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EFFECT OF GA_3 AND NAA ON GROWTH AND YIELD OF CABBAGE

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Abstract

A field experiment was conducted at the Plant Physiology Field of Horticulture Research Center (HRC), Bangladesh Agricultural Research Institute, Gazipur during the r*abi* seasons of 2015-16 and 2016-17 to study the response of cabbage (var. Krishibid Hybrid-1 and Atlas-70) to foliar application of GA_3 and NAA with different concentrations. The experiment was laid out in a Randomized Complete block Design with three replications. The experiment consisted of eight treatments viz., three levels of GA_3 (at 50, 75 and 100 ppm) and four levels of NAA (at 40, 60, 80 and 100 ppm) along with distilled water as control. The varieties Krishibid Hybrid-1 and Atlas-70 were used in 2015-16 and 2016-17, respectively. Foliar spray of GA_3 and NAA was given at 25 and 45 days after transplanting of seedling. The results of the investigation indicated significant differences among the treatments on most of the parameters studied. In Krishibid Hybrid-1, application of 50 ppm GA_3 and 60 ppm NAA increased plant height, plant spread, number of leaves, chlorophyll content, head height, head diameter, single head weight without unfolded leaves as well as head yield (81.18 t/ha for 50 ppm GA_3 and 78.57 t/ha for 60 ppm NAA) than the control (67.29 t/ha) and other treatments. But, in Atlas-70, application of 75 ppm GA_3 gave the maximum values of most of the growth parameters, yield components and yield (102.40 t/ha), which was followed by 50 ppm GA_3 (94.96 t/ha). In Krishibid Hybrid-1, application of 60 ppm NAA gave the highest benefit-cost ratio (BCR) of 3.63 followed by 75 ppm GA_3 (3.59) while in Atlas-70, 75 ppm GA_3 recorded the highest BCR of 4.79 followed by 50 ppm GA_3 (4.54) and 60 ppm NAA (4.37). Therefore, application of GA_3 @ 50-75 ppm or NAA @ 60 ppm concentration can be recommended for increasing the yield of cabbage with higher return.

Keywords: Gibberellic Acid, Naphthalene Acetic Acid, Cabbage, Head yield, BCR.

Introduction

Cabbage (*Brassica oleracea* var. c*apitata* L.) locally known as ‘badhacopy‘ is an important leafy vegetables grown in winter season throughout Bangladesh. It is a member of the family Brassicaceae (or Cruciferae). It is a herbaceous, biennial,

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dicotyledonous flowering plant distinguished by a short stem upon which is crowded mass of leaves, usually green but in some varieties red or purplish, which while immature form a characteristic compact, globular cluster known as *cabbage head*. The head is used as salad, boiled vegetable, cooked in curries, used in pickling as well as dehydrated vegetable. Cabbage head is an excellent source of many nutrients especially vitamin C, vit. B_6, vit. K, folate, biotin, calcium, magnesium, potassium and manganese. It also contains significant amounts of glutamine, an amino acid that has anti-ulcer properties. Cabbage is a source of indole-3-carbinol, a chemical which boosts DNA repair in cells and appears to block the growth of cancer cells. The taste in cabbage is due to the "Sinigrin glucoside" (Singh *et al*., 2004).

There is a necessity of boosting up vegetable production to increase the per capita per day intake of vegetables in Bangladesh. Application of plant growth regulator is one of the best means for the increased vegetable production. Now-a- days, plant growth regulators have been tried to improve growth and ultimately yield. Growth regulators are organic compounds other than nutrients; small amounts of which are capable of modifying growth. Among the growth regulators, auxin causes enlargement of plant cell and gibberellins stimulates cell division, cell enlargement or both (Nickell, 1982). Gibberellic acid (GA_3) and Napthalene acetic acid (NAA) exhibited beneficial effect in several crops (Thapa *et al*., 2013; Mello *et al*, 2013; and Roy and Nasiruddin, 2011). Due to diversified use of productive land, it is necessary to increase food production and growth regulators may be a contributor in achieving the desired goal. Cabbage was found to show a quick growth, increase number of leaves/plant and higher yield when treated with plant growth regulator especially GA_3 and NAA (Dhengle *et al*., 2008; Yadav *et al*., 2000; Kumar *et al*., 1996). A very little research work has been done on this aspect in Bangladesh. Therefore, the present investigation was undertaken to find out the appropriate concentration of GA_3 and NAA for better growth and yield of cabbage.

Materials and Methods

The experiment was conducted at the field of plant physiology section of HRC during the *rabi* seasons of 2015-16 and 2016-17. The experiment was laid out in a Randomized Complete Block Design with 3 replications. Eight growth regulator treatments viz., T_0 = Distilled water (control), T_1 = GA_3 @ 50 ppm, T_2 = GA_3 @ 75 ppm, T_3 = GA_3 @ 100 ppm, T_4 = NAA_3 @ 40 ppm, T_5 = NAA @ 60 ppm, T_6 = NAA @ 80 ppm and T_7 = NAA @ 100 ppm were included in this study. The test varieties were Krishibid Hybrid-1 (V_1) and Atlas-70 (V_2); the former was used in 2015-16 but the latter was used in 2016-17. Twenty eight day-old seedlings were transplanted on 20 December, 2015 at 60 cm x 40 cm spacing. But the twenty seven days old seedlings were transplanted on 22 December, 2016 at 60 cm x 50 cm spacing. In 2015-16 and 2016-17, the unit plot size was 2.40 m x 1.20 m (2.88 m^2 and 2.00 m x 1.80 m (3.60 m^2), respectively.

The seedlings were watered immediately after transplanting. Gap filling was done as and when required. Gibberellic acid (GA_3) and Naphthalene acetic acid (NAA) belong to the company Merck KGaH, Germany. The growth regulators were sprayed at 25 and 45 days after transplanting. Control plants were sprayed with distilled water. The land was fertilized with 5.00 t/ha cowdung + 140 - 40 - 125- 30- 1.4- 5.00 -2.00 kg/ha of N-P-K-S-B-Zn-Mg (Anon., 2006). The sources of N, P, K, S, B, Zn and Mg were urea, TSP, MoP, gypsum, boric acid (medicated), zinc sulphate and magnesium sulphate. The total amount of cowdung, P, S, B, Zn, Mg and one-third of each N and K were applied during land preparation. The rest of N and K were applied in two equal installments at 20 and 35 days after transplanting (DAT). Weeding was done as when necessary. A total of four irrigations were given to the crop. Head harvest of the variety Krishibid Hybrid-1 was done on 26 February 2016 to 03 March, 2016. But head harvest of the variety Atlas-70 was done on 28 February 2017 to 08 March, 2017. The data on plant height, plant spread, number of unfolded leaves, folded leaves and total leaves/plant, head height, head diameter, head diameter, head compactness, single head weight with unfolded leave, single head weight without unfolded leaves and head yield/plot were recorded at harvest. Chlorophyll content index (CCI) (taken by Chlorophyll Content Meter (Model:CCM-200, Opti-sciences, USA) was recorded at 55 days after transplanting (DAP). Head yield/plot was converted per hectare yield. Head compactness was measured in Newton (N) using Fruit texture Analyzer (GUSS, Model No. GS 25, SA). The MSTAT-C computer package was used to analyze the data. Mean separation was done by Tukey's W Test at 5% level of probability.

Results and Discussion

Effect of GA_3 and NAA on the growth parameters of cabbage

The maximum plant height was recorded in the variety Krishibid Hybrid-1 from GA_3 at 50 ppm (26.40 cm) which was statistically similar to NAA at 60 ppm (24.96 cm), GA_3 at 75 ppm (24.82 cm), and NAA at 80 ppm (24.03 cm), but in Atlas-70 the maximum plant height was recorded from GA_3 at 75 ppm (23.30 cm) which was statistically similar to NAA at 60 ppm (22.78 cm), GA_3 at 50 ppm (22.50 cm), GA_3 at 100 ppm (22.23 cm) and NAA at 80 ppm (21.93 cm) (Table 1). The control treatment gave the lowest plant height (18.48 cm in Krishibid Hybrid-1 and 17.25 cm in Atlas-70). Application of 60 ppm NAA gave the maximum plant spread (65.12 cm) which was statistically similar to GA_3 at 50 (64.90 cm) and 75 ppm (61.41 cm), NAA at 40 ppm (63.19 cm) and NAA at 80 ppm (62.51 cm) in Krishibid Hybrid-1, but, in Atlas-70 , application of GA_3 at 75 ppm produced the maximum plant spread (57.80 cm) which was identical to NAA at 60 ppm (56.92 cm). In both the varieties, the minimum plant spread was recorded in control treatment. These are in agreement with Moyazzama (2008), Chaurasiy *et al.* (2014), Mazed *et al.* (2015), Paul (2011) and Afrin (2013) who found maximum plant height and plant spread from the spray of GA_3 @ 85, 60, 90, 90 and 70 ppm. Roy and Nasiruddin (2011) obtained the highest plant height from GA_3 at 75 ppm being identical with GA_3 at 50 ppm. But Islam *et al.* (2017) reported the highest plant height from the application of GA_3 at 120 ppm to the late planting (on 10 December, 2016) cabbage. Chaurasiy *et al.* (2014) recorded maximum plant height from 80 ppm NAA among 40, 80 and 120 ppm NAA.

Table 1. Effect of GA_3 and NAA on the growth of cabbage

Treat.	Plant height (cm)		Plant spread (cm)		*Days to head initiation		*Days to head maturity	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
T_0	18.48d	17.25c	54.95d	46.81d	46.27a	40.25	76.76a	79.46a
T_1	26.40a	22.50ab	64.90ab	54.46bc	38.59b	35.20	69.72cd	72.22c
T_2	24.82abc	23.30a	61.41abc	57.80a	39.09b	35.42	73.95abc	70.42c
T_3	22.83bc	22.23abc	56.50cd	54.40bc	40.61ab	35.65	75.12ab	72.62c
T_4	23.10bc	20.60c	63.19ab	53.34c	40.78ab	36.70	69.11d	74.64bc
T_5	24.96ab	22.78a	65.12a	56.92ab	40.72ab	35.35	69.75cd	70.45c
T_6	24.03abc	21.93abc	62.51ab	53.30c	41.82ab	36.82	70.40bcd	73.82bc
T_7	21.78c	20.98bc	59.38bcd	53.85bc	42.62ab	36.90	75.00ab	77.25ab
CV (%)	4.55	4.82	3.19	3.11	4.94	5.18	2.28	3.99

Table 1.cont'd

Treatment	Unfolded leaves/plant (no.)		Folded leaves/plant (no.)		Total leaves/plant (no.)	
	V_1	V_2	V_1	V_2	V_1	V_2
T_0	13.23d	11.17d	34.09e	37.33d	47.09c	48.60f
T_1	16.46a	13.40ab	40.89a	45.73bc	57.35a	59.13bc
T_2	15.60bc	13.60a	38.79bc	48.73a	54.39ab	62.33a
T_3	15.54bc	12.60bc	34.92e	45.60bc	50.46bc	58.20bcd
T_4	15.41bc	11.93cd	36.98d	43.53c	52.39ab	55.47e
T_5	15.86b	13.47ab	40.44ab	46.67ab	56.30a	60.13ab
T_6	15.26c	12.40c	38.25cd	43.83c	53.51ab	56.23de
T_7	15.18c	12.20cd	35.18e	44.67bc	50.36ab	56.87cde
CV (%)	4.30	4.19	3.61	4.00	3.31	3.62

Means with uncommon letters in a column are significantly different at 5% level by Tukey's W test.

T_0 = Control, T_1 = GA_3 at 50 ppm, T_2 = GA_3 at 75 ppm, T_3 = GA_3 at 100 ppm, T_4 = NAA at 40 ppm, T_5 = NAA at 60 ppm, T_6 = NAA at 80 ppm, T_7= NAA at 100 ppm

'*' indicates days after transplanting

V_1 = Krishibid Hybrid -1; V_2 = Atlas-70

The control treatment took maximum time (46.27 days) for head initiation of Krishibid Hybrid-1, which was statistically similar to all treatments except GA_3 at 50 and 75 ppm. Application of GA_3 at 50 ppm initiated head formation with minimum time (38.59 days). But in Atlas-70, days to head initiation was not significantly influenced by growth regulator treatments; however, the lowest time was required to head initiation for the plants treated with 50 ppm GA_3 (35.20 days) followed by 75 ppm GA_3 (35.42 days). The control treatment took the maximum time (76.76 days) for head maturity of Krishibid Hybrid-1; while NAA at 40 ppm took minimum time (69.11 days) for head maturity of the same variety. In Atlas-70, the maximum time (76.76 days) was required for head maturity of the plants that were not treated with PGR and the minimum time required for head maturity of the plants that was treated with 50 ppm GA_3 (70.42 days) closely followed by 75 ppm GA_3 (70.42 days) and 60 ppm NAA (70.45 days). These corroborate the results of Roy and Nasiruddin (2011), Chaurasiy *et al.* (2014), Afrin (2013) and Lina (2015) who recorded minimum time to head formation and head maturity from 50, 60, 70 and 95 ppm GA_3, respectively.

The maximum unfolded leaves/plant was obtained from Krishibid hybrid-1 when treated with 50 ppm GA_3 (16.46) followed by 60 ppm NAA (15.86) and the lowest from control (13.23). In the variety Atlas-70, GA_3 at 75 ppm produced the highest number of unfolded leaves (13.60), which was identical to GA_3 at 50 ppm (13.40) and NAA at 60 ppm (13.47).

This is in line with the results of Roy and Nasiruddin (2011), Chaurasiy *et al.* (2014), Mazed *et al.* (2015), Afrin (2013), Lina (2015) and Islam *et al.* (2017) who obtained maximum number of unfolded leaves/plant from 50, 60, 90, 90, 115 and 120 ppm GA_3, respectively. Application of GA_3 at 50 ppm gave the maximum folded leaves/plant (40.89) in Krishibid Hybrid-1 which was identical with NAA at 60 ppm (40.44). In Atlas-70, maximum number of folded leaves/plant was recorded from GA_3 at 75 ppm (48.73) which was statistically similar to NAA at 60 ppm (46.67). In both the varieties, the control treatment gave the lowest number of unfolded leaves. Similar result was also found by Roy and Nasiruddin (2011) who found that GA_3 at 50 ppm produced the highest number of folded leaves/plant. In Krishibid Hybrid-1, application of GA_3 at 50 ppm produced the highest number of total leaves/plant (57.35 and) which was identical with GA_3 at 75 ppm, (54.39) and NAA at 60 ppm (56.30), NAA at 40 ppm (52.39), NAA at 80 ppm (53.51) and NAA at 100 ppm (50.36). But in Alas-70, the highest number of total leaves/plant (62.33) was recorded from GA_3 at 75 ppm (62.33) which was statistically similar to NAA at 60 ppm (60.13). The superiority in growth parameters of different treatments over control might be due to foliar application of GA_3 and NAA, as they have physiological effects on growth parameters of plants. The suppressive action of GA_3 and NAA on apical meristem and interference with gibberellin synthesis might be resulted in cell elongation and cell division, increase in photosynthesis activity, better food accumulation and the early head formation and maturity. The fall in endogenous gibberellin levels in control might be responsible for delayed head initiation and head maturity.

Effect of GA_3 and NAA on chlorophyll content index (CCI) of cabbage leaf

In both the varieties all growth regulator treatments produced higher chlorophyll content index (CCI) over control (Fig. 1). In Krishibid Hybrid-1, application of

NAA at 60 ppm gave the maximum CCI (64.65) which was statistically similar to GA_3 at 50 ppm (63.28); whereas, in Atlas -70, GA_3 at 75 ppm produced the maximum CCI (58.80) which was statistically similar to NAA at 60 ppm (58.70) and GA_3 at 50 ppm (58.60). The control treatment gave the lowest CCI (45.57 in Krishibid Hybrid-1 and 51.60 in Atlas-70) in both the varieties. CCI in growth regulator treated plants might be increased due to creation of available environment for chlorophyll synthesis by application of GA_3 and NAA.

Table 2. Effect of GA_3 and NAA on yield components and yield of cabbage

Treatment	Head height (cm)		Head diameter (cm)		Head compactness (N)	
	V_1	V_2	V_1	V_2	V_1	V_2
T_0	12.37 b	11.97c	17.91 b	17.60c	9.09	9.00
T_1	14.50 a	13.97ab	23.76 a	21.69ab	8.89	9.50
T_2	13.64 ab	14.23a	22.90 a	22.60a	8.65	9.63
T_3	13.09 ab	13.53ab	21.53 ab	21.80ab	8.82	9.60
T_4	14.22 a	13.00bc	21.49 ab	20.34b	8.92	9.52
T_5	14.26 a	13.90ab	23.64 a	22.42ab	8.99	9.45
T_6	13.96 a	13.47ab	22.69 ab	21.09ab	9.05	9.48
T_7	13.54 ab	13.43ab	21.02 ab	20.70ab	8.97	9.52
CV (%)	3.76	4.77	7.72	3.65	5.90	4.19

Table 2.cont'd.

Treatment	Single head weight with unfolded leaves (kg)		Single head weight without unfolded leaves (kg)		Head yield (t/ha)		% Head yield increase over control	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
T_0	2.08 c	2.92c	1.70 de	2.28e	67.29 d	72.32e	-	-
T_1	2.74 a	3.79ab	2.22 a	2.97b	81.18 a	94.96ab	17.11	23.84
T_2	2.33 b	4.13a	1.95 bc	3.23a	75.28 abc	102.40a	10.61	29.38
T_3	2.10 c	3.41bcd	1.75 de	2.53cd	67.57 d	80.34cd	0.41	9.98
T_4	2.64 a	3.18de	1.60 e	2.39de	75.24 abc	75.73de	10.57	4.50
T_5	2.70 a	3.58bc	2.03 b	2.75bc	78.57 ab	87.26bc	14.36	17.12
T_6	2.43 b	3.38cd	1.87 bcd	2.67c	72.20 bcd	84.61c	6.80	14.53
T_7	2.38 b	3.26cde	1.78 cd	2.57cd	68.71 cd	81.54cd	2.07	11.31
CV (%)	3.47	3.88	3.58	3.16	4.30	7.25	-	-

Means with uncommon letters in a column are significantly different at 5% level by Tukey's W test.

T_0 = Control, T_1 = GA_3 at 50 ppm, T_2 = GA_3 at 75 ppm, T_3 = GA_3 at 100 ppm, T_4 = NAA at 40 ppm, T_5 = NAA at 60 ppm, T_6 = NAA at 80 ppm, T_7= NAA at 100 ppm

V_1 = Krishibid Hybrid -1; V_2 = Atlas-70

Table 3. Partial cost benefit analysis of cabbage production by the application of GA_3 and NAA

Treatments	Head yield (t/ha)		Gross return ('000 Tk./ha)		Cost of treatment ('000 Tk./ha)	Total cost of cultivation ('000 Tk./ha)	Net return ('000 Tk./ha)		Benefit-cost ratio (BCR)	
	V_1	V_2	V_1	V_2			V_1	V_2	V_1	V_2
T_0	67.29	72.32	403.74	470.08	0.00	125.40	278.34	344.68	3.22	3.75
T_1	81.18	94.96	487.08	617.24	6.25	135.85	351.23	481.39	3.59	4.54
T_2	75.28	102.40	451.68	665.60	9.37	138.97	312.71	526.63	3.25	4.79
T_3	67.57	80.34	405.42	522.21	12.50	142.10	263.32	380.11	2.85	3.67
T_4	75.24	75.73	451.44	492.25	0.22	129.82	321.62	362.43	3.48	3.79
T_5	78.57	87.26	471.42	567.19	0.33	129.93	341.49	437.26	3.63	4.37
T_6	72.20	84.61	433.2	549.97	0.44	130.04	303.16	419.93	3.33	4.23
T_7	68.71	81.54	412.26	530.01	0.55	130.15	282.11	399.86	3.17	4.07

T_0 = Control, T_1 = GA_3 at 50 ppm, T_2 = GA_3 at 75 ppm, T_3 = GA_3 at 100 ppm, T_4 = NAA at 40 ppm, T_5 = NAA at 60 ppm, T_6 = NAA at 80 ppm, T_7 = NAA at 100 ppm; V_1 = Krishibid Hybrid-1, V_2 = Atlas-70

Basic cost of cultivation: 125.40 thousand Tk./ha

Cost of PGRs::

1. Gibberellic acid (GA_3): Tk. 500.00/g
2. Naphthalelene Acetic Acid (NAA): Tk. 2200.00/100 g

Market selling price of head:

1. Tk. 6.00/kg (Tk. 6000.00/ton) in 2016
2. Tk. 6.50/kg (Tk. 6500.00/ton) in 2017

Effect of GA_3 and NAA on yield components and yield of cabbage

Application of GA_3 and NAA had significant effect on most of the yield components and yield of cabbage except head compactness (Table 2). All hormonal treatments gave higher head height and head diameter than control. The maximum head height (14.50 cm) and head diameter (23.76 cm) of Krishibid Hybrid-1 were recorded with GA_3 at 50 ppm, which was statistically similar to all other treatments except control. But the maximum head height was recorded in Atlas-70 with GA_3 at 75 ppm (14.23 cm) which was statistically similar to GA_3 at 50 ppm (13.97 cm) and NAA at 60 ppm (13.90 cm). The highest head diameter was recorded with GA_3 at 75 ppm (22.60 cm) in Atlas-70 followed by NAA at 60 ppm (22.42 cm) and GA_3 at 50 ppm (21.69 cm). In Krisibid Hybrid-1, the maximum single head weight with unfolded leaves was obtained from GA_3 at 50 ppm (2.74 kg) closely followed by NAA 60 ppm (2.70 kg) and NAA 40 ppm (2.64 kg); whereas, the highest head weight with unfolded leaves was recorded in Atlas-70 from 75 ppm GA_3 (4.13 kg) which was statistically similar to 50 ppm GA_3 (3.79 kg) and its minimum value was found in control (2.08 kg in Krishibid Hybrid-1 and 2.92 kg in Atlas-70). Application of 50 ppm GA_3 gave the highest single head weight without unfolded leaves (2.22 kg) and the control produced the lowest single head weight without unfolded leaves (1.70 kg in Krishibid Hybrid-1. But in Atlas-70, the maximum head weight without unfolded leaves was obtained from the application of GA_3 at 75 ppm (3.23 kg) and the control gave the lowest value (2.28 kg). These are in agreement with the results of Roy and Nasiruddin (2011), Chaurasiy *et al*. (2014), Mazed *et al.* (2015), Afrin (2013), Lina (2015), Paul (2011) and Islam *et al.* (2017) who recorded maximum head diameter, single head weight without unfolded leaves and single head weight without unfolded leaves from 50, 60, 90, 70, 95, 90 and 120 ppm GA_3, respectively.

In Krishibid hybrid-1, application of GA_3 at 50 ppm gave the maximum head yield (81.18 t/ha) being identical with NAA at 60 ppm (78.57 t/ha), GA_3 at 75 ppm (75.28 t/ha) and NAA at 40 ppm (75.24 t/ha); whereas, the highest head yield, in Atlas-70, was recorded from 75 ppm GA_3 (102.40 t/ha) which was statistically similar to 50 ppm GA_3 (94.96 t/ha). The minimum head yield was recorded from the control (67.29 t/ha in Krishibid Hybrid-1 and 72.32 in Atlas-70). In Krishibid Hybrid-1, GA_3 at 50 ppm, NAA at 60 ppm and GA_3 at 75 ppm increased head yield over control by 17.11, 14.36 and 10.61%, respectively; whereas in ATlas-70, GA_3 at 75 and 50 ppm and NAA at 60 ppm increased head yield over control by 29.38, 23.84 and 17.12%, respectively. Islam *et al.* (1993), Rahman and Mondal (1995), Dhengle and Bhosale (2008) and Roy and Nasiruddin (2011) got the highest yield of cabbage at 50 ppm GA_3. But Chaurasiy *et al*. (2014) obtained the maximum yield of cabbage from GA_3 at 60 ppm which was statistically similar to NAA at 80 ppm. Yadav *et al* (2000), Mazed *et al.* (2015), Paul (2011), Afrin(2013), Lina (2015), and Islam *et al*. (2017) recorded maximum head yield from 100, 90, 90, 70, 95 and 120 ppm GA_3, respectively. The increase in weight of head and yield might be due to greater photosynthesis, higher food accumulation; better plant growth, better chlorophyll formation and higher quantum yield (Fv/Fm) because the economic part of cabbage is head and which is formed by thick overlapping of leaves. 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 head yield.

Partial cost analysis

The present study (Table 3) revealed that among the various treatments in the variety Krishibid Hybrid-1, gross return and net return were found maximum with 50 ppm GA_3 followed by 60 ppm NAA; whereas in the variety Atlas-70, gross return and net return were found maximum with 75 ppm GA_3 followed by 50 ppm GA_3 and 60 ppm NAA. In Krishibid Hybrid-1, all the treatments except GA_3 and NAA both @ 100 ppm recorded higher benefit:cost ratio (BCR) over control while in Atlas-70, all the treatments except GA_3 @ 100 ppm recorded the maximum BCR. The highest BCR was obtained from NAA 60 ppm (3.63) followed by 50 ppm GA_3 (3.59) in Krishibid Hybrid-1, whereas in Alas-70, the maximum BCR was obtained from 75 ppm GA_3 (4.79) followed by 50 ppm GA_3 (4.54) and 60 ppm NAA (4.37). The control treatment gave the lowest gross and net return in case of both varieties.

Conclusion

The results of the experiment led to the conclusion that the head yield of cabbage was greatly improved by application of GA_3 and NAA. Application of GA_3 @ 50-75 ppm, and NAA @ 60 ppm increased head yield of cabbage significantly over control. In Krishibid Hybrid-1, application of GA_3 @ 50 ppm, NAA @ 60 ppm and GA_3 @ 75 ppm yielded 81.18, 78.57 and 75.28 t/ha, respectively which was 17.11, 14.36 and 10.61%, respectively over control (67.21 t/ha). On the other hand in Atlas-70, spray of GA_3 @ 75 and 50 ppm and, NAA @ 60 ppm produced 102.40, 94.96 and 87.26 t/ha of cabbage head, respectively which was 29.38, 23.84 and 17.12%, respectively over control. Spray of NAA @ 60 ppm to the plants of the variety Krishibid Hybrid-1 recorded the maximum benefit-cost ratio (BCR) (3.63) followed by GA_3 @ 50 ppm (3.59). But in Atlas-70, the maximum BCR was obtained from the spray of GA_3 @ 75 ppm (4.79) which was followed by GA_3 @ 50 ppm (4.54) and NAA @ 60 ppm (4.37). From the point of economics, it is thus inferred that the use of GA_3 @ 50-75 ppm or NAA @ 60 ppm could be recommended for increasing the head yield of cabbage with higher return.

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