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Effects of plant spacing and nitrogen levels on the growth and yield of broccoli

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ABSTRACT

The present study was aimed to determine the optimum nitrogen level and plant spacing for increasing growth and yield of broccoli. Experiment was done at the Horticultural Research farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during the winter season. There were 15 treatments in the experiment comprising five levels of N (0, 80, 120,160 and 200 kg/ha), three plant spacing (60cm × 60cm, 60cm × 45cm and 60cm × 30cm) to determine optimum level of nitrogen and spacing for higher growth and yield of broccoli. The highest plant heights (75.4 cm), leaves/plant (17.8) and SPAD value (71.3) were recorded at 60 DAT from the plants treated with $S_{60}\times_{60}N_{200}$. The highest canopy spreading (70.6 cm), stem diameter (38.2 mm), leaf size (335.8 cm^2), curd diameter (20.8 cm), secondary curd per plant (7.0) and curd weight (480.8 g) were also noted with $S_{60}\times_{60}N_{200}$. The maximum curd length (16.0 cm) and the highest yield (28.7 t ha^{-1}) were obtained from $S_{60}\times_{30}N_{200}$. Results demonstrated that, treatment combination $S_{60\times60}N_{200}$ performed the best in most characteristics but the maximum yield per hectare was recorded with $S_{60\times30}N_{200}$.

INTRODUCTION

Broccoli *(Brassica oleracea* L. var. *italica)* is a non-traditional and relatively new cole crop in Bangladesh. It is a biennial and herbaceous crop belonging to the family Cruciferae. Morphologically, broccoli resembles cauliflower. The terminal curd is rather loose, green in color and flower stalks are larger than cauliflower. Broccoli originated from west Europe (Prasad and Kumar, 1999). Broccoli is better adapted and can withstand comparatively higher temperature than cauliflower and it can be grown on a variety of soils (Rashid, 1976).

The total vegetable production in Bangladesh is far below the requirement. In 2009-2010, total vegetable production area was 358148 hectares with a production of 2.99 million tons (BBS, 2010). To fulfill the nutritional requirement of people total production as well as number of vegetables should be increased.

Cultivation of any crop depends on several factors. Plant spacing is one of them. It is well established that plant spacing has significant influence on the growth and yield of crop. Optimal plant spacing is important for crop production through efficient utilization of light, nutrients and water by the plants.

Never the less balanced application of fertilizer is a prerequisite for obtaining higher yield and better quality of broccoli (Brahma et al., 2002). Among the fertilizers, nitrogen appears to be the most important. Nitrogen is important for the vegetative growth of plant. Mitra et al. (1990) reported that, increasing N rates 224 kg /ha from 65 kg/ha caused linear increase in broccoli head weight and total yield.

The cultivation of broccoli has not been extended much beyond the farms of different agricultural organizations in Bangladesh. The growth and yield of broccoli are not good compared to other countries. The main reasons for lower growth and

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yield of broccoli in this country are lack of judicious application of fertilizers and sub-optimal management practices followed by the growers. Considering the above circumstances the present study was undertaken to determine the optimum nitrogen level and plant spacing for increasing growth and yield of broccoli.

MATERIALS AND METHODS

The experiment was conducted at the horticultural research farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during the period from 10 October 2011 to 21 February 2012. The experiment comprised five levels of N viz. 0, 80, 120, 160 and 200 kg/ha and three plant spicing viz. 60cm × 60cm, 60cm × 45cm and 60cm × 30cm. The field experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The size of each unit plot was 2.4 m × 1.8 m. Full dose of cow dung (10 t/ha), P_2O_5 (35 kg/ha), K_2O (60 kg/ha) and $^1/_3$ urea were incorporated during final land preparation. Urea was top dressed in two equal installments at 15 and 30 DAT. Molybdenum was also top dressed at 1 kg/ha after 15 days of transplanting. Intercultural operations such as weeding, mulching with straw and irrigation were done as per need. Data collection was started from 20 DAT and ten plants were selected randomly from each plot and data were recorded on individual plant on: plant height (cm), number of leaves/plant, canopy spread (cm), stem diameter (mm), SPAD value, main curd length (cm), main curd diameter (cm), secondary curds per plant, secondary curds weight (g), main curd weight (g), yield per plot (kg/ha) and yield (t/ha). The data were statistically analyzed with the help of MSTATC software program. Analysis of variance was done according to Gomez and Gomez (1984). Means were separated using Duncan's Multiple Range Test (DMRT) at 1% or 5% level of probability.

RESULTS AND DICUSSION

Plant height

The effect of different levels of nitrogen and spacing on plant height differed significantly on all dates of observation (Table 1). At 60 DATs, the tallest plant of broccoli (75.4 cm) was recorded in the treatment combination of the highest dose of N fertilizer (200 kg N/ha) with the widest spacing (60 cm × 60 cm) followed by T_4 (73.8 cm), T_{10} (72.7 cm), T_{15} (71.76 cm), T_9 (70.3 cm), T_{14} (69.5 cm), T_3 (67.36 cm) and T_8 (67.4 cm). The lowest plant height (56.4 cm) was found in the treatment combination of closest spacing (60cm × 30cm) in absence of N (Table 1).

Number of leaves/ plant

The effect of N fertilizers and plant spacing on the number of leaves per plant was found statistically significant at 40 and 60 DAT and it was non-significant at 20 DAT (Table 1). The maximum number of leaves per plant (17.8) was obtained from T_5 ($S_{60\times60}N_{200}$), which was statistically identical to T_{15} (17.7), T_{10} (17.5), T_{14} (17.3) and T_{15} (17.1) whereas the minimum number of leaves per plant (14.4) was in T_{11} ($S_{60\times30}N_0$) at 60 DAT. The results indicated a positive effect of nitrogen on number of leaves per plant.

Canopy spread of plant

It was observed that the combination of N fertilizers and plant spacing had significant influence on the canopy spread of plant (Table 2). The widest canopy spread (70.6 cm) was found in T_5 which ($S_{60\times60}N_{200}$) was statistically identical to T_{10} (70.5 cm), T_4 (69.8 cm), T_3 (66.5 cm), T_9 (65.4 cm), T_8 (64.5 cm), T_{13} (61.9 cm) and T_{15} (61.6 cm) while it was the lowest (50.4 cm) in T_{11} ($S_{60\times30}N_0$).

Stem diameter

The combined effect of N fertilizers and plant spacing on stem diameter of broccoli was found significant (Table 2). The highest diameter of stem (38.2 cm) was found in T_5 ($S_{60\times60}N_{200}$), which was statistically identical to all treatment combinations except T_1 (32.2 mm), T_6 (31.8 mm) and T_{11} (31.4 mm). The smallest diameter (31.4 mm) was observed in T_{11} ($S_{60\times30}N_0$). Higher diameter of stem was found with high N rate with wide spacing due to higher vegetative growth and more space for development as well as less interplant competition for nutrient.

SPAD value

The effect of different levels of N fertilizers and plant spacing on the SPAD value at different DAT was found significant in all dates of observation (Table 2). At 60 DAT, the highest SPAD value of leaf (71.3) was recorded in T_{10} ($S_{60\times45}N_{200}$), which was statistically identical to T_4 (70.9), T_5 (70.3), T_{15} (70.3), T_9 (69.7) and T_{14} (67.9). The lowest value (51.6) was found in T_{11} ($S_{60\times30}N_0$) which was statistically identical to T_6 (53.8) and T_1 (54.9). Similar results were also reported by Yildirim et al. (2007).

Length and diameter of main curd

The combined effect of N fertilizers and plant spacing was found significant on the length of main curd (Table 3). The maximum length of curd (16.0 cm) was found in T_{10} ($S_{60\times45}N_{200}$), which was statistically identical to all treatment combinations except T_{11} ($S_{60\times30}N_0$). The minimum (18.3 cm) was observed in T_{11} ($S_{60\times30}N_0$).

Significant effect of N fertilizers and plant spacing was also noticed in diameter of main curd (Table 3). The largest diameter of curd (20.8 cm) was found in T_5 ($S_{60\times60}N_{200}$) followed by T_{10} (20.3 cm), T_4 (19.3 cm), T_{14} (18.5 cm), T_{13} (17.9 cm), T_7 (16.6 cm), T_1 (15.3 cm) and smallest (15.0 cm) was observed from the treatment combination T_{11} ($S_{60\times30}N_0$)

Table 1
Effects of plant spacings and nitrogen levels on plant height (cm) and leaves/plant of broccoli at different days after transplanting (DAT).

Treatment combination (S × N)	Plant Height (cm) at DAT			Leaves per plant at DAT		
	20	40	60	20	40	60
T_1 ($S_{60\times60}$ N_0)	28.2 fgh	48.4 gh	61.5 g	5.9	11.3 b-e	15.3 ef
T_2 ($S_{60\times60}$ N_{80})	29.3 d-g	49.6 fg	65.0 f	5.9	11.7 b-e	15.7 de
T_3 ($S_{60\times60}$ N_{120})	30.8 b-f	50.4 ef	67.4 e	6.0	12.0 bcd	16.1 cd
T_4 ($S_{60\times60}$ N_{160})	33.3 ab	55.3 b	73.8 b	6.3	12.3 abc	16.7 bc
T_5 ($S_{60\times60}$ N_{200})	34.8 a	57.5 a	75.4 a	6.9	13.3 a	17.8 a
T_6($S_{60\times45}$ N_0)	26.8 gh	45.0 i	58.0 h	5.5	10.5 e	14.6 fg
T_7 ($S_{60\times45}$ N_{80})	29.3 d-g	48.8 fgh	62.4 g	5.9	10.7 de	15.1 efg
T_8 ($S_{60\times45}$ N_{120})	29.9 c-f	51.7 de	67.0 e	6.2	11.0 cde	16.2 cd
T_9 ($S_{60\times45}$ N_{160})	32.0 bcd	54.0 bc	70.3 d	6.6	11.9 bcd	17.1 ab
T_{10} ($S_{60\times45}$ N_{200})	32.8 ab	54.9 b	72.6 bc	6.6	12.2 abc	17.5 a
T_{11} ($S_{60\times30}$ N_0)	25.9 h	43.7 i	56.4 i	5.7	10.5 e	14.4 g
T_{12} ($S_{60\times30}$ N_{80})	28.5 fgh	47.5 h	61.6 g	6.0	10.4 e	15.1 efg
T_{13} ($S_{60\times30}$ N_{120})	28.8 efg	50.5 ef	66.3 e	7.0	11.4 b-e	16.3 cd
T_{14} ($S_{60\times30}$ N_{160})	31.4 b-e	52.4 cd	69.5 d	6.7	12.3 abc	17.3 ab
T_{15} ($S_{60\times30}$ N_{200})	32.1 bc	54.5 b	71.8 c	6.9	12.7 ab	17.7 a
Level of significance	**	**	**	NS	**	*
CV (%)	3.66	7.49	6.84	16.95	4.48	7.41

Figures bearing same letter (s) in a column do not differ significantly at 1 or 5% level of probability by DMRT.
NS- Non Significant.

Table 2
Effects of plant spacings and nitrogen levels on canopy spread, stem diameter and SPAD value of broccoli.

Treatment combination (S × N)	Canopy spread (cm)	Stem diameter (mm)	SPAD Value at DAT		
			20	40	60
T_1 ($S_{60\times60}$ N_0)	58.0 b-e	32.2 b	52.7 e	61.2 ghi	54.9 fg
T_2 ($S_{60\times60}$ N_{80})	55.8 cde	34.6 ab	58.7 d	65.1 efg	63.0 cde
T_3 ($S_{60\times60}$ N_{120})	66.5 ab	34.8 ab	65.5 bc	69.3 cd	66.0 bcd
T_4 ($S_{60\times60}$ N_{160})	69.8 a	35.9 ab	66.0 bc	74.4 ab	70.9 ab
T_5 ($S_{60\times60}$ N_{200})	70.6 a	38.2 a	68.5 ab	76.4 a	70.3 ab
T_6 ($S_{60\times45}$ N_0)	53.9 de	31.8 b	48.2 f	59.1 hi	53.8 g
T_7 ($S_{60\times45}$ N_{80})	53.2 de	34.2 ab	55.5 de	64.5 fg	61.3 de
T_8 ($S_{60\times45}$ N_{120})	64.5 abc	34.5 ab	63.0 c	68.5 cde	65.7 bcd
T_9 ($S_{60\times45}$ N_{160})	65.6 ab	36.6 ab	63.7 c	73.9 ab	69.7 ab
T_{10} ($S_{60\times45}$ N_{200})	70.5 a	36.0 ab	70.3 a	75.8 a	71.3 a
T_{11} ($S_{60\times30}$ N_0)	50.4 e	31.4 b	45.0 f	57.9 i	51.6 g
T_{12} ($S_{60\times30}$ N_{80})	59.4 b-e	34.1 ab	55.6 de	62.0 gh	58.7 ef
T_{13} ($S_{60\times30}$ N_{120})	61.9 a-d	34.4 ab	59.0 d	67.9 def	64.0 cd
T_{14} ($S_{60\times30}$ N_{160})	66.0 ab	35.2 ab	64.9 bc	70.7 bcd	67.9 abc
T_{15} ($S_{60\times30}N_{200}$)	61.6 a-d	36.5 ab	68.7 ab	72.4 abc	70.3 ab
Level of significance	*	**	**	**	**
CV (%)	8.15	6.03	6.70	9.50	7.35

Figures bearing same letter (s) in a column do not differ significantly at 1 or 5% level of probability by DMRT

Table 3
Effects of plant spicing and nitrogen levels on curd length, curd diameter and secondary curds per plant of broccoli.

Treatment combination (S × N)	Curd length (cm)	Curd diameter (cm)	Secondary curds per plant
T_1 ($S_{60\times60}$ N_0)	12.9 ab	15.3 h	4.3 g
T_2 ($S_{60\times60}$ N_{80})	14.5 ab	16.8 g	5.2 e
T_3 ($S_{60\times60}$ N_{120})	14.8 ab	18.3 ef	5.8 cd
T_4 ($S_{60\times60}$ N_{160})	15.5 ab	19.3 cd	6.3 b
T_5 ($S_{60\times60}$ N_{200})	16.0 a	20.8 a	7.0 a
T_6 ($S_{60\times45}$ N_0)	12.7 ab	15.1 h	4.0 h
T_7 ($S_{60\times45}$ N_{80})	14.1 ab	16.6 g	4.6 fg
T_8 ($S_{60\times45}$ N_{120})	14.5 ab	18.0 ef	5.3 e
T_9 ($S_{60\times45}$ N_{160})	15.1 ab	18.9 cde	5.8 cd
T_{10} ($S_{60\times45}$ N_{200})	16.0 a	20.3 ab	6.3 b
T_{11} ($S_{60\times30}$ N_0)	12.5 b	15.0 h	3.8 h
T_{12} ($S_{60\times30}$ N_{80})	13.9 ab	16.4 g	4.4 g
T_{13} ($S_{60\times30}$ N_{120})	14.3 ab	17.9 f	4.9 f
T_{14} ($S_{60\times30}$ N_{160})	15.0 ab	18.5 def	5.7 d
T_{15} ($S_{60\times30}N_{200}$)	15.8 ab	19.8 bc	6.0 bc
Level of significance	*	**	*
CV (%)	11.84	11.22	9.46

Figures bearing same letter (s) in a column do not differ significantly at 1 or 5% level of probability by DMRT.

Table 4
Effects of plant spacings and nitrogen levels on the yield and yield attributes of broccoli.

Treatment combination (S × N)	Main curd weight (g)	Secondary curd weight (g)	Yield per plant (g)	Yield (t/ha)
T_1 ($S_{60\times60}$ N_0)	268.0 f	53.0 g	321.1 f	8.7 h
T_2 ($S_{60\times60}$ N_{80})	382.3 cde	67.5 f	450.2 cde	12.9 fgh
T_3 ($S_{60\times60}$ N_{120})	409.7 bcd	76.4 b-f	491.8 bcd	13.9 e-h
T_4 ($S_{60\times60}$ N_{160})	457.3 ab	81.8 abc	539.3 ab	15.1 d-h
T_5 ($S_{60\times60}$ N_{200})	480.8 a	87.4 a	571.1 a	15.8 d-g
T_6 ($S_{60\times45}$ N_0)	217.7 f	53.6 g	281.5 f	10.4 gh
T_7 ($S_{60\times45}$ N_{80})	363.3 cde	69.7 ef	433.2 de	16.0 d-g
T_8 ($S_{60\times45}$ N_{120})	370.9 cde	72.7 c-f	443.9 de	16.4 e-g
T_9 ($S_{60\times45}$ N_{160})	412.3 bcd	79.1 a-d	491.9 bcd	17.9 c-f
T_{10} ($S_{60\times45}$ N_{200})	458.7 ab	85.3 ab	544.4 ab	20.2 b-e
T_{11} ($S_{60\times30}$ N_0)	206.8 f	51.5 g	258.4f	14.4 e-h
T_{12} ($S_{60\times30}$ N_{80})	336.3 e	67.6 f	404.2 e	22.1 a-d
T_{13} ($S_{60\times30}$ N_{120})	350.8 de	71.8 d-f	422.9 de	23.3 abc
T_{14} ($S_{60\times30}$ N_{160})	377.7 cde	78.6 a-e	456.7 cde	25.4 ab
T_{15} ($S_{60\times30}N_{200}$)	431.7 abc	83.6 ab	515.9 abc	28.7 a
Level of significance	**	**	**	**
CV (%)	7.70	9.22	10.29	16.08

Figures bearing same letter (s) in a column do not differ significantly at 1% level of probability by DMRT.

Weight of main curd

The combined effect of N fertilizers and plant spacing in respect of weight of individual curd was found to be significant (Table 4). Maximum main curd weight (480.8 g/plant) was obtained from T_5 ($S_{60\times60}N_{200}$) and it was statistically identical to T_{10} (458.7 g), T_4 (457.3 g) and T_{15} (431.8 g). The lowest weight of main curd (206.8 g /plant) was obtained from T_{11} ($S_{60\times30}N_0$).

Curd yield

The curd yield per plant was significantly affected by N fertilizers and plant spacings (Table 4). The highest yield per plant (571.1 g) was recorded from T_5 ($S_{60\times60}N_{200}$) and it was statistically similar to T_{10} (544.4 g), T_4 (539.3 g) and T_{15} (515.9 g). The lowest yield per plant (258.4 g) was obtained from the treatment combination T_{11} ($S_{60\times30}N_0$). The results reported by Pornsuriya et al. (1997) are in conformity.

Significant effect of N fertilizer and plant spacing was observed on per hectare yield (Table 4). The maximum yield per hectare (28.7 t) were recorded from the treatment combination T_{15} ($S_{60\times30}N_{200}$) and it was statistically similar to T_{14} (25.4 t/ha), T_{13} (23.3 t/ha) and T_{12} (22.1 t/ha) followed by T_{10} (20.2 t/ha), T_9 (17.9 t/ha), T_8 (16.4 t/ha), T_7 (16.0 t/ha), T_5 (15.8 t/ha) and T_4 (15.1 t/ha). The lowest yield per hectare (8.7 t) was recorded from T_{11} ($S_{60\times60}N_0$).

CONCLUSION

The treatment combination $S_{60\times60}N_{200}$ performed the best in terms of plant height, leaves/plant, canopy spread, stem diameter, curd diameter and yield per plant, however the maximum yield per hectare was recorded with $S_{60\times30}N_{200}$.

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