

Effect of genotype and spacing on yield and quality traits in broccoli (*Brassica oleracea* var. *italica* Plenck) under Pune conditions

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Abstract

The present investigation was carried out to study the effect of two varieties *viz.*, Ganesh Broccoli and Pusa Broccoli KTS-1 and five spacing *viz.*, 60 ' 60 cm, 60 ' 45 cm, 45 ' 45 cm, 60 ' 30 cm and 45 ' 30 cm on yield and quality traits in broccoli. The experiment was laid out in factorial randomized block design with three replications under Pune conditions. The experimental results revealed significant differences among the varieties and spacing for most of growth, yield and quality parameters under study. The variety Ganesh Broccoli performed superior over the variety Pusa Broccoli KTS-1 with number of days to head appearance (32.80 days), days to first harvest (44.00 days), days to 50% harvest (53.40 days), days to last harvest (68.40 days), head diameter (10.81 cm), average weight of head (154.80 g), number of auxiliary tillers (15.11), yield per hectare (70.75 q) and stem hollowness (18.69 %). While variety Pusa Broccoli KTS-1 recorded significantly maximum plant height (65.69 cm), number of leaves (19.81), plant spread (68.65 cm in N-S and 65.8 cm in E-W), days to head appearance (48.47 days), days to first harvest (59.73 days), days to 50 % harvest (70.93 days), days to last harvest (85.27 days), number of auxiliary tillers (10.85) and stem hollowness (66.72 %). Amongst five spacing under study, S₅ (45 ' 30 cm) recorded significantly minimum plant height (56.78 cm), number of leaves (15.73), plant spread (53.39 in N-S and 55.63 cm in E-W), days to head appearance (37.00), days to first harvest (49.17 days), head diameter (7.93 cm), average weight of head (104.14 g), number of auxiliary tillers (5.18) and percentage of stem hollowness (37.28 %). However, S₁ (60 ' 60 cm) gave significantly maximum values of the various parameters under study except days to 50% harvest (59.83 days) days to last harvest (74.00 days). Hence, variety Ganesh Broccoli performed well than Pusa Broccoli KTS-1 at spacing of 60 '

45 cm and is better suited for commercial cultivation under Pune conditions.

Keywords: Broccoli, Ganesh Broccoli, Pusa Broccoli KTS-1, Spacing

Introduction

Broccoli (*Brassica oleracea* L. var. *italica* Plenck) is one of the important exotic vegetable crops after cabbage and cauliflower from family Brassicaceae; and is cherished for its delicious taste, flavor and nutritive value (Singh et al. 2018). It was introduced in England in the early 16th century known as "Italian Asparagus" or "Sprout Cauliflower." Being second largest producer of vegetables in world, in 2018-2019, India produced 187.474 million tones of vegetables from an area of 104.36 million hectares of land. (Anonymous 2018). Besides anticarcinogenic properties broccoli is a rich source of vitamins, minerals, proteins etc. It contains 130 times more vitamin A contents than cauliflower and 22 times more than cabbage. It is rich source of sulphoraphane, a compound associated with reducing risk of cancer. It contains vitamin A (9000 mg/100g), vitamin B (33 mg/100g), vitamin C (137 mg/100g), minerals *viz.*, Ca (1.29%), P (0.79 %), K (3.5 %), S (1.26 %), Fe (205 ppm), I (1.965 ppm), Cu (24 ppm), protein (3.3 %), total carbohydrates (5.5 %), fat (0.2 %), water (89.9 %) and calories (36/100g) (Thamburaj and Singh 2001).

In North India it is planted in September-October and harvested from late November to early December and may continue till early February. In this crop, planting distance needs to be maintained properly to avoid pest problems and to get quality head for the market. The planting distance of broccoli can be reduced to avoid stem hollowness in the stem (Verma and Sharma 1998). The effect of growing different varieties at various spacing under Pune conditions is yet not tested. Hence, an experiment was conducted to study the effect of different varieties and spacing on growth, yield and

quality parameters of broccoli under Pune conditions.

Material and Methods

The soil of the experimental field was medium to deep black having good texture, drainage and good water holding capacity. A field experiment was conducted using two varieties *viz.*, Ganesh Broccoli and Pusa Broccoli KTS-1 with five spacing *viz.*, 60 ' 60 cm, 60 ' 45 cm, 45 ' 45 cm, 60 ' 30 cm and 45 ' 30 cm in factorial randomized block design with three replications. A basal dose of FYM @ 20 tonnes per hectare to all treatment combinations was applied to all plots uniformly and incorporated in the soil before the layout was prepared. Nitrogen was applied in the form of urea in two split doses, half the dose of nitrogen and full dose of phosphorus and potassium were applied through urea (141.30 kg), single super phosphate (125 kg), and muriate of potash (51.72 kg), respectively. The 30 days old healthy seedlings with consistent sturdy growth were lifted from the nursery beds and dipped in the solution of azotobacter and phosphate solubilizing bacteria (2.5 kg/ ha each) then transplanted to the previously laid flat beds. Then observations on growth parameters *viz.*, plant height, number of leaves per plant, plant spread, days to head appearance, days to first harvest, days to 50 % harvest, days to last harvest, quality parameters *viz.*, stem hollowness (%) and yield parameters *viz.*, head diameter, average weight of curd, number of auxiliary tillers, yield per hectare were subjected to statistical analysis as per Panse and Sukhatme (1985).

Results and Discussion

Effect of varieties on growth parameters: The data presented in Table 1 revealed that both varieties under studied showed significant difference for growth parameters. The variety Pusa Broccoli KTS-1 recorded significantly maximum plant height (65.69 cm) than

variety Ganesh Broccoli (53.95 cm). The existence of significant variation in plant height might be due to genetic differences. The results obtained are in agreement with those of results obtained by Sharma (2003) who recorded tallest plant (62.00 cm) in Pusa Broccoli KTS-1 whereas lowest height (58.00 cm) was observed in EC-10356 among four varieties of broccoli.

The variety Pusa Broccoli KTS-1 produced significantly maximum number of leaves per plant (19.81) than variety Ganesh Broccoli (16.97). The differences regarding number of leaves produced by different varieties of broccoli could be due to their varietal characteristics. The present findings are in conformity with work reported by Singh et al. (1997) in fourteen varieties of early cauliflower. Both the varieties had significant influence on spread of plant in north- south and east- west directions. Significantly maximum plant spread in north- south was recorded in Pusa Broccoli KTS-1 (68.65 cm) than variety Ganesh Broccoli (54.98 cm). In case of east - west direction significantly maximum plant spread was observed in Pusa Broccoli KTS-1 (65.88 cm) over variety Ganesh Broccoli (52.04 cm). Significantly earlier head appearance was observed in Ganesh Broccoli (32.80 days) while, Pusa Broccoli KTS-1 took maximum number of days to head appearance (48.67 days). The early or late head appearance and harvesting behavior is a varietal characteristic. These results are in conformity with the findings reported by Afzal et al. (2003). Analysis of data given in Table 1 reveals that different varieties showed significant differences for days to first harvest, days to 50 per cent harvest and days to last harvest of head. Variety Ganesh Broccoli gave significantly early harvesting of first head (44.00 days) while, Pusa Broccoli KTS-1 took significantly maximum number of days (59.73) for first head harvest and was late in harvesting. Ganesh Broccoli was found earliest in 50

Table 1: Effect of different varieties and spacing on growth and quality parameters of broccoli under Pune conditions.

Treatments	Plant height (cm)	Number of leaves per plant	Plant spread (cm)(N-S)	Plant spread (cm) (E-W)	Days to head appearance	Days to first harvest	Days to 50% harvests	Days to last harvest	Stem hollowness (%)
Varieties									
V1(Ganesh Broccoli)	53.95	16.97	54.98	52.04	32.80	44.00	53.40	68.40	18.69
V2 (Pusa Broccoli KTS-1)	65.69	19.81	68.65	65.88	48.47	59.73	70.93	85.27	66.73
S.E ±	0.35	0.22	0.27	0.26	0.21	0.19	0.25	0.24	0.36
C.D. (0.05%)	1.05	0.68	0.82	0.79	0.65	0.58	0.74	0.73	1.09
Spacing									
S1(60 × 60 cm)	62.52	21.06	65.11	62.55	44.17	54.17	59.83	74.00	47.79
S2(60 × 45cm)	61.15	19.69	63.65	60.58	42.50	53.17	61.00	75.67	45.99
S3(45 × 45cm)	59.44	18.32	61.65	58.82	40.67	52.33	62.33	76.33	42.38
S4(60 × 30cm)	59.22	17.13	60.27	57.23	38.83	50.50	63.17	78.33	40.09
S5(45 × 30cm)	56.78	15.73	58.39	55.63	37.00	49.17	64.50	79.33	37.28
S.E ±	0.55	0.36	0.44	0.42	0.34	0.31	0.39	0.38	0.58
C.D. (0.05%)	1.66	1.07	1.31	1.25	1.02	0.92	1.17	1.15	1.73

per cent harvesting of heads (53.40 days) which was significant over Pusa Broccoli KTS-1 (70.93 days). Variety Pusa Broccoli KTS-1 required significantly maximum number of days (85.27 days) for final harvest of heads over Ganesh Broccoli which took minimum duration for last harvest (68.40 days). These findings are in conformity with work reported by Larsen (1988).

Effect of spacing on growth parameters: Effect of different spacing on different growth parameters showed significant differences. Data presented in Table 2 showed that S_1 (60 ' 60 cm) produced significantly maximum plant height (62.52 cm) which was at par with the spacing of 60 ' 45 cm (61.15 cm). While, S_3 (45 ' 30 cm) recorded significantly minimum plant height (56.78 cm). Similar results were noticed by Gopal Lal (1996). The spacing 60 ' 60 cm produced significantly maximum number of leaves per plant (21.06) followed by spacing 60 ' 45 cm (19.69) and 45 ' 45 cm (18.32) while, closer spacing produced significantly minimum number of leaves per plant (15.73). The results are in conformity with results obtained by Meena and Paliwal (2003) who found in cabbage that number of leaves per plant were significantly increased with increase in levels of plant spacing.

Different plant densities significantly influenced the spread of the plant as shown in Table 1. Spacing S_1 (60 ' 60 cm) recorded maximum plant spread in north-south (65.11 cm) which was significantly superior over all other spacing and found minimum (58.49 cm) at spacing of 45 ' 30 cm. Significantly maximum plant spread in east-west direction (62.55 cm) was recorded at spacing of 60 ' 60 cm, while minimum spread of the plant (55.63 cm) was produced at spacing 45 ' 30 cm. These results are in accordance with Sandhu et al. (1999) and Singh et al. (2004) who reported that wider spacing produced maximum plant spread in cabbage. Data presented in Table 1 reveals that different levels of spacing significantly influenced the days to head appearance, days to first harvest, days to 50 per cent harvest and days to last harvest. Wider spacing of 60 ' 60 cm showed significantly maximum (44.17 days) number of days for first curd appearance followed by spacing 60 ' 45 cm (42.50 days) and 45 ' 45 cm (40.67 days). It was observed that closer spacing of 45 ' 30 cm showed earliest appearance of curd on 37th day. However, contrasting results were obtained by Salter and James (1975) who reported that plant spacing had no effect on variability in time of curd initiation in both cultivars of cauliflower under studied (No.110 and Hylite). For first harvest of head, wider spacing of 60 ' 60 cm took significantly maximum number of days (54.17 days) while, closer spacing (45 ' 30 cm) took minimum

number of days (49.17). Thus, wider spacing had little bit delayed appearance of first head. Significantly minimum numbers of days (59.83) were taken by wider spacing of 60 ' 60 cm than closer spacing of 45 ' 30 cm (64.50 days) for 50 per cent harvesting of head. The days required for last harvesting were found minimum (74.00) at spacing of 60 ' 60 cm and it was increased with increase in plant spacing and recorded maximum (79.33 days) at closer spacing of 45 ' 30 cm. These results are in conformity with the findings of Lawande et al. (1986) who reported that in cabbage, closer spacing slightly delayed maturity and prolonged duration of crop than wider spacing.

Effect of varieties on yield parameters: Data presented in Table 2 revealed that both varieties under study has significant influence on yield parameters *viz.*, diameter of head, average weight of head, number of auxiliary tillers and yield per hectare. Variety Ganesh Broccoli recorded significantly maximum diameter of head (10.81cm) with highest average weight of head (154.79 g) over variety Pusa Broccoli KTS-1 which recorded significantly minimum diameter of head (9.89 cm) with lowest average weight of head (132.93 g). Results presented in Table 2 showed that variety Pusa Broccoli KTS-1 produced significantly maximum number of auxiliary tillers (10.85) while, Ganesh Broccoli produced minimum number of auxiliary tillers (5.11). Overall variety Ganesh Broccoli produced significantly highest yield per hectare (70.75 q), which was significantly superior over the variety Pusa Broccoli KTS-1 (60.16 q). Yield potential is supposed to be a varietal character. Similar results were reported by Patil *et al.* (1994) in cabbage and Sharma (2003) in broccoli.

Effect of spacing on yield parameters: Different spacing has significant influence on various yield parameters as shown in Table 2. Wider spacing of 60 ' 60 cm recorded significantly maximum diameter of head (12.61 cm) which was at par with spacing at 60 ' 45 cm (11.78 cm). Significantly maximum average weight of head (181.54 g) was recorded at spacing of 60 ' 60 cm. An average weight of head was found to be decreased with the decrease in plant spacing and recorded significantly minimum at closer spacing of 45 ' 30 cm (104.14 g). The maximum number of tillers (10.67) were recorded at spacing of 60 ' 60 cm which was at par with 60 ' 45 cm spacing (9.28). The spacing of 45 ' 45 cm produced 7.82 number of auxiliary tillers which was significantly superior over spacing 60 ' 30 cm (6.55). The lowest numbers of auxiliary tillers (5.58) were observed at 45 ' 30 cm spacing. The yield data presented in Table 2 reveals that significantly maximum yield per hectare (77.08 q/ha) was obtained with closer

Table 2: Effect of different varieties and spacing on yield parameters of broccoli under Pune conditions.

Treatments	Head diameter (cm)	Average weight of head (g)	Number of auxiliary tillers	Yield per hectare (q)
Varieties				
V1(Ganesh Broccoli)	10.81	154.79	5.11	70.75
V2 (Pusa Broccoli KTS-1)	9.89	132.93	10.85	60.16
S.E ±	0.10	1.12	0.17	0.62
C.D. (0.05%)	0.30	3.34	0.50	1.84
Spacing				
S1(60 × 60 cm)	12.61	181.54	10.67	50.38
S2(60 × 45cm)	11.78	169.10	9.28	61.35
S3(45 × 45cm)	10.23	138.03	7.82	68.18
S4(60 × 30cm)	9.21	126.51	6.55	70.26
S5(45 × 30cm)	7.93	104.14	5.58	77.08
S.E ±	0.16	1.77	0.27	0.98
C.D. (0.05%)	0.48	5.28	0.80	2.91

spacing of 45 ' 30 cm which was significantly higher as compared with all other spacing treatments. Spacing 45 ' 45 cm recorded 68.18 q yield per hectare which was at par with yield obtained at spacing of 60 ' 30 cm. But, closer spacing of 45 ' 30 cm recorded significantly least diameter of head (7.93 cm). Significantly highest average weight of head (181.54 g) was observed at spacing of 60 ' 60 cm followed by 60 ' 45 cm (169.1 g) which was significantly superior over spacing at 45 ' 45 cm (138.03 g). Similar results obtained by Maheshkumar and Rawat (2002) and Lawande et al. (1986) who reported that wider spacing resulted in higher head weight in cabbage. In case of auxiliary tillers Verma and Sharma (1998) reported that in broccoli, as plants produced more laterals with the increase in planting distance.

Effect of varieties on quality parameter: Data presented in Table 2 reveals that, the percentage of stem hollowness was significantly influenced by different varieties. Significantly maximum percentage of stem hollowness (66.73 %) was recorded in Pusa Broccoli KTS-1 over variety Ganesh Broccoli which recorded least percentage of stem hollowness (18.69 %). Stem hollowness is a variety specific character. Similar results have been reported by Trotta et al. (2000) in broccoli

that, no hollow stem was observed in cv. Gran Vert whereas XPH 4142 showed 16 % hollow stem.

Effect of spacing on quality parameter: Different spacing has significant influence on percentage of stem hollowness as shown in Table 2. Significantly maximum percentage of stem hollowness (47.79 %) was observed at spacing of 60 ' 60 cm which was followed by spacing of 60 ' 45 cm (45.99 %) and 45 ' 45 cm (42.38 %). Significantly minimum percentage of stem hollowness (37.28 %) was recorded at closer spacing of 45 ' 30 cm. These results are in conformity with the findings of Chadha et al. (2001) who stated that, in broccoli plant spacing was reduced to 45 ' 30 cm to avoid stem hollowness.

Interaction effect of varieties and spacing: The interaction effects between varieties and spacing were found non - significant for all the characters under study except percentage of stem hollowness. Data presented in Table 4 reveals that significantly minimum percentage of stem hollowness (17.32%) was recorded by Ganesh Broccoli at a spacing of 45 ' 30 cm which increased with increase in spacing and recorded maximum at wider spacing of 60 ' 60 cm (20.27 %) which was at par with spacing at 60 ' 45 cm (19.45 %). However, maximum

Table 3: Interaction effect of different varieties and spacing on growth and yield parameters of broccoli under Pune conditions

Treatments	Plant height (cm)	Number of Leaves per plant	Plant spread (cm)		Days to head appearance	Days to first harvest	Days to 50% harvests
			(N-S)	(E-W)			
V1S1	56.39	19.52	58.29	55.84	36.00	46.00	51.33
V1S2	55.08	18.10	56.78	53.44	34.33	45.33	52.00
V1S3	53.43	16.75	54.98	51.90	32.33	44.33	53.67
V1S4	54.24	15.76	53.25	50.31	31.33	42.67	54.33
V1S5	50.61	14.72	51.59	48.72	30.00	41.67	55.67
V2S1	68.64	22.60	71.92	69.26	52.33	66.33	68.33
V2S2	67.21	21.28	70.51	67.71	50.67	61.00	70.00
V2S3	65.44	19.89	68.32	65.74	49.00	60.33	71.00
V2S4	64.20	18.50	67.28	64.14	46.33	58.33	72.00
V2S5	62.94	16.75	65.19	62.54	44.00	56.67	73.00
S.E ±	0.79	0.51	0.62	0.59	0.49	0.43	0.56
C.D.(0.05%)	NS	NS	NS	NS	NS	NS	NS

Table 4: Interaction effect of different varieties and spacing on yield and quality parameters of broccoli under Pune conditions

Treatments	Days to last harvest	Stem hollow ness (%)	Head diameter (cm)	Average weight of head (g)	Number of auxiliary tillers	Yield per hectare (q)
V1S1	65.00	20.27	13.03	194.06	7.80	53.86
V1S2	67.33	19.45	12.09	183.73	6.23	68.03
V1S3	68.67	18.32	10.75	147.54	4.77	72.94
V1S4	70.00	18.09	9.72	135.79	3.63	75.38
V1S5	71.00	17.32	8.47	112.85	3.10	83.53
V2S1	83.00	75.31	12.20	169.02	13.53	46.91
V2S2	84.00	72.53	11.45	154.46	12.33	54.68
V2S3	85.00	66.45	9.70	128.52	10.87	63.42
V2S4	86.67	62.09	8.71	117.22	9.47	65.15
V2S5	87.67	57.25	7.39	95.43	8.07	70.62
S.E ±	0.55	0.82	0.23	2.51	0.38	1.38
(C.D. 0.05%)	NS	2.45	NS	NS	NS	NS

percentage of stem hollowness (75.31 %) was observed in variety Pusa Broccoli KTS-1 at spacing 60 × 60 cm which was at par with the results obtained at a spacing of 60 × 45 cm (72.53 %). However, minimum percentage of stem hollowness was recorded at spacing of 45 × 30 cm (57.25 %) in variety Pusa Broccoli KTS-1. These results are in close confirmation with Gorski and Armstrong (1985) who concluded that closer spacing and higher plant densities decreased the incidence of hollow stem.

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ब्रोकली में दो किस्मों— गणेश ब्रोकली एवं पूसा ब्रोकली केटीएस-1 व पाँच रोपड दूरियों— 60 x 60 सेमी., 60 x 45 सेमी., 45 x 45 सेमी., 60 x 30 सेमी. तथा 45 x 30 सेमी. का उपज एवं गुणवत्ता घटकों पर प्रभाव को ज्ञात करने के लिये परीक्षण किया गया। प्रयोग फैंक्टोरियल रैण्डोमाइज्ड ब्लॉक डिजाइन में 3 बार प्रतिकृति कर पूना (महाराष्ट्र) की दशा में किया गया। प्रयोग परिणाम से सार्थक विविधता प्रजातियों एवं दूरियों में वृद्धि, उपज एवं गुणवत्ता घटकों के लिये देखा गया। ब्रोकली की किस्म गणेश को निष्पादन पूसा ब्रोकली केटीएस-1 की तुलना में शीर्ष विकास में लगे दिन (32.80 दिन), प्रथम कटाई के दिन (44.00 दिन), 50 प्रतिशत कटाई के दिन (53.40 दिन), अन्तिम कटाई के दिन (68.40 दिन), शीर्ष व्यास (10.81 सेमी.), औसत शीर्ष भार (154.80 ग्राम), सहायक शाखाओं की संख्या (15.11), उपज प्रति हेक्टेयर (70.75 कुन्तल) एवं तना का खोखलापन (18.69 प्रतिशत) के प्रति पाया गया। जबकि पूसा ब्रोकली केटीएस-1 में सार्थक विविधता अधिकतम पौध ऊँचाई (65.69 सेमी.), पत्तियों की संख्या (19.81), पौध फैलाव (68.85 सेमी. एन-एस में व 65.80 सेमी. ई-डब्ल्यू में), शीर्ष विकास के दिन (48.47 दिन), प्रथम कटाई के दिन (59.73 दिन), 50 प्रतिशत कटाई के दिन (70.93 दिन), अन्तिम कटाई के दिन (85.27 दिन), सहायक शाखाओं की संख्या (10.85 दिन) तथा तना का खोखलापन (66.72 प्रतिशत) पाया गया। पाँच दूरियों के अध्ययन में एस-5 (45 x 30 सेमी.) में सार्थकता कम पौध ऊँचाई (56.78 सेमी.), पत्तियों की संख्या (15.73), पौध फैलाव (53.39 एन-एस में व 55.63 सेमी. ई-डब्ल्यू में), शीर्ष विकास के दिन (37.00) प्रथम कटाई के दिन (49.17 दिन), शीर्ष व्यास (7.93 सेमी.), औसत शीर्ष भार (104.14 ग्राम), सहायक शाखाओं की संख्या (5.18) एवं तना का खोखलापन (32.28 प्रतिशत)

पाया गया जबकि एस-1 (60 x 60 सेमी.) में केवल 50 प्रतिशत कटाई के दिन (59.83 दिन) एवं अन्तिम कटाई के दिन (74.00 दिन) को छोड़कर कई घटकों के लिए अधिकतम पाया गया। चूँकि गणेश ब्रोकली का निष्पादन पूसा ब्रोकली केटीएस-1 की तुलना में 60 x 45 सेमी. की दूरी पर उत्तम पाया गया है। अतः इसे पूना (महाराष्ट्र) की दशा हेतु अनुशंसा की जाती है।

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