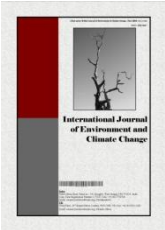

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Effect of Gibberellic Acid and Naphthalene Acetic Acid on Growth, Yield and Quality of Chilli (*Capsicum annum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment entitled "Effect of gibberellic acid and naphthalene acetic acid on growth yield and quality of chilli (*Capsicum annum* L.)" was conducted at Department of Horticulture, Naini Agricultural Institute, SHUATS, Prayagraj during August to December, 2021. Experiment was laid out in Factorial Randomized Block Design with three replications and ten treatment combinations. The experiment consisted of two factors. Factor A: Variety (two variety) as TMPH-449, TMPH-443 and Factor B: Plant growth regulator T_1: NAA (30ppm) T_2: NAA (40ppm) T_3: GA_3 (50ppm) T_4: GA_3 (100ppm). The results revealed that among the varieties studied, variety TMPH-449 resulted better in vegetative growth (Plant height, leaf area) whereas variety TMPH-443 resulted better in vegetative growth (Number of branches per plant), yield parameter (Minimum days taken for 50 percent flowering, minimum days to first harvest, length of fruit, fruit girth, weight of fruit, number of chilli fruit per plant, average fruit yield per plant, fruit yield per hectare), and quality parameter (total soluble solids). Among different concentrations of growth regulator application T_2: NAA (40ppm) gave better result in vegetative growth (Plant height, Number of branches per plan, leaf area), yield parameter (Minimum days taken for 50 percent flowering, minimum days to first harvest, length of fruit, fruit girth, weight of fruit, number of chilli fruit per plant, average fruit yield per plant, fruit yield per hectare), and quality parameter (total soluble solids). The best interaction amount different variety and growth regulators were found to be variety TMPH-443 and Growth regulator T_2: NAA (40ppm) which give maximum growth and quality characteristics of chilli.

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1. INTRODUCTION

Chilli is an annual crop belongs to Solanaceae family having somatic chromosome number of 2n=24.The native land of chilli is considered to be Mexico with secondary origin in Gautemala. Chilli is said to be the first ever domesticated crop in America. The three species *C. annum*, *C. frutescence* and *C. chinense* evolved from a common ancestor located in the North of the Amazon basin (NW-Brazil, Columbia). Chilli imports pungency and colour to the dishes. It is an important ingredient in day-to-day curries, pickles and chutneys. It is also used for vegetables, spices, condiments, sauces and pickles. It prevents heart disease by dilating blood vessels. Red colour in chilli is due to "Capsanthin". Pungency in chilies is due to the active constituent "Capsaicin", an alkaloid, is extracted from chilies and is used to medicine.

Green chillies are rich in vitamin A and C. Peppers are good source of vitamin B, B_6, carotene, thiamine, riboflavin, niacin and carbohydrate. Also seed contains starch. The production of chilli is governed not only by the inherent genetic yield potential but also influenced by many environmental factors and cultivation practices. But the production of chilli is reduced due to flower bud, flower and young fruit drop which is because of physiological and hormonal imbalance in plant mainly in unfavourable environment [1,2].

India grows the largest number of vegetables in the world and is the second largest producer after China. Day by day the vegetable production in India is increasing very rapidly. Chili is native to South America and was introduced to India by the Portuguese in the 17^{th} century [3,4]. The main chili producing countries in the world are Egypt, Ghana, Nigeria, Tunisia, Mexico, USA, Argentina, Indonesia, Korea, Pakistan, India, Sri Lanka, Turkey, Bulgaria, Hungary, Italy, Romania, Spain and Yugoslavia.

A group of chemicals known as plant growth regulators, plant hormones and growth inhibitors have found many practical controlling implications in growth and many other physiological activities and metabolic processes of the plants. Plant growth regulators are considered as new generation of agro-chemicals after fertilizers, pesticides and herbicides to augment seed yield and quality. The plant growth regulators are known to enhance the source sink relationship and stimulate the translocation of photo assimilates thereby helping in better retention of flowers and fruits. Besides this, the growth regulators have the ability to cause accelerated growth in plants [5-7].

Gibberellic acid (GA_3) is a phytohormone which is needed in small quantities at low concentration to accelerate plant growth and development.GA_3 helps in increasing plant height, shoot and root weight of the plant [4,8]. GA_3 also used for promotion of fruit sets in some fruits and vegetable production and can increase yields to four times. NAA helps to enhance the photosynthetic activity, accelerated transport and utilizing photosynthetic product resulting rapid cell elongation and division in meristem. Thus, growth and yield of the crop can be increased.

2. MATERIALS AND METHODS

The experiment was conducted at Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (UP) during August, 2021 – December, 2021. The experiment was laid out in Factorial Randomized Block Design (FRBD) with 10 treatments and three replications *viz.* T_0: V_1T_0 (TMPH-449) Control, T_1: V_1T_1 (TMPH-449 + NAA @ 30 ppm), T_2: V_1T_2 (TMPH-449 + NAA @ 40 ppm), T_3: V_1T_3 (TMPH-449 + GA_3 @50 ppm), T_4: V_1T_4 (TMPH-449 + GA_3 @100 ppm), T5: V_2T_0 (TMPH-443) Control, T_6: V_2T_1(TMPH-443 + NAA @ 30 ppm), T_7: V_2T_2 (TMPH-443 + NAA @ 40 ppm), T_8: V_2T_3 (TMPH-443 + GA_3 @50 ppm), T_9: V_2T_4 (TMPH-443 + GA_3 @100 ppm). Chilli cv. TMPH-449 (Trimurti plant science Pvt. Ltd.), TMPH-443 (Trimurti plant science Pvt. Ltd.) these two varieties were used for the experiment. Raised beds was prepared for the sowing of chilli seeds in the nursery in polyhouse. Seedlings were observed after a range of five to twelve days after sowing. The beds having 135 cm length and 120 cm width were prepared with addition of vermicompost and NPK. The 30-35 days old seedlings were transplanted in the main field on 05 September 2021. Gap filling of seedlings was done a week after transplanting. Weeding and proper plant protection measures were taken as and when required. Spraying the plant growth regulator treatments was done at 20 DAT and 40 DAT stages. Required quantities of growth regulator solutions were prepared

separately by dissolving in a small quantity of alcohol and the volume was made up to one litre with water. Plant growth regulators treatments included NAA @ 30 ppm and 40 ppm, GA_3 @ 50 ppm and 100 ppm and were applied by a mini hand sprayer. The observations recorded during the course of investigation were subjected to statistical analysis. The significance and non-significance of treatment effects were judged with the help of 'F variance ratio test. The significance difference on the means was tested against the critical difference at 5 percent level.

3. RESULTS AND DISCUSSION

Observations were recorded on growth parameters *viz.* plant height (cm), number of branches and leaf area (cm^2), yield parameter days to 50 percent flowering, days to first harvest, number of fruits per plant, fruit length (cm), fruit weight (g), fruit girth (cm), average yield per plant (g), fruit yield per hectare (t) and quality parameters total soluble solid (ºBrix).

3.1 Growth Characters of Chilli

Maximum plant height at last harvest was found in variety TMPH-449 (67.53 cm) and minimum in variety TMPH-443 (59.81 cm). Due to the different concentrations of PGR the maximum plant height (68.26 cm) was recorded in NAA @40 ppm and the minimum (58.79 cm) in Control (water spray). Interaction data revealed TMPH-449 + NAA @40 ppm was recorded with maximum plant height (71.89 cm) and minimum (56.03 cm) was recorded in TMPH-443 + Control. Similar effect of growth regulators on plant height were reported in chilli by Jakhar et al. [9]. Maximum number of branches per plant at last harvest was found in variety TMPH- 443 (24.67) and minimum is variety TMPH-449 (24.20). Due to the different concentrations of PGR number of branches per plant was found maximum (26.78) was recorded in NAA @40 ppm and the minimum (21.94) in Control (water spray). The interaction data found non-significant. Similar effect of growth regulators on number of branches per plant were reported in chilli by Kannan et al. (2009) and Kalshayam et al. [10]. Maximum leaf area was found in variety TMPH-449 (34.07 cm^2) and minimum is variety TMPH 443 (15.54 cm^2). Due to the different concentrations of PGR leaf area was found maximum (30.07 cm^2) was recorded in NAA @40 ppm and the minimum (20.87 cm^2) in Control (water spray). Interaction data revealed TMPH-449 + NAA @40 ppm is recorded with maximum leaf area (41.56 cm^2) and minimum (12.93 cm^2) was recorded in TMPH-443 + Control. Similar findings recorded by Kiranmayi et al. [11].

3.2 Yield Characters of Chilli

Least number of days taken for 50 percent flowering was found in variety TMPH-443 (26.40), whereas maximum days to 50 percent flowering was recorded in variety TMPH-449 (30.20). Due to the different concentrations of PGR the minimum days taken for 50 percent flowering was found in treatment NAA @40 ppm (26.33), whereas the maximum number of days to 50 percent flowering (30.50) was observed in control. The interaction data found non-significant.

Least number of days taken for 1st harvesting was found in variety TMPH-443 (48.07), whereas maximum days to 1st harvesting was recorded in variety TMPH-449 (50.86). Due to the different concentrations of PGR the minimum days taken for 1st harvesting was found in treatment NAA @40 ppm (47.17), whereas the maximum number of days to 1st harvest (51.50) was observed in control. The interaction data found non-significant. Maximum fruit length was found in variety TMPH-443 (8.35 cm) and minimum in variety TMPH-449 (7.77 cm). Due to the different concentrations of PGR length of fruit was found maximum (8.68 cm) was recorded in NAA @40 PPM and the minimum (7.42 cm) in Control (water spray). Interaction data revealed TMPH-443 + NAA @40 ppm is recorded with maximum fruit length (9.08 cm) and minimum (7.16 cm) was recorded in TMPH-449 + Control. Similar effect of growth regulators on fruit length were reported in chilli by Kannan et al., (2009). Maximum girth of fruit was found in variety TMPH-443 (3.67 cm) and minimum in variety TMPH-449 (3.55 cm). Due to the different concentrations of PGR girth of fruit was found maximum (4.10 cm) was recorded in NAA @40 ppm and the minimum (3.19 cm) in Control (water spray). Interaction data revealed TMPH-443 + NAA @40 ppm was recorded with maximum girth of fruit (4.10 cm) and minimum (3.16 cm) was recorded in TMPH-449 + Control. Maximum fruit weight was found in variety TMPH-443 (5.04 g) and minimum in variety TMPH-449 (4.99 g). Due to the different concentrations of PGR fruit weight was found maximum (5.15 g) was recorded in NAA @40 ppm and the minimum (4.85 g) in Control (water spray). The interaction data found non-significant. Maximum number of chilli fruits

Table 1. Effect of two variety on growth, yield and quality of chilli

Variety	Height at harvest (cm)	Number of branches at harvest	Leaf area (cm^2)	Days to 50 percent flowering	Days to 1st harvest	Fruit Length (cm)	Fruit girth (cm)	Fruit weight (g)	Number of Fruits per plant	Average fruit yield per plant (g)	Average fruit yield per hectare (t)	TSS (˚Brix)
V_1	67.53	24.2	34.07	30.2	50.86	7.77	3.55	4.99	81.78	409.12	13.64	7.38
V_2	59.81	24.67	15.54	26.4	48.07	8.35	3.67	5.04	84.55	426.95	14.23	7.92
CD $_{0.05}$	0.34	0.38	0.23	0.66	0.89	0.04	0.03	0.02	0.52	3.23	0.11	0.09
S.Ed (±)	0.16	0.18	0.1	0.22	0.29	0.02	0.02	0.008	0.25	1.52	0.05	0.05

Table 2. Effect of GA_3 and NAA on growth yield and quality of chilli

Treatment	Height at harvest (cm)	Number of branches at harvest	Leaf area (cm^2)	Days to 50 percent flowering	Days to 1st harvest	Fruit Length (cm)	Fruit girth (cm)	Fruit weight (g)	Number of Fruits per plant	Average fruit yield per plant (g)	Average fruit yield per hectare (t)	TSS (˚Brix)
T_0	58.79	21.94	20.87	30.5	51.5	7.42	3.19	4.85	74.28	360.62	12.02	7.36
T_1	65.65	25.39	27.11	27	48	8.4	3.9	5.09	89.44	454.99	15.16	7.81
T_2	68.26	26.78	30.07	26.33	47.17	8.68	4.1	5.15	95.89	494.18	16.47	7.91
T_3	63.34	24.33	23.9	28.17	49.83	8	3.51	5.03	79.33	399.07	13.3	7.63
T_4	62.32	23.72	22.07	29.5	50.83	7.66	3.37	4.96	76.89	381.31	12.71	7.53
CD $_{0.05}$	0.53	0.6	0.36	1.04	1.41	0.06	0.05	0.03	0.83	5.11	0.17	0.14
SEd (±)	0.25	0.28	0.17	0.35	0.47	0.03	0.02	0.013	0.39	2.41	0.08	0.07

Table 3. Interaction effect of GA_3 and NAA on growth, yield and quality of two different variety of chilli

Interaction	Height at harvest (cm)	Number of branches at harvest	Leaf area (cm^2)	Days to 50 percent flowering	Days to 1st harvest	Fruit Length (cm)	Fruit girth (cm)	Fruit weight (g)	Number of Fruits per plant	Average fruit yield per plant (g)	Average fruit yield per hectare (t)	TSS (˚Brix)
$V_1 \times T_0$	61.54	21.33	28.81	32.67	53.33	7.16	3.16	4.81	73.56	354.05	11.8	7.13
$V_1 \times T_1$	69.92	25.22	37.26	28.67	49.33	8.04	3.78	5.07	87.67	444.76	14.82	7.53
$V_1 \times T_2$	71.89	26.67	41.56	28.33	48.33	8.29	4.06	5.13	94	482.32	16.08	7.63
$V_1 \times T_3$	67.67	24.22	32.85	29.67	51	7.74	3.42	5.01	77.79	389.74	12.99	7.33
$V_1 \times T_4$	66.64	23.56	29.89	31.67	52.33	7.36	3.3	4.93	75.89	374.73	12.49	7.26
$V_2 \times T_0$	56.03	22.56	12.93	28.33	49.67	7.69	3.23	4.9	75	367.19	12.24	7.6
$V_2 \times T_1$	61.38	25.56	16.96	25.33	46.67	8.76	3.99	5.1	91.22	465.23	15.51	8.1
$V_2 \times T_2$	64.62	26.89	18.59	24.33	46	9.08	4.1	5.18	97.78	506.05	16.87	8.2
$V_2 \times T_3$	59.02	24.44	14.96	26.67	48.67	8.27	3.6	5.04	80.89	408.4	13.61	7.93
$V_2 \times T_4$	57.99	22.89	14.26	27.33	49.33	7.96	3.45	4.98	77.89	387.89	12.93	7.8
CD $_{0.05}$	0.75	N/A	0.5	N/A	N/A	0.09	0.07	N/A	1.18	N/A	N/A	N/A
SEd (±)	0.35	0.4	0.24	0.7	0.94	0.04	0.03	0.028	0.56	3.41	0.11	0.09

per plant were found in variety TMPH-443 (84.55), whereas minimum number of chilli fruits per plant was recorded in variety TMPH-449 (81.78). Due to the different concentrations of PGR the maximum number of chilli fruits per plant was found in treatment NAA @40 ppm (95.89), whereas the minimum number of chilli fruits per plant (74.28) was observed in control. Maximum average fruit yield per plant was found in variety TMPH-443 (426.95 g), whereas minimum average fruit yield per plant was recorded in variety TMPH-449 (409.12 g). Due to the different concentrations of PGR the average fruit yield per plant was found in treatment NAA @40 ppm (494.18 g), whereas the minimum average fruit yield per plant (360.62 g) was observed in control. The interaction data found non-significant. Similar findings recorded by Tapdiya et al. [12]. Maximum fruit yield per hectare was found in variety TMPH-443 (14.23 t), whereas minimum number of chilli fruits per plant was recorded in variety TMPH-449 (13.64 t). Due to the different concentrations of PGR the Maximum fruit yield per hectare was found in treatment NAA @ 40 ppm (16.47 t), whereas the minimum fruit yield per hectare (12.02 t) was observed in control. The interaction data found non-significant.

3.3 Quality Characters of Chilli

Maximum TSS was found in variety TMPH-443 (7.92), whereas minimum TSS was recorded in variety TMPH-449 (7.38). Due to the different concentrations of PGR the maximum TSS was found in treatment NAA @ 40 ppm (7.91), whereas the minimum TSS (7.36) was observed in control. The interaction data found non-significant.

3.4 Economics of Cultivation

The economics of all the treatment along with the cost of cultivation of chilli it was observed that highest net return (202340.09 Rs. /ha) was obtained in TMPH-443 + NAA @ 40 ppm and lowest (126001.70 Rs. /ha) net return was obtained in TMPH-449+ Control. As regard to the cost benefit ratio, it was observed that highest B:C ratio (4.92) was recorded in TMPH-443 + NAA @ 40 ppm and lowest (3.47:1) was recorded in TMPH-449 + control.

4. CONCLUSION

Based on the findings of the experiment it is concluded that the variety TMPH-443 is superior with the interaction of growth regulator (NAA @ 40 ppm) with respect to the number of branches, days to 50 percent flowering, days to 1st harvest, fruit length, fruit girth, fruit weight, number of fruits per plant, fruit yield per plant, fruit yield per hectare, TSS. Also, the highest economic return of Rs. 202340.09/ha and the best B:C ratio of 4.92 was obtained in TMPH-443 with the interaction of growth regulator NAA @ 40 ppm. Hence the treatment T_7 (TMPH-443 + NAA @ 40 ppm) is best suited for getting higher yield and economics.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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