

Original Research Article

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Effect of Integrated Nutrient Management and Bio-regulators on Quality Attributes of Sprouting Broccoli [*Brassica oleracea* (L.) Var. *Italica* Plenck]

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ABSTRACT

The field experiment was conducted at Horticulture Farm, S.K.N. College of Agriculture, Jobner (Jaipur) during *Rabi* season 2016-17 and 2017-18. The experiment consisted of thirty five treatment combinations including seven INM (100 per cent RDF through inorganic fertilizer, 75 per cent RDF through inorganic fertilizer + 25 per cent through FYM (5 t/ha), 50 per cent RDF through inorganic fertilizer + 50 per cent through FYM, 100 per cent RDF through FYM, 75 per cent RDF through inorganic fertilizer + 25 per cent through VC, 50 per cent RDF through inorganic fertilizer + 50 per cent through VC and 100 per cent RDF through vermicompost and five bio-regulators levels [Control, Brassinoids @ 5 ppm, Brassinoids @ 10 ppm, Salicylic acid @ 100 ppm and Salicylic acid @ 150 ppm] were under taken in Split plot design with three replications. The results showed that the maximum TSS (10.58 °Brix), nitrogen content (0.365%), protein content (2.28 %), phosphorus content (0.083 %) potash content (0.278 %) were recorded with the application of 50 per cent RDF through inorganic fertilizer and 50 per cent through vermicompost in sprouting broccoli. Ascorbic acid content was found non significant. Similarly, different bio-regulators significantly increased the TSS (10.18 °Brix), nitrogen content (0.335%), protein content (2.11 %), phosphorus content (0.077 %) potash content (0.261 %), were recorded significant with foliar application of 5 ppm brassinoids while ascorbic acid content was found non significant to broccoli.

Keywords

Growth, Yield, Organic, Inorganic, Vermicompost and Sprouting broccoli.

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Introduction

Sprouting broccoli (*Brassica oleracea* var. *italica*) has originated in the Mediterranean region and commonly known as *Hari gobhi* in Hindi and a member of cole group, belongs to the family brassicaceae while the broccoli derived its name from the Latin word *Branchium* meaning an arm or branch. It is used as curries, soups, pickles, eaten as a salad and cooked as a single or mixed vegetable with potato (Thamburaj and Singh,

2001). Sprouting broccoli is high value exotic vegetable with a kind of terminal head consisting of green buds and thick fleshy flower stalks morphologically resembles the cauliflower except secondary heads, which develop in the axil of leaves and may contribute up to 50 per cent of the total yield. It is one of the most nutritious cole crop and contains vitamin A (130 times and 22 times higher than cauliflower and cabbage, respectively), thiamin, riboflavin, niacin, vitamin C and minerals like Ca, P, K and Fe

(Hazra and Som, 1999). It contains carbohydrates (5.5 %), protein (3.3 %), vitamin-A (3500 IU), vitamin-C (137 mg), vitamin-B₁ (0.05 mg), vitamin-B₂ (0.12 mg), calcium (0.80 mg) and phosphorus (0.79 mg). Broccoli has 4.0, 2.5 and 2.0 times more riboflavin, calcium and ascorbic acid contents, respectively as compared to cauliflower (Thamburaj and Singh, 2001). It is also a rich source of sulphoraphane, a compound associated with reducing the risk of cancer (Thamburaj and Singh, 2001).

Organic manures play direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization and improving physical and chemical properties of soils (Chaterjee *et al.*, 2005). The advantages of integrated use of inorganic and organic sources of fertilizers generally superior over use of each component separately. Integration of chemical fertilizers with organic manures had maintained long time fertility and sustains higher productivity (Bhardwaj *et al.*, 2000). Use of organic manures is not only perfect way for obtaining fairly high productivity with suitable fertilizers economy but also a concept of ecological soundness leading to sustainable agriculture. Therefore, it is hypothesized that growth and yield of broccoli can be enhanced to a great extent by application of organic and inorganic fertilizers with integration of farm yard Manure, vermicompost and chemical fertilizers.

Brassinosteroids are a new group of plant hormones with growth promoting activity (Mandava, 1988). Brassinosteroids are considered as plant hormones with pleiotropic effects as they influence wide array of developmental processes such as growth, seed germination, rhizogenesis flowering, senescence, abscission and maturation (Sasse, 1999). Brassinosteroids improve the resistance of plants against environmental

stresses such as water stress, salinity stress, low temperature stress and high temperature stress (Rao *et al.*, 2002). brassinosteroids also enhances the crop productivity (Vardhani *et al.*, 2006). Brassinosteroids being an eco-friendly chemical, has a potential application in agriculture to increase yield by regulating defense system under field condition in *Brassica juncea* L. Sirhindi *et al.*, (2009). Mitchell *et al.*, (1970) reported about promotion in stem elongation and cell division by the treatment of organic extracts of rapeseed pollen.

Similarly, Salicylic acid (SA) also a plant hormone plays an important role in induction of plant defense against a variety of biotic and abiotic stresses through morphological, physiological and biochemical mechanisms (War *et al.*, 2011). Salicylic acid not only improved the growth and yield in no-stress condition but also for adjusting the drought stress especially at vegetative stress is recommended in bean (*Phaseolus vulgaris* L.) (Sepehri *et al.*, 2015). Salicylic acid (SA) is classified as phenolic growth regulator, a non-enzymatic antioxidant, messenger molecule in plants to induce responses of plants to environmental stresses. SA is a monohydroxy benzoic acid, a type of phenolic acid and a beta hydroxy acid. SA is a phenolic phytohormones and is found in plant which play vital role in plant growth and development, photosynthesis, transpiration, ion uptake and transport. SA also induces specific change in leaf anatomy and chloroplast structure. SA also involved in the systemic acquired resistance (SAR) in which a pathogenic attack on one part of the plant includes resistance in other parts. SA also plays an important role in the regulation of some physiological processes in plants. It has been found that SA positively affects growth and development, ion uptake and transport, and membrane permeability (Simaei *et al.*, 2012).

Materials and Methods

The field experiment was conducted at Horticulture Farm, S.K.N. College of Agriculture, Jobner (Jaipur) during *Rabi* season 2016-17 and 2017-18. The experiment consisted of thirty five treatment combinations including seven INM (F_0 -100 per cent RDF through inorganic fertilizer, F_1 - 75 per cent RDF through inorganic fertilizer + 25 per cent through FYM (5 t/ha), F_2 - 50 per cent RDF through inorganic fertilizer + 50 per cent through FYM, F_3 - 100 per cent RDF through FYM, F_4 - 75 per cent RDF through inorganic fertilizer + 25 per cent through VC, F_5 - 50 per cent RDF through inorganic fertilizer + 50 per cent through VC and F_6 - 100 per cent RDF through vermicompost and five bio-regulators levels [B_0 - Control, B_1 - Brassinoids @ 5 ppm, B_2 - Brassinoids @ 10 ppm, B_3 - Salicylic acid @ 100 ppm and B_4 - Salicylic acid @ 150 ppm] were under taken in Split plot design with three replications. Each plot measured $2.25 \times 1.8 \text{ m}^2$ area. The variety was sowed at the spacing between plants to plant as well as row to row was kept at 45 x 45 cm. Before sowing the seed were treated with Azotobactor and PSB inoculums, which was added with 5 g jiggery in 50 ml of boiled water and made in to a sticky paste. The seed were treats for half an hour and then dried in shade for 30 minutes and then sown the experimental plot immediately. These healthy seedling uniform shape and size were selected and transplanting in well prepared field. All the cultural operations were followed which were necessary to raise the good crop. Five plants were randomly selected and tagged before flowering from each line to record the data on the following attributes. The observations were recorded on total soluble solids ($^{\circ}\text{Brix}$) was measured with the help of an Erma hand refractometer and were corrected using standard reference table and express in terms of ($^{\circ}\text{Brix}$) at 200, ascorbic acid (mg/100g) Ascorbic acid

content was determined by diluting the known volume of juice with 3% meta-phosphoric acid and titrating with 2,6- dichlorophenol- indo-phenol solution with (AOAC,1960), protein content in curd was analyzed separately for nitrogen (%) content by colorimetric method (Snell and Snell, 1949). Nitrogen content was multiplied with 6.25 factors to calculate crude protein content in curd (A.O.A.C., 1960). N content: First of all wet digestion of curd sample with H_2SO_4 and H_2O_2 carried out and then colorimetric determination was performed on spectronic-20 after development of yellow colour with Nessler's reagent in digestion-I (Snell and Snell, 1949). In order to determination of P content in the broccoli curd, wet digestion of sample with diacid mixture (nitric acid and perchloric acid in ratio of 9:4) was carried out and then estimation of phosphorus on Spectronic-20 was done by using vanadomalybde phosphoric acid in performed stilled yellow colour development (Jackson, 1967). For determination of K content in the curd of broccoli wet digestion of curd sample with H_2SO_4 was carried out and analysed the suitable aliquot on flame photometer (Metson, 1956). All the parameters were collected from five randomly selected plants of each treatment. Least significant difference at 5% level was used for finding the significant differences among the treatment means. The data obtained from selected plants were subjected to analysis of variance Panse and Sukhamate (1961).

Results and Discussion

Effect of integrated nutrient management

Data pertaining to the effect of various sources of RDF on TSS of sprouting broccoli revealed that all the treatments significantly influenced all the quality parameters of sprouting broccoli (Table 1). Pooled analysis recorded that the maximum TSS (10.58°Brix)

was found in F₅ treatment *i.e.* 50 per cent RDF supplied through inorganic fertilizer and 50 per cent through vermicompost. The percentage increased in TSS content under F₅ treatment was 7.52, 8.51, 16.62, 21.05 and 23.31 per cent over F₄, F₀, F₆, F₁ and F₃ treatments, respectively. It was also found that F₅ treatment being statistically at par with F₂ treatment. The minimum TSS (8.58 °Brix) was recorded under F₃ treatment. The maximum nitrogen content (0.365 %) was noticed under F₅ treatment, which was statistically at par with F₂. However, the minimum nitrogen content (0.269 %) was observed under F₃ treatment. The per cent increase in nitrogen content of curd in F₅ was 8.31, 21.26, 22.48, 29.89 and 35.69 per cent more over F₄, F₀, F₆, F₁, and F₃ treatments, respectively. Pooled data showed that the maximum protein content (2.28%) was recorded in F₅ treatment *i.e.* 50 per cent RDF supplied through inorganic fertilizer and 50 per cent through vermicompost, which was statistically at par with F₂ treatment. The per cent increase in protein content under F₅ treatment was 35.71, 30.29, 22.58, 21.27 and 8.57 per cent higher over F₃, F₁, F₆, F₀ and F₄ treatments, respectively. The maximum phosphorus content (0.083%) was found under F₅ treatment *i.e.* 50 per cent RDF supplied through inorganic fertilizer and 50 per cent through vermicompost and this treatment was at par with F₂ treatment which proved significantly superior to rest of the treatments. The minimum phosphorus content (0.060%) was observed in the F₃ treatment as pooled mean basis. The increase in phosphorus content due to F₅ was 38.33, 31.75, 22.06, 13.69 and 10.67 per cent higher over F₃, F₁, F₆, F₀ and F₄ treatments respectively. The highest concentration of potash (0.278 %) was found in F₅ treatment *i.e.* 50 per cent RDF supplied through inorganic fertilizer and 50 per cent through vermicompost. This treatment was closely accompanied by F₂ treatment, where 50 per

cent RDF supplied through inorganic fertilizer and 50 per cent through FYM (0.272 %) in pooled mean analysis. The increase in potash content under F₅ was registered as 33.65 per cent higher over control. The minimum potash content 0.208 per cent was recorded in F₃ treatment on pooled mean analysis. While ascorbic acid was found non-significantly with different sources of integrated nutrient management during both the year and pooled mean analysis.

The increase in nitrogen and protein content might be due to better availability of desired and required quantity of N in root zone of the crop resulting from its solubilization called by organic acid and produced from the decaying of the organic matter. The increase in protein may also be due to the increased activity of nitrate reductase enzymes which might help in synthesis of amino acids and protein (Gupta, 2003) in cabbage. The increase in quality parameters in cabbage might be due to increase in microbial activity of soil which might have added growth regulators, vitamins and hormones to the plants. Similar findings have also been observed by Mohapatra *et al.*, (2013) in broccoli and Patil *et al.*, (2004) in tomato.

Effect of bio-regulators

Further, data indicated that bio-regulators significantly increased all the quality parameters of sprouting broccoli during both the years and pooled mean analysis (Table 1). The maximum TSS (10.18 °Brix) was recorded with the application of treatment B₁ (Brassinoids @ 5 ppm), However, the minimum TSS was recorded (8.45 °Brix) under control (B₀). The increase in TSS under B₁ was registered as 20.47, 6.26 and 5.82 per cent higher over B₀ (control), B₄ (Salicylic acid @ 150 ppm) and B₃ (Salicylic acid @ 100 ppm) treatments respectively. The treatment B₂ found statistically at par with B₁.

The maximum nitrogen content (0.335%) was recorded with brassinoids @ 5 ppm, However, it was found statistically at par with treatment B₂. The increase in nitrogen content under B₁ treatment registered 20.07 per cent higher than control (B₀). The maximum protein content (2.118 %) was recorded with

the application of 5 ppm brassinoids (B₁), However, this was noted as minimum 1.741 per cent under control in pooled mean analysis. The increase in protein under B₁ was registered as 21.26 per cent higher over control.

Table.1 Effect of INM and bio-regulators on total soluble solid and ascorbic acid of sprouting broccoli

Treatments	Total soluble solid (⁰ Brix)	Ascorbic acid (mg/100g)	N content (%)	Protein content (%)	P content (%)	K content (%)
INM						
F ₀ -100% RDF (100:80:60 kg NPK/ha) through inorganic fertilizer	9.75	79.51	0.301	1.878	0.073	0.242
F ₁ - 75% RDF through inorganic fertilizer + 25% through FYM (5 t/ha)	8.74	82.61	0.281	1.753	0.063	0.224
F ₂ -50% RDF through inorganic fertilizer + 50% through FYM (10 t/ha)	10.34	85.98	0.356	2.225	0.080	0.272
F ₃ -100% RDF through FYM (20 t/ha)	8.58	83.22	0.269	1.681	0.060	0.208
F ₄ -75%RDF through inorganic fertilizer + 25% through VC (1.75 t/ha)	9.84	89.06	0.337	2.103	0.075	0.251
F ₅ -50% RDF through inorganic fertilizer + 50% through VC (3.5 t/ha)	10.58	87.44	0.365	2.281	0.083	0.278
F ₆ -100% RDF through VC (7 t/ha)	9.10	86.23	0.298	1.859	0.068	0.233
SEm±	0.17	1.55	0.005	0.035	0.001	0.004
CD (P=0.05)	0.48	NS	0.016	0.101	0.004	0.012
Bio-regulators						
B ₀ -Control (water spray)	8.45	81.83	0.279	1.741	0.063	0.216
B ₁ -Brassinoids (5 ppm)	10.18	87.31	0.335	2.108	0.077	0.261
B ₂ -Brassinoids (10 ppm)	9.97	86.13	0.329	2.054	0.075	0.254
B ₃ -Salicylic acid (100 ppm)	9.62	85.58	0.317	1.978	0.072	0.245
B ₄ -Salicylic acid (150 ppm)	9.58	83.47	0.315	1.962	0.071	0.243
SEm±	0.11	1.04	0.004	0.024	0.001	0.003
CD (P=0.05)	0.32	NS	0.011	0.067	0.002	0.008

The maximum phosphorus content (0.077 %) was recorded under treatment B₁ (Brassinoids @ 5 ppm) while minimum (0.063 %) phosphorus content was recorded under control. The treatment B₂ remained statistically at par with treatment B₁. The increase in phosphorus content under B₁ was registered as 22.22 per cent higher over control. The maximum potash content (0.261 %) was recorded with the application of brassinoids @ 5 ppm (B₁). However, treatment B₂ found statistically at par with B₁. The increase in potash content under B₁ was registered as 20.83 per cent higher over control. While ascorbic acid was found non-significantly with different sources of bio-regulators during both the year and pooled mean analysis.

The beneficial role of brassinoids is increasing beneficial effects through various physiological and bio-chemical changes especially at lower concentrations significantly. Production and mobilization of carbohydrates, uptake of nutrients and water from the soil and the hormonal balance. Favorable influence of brassinoids on photosynthesis and metabolic processes augmented the production of photosynthesis ultimately increased the concentrations of different nutrients in curd of sprouting broccoli. The results obtained in present investigation are in line with finding of Maity and Bera (2009) in green gram who reported more starch and soluble protein content in leaves. Similarly, Bhadala (2017) reported increased protein content in vegetable cluster bean at 5 ppm of brassinoids. The results were also with those of Vardhani *et al.*, (2006), Alyemeni and Al-Quwaiz (2014) in green gram and Dhall and Singh (2014) in cucumber.

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