Environment and Ecology 41 (4D) : 3049—3053, October—December 2023
Article DOI: https://doi.org/10.60151/envec/OJIR6814
ISSN 0970-0420

Impact of Nitrogen on Growth and Yield of Broccoli (*Brassica oleracea* L. var. *italica*) under Open and Protected Environment

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Received 17 July 2023, Accepted 26 October 2023, Published on 29 December 2023

ABSTRACT

A field experiment was conducted at Vegetable Research Farm, Department of Agriculture, Khalsa College, Amritsar during the year 2020-21. Ten treatments with three replications were designed in a Factorial Randomized Block Design to conduct the research. The obtained results showed the significant synergistic effect of environmental conditions and nitrogen doses on the growth, yield and quality of broccoli as compared to the control. Better vegetative and yield characters were observed in the protected environment with a 125% nitrogen application, while the utmost quality was observed under the protected environment with a 100% nitrogen application, and control recorded the poorest result of all.

Keywords Broccoli, Environmental conditions, Fertilizers, Nitrogen, Yield and quality.

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INTRODUCTION

Sprouting broccoli or Harigobhi (*Brassica oleracea* L. var. *italica*) belongs to the Cruciferae family. In India, it is an uncommon winter vegetable, although it is gradually gaining appeal in metropolitan areas. Sprouting broccoli mimics cauliflower morphologically, with the exception of secondary heads that form in the leaf axils and can contribute up to 50% of total production. It is used in curries, soups, pickles, salads, and as a single or mixed vegetable in cooking (Thamburaj and Singh 2001). According to (Swarup 2012), it is a high-value exotic crop grown for its delicate blooming head and secondary heads or spears. It is often divided into three groups: White, purple and green, with the green kind being the most nutritious (Yoldas *et al*. 2008). Broccoli is high in vitamins, minerals and vital amino acids and it also includes the anti-cancer chemical glucoraphanin. Sprouting broccoli has recently developed as an important off-season crop produced in and near metropolitan areas and tourist sites under regulated circumstances (Swarup 2012). Broccoli curd has 89.9 g of moisture, 5.5 g of carbohydrates, 0.2 g of fat, 3.3 g of protein, 3500 IU of vitamin A, 0.05 mg of thiamine, 0.12 mg of riboflavin, 79 mg of phosphorus, 80 mg of calcium, 0.8 mg of iron, 137 mg of ascorbic acid, and 37 g of calories per 100 g edible quantity (Singh and Nath 2012).

Sprouting broccoli is a cool-season crop. Broccoli is very sensitive to high temperatures, which

causes the heads to be distorted and unevenly-sized flower buds to develop in inflorescence, making it a high-risk crop. Different cultivars have different quality parameters varying with growing conditions (Thapa *et al.* 2013). The best quality broccoli heads are produced when the day temperature is between 25°C and 26°C and the night temperature is between 15-16°C. India is endowed with a wide range of agro-climatic conditions, and that is why broccoli is grown in the winter season (Suthar *et al.* 2017). The cultivation of open fields is frequently harmed by rapid changes in meteorological conditions. Naturally ventilated polyhouses, on the other hand, give shelter from such circumstances (Thakur *et al.* 2016). Nitrogen is an essential plant nutrient that plays an important function in crop growth and development (Bika *et al.* 2018).

Nitrogen is considered to be responsible for the vegetative growth of broccoli plants (Neethu *et al.* 2015). Mineral fertilizer (N, P and K) increases broccoli vegetative growth, production and quality, according to (Nkoa *et al.* 2002). Nitrogen is necessary for enzymatic reactions in plants since all plant enzymes are proteins (Giri *et al.* 2013). As a result, the goal of this study was to see how varied nitrogen dosages and environmental circumstances influenced broccoli plant vegetative development, head output, and head quality.

MATERIALS AND METHODS

The present investigation was conducted in the Vegetable Research Farm, Department of Vegetable Science, Khalsa College, Amritsar during the years 2020-21 using the cultivar Palam Samridhi. As per the recommendation, 40 tonnes of FYM, 155 kg of single superphosphate and 40 kg of Murate of potash per acre were applied. The experiment was laid out in Factorial Randomized Block Design (RBD) with three replications. The experiment was carried out with five different concentrations, namely 50% N (A1), 75% N (A2), 100% N (A3), 125% N (A4) and control (A5) and two environments, viz. protected (B1) and open field (B2). The performance of broccoli was studied and data recorded on the number of leaves per plant, plant height upto the largest leaf (cm), leaf size (cm^2), days to first harvest, head size (cm), weight of head (g), weight of auxillary bud (g), total yield per plant (kg), TSS (^{o}Brix), ascorbic acid (mg per 100 g). The mean data was subjected to statistical analysis following the analysis of variance technique of Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The findings of (Table 1) of the present experiment revealed a significant effect of nitrogen doses and environmental conditions on the number of leaves per plant, plant height upto the largest leaf (cm), leaf size (cm^2), TSS (^{o}Brix) and ascorbic acid (mg per 100 g). Among the nitrogen treatments, the maximum number of leaves per plant (16.99), plant height upto the largest leaf (cm) (67.98) and leaf size (cm^2) (486.76) were determined in A4 (125% nitrogen), while a minimum was noted in A5 (control) viz. (13.57), (55.77) and (322.15). As one of the most essential nutrients, nitrogen plays a vital role in plant metabolism and development and its application stimulates plant growth (Neethu *et al.* 2015). Giri *et al.* (2013) have found favorable findings. Because nitrogen aids plant development, higher nitrogen dosages result in increased leaf area. When the availability of nitrogen to the roots is increased, cytokinin production rises and more cytokinin is sent to the leaves for growth and expansion (Agarkar *et al.* 2009). The rise in plant spread can be ascribed to the increase in vegetative growth, leaf length, leaf breath and leaf area under different treatments (Kumar *et al.* 2013).On the other hand, maximum TSS (^{o}Brix) (6.81) and ascorbic acid (mg per 100 g) (107.28) were observed in A3 (100% nitrogen) and a minimum was obtained in A5 (control) viz. (5.56) and (95.05). Increased microbial activity in the soil may have given growth regulators, vitamins, and hormones to the plants, resulting in a rise in quality metrics. Mohapatra *et al.* (2013) discovered comparable findings in broccoli.

Among the environmental treatments, maximum number of leaves per plant (15.88), plant height upto largest leaf (cm) (62.70) and leaf size (cm^2) (423.77) were more in B1 (protected environment) while less in B2 (open environment), viz. (14.99), (60.67) and (396.60). Due to the favorable photosynthetic climate for vegetative growth, the crop performed fairly well under the polyhouse. Similar results were obtained

Table 1. Impact of nitrogen on growth and quality traits of broccoli under open and protected environment.

Treatments		Number of leaves per plant	Plant height upto largest leaf (cm)	Leaf size (cm^2)	TSS (^{o}brix)	Ascorbic acid (per 100 mg)
A1	50% N	18.59	61.88	360.41	5.88	86.06
A2	75% N	21.73	64.67	414.32	6.11	93.83
A3	100% N	24.70	68.64	467.31	**6.65**	**103.50**
A4	125% N	**27.21**	**70.49**	**486.76**	6.72	102.68
A5	Control	16.01	55.37	322.15	5.68	76.54
CD		**4.53**	**4.14**	**2.26**	**0.25**	**3.70**
B1	Protected environment	22.74	65.67	423.78	6.31	95.29
B2	Open environment	20.56	62.76	396.61	6.11	89.76
CD		**N/A**	**2.62**	**1.43**	**0.16**	**2.34**

by Thapa *et al* (2013). On the other hand, maximum TSS (^{o}brix) (6.29), ascorbic acid (mg per 100 g) (102.72) were observed in A3 (A3-100% nitrogen) and a minimum was obtained in A5 (control) viz., 6.07 and (100.01). These findings are in accordance with (Thakur *et al.* 2016) in multiple varieties of the broccoli crop.

The findings (Table 2) show the significant effect of nitrogen doses and environmental conditions on days to first harvest, head size (cm), weight of head (g), weight of auxillary bud (g) and total yield per plant (kg). Among the nitrogen treatments, a minimum number of days taken to first harvest (68.95) was observed in A4 (125% nitrogen), while a maximum of 78.95 was noted in A5 (control). Head size (cm), weight of head (g), weight of auxillary bud (g) and total yield per plant (kg) were found to be maximum viz., 190.25, 232.29, 155.79 and 382.64 in A4 (125% nitrogen) and minimum viz. 145.26,171.43,122.48 and 294.71 were in A5 (control). Due to appropriate use of carbohydrates, proteins, and photosynthetic accumulation, the crop performed well after nitrogen application. Various activities such as glucose metabolism, enzyme activation, and sugar and starch translocation to the storage organ (the head) are affected by the nitrogen content in the soil. Sahah *et al.*(2010), Giri *et al*. (2013) and Singh *et al.* (2015) published relatable findings. The higher ultimate yield is a result of enhanced vegetative growth, development, photosynthesis and dry matter synthesis. It might be because of the optimal buildup of nitrogen resulting in an increase in crop production. Supe and Marbhal (2008) and Singh *et al.* (2015) found comparable findings. To develop a succulent floral head with a delicate texture, nitrogen is applied (Neethu *et al*. 2015).

Among the environmental treatments, a minimum number of days taken to first harvest (73.08) was observed in A4 (125% nitrogen), while a maximum (75.16) was noted in A5 (control). The maximum values for head size (cm), weight of head (g), weight

Table 2. Impact of nitrogen on yield and yield attributing traits of broccoli under open and protected environment.

Treatments		Days to first harvest	Head size (cm)	Weight of head	Weight of auxillary bud (g)	Total yield per plant (kg)
A1	50% N	75.56	155.62	182.73	179.53	307.40
A2	75% N	72.33	169.82	200.35	197.44	318.22
A3	100 % N	69.13	184.38	222.17	218.35	333.82
A4	125% N	**66.72**	**189.09**	**233.02**	**230.57**	**339.49**
A5	Control	78.83	146.03	169.40	165.70	293.80
CD		**3.49**	**4.50**	**3.40**	**3.01**	**4.89**
B1	Protected environment	71.36	172.88	207.51	203.64	323.71
B2	Open environment	73.67	165.09	195.56	193.00	313.38
CD		**2.21**	**2.85**	**2.15**	**1.90**	**3.09**

Table 3. Interaction table on impact of nitrogen on growth and yield of broccoli under open and protected environment.

Characters		Leaf size		Weight of head		Total yield per plant		Weight of auxillary bud(g)	
Environment →		Protected	Open	Protected	Open	Protected	Open	Protected	Open
A1	50% N	367.52	353.30	186.23	179.22	309.11	305.68	182.65	176.42
A2	75% N	425.12	403.53	205.43	195.26	320.88	315.56	201.00	193.88
A3	100% N	481.64	452.97	232.13	212.21	342.03	325.61	228.14	208.56
A4	**125% N**	509.32	464.21	240.72	225.32	348.31	330.68	237.95	223.19
A5	Control	335.28	309.02	173.01	165.79	298.22	289.38	168.47	162.93
CD (A×B)		**3.20**		**4.80**		**6.92**		**4.25**	

of auxillary bud (g), and total yield per plant (kg) were found to be 173.52,208.77, 143.87 and 350.12 in A4 (125% nitrogen), and the minimum values were 166.54,199.72,138.37 and 335.92 in A5 (control). Temperature receptivity plays an important role in the early development of the broccoli head. Curd formation is dependent on the temperature as crucifer crops are cool season vegetables. Low temperatures can boost the yield and quality of sprouting broccoli under protected conditions. According to (Thapa *et al.* 2013), polyhouse production was found to be effective for successful cultivation of sprouting broccoli.

Interaction (Table 3) between the environment and nitrogen concentration was significant for characters, namely weight of auxillary buds, plant height up to the largest leaf, leaf size, head size, weight of head, and total yield per plant. The maximum weight of auxillary buds was obtained with the combination of 125% N under protected conditions (158.80 g), while the minimum weight of auxillary buds was obtained with control under open conditions (120.70 g). Further, interaction between the protected environment and 125% N reported maximum height upto the largest leaf (69.38 cm) and a minimum were observed in control under the open environment (55.60 cm). The combination of protected environment and 125% N resulted in the largest leaf size (509.32 cm^2) and the smallest in open environment and control interaction (309.02 cm^2). Size was found to be highest (195.56 cm) in the combination of protected environment and 125% N, while the lowest head size (143.80 cm) was in control in the open environment. Interaction between the protected environment and 125% N had maximum head weight (236.76 g) and total yield per plant (394.54 g), whereas minimum head weight (168.57 g) and total yield per plant (370.75 g) were obtained with a combination of control and open environment. It might be due to the fact that with increasing application of nitrogen, vegetative growth and metabolism increase, which leads to an increase in photosynthesis rate and synthesis of dry matter, i.e., carbohydrates, proteins, sugar, which ultimately increases the vegetative growth and yield of broccoli. Sahah *et al.* (2010), Giri *et al.* (2013) and Thakur *et al.* (2016) found comparable results. The interaction effect of nitrogen with environmental conditions was significant for all the growth and production attributing characteristics of broccoli.

CONCLUSION

According to the findings of this study, a naturally ventilated polyhouse was superior to an open field for vegetative, yield and quality attributes in sprouting broccoli. It is concluded that among the nitrogen treatments, 125% N application suited best to the crop and gave outstanding results in terms of vegetative and yield characteristics, whereas quality attributes were found to be better in the 100% nitrogen treatment. The interaction effect of nitrogen doses with environmental conditions was significant for vegetative and yield parameters.

ACKNOWLEDGMENT

The authors would like to thank the department of Horticulture, Khalsa College and Amritsar for providing necessary equipments for this research work.

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