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Improving Growth and Yield of Chilli (*Capsicum spp.*) Through Plant Growth Regulator Application

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ABSTRACT

The current investigation was carried out to determine the growth and yield and Quality parameters of chilli (*Capsicum spp*.) as influenced by different levels of growth regulators i.e. Naphthalene Acetic Acid (NAA) and Gibberellic Acid (GA_3) There were seven treatments as follows: 1) Control (no PGR application); 2, 3, and 4) three NAA levels (30, 40, and 50 ppm), and 5, 6, and 7) three GA_3 levels (9, 10, and 11 ppm), respectively. The results reflected that the use of PGR affects plant height, number of fruits/plants, fruit length, diameter, and average weight of fruits. Among the treatments, NAA (40 ppm) (T_2) and GA_3 (10 ppm) (T_5) were recorded as significantly better than the control and other treatments. The tallest plants (50 cm) and the longest (15 cm) and widest (6 cm) fruit and highest average fruit weight (3 g) were recorded for T_2, while the greatest number of fruits per plant (30) was recorded for T_5 as well as the highest average fruit weight (4 g). Among all the parameters measured, the control (T_0) always revealed the lowest values. Significant differences among treatments were confirmed by the statistical analysis at $P < 0.05$. Based upon these produce characteristics, it can be recommended that application of NAA 40 ppm and GA_3 10 ppm under field conditions can improve growth and productivity in chilli.

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Introduction

Chilli (*Capsicum spp.*) is utilized both as a spice and as vegetable, grown globally in the tropical and subtropical regions, because of its pungent fruits containing vitamins, antioxidants, and capsaicinoids. Chilli is an important cash crop grown by smallholders in many developing countries such as Bangladesh as it has market and economic value. But, at times chilli productivity is limited by low plant vigor, low fruit set, low fruit quality exacerbated under abiotic stress and unbalanced contribution of different plant parts for nutrition. The use of plant growth regulators (PGRs) has received a lot of interest lately as a relatively inexpensive means to improve plant performance and alter the physiological and biochemical processes involved (Taiz et al., 2015). Naphthalene acetic acid (NAA), a synthetic auxin used as one of the most common PGRs, promotes root initiation, induction of fruit set, elongation of cells and abscission of flowers and fruits (Arteca, 1996). In contrast, gibberellic acid (GA_3) is essential for stem elongation, activation of other enzymes, and enhancing fruit development by inducing cell division and enlargement (Salisbury & Ross, 1992). Reports pertaining to the beneficial effects of NAA and GA_3 in solanaceous crops, namely chilli, to improve growth and yield traits have been confirmed by various studies (Kumar et al., 2019; Verma et al., 2021). The response of chilli plants to various densities of these PGRs, on the other hand, is highly diverse due to a difference in genotype, environment, and timing of application. Hence, the current study was conducted to evaluate the effect levels of NAA and GA_3 on growth, yield and fruit quality parameters of chilli under field conditions. The aim was to determine the best concentration of each PGR to enhance vegetative growth and reproductive yield and thus the chilli productivity.

Materials and Methods

The present study was conducted to assess the effect of various concentrations of PGRs on growth, yield and quality of fruit of chilli (Binamorich 1) in field condition. The experiment was designed in a randomized complete block design (RCBD) with 7 treatments and 3 replications. Treatments comprised of T_0: control (not coloured PGRs spray), T_1: NAA 30 ppm, T_2: NAA 40 ppm, T_3: NAA 50 ppm, T_4: GA_3 9 ppm, T_5: GA_3 10 ppm and T_6: GA_3 11 ppm. The experiment consisted of two treatments, wherein Naphthalene acetic acid (NAA) and gibberellic acid (GA_3) were applied as foliar spray at flowering stage and repeated after 15 days of first application, respectively. Uniform, healthy chilli plants with proper spacing for growth & development were maintained in each plot. All plots received the same irrigation, fertilization, weeding, and pest control in accordance with standard agronomic practices. Plant height (cm), number of fruits per plant, fruit length (cm), fruit diameter (cm), and average fruit weight (g) were among the many growth and yield parameter data that were documented. Each plot's five randomly chosen plants were measured, and the results were averaged for statistical analysis. To determine the statistical significance of treatments, mean comparisons were conducted using Duncan's Multiple Range Test (DMRT) at the 5% level of significance and analysis of variance (ANOVA) was applied to the gathered data.

Results

Plant growth regulators (PGR) exerted substantial influence on growth and yield attributes in chilli (Capsicum spp.), as shown in Table 1. Of the treatments, T2 (NAA 40 ppm) had the highest plant height (50±3.4cm), significantly better than all other treatments and control (T0) had the shortest plants (37±2.1cm). This shows that NAA were 0.0 and 40 ppm NAA was suitable for promoting vegetative growth. The highest number of fruits per plant (30±3.7) was recorded in treatment T5 (GA_3 10 ppm) being statistically similar to T2 (28±4.2); meanwhile, the minimum fruit number (20±5.6) was recorded in the control which indicates that both NAA and GA_3 was effective for good fruit set and GA_3 was slightly better for this parameter.

For fruit length, the highest fruits were found in T2 (15±0.04 cm) and T5 (14±0.04 cm) which were significantly higher than the control (10±0.08 cm), showing that the fruit developed well when PGR applied. The differences in fruit diameter among treatments were also significant with the highest value in T2 (6±0.6cm) whereas control (3±0.1cm) had the lowest diameter (Table 2). NAA (40 ppm) increased fruit size significantly over the control. In terms of average weight of the fruit, the heaviest weight was in T5 (4±2.2g), followed by T2 (3±5.6g) and the control produce the lightest (1.5±4.6g) fruit. These results show that GA_3 10 ppm improved fruit biomass. Results from statistical analysis indicated significant differences among treatments for all parameters ($P < 0.05$) reflecting the effect of PGRs on growth and Yield attributes. In general, the findings indicate 40 ppm of NAA and 10 ppm of GA_3 are effective in enhancing the agro-morphological performance of chilli plants. NAA 40 ppm (T2) ranked top for plant height, fruit length, diameter of fruit and GA_3 10 ppm (T5) for number of fruits and average weight of fruit. This potential of targeted application of PGR can be utilized to optimise chilli production under field condition as indicated by the current findings.

Discussion

This study provides strong evidence that the application of plant growth regulators or PGRs, that is naphthalene acetic acid or NAA and gibberellic acid or GA 3, increased the growth, yield, and quality of fruits of chilli or Capsicum spp. In the cases of both PGRs, the central tendency was followed where T 2 had a plant height of 50 cm and T 5 was close behind with a height of 47 cm, while the control accounts for the number of plants at a height of 37 cm. This is in agreement with the findings of Kumar et al., who stated the application of NAA and GA 3 exogenously aided the stem to develop into the length by way of stimulating the division and elongation. Meanwhile, Taiz et al. highlighted that gibberellins – specifically GA 3 – were responsible for the activation of growth alleles and thereby, the elongation of stem. Auxins, on the other hand, such as NAA provided the apical locales to its portion and thereby, produced greater vegetative development. Moreover, the number of fruits per plant was increased significantly by GA 3 at 10 ppm or 30 fruits, followed by NAA at 40 ppm or 28 fruits, whereas the control had only 20 fruits. This is due to the ability of GA 3 to increase the viability of pollen and the receptivity of stigma, which, in turn, increases their fruit set and their retention as seen in the flowers.

PGR treatments also significantly enhanced fruits length and diameter. T2 (NAA 40 ppm) gave the longest fruits (15cm) and widest diameter (6cm) which is in the order of outsized fruits due to predominated role of auxins. According to Thirupathi et al. Sengupta et al Sinha et al (2018) NAA the fruit size enhancement effect of NAA may be due to stimulation of cell expansion and increased sink strength of developing fruits. These results are similar to Ramakrishna et al. (2016) who found that NAA increased photosynthate translocation to developing fruit which resulted in bigger fruit size. Regarding the average weight of the fruit, the heaviest fruits (4g) were produced under GA_3 at 10 ppm (T5), while the lightest fruits (1.5g) were produced under the control treatment. GA_3 redirected cell extension activity and delayed senescence, consequently increasing the fruit growth period (Salisbury and Ross, 1992) whereby the fruit was expected to grow larger. Sharma et al had similar results. Growth regulators like GA_3 is used to induce parthenocarpy, monsoon dissemination and increase individual fruit weight and increase yield as reported by Talama et al (2020).

In conclusion, the statistical significance ($P < 0.05$) of all evaluated characteristics clearly demonstrates that PGRs can enhance the physiological and reproductive performance of chilli plants. NAA at 40 ppm was found most effective to increase plant height and size of fruit, whereas GA_3 at 10 ppm was effective to increase number and weight of fruit. This variation in response by concentration emphasizes the importance of optimum PGR dosage as application of higher or lower levels can have undesirable effects.

This really confirms the precision usage of PGRs is feasible and affordable in enhancing chilli productivity. The incorporation of these treatments can provide a limited yet notable contribution toward increasing both yield and fruit quality, especially when environmental constraints are acting on the growth of chilli crops.

Conclusion

The results of this study conclusively demonstrate that the use of plant growth regulators (PGRs) especially naphthalene acetic acid (NAA) and gibberellic acid (GA_3) significantly promoted the growth, yield and fruit quality of chilli (*Capsicum spp*.). It can be concluded that the highest effect among all treatments was observed with NAA 40 ppm (T2) and GA_3 10 ppm (T5). The maximum plant height, fruit length and fruit diameter as recorded under NAA 40 ppm while maximum number of fruits / plant and highest average fruit weight as resulted from GA_3 10 ppm. All parameters measured in all PGR-treated plants showed significant greater values with respect to the untreated control (T0), which showed the lowest values of all parameters measured. The statistical analysis confirmed that these improvements achieved a high degree of confidence ($P < 0.05$) and thus it can be concluded that PGRs are capable of having a substantial positive impact on the physiological as well as the reproductive performance of chilli. Hence, it is concluded that wise foliar application of NAA at 40 ppm and GA_3 at 10 ppm can be adopted in chilli cultivation to maximize yield and quality of fruit under field conditions. Future research might focus on the interaction of PGRs and different genotypes under varied environmental conditions to provide us with more /optimized/ crop managerial options.

Table 1. Effect of NAA and GA3 on chilli growth and yield

Treatments	Plant Height (cm)	No. of fruits / plant	Fruit length (cm)	Fruit diameter (cm)	Average weight (g / fruit)
T0	37±2.1e	20±5.6e	10±0.08c	3±0.1c	1.5±4.6c
T1	40±4.5d	22±4.3d	12±0.07b	5±0.7b	2±8.7b
T2	50±3.4a	28±4.2b	15±0.04a	6±0.6a	3±5.6a
T3	41±3.7d	26±5.6c	12±0.03c	5±0.5b	2±7.1b
T4	42±4.4c	25±7.8c	11±0.01c	4±0.7c	2±3.3b
T5	47±4.2b	30±3.7a	14±0.04a	5±0.5b	4± 2.2a
T6	43±2.7c	25±2.8c	13±0.06b	5±0.2b	2.5±4.6b
P value	*0.000*	*0.003*	*0.010*	*0.000*	*0.007*

At the five percent significance level, figures in a column with similar letters do not differ significantly; SE (±) is the standard error of means; p is the probability. The treatments are: T0: Control (No PGRs Spray), T1: NAA 30 ppm spray, T2: NAA 40 ppm spray, T3: NAA 50 ppm spray, T4: GA3 9 ppm spray, T5: GA3 10 ppm spray, T6: GA3 11 ppm spray

Conflict of Interest

No conflicts of interest have been declared by the writers.

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