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Effect of NAA and boron levels on growth and quality 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 2017-18. The experiment consisted of sixteen treatment combinations including four NAA (control, NAA @ 100 ppm, NAA @ 200 ppm, and NAA @ 300 ppm) and four boron levels (control, boron @ 0.75 kg/ha, boron @ 1.5 kg/ha and boron @ 2.25 kg/ha) were under taken in randomized block design with three replications.
The results of the study clearly indicated that application of NAA @ 300 ppm to the sprouting broccoli significantly increased the plant height, stem diameter, number of leaves per plant, leaf area, chlorophyll content in leaves (3.01mg/g), ascorbic acid content (83.89 mg/100g) protein content, boron content, as compared to control and found at par to NAA @ 200 ppm. Application of NAA @ 300 ppm days taken to curd formation was found minimum as compared to control. Similarly, boron levels significantly increased the plant height, stem diameter, number of leaves per plant, leaf area, chlorophyll content in leaves (2.98 mg/g), ascorbic acid content (88.36 mg/100g) protein content, boron content, as compared to control and found at par to boron @ 1.5kg/ha. Application of NAA @ 300 ppm days taken to curd formation was found minimum as compared to control.

Keywords: Growth, quality, boron, NAA and sprouting broccoli

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, and pickles, eaten as a salad and cooked as a single or mixed vegetable with potato (Thamburaj and Singh, 2001) [19]. 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) [4]. It contains carbohydrates (5.5%), protein (3.3%), vitamin-A (3500 IU), vitamin-C (137 mg), vitamin-B-$_1$ (0.05 mg), vitamin-B$_2$ (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) [19]. It is also a rich source of sulphoraphane, a compound associated with reducing the risk of cancer (Thamburaj and Singh, 2001) [19].
Naphthalene acetic acid (NAA) is an organic compound. This colorless solid is soluble in organic solvents. NAA is synthetic plant hormone in the auxin family and is an ingredient in many commercial plant rooting horticultural product. This rooting agent is useful for vegetative propagation of plants, from stem and leaf cutting, plant tissue culture. NAA has been found to greatly increase cellulose fiber formation in plants when paired with another phytohormone called gibberellic acid because it is in the auxin family. It has also been understood to prevent pre mature dropping and thinning of fruits from stems. It is applied after blossom fertilization. NAA present in environment undergoes oxidation reactions with hydroxyl radicals and sulphate radicals. A radical reaction of NAA was studied by using pulses radiolysis technique. The growth substance like Naphthalene Acetic Acid (NAA) affects plants very much. It may be useful in regulation of growth development and flowering of plant and also involved in biosynthetic process of plant and works with enzymes. The application to NAA affected the physiological processes particularly respiration and

Photosynthesis, which ultimately lead to accumulation of dry matter, minerals and carbohydrates.

Further, more the boron is absorbed by plants in the form of boric acid (H_3BO_3), it plays an important role in the development and growth of new cells in plant meristem. It also acts as regulator of K/Ca ratio in plants and necessary for the translocation of sugar, starch, phosphors and synthesis of amino acid and proteins. Boric acid also increases the TSS content (Kotur, 1993) [7]. Boron is concerned with the precipitation of excess cation, buffer action, maintenance of conducting tissues and help in absorption of nitrogen. Its primary role is concerned with metabolism both with its uptake and efficient use in plants. Boron also affect the cambial and phloem tissues of storage root or stem apical meristems and leaves, vascular cambia of fruits and other organs which are capable of meristema tic activities (Singh, 1991) [17].

Materials and Methods-

The field experiment was conducted at Horticulture Farm, S.K.N. College of Agriculture, Jobner (Jaipur) during *Rabi* season 2017-18. The experiment consisted of sixteen treatment combinations including four NAA (control, NAA @ 100 ppm, NAA @ 200 ppm, and NAA @ 300 ppm) and four boron levels (control, boron @ 0.75 kg/ha, boron @ 1.5 kg/ha and boron @ 2.25 kg/ha) were under taken in randomized block design with three replications.

Each plot measured 2.40 × 1.8 m^2 area. The variety was sowed at the spacing between plants to plant as well as row to row was kept at 60 x 60 cm. All the cultural operations were followed which were necessary to raise the good crop. The observations like Plant height, Average number of leaves per plant, Leaf area, Days to primary curd formation, chlorophyll content in leaves, Nitrogen content, Crude protein content in head TSS and Ascorbic acid content. Chlorophyll content in leaves was determined using the method of Hiscox and Israelstom (1979) [5] with slight modifications. The data of the trial obtained were subjected to statistical analysis and the results were documented, analysed and presented in tabular form.

Results and Discussion

Effect of NAA levels

Growth attributes

It is revealed from the Table 1 and 2 that the maximum plant height (21.98, 45.01 and 59.67cm), number of leaves per plant (9.27, 17.62 and 22.87) at 30, 60 DAT and at last harvest, respectively, maximum stem diameter (2.60 cm), leaf area (898.67 cm^2), chlorophyll content (3.01 mg/g) and minimum days taken to curd formation (64.01) were recorded under N_3 treatment (300 ppm NAA) and this treatment was also at par with N_2 treatment *i.e.* 200 ppm NAA. The superiority in growth parameters of different treatments over control was due to foliar application of NAA, the possible reason for increase in the growth parameters was due to the physiological effects of auxins on growth parameters of plants *e.g.* cell elongation and cell division, increase in photosynthetic activity and better food accumulation and the early curd initiation and maturity may be due to the suppressive action of NAA on apical meristem and interference with auxin synthesis. The fall in indigenous NAA levels which are responsible for delayed head initiation and head maturity recorded by control. The similar trend was also reported by Yadav *et al.* (2000) [21] in cabbage and Patil *et al.* (2003) [12] in Knol-khol. Enhancement in morphological parameters by the mixture of NAA (through seed dressing) may be due to their effect on cell enlargement, cell growth, physio-chemical properties of protoplasm, respiration, nitrogen and nucleic acid metabolism etc. NAA promoted cell division in pericycle and cortical tissue, the pattern was similar as occurring during lateral root development. Auxin is responsible for initiating a fundamental change in enzyme system of cytoplasm. The role of auxin plays in this master reaction may be as a coenzyme or protecting agent in an enzyme system. Alternatively, the auxin induced master reaction in nucleic acid metabolism may cause synthesis. The beneficial influence of plant growth regulators on growth parameters of horticultural crops have also been reported by Gupta *et al.* (2001) [3], Khamparia and Tiwari (2006) [6] in onion, Soni (2007) [18] in tomato, Mishra (2006) [9] in cabbage, Thapa *et al.* (2013) [20] broccoli and Singh (2015) [16] cabbage.

Table 1: Effect of NAA and boron levels on plant height and number of leaves of sprouting broccoli

Treatment	Plant height (cm)			Number of leaves		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
NAA Levels						
Control	14.03	30.11	43.04	5.33	10.33	16.67
100ppm	17.67	36.45	51.33	7.01	15.08	20.24
200ppm	20.11	42.66	58.01	9.11	17.22	22.11
300ppm	21.98	45.01	59.67	9.27	17.62	22.87
SEm±	0.52	1.10	1.51	0.23	0.44	0.58
CD (P = 0.05)	1.51	3.18	4.35	0.66	1.28	1.67
Boron Levels						
Control	14.83	31.00	42.62	6.17	12.11	16.46
0.75 kg/ha	17.34	36.24	49.83	7.22	14.16	19.24
1.5 kg/ha	19.85	41.49	57.04	8.26	16.21	22.03
2.25 kg/ha	21.77	45.50	62.55	9.06	17.77	24.16
SEm±	0.52	1.10	1.51	0.23	0.44	0.58
CD (P = 0.05)	1.51	3.18	4.35	0.66	1.28	1.67

Table 2: Effect of NAA and boron levels on stem diameter, leaf area chlorophyll content and days taken to curd formation and leaf area (cm^2) of sprouting broccoli

Treatment	Stem diameter (cm)	Leaf area (cm^2)	Chlorophyll (mg/g)	Days taken to curd formation
NAA Levels				
Control	2.01	690.34	1.93	74.20
100ppm	2.25	760.21	2.40	70.87
200ppm	2.45	854.23	2.90	65.50
300ppm	2.60	898.67	3.01	64.01
SEm±	0.06	22.27	0.07	1.90
CD (P = 0.05)	0.19	64.31	0.21	5.49
Boron Levels				
Control	1.87	643.89	2.06	73.12
0.75 kg/ha	2.19	752.81	2.41	70.84
1.5 kg/ha	2.55	876.23	2.80	66.92
2.25 kg/ha	2.70	930.51	2.98	63.70
SEm±	0.06	22.27	0.07	1.90
CD (P = 0.05)	0.19	64.31	0.21	5.49

Quality attributes

It is revealed from the Table 3 that the maximum TSS (9.45 ^{0}Brix), (83.89 mg /100 g), nitrogen content (0.37%), crude protein content (2.31%), boron content (51.23 ppm) were recorded under N_3 treatment and this treatment was also at par with N_2 treatment *i.e.* 200 ppm NAA. The data presented in the experimental results clearly indicate the significant effect of NAA on quality attributes of head. The ascorbic acid content and yield also increased by application of NAA at 120

ppm (Chaurasiya *et al.*, 2014 in cabbage; Patil and patil, 1987 in cabbage; Sawant *et al.*, 2010 in cabbage; Muthoo *et al.*, 1987 in cauliflower) [1, 11, 13, 15].

Effect of Boron

Growth attributes

It is revealed from the Table 1 and 2 that the maximum plant height (21.77, 45.50 and 62.55 cm) number of leaves (9.06, 17.77and 24.16) at 30, 60 DAT and at harvest respectively, maximum diameter of stem (2.70 cm), leaf area (930.51 cm^2), chlorophyll content (2.98 mg/g) and minimum days to curd formation (63.70) were found under the B_3 treatment(2.25 kg boron/ha) and this treatment was also statically at par with B_2 treatment *i.e.* 1.5 kg boron/ ha. These findings clearly indicated that boron played a significant role for enhancing the growth of sprouting broccoli. It might be due to supply of micronutrients and availability of uptake nutrients in soil due to favorable conditions. Boron is a constituent of cell membrane and is essential for cell division. In case of boron deficiency cell division ceases at the growing point which especially lead to disorder in cauliflower like hollow stem and browning (Singh, 1991) [17]. It is also concerned with the precipitation of excess cations, buffer action, and maintenance of conduction tissue and also helped in absorption of nitrogen (Singh, 1991) [17]. These results are in close conformity with the findings of Moniruzzaman *et al.* (2007) [10] in broccoli, Kumar *et al.* (2012) also in cauliflower and Devi *et al.* (2012) in cabbage [2].

Table 3: Effect of NAA and boron levels TSS, ascorbic acid, N content, protein content and boron content of sprouting broccoli

Treatment	TSS (^{0}Brix)	Ascorbic acid (mg/100g)	N content (%)	Protein content (%)	Boron content (ppm)
NAA Levels					
Control	7.23	67.16	0.23	1.44	39.34
100ppm	8.01	73.24	0.31	1.94	45.06
200ppm	8.90	80.01	0.35	2.19	48.45
300ppm	9.45	83.89	0.37	2.31	51.23
SEm±	0.23	2.10	0.01	0.06	1.28
CD (P = 0.05)	0.67	6.07	0.03	0.16	3.69
Boron Levels					
Control	6.75	61.16	0.25	1.58	37.00
0.75 kg/ha	7.89	71.51	0.30	1.85	43.26
1.5 kg/ha	9.19	83.26	0.34	2.15	50.36
2.25 kg/ha	9.76	88.36	0.37	2.29	53.46
SEm±	0.23	2.10	0.01	0.06	1.28
CD (P = 0.05)	0.67	6.07	0.03	0.16	3.69

Quality parameters

The Maximum TSS (9.76 ^{0}Brix), ascorbic acid content in curd (88.36 mg /100 g), nitrogen content (0.37%), Crude protein content in the head (2.29%) and boron content (53.46 ppm) significantly increased with the application of 2.25 kg boron per ha in soil. However, this treatment was statistically at par with 1.50 kg boron per ha (Table 3). This might be due to increased concentration of nutrient in plant under boron fertilization. Due to adequate supply of nutrients with higher dose of boron might have utilization of more nutrients as compared to lower doses resulting in increasing N, B and TSS in head of sprouting broccoli. It is established fact that nutrient uptake by the crop depends primarily on boron accumulation and secondary nutrient concentration at cellular levels. The increase photosynthetic efficiency there by more dry matter prediction and nutrient concentration in plants seems to be major factor responsible for higher NPK and B content of curd under the influence of boron application. The results obtained in the present investigation are in close conformity with the findings of Saha *et al.* (2010) [141] in broccoli.

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