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Studies on the Effect of Plant Growth Regulators on Growth and Yield of Chilly (*Capsicum annuum* L.) Cv. Sivam

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ABSTRACT

The experiment on "Studies on the effect of plant growth regulators on growth and yield of chilli (*Capsicum annuum* L.) cv. Sivam" was carried out in the Department of Horticulture, Faculty of Agriculture, Annamalai University during 2019 – 2020. The experiment was conducted in Randomized Block Design with 10 treatments in three replications. The treatments consist of foliar spray of three plant growth regulators viz., NAA, GA_3 and Ascorbic Acid along with recommended dose of manures and fertilizers. The foliar application of NAA @ 40 ppm resulted in improving the growth characters like plant height, number of branches, number of leaves, days to fifty per cent flowering and yield components like number of flowers $plant^{-1}$, number of fruits $plant^{-1}$, fruit length, fruit girth, single fruit weight and fruit yield $plant^{-1}$ which was followed by NAA @ 60 ppm. Fruit set percentage was found to be highest in plants sprayed with NAA @ 20 ppm followed by NAA @ 40 ppm. Yield characters like fruit yield $plant^{-1}$ was also found to be significantly influenced by the application of GA_3. The Ascorbic Acid @ 400 ppm increased the ascorbic acid content of chillies. The highest net return and benefit cost ratio were observed in NAA @ 40 ppm.

Key words: *Capsicum annuum*, NAA, GA_3, Ascorbic acid, Growth, Yield, Quality

Capsicum annuum L. (Chilli) belongs to solanaceae family is one of the most important vegetable crops cultivated in India. It is also used as spice across the country called as universal spice of India, has its origin in Mexico, Southern Peru and Bolivia. There are mainly five cultivated species of capsicum are identified. They are *Capsicum annuum*, *Capsicum baccatum*, *Capsicum chinense*, *Capsicum frutescens* and *Capsicum pubescens*. Among all, *C. annuum* L. is mostly cultivated species in major parts of the world which is predominantly popular for its green pungent fruits, used for culinary purpose. It is an essential ingredient of Indian curry, which is characterized by tempting colour and exciting pungency. It is commercially important for its red colour due to the chemical constituent capsanthin ($C_{40}H_{56}O_3$).

The world consumption of chilli is going up due to the increasing popularity of ethnic foods. The increased availability of oleoresins and spice oils of chilli has also enhanced its consumption in various food preparations. Chilli is a good source of antioxidants and vitamins like A, C and E with minerals like molybdenum, magnesium, potassium and copper. Recently, Russian scientists have identified vitamin P in green chilli which is used as a protectant from secondary irradiation injury [16]. It also contains capsaicin ($C_{18}H_{37}NO_3$) and several related chemicals, collectively called capsaicinoides, which is responsible for pungency. Indian subcontinent is the major producer, consumer and exporter of chilli. Portuguese introduced chilli into India by the end of 15th century. India, China, Ethiopia, Myanmar, Mexico, Vietnam, Peru, Pakistan, Ghana and Bangladesh are the top ten chilli producing countries. Andhra Pradesh, Maharashtra, Orissa, West Bengal, Karnataka, Rajasthan and Tamil Nadu are the important chilli producing states in India and among which Andhra Pradesh alone contributes 46% of the total chilli production in India. India accounts for approximately 40% of total global production. In India, area under chilli is about 3.66 million hectares with a production of 37.37 million tonnes. In Tamil Nadu, chilli is grown in an area of 50.7 thousand hectares with a total production of 23.1 thousand tonnes and the productivity is 0.46 tonnes per hectare [8].

Plant growth regulators play a crucial role in the growth and development of the crops. Plant growth regulators have potential ability to increase productivity of vegetables. They are the compounds other than the nutrients and are mostly organic in nature. Some growth regulators are produced by plants and are called phytohormones. These plant growth regulators are classified under different groups like Auxins, Gibberellins, Cytokinins, ethylene and

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morphactins. Plant growth regulators act both as growth promoters and growth retardants. They also induce and breakdown the seed dormancy of the seeds. Present study includes three plant growth regulators viz., NAA, GA_3 and Ascorbic acid. NAA is related to auxin, GA_3 is related to gibberellin and ascorbic acid is related to vitamin C. There is a great potential to increase yield of chilli by reducing flower drops and by increasing fruit set. To achieve this, plant growth regulators are considered new generation agro-chemicals after fertilizers, pesticides and herbicides. In hot region, there is great problem of premature flower and fruit drop in chilli due to environment factors and cultivation practices. Hormonal imbalance occurs due to sudden rise in atmospheric temperature. Poor fruit set is one of the major bottlenecks in the production of chillies and it directly affects the yield. It is by the adverse weather condition like increasing or decreasing temperature and rainfall. Especially NAA has been reported to enhance fruit set and consequently yield. NAA in optimum concentration decrease flower shedding, promoting the vegetative growth and maximize yield of chilli. Growth regulator GA_3 increases the plant height, weight of shoot and root of the plant. NAA, GA_3 and AA regulate growth, fruitfulness, yield and also improve the quality contents of chilli. The growth regulators not only improve the growth but also the productivity of many crops. They play a significant role in promoting root growth, increase in number of flowers, fruit size and inducing early and uniform fruit setting and ripening. They are applied as foliar spray or as seed treatment. Higher physiological efficiency including photosynthetic ability of plants can be induced by application of NAA (Naphthalene Acetic Acid). Gibberellic acid has many effects regulating various physiological processes, including seed germination, the mobilization of endosperm storage reserves, shoot growth, flowering, floral development and fruit set [10]. Ascorbic acid functions as a major redox buffer and as a co-factor for enzymes involved in regulating photosynthesis, hormonal biosynthesis and regenerating other antioxidants. It also regulates cell division and growth [6]. In view of above background, the present research work on the "Studies on effect of different plant growth regulators on growth, yield and quality of chilli cv. Shivam" was conducted with objectives of identifying the optimum concentration of growth regulators for enhancing fruit yield and quality in chillies.

MATERIALS AND METHODS

The experiment was conducted in the Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalainagar. The experiment was conducted in a Randomized block design (RBD) with three replications. Thirty days old seedlings of chilli cultivar Shivam Local was transplanted at the experimental site. The details are as given below:

Treatment details:

Treatment	Growth regulator	Concentration (ppm)
T_1	NAA	20
T_2	NAA	40
T_3	NAA	60
T_4	GA_3	25
T_5	GA_3	50
T_6	GA_3	75
T_7	Ascorbic acid	100
T_8	Ascorbic acid	200
T_9	Ascorbic acid	400
T_{10}	Control	-

There are three plant growth regulators (NAA, GA and Ascorbic acid) applied at different concentrations in chilli cv. Shivam Local at pre-flowering and pre-fruiting stages.

Chilli seeds were sown in raised beds along the rows at spacing of 5 cm across the beds and a depth of 0.25 cm. The beds were mulched with paddy straw and watered using rose can. Necessary plant protection and cultural operations were carried out from time to time to get healthy seedlings. The main field was ploughed to a fine tilth. Farmyard manure was applied at the rate of 25 t ha^{-1} a week before transplanting and mixed well with the soil. Thirty days old, healthy seedlings of uniform size and growth were transplanted at the rate of one seedling per hill at a spacing of 60 × 45. Gap filling was done one week later to maintain the optimum plant population. Fertilizers at the rate of 60:60:30 kg NPK per ha were applied in the form of urea (130 kg), superphosphate (375 kg) and muriate of potash (50 kg) as sources of nitrogen, phosphorus and potash respectively. The full dose of phosphatic and potassic fertilizers and half dose of nitrogenous fertilizer was applied at the time of transplanting and the remaining half dose of nitrogen was applied in three equal splits on 30, 60, 90 days after transplanting. Irrigation was given before planting to wet the top 40 cm layer. Immediately after planting, life irrigation was given on the third day and subsequent irrigations were given as and when required to the crop. Weeding, hoeing and earthing up were done as and when required to the crop. Regular spraying with plant protection chemical comprising of 2 ml Imidacloprid + 2 g of wettable sulfur in a litre of water was taken up at monthly intervals to control thrips, whiteflies, leaf spots, anthracnose and powdery mildew which were observed affecting the crop in different stages of growth. Observation was recorded on growth characters like plant height, number of branches, number of leaves, days to fifty per cent flowering and yield components like number of flowers $plant^{-1}$, number of fruits $plant^{-1}$, fruit length, fruit girth, single fruit weight and fruit yield $plant^{-1}$ and ascorbic acid content. The data were statistically analyzed by adopting the standard procedure of [15] and using AGRISTAT software.

RESULTS AND DISCUSSION

In any vegetable, chilli in particular, the growth parameters like plant height, number of branches and number of leaves directly contribute the economic yield of fruits. In fact, the variable trend in vegetative growth during successive growth stages before start of reproductive phase is govern by the crop management practices and as well as agro-climatic conditions of region. The plant growth regulators require in optimum concentration otherwise they caused toxicity to the plant. They promote the growth parameters like plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$and days taken to 50% flowering.

From the present study it is observed that NAA markedly influenced the growth attributed viz., plant height, number of branches and number of leaves (Table 1) which were recorded at maturity showed that NAA can increase the morphological traits in chillies. The promoting effect on plant height by the application of NAA is might be due to its action as a group of auxins, the cell wall probably reacted favorably and high deposition of cell wall material took place due to high catalyzing activities of carbohydrates and pectiolase. It also increases photosynthetic activities, efficient translocation and utilization of photosynthetic which might be causing rapid cell division in growth portion of the plant (or) stimulation of growth, besides increasing the uptake of nutrients thereby resulted in plant height increase. NAA treatment might be attributed to the activation of cell division and cell elongation in the axillary buds, which had a promoting effect on increased number of branches. The plant height of 55.52cm (Table 1) in the plants sprayed with NAA @ 40 ppm (T_2) which is greater when compared to control. It might be due to higher bio-activities of endogenous hormones in the plant system [2], [4], [11-14], [18], [20], [23].

In the experiment, it is observed that the application of NAA @ 40ppm (T_2) also increased number of leaves (79.06) (Table 1) and number of branches (26.23) (Table 1). It may be due to antimitotic action and thus providing an inhibitory effect on the suppression of the apical growth of main axis and thereby increased number of branches per plant. The reason is that, NAA has the growth stimulatory effect which might have increased the branches per plant and also due to the fact, that increase in the plant height will increase the number of branches and number of leaves of the plant [2], [11], [13-14], [20-21], [23].

Table 1 Effect of different plant growth regulators on growth attributes in chillies (*Capsicum annuum* L.) cv. Sivam

Treatments	Plant height (cm)			No. of branches plant^{-1}			No. of leaves plant^{-1}		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_1: NAA @ 20 ppm	29.44	40.38	46.93	5.61	13.66	16.91	30.98	49.03	64.33
T_2: NAA @ 40 ppm	33.86	44.31	55.52	8.96	22.08	26.23	39.43	64.67	79.06
T_3: NAA @ 60 ppm	31.52	43.02	51.88	7.18	18.47	22.46	35.71	61.66	76.28
T_4: GA_3 @ 25 ppm	28.57	38.01	47.91	5.27	12.12	15.06	28.76	45.68	66.86
T_5: GA_3 @ 50 ppm	30.66	40.67	51.25	6.38	15.46	18.98	33.36	56.03	72.73
T_6: GA_3 @ 75 ppm	29.27	38.94	48.27	6.17	12.62	15.27	32.62	51.01	68.98
T_7: Ascorbic acid @ 100 ppm	23.96	33.33	40.62	4.22	9.28	12.33	24.83	42.37	62.77
T_8: Ascorbic acid @ 200 ppm	24.77	35.02	43.64	5.01	11.68	14.23	27.47	47.28	65.38
T_9: Ascorbic acid @ 400 ppm	26.34	36.91	45.72	5.77	12.86	15.28	33.41	52.52	67.98
T_{10}: Control	17.64	28.06	38.76	3.58	8.58	11.23	16.87	36.71	62.53
S.Ed.	0.38	0.20	0.39	0.28	0.50	0.31	1.02	0.53	1.26
CD (p = 0.05)	0.84	0.45	0.85	0.64	1.10	0.69	2.21	1.21	2.71

Earliness is the important character in the cultivated crops, especially in vegetable. The effect of various treatments was studied for earliness in the experiment. In case of early maturing of the produce, the expenditure on cultivation will be reduced. Although, it is a genetical trait, other factors like environmental and cultural practices can also influences it to an appreciable extent. The growth regulator might have influenced the physiological regulation of flower formation of the plant possibly influencing the timing of anthesis mechanism.

Table 2 Effect of different plant growth regulators on flowering and yield attributes in chillies (*C. annuum* L.) cv. Sivam

Treatments	Days to 50% flowering	Number of flowers plant^{-1}	Number of fruits plant^{-1}	Fruit set percentage	Fruit length (cm)	Fruit girth (cm)	Average fruit weight (g)
T_1: NAA @ 20 ppm	32.12	57.90	40.83	70.51	9.13	1.76	36.91
T_2: NAA @ 40 ppm	30.33	71.15	47.31	66.49	10.36	1.93	42.08
T_3: NAA @ 60 ppm	30.32	68.65	42.16	61.41	9.67	1.82	39.87
T_4: GA_3 @ 25 ppm	32.66	60.17	33.58	55.80	8.18	1.51	30.36
T_5: GA_3 @ 50 ppm	31.32	65.46	38.24	58.41	9.36	1.66	35.01
T_6: GA_3 @ 75 ppm	31.56	62.08	36.67	59.06	8.71	1.63	31.78
T_7: Ascorbic acid @ 100 ppm	35.47	56.50	24.78	43.85	7.11	1.31	24.58
T_8: Ascorbic acid @ 200 ppm	33.58	58.84	28.37	48.21	7.77	1.46	25.61
T_9: Ascorbic acid @ 400 ppm	32.46	61.18	30.38	49.65	8.88	1.52	28.06
T_{10}: Control	36.67	56.28	22.33	39.67	6.62	1.21	20.76
S.Ed.	0.34	0.46	0.14	0.14	0.19	0.007	0.60
CD (p = 0.05)	0.79	1.05	0.37	0.37	0.48	0.02	1.27

From the present study, NAA @ 40 ppm (T_2) recorded the maximum number of flowers which is 71.15 flowers plant^{-1} (Table 2) and also it takes 28.33 days to 50% flowering which shows earliness when compared with control and all the other treatments. It may be due to the fact that increased production of leaves might help to elaborate more photosynthates and inducing flower stimulus, thus effecting early initiation of flower bud and also may be due to the increased synthesis of cytokinin and auxin in the root tissue by their enhanced activity due to the application of

NAA. Another reason for earliness is may be due to the increased level of neutral auxins which may be responsible for early induction of flowers and its involvement in transition of vegetative apices to floral apices remained more physiologically active to build up sufficient food reserve for the developing flower.

Yield is the major parameter considered by farmers. The plants sprayed with growth regulators remained physiologically more active to build up sufficient food reserve (source) for developing flowers and fruits (sink). Better performance of plant by the application of growth regulators may be due to appropriate growth of plants, control of abscission layer in full bloom stage and acceleration in fruit development by the positive hormonal actions. As growth regulators such as NAA and GA_3 are involved in increasing photosynthetic activity, efficient translocation and utilization of photosynthates causing rapid cell elongation and cell division in growth pattern of the plant or stimulation of growth, besides increasing the uptake of nutrients.

On reviewing the data computed in tables. It was observed that there was sizeable improvement in the yield characters of the plants in the treatment T_2 which is NAA @ 40 ppm (T_2). This treatment is significantly superior over the other treatments. It shows the highest yield attributes like number of flowers plant^{-1} (71.15), number of fruits plant^{-1} (47.31), fruit length (10.46 cm), fruit girth (1.93 cm), average fruit weight (42.08 g), fruit yield plant^{-1} (235.39 g), fruit yield plot^{-1} (10.36 Kg), fruit yield hectare^{-1} (8.63 t), dry fruit yield plant^{-1}(58.96 g) and dry fruit yield plot^{-1}(2.59 Kg). This was followed by the treatment T_3 (NAA @ 60 ppm) in the parameters like number of flowers plant^{-1} (68.65) (Table 2), number of fruits plant^{-1} (42.16) (Table 2), fruit length (9.67 cm) (Table 2), fruit girth (1.82 cm) (Table 2), average fruit weight (39.87 g) (Table 2), fruit yield plant^{-1}(223.98 g) (Table 3),fruit yield plot^{-1} (9.86 Kg) (Table 3), fruit yield hectare^{-1} (8.22 t) (Table 3), dry fruit yield plant^{-1} (54.31 g) (Table 3) and dry fruit yield plot^{-1}(2.39 Kg) (Table 3). The physiological action of NAA might have been responsible for increasing the yield attributes.

Table 3 Effect of different plant growth regulators on yield attributes in chillies (*Capsicum annuum* L.) cv. Sivam

Treatments	Fruit yield plant^{-1} (g)	Fruit yield plot^{-1} (kg)	Fruit yield ha^{-1} (t)	Dry fruit yield plant^{-1} (g)	Dry fruit yield plot^{-1} (kg)
T_1: NAA @ 20 ppm	203.98	8.98	7.48	51.01	2.24
T_2: NAA @ 40 ppm	228.39	10.36	8.63	58.96	2.59
T_3: NAA @ 60 ppm	223.98	9.86	8.22	54.31	2.39
T_4: GA_3 @ 25 ppm	183.97	8.10	6.75	40.78	1.79
T_5: GA_3 @ 50 ppm	215.31	9.47	7.90	53.04	2.33
T_6: GA_3 @ 75 ppm	196.68	8.65	7.20	45.33	1.99
T_7: Ascorbic acid @ 100 ppm	147.32	6.48	5.40	35.17	1.55
T_8: Ascorbic acid @ 200 ppm	160.97	7.08	5.90	36.57	1.61
T_9: Ascorbic acid @ 400 ppm	168.31	7.41	6.18	39.38	1.73
T_{10}: Control	137.32	6.04	5.03	33.78	1.49
S.Ed.	1.47	0.04	0.03	0.42	0.06
CD (p = 0.05)	3.15	0.13	0.09	0.93	0.20

Further accumulation of greater dry matter content due to better photosynthetic and other metabolic activities and efficient nutrient uptake from soil in chilli due to hormonal activity of both the regulators directly reflects in yield. Increase in yield with the application of NAA @ 40 ppm as against the rest of the treatments thus might be due to the probable reason that NAA might be responsible for increase in photosynthetic activities within the plant which might be resulted in the production of more carbohydrates and related products responsible for increased yield of chilli [5], [7], [9]. Treatment T_3 is followed by the treatment T_5 which is GA_3 @ 50 ppm which showed the third highest yield parameters like number of flowers plant^{-1} (65.46), number of fruits plant^{-1} (38.24), fruit length (9.36 cm), fruit girth (1.66cm), average fruit weight (35.01 g), fruit yield plant^{-1}(215.31 g), fruit yield plot^{-1} (9.47 Kg), fruit yield hectare^{-1} (7.90 t), dry fruit yield plant^{-1} (53.04 g) and dry fruit yield plot^{-1} (2.33 Kg) [1], [3], [17], [19], [22], [24].

CONCLUSION

Among the different growth regulators tested, NAA @ 40 ppm (T_2) was found to produce best results in improving the growth and yield of chillies cv. Sivam local. Application of Gibberellic acid was also found to produce significant improvement in growth and yield of chillies.

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