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EFFECT OF PLANT SPACING AND NITROGEN LEVELS ON NUTRITIONAL QUALITY OF BROCCOLI *(Brassica oleracea* L.)

M. S. RONI[1], M. ZAKARIA[1], M. M. HOSSAIN[1] AND M. N. SIDDIQUI[2]

Abstract

The study was carried out in the research field and laboratory of the Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur-1706 during October 2011 to April 2012 to determine optimum level of nitrogen and spacing for improving the nutritional quality of broccoli. There were 15 treatments in the experiment comprising five levels of N viz., 0, 80, 120,160, and 200 kg/ha and three plant spacings viz., 60cm x 60cm, 60cm × 45cm, and 60cm × 30cm. The results revealed that the highest ascorbic acid content (50.38 mg/100g) was obtained from $S_{60X30}N_0$ and the highest β-carotene content (50.67 IU/100g) was found in $S_{60X60}N_0$. Maximum Ca (0.556%) was found in $S_{60X60}N_0$ whereas maximum Fe (159.002 ppm) was in $S_{60X60}N_{200}$. The maximum P content (0.081%) was observed in $S_{60X60}N_{160}$ and maximum K content (0.854%) was found in $S_{60X45}N_{120}$.

Keywords: Nitrogen, plant spacing, β-carotene, ascorbic acid, broccoli, etc.

Introduction

Broccoli *(Brassica oleracea* L. var. *italica)* is one of the non-traditional and relatively new cole crops 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 colour and flower stalks are larger than cauliflower. Broccoli originated from west Europe (Prasad and Kumer, 1999) is a very popular vegetable in the United States of America, and very recently Japan has occupied a respectable position in the production of this crop. The crop is also considered as a commercial crop in India (Nonnecke, 1989).

Vegetables play an important role in human nutrition. It provides carbohydrates, fat, minerals, vitamins, and roughages, which constitute the essentials of a balanced diet. But vegetable consumption in Bangladesh is very low and only 80g per person per day against the minimum recommended quantity of 220g per day (Roy, 2011). The total vegetable production is far below the requirement. In 2009-2010, total vegetable production area was 358148.20 hectares with a production of 2.99 million tons (Anon., 2010). To fulfill the nutritional requirement of people, total production as well as number of vegetables should be increased. Broccoli is a nutritious vegetable than any other

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[1]Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur-1706, [2]Department of Biochemistry and Molecular Biology, BSMRAU, Gazipur-1706, Bangladesh.

cole crops (Nieuwhof, 1969). Vitamin C content in fresh broccoli is almost twice that in cauliflower (Lisiewska and Kmiecik, 1969). Per pound of edible portion of broccoli contains protein 9.10 g, fat 0.60 g, carbohydrate 15.20 g, calcium 360.00 mg, phosphorus 211.0 mg, iron 3.60 mg, vitamin-A 970.00 I.U., ascorbic acid 327.00 mg, riboflavin 0.59 mg and thiamine 0.26 mg (Thompson and Kelly, 1985). According to analytical data (Appendix II) presented by Thompson and Kelly (1985), broccoli is more nutritious than any other cole crops (cabbage, cauliflower). Devouring broccoli enriched in antioxidants can reduce the risk of some forms of cancer and heart disease. Thus broccoli can play a vital role in improving the nutritional status of the people of Bangladesh. Many people consider this as the most tasteful among the cole crops. Unlike cauliflower, broccoli produces smaller flowering shoots from the leaf axis after the harvest of main apical flower head. Consequently, broccoli may be harvested over a considerable period of time. The stem of broccoli plant, which core is soft and sweet, may also be eaten like vegetable (Sazzad, 1996). As a result, its popularity is increasing day by day in our country. Considering the above points, the present study aimed to investigate the optimum dose of nitrogen and spacing for increasing the nutritional quality of broccoli.

Materials and Method

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 and the nutritive quality analysis was done in the laboratory of the Department of Horticulture, BSMRAU, Gazipur-1706, Bangladesh. The field experiment was laid out in Randomized Complete Block Design with three replications. The whole experimental area was divided into three blocks which represented three replications. The treatments were randomly allotted in each replication. Replication to replication and plot to plot distance were 0.75m and 0.5m, respectively. The size of each unit plot was 2.4m × 1.8m. Total number of plots was 45. For nutritive quality analysis of broccoli, the curds were placed in laboratory room. A drying oven (Sanyo, Japan) was used to dry the curd samples for mineral analysis and the laboratory part of the experiment was laid out in Complete Randomized Design with three replications. The experiment consisted of two factors as follows

Factor – A : Nitrogen levels (5):

a. N_1 = 0 kg/ha
b. N_2 = 80kg/ha
c. N_3 = 120 kg/ha
d. N_4 = 160 kg/ha
e. N_5 = 200 kg/ha

Factor – B : Plant spacing (3):

a. S_1 = 60 cm x 60 cm
b. S_2 = 60 cm x 45 cm
c. S_3 = 60 cm x 30 cm

Broccoli (*Brassica oleracea* var. *italica*) cv. Premium was used as plant material. The seed was collected from Rajdhani Seed Company, Hannan Mansion (Ground floor), 178, Station road, Seddik Bazer, Dhaka-1000. The seeds were sown in seed bed on 22 October 2011. Proper cares were taken to get normal seedlings. The crop was harvested during 10 January to 30 January 2011. The Broccoli curd was harvested before the buds opened (Thompson and Kelly, 1985).

The harvested curds were used for biochemical analysis. The following data were recorded immediately after harvesting -

i. Water content (%)
ii. Dry matter (%)
iii. Ascorbic acid (mg/100g)
iv. β-Carotene (IU/100g)
v. Calcium (%)
vi. Iron (ppm)
vii. Potassium (%)
viii. Phosphorus (%)

Water content (%)

Water content (%) was determined by using the following formula:

$$\% \text{ Water} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100.$$

Dry matter (%)

Dry matter (%) was estimated by using the following formula:

$$\% \text{ Dry matter} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100.$$

Estimation of ascorbic acid

Preparation of the extract for the determination of ascorbic acid:

A sample of 50g sample was taken in a warring blender. The sample was homogenized with warring blender by adding 50 ml distilled water. The homogenized solution was transferred into a 250 ml volumetric flask and its volume was made up to the mark with distilled water and then centrifuged at 0^0C for 20 minutes at a speed of 4000 rpm. The supernatant liquid was collected in the 250 ml volumetric flask. This was the extract solution for the determination of ascorbic acid.

Ascorbic acid determination

The ascorbic acid content was determined as per the procedure described by Pleshkov (1976). For estimating free ascorbic acid 10 ml of prepared extract was taken in a conical flask. Five ml 5% KI, 2 ml of 2% starch solution, 2 ml glacial acetic acid was added to the extract. Finally it was titrated with 0.001N KIO_3 solution. Free ascorbic acid was quantified by using the following formula:

$$\text{Ascorbic acid content (mg/100 g)} = \frac{\text{TFV}}{\text{v W}} \times 100.$$

Where,

T = Titrated volume of KIO_3 (ml)

F = 0.088 mg of ascorbic acid per ml of 0.001N KIO_3

V = Total volume of sample extracted (ml)

v = Volume of the extract (ml) taken for titration

W = Weight of the sample taken

Estimation of β-carotene

One gram of sample was crushed and mixed thoroughly with 10 ml acetone: hexane (4:6) solution. This sample was centrifuged and optical density of the supernatant was measured by spectrophotometer (Model no. 200-20, Hitachi, Japan) at 663 ηm, 645 ηm, 505 ηm and 453 ηm. Calculation was done by the following formula (Nagata *et al*., 1992).

β-Carotene (mg/100g) = 0.216 (OD_{663}) + 0.452 (OD_{453}) - 1.22 (OD_{645}) - 0.304 (OD_{505})

Where, bold figure indicates optical density.

Total iron

Dried plant materials were digested with concentrated HNO_3 and $HClO_4$ mixture as described by Piper (1966) for determination of total iron content. The instrument (Atomic Absorption Spectrophotometer. Model no. 170-30, Hitachi, Japan) was calibrated with standard solution of Fe and calibration curve was prepared by the series of standard solution. AAS readings of each standard solutions and sample extracts were recorded at wave length of 248.3 ηm for Fe.

Fe in plant (ppm) = Fe in the filtrate (mg/L) × 1000ml / 0.5g

Total calcium

Dried plant materials were digested with concentrated HNO_3 and $HClO_4$ mixture as described by Piper (1966) for determination of total calcium content.

Total Ca (%) = (S – B) × (1000ml / 10ml) × (50ml / 0.5g) × 1 /10^4

Where,

S = Sample absorbance

B = Blank absorbance

Total phosphorus

Dried plant materials were digested with concentrated HNO_3 and $HCIO_4$ mixture as described by Piper (1966) for determination of total phosphorus content.

Total P (%) = (S – B) × (1000 ml / 10ml) × (50ml / 0.5g) × 1/10^4

Where,

S = Sample absorbance

B = Blank absorbance

Total potassium

Dried plant materials were digested with concentrated HNO_3 and $HClO_4$ mixture as described by Piper (1966) for determination of total potassium content.

Total K (%) = (S – B) x (1000 ml / 10ml) × (50ml / 0.5g) × 1 /10^4

Where,

S = Sample absorbance

B = Blank absorbance

Statistical analysis

The data of various parameters recorded in the experiment were compiled and statistically analyzed through partitioning the total variance with the help of computer MSTATC 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 Discussion

Water content

The water content of curd was significantly influenced by different levels of N fertilizer (Table 1). The maximum water content (92.08%) was recorded from the highest dose of N fertilizer N_5 (200kg N/ha) followed by N_4 (91.72%), which was statistically identical to N_3 (91.51%) and N_2 (91.29%) whereas minimum water content (90.62%) was recorded from N_1 (0 kg N/ha). Similar results were reported by Candido *et al.* (2010) in case of cauliflower.

The water content of curd was also significantly influenced by the different plant spacings (Table 2). The maximum water content (91.58%) was recorded from the widest spacing S_1 (60 cm x 60 cm) which was statistically identical to S_2 (91.46%) and minimum water content (91.29%) was recorded from S_3 (60 cm x 30 cm). Similar results were found by Waseem and Nadim (2001) in case of spinach.

Table 1. Effect of nitrogen levels on water content (%) and dry matter content (%) of broccoli.

Levels of nitrogen	Water content (%)	Dry matter content (%)
N_1 (0)	90.62 c	9.38a
N_2 (80)	91.29 b	8.71b
N_3 (120)	91.51 b	8.49 b
N_4 (160)	91.72 ab	8.28 bc
N_5 (200)	92.08 a	7.92 c
Level of significance	**	**
CV%	1.39	4.20

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

Table 2. Effect of plant spacing on water content (%) and dry matter content (%) of broccoli.

Spacings	Water content (%)	Dry matter content (%)
S_1 (60×60)	91.58 a	8.42 b
S_2 (60×45)	91.46 ab	8.54 ab
S_3 (60×30)	91.29 b	8.71 a
Level of significance	*	*
CV%	1.39	4.20

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

The interaction effect of different levels of nitrogen and plant spacing on the water content in curd was found significant (Table 3). The highest water content (92.36%) was recorded in T_5 ($S_{60X60}N_{200}$), which was statistically identical to all except T_6 (91.33%), T_7 (90.90%), T_8 (91.27%), T_{11} (90.46%), T_{12} (91.28%), T_{13} (91.40%), T_{14} (91.40%) and T_1 (90.08). The lowest water content (90.08%) was found in T_1 ($S_{60X60}N_0$).

Table 3. Interaction effect of spacing and nitrogen levels on water content (%), dry matter content (%), ascorbic acid and β-carotene content of broccoli.

Treatment combination (S X N)	Water content (%)	Dry matter content (%)	Ascorbic acid (mg/100g)	β-carotene(IU/100g)
T_1 ($S_{60\times60}$ N_0)	90.08 e	9.92 a	46.50 ab	50.67 a
T_2 ($S_{60\times60}$ N_{80})	91.68 abc	8.32 cde	45.06 bc	45.67 c
T_3 ($S_{60\times60}$ N_{120})	91.88 ab	8.12 de	43.33 bcd	38.00 e
T_4 ($S_{60\times60}$ N_{160})	91.92 ab	8.08 de	34.34 gh	33.67 g
T_5 ($S_{60\times60}$ N_{200})	92.36 a	7.64 e	30.79 h	32.00 i
T_6 ($S_{60\times45}$ N_0)	91.33 bcd	8.67 bcd	44.50 bc	47.00 b
T_7 ($S_{60\times45}$ N_{80})	90.90 cde	9.09 abc	43.13 bcd	42.00 d
T_8 ($S_{60\times45}$ N_{120})	91.27 bcd	8.73 bcd	42.19 bcd	35.67 f
T_9 ($S_{60\times45}$ N_{160})	91.84 ab	8.16 de	36.01 fg	32.00 i
T_{10} ($S_{60\times45}$ N_{200})	91.95 ab	8.05 de	30.14 h	30.33 k
T_{11} ($S_{60\times30}$ N_0)	90.46 de	9.54 ab	50.38 a	45.67 c
T_{12} ($S_{60\times30}$ N_{80})	91.28 bcd	8.72 bcd	40.97 cde	42.00 d
T_{13} ($S_{60\times30}$ N_{120})	91.40 bc	8.60 cd	39.38 def	32.67 h
T_{14} ($S_{60\times30}$ N_{160})	91.40 bc	8.60 cd	37.17 efg	31.00 j
T_{15} ($S_{60\times30}N_{200}$)	91.92 ab	8.08 de	32.68 gh	30.01 l
Level of significance	**	**	*	**
CV (%)	1.39	4.20	6.61	5.51

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

Dry matter

The dry matter content of curd was significantly influenced by the different levels of N fertilizer (Table 1). The maximum dry matter (9.38%) was recorded from N_1 (0kg N/ha) followed by N_2 (8.71%), N_3 (8.49%), and N_4 (8.28%), whereas the lowest dry matter content (7.92%) was recorded from the highest level of nitrogen. Rembialkowska *et al.* (2003) reported that plants grown without nitrogen fertilizer contained more dry matter compared to plants grown with nitrogen fertilizer, which are in conformity with the present findings.

The dry matter content of curd was also significantly influenced by the different spacings (Table 2). The maximum dry matter content (8.71%) was recorded from the closest spacing S_3 (60 cm x 30 cm), which was followed by S_2

(8.54%) treatment and the minimum dry matter content (8.42%) was recorded in S_1 (60cm x 60cm).

The interaction effect of different levels of N fertilizers and plant spacings on the dry matter content was significant (Table 3). The highest dry matter content (9.92%) was recorded in T_1 ($S_{60X60}N_0$), which was statistically identical to T_7 (9.10%) and T_{11} (9.54). The lowest dry matter content (7.64%) was found in T_5 ($S_{60X60}N_{200}$).

Ascorbic acid

Variation in ascorbic acid due to the nitrogen level was statistically significant (Fig. 1). It ranged from 31.20 to 47.13 mg/100g. The highest ascorbic acid content (47.13 mg/100g) was recorded in N_1 (0 kg N/ha) and the lowest (31.20 mg/100g) was in N_5 (200 kg N/ha). In a study Karitonas (2001) stated that increased level of N supply slightly reduced the vitamin C content from 83 to 73 mg/100g, which was more or less similar to the present findings.

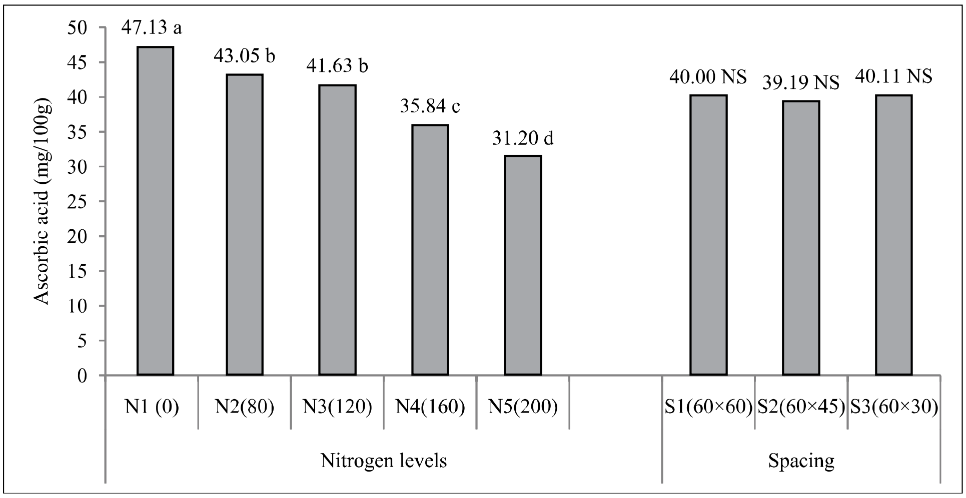

Fig. 1. Effect of nitrogen levels and plant spacing on ascorbic acid content.

The ascorbic acid content of curd did not vary significantly by the different spacings (Fig. 1). Numerically it ranged from 39.19 mg/100g to 40.11mg/100g.

The interaction effect of different levels of N fertilizers and plant spacings on the ascorbic acid content in curd was found significant (Table 3). The highest ascorbic acid content (50.38 mg/100g) was recorded in T_{11} ($S_{60X30}N_0$), which was statistically identical to T_1 (46.50 mg/100g) and the lowest ascorbic acid content (30.14 mg/100g) was found in T_{10} ($S_{60X45}N_{200}$). This was might be due to the highest nitrogen dose which reduced dry matter content resulting in less ascorbic acid.

β-carotene

Significant variations in the amount of β-carotene were found due to influence of nitrogen levels. It varied from 47.78 to 30.78 IU/100g (Fig. 2). The highest β-carotene content (47.78 IU/100g) was recorded in N_1 (0 kg N/ha), which was followed by N_2 (43.22 IU/100g), N_3 (35.44 IU/100g) and N_4 (32.22 IU/100g). The lowest (30.78 IU/100g) was in N_5 (200kg N/ha). Rembialkowska *et al.* (2003) reported that plants grown without fertilizer contained higher amount of β-carotene than that grown with inorganic fertilizer.

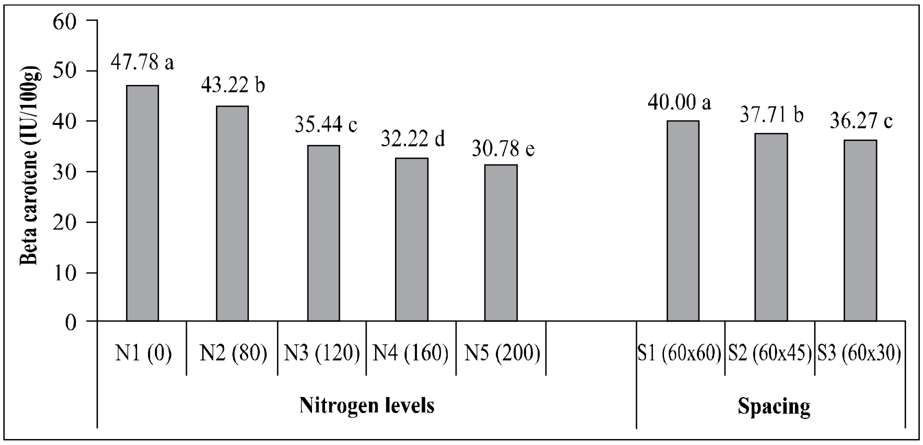

Fig. 2. Effect of nitrogen levels and plant spacing on β-carotene content.

The β-carotene content of curd was also significantly influenced by the different plant spacings (Fig. 2). The maximum β-carotene content (40.00 IU/100g) was recorded from the widest spacing S_1 (60 cm x 60 cm), which was followed by S_2 (37.40 IU/100g) treatment and minimum β-carotene content (36.27 IU/100g) was recorded from S_3 (60 cm x 30 cm).

Different levels of N fertilizer and plant spacing had significant influence on the β-carotene content in curd (Table 3). The highest β-carotene content (50.67 IU/100g) was recorded in the treatment combination T_1 ($S_{60X60}N_0$), which was followed by T_6 (47.00 IU/100g), T_2 (45.67 IU/100g), T_7 (42.00 IU/100g), T_3 (38.00 IU/100g) T_8 (35.67 IU/100g) T_4 (33.67 IU/100g) and T_{13} (32.67 IU/100g). The lowest β-carotene content (30.01 IU/100g) was found in T_{15} ($S_{60X30}N_{200}$).

Iron

Differences in iron content (Fig. 3) in broccoli curd were found significant. Iron content was maximum (154.896 ppm) in N_5 (200 kg N/ha) and minimum (88.031 ppm) in N_1 (0 kg N/ha).

In case of plant spacing a significant result was found in iron content (Fig. 3). The maximum iron content (131.410 ppm) was recorded from the medium spacing S_2 (60cm × 45cm), which was followed by S_3 (120.304 ppm) and minimum iron content (106.210 ppm) was recorded from widest spacing S_1 (60 cm x 60 cm).

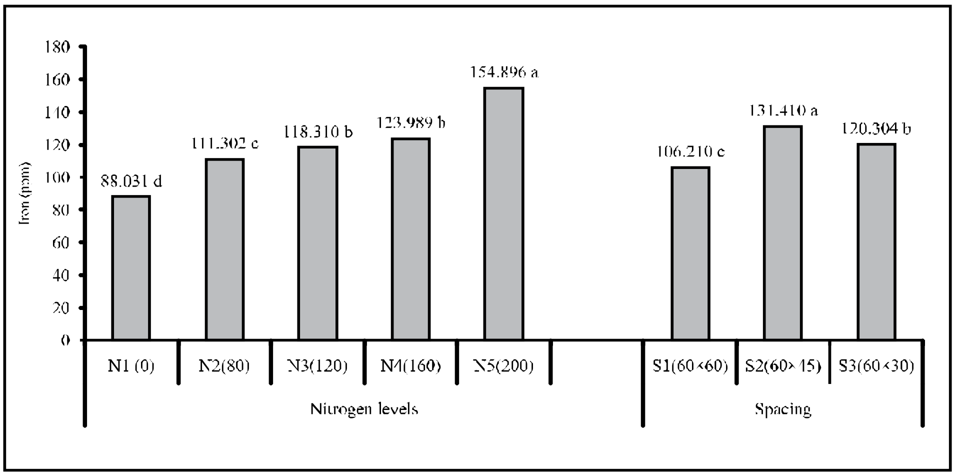

Fig. 3. Effect of nitrogen levels and plant spacing on iron content.

Iron content varied due to the interaction effect of different levels of N fertilizer and plant spacing (Table 4). The highest iron content (161.001 ppm) was recorded in T_{10} ($S_{60X45}N_{200}$), which was statistically identical to T_5 (159.002 ppm). The lowest iron content (72.201 ppm) was found in T_1 ($S_{60X60}N_{200}$). Sharma and Chandra (2004) reported similar results.

Calcium

Significant variation in calcium content (Fig. 4) was observed due to influence different nitrogen levels. The highest (0.548%) calcium content was found in N_1 (0 kg N/ha), which was followed by N_2 (0.474%) and N_3 (0.429%) and the lowest (0.391%) calcium was found in N_5 (200 kg N/ha).

In case of plant spacings, an insignificant result was found in calcium content (Fig. 4). Apparently the maximum calcium content (0.459%) was recorded from the moderate spacing S_2 (60cm × 45cm), which was followed by S_3 (0.457%) and minimum calcium content (0.447%) was recorded from the widest spacing S_1 (60cm × 60cm).

The interaction effect of different levels of N fertilizers and plant spacings on the calcium content was found significant (Table 4). The highest calcium content (0.556%) was recorded in the treatment combination of T_1 ($S_{60X60}N_0$), which was statistically identical to treatment T_{11} (0.550%) and T_6 (0.536%). The lowest calcium content (0.366%) was found in T_5 ($S_{60X60}N_{200}$).

Phosphorus

There was a significant variation in phosphorus content in curd (Fig. 5) due to different nitrogen levels. It ranged from 0.161% to 0.201%. The maximum phosphorus content was recorded in N_5 (0.201%.) followed by N_4 (0.196 %.), N_3 (0.186%.), N_2 (0.176%.). The lowest (0.161%) was in N_1 (0 kg N/ha).

Table 4. Interaction effect of spacing and nitrogen levels on iron (Fe), calcium (Ca), phosphorus (P) and potassium (K) content in broccoli.

Treatment combination (S X N)	Iron (Fe) (ppm)	Calcium (Ca) (%)	Phosphorus (P) (%)	Potassium (K) (%)
T_1 ($S_{60×60}$ N_0)	72.201 i	0.556 a	0.166 g	0.836 d
T_2 ($S_{60×60}$ N_{80})	97.732 h	0.446 cd	0.190 c	0.846 b
T_3 ($S_{60×60}$ N_{120})	99.150 h	0.420 df	0.190 c	0.820 f
T_4 ($S_{60×60}$ N_{160})	103.001 gh	0.446 cd	0.210 a	0.820 f
T_5 ($S_{60×60}$ N_{200})	159.002 a	0.366 e	0.186 d	0.836 d
T_6 ($S_{60×45}$ N_0)	99.404 h	0.536 ab	0.156 i	0.816 g
T_7 ($S_{60×45}$ N_{80})	123.601 def	0.490 bc	0.166 g	0.840 c
T_8 ($S_{60×45}$ N_{120})	134.804 bcd	0.446 cd	0.180 e	0.850 a
T_9 ($S_{60×45}$ N_{160})	138.003 bc	0.420 de	0.190 c	0.816 g
T_{10} ($S_{60×45}$ N_{200})	161.001 a	0.400 de	0.206 b	0.830 e
T_{11} ($S_{60×30}$ N_0)	92.502 h	0.550 a	0.160 h	0.816 g
T_{12} ($S_{60×30}$ N_{80})	112.605 fg	0.486 bc	0.170 f	0.820 f
T_{13} ($S_{60×30}$ N_{120})	120.903 ef	0.420 de	0.186 d	0.836 d
T_{14} ($S_{60×30}$ N_{160})	130.802 cde	0.420 de	0.186 d	0.816 g
T_{15} ($S_{60×30}N_{200}$)	144.702 b	0.406 de	0.210 a	0.846 b
Level of significance	**	*	*	*
CV (%)	4.47	6.93	4.31	1.76

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

In case of plant spacing, a significant result was found in phosphorus content (Fig. 5). The maximum phosphorus content (0.189%) was recorded from the widest spacing S_1 (60cm × 60cm), which was followed by S_3 (0.183%) treatment and minimum phosphorus content (0.180%) was recorded from medium spacing S_2 (60cm × 45cm).

Different levels of N fertilizer and plant spacing had significant effect on the phosphorus content in curd (Table 4). The highest phosphorus content (0.210%)

was recorded in T_4 ($S_{60X60}N_{160}$) and T_{15} ($S_{60X30}N_{200}$). The lowest phosphorus content (0.160%) was found in the treatment combination T_{11} ($S_{60X30}N_0$).

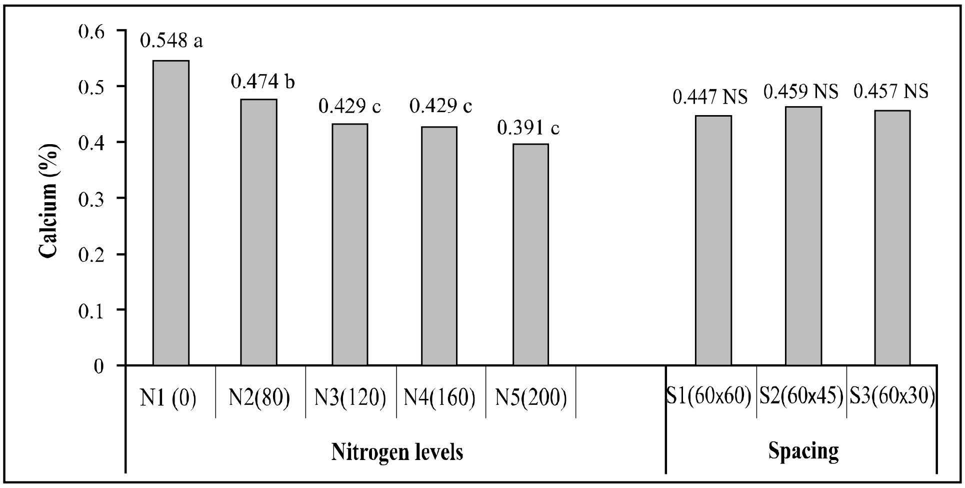

Fig. 4. Effect of nitrogen levels and plant spacing on calcium content.

Potassium

Potassium content was also significantly influenced by the nitrogen levels (Fig. 6). The highest amount of potassium (0.838 %) was recorded in N_5 (200 kg N/ha) closely followed by that of N_3 (0.836%) and N_2 (0.836%). The lowest potassium content (0.818 %) was observed in N_4 (160 kg N/ha).

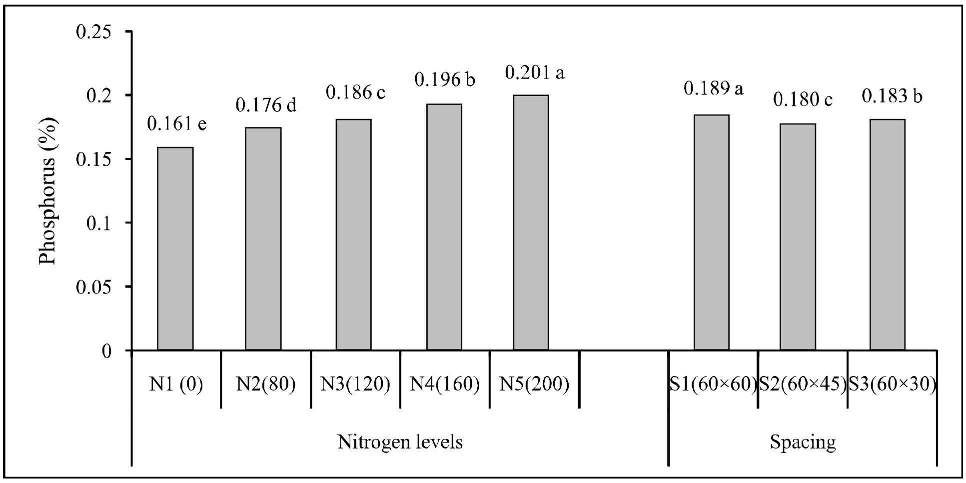

Fig. 5. Effect of nitrogen levels and plant spacing on phosphorus content.

In case of plant spacings, a significant result was found in potassium content (Fig. 6). The maximum potassium content (0.883%) was recorded from the widest spacing S_1 (60 cm x 60 cm), which was followed by S_2 (0.831%) and minimum potassium content (0.823%) was recorded from the closest spacing S_3 (60 cm x 30 cm).

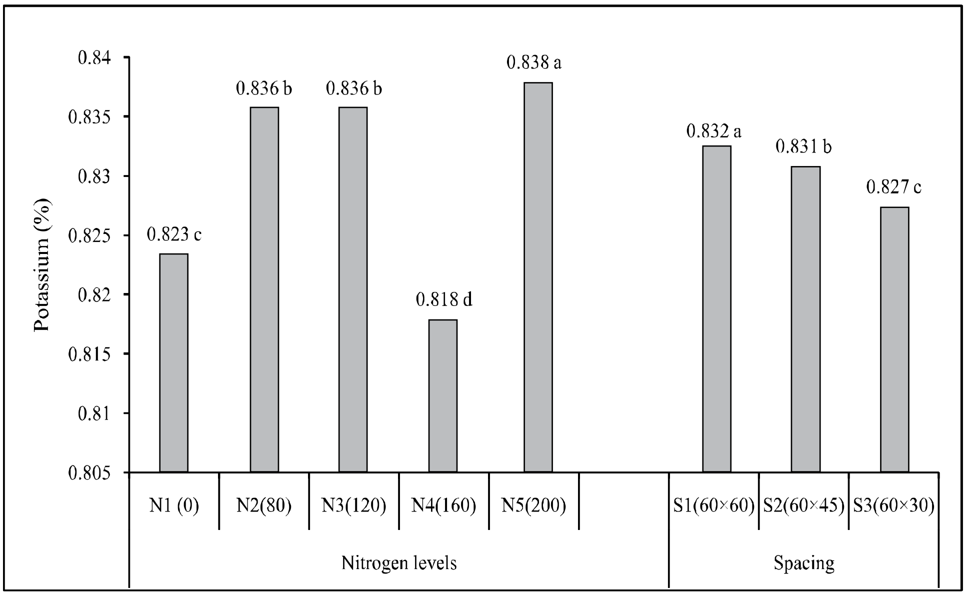

Fig. 6. Effect of nitrogen levels and plant spacing on content of potassium.

The interaction effect of different levels of N fertilizers and plant spacings on the potassium content was significant (Table 4). The highest potassium content (0.850%) was recorded in T_8 ($S_{60X45}N_{120}$) and the lowest potassium content (0.816%) was found in T_6, T_9, T_{11}, and T_{14}.

Conclusion

On the basis of the results of the present study, it can be concluded that the content of ascorbic acid, β-carotene, and calcium were maximum in broccoli produced in absence of inorganic nitrogen whereas iron, phosphorus, and potassium were maximum in broccoli produced with the highest dose of nitrogen (200 kg/ha).

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