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Full Length Research Paper

Effect of GA_3 and kinetin on growth, yield and quality of sprouting broccoli (*BRASSICA OLERACEA* var. italica)

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A field experiment was carried out during the winter season of 2009 to 2010 on sprouting broccoli cultivar Palam Samridhi at Horticultural Research Centre and Department of Horticulture, H.N.B Garhwal University, Srinagar (Garhwal) Uttarakhand, India. 4 weeks old seedlings were treated before transplanting by dipping their roots for 24 h in different concentration of GA_3 (gibberellic acid), kinetin and their combinations solutions. The GA_3, kinetin and their combination significantly influenced the growth performance, yield and quality characters of sprouting broccoli. GA_3 30 mg L^{-1} + kinetin 30 mg L^{-1} treatment gave maximum growth and yield of sprouting broccoli whereas, highest vitamin A content found with 40 mg L^{-1} GA_3 and vitamin C was found maximum in GA_3 20 mg L^{-1} + kinetin 20 mg L^{-1} dipping.

Key words: Gibberellic acid, kinetin, *Brassica oleracea var. italica*, quality, yield.

INTRODUCTION

Sprouting Broccoli *(Brassica oleracea* var. italica) is an important winter season vegetable crop, which resembles cauliflower. Broccoli is a member of the *Brassicaceae* family as a wild form of this family, which is found along the Mediterranean region (Decoteau, 2000). Broccoli is an Italian vegetable, native to the Mediterranean region, cultivated in Italy in ancient roman times and about 1720 in England. On the other hand, in the USA, it first appeared in 1806, but its commercial cultivation was started around 1923 (Decoteau, 2000). However, due to increase in its popularity, there is a trend to increase cultivation by farmers, as well as consumption by consumers. Broccoli is an important vegetable crop and has high nutritional and good commercial value (Yoldas et al., 2008). It is low in sodium food, fat free and calories, high in vitamin C and good source of vitamin A, vitamin B_2 and calcium (Decoteau, 2000). According to Brown and Hutchison (1949), it contains 137 mg vitamin C and 9000 IU vitamin A. Sprouting broccoli has about 130 times more vitamin A contents then cauliflower and 22 times more than cabbage (Singh, 2007). Nowadays, broccoli attracted more attention due to its multifarious use and great nutritional value (Salunkhe and Kadam, 1998; Talalay and Fahey, 2001; Rangkadilok et al., 2002, 2004). The plants form a kind of head consisting of green buds and thick fleshy flower stalk. The terminal head rather loose, green in color and the flower stalks are longer than cauliflower (Bose et al., 2002). The sprouts in the axils develop strongly specially after removal of terminal head. Both the terminal head and sprouts with buds are consumed by human as food. Broccoli is usually boiled or steamed, but may be eaten raw and has become popular as a raw vegetable in trays. It is also a rich source of sulphoraphane, a compound associated with reducing the risk of cancer (Singh, 2007).

In recent years a great deal of research work has been reported on the uses of plant growth regulators in vegetable crops. Plant growth regulators modify the physiological processes within the plant, which ultimately affect the yield and quality of the crop. Among, plant growth regulators, GA_3 and kinetin exhibited beneficial effect in several cole crops (Chhonkar and Singh, 1963; Badawi and Sahhar, 1978). So, to evaluate the response of GA_3, kinetin and their combinations on yield and quality improvement of sprouting broccoli is taken and conducted.

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Table 1. Effect of GA_3 and kinetin on growth characters of sprouting broccoli.

Treatment	Plant height (cm)	No. of leaves	Days to central head formation	Days to secondary head formation	Plant frame (cm^2)	No. of secondary head	Head size (cm^3)	Harvest duration (days)
20 mg L^{-1}	60.73	13.73	61.40	70.93	75.85	10.40	1306.65	7.53
GA_3 40 mg L^{-1}	63.07	13.47	61.53	71.33	72.66	10.00	1369.48	7.90
GA_3 60 mg L^{-1}	60.93	14.53	57.86	66.20	79.63	8.53	1496.47	7.66
GA_3 80 mg L^{-1}	60.27	14.87	61.53	70.60	79.61	9.80	1199.60	8.56
GA_3 100 mg L^{-1}	58.37	14.80	60.40	70.00	72.70	8.80	1179.66	8.33
kinetin 20 mg L^{-1}	55.40	14.80	59.86	69.60	73.53	8.73	1356.81	8.33
kinetin 40 mg L^{-1}	61.47	15.67	59.87	69.93	76.72	10.13	1412.67	8.47
kinetin 60 mg L^{-1}	60.80	14.53	60.40	71.86	76.13	10.20	1509.20	7.54
kinetin 80 mg L^{-1}	57.93	15.40	61.66	71.90	77.43	9.67	1001.55	8.33
kinetin 100 mg L^{-1}	59.67	14.07	61.20	71.60	75.15	8.27	991.70	8.03
GA_3 10 mg L^{-1} + kinetin 10mg L^{-1}	59.67	15.33	58.86	69.60	75.46	9.20	1272.16	8.30
GA_3 20 mg L^{-1} + kinetin 20mg L^{-1}	57.83	15.20	61.13	71.53	75.47	7.93	1518.83	8.33
GA_3 30 mg L^{-1} + kinetin 30 mg L^{-1}	63.77	16.00	60.73	70.06	78.67	9.07	1542.66	8.43
GA_3 40 mg L^{-1} + kinetin 40 mg L^{-1}	58.47	13.60	61.86	71.26	78.66	9.00	1109.53	8.30
GA_3 50 mg L^{-1} + kinetin 50 mg L^{-1}	56.23	15.20	61.53	70.86	71.23	9.20	1119.25	7.60
control	58.27	13.33	63.60	74.53	67.23	8.60	884.64	8.01
S.Em.+	1.76	0.69	0.90	1.01	4.14	0.46	166.79	0.60
C.D at 5%	5.09	2.01	2.62	2.94	11.96	1.35	481.70	1.75

MATERIALS AND METHODS

The experiment was conducted during the winter season of 2009 to 2010 at the Horticultural Research Centre of H N B Garhwal University, Srinagar (Garhwal), Uttarakhand, India situated in the Alaknanda valley (78° 47' 30" E longitude and 30° 13' 0" N latitude and at an elevation of 540 m above msl), a semi-arid, sub-tropical climate with dry summer and rigorous winters with occasional dense fog in the morning hours from mid December to mid February. The experiment was laid out in randomized block design (RBD) with three replications and 16 treatments. The seedling treatments comprised of five different concentrations of GA_3 that is, 20, 40, 60, 80 and 100 mg L^{-1}, kinetin that is, 20, 40, 60, 80 and 100 mg L^{-1} and their combination at 10, 20, 30, 40 and 50 mg L^{-1} by dipping the seedling roots for 24 h in solutions of the aforementioned growth regulators before transplanting in field. For the control seedlings were dipped in distilled water. The treated healthy seedlings were planted in beds supplied with FYM 20 tones, nitrogen 80 kg, phosphorus and potash each of 100 kg/ha at a distance of 60 × 45 cm. During whole period of experiment, uniform cultural practices were adopted. Average number of leaves per plant was counted by taken plants from each treatment after two months of transplantation. The number of days taken from the transplanting to the day when first central head appeared is used as days to central head formation. Heads with stems were cut to 15 cm long (Decoteau, 2000) and the yield and its components were calculated and expressed on per hectare basis using electronic top loading balance.

The vitamin C content was determined by titration of sample against 2,6-dichlorophenol-indophenol and vitamin A content was estimated by the method given by Ranganna (2004). Data were subjected to analysis of variance (ANOVA) given by Cochran and Cox (1992).

RESULTS AND DISCUSSION

Growth characters

Growth is function of various vegetative characters put together namely, height of plant, number of leaves, plant spread, no of secondary head, days to central head formation, days to secondary head formation, head size and harvest duration. The different growth parameters were significantly affected by dipping the roots of seedlings in different growth regulators solution before transplanting (Table 1). GA_3 30 mg L^{-1} + kinetin 30 mg L^{-1} treatment had maximum influence over other treatments with respect to plant height (63.77 cm), number of leaves (16.00) and head

Table 2. Effect of GA_3 and kinetin on yield and quality characters of sprouting broccoli.

Treatment	Central head yield plant^{-1} (gm)	Secondary head yield plant^{-1} (gm)	Central head yield plot^{-1} (Kg)	Secondary head yield plot^{-1} (Kg)	Total yield hectare^{-1} (q)	Vit. A content (I.U/100 g)	Vit. C content (mg/100 g)
GA_3 20 mg L^{-1}	397.00	426.67	4.58	5.62	169.80	5460.71	78.80
GA_3 40 mg L^{-1}	461.67	376.67	5.09	5.43	175.29	5995.75	65.89
GA_3 60 mg L^{-1}	482.33	428.33	5.28	5.29	176.11	3214.62	71.14
GA_3 80 mg L^{-1}	430.67	410.00	4.52	5.52	167.33	3289.08	72.23
GA_3 100 mg L^{-1}	398.33	421.66	4.61	5.43	167.38	4660.91	70.75
kinetin 20 mg L^{-1}	396.33	460.00	4.07	5.76	163.88	5386.22	81.02
kinetin 40 mg L^{-1}	480.33	453.33	4.60	5.89	174.94	4461.94	82.48
kinetin 60 mg L^{-1}	433.33	493.33	4.94	6.16	185.16	4655.21	86.43
kinetin 80 mg L^{-1}	367.33	441.67	4.67	5.97	177.48	4553.35	77.13
kinetin 100 mg L^{-1}	322.33	285.00	3.45	5.31	145.74	3698.49	79.40
GA_3 10 mg L^{-1}+ kinetin 10mg L^{-1}	330.00	451.67	4.86	5.37	170.58	4914.64	114.33
GA_3 20 mg L^{-1}+ kinetin 20mg L^{-1}	471.67	390.00	5.19	6.03	187.05	5278.69	117.59
GA_3 30 mg L^{-1} + kinetin 30 mg L^{-1}	511.67	415.00	5.35	6.02	189.67	3695.63	103.63
GA_3 40 mg L^{-1} + kinetin 40 mg L^{-1}	318.33	381.67	4.34	5.64	166.37	4346.51	112.01
GA_3 50 mg L^{-1} + kinetin 50 mg L^{-1}	340.00	295.00	3.56	5.97	158.89	5110.45	103.87
Control	278.67	270.00	4.13	4.58	145.15	2289.08	60.94
S.E.m.+	53.07	39.22	0.60	0.46	14.52	77.2196	1.08
C.D at 5%	153.29	113.28	1.73	1.34	42.24	223.017	3.12

GA_3 – gibberellic acid mg L^{-1} – milligram per litre, cm-centimeter, cm^2- square centimeter, cm^3-centimeter cube, gm-gram, Kg-kilogram, q-quintal, Vit. A- vitamin A, Vit. C- vitamin C, I.U.- international unit, mg-milligram, S.E.m-standard error of mean, C.D.- critical difference.

size (1542.66 cm^3). Similar result were found by Gonzalez et al. (2007), Lone et al. (2005), Khan et al. (2002) and Kumar and Ray (2000) in both GA_3 and kinetin. So might be due to combination of both regulators. GA_3 60 mg L^{-1} treatment proves to be most effective among all the treatments and required minimum days to central head formation (57.86 days) and secondary head formation (66.20 days). This is in agreement with the result obtained by Patil et al. (1987) and Chhonkar and Singh (1963). Further, GA_3 60 mg L^{-1} concentration was found effective in increasing the plant frame significantly then other treatments. Similar results have been reported by Kumar et al. (1996). The plant growth regulators increased the plant height and number of leaves per plant. As a result of this there was an increase in plant spread. Number of secondary heads per plant found maximum in GA_3 20 mg L^{-1} treatment. Singh and Lal (2001) found same findings. GA_3 80 mg L^{-1} treatment taken longest duration of harvest between central head to secondary heads harvesting. The possible reason for increase in plant frame, number of secondary heads per plant and harvest duration of sprouting broccoli plants may be due the gibberllic acid, which promotes vegetative growth by way of cell elongation and cell division.

Yield and yield attributes

It is evident from Table 2 that GA_3, Kinetin and their combination increased the central and secondary heads and yield as compared to control. Combination treatment GA_3 30 mg L^{-1} + kinetin 30 mg L^{-1} produced central head of 511.67 gm and kinetin 60 mg L^{-1} produced secondary heads of 493.33 gm per plant, which was

statically maximum to all the treatments. The treatment of GA_3 30 mg L^{-1} + kinetin 30 mg L^{-1} produced the maximum yield of 189.67 q ha^{-1}, while the lowest yield of 145.15 q ha^{-1} was found in absolute control. The effects of gibberellic acid on broccoli was studied by Wang and Yang (2008) and reported that inflorescence differentiation and curd yield was increased, but the vitamin C of curd was decreased or varied disobviously. Similarly, Wang et al. (2009) also studied effect of different concentration of cytokinin on broccoli and found that it increases ball-flower yield and plants economic coefficient, but weakened ball-flower quality. In present investigation, the combination of GA_3 and kinetin gives the best performance in terms of yield and quality. Similar results were reported by Chauhan and Bordia (1971), Arora et al. (1989), Chhonkar and Singh (1963) and Chauhan and Tandel (2009). The combination of both regulators gives best result in yield. The increasing central head weight and secondary heads weight by GA_3 and kinetin treatments might be due to the rapid and better nutrient translocation from roots to aerial parts of the plant. Both the regulators play important role such as gibberllic acid help in cell elongation, fruit growth, tissue growth and development and kinetin mainly done incitation of cell division, delay of senesce and cell enlargement etc. So, that the combinations showing the best result.

Quality attributes

The data presented in Table 2 indicate that the plant growth regulator treatments significantly increased the vitamin A and C content of sprouting broccoli. Significant increase in beta carotien content of the head was recorded with GA_3 40 mg L^{-1} soaking treatment which is significantly higher among all the treatments and followed by GA_3 20 mg L^{-1}. Whereas, ascorbic content significantly increased by soaking in combination GA_3 20 mg L^{-1}+ kinetin 20 mg L^{-1}, then other treatments. Chauhan and Tandel (2009) reported that application of GA_3 increased the ascorbic content in cabbage. Khalili et al. (2008) found that kinetin also affect vitamin C content in broccoli. The increased vegetative growth influence other characters might have promoted the metabolic activities of the plants due to application of plant growth regulators such as GA_3, kinetin and their combinations and increased the vitamin A and C content of the broccoli heads, which is ultimately improvement in quality of sprouting broccoli heads.

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