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Effect of Different Varieties and Plant Spacing on Growth Yield and Quality Attribute of Sprouting Broccoli (*Brassica oleracea* var. *italica* Plenck)

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Authors' contributions

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

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ABSTRACT

The present experiment was conducted at Horticulture Research Farm, Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow, India during the *Rabi* season 2019-2020. The research work was formulated to investigate the effect of different plant spacing S_1 (45x45 cm), S_2 (60x45 cm) and S_3 (50x45 cm) and varieties (V_1; Broccoli Green, V_2; Pusa KTS-1 and V_3; Ganesh) on different growth, yield and quality attributes in sprouting broccoli (*Brassica oleracea* var. *italica* Plenck) with nine treatments which designed as RBD design. We were examined different growth parameters (plant height, number of leaves, length of leaves (cm), days

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to 50% curd initiation and 50% curd maturity), yield parameters such as number of auxiliary branches in broccoli, weight of curd, as well as quality parameters like curd colour, shape of curd and curd compactness. We have found the best performance in the variety of (Pusa KTS-1) with spacing (S_2; 60 x 45 cm) in the most of growth, yield and quality parameters as compared to Ganesh with (S_3 50 x 45 cm) and lower recorded in the variety Green Broccoli with (S_1 45 x 45 cm).

Keywords: Broccoli; experiment; spacing; varieties.

1. INTRODUCTION

Broccoli (*Brassica oleracea* var. *italica* Plenck) is a member of the Cole group of crops. It is a native place in the Mediterranean region. The word "Cole" is abbreviated from "Caulis", which means stem. Broccoli belongs to the family Brassicaceae. All the Cole group of crops originated from a common ancestor, wild cabbage/Colewort (*Brassica oleracea*var. *Sylvestris*) [1].

Morphologically, broccoli resembles cauliflower, but the major difference between cauliflower and broccoli is cauliflower's lack of an auxiliary branching habit [2-4]. The edible parts of the broccoli crop are the modified inflorescence and the flower stalk terminal head [5-7].

Broccoli grown in India is commonly known as green sprouting broccoli or Calabrese. In the case of broccoli, after the completion of the growth of the primary inflorescence (terminal head), a small secondary inflorescence (sprout) appears in the axils of the lower leaves [8,9]. They are used for salads with half-boiled vegetables. It is also used in soups with other vegetable juices or as a single vegetable mixed with potatoes [10,11]. Broccoli is a rich source of sulphoraphane, kaemferol and Glucorapaphinanin, which have carcinogenic properties means reducing the risk of cancer and antioxidant [12,13]. Among Cole crops it has high nutritive. It contain (9000 IU/100g) vitamin A, (300mg/100g) thiamine, (137mg/100g) vitamin C, and iron 137mg/100g (Fageria et al. 2022).

Availability of a suitable high-yielding variety and the ideal plant spacing are increase farmers income at per unit area at given time [14,15]. Because of variations in morphology and phenology, the cultivars exhibit a viable response to plant density [16]. Different cultivars show varying growth, yield, and quality characteristics depending on the growing environment [17-21]. No symmetrical study to measure the response of varieties and spacing in Lucknow condition. The aim of this research work is identifying and standardising various types of ideal plant spacing and varieties to get better yield in Lucknow climatic condition.

2. MATERIALS AND METHODS

The experiment was lead on Horticulture Research farm Department of Horticulture, Babasaheb Bhimrao Ambedkar University Lucknow-226025 (U.P.) during Rabi season October to February 2019-2020. Geographically experimental area is located at $26^{O}50'$ North latitude, $80^{O}52'$ East longitude and an altitude of 123 meter mean sea level (MSL). Lucknow has a sub-tropical climate with an average annual rainfall of about 1000 mm. The maximum temperature generally goes to 43℃ in summer and the minimum up to 3℃ in winter. Monsoon generally sets in during the third week of June and recedes by the end of September with heavy rainfall during monsoon season. Meteorological observation taken by IISR Lucknow and soil type of field was sandy clay loam with slightly alkaline while pH is near about 6.5 to 8.5. Factorial RBD design used in experiment with two factors (factor.1-variety and factor 2- spacing in 9 treatments. The seedling becomes ready for transplanting 28 days after sowing (4 to 5 leaf stage). The treatments included of three varieties (Pusa KTS-1, broccoli green, and Ganesh) as well as three planting spacing (60 x 45cm, 50x45cm, and 45 x 45 cm). the recorded observations in growth parameters, plant height (cm), number of leaves, length of leaves (cm), days to 50% curd initiation and days to 50% curd maturity, and in yield parameter as number of auxiliary branches, weight of curd in broccoli, as well as in quality parameter curd colour, the shape of curd, curd compactness, etc**.** Application of fertilizer in the field at the recommended dose of our crop in the field, 100kg of N and 80 kg of P_2O_5 and as well as 60 kg of K_2O kg/ha half dose of N**,** and full dose of P**,** and K at the time of transplanting as per recommended. The half doses of N are given two times in experiment field, one of them at 30 days after and second is 45 days after transplanting. Statistical analysis of data obtained in different

set of experiments was calculated following the standard procedure.

3. RESULTS AND DISCUSSION

3.1 Effect of Varieties

Data was collected on a daily basis for the first few days after transplantation 30DAT, 45DAT and 60DAT. The data presented in the Table-1 reveals a significant effect of varieties. Among the varieties V_2 (Pusa KTS-1) reported maximum plant height (36.9 cm), number of leaves (13.1), and length of leaves (20.8 cm), as compare to V_3 (Genesh), and minimum reported V_1 (Broccoli Green) at 60DAT similar result recorded by Singh et al. [22]. While in the case of days after 50% curd initiation, it was recorded that varieties reported that V_2 (Pusa KTS 1) take more days (68.4 days) over V_3 (Ganesh) and less days taken V_1 (Broccoli Green) reported by Thapa et al. (2013) and Thapa and Rai [23]. In 50% curd maturity V_2 (Pusa KTS-1) takes more days to curd maturity (73.2 days) as compare to V_3 (Genesh), and minimum reported V_1 (Broccoli Green) similar result are reported by Singh et al. [22] and Thapa and Rai [23].

3.2 On Yield Parameter

In the case of yield parameters, number of auxiliaries branches and curd weight, V_2 (Pusa KTS-1) has maximum number of auxiliary branch (10.6) and average curd weight (193.8g) as compared to V_3 (Genesh) and minimum are reported in V_1 (Broccoli Green) . Similar result found Ngullie and Biswas [24].

3.3 On Quality Parameter

In the case of quality parameters showed in Table-3 such as curd colour, shape of curd, and curd compactness, found that Pusa KTS-1, green colour, flat shape and slightly loose; and Ganesh, the dark green colour is domed and compact; and Broccoli Green, the green colour curd, head shape curd and slightly loose similar result found was Bhangre et al. [14].

3.4 Effect of Spacing

The data was collected on a regular basis for several days after the broccoli crop was planted 30DAT, 45DAT and 60DAT. The data presented in the Table-1 reveals a significant effect of spacing. Among spacing S_2 (60x45cm), maximum influence plant height (37.4cm) as compared to S_3 (50x45cm), where minimum reported S_1 (45x45cm) observed by Singh et al. (2006), Bhangre et al. [14], and Yadav et al. (2016). Maximum number of leaves (13.1) is observed at spacing S_2 (60x45cm) as compared to S_3 (50x45cm), and minimum recorded at spacing S_1 (45x45cm) closely result reported by Singh et al. (2006), Gariya et al. (2016). While Maximum leaf length (21.3cm) found with spacing S_2 (60x45cm) over S_3 (50x45cm), while minimum leaf length is recorded S_1 spacing (45 x 45 cm) reported by Yadav et al. (2016). While in case of days to 50% curd initiation S_2 (60x45cm) takes more days (65.3days) as compared to S3 (50x45cm), where minimum days are recorded at spacing S_1 (45x45cm) Similar results were reported by Thapa and Rai [23] and Rhapa et al. (2013) and days after 50% curd maturity Plant spacing S_2 (60x45cm) takes more days (71.2 days) as compared to S_3 (50x45cm), where minimum days are recorded at spacing S_1 (45x45cm) reported by Singh et al. [22] and Thapa and Rai [23].

3.5 On Yield Parameter

In the case of yield parameters, the number of auxiliary branches and curd weight, found that at plant spacing S_2 (60x45cm), maximum influence weight of curd (183.2) and number of auxiliary branch (10.22) over S_3 (50x45cm), where minimum weight of curd is recorded at spacing S_1 (45x45cm) same as result reported by Prasad et al. [16] and Bhangre et al. [14].

3.6 On Quality Parameter

In terms of quality parameters showed in Table 3, curd colour, curd shape, and curd compactness, they found that Pusa KTS-1 in all spacing green colour curd, flat shape, and slightly loose curd; Ganesh in all spacing, dark green colour curd, dome shape, and compact curd; and Broccoli Green varieties in all spacing, green colour curd, head shape, and slightly loose curd Similar results are found by Bhangre et al. [14].

3.7 Interaction Effect of Varieties and Spacing

Combining effect of varieties and spacing showed significant for growth parameters in Table 2. The maximum plant height, number of leaves, length of leaves (cm), 50% curd initiation, and 50% curd maturity observed V_2S_2 treatment over V_3S_3 and minimum V_1S_1treatment

Table 1. Effect of different spacing and varieties on growth, yield parameter

Treatments	Plant height (cm)			Number of leaves			Length of leaves (cm)			50% curd initiation	50% curd maturity	Weight of cured	Number of auxiliary branch
	30DAT	45DAT	60DAT	30DAT	45DAT	60DAT	30DAT	45DAT	60DAT				
V_1	14.9	22.9	35.6	6.2	8.9	11.4	7.2	14.3	19.2	57.7	62.6	137.8	6.7
V_2	16.6	25.3	36.9	8.0	11.0	13.1	8.2	16.2	20.8	68.4	73.2	193.8	10.6
V_3	15.9	24.13	36.7	7.4	10.4	12.9	7.7	15.5	20.5	62.8	68.9	149.8	10.2
SEm ±	0.24	0.25	0.27	0.22	0.27	0.31	0.16	0.22	0.26	0.54	0.51	8.80	0.18
CD(P=0.05)	0.72	0.76	0.82	0.67	0.81	0.95	0.49	0.65	0.80	1.64	1.55	25.60	0.54
Spacing													
S_1	15.1	23.3	35.4	6.7	9.4	11.7	7.3	14.3	18.9	59.6	64.3	141.1	7.7
S_2	16.3	24.7	37.4	7.6	10.6	13.1	8.0	16.2	21.3	65.3	71.2	183.2	10.22
S_3	15.9	24.4	36.4	7.4	10.3	12.7	7.7	15.5	20.3	63.4	69.1	156.1	9.5
SEm ±	0.24	0.25	0.27	0.22	0.27	0.31	0.16	0.22	0.26	0.54	0.51	8.80	0.18
CD(P=0.05)	0.72	0.76	0.82	0.67	0.81	0.95	0.49	0.65	0.80	1.64	1.55	25.60	0.54

Table 2. Interaction effect different plant spacing and varieties on growth yield and quality of broccoli crop

Interaction	Plant height (cm)			Number of leaves			Length of leaves (cm)			50% curd initiation	50% curd maturity	Weight of cured	Number of auxiliary branch
	30DAT	45DAT	60DAT	30DAT	45DAT	60DAT	30DAT	45DAT	60DAT				
V_1S_1	14.7	22.2	35.2	5.3	7.7	10.7	6.9	12.8	17.5	55.3	60.7	134.5	5.7
V_1S_2	15.5	23.5	36.0	6.7	9.7	11.3	7.1	15.5	21.0	57.3	62.7	141.4	6.7
V_1S_3	14.7	23.1	35.7	6.7	9.3	12.3	7.5	14.6	19.2	58.7	64.3	137.7	7.7
V_2S_1	15.3	24.2	35.3	7.3	10.3	12.7	7.7	15.6	19.7	64.7	67.7	169.9	9.7
V_2S_2	17.9	26.9	39.1	9.3	12.3	15.3	9.2	17.6	22.5	75.3	81.3	259.5	13.3
V_2S_3	16.4	24.9	36.2	7.3	10.3	11.3	7.6	15.4	20.5	65.3	70.7	151.9	8.7
V_3S_1	15.5	23.5	35.7	7.3	10.3	11.7	7.3	14.4	19.7	59.6	64.7	122.1	7.7
V_3S_2	15.4	23.6	36.9	6.7	9.7	12.7	7.7	15.7	20.6	65.3	69.7	148.8	10.2
V_3S_3	16.8	25.2	37.3	8.3	11.3	14.3	8.1	16.4	21.2	63.4	72.3	178.5	9.5
SEm ±	0.41	0.44	0.47	0.39	0.45	0.54	0.28	0.37	0.46	0.94	0.89	15.23	0.31
CD(P=0.05)	1.25	1.32	1.41	1.16	1.41	1.64	0.83	1.12	1.38	2.84	2.68	46.1	0.94

Table 3. Effect of different spacing and varieties on quality parameter of broccoli crop

Treatment		Colour	Shape	Compactness
Varieties	**Spacing**			
Ganesh broccoli	**S_1(45x45cm)**	Dark green	Dome	Compact
	S_2(60x45cm)	Dark green	Dome	Compact
	S_3(50x45cm)	Dark green	Dome	Compact
Pusa KTS-1	**S_1(45x45cm)**	Green	Flat	Slightly loose
	S_2(60x45cm)	Green	Flat	Slightly loose
	S_3(50x45cm)	Green	Flat	Slightly loose
Broccoli Green	**S_1(45x45cm)**	Green	Head	Slightly loose
	S_2(60x45cm)	Green	Head	Slightly loose
	S_3(50x45cm)	Green	Head	Slightly loose

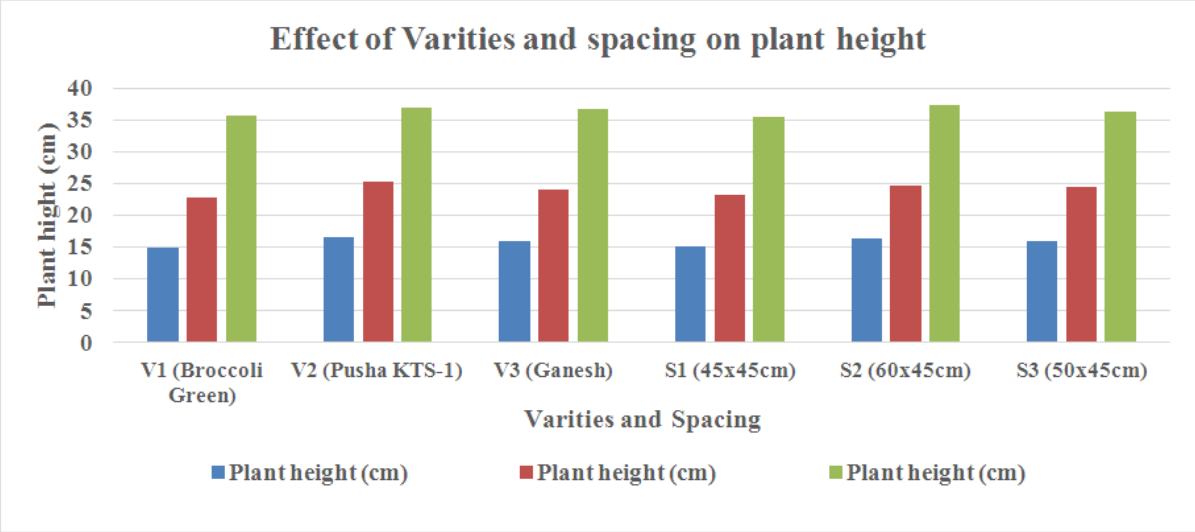

Fig. 1. Effect of variety and spacing on plant height 30,45and 60 DAT (days after transplanting)

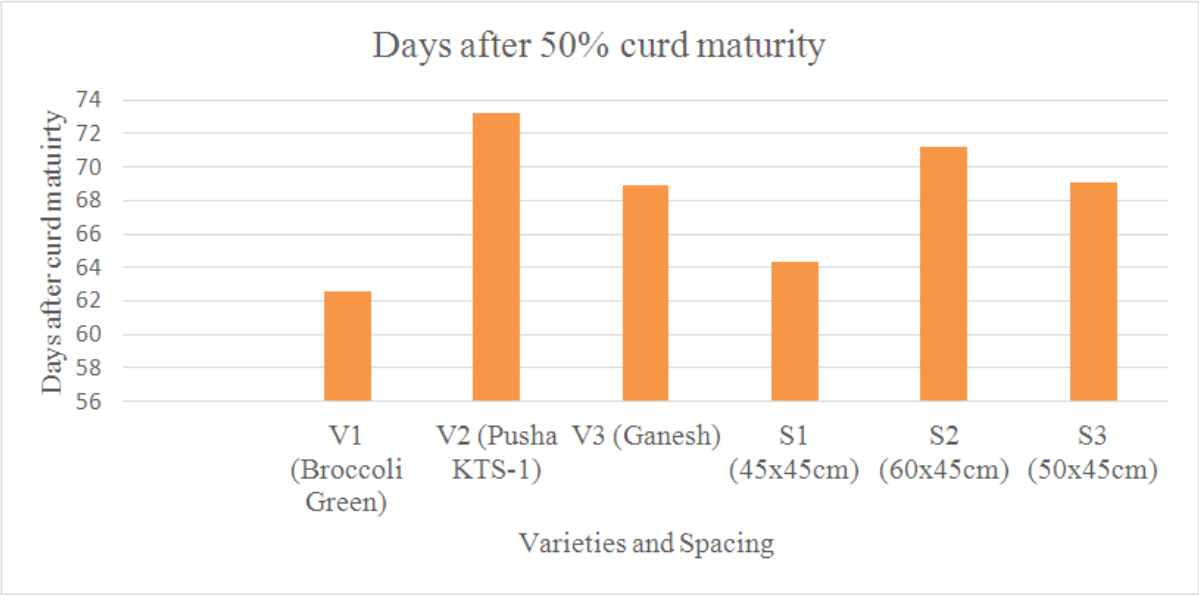

Fig. 2. Effect of variety and spacing on 50% curd maturities

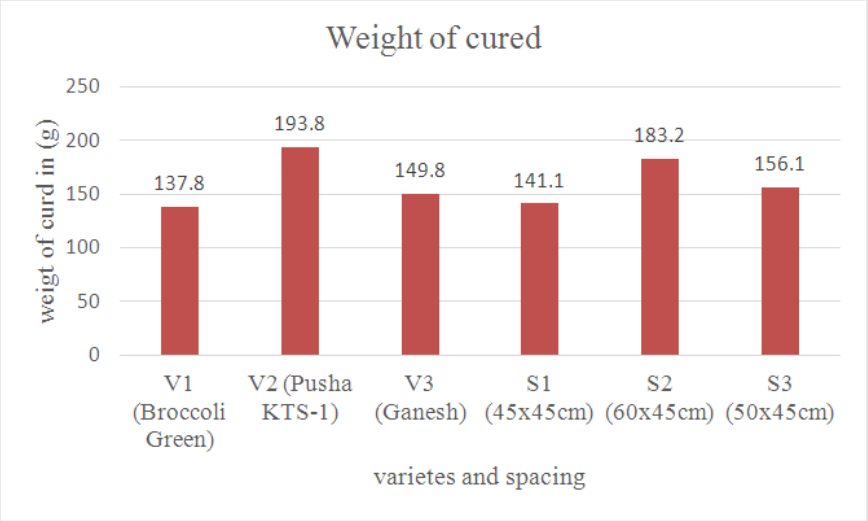

Fig. 3. Effect of variety and spacing on the weight of curd

respectively (39.1cm), (15.3) (22.5), (75.3 days) and (81.3days). While in yield parameter, weight of curd and number of auxiliary branches found significantly V_2S_2 followed by V_3S_3 and minimum reported with V_1S_1. In the case of quality parameters, curd colour, curd shape, and curd compactness are influenced by varieties but not influenced by spacing showed in Table 3 similar result are Bhangre et al. [3].

4. CONCLUSION

It was found that the combined effect of varieties and spacing on the growth parameters such as plant height, number of leaves, length of leaves (cm), days to 50% curd initiation and days to 50% curd maturity was and yield parameters such as weight curd, number of auxiliary branches were also significant influence V_2 (Pusa KTS-1) with a wider spacing S_2 (60 x 45 cm) followed by V_3 (Ganesh) with (50 x 45 cm) minimum influence byV_1 (Broccoli Green) with S_1 (45 x 45 cm).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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