2320-7035

Qualitative and Quantitative Aspects of Broccoli (*Brassica oleracea* var. *italica* Plenck.) Influenced by Plant Spacing and Varieties

Urvi V. Bangoria [a++*], Monu Kumari [b#], N. B. Patel [b†] and Dushyant. D. Champaneri [b++]

[a] Department of Vegetable Science, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, Mehsana, Gujarat, India.
[b] Department of Vegetable Science, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2024/v36i44492

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/113508

Original Research Article

Received: 30/12/2023
Accepted: 03/03/2024
Published: 12/03/2024

ABSTRACT

Optimum plant spacing and availability of suitable high yielding cultivars may help the farmers to achieve more returns per unit area by efficient absorption of nutrients and trapping of solar energy. The effect of growing different varieties at various spacing under south Gujarat condition is not tested. Keeping this in view, the present investigation was planned to study during *Rabi*, 2019-20 at Vegetable Research Farm, Regional Horticultural Research Station, Navsari Agricultural University,

[++] Ph.D Scholar;
[#] M.Sc. Scholar;
[†] Associate Professor;
**Corresponding author: E-mail: urvi.bangoria@gmail.com;*

Navsari, Gujarat, India. There were nine treatment combinations comprising three levels of plant spacings *i.e.* S_1: 30 cm × 30 cm, S_2: 45 cm × 30 cm and S_3: 45 cm × 45 cm as well as three varieties *i.e.* V_1: Pusa KTS 1, V_2: Palam Samridhi and V_3: Ganesh Broccoli in a Randomized Block Design (Factorial) with three replications. The results of the study inferred that, maximum values for growth, yield and quality parameters were observed at wider spacing of 45 cm × 45 cm while maximum yield was obtained from closer spacing of 30 cm × 30 cm. Among the all varieties Palam Samridhi performed best and recorded highest values for growth, yield and quality parameters. Variety Palam Samridhi at closer spacing of 30 cm × 30 cm found best for securing higher yield (13.86 t ha^{-1}) and higher BCR (1.91) ratio of broccoli.

Keywords: Pusa KTS 1; Palam Samridhi; Ganesh Broccoli; Plant density; economics; quality parameters; broccoli; green leafy;

1. INTRODUCTION

"Vegetables occupy a significant role in the field of Indian agriculture to boost up production per unit area and time. In this era of global warming and climate change, vegetables are considered an essential food as they are rich in proteins, carbohydrates, minerals, vitamins and many more essential nutrients for better survival of humans" [1]. They are also reckoned as protective food essential for human health and by considering this fact Indian council of medical research (ICMR) have recommended a daily uptake of 300 g vegetables/day including 125 g green leafy vegetables, 100 g root vegetables and 75 g other vegetables [2]. "Broccoli is member of Brassicaceae family and one of the important exotic vegetable grown on small scale in India. It is mostly cultivated in hilly areas of Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir, Nilgiri hills and Southern plains of India [3]. Cauliflower and broccoli are cultivated in the area of 0.43 million hectares with an annual production of 8.57 million tonne and productivity of 19.47 tonne per hectare" [4].

"Broccoli is known for its better taste, flavour and high nutritive and medicinal value. Curds and spears of the broccoli are used as salad, single or mixed vegetable curry, soup, sauces, boiled, stir fried and also as a dried product. It contains energy (32 kcal), moisture (89.1 %), protein (3.6 g), fat (0.3 g), vitamin A (2500 IU), vitamin C (78 mg), thiamin (0.11 mg), riboflavin (0.1 mg), niacin (0.9 mg), calcium (103 mg), phosphorus (78 mg), iron (1.1 mg), carbohydrates (5.9 g) and CHO (4.9 g) per 100 g of edible portion" [5]. "Optimum plant spacing and availability of suitable high yielding cultivars may help the farmers to achieve more returns per unit area and also for efficient absorption of nutrients and trapping of solar energy. The contribution of farming to Indian GDP can be increased with right selection of crops and varieties alongside proper cultivation practices" [6]. The effect of growing different varieties at various spacing under south Gujarat condition is not tested. The response may differ in growth, yield and quality parameters of broccoli with respect to varieties and spacing.

2. MATERIALS AND METHODS

The experiment was carried out during *Rabi* 2019-20 at Vegetable Research Farm, Regional Horticultural Research Station, Navsari Agricultural University, Navsari, in block 'E', plot 7. The experimental soil was deep black, having well drainage as well as good water holding capacity and reasonably suitable for broccoli growing. Seed sowing was done during third week of September, 2019 on raised beds. Seedlings of broccoli were raised in nursery under protected structure (Polyhouse) to enhance better germination and growth. The raised bed of 60 cm width, 30 cm height and 15 m length was used for raising seedlings.

The experimental field was thoroughly prepared by ploughing and harrowing before transplanting of seedlings. Land leveling was done with the help of wooden plank. The plots were prepared manually as per the lay out. As per recommended dose, well decomposed farm yard manure (10 t ha^{-1}) and inorganic fertilizer (160 kg N, 60 kg P_2O_5 and 60 kg K_2O) per hectare were applied. Full dose of FYM 10 t ha^{-1}, P_2O_5 60 kg ha^{-1}, K_2O 60 kg ha^{-1} and half dose of N 80 kg ha^{-1} were applied as basal dose. Remaining half dose of N 80 kg ha^{-1} was applied at 30 DATP. One month old uniform seedlings, healthy, well developed, free from diseases and insect infestation were transplanted in the experimental plot during third week of October, 2019. Earthing up was done at 30 DATP for good, upright growth and also for support after transplanting to the young growing plant.

The experiment was conducted in Randomized Block Design (Factorial) with three replications. There were nine treatment combinations comprising three levels of plant spacings *i.e.* S_1: 30 cm × 30 cm, S_2: 45 cm × 30 cm, S_3: 45 cm × 45 cm and three varieties *i.e.* V_1: Pusa KTS 1, V_2: Palam Samridhi and V_3: Ganesh Broccoli. For recording different observations of growth parameters, five plants of broccoli from each net plot area were selected randomly in the beginning and tagged with the labels. Growth parameters were observed at 30 DATP and at the time of Harvesting. For yield and quality parameters, five marketable curds were selected and observations were recorded. Yield was recorded from whole net plot area.

3. RESULTS AND DISCUSSION

3.1 Influence of Plant Spacings on Growth, Yield and Quality

Data regarding effect of plant spacings on growth parameters (Table 1) was found significant and spacing S_1 (30 cm × 30 cm) was found best for minimum days to first curd initiation (52.33), days taken for curd harvesting (60.67) and maximum plant height at 30 DATP (30.18 cm) and at the time of harvesting (58.56 cm). In lower spacing maximum competition exists among the plants resulting in less vegetative growth and forcing them to initiate early and harvesting was also early as compared to higher plant spacing. In narrow spacing spreading of plant was less and plant growth was upward so plants have more height in lower spacings. Similar results were observed by Thirupal *et al.* [7] and Gurjeet Kaur [8] in broccoli as well as Yadav *et al.* [9] in cabbage. Spacing S_3 (45 cm × 45 cm) produced highest values for plant spread (N-S) (30.53 cm and 52.64 cm), plant spread (E-W) (30.93 cm and 54.16 cm), number of leaves plant^{-1} (9.97 and 24.12), length of leaf (14.07 cm and 33.07 cm) at 30 DATP and at the time of harvesting, respectively. The wider plant spacing leads to good growth and development as there was less competition for the uptake of nutrients, water and sunlight, which leads to more lateral growth which increases number of leaves plant^{-1}, plant spread and length of leaf. Results are in close conformity with Lamo *et al.* [10] Malviya [11], Tejaswini [12] and Kumar *et al.* [13] in broccoli while Mishra *et al.* [14] in cabbage.

Data depicted in Table 2 revealed that effect of plant spacings was found significant for yield parameters and revealed that maximum values for curd length (11.20 cm), curd diameter (10.73 cm), stalk diameter (36.05 mm), gross curd weight (stalk + curd) (154.38 g), net curd weight (129.29 g) and minimum stalk length (3.22 cm) were recorded with spacing S_3 (45 cm × 45 cm). Better growth of plant in wider plant spacing might be due to more interception of light, less competition for moisture and nutrients which increases photosynthesis and accumulation of photosynthates in the main head therefore curd weight will be more which further shows increased head size. The results are in accordance with Yadav *et al.* [15], Malviya [11], Tejaswini [12] and Kumar *et al.* [16] in broccoli. Maximum curd yield (10.73 t ha^{-1}) and harvest index (19.62 %) were observed at spacing S_1 (30 cm × 30 cm). Maximum yield hectare^{-1} was obtained at closer spacing that might be due to significant increases in number of marketable heads with increasing plant density and plants produced smaller sized curds along with too much retarded vegetative growth which also increase the harvest index. The result confirmed the findings of Gogoi *et al.* [17], Malviya [11], Tejaswini [12], Akshatha [18] and Kumar *et al.* [16] in broccoli as well as Mishra *et al.* [14] and Yadav *et al.* [9] in cabbage.

The effect of various plant spacings was found significant for quality parameters (Table 3). Maximum dry matter content of curd (10.75 %) was recorded from spacing S_3 (45 cm × 45 cm) that might be due to more synthesis of metabolites in wider plant spacing. Similar results were observed from, Roni *et al.* [19] and Malviya [11] in broccoli as well as Kolota and Chohura [20] in cabbage. Highest value for vitamin C (26.22 mg 100 g^{-1}) was observed at spacing S_1 (30 cm × 30 cm). The results are in close conformity with Yadav *et al.* [15] in broccoli and Kolota and Chohura [20] in cabbage.

3.2 Influence of Varieties on Growth, Yield and Quality

The effect of varieties was found significant with growth parameters (Table 4). Variety V_2 (Palam Samridhi) recorded maximum plant height (29.86 cm and 56.42 cm), plant spread (N-S) (34.84 cm and 55.19 cm), plant spread (E-W) (34.76 cm and 52.76 cm), number of leaves plant^{-1} (9.91 and 22.51), length of leaf (14.40 cm and 35.37 cm) at 30 DATP and at the time of harvesting, respectively. Minimum days to first curd initiation (47.33) and days taken for curd harvesting (56.89) were observed with variety V_3 (Ganesh Broccoli). Effect of varieties on growth

Table 1. Effect of plant spacing on growth parameters

Factor (S)	Plant height (cm)		Plant spread (N-S) (cm)		Plant spread (E-W) (cm)		Number of leaves per plant		Length of leaf (cm)		Days to first curd initiation	Days taken for curd Harvesting
	30 DATP	At Harvest	30 DATP	At Harvest	30 DATP	At Harvest	30 DATP	At Harvest	30 DATP	At Harvest		
S_1	30.18	58.56	27.18	38.71	27.37	40.54	8.51	17.61	8.61	26.64	52.33	60.67
S_2	26.58	52.47	29.21	45.74	29.47	46.04	9.20	20.43	10.91	31.28	54.33	63.11
S_3	22.42	45.07	30.53	52.64	30.93	54.16	9.97	24.12	14.07	33.07	57.67	67.11
S.Em. ±	0.56	1.35	0.78	1.07	0.88	1.17	0.25	0.57	0.44	0.86	1.29	1.56
C.D. at 5%	1.69	4.06	2.35	3.21	2.64	3.51	0.75	1.72	1.31	2.57	3.88	4.69

Table 2. Effect of plant spacing on yield parameters

Factor (S)	Curd length (cm)	Curd diameter (cm)	Stalk length (cm)	Stalk diameter (mm)	Gross curd weight (g)	Net curd weight (g)	Curd yield plot^{-1} (kg)	Curd yield (t ha^{-1})	Harvest index (%)
S_1	7.77	7.39	4.29	19.20	97.97	79.81	6.76	10.73	19.62
S_2	9.34	9.09	3.80	24.96	122.22	95.83	5.01	8.84	17.57
S_3	11.20	10.73	3.22	30.14	154.38	129.29	3.60	7.40	15.47
S.Em. ±	0.26	0.22	0.11	0.73	3.47	3.07	0.16	0.28	0.20
C.D. at 5%	0.77	0.65	0.32	2.19	10.39	9.20	0.47	0.83	0.59

Table 3. Effect of plant spacing on quality parameters

Factor (S)	Dry matter content of curd (%)	Vitamin C (mg 100 g^{-1})	Vitamin A (µg 100 g^{-1})
S_1	9.86	26.22	44.78
S_2	10.38	23.67	43.89
S_3	10.75	21.00	44.89
S.Em. ±	0.16	0.37	0.70
C.D. at 5%	0.49	1.10	2.11

Table 4. Effect of varieties on growth parameters

Factor (V)	Plant height (cm)		Plant spread (N-S) (cm)		Plant spread (E-W) (cm)		Number of leaves per plant		Length of leaf (cm)		Days to first curd initiation	Days taken for curd Harvesting
	30 DATP	At Harvest	30 DATP	At Harvest	30 DATP	At Harvest	30 DATP	At Harvest	30 DATP	At Harvest		
V_1	26.67	53.31	27.51	43.69	26.79	46.77	8.71	21.04	10.36	33.21	58.44	67.89
V_2	29.86	56.42	34.84	55.19	34.76	52.76	9.91	22.51	14.40	35.37	58.56	66.11
V_3	22.66	46.36	24.57	38.22	26.22	41.22	9.06	18.61	8.83	22.41	47.33	56.89
S.Em. ±	0.56	1.35	0.78	1.07	0.88	1.17	0.25	0.57	0.44	0.86	1.29	1.56
C.D. at 5%	1.69	4.06	2.35	3.21	2.64	3.51	0.75	1.72	1.31	2.57	3.88	4.69

Table 5. Effect of varieties on yield parameters

Factor (V)	Curd length (cm)	Curd diameter (cm)	Stalk length (cm)	Stalk diameter (mm)	Gross curd weight (g)	Net curd weight (g)	Curd yield plot^{-1} (kg)	Curd yield (t ha^{-1})	Harvest index (%)
V_1	8.34	9.21	3.51	24.79	126.08	101.30	5.30	9.27	17.26
V_2	9.29	10.58	3.24	28.51	161.39	133.43	6.63	11.64	18.76
V_3	10.68	7.41	4.56	21.01	87.10	70.20	3.43	6.06	16.63
S.Em. ±	0.26	0.22	0.11	0.73	3.47	3.07	0.16	0.28	0.20
C.D. at 5%	0.77	0.65	0.32	2.19	10.39	9.20	0.47	0.83	0.59

Table 6. Effect of varieties on quality parameters

Factor (V)	Dry matter content of curd (%)	Vitamin C (mg 100 g^{-1})	Vitamin A (µg 100 g^{-1})
V_1	10.95	20.11	49.22
V_2	10.94	18.33	44.11
V_3	9.09	32.44	40.22
S.Em. ±	0.16	0.37	0.70
C.D. at 5%	0.49	1.10	2.11

Table 7. Effect of interaction of plant spacing and varieties on growth parameters

Factor (V×S)	Plant height (cm)		Plant spread (N-S) (cm)		Plant spread (E-W) (cm)		Number of leaves per plant		Length of leaf (cm)		Days to first curd initiation	Days taken for curd Harvesting
	30 DATP	At Harvest	30 DATP	At Harvest	30 DATP	At Harvest	30 DATP	At Harvest	30 DATP	At Harvest		
V_1S_1	30.10	57.93	26.13	35.00	25.50	39.83	8.03	17.30	8.42	30.44	55.00	65.00
V_1S_2	26.47	52.47	27.33	41.13	26.87	43.27	8.70	20.70	9.16	36.73	58.00	67.33
V_1S_3	23.43	49.53	29.07	54.93	28.00	57.20	9.40	25.13	13.51	32.44	62.33	71.33
V_2S_1	35.07	67.67	32.73	49.27	31.80	45.07	8.97	18.20	9.67	31.42	57.00	62.33
V_2S_2	30.83	56.07	35.27	56.63	35.07	52.00	9.87	22.00	14.82	34.91	58.67	66.00
V_2S_3	23.67	45.53	36.53	59.67	37.40	61.20	10.90	27.33	18.70	39.78	60.00	70.00
V_3S_1	25.37	50.07	22.67	31.87	24.80	36.73	8.53	17.33	7.74	18.04	45.00	54.67
V_3S_2	22.43	48.87	25.03	39.47	26.47	42.87	9.03	18.60	8.74	22.20	46.33	56.00
V_3S_3	20.17	40.13	26.00	43.33	27.40	44.07	9.60	19.90	10.00	26.98	50.67	60.00
S.Em. ±	0.97	2.35	1.36	1.86	1.53	2.03	0.43	0.99	0.76	1.49	2.24	2.71
C.D. at 5%	2.92	7.03	NS	5.57	NS	6.08	NS	2.98	2.27	4.45	NS	NS
C.V. (%)	6.39	7.81	8.11	7.04	9.03	7.49	8.1	8.32	11.69	7.81	7.09	7.38

Table 8. Effect of interaction of plant spacing and varieties on yield parameters

Factor (V×S)	Curd length (cm)	Curd diameter (cm)	Stalk length (cm)	Stalk diameter (mm)	Gross curd weight (g)	Net curd weight (g)	Curd yield plot^{-1} (kg)	Curd yield (t ha^{-1})	Harvest index (%)
V_1S_1	7.60	7.65	3.80	20.80	106.80	86.13	7.23	11.47	19.41
V_1S_2	8.17	9.03	3.40	24.70	127.67	101.00	5.18	9.14	17.61
V_1S_3	9.27	10.96	3.33	28.86	143.77	116.77	3.50	7.20	14.76
V_2S_1	7.20	8.13	3.80	20.11	125.57	102.27	8.73	13.86	20.79
V_2S_2	9.07	10.80	3.53	29.38	155.80	124.80	6.55	11.54	18.28
V_2S_3	11.60	12.79	2.40	36.05	202.80	173.23	4.63	9.52	17.22
V_3S_1	8.50	6.37	5.27	16.70	61.53	51.03	4.32	6.86	18.66
V_3S_2	10.80	7.43	4.47	20.81	83.20	61.70	3.31	5.83	16.82
V_3S_3	12.73	8.44	3.93	25.51	116.57	97.87	2.66	5.48	14.42
S.Em. ±	0.44	0.37	0.18	1.26	6.00	5.32	0.27	0.48	0.34
C.D. at 5%	1.33	1.12	0.55	3.79	18.00	15.94	0.82	1.43	NS
C.V. (%)	8.15	7.16	8.47	8.83	8.33	9.06	9.2	9.21	3.35

Table 9. Effect of interaction of plant spacing and varieties on quality parameters

Factor (V×S)	Dry matter content of curd (%)	Vitamin C (mg 100 g^{-1})	Vitamin A (µg 100 g^{-1})	BCR
V_1S_1	10.13	22.00	51.00	1.43
V_1S_2	11.00	20.00	49.33	1.27
V_1S_3	11.71	18.33	47.33	1.15
V_2S_1	10.59	22.00	44.33	1.91
V_2S_2	11.01	18.33	42.00	1.83
V_2S_3	11.22	14.67	46.00	1.81
V_3S_1	8.84	34.67	39.00	0.48
V_3S_2	9.12	32.67	40.33	0.47
V_3S_3	9.32	30.00	41.33	0.66
S.Em. ±	0.28	0.63	1.22	-
C.D. at 5%	NS	NS	NS	-
C.V. (%)	4.71	4.64	4.73	-

parameters might be due to specific varietal characteristics of particular variety in that climatic conditions. Results are in accordance with Gurjeet Kaur [8], Malviya [11], Tejaswini [12] and Kumar *et al.* [13] in broccoli as well as Mishra *et al.* [14] in cabbage.

The significant effect of varieties was found for yield parameters (Table 5) and results confirmed that maximum curd length (10.68 cm) was obtained from variety V_3 (Ganesh Broccoli). Highest values for curd diameter (10.58 cm), stalk diameter (28.51 mm), gross curd weight (stalk + curd) (161.39 g), net curd weight (133.43 g), curd yield (11.64 t ha^{-1}), harvest index (18.76 %) and minimum stalk length (3.24 cm) were recorded from variety V_2 (Palam Samridhi). The variation observed among the varieties for yield parameters may be attributed to the variability in their genetic configuration and variability with respect to suitability of the climate of the particular region. The result confirmed the findings of Giri *et al.* [21], Thakur, Seema *et al.* [22], Tejaswini [12] and Kumar *et al.* [16] in broccoli while Mishra *et al.* [14] and Yadav *et al.* [9] in cabbage.

The effect of varieties was found significant on quality parameters (Table 6). Maximum values of dry matter content of curd (10.94 %) and Vitamin A (49.22 µg 100 g^{-1}) were recorded from variety V_1 (Pusa KTS 1). Highest value for vitamin C (32.44 mg 100 g^{-1}) was obtained from variety V_3 (Ganesh Broccoli). The variation in quality parameters of different varieties may be due to inherent characters of different genotype and genetic setup. Similar results are observed by Abou El-magd [23] and Kumar *et al.* [16] in broccoli as well as Kolota and Chohura [20] and Yadav *et al.* [9] in cabbage.

3.3 Influence of Interaction Effect of Plant Spacings and Varieties

The combined effect of plant spacings and varieties was found significant on growth parameters (Table 7) and revealed that maximum plant height at 30 DATP (35.07 cm) and at the time of harvesting (67.67 cm) was recorded from treatment combination V_2S_1 (Palam Samridhi at 30 cm × 30 cm). Highest values for plant spread at the time of harvesting (N-S 59.67 cm and E-W 61.20 cm), number of leaves $plant^{-1}$ at the time of harvesting (27.33), length of leaf at 30 DATP (18.70 cm) and at the time of harvesting (39.78 cm) were observed from treatment combination V_2S_3 (Palam Samridhi at 45 cm × 45 cm). The results are in close conformity with Malviya [11], Tejaswini [12] and Kumar *et al.* [13] in broccoli while Shivran *et al.* [24] in knol khol.

The combined effect of plant spacings and varieties (Table 8) was significant on yield parameters. The highest curd length (12.73 cm) was observed from treatment combination V_3S_3 (Ganesh Broccoli at 45 cm × 45 cm). Highest values for curd diameter (12.79 cm), stalk diameter (36.05 mm), gross curd weight (stalk + curd) (202.80 g), net curd weight (173.23 g) and minimum stalk length (2.40 cm) were obtained from treatment combination V_2S_3 (Palam Samridhi at 45 cm × 45 cm). Highest curd yield (13.86 t ha^{-1}) was recorded from treatment combination V_2S_1 (Palam Samridhi at 30 cm × 30 cm). Results are in accordance with Malviya [11], Tejaswini [12] and Kumar *et al.* [16] in broccoli; Shivran *et al.* [24] in knol khol as well as Pavithra *et al.* [25] in onion.

The combined effect of plant spacings and varieties on quality parameters (Table 9) *viz.,* dry matter content of curd (%), vitamin C (mg 100 g^{-1}) and Vitamin A (µg 100 g^{-1}) were found non-significant.

3.4 Influence on Economics

For farmers, economics plays very crucial role in selection of crop as well as it is an integral part of production technology of vegetable crops. Economic feasibility of vegetable cultivation is an essential element to improve crop productivity [26]. The economics in terms of gross and net return for effect of plant spacings and varieties involved in present investigation was worked out. Among, different treatment combinations, V_2S_1 (Palam Samridhi at 30 cm × 30 cm) registered the highest net profit 272761 ₹ ha^{-1} with BCR value of 1.91 as compared to other treatment combinations. Similar result was confirmed by Tejaswini [12].

4. CONCLUSION

The results of the study inferred that maximum values for growth, yield and quality parameters were observed at wider spacing of 45 cm × 45 cm while maximum yield was obtained from closer spacing of 30 cm × 30 cm. Among all varieties, Palam Samridhi performed best and recorded the highest values for growth, yield and quality parameters. Variety Palam Samridhi at closer spacing of 30 cm × 30 cm was found best

for securing higher yield (13.86 t ha^{-1}) and higher BCR (1.91) ratio of broccoli.

FUTURE SCOPE

The results of this experiments can be used to identify integrated nutrient management practices, organic cultivation and application of growth regulators in broccoli to improve yield and quality parameters for south Gujarat region.

AKNOWLEDGEMENT

The authors are highly thankful to staff of Department of Vegetable Science, ASPEE College of Horticulture and Forestry, NAU, Navsari for providing all necessary to carry out the present study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Champaneri DD, Patel NK. Photo selective shade net: An effective tool to reduce the impact of global warming and pesticide residues in vegetable production: A review. Agricultural Reviews. 2022;43(2):135-144. DOI: 10.18805/ag.R-2363
2. Champaneri DD, Patel NK, Desai CS, Desai DH. Efficacy of novel organic liquid nutrient and novel plus organic liquid nutrient on quantitative traits of Indian bean [*Lablab purpureus* (L.) Sweet]. International Journal of Plant & Soil Science. 2021;33(17):105-115. DOI: 10.9734/IJPSS/2021/v33i1730555
3. Chadha KL. Handbook of Horticulture, ICAR, New Delhi. 2001;360-362.
4. Anonymous. Horticultural Statistics at A Glance", NHB, New Delhi. 2017;488.
5. Sable PA, Saravaiya SN, Sharma A. Vegetable crops package of practices. Narendra Publising House, Delhi. 2020;385.
6. Champaneri DD, Desai KD, Ahlawat TR, Shrivastava PK. Assessment of various uniformity aspects under surface drip irrigation system in tomato. International Journal of Environment and Climate Change. 2023;13(3):47–55. DOI:10.9734/ijecc/2023/v13i31680
7. Thirupal D, Madhumathi C, Syam Sundar Reddy P. Effect of planting dates and plant spacings on growth, yield and quality of broccoli under Rayalaseema zone of Andhra Pradesh, India. Plant Archives. 2014;14(2):1095-1098.
8. Gurjeet Kaur. Growth, yield and quality of broccoli (*Brassica oleracea* var. italica Plenck.) as influenced by nitrogen and plant population under different dates of sowing. Thesis, M.Sc. submitted to Punjab Agricultural University, Ludhiana. 2016;28-70.
9. Yadav S, Kumar S, Verma RS, Kumar L, Anushruti Singh V, Meena D, Shukla U, Sonkar VK. Effect of different varieties and spacings on yield and quality of cabbage (*Brassica oleracea* L. var. capitata). The Pharma Innovation Journal. 2023; 12(3): 458-461.
10. Lamo K, Parveen WK, Hussain KS. Response of broccoli–F_1 to different planting dates, nutrient levels and spacings under cold arid conditions of Ladakh (India). Global Journal for Research Analysis. 2017;6(3):671-674.
11. Malviya MK. Effect of plant spacing on growth, yield and quality of different varieties of sprouting broccoli (*Brassica oleracea* var. *italica* Plenck.). Thesis, M.Sc. submitted to Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior. 2017;56-100.
12. Tejaswini T. Performance of different varieties with respect to growth, yield and quality of broccoli (*Brassica oleracea* var. *italica* Plenck.) under north Gujarat conditions. Thesis, M.Sc. submitted to Sardarkrushinagar Dantiwada Agricultural University, Dantiwada. 2018;26-48.
13. Kumar S, Kumar P, Meena ML, Kumar R, Rawat R, Yadav S. Influence of varieties and spacing on growth characters of sprouting broccoli (*Brassica oleracea* L.). Annals of Plant and Soil Research. 2021a; 23(1):99-103.
14. Mishra P. Effect of different varieties and spacings on growth and yield attributes of cabbage (*Brassica oleracea* var. *capitata* L.) under Lucknow conditions. The Pharma Innovation Journal. 2022; 11(3):1174-1178.
15. Yadav LP, Singh A, Malhotra SK. Growth, yield and quality response of organic broccoli to intercrops and crop geometry. Indian Journal of Horticulture. 2016;73(3): 376-382.

16. Kumar P, Kumar S, Meena ML, Kumar R, Rawat R, YADAV S. Influence of varieties and spacing on yield and quality of sprouting broccoli (*Brassica oleracea* L.). Annals of Plant and Soil Research. 2021b;23(1):108-111.
17. Gogoi S, Das MR, Bora P, Mazumdar N, Das BK. Effect of sowing dates and spacing on broccoli (*Brassica oleracea* var. italica) seed production. Indian Journal of Agricultural Research. 2016;50(4):350-353.
18. Akshatha N, Panchal BH, Mahida S. Study the effect of different dates of transplanting and spacing on yield and quality of broccoli (*Brassica oleracea* var. *italica* Plenck.) cv. Palam Samridhi in middle Gujarat condition. International Journal of Chemical Studies. 2019;7(4): 1736-1738.
19. Roni MS, Zakaria M, Hossain MM, Siddiqui MN. Effect of plant spacing and nitrogen levels on nutritional quality of broccoli (*Brassica oleracea* L.). Bangladesh Journal of Agricultural Research. 2014;39(3):491-504.
20. Kolota E, Chohura P. Control of head size and nutritional value of cabbage by plant population and nitrogen fertilization. Acta Scientiarum Polonorum Hortorum Cultus. 2015;14(2):75-85.
21. Giri RK, Sharma MD, Shakya SM, Yubak Dhoj GC, Kandel TP. Growth and yield responses of broccoli cultivars to different rates of nitrogen in western Chitwan, Nepal. Agricultural. Science. 2013;4(7A): 8-12.
22. Thakur Seema, Thakur R, Mehtha DK. Evaluation of different genotypes of broccoli in dry temperate conditions of Kinnur district of Himachal Pradesh in India. International Journal of science, Environment and Technology. 2016;5(3): 1673-1679.
23. Abou El-Magd MM. Evaluation of some broccoli cultivars growth, head yield and quality under different planting dates. Journal of Applied Sciences Research. 2013;9(11):5730-5736.
24. Shivran BC, Meena ML, Kumar S, Pal H, Prakash S. Determining the combined effect of varieties and spacing on growth, yield and quality of Knolkhol (*Brassica oleracea* var. *gongylodes* L.). The Pharma Innovation Journal. 2021;10 (8):1482-1485.
25. Annem Pavithra V, Suchitra K, Nirosha R, Preetham Goud, Saravanan L. Study on efficacy of planting methods and spacing on growth and yield attributes of onion produced through bulb sets. Biological Forum – An International Journal. 2023;15 (10):33-38.
26. Champaneri DD, Patel NK, Desai CS, Tandel BM. Economics of Indian Bean [*Lablab purpureus* (L.) Sweet] production influenced by application of novel organic liquid nutrient and novel plus organic liquid nutrient. Asian Journal of Agricultural Extension, Economics & Sociology. 2020; 38(9):121-126.
DOI: 10.9734/AJAEES/2020/v38i930414

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/113508