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Effect of Some Plant Growth Regulators on Growth, Yield and Quality of Broccoli (*Brassica oleracea* L. var. *italica* Plenck)

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A B S T R A C T

An experiment was conducted to assess exogenous application of phytohormones on growth, yield and quality of broccoli in the lower gangetic plains of West Bengal. There was ten treatment combinations i.e. control , three levels of GA_3 (30 ppm, 60 ppm and 90 ppm), three levels of NAA (40 ppm, 80 ppm and 120 ppm) and three levels of Ethrel (50 ppm, 100 ppm and 150 ppm) applied as aqueous spray twice at 28 and 45 days after transplanting. Data was taken on nine growth and yield related parameters (i.e. plant height (cm), plant spread (cm), stem diameter (cm), number of leaves, leaf length (cm), leaf area (sqcm), head diameter (cm), fresh head weight (g), total yield (Q/ha) and three biochemical traits (i.e. total sugar content, vitamin C and vitamin A). Maximum value for the characters plant height (66.55 cm), plant spread (85.73cm), head diameter (22.77 cm), fresh head weight (480.43g), total sugar content (5.8g/100g) and total yield (237.25 q/ha) was recorded by the treatment 120 ppm NAA followed by GA_3 60 ppm which comes out as the next equally better treatment for yield and quality improvement in broccoli.

Introduction

Morphologically, Broccoli (*Brassica oleraceae* L. var. *italica*) resembles its close relative cauliflower and belongs to the same family Brassicaceae. It possesses profuse fleshy green flower heads surrounded by leaves that brings together in a tree-like fashion on branches emerging from a thick, edible stalk. It is a cool season vegetable crop which is highly nutritious among cole vegetables. Nowadays, it draws the attention of Indian modern agriculture due to its diverse use and immense nutritional value. It provides considerable amounts of nutrients such as vitamins A (567IU), C (81.2mg) and E, magnesium, selenium which are essential for human health (Munger, 1999). Sprouting broccoli has about 130 times more vitamin A than cauliflower and 22 times more than cabbage (Singh, 2007). It is the richest source of sulforaphane (SFN) compound to the range of 214µg (stem) to 499 µg (inflorescence) per gram dry weight (Olga *et al.*, 2009), which has therapeutic potential for patients with high-risk prostate cancer (Kalia, 1995) as well

as other cancers. An enormous research works have been reported on the uses of plant growth regulators in vegetable crops in recent years. However this kind of work is very scanty for non traditional vegetable crops like Broccoli. Various commercially exploited plant growth regulators like gibberellins (GA_3), auxin (NAA), cytokinin and ethrel have been found modifying the morphology and physiological processes that in the end affect the yield and quality of the crop.

In several cole crops, beneficial effect has been reported by earlier workers through application of GA_3 and kinetin (Chhonkar and Singh, 1963; Badawi and Sahhar, 1978), although these effects are very much location specific. Hence, the present investigation was conducted to find out the best suitable plant growth regulator along with it's dose for improvement in quality and yield in broccoli in the lower gangetic plains of West Bengal.

Materials and Methods

The experiment was conducted during winter season of November, 2016 to February, 2017 at the Instructional Farm of Ramkrishna Ashram Krishi Vigyan Kendra, Nimpith, South 24 Parganas, West Bengal. This consisted of ten treatment combinations i.e. control, three levels of GA_3 (30 ppm, 60 ppm, and 90 ppm), three levels of NAA (40 ppm, 80 ppm and 120 ppm), and three levels of ethrel (50 ppm, 100 ppm and 150 ppm).

Treatments were applied twice as foliar spray of synthetic plant hormones upon growing broccoli plants at 28 and 45 days after transplanting in 4m X 5m sized plots, designed in RBD with three replications. Data was recorded from five randomly selected plants from each plots at 60 days after transplanting on nine growth and yield related parameters (i.e. plant height (cm), plant spread (cm), stem diameter (cm), number of leaves, leaf length (cm), leaf area (sqcm), head diameter (cm), fresh head weight (g) and total yield (q/ha)) and three biochemical traits (i.e. total sugar content (%), Vitamin C (mg/100g), Vitamin A (IU)). Statistical analysis was done using standard formula through Microsoft excel.

Results and Discussion

Analysis of Variance was worked out for all the twelve characters under study, which has been given in Table 1. It shows that the treatments are significantly different for all the traits, which means treatments have remarkable effect on growth, yield and quality parameters of broccoli.

Plant characters: 120 ppm of NAA recorded maximum plant height (66.55 cm) and plant spread (85.73 cm) followed by GA_3 90 ppm (65.33 cm and 85.27 cm respectively). Minimum plant height was recorded with the treatment 150 ppm ethrel (61.33 cm), but in case of plant spread it was found in application of 40 ppm NAA (81.32 cm) that was statistically closer to control.

The reduced plant height due to ethrel application might be its inhibitory action on auxin transport. Ethylene is an inhibitor of cell division, cell expansion and transport of auxin, which presents expressive effects on the reduction of stem growth in length; however it provides its radial expansion and horizontal orientation (Coll *et al.*, 2001).

Maximum stem diameter was recorded with 60 ppm GA_3 (3.54 cm) followed by GA_3 90 ppm (3.42 cm) and NAA 120 ppm (3.40 cm). Lowest value of stem diameter was recorded with control (2.86 cm) followed by ethrel 150 ppm (2.88 cm). In cabbage, Chaurasiy *et al.*, (2014) [2] recorded highest stem diameter (3.05cm) with GA_3 60 ppm followed by NAA 80 ppm (2.73cm) (Fig. 1 and 2; Table 2).

Table.1 Analysis of Variance on growth, yield and quality traits of Broccoli

	df	Plant height (cm)	Plant spread (cm)	Stem diameter (cm)	Leaf length (cm)	Leaf area (sqcm)	No. of leaves per plant	Head diameter (cm)	Fresh head weight (g)	Total yield (Q/ha)	Total sugar content (g/100g)	Vitamin C (mg/100g)	Vitamin A (I.U/100g)
Replication	2	6.64	33.01	49.42	3.21	0.17	0.42	8.61	0.03	181.07	0.36	13.11	133.31
Treatment	9	76.99*	577.98*	1838.86*	37.39**	2.18*	37.81*	152.73*	0.28*	42729.23*	0.14*	321.65*	716.11 *
Error	18	4.99	32.69	100.65	1.64	0.13	1.24	6.46	0.02	181.07	0.22	4.91	71.89

*Significance at 0.05 **Significance at 0.01

Table.2 Effect of plant growth hormones on growth, yield and quality traits of Broccoli

Treatments	Plant height (cm)	Plant spread (cm)	Stem diameter (cm)	Leaf length (cm)	Leaf area (sqcm)	No. of leaves per plant	Head diameter (cm)	Fresh head weight (g)	Total yield (Q/ha)	Total sugar content (g/100g)	Vitamin C (mg/100g)	Vitamin A (I.U/100g)
T1 Control	62.78	81.21	2.86	16.02	67.91	20.97	16.37	248.33	122.63	5.23	74.27	277.48
T2 GA_3@30 ppm	64.67	83.30	3.28	18.40	77.20	23.20	19.33	338.46	168.14	4.68	74.40	279.60
T3 GA_3@60 ppm	64.33	84.22	3.54	17.43	75.13	24.30	22.04	443.33	217.93	5.31	75.70	297.90
T4 GA_3@90 ppm	65.33	85.27	3.42	17.51	72.36	23.33	20.51	414.13	201.44	5.06	74.24	293.40
T5 NAA @40 ppm	63.11	81.32	3.19	17.96	74.69	22.07	20.42	400.66	198.53	4.92	73.57	293.17
T6 NAA @80 ppm	63.77	82.77	3.31	17.83	79.53	21.53	19.39	393.75	192.44	4.65	73.87	293.16
T7 NAA @120 ppm	66.55	85.73	3.40	18.12	77.89	22.97	22.77	480.43	237.25	5.80	75.27	291.30
T8 Ethrel @50 ppm	63.11	81.53	3.16	17.78	73.87	21.30	19.33	334.09	167.98	4.97	72.77	285.93
T9 Ethrel @100 ppm	61.34	82.33	3.12	18.09	74.33	22.40	18.63	327.78	160.87	5.13	71.47	294.88
T10 Ethrel @150 ppm	61.33	82.52	2.88	17.54	72.25	22.77	17.85	323.08	159.54	5.44	68.53	289.25
SE.m (±)	1.29	1.31	0.21	0.64	1.79	0.97	0.47	9.12	15.89	0.34	1.62	4.9
CD (0.05)	3.43	3.81	0.51	1.91	3.21	2.19	1.36	26.21	31.67	0.81	3.8	14.54

Fig.1 Effect of treatment on head diameter (cm), fresh head weight (g) & total yield (g)

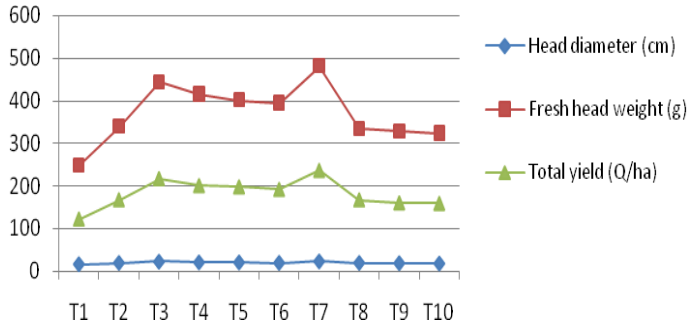
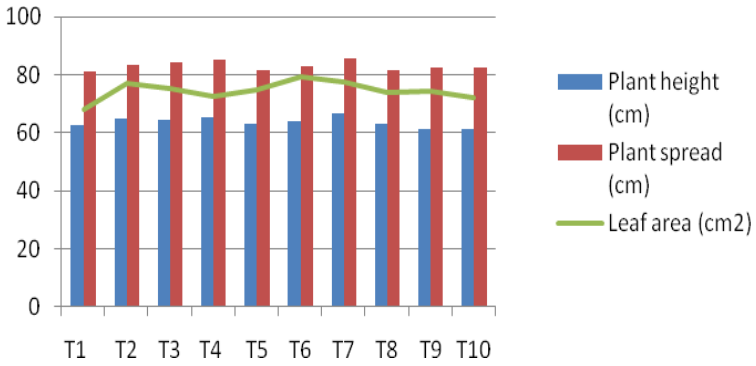


Fig.2 Effect of treatment on plant height (cm), plant spread (cm) and leaf area (sqcm)



Leaf characters: In this investigation, highest leaf length was recorded with GA_3 30 ppm (18.40 cm) followed by NAA 120 ppm (18.12 cm) and ethrel 100 ppm (18.09 cm). Whereas highest leaf area was recorded with NAA 80 ppm (79.53 sqcm) followed NAA 120 ppm (77.89 sqcm) and GA_3 30 ppm (77.20 sqcm). Leaf area is an important character having direct effect on yield. Here, each phytohormone treatment recorded significant increase in leaf area compared to control. However, earlier findings of Mir *et al.*, (2008) and Devi (2011) reported that foliar application of ethephon increased leaf area index in brassica and soybean. Khairul Mazed *et al.*, (2015) observed an increase in leaf length and width with increase in GA_3 concentration from 0 ppm (L- 32.36 cm; W- 26.39 cm) to 110 ppm (L- 34.28 cm; W- 28.56 cm) with maximum value at GA_3 90 ppm concentration (L- 36.14 cm; W- 30.46 cm).

Maximum number of leaves per plant was recorded with foliar application of 60 ppm of GA3 (24.30), which is statistically at par GA_3 90 ppm (23.33), 30 ppm (23.2) & NAA 120 ppm (22.97). Among nine treatments, minimum number of leaves was recorded with 50 ppm Ethrel (21.33) followed by NAA 80 ppm (21.53). Singh *et al.*, (2011) observed that GA_3 30 ppm in combination with kinetin 30 ppm recorded 16.00 number of leaves per plant in broccoli.

Head characters and yield: Maximum head diameter (22.77 cm) was recorded with 120 ppm NAA followed by GA_3 60 ppm (22.04

cm), both were statistically at par to each other. Khairul Mazed *et al.,* (2015) recorded maximum value for head diameter (12.90 cm) in cabbage by application of 90 ppm GA_3.

Significantly highest value for fresh head weight and total yield was recorded with NAA 120 ppm (480.43 g and 237.25 q/ha respectively) followed by GA_3 60 ppm (443.33 g and 217.93 q/ha respectively). Superior and statistically at par value for these two traits were recorded by GA_3 90 ppm (414.13 g and 201.44 q/ha respectively), NAA 40 ppm (400.66 g and 198.53 q/ha respectively) and NAA 80 ppm (393.75 g and 192.44 q/ha respectively). In cabbage, similar findings have been observed by Chaurasiy *et al.,* (2014). They recorded highest head weight (1.73 kg), head diameter (18.88 cm) and yield per hectare (51.26 t/ha) with treatment of GA_3 60 ppm followed by NAA 80 ppm and lowest in control (0.74 kg, 10.87cm and 21.93 t/ha respectively). Similarly, Roy and Nasiruddin (2011) also recorded highest head weight (3.55 kg) in cabbage from 50 ppm GA_3 followed by 75 ppm GA_3 (3.43kg). The lowest head weight (2.69 kg) was recorded by the treatment control.

Biochemical characters: NAA at 120 ppm recorded maximum total sugar content (5.80 g/100g) followed by 150 ppm ethrel (5.44 g/100g) and 60 ppm GA_3 (5.31 g/100g). Minimum value for total sugar content was recorded with 80 ppm NAA (4.65 g/100g). In case of Vitamin C content, highest value was recorded with GA_3 60 ppm (75.70 mg/100g) followed by 120 ppm NAA (75.27 mg/100g). Significantly least Vitamin C content was recorded with 150 ppm ethrel (68.53 mg/100g) followed by 100 ppm ethrel (71.47 mg/100g). However, all were statistically at-par with untreated control for both total sugar and vitamic C content.

In case of vitamin A content, 60 ppm GA_3 recorded maximum value (297.90 IU/100g) but was found to be at par with 100 ppm ethrel (294.88 I.U/100g), 90 ppm GA_3 (293.40 I.U/100g), 40 ppm NAA (293.17 I.U/100g), 80 ppm NAA (293.16 I.U/100g) and 120 ppm NAA (291.30 I.U/100g). Significant increase in beta carotene content in broccoli head was recorded by Singh *et al.,* (2011) with GA_3 40 ppm soaking treatment.

In conclusion the experiment has conclusively brought out some vital information on the influence of the plant growth regulators applied at 28 and 45 DAT on growth, yield and biochemical traits of broccoli. Among different treatments, foliar application of NAA 120 ppm proved best for increasing head yield and its contributing parameters as well as quality of head. However, GA_3 60 ppm treatment was statistically at-par with it for most of the characters including quality and yield. So, both the PGRs can be recommended for broccoli commercial cultivation with a view to yield improvement, as well as quality enhancement.

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