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Influence of growing conditions and integrated nutrient management on yield and quality of broccoli

P. A. Maheriya, B. N. Satodiya, A. S. Thounaojam

Abstract

The present investigation was conducted at Horticultural Research Farm, B. A. College of Agriculture, Anand Agricultural University, Anand in rabi season during the two consecutive years, 2019-20 and 2020-21. In triplicate replications, the experiment was designed in a split plot which consists of twelve treatment combinations. Three main plot treatments of growing conditions [G_1: Poly house, G_2: Green shade net (50 % Shade net) and G_3: Open condition] and four subplot treatments of integrated nutrient management reside of N_1: 50% RDF(chemical fertilizer)+ 50% RDF (FYM), N_2: 50% RDF (chemical fertilizer) +50% RDF(vermicompost), N_3: 50% RDF (chemical fertilizer) + 50% RDF (poultry manure) and N_4: Control (RDF, 100:50:50 NPK kg/ha). Growing broccoli in polyhouse conditions recorded minimum days for first harvest and maximum curd height, curd diameter, curd weight, yield (t/ha), TSS, dry matter content, and ascorbic acid. The minimum days for the first harvest and maximum curd height, curd diameter, curd weight, yield (t/ha), TSS, dry matter content, and ascorbic acid were observed with the application of 50 % RDF through chemical fertilizer +50% RDF through vermicompost. Growing broccoli in polyhouse condition with application of 50 % RDF through chemical fertilizer +50% RDF through vermicompost recorded maximum curd height, curd diameter, curd weight, and yield (t/ha).

Keywords dry matter content, growing condition, integrated nutrient management, poly house, yield

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Introduction

Broccoli (*Brassica oleracea* var. *italica* L.) is a cole crop that belongs to the family Brassicaceae. The cultivation of broccoli in recent years has increased exponentially; even in India it has become very popular because of its nutritional value and market potential. Broccoli is more sensitive to temperature. It cannot withstand temperatures as high or low as cabbage. High temperatures delay maturity and increase vegetative growth (number of leaves) and the clusters grow loose quickly. When the plants are small and tender, they are susceptible to cold injury and cool temperatures hasten maturity and may induce "bolting''. Plant growth and development is greatly influenced by changing climatic condition; protected cultivation like plants growing in polyhouse, net house, greenhouse, plastic tunnel etc. can provide optimum environmental conditions. Ultimately it protects the plant from various biotic and abiotic stresses. Thereby better vegetative and reproductive growth resulting in improving quality and other related parameters has been reported in

various crops. Therefore, protected cultivation disclosed higher net income than open conditions in high-value crops like broccoli. The plant requires adequate nutrient supplements apart from providing suitable environmental conditions for proper growth and development. There are different types of organic or inorganic-based fertilizers are being used as a nutrient supplement in plants. In most of the conventional agriculture practices synthetic fertilizers are commonly preferred as it's readily make nutrients available to the crops [1]. However, organic based fertilizer supplement needs to be mineralized to get nutrients available in plants though it depends on the soil physical and chemical properties and interaction with soil microfauna [2]. Many researchers showed that inorganic based fertilizer is used with respect to the enhancement of production and productivity but there is an inferior in secondary metabolite accumulation which is directly correlated with low quality [3]. Beside this, heavy doses of chemical fertilizers without organic manures cause deterioration of soil health in terms of physical and chemical properties, decline of soil microbial activities, reduction in soil humus, and increased pollution of soil, water, and air. Hence, integrated nutrient management (INM) is a right and sustainable practice to overcome such constraints without compromising production. The INM is an approach of using all potential sources of organic, inorganic, and biological components systematically to maintain the soil fertility and plant nutrient supply at an optimal level for maintaining the desired productivity. Its impact on soil health is long lasting and ensures sufficient nutrient levels. With these backgrounds, the present investigation was framed and checked on the yield and quality parameters of broccoli under different growing conditions and INM practices.

Methodology

The present investigation was carried out at Horticultural Research Farm, Department of Horticulture, Anand Agricultural University, Anand during the *rabi* season in two consecutive years 2019-20 and 2020-21. The experimental design was a split plot Design which consisted of twelve treatment combinations comprising three main plot treatments of growing conditions and four sub-plot treatments of integrated nutrient management and conducted in triplicate replications.

Treatment details

Growing conditions (G)

G_1: Poly house
G_2: Green shade net (50 % Shade net)
G_3: Open condition

Integrated nutrient management (INM)

N_1: 50% RDF (chemical fertilizer) + 50% RDF (FYM)
N_2: 50% RDF (chemical fertilizer) + 50% RDF (vermicompost)
N_3:50 % RDF (chemical fertilizer) + 50% RDF (poultry manure)
N_4: Control (RDF, 100:50:50 NPK kg/ha)

Yield and quality parameters observations

Observations of yield and quality parameters were recorded from the five randomly selected tagged plants. The first harvest was recorded by counting the days required from the transplanting date of seedlings to the date when the first curd was harvested and the average was worked out for each net plot. For curd height, a middle portion of curd of the five random marketable curds from each net plot was measured by the scale, and the average was worked out. For curd diameter five randomly selected curds from each treatment of respective replication were recorded with verniercalliper by measuring at the maximum widest part of the curd and the average was worked out and expressed in centimeters. For curd weight from each net plot randomly selected five curds of

different plants remained selected and their mean average weight was recorded in grams. The yield was calculated in terms of hectare for each treatment by considering the net plot. Total soluble solids content in curd was determined by Erma Hand Refractometer (0 to 32 °Brix). The curd was removed from the randomly selected five plants from each treatment and then kept in the oven at 60 ± 5°C until the weight was constant. The oven-dried weight was measured and represents the dry matter content, expressed in grams. The ascorbic acid content was determined by Ranganna [4].

Results and Discussion

Effect of growing conditions on yield parameters of broccoli

The two years of pooled statistical data are depicted in Table 1 and it showed that growing conditions exhibited significant response with regards to days required for first harvest and curd height, diameter, weight, and yield.

Table 1. Yield parameters of broccoli as influenced by growing conditions and INM (Pooled over two years)

Treatments	First harvest (days)	Curd height (cm)	Curd diameter (cm)	Curd weight (g)	Yield (t/ha)
Growing conditions					
G_1- Polyhouse	66.90	17.72	20.23	405.19	15.18
G_2-Green shade net (50 % Shade net)	70.55	17.20	16.25	327.65	12.08
G_3- Open condition	68.78	16.35	18.73	374.38	13.83
S. Em. ±	**0.43**	**0.15**	**0.24**	**4.68**	**0.22**
C.D.at 5 %	**1.40**	**0.48**	**0.77**	**15.25**	**0.71**
C.V.%	**3.06**	**4.18**	**6.28**	**6.21**	**7.76**
Integrated nutrient management (INM)					
N_1-50% RDF (chemical fertilizer)+ 50% RDF (FYM)	69.06	16.69	17.46	350.02	13.01
N_2-50% RDF (chemical fertilizer) +50% RDF (vermicompost)	66.91	17.47	19.60	391.66	14.57
N_3-50% RDF (chemical fertilizer) + 50% RDF (poultry manure)	69.00	17.37	18.57	373.54	13.84
N_4-Control (RDF, 100:50:50 NPK kg/ha)	70.01	16.82	17.98	361.07	13.36
S. Em. ±	**0.21**	**0.21**	**0.21**	**4.01**	**0.14**
C.D.at 5 %	**0.61**	**0.60**	**0.61**	**11.51**	**0.40**
Year effect	**NS**	**NS**	**NS**	**NS**	**NS**
Sig. interaction	**-**	**G X N**	**G X N**	**G X N**	**G X N**
C.V.%	**1.32**	**5.17**	**4.90**	**4.61**	**4.36**

First harvest

The minimum days required for the first harvest (66.90) was observed with treatment G_1 (polyhouse condition). This might be due to the higher temperature that prevailed inside polyhouse, which acted as a stress and allowed the plant to complete its life cycle at a faster rate. These results have parity with findings obtained by Pooja and Hakkim [5] in tomatoes.

Curd height (cm)

The maximum curd height (17.72 cm) was recorded in treatment G_1 (polyhouse condition). This might be due to increased nutrient use efficiency under polyhouse with a favorable microclimate governed by the appropriate level of temperature, relative humidity, light, and CO_2 which helped to enhance curd height.

Curd diameter (cm)

The maximum curd diameter (20.23 cm) was observed with treatment G_1 (polyhouse condition) This might be due to the translocation of more photosynthates from source to sink and congenial growing conditions like temperature, relative humidity, and light under polyhouse. These results have parity with findings obtained by Thapa et al., [6] Kumar and Biradar [7] in broccoli, Rana et al., [8] on tomatoes.

Curd weight (g) and yield (t/ha)

The maximum curd weight (405.19 g) and yield (15.18 t/ha) were observed with treatment G_1 (polyhouse condition). This might be due to a favorable microclimate governed by the appropriate level of temperature, relative humidity, light, CO_2, and protection from heavy wind, pests, and diseases which helped to increase the length and width of the leaves ultimately contributing to more carbohydrates, photosynthesis from a larger area of the leaves and the translocation of photosynthate to the sink which is ultimately the curd consequently more diameter and weight of curd. These results have parity with findings obtained by different researchers [6-9].

Effect of INM on yield parameters of broccoli

The statistical data presented in Table 1 revealed that integrated nutrient management showed significant responses with regard to first harvest and height, diameter, weight, and yield of curd.

First harvest

Minimum days taken for the first harvest (66.91) was observed in treatment N_2 [50% RDF (chemical fertilizer) +50% RDF (vermicompost)]. It might be due to the suitable nutrition provided which induces proper and balanced uptake of nutrients by the plants. These results are similar to the findings of Meena et al., [10] in broccoli.

Curd height (cm)

The maximum curd height (17.47 cm) was observed with treatment N_2 [50% RDF (chemical fertilizer) +50% RDF (vermicompost)]. It might be due to vermicompost and chemical fertilizers increasing the availability of major elements like nitrogen, phosphorous, and potassium. These elements are directly or indirectly related to an increase in the synthesis of chlorophyll and amino acids and also help in the translocation of photosynthate from source (leaves) to sink (curd), particularly during the reproductive stage ultimately increasing support to more growth in curd. This finding is in agreement with Mohanta et al., [11] in broccoli.

Curd diameter (cm)

The maximum curd diameter (19.60 cm) was observed with treatment N_2 [50% RDF (chemical fertilizer) +50% RDF (Vermicompost)]. The additional support of organic or inorganic forms of nutrition in soil provides better root growth due to the more uptakes of nutrients along with water. Resulting in profuse plant growth in terms of leaf area hence in efficient photosynthesis, high translocation of metabolites, and enhanced dry matter accumulation. The findings about the diameter of the curd are in close agreement with those reported by several researchers [7, 10-13].

Curd weight (g) and yield (t/ha)

The maximum curd weight (391.66 g) and yield (14.57 t/ha) were observed with treatment N_2 [50% RDF (chemical fertilizer) +50% RDF (vermicompost)]. It might be due to the availability of major and micronutrient nutrients in the soil due to vermicompost and inorganic fertilizers which favor balanced nutrition and better uptake of nutrients by the plants which helped for better curd weight. These results are in accordance with different researchers [7, 10-11].

Effect of growing conditions on quality parameters of broccoli

Data furnished in Table 2 indicate that among the quality parameters, growing conditions showed significant responses with regards to TSS, dry matter content, and ascorbic acid whereas total carotenoid observed non-significant differences.

Table 2. Quality parameters of broccoli as influenced by growing conditions and INM (Pooled over two years)

Treatments	TSS (°Brix)	Dry matter content (g)	Ascorbic acid (mg/100g)	Total carotenoid (mg/100 g)
Growing conditions				
G_1- Polyhouse	13.97	61.09	32.95	22.83
G_2-Green shade net (50 % Shade net)	12.91	56.21	26.71	21.92
G_3- Open condition	13.25	58.94	29.39	24.18
S. Em. ±	**0.13**	**0.30**	**0.50**	**0.54**
C.D.at 5 %	**0.43**	**0.98**	**1.63**	**NS**
C.V.%	**4.87**	**2.50**	**8.25**	**11.51**
Integrated nutrient management (INM)				
N_1-50% RDF (chemical fertilizer)+ 50% RDF (FYM)	13.18	58.41	29.21	22.74
N_2-50% RDF (chemical fertilizer) +50% RDF (vermicompost)	13.80	59.89	33.49	23.78
N_3-50% RDF (chemical fertilizer) + 50% RDF (poultry manure)	13.43	58.94	29.68	23.25
N_4-Control (RDF, 100:50:50 NPK kg/ha)	13.09	57.74	26.36	22.15
S. Em. ±	**0.10**	**0.32**	**1.14**	**1.08**
C.D.at 5 %	**0.28**	**0.92**	**3.26**	**NS**
Year effect	**NS**	**NS**	**NS**	**NS**
Sig. interaction	**-**	**-**	**-**	**-**
C.V.%	**3.08**	**2.31**	**16.24**	**19.89**

TSS (°Brix)

The maximum TSS (13.97 °Brix) was observed with treatment G_1 (polyhouse condition). The plants growing inside the protected structure have a different microenvironment compared to outside open conditions. Under favorable microclimatic conditions, maintain the photosynthetically active solar radiations (400-700 nm) with the required optimum light intensity and minimum temperature difference in day and night inside the structure. Light intensity and temperature greatly impact the sugar accumulation in vegetables predominantly due to an increase in carbohydrate biosynthetic enzyme activity could enhance the TSS of curd. These results are in conformity with the findings of Pooja and Hakkim [5] and Karetha et al., [14].

Dry matter content

The maximum dry matter content (61.09 g) was observed with treatment G_1 (poly condition). It might be due to the fact that higher TSS content in broccoli curd correlates to higher dry matter content.

Ascorbic acid

The maximum ascorbic acid (32.95 mg/100g) was observed with treatment G_1 (polyhouse condition). It might be due to favorable climatic conditions and optimum light intensity. Due to the increase in primary metabolites synthesis inside the polyhouse could enhance ascorbic acid content. These results conform with the findings of Thakur et al., [15] in broccoli.

Effect of INM on quality parameters of broccoli

Data furnished in Table 2 indicate that among the quality parameters, integrated nutrient management showed significant responses with regards to TSS, dry matter content, and ascorbic acid whereas total carotenoid observed a non-significant difference.

TSS (°Brix)

The maximum TSS (13.80 °Brix) was observed with treatment N_2 (50 % RDF through chemical fertilizer +50% RDF through Vermicompost). It was revealed that vermicompost is an ideal organic amendment for plant growth which contains higher nutritional value than traditional composts [16]. The presence of humic substances in vermicompost and vermicompost-added soil has high porosity, aeration, drainage, and water-holding capacity [17] thereby better TSS as compared to other types of organic manures.

Dry matter content

The maximum dry matter content (59.89 g) was observed in treatment N_2 [50% RDF (chemical fertilizer) +50% RDF (vermicompost)]. Due to the constant mineralization, it provides a sufficient quantity of mineral nutrients to the plants resulting higher rate of photosynthesis and partitioning to different plant parts with higher dry matter accumulation; similar results were also revealed by Kumar et al., [18], and Kaur et al., [19].

Ascorbic acid

The maximum ascorbic acid (33.49 mg/100g) was observed with treatment N_2 (50 % RDF through chemical fertilizer +50% RDF through Vermicompost). An increased uptake of NPK, micronutrients, and growth-promoting substances could enhance metabolic activities resulting in the synthesis of higher amounts of primary metabolites which might have contributed to the synthesis of vitamin C. These results conform with the findings of Meena et al., [10], and Singh et al., [13].

Interaction effect of growing condition and INM on yield parameters of broccoli

The data depicted in Table 3 revealed that the interaction effect of growing conditions and INM on height, diameter, weight, and yield of curd (t/ha) remained significant. Maximum curd height (17.93 cm) was observed with G_1N_2 [Polyhouse condition and 50% RDF (chemical fertilizer) + 50% RDF (vermicompost)]. It might be due to favorable micro-climatic conditions in polyhouse enhanced photosynthesis by providing suitable environmental conditions necessary for photosynthesis. The combined application of nutrients through organic (vermicompost) and inorganic fertilizers increased the rate of nutrient translocation from soil to plants, especially nitrogen. Resulting in an increase in cell proliferation, elongation, and differentiation which is directly related to the increase in plant growth. Maximum curd diameter (21.74 cm) was observed with G_1N_2 [Polyhouse condition and 50% RDF (chemical fertilizer) +50% RDF (vermicompost)]. It might be due to the congenial climatic condition in the polyhouse and better availability of nutrients which helped in the development of curd. Maximum curd weight (434.63 g) and yield (16.41 t/ha) were observed with G_1N_2 (Polyhouse condition and 50% RDF (chemical fertilizer) + 50% RDF (vermicompost)]. This might be due to polyhouse favorable microclimate governed by appropriate levels of temperature, relative humidity, light, CO_2, and protection from heavy wind, pests, and diseases which helped to increase plant spread. The larger leaf area is engaged with maximum photosynthesis and better translocation of photosynthates. An application of vermicompost and inorganic fertilizer provides balanced nutrients and better uptake of nutrients for curd developments consequently more weight of curd such nutrient supplement and protected polyhouse condition.

Table 3. Interaction effect of growing condition and INM on yield parameters of broccoli

INM	Growing conditions											
	Curd height (cm)			Curd diameter (cm)			Curd weight (g)			Yield (t/ha)		
	G_1	G_2	G_3	G_1	G_2	G_3	G_1	G_2	G_3	G_1	G_2	G_3
N_1	17.62	17.40	15.07	19.69	16.23	16.46	393.37	327.27	329.43	14.66	12.10	12.28
N_2	17.93	17.82	16.67	21.74	17.08	19.98	434.63	340.70	399.63	16.41	12.54	14.75
N_3	17.63	17.22	17.27	20.12	16.32	19.26	403.60	332.27	384.77	15.02	12.23	14.26
N_4	17.70	16.35	16.40	19.37	15.36	19.22	389.17	310.37	383.67	14.61	11.45	14.03
S. Em. ±	**0.36**			**0.37**			**6.95**			**0.24**		
C.D.at 5 %	**1.04**			**1.06**			**19.93**			**0.70**		
C.V.%	**5.17**			**4.90**			**4.61**			**4.36**		

Conclusion

From the two years of field study, it can be concluded that growing broccoli in polyhouse conditions with an application of required nutrients by 50% RDF (chemical fertilizer) and 50% RDF (vermicompost) recorded minimum days taken to first harvest and maximum height, diameter, weight and yield of curd.

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