Impact of Plant Growth Regulators on Vegetative Parameters and Yield of Zucchini (Cucurbita pepo L.)

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DOI: https://dx.doi.org/10.51244/IJRSI.2026.1304000200

Received: 23 April 2026; Accepted: 28 April 2026; Published: 14 May 2026

ABSTRACT

The present investigation was to study the "Effect of plant growth regulators on vegetative parameters and yield of Zucchini (*Cucurbita pepo* L.)" was conducted out at the Agricultural Research Station, Binjhagiri, Department of Vegetable Science, SOADU, Bhubaneswar, Odisha during rabi 2023-24 to assess the effect of various plant growth regulators viz. Naphthalene acetic acid (NAA)@50ppm and 100ppm, Gibberellic acid (GA_3) @50ppm and 100ppm, Etherel @150ppm and 200ppm, Maleic Hydrazide (MH) @ 150 ppm and 200 ppm, along with control on growth and yield of Zucchini. The experiment was planned in a randomized block design with nine treatments and three replications. The growth regulators were applied twice, i.e., first spray at 2nd true leaf stage and second spray at 4th leaf stage. The study revealed application of NAA @100ppm was found to be the most effective in increasing plant height (47.47cm), leaf area (108.50 sq.cm), number of leaves per plant (11.96), number of primary branches per plant (11.96), number of female flowers (12.08)and number of male flowers (15.23) per plant, femaleness percentage (50.66%),average number of fruit per plant (9.08), the average single fruit weight (1255.35g), fruit length (18.36cm), fruit girth (16.96cm), fruit set percentage (34%), yield per plant (5.62kg), yield per plot (82.74kg) and total yield per hectare (138.27 t). Application of NAA @ 100 ppm as foliar spray also decreased the number of male flowers per plant, lowered male: female flower ratio in zucchini. From the results of the study, it could be concluded that NAA @100ppm was the most effective growth regulators in improving the growth and yield with a maximum benefit-cost ratio (3.85), also net and gross income of Zucchini significantly over control, followed by Etherel @150ppm.

Keywords: auxin; naphthalene acetic acid; plant growth regulators; yield; zucchini.

INTRODUCTION

Zucchini (*Cucurbita pepo* L.) belongs to the Family Cucurbitaceae. It is a vineless cucurbit (restricted vine) having a bushy growth habit, little known and grown in the Asian and African continents, considered to have originated in Northern Mexico. Zucchini plant bears both male and female flowers on the same plant i.e. monoecious, where male and female flowers are borne on separate nodes. Summer squash generally displays more male flowers than female flowers. Sex expression in cucurbits is greatly influenced by hormones produced inside plants as well as outside application of synthetic growth regulators. Growth regulators are recognized as significant treatments applied now-a-days in agriculture, which in most cases rephase the plant growth and fruiting. Plant growth regulators are usually organic compounds. They are either natural or synthetic compounds and applied directly to a plant to alter its life processes or structure in some beneficial ways to enhance yield and improve the quality of produce. Growth regulators are very important for the growth, yield, and quality of Zucchini in a better way. Plant growth regulators like NAA, GA_3, Etherel and MH suppress the number of male flowers and increases the female flowers production, thereby ultimately increasing the yield (1, 2). Since very little information is available on the effect of growth regulators on the yield of Zucchini plants, the present study was conducted to discover convenient growth regulators for increasing the yield potential of Zucchini. Growth regulators are regarded as one of the most important treatments used currently in agriculture, which in most cases

influence the fruit yield. Therefore, the present study was conducted to investigate the effect of growth regulators on the yield and quality parameters of Zucchini.

MATERIALS AND METHODS

The experiment "Impact of plant growth regulators on vegetative parameters and yield of Zucchini (*Cucurbita pepo* L.)" was carried out during Rabi 2023-24, at ARS, Binjhagiri, Chhatabara, Bhubaneswar, Odisha to study the effect of different concentration levels of NAA, GA_3, Etherel and MH on growth and yield of Zucchini. The variety taken was Long Green. Nine treatments were taken, comprising different concentration levels, with a control (water spray), in a Randomized Block Design (RBD) with three replications. The plant growth regulators (NAA, GA_3, Etherel, and MH) were applied twice in the experimental field, i.e., at the 2nd true leaf stage and the 4th leaf stage of the crop. For field preparation, farmyard manure @10 t/ha was applied to the soil as a basal dressing. For better growth and quality of fruits, 75kg of nitrogen, 80 kg of phosphorus, and 80kg of potassium were applied per ha. For the experimental field, Nitrogen is applied in two split doses. In 1st dose, half of the nitrogen, full of phosphorus and potassium, was applied as basal, the remaining half of the nitrogen was applied after 30 days of sowing. The experimental plot was sandy loam, having a pH of 5.8. The organic carbon content of the soil was 0.42% and the electrical conductivity was 1.37 ds/soil pH. The crop was planted at a spacing of 60cm *60cm. All the data concerning various vegetative parameters and yield were analysed statistically. The analysis of the variance table was prepared. The treatment effects were tested by the 'F' test at 5% level of significance. The critical difference at the 5% level was calculated for comparing treatment means.

RESULTS

Vegetative parameters

Plant height (cm)

The observations on plant height were recorded, and the data are given in Table I. It was observed from the table that plant height increased significantly with the application of NAA, GA_3, Etherel, and MH. Maximum plant height, i.e., 47.47 cm, was recorded with treatment T_2 (NAA @ 100ppm), followed by 42.23cm in T_4 (etherel@150ppm). The minimum plant height, i.e., 19.53cm, was recorded in T_9, which happened to be the control.

Leaf area (cm^2)

It was observed from Table I that there were significant differences regarding the leaf area of zucchini plant. The maximum leaf area was observed in T_2, i.e., 108.50 sq. cm (NAA @100ppm), followed by T_5, i.e., 86.71 sq. cm (etherel@150ppm). The minimum leaf area was observed in the control, i.e., T_9 (48.71) sq. cm.

Number of leaves per plant

The observations of the number of leaves per plant were presented in Table I. It was observed that the number of leaves increased significantly with the application of NAA. Maximum number of leaves per plant was observed in treatment T_2, i.e., 11.96 (NAA @ 100ppm), followed by treatment T_5, i.e., 11.16 (Etherel @150ppm), which were statistically at par with each other. The minimum number of leaves per plant was observed in control T_9, i.e., 6.4.

Number of primary branches

The observations on the number of primary branches were recorded and presented in Table I. It was observed that the number of branches increased significantly with the application of NAA. The maximum number of primary branches, i.e., 11.96 in T_2 (NAA@ 100 ppm). Followed by treatment T_5, i.e., 11.16 (Etherel @ 150ppm), which statistically at par with each other, the minimum number of primary branches was observed to be 6.4 in T_9, which was the control.

Flowering parameters

Number of male flowers

The observations of number of male flowers were presented in Table II. It was noticed that the number of male flowers increased with treatment T_9, i.e., 20.23 (control). Followed by Treatment T_8 (MH@200ppm), i.e., 19.41, the minimum number of male flowers were observed in T_2, i.e., 15.23 (NAA @ 100ppm).

Number of female flowers

The observations of number of female flowers were presented in Table II. It was noted that the number of female flowers increased significantly with application of NAA. Maximum number of females observed in Treatment T_2, i.e., 12.08 (NAA @ 100ppm), followed by Treatment T_5 (etherel@150ppm), i.e., 11.44, minimum number of female flowers were observed in Treatment T_9, i.e., 8.12, which was the control.

Femaleness (%)

The observations of femaleness percentage were presented in Table II. It was observed that the femaleness percentage increased significantly with the application of NAA. Maximum percentage of femaleness observed in Treatment T_2, i.e., 50.66% (NAA @ 10 ppm) followed by Treatment T_5 (Etherel@150ppm), i.e., 46%. The minimum percentage of femaleness observed in T_9, i.e., 23.66%, which was the control.

Sex ratio (%)

The observations of sex ratio percentage were presented in Table II. It was observed that the sex ratio increased significantly in the control. The maximum percentage of sex ratio was observed in Treatment T_9, i.e., 2.49 (Control), followed by Treatment T_8 (MH@200ppm), i.e., 2.22, and the minimum percentage of sex ratio was observed in T_2, i.e., 1.25 (NAA@100ppm).

Fruit characters

Number of fruits per plant

The observations of number of fruits per plant were presented in Table III. It was observed that the number of fruits increased significantly with the application of NAA and Etherel. The maximum number of fruits per plant was recorded in treatment T_2, i.e., 9.08 (NAA @100ppm) followed by T_5, i.e., 8.62 (Etherel @150ppm). The minimum number of fruits per plant were monitored in T_9, i.e., 4.23cm, which was the control.

Single fruit weight (g)

The observations on single fruit weight were recorded, and the data are given in Table III. It was observed from the table that the single fruit weight increased remarkably with the application of NAA and Etherel. Maximum single fruit weight, i.e., 1255.33 g, was recorded with treatment T_2 (NAA@100ppm), followed by treatment T_5, i.e., 1133.85 g (Etherel@150ppm). The minimum single fruit weight, i.e., 243.71 g, was observed in T_9, which was the control.

Fruit length and Fruit girth (cm)

The observations on fruit length were recorded, and the data are given in Table III. It was observed from the table that the fruit length increased significantly with the application of NAA, Etherel, and Malic hydrazide. The maximum fruit length was observed in treatment T_2, i.e., 18.36 (NAA @ 100ppm), followed by 17.86 cm in T_5 (Etherel @ 150ppm) and 15.66 cm in T_7 (MH @ 150ppm). The minimum fruit length, i.e., 6.73cm, was recorded in T_9, which was the control.

Fruit set (%)

The observation on fruit set percentage was recorded, and the data are given in Table III. It was observed from the table that the fruit set percentage increased significantly with the application of NAA and Etherel. The maximum fruit set percentage was noted in treatment T_2, i.e., 34% (NAA @ 100ppm), followed by 31% in T_5 (Etherel @150ppm). The minimum fruit set percentage, i.e., 20%, was recorded in T_9, which was the control.

Fruit yield characters

Fruit yield per plant (kg)

Yield per plant was documented and presented in Table IV. The maximum fruit yield per plant was recorded in T_2, i.e., 5.62kg (NAA @ 100ppm), followed by T_5, i.e., 5.23kg (Etherel @ 150ppm). The lowest yield per plant was observed in T_9, i.e., 1.72kg, which was the control.

Fruit yield per plot (kg)

Yield per plot was noted and presented in Table IV. The maximum yield per plot was observed in T_2, i.e., 82.74 kg (NAA@100ppm). Followed by T_5, i.e., 81.71 kg (Etherel @ 150ppm), which is statistically at par with each other. Lowest yield per plot was observed in T_9, i.e., 37.56 kg, which was the control.

Fruit yield (t /ha)

Yield per hectare was recorded and presented in Table IV. The maximum yield per hectare was observed in T_2, i.e., 138.27 t (NAA @ 100ppm), followed by T_5, i.e.134.76 t (Etherel @ 150ppm). Minimum per hectare was observed in T_9, i.e., 59.64 t, which was the control.

Economics of Zucchini as influenced by plant growth regulators

Uses of plant growth regulators with different concentrations noticeably influence the economics of Zucchini cultivation during the year of experiment (2023-24). (Table V)

Total cost of cultivation: The total cost of cultivation in Zucchini is Rs. 170940 per hectare under all the treatments during 2023-24.

Gross income: Remarkable variation in gross returns was observed due to the use of different concentrations of plant growth regulators during the year (2023-24) of the crop trial (Table V). Uses of different concentrations of plant growth regulators recorded the highest gross return of Rs. 829620 in treatment T_2 (NAA@100ppm), followed by Rs. 805080 in treatment T_5 (Etherel@150ppm), respectively, and the lowest gross return of Rs. 357840 was obtained in treatment T_2, which was the control.

Net income: A market difference in net income was observed due to the use of different concentrations of plant growth regulators during the year (2023-24) of the crop trial (Table V). The highest net return of Rs. 658680 was obtained in treatment T_2 (NAA@100ppm), followed by Rs. 634140 in treatment T_5 (Etherel@150ppm), respectively. However, the lowest net income of Rs. 186900 was obtained in treatment T_9, which was the control.

Benefit-cost ratio: The benefit-cost ratio was calculated in all the treatments for the year (2023-24) of the study and presented in Table V. Maximum benefit-cost ratio (3.82) was obtained in treatment T_2 (NAA@100ppm), followed by (3.70) in treatment T_5 (Etherel@150ppm), respectively. However, the lowest benefit-cost ratio (1.09) was observed in treatment T9, which was the control. The benefit–cost ratio further indicated that the crop receiving well with concentration of 100 ppm (NAA), followed by 150 ppm (Etherel), gave the best results, where farmers can earn Rs. 3.82, followed by Rs. 3.70 per rupee of investment.

DISCUSSION

Vegetative parameters

Plant height (cm)

This might be due to the application of NAA; according to various reports, the growth of intact plants is promoted by NAA. NAA enhances cell prolongation, quick cell division in the growing tip, stimulates RNA, and quick cell division in the apical portion of the plant, thereby leading to enhanced growth and development of plants. Effects on plant growth are due to the potentiality of NAA to aggravate growth by influencing the process of photosynthesis, which triggers the activity of NAA on speedy cell division in the apical portion of the plant, leading to cell lengthening and enhancement in the growth process (3,4).

Leaf area (cm^2)

The maximum leaf area (cm^2) was obtained with the application of NAA in higher doses. Leaf area, a vital photosynthetic character, was found significantly affected by the application of different growth regulators. NAA application surely enhances rapid cell division and the elongation process, resulting in increased leaf area (5,6).

Number of leaves per plant

Maximum number of leaves (11.96) were obtained with the application of NAA in higher concentrations. NAA is an artificially produced hormone in the auxin family or auxin analogue that boosts cell division and expansion as a broad-spectrum plant growth regulator that take off the function of natural auxins. Literature reviewed has mentioned that auxin increases the number and size of the leaves in different plants (7,8).

Number of primary branches

The maximum numbers of branches were also significantly influenced using NAA at higher concentrations. The highest number of primary branches arising from the plant height and the quantity of primary branches that are created in the plant are directly proportional to one another, i.e., an increase in plant height causes a bump up in the number of primary branches & vice versa. This may be due to the application of NAA, which plays an important role in cell protraction, cell splitting along with vegetative growth (4,9).

Flowering parameters

Number of male flowers

Zucchini generally displays more male flowers and fewer female flowers. But exogenous application of substances can able to modify the ratio of male and female flowers in the case of cucurbitaceous crops. The data recorded on floral attributes of zucchini revealed that foliar application of NAA @100ppm shows the lowest number of male flowers per plant this was followed by the treatment that received foliar application of the treatment Etherel @ 150ppm. The present study found that the growth promoters (NAA) lowered the commencement of male flowers at the optimum doses, which may be because they are at an optimal level known to slowdown the metabolization of photosynthates as a result, there were fewer male flowers (4,6,10).

Number of female flowers

Data revealed that the highest number of female flowers were obtained with foliar spraying of (NAA @ 100ppm), which might be due to surge in the mobilization of auxin in the plant & also in the decrease of sugar, resulting in membrane permeability (11, 12). NAA @ 100 ppm decreased the male flowers & increased the female flowers production in Cucumber (13). A minimum number of male flowers and a maximum number of female flowers per Plant was obtained with the application of 75 ppm NAA in bitter gourd (14). A lowest number of male flowers and highest number of female flowers per plant was obtained by spraying NAA@ 100,150 ppm & GA_3@

10 ppm in Sponge gourd (15). Reports also revealed that GA & auxin promote the production of male & female flowers, respectively.

NAA induces femaleness in cucurbits & regulates the metabolic activity in plants (16). The present study found that the growth promoters (NAA) reduce the male flower development, which may be due to an optimal level which slowdown the process of metabolization of photosynthates. As a result, there were fewer male flowers development NAA compounds are said to improve the functionality and compatibility of female organs, also decreasing the embryo abortion in plants (4,10).

Femaleness (%)

Plant growth regulators remarkably contribute to early flowering & instigate femaleness or maleness in cucurbits. Female flowers per plant and sex ratio are flowering parameters that regulates the net production capacity of a plant. Minimum Sex ratio induced by application of auxin (NAA) to the plants in higher doses, which may increase functional female organs and affinity besides lowering embryo abortion in plants (17). NAA is also known to reduce the flower and fruit drop in cultivated plants. Femaleness differs due to the environmental impacts such as temperature, photoperiod & nutrition, or by PGRS application (18). NAA application at 2 or 4 leaf stage, the critical stage for promotion or suppression of both sexes, plays a significant role in the alteration of sex in cucurbits.

Sex ratio (%)

Present studies indicated that the response of different treatments to the male: female sex ratio differed considerably. All the treatments notably lowered the male: female sex ratio over control, it could probably be attributed to the suppression of the number of male flowers and promotion of a greater number of female flowers in bitter gourd, bottle gourd, and Cucumber (13,19,20).

Another study revealed that this might be due to decline of starch digestion transpiration as well as respiration in plant tissues after Etherel treatment (5, 21, 22, 23). The present study found that the growth promoters (NAA) lowered the commencement of male flowers at the higher doses, which may be because they are at an optimum level which slow down the metabolization of photosynthates. As a result, there were fewer male flowers. The highest sex ratio is caused by the inhibition of staminate blooms and the promotion of more pistillate flowers (10).

Fruit characters

Number of fruits per plant

Application of NAA@ 100 ppm significantly attributed to a higher number of fruits per plant; the large improvement in fruit development may be attributable to growth regulators, which stimulate the plant metabolism. This, in turn, enhances the reproductive phase and increases the production of pistillate flowers, which leads to a greater amount of fruit per plant in summer squash (4). There was an increase in the number of fruits with NAA treatment in bitter gourd (24). Application of NAA increases the number of fruits in bottle gourd and cucumber (20,30).

Single fruit weight (g)

Maximum individual fruit weight was obtained with NAA. The results exhibited that growth regulators treated plants gave more individual fruit weight compared to the control. Exogenous application of auxin elevates source capacity, transportation efficiency & sink strength, promoting the synthesis and distribution of photo assimilate, ultimately enhancing the fruit size in cucumber (10,25).

Fruit length and Fruit girth (cm)

The observations on fruit girth were recorded, and the data are given in Table III. It was observed from the table that the fruit girth increased significantly with the application of NAA and Ethrel. Maximum fruit girth, i.e.,

16.96 cm, was recorded with treatment T_2 (NAA@100ppm) followed by Treatment T_5, i.e., 14.96 cm (Etherel @ 150 ppm). The minimum fruit girth, i.e., 6.73cm, was observed in T_9, which was the control.

Application of NAA significantly influences the fruit length & girth due to changes in carbohydrate level. The carbohydrate content among the treated fruits differs with enzymatic activity. Translocation of carbohydrate can be increased in the presence of the NAA hormone. The increase in fruit length and girth may be due to the foliar application of NAA, that helps in improving the function of internal organs by upgrading the supply of nutrients, water, and other Compounds necessary for fruit growth & development in cucumber (26). The augmentation in fruit size could also be due to the role of NAA in cell multiplication, which leads to vacuole widening & cell wall loosening after increased cell wall elasticity in muskmelon and cucumber (27, 28).

Fruit set (%)

Application of NAA in higher doses significantly increases the number of female flowers per plant and finally leads to high numbers of fruits, which ultimately gives a higher fruit set percentage in cucumber (12). NAA @ 10ppm had a higher effect on sex expression, fruit set, and yield in the Bhaktapur local variety of the cucumber (29, 30).

Fruit yield characters

Fruit yield per plant (kg)

The results of the present study confirmed that the NAA concentration in higher doses was significantly superior in recording more yield in gram per plant as well as tonnes per hectare, as compared to the control. Increase in fruit yield in treated plants may owing to that the plant remained physiologically more in action to hype sufficient food stock for the developing flowers and fruits, eventually leading to higher yield. Increased fruit yield, it may also due to the enrich in female flower production ultimately, a higher number of fruits per plant was harvested in cucumber (20, 24, 31).

Fruit yield per plot (kg)

The increase in fruit yield per plot with NAA may be because auxin causes physiological modifications in the plants, mainly on sex ratio, increased fruit set, fruit weight, higher photosynthetic activity, and translocation of metabolites from source to sink points in ridge gourd (32). An increase in fruit yield might be due to an increase in pistillate flower production and, ultimately, harvest of a greater number of fruits per plant in ridge gourd (33).

Fruit yield (t /ha)

An augmentation in total yield in treated plants attributed to the fact that the plants remain to be physiologically active to absorb the nutrients for promotion of flowers & fruits which eventually produces higher yield. The increase in fruit yield with foliar application of auxin may be due to an increase in carbohydrate metabolism and accumulation of carbohydrates. Also reports says that spraying of NAA significantly increased total yield by increasing the number of female flowers, number of fruits, and average fruit weight by decreasing the sex ratio in watermelon and summer squash (34, 35).

Economics of Zucchini as influenced by plant growth regulators

Uses of plant growth regulators with different concentrations noticeably influence the economics of Zucchini cultivation during the year of experiment (2023-24).(Table V)

Benefit-cost ratio: The benefit-cost ratio was estimated in all the treatments for the year (2023-24) of the study and presented in Table V. This might be because of the higher production of Zucchini under these treatments. Maximum net return and benefit-cost ratio was obtained with NAA@100ppm, followed by Etherel@150ppm. Increase in growth, number of female flowers, narrowing sex ratio, an increase number of fruits per plant, fruit length, fruit diameter might be the reason behind the net return in bitter gourd and cucumber (29, 36).

Table I. Effect of different concentrations of NAA, GA_3, Etherel and MH on vegetative parameters

Treatment		Plant height (cm)	Leaf area (cm^2)	Number of leaves/plants	Number of primary branches
T1	NAA@50ppm	35.59	83.73	10.5	10.5
T2	NAA@100ppm	47.47	108.50	11.96	11.96
T3	GA_3 @50ppm	28.85	71.96	10.03	10.03
T4	GA_3@ 100ppm	26.95	64.23	10.02	10.02
T5	Etherel @150ppm	42.23	86.71	11.16	11.16
T6	Etherel @200ppm	31.66	82.25	10.31	10.31
T7	MH @ 150ppm	24.30	55.51	9.44	9.44
T8	MH @ 200ppm	22.16	51.90	9.34	9.34
T9	Control	19.53	48.71	6.14	6.14
SE(m) ±		1.15	1.93	0.21	0.21
CD (0.05)		3.47	5.78	0.64	0.64

Table II: Effect of different concentrations of NAA, GA3, Etherel and MH on Reproductive parameters

Treatment		Number of male flowers	Number of female flowers	Femaleness (%)	Sex ratio (%)
T1	NAA@50ppm	16.2	10.52	38.66	1.53
T2	NAA@100ppm	15.23	12.08	50.66	1.25
T3	GA3 @50ppm	17.13	9.33	35.66	1.83
T4	GA3@ 100ppm	17.76	9.24	34.00	1.92
T5	Etherel @ 150ppm	15.61	11.44	46.00	1.36
T6	Etherel @ 200ppm	16.72	10.43	36.00	1.59
T7	MH @ 150ppm	18.51	9.14	33.00	2.01
T8	MH @ 200ppm	19.41	8.65	27.33	2.22
T9	CONTROL	20.23	8.12	23.66	2.49
Se(m)±		0.08	0.12	0.68	0.01
CD (0.05)		0.24	0.37	2.05	0.03

Table III: Effect of different concentrations of NAA, GA3, Etherel and MH on fruit parameters

Treatment		Number of fruits/plants	Single fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Fruit set %
T1	NAA@50ppm	7.24	1014.23	15.43	13.03	27.33
T2	NAA@100ppm	9.08	1255.33	18.36	16.96	34.00
T3	GA3 @50ppm	7.05	800.57	12.73	9.36	25.66
T4	GA3@ 100ppm	6.52	585.72	12.06	8.06	24.00
T5	Etherel@150ppm	8.62	1133.85	17.86	14.96	31.00
T6	Etherel@200ppm	6.82	964.17	14.43	12.71	24.00
T7	MH @ 150ppm	6.54	416.72	11.33	7.43	22.00
T8	MH @ 200ppm	6.21	391.24	10.56	7.06	21.00
T9	CONTROL	4.23	243.71	7.41	6.73	20.00
Se(m)±		0.11	0.76	0.24	0.52	0.63
CD (0.5)		0.33	2.28	0.73	1.58	1.89

Table IV: Effect of different concentrations of NAA, GA3, Etherel and MH on fruit yield characters

Treatment		Fruit yield per plant (kg)	Fruit yield per plot (kg)	Fruit yield (t/ha)
T1	NAA@50ppm	5.13	81.23	131.81
T2	NAA@100ppm	5.62	82.74	138.27
T3	GA3 @50ppm	3.98	48.83	80.89
T4	GA3@ 100ppm	3.85	45.56	75.80
T5	Etherel @ 150ppm	5.23	81.71	134.76
T6	Etherel @ 200ppm	4.85	67.58	103.18
T7	MH @ 150ppm	3.12	45.75	72.12
T8	MH @ 200ppm	2.56	41.43	64.05
T9	CONTROL	1.72	37.56	59.64
SE(m) ±		0.11	0.68	0.75
CD (0.05)		0.34	2.05	2.26

Table V: Economics of Zucchini cultivation as influenced by plant growth regulators

treatment		Yield (t /ha)	Gross income (Rs ha^{-1})	Net income (Rs. ha^{-1})	B:C Ratio
T1	NAA@50ppm	131.81	790860	619920	1:3.62
T2	NAA@100ppm	138.27	829620	658680	1:3.85
T3	GA3 @50ppm	80.89	485340	314400	1:1.83
T4	GA3@ 100ppm	75.80	454800	283860	1:1.66
T5	Etherel@150ppm	134.76	805080	634140	1:3.70
T6	Etherel@200ppm	103.18	619080	448140	1:2.62
T7	MH @ 150ppm	72.12	432720	261780	1:1.53
T8	MH @ 200ppm	64.05	384300	213360	1:1.24
T9	Control	59.64	357840	186900	1:1.09

CONCLUSION

Based on the outcome of this study, it may be inferred that among the different growth regulators applications, NAA@100ppm showed superior performance for growth and yield characters in zucchini with a maximum benefit-cost ratio, followed by Etherel @150ppm, which was applied in two- and four-leaf stage. So, the application of NAA @100ppm and Etherel @150ppm as foliar application may be recommended to the farmers of Odisha for the cultivation of Zucchini.

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