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Effect of foliar spray of plant growth regulators on yield of sprouting broccoli (*Brassica oleracea* var. *italica* L.)

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Abstract
The experiment consisted of sixteen treatment combination including four NAA (control, NAA @ 80 ppm, NAA @ 120 ppm and NAA @ 180 ppm) and four GA_3 levels (control, GA_3 @ 25 ppm, GA_3 @ 50 ppm and GA_3 @ 75 ppm) were undertaken randomized block design (RBD) with three replications at Horticulture Farm S.K.N College of Agriculture, Jobner (Jaipur) during *rabi* 2018-19. The result of study clearly indicated that application of NAA @ 180 ppm to the sprouting broccoli significantly increased the weight of primary head (250.50 g), secondary head (150.90 g), diameter of head (15.30 cm), total yield per plot (6.42 kg) and total yield per hectare (198.25 q) as compared to control and found statically at par to NAA @ 120 ppm. Similarly, GA_3 significantly increased the weight of primary head (275.75 g), secondary head (151.51 g), diameter of head (14.10 cm), total yield per plot (6.44 kg) and total yield per hectare (198.64 q) as compared to control and statistically at par to GA_3 @ 50 ppm. The interaction effect of NAA @ 180 ppm and GA_3 @ 75 ppm (N_3G_3) was recorded maximum head diameter (17.74 cm), yield per plot (8.21 kg) and yield per hectare (253.25 q/ha) which was significantly higher over rest of treatment combinations but statistically at par to the treatment combination N_3G_2, N_2G_2 and N_2G_3.

Keywords: NAA, GA_3, broccoli and plant growth regulator

Introduction
Broccoli (*Brassica oleracea var. italica* L.), belongs to family Brassicaceae is a member of Cole group. The term 'Cole' originated from the word 'Colewort' meaning 'wild cabbage'. It is also known as 'green gobhi'.

Growth regulators are organic compounds can be natural and synthetic. It modified or control one or more specific physiological processes within a plant but the site of action and production are different. Among the growth regulators, auxin causes enlargement of plant cell and Gibberellins stimulates cell division, cell enlargement or both (Nickell, 1982) [9]. Gibberellic acid (GA_3) and Naphthalene acetic acid (NAA) exhibited beneficial effect in several crops (Sharma and Sardana, 2012; Thapa *et al*., 2013; Mello *et al*., 2013; Gayakvad *et al*., 2014) [12, 14, 7, 3]. Due to diversified use of productive land, it is necessary to increase the food production and growth regulators may a contributor in achieving the desired goal.

NAA is synthetic plant hormone in the auxin group and is an ingredient in many commercial plants rooting horticultural product, it is rooting agent is use for vegetative propagation of plants, from stem and leaf cutting, plant tissue culture. NAA has been shown to greatly increase cellulose fibre formation in plants when paired with another phytohormone called gibberellic acid. Because it is in the auxin group 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.

GA_3 accumulation of dry matter, minerals and carbohydrates. stimulates the cell of germinating seeds to produced mRNA molecules that code for hydrolytic enzymes. Gibberellic acid increases fresh and dries weight leaves and curd of cauliflower in association with NAA and Molybdenum (Muthoo *et. al*.1987) [8].

Material and methods

The experiment was laid out at Horticulture farm, S.K.N. College of Agriculture, Jobner, District Jaipur during *Rabi* season, 2018-19. Geographically, Jobner is situated 45 km in West of Jaipur on $26^0$5' North latitude, 75^0 20' East longitude and at an attitude of 427 meters above mean sea level. The experiment consisted of sixteen treatment combination including four NAA (control, NAA @ 80 ppm, NAA @ 120 ppm and NAA @ 180 ppm) and four GA_3 levels (control, GA_3 @ 25 ppm, GA_3 @ 50 ppm and GA_3 @ 75 ppm) were undertaken randomized block design (RBD) with three replications. The observations on various traits like weight of primary head, weight of secondary head, diameter of head, total yield per plots, total yield per hectare were recorded as per standard method.

Result and Discussion

Effect of NAA

It is revealed from the Table 1 and 2 that the maximum weight of primary head (250.55 g), maximum weight of secondary head (150.90 g), diameter of head (15.30 cm), total yield per plots (6.42 kg) and total yield per hectare (198.25 q) were recorded under N_3 treatment (180 ppm) and this treatment was also at par with N_2 treatment *i.e.* 120 ppm of NAA. The reason for this trend in the parameters related to yield attributes due to application of NAA increase in weight of curd and yield might be due to accumulation of carbohydrates owing to greater photosynthesis, higher food accumulation of carbohydrate and better plant growth because the economic part of sprouting broccoli is head. The another probable reason for increasing yield attributes might be due to the increasing growth characters by cell division, cell elongation and cell expansion that might have ultimately increased in the yield. Similar trend was also observed by Yadav *et al.* (2000) [15]; Sawant *et al.* (2010) [11] and Lendve *et al.* (2010) [5] in cabbage.

Table 1: Effect of foliar spray of plant growth regulators on weight of primary and secondary head per plant and diameter of head of sprouting broccoli

Treatment	Weight of primary head per plant (g)	Weight of Secondary head per plant (g)	Diameter of head (cm)
NAA Levels			
N_0-Control	80.20	78.50	7.50
N_1-80ppm	190.35	125.67	12.35
N_2-120ppm	240.25	145.33	13.50
N_3-180ppm	250.55	150.90	15.30
SEm±	5.61	3.18	0.14
CD (p=0.05)	16.21	9.17	0.40
GA_3 Levels			
G_0-Control	82.15	85.59	8.35
G_1-25 ppm	188.35	119.28	12.55
G_2-50 ppm	240.10	144.03	13.65
G_3-75 ppm	250.75	151.51	14.10
SEm±	5.61	3.18	0.14
CD (p=0.05)	16.21	9.17	0.40

Table 2: Effect of foliar spray of plant growth regulators on total yield of per plot and per hectare of sprouting broccoli.

Treatment	Total yield per plot (kg)	Total yield per ha (q.)
NAA Levels		
N_0-Control	2.54	78.37
N_1-80ppm	5.06	156.06
N_2-120ppm	6.17	190.41
N_3-180ppm	6.42	198.25
SEm±	0.13	3.63
CD (p=0.05)	0.38	10.49
GA_3 Levels		
G_0-Control	2.68	82.84
G_1-25 ppm	4.92	151.91
G_2-50 ppm	6.15	189.69
G_3-75 ppm	6.44	198.64
SEm±	0.13	3.63
CD (p=0.05)	0.38	10.49

Effect of GA_3

It is revealed from the table 1 and 2 that the maximum weight of primary head (250.75 g), secondary head (151.51 g), diameter of head (14.10 cm), yield per plot (6.44 kg), and per hectare (198.64 q) were recorded under treatment GA_3 @ 75 ppm and this treatment also at par with 50 ppm of GA_3. These might be due to the exogenous application of growth regulators, which enhanced and activated the enzymatic activities for various physiological process and metabolic activities *viz*. vegetative growth, photosynthetic area and leaf pigments to maximize yield of the crop. These results were in accordance with the finding of Singh and Saimbhi (1968) [13] in Chinese cabbage, Badawi and Sahhar (1978) [1], Chauhan and Singh (1970) [2], Patil *et al.* (1987) [10], Yadav *et al.* (2000) [15] and Makwana JJ (2005) [6] in cabbage and Kumar and Ray (2000) [4] reported significant effect on growth due to GA_3 in cauliflower.

Table 3: Interactive effect of NAA and GA_3 levels on diameter of head (cm).

	N_0	N_1	N_2	N_3	Mean
G_0	5.15	8.48	9.27	10.50	8.35
G_1	7.74	12.74	13.93	15.79	12.55
G_2	8.42	13.86	15.15	17.17	13.65
G_3	8.69	14.32	15.65	17.74	14.1
Mean	7.5	12.35	13.5	15.3	12.16

Table 4: Interactive effect of NAA and GA_3 levels on total yield per plot (Kg) of sprouting broccoli.

	N_0	N_1	N_2	N_3	Mean
G_0	1.41	2.69	3.25	3.38	2.61
G_1	2.47	4.93	6.02	6.27	4.92
G_2	3.06	6.16	7.53	7.84	6.14
G_3	3.21	6.45	7.88	8.21	6.43
Mean	2.53	5.05	6.17	6.42	5.02

Table 5: Interactive effect of NAA and GA_3 levels on total yield per hectare (q) of sprouting broccoli.

	N_0	N_1	N_2	N_3	Mean
G_0	43.62	83.03	100.31	104.39	82.83
G_1	76.15	152.19	185.83	193.49	151.91
G_2	94.59	190.02	232.29	241.87	189.69
G_3	99.12	198.99	243.21	253.25	198.64
Mean	78.37	156.05	190.41	198.25	155.77

Interactive effect of NAA and GA_3

The result in table 3, 4 and 5 indicated significant variation in treatments from control due to effect of GA_3 and NAA on yield and its attributes. The maximum diameter of head (17.74 cm) yield per plot (8.21 kg) and yield per hectare (253.25 q/ha) were recorded with treatment NAA @ 180 ppm and GA_3 @ 75 ppm (N_3G_3) and lowest in control N_0G_0 (5.15 cm, 1.41 kg and 43.62 q/ha respectively). This might be due to more accumulation of carbohydrate by maximum rate of photosynthesis and increasing the cell elongation, cell division and cell expansion that might be effect the increase in yield and also due to the higher accumulation of food (Thapa *et al*., 2013) [14] in broccoli.

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