RESPONSE OF FOLIAR APPLICATION OF GA_3 IN DIFFERENT PLANT AGES FOR SEED PRODUCTION IN BLACK CUMIN

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Abstract

The effect of foliar application of plant growth regulator viz. GA_3 in different growth stages was investigated on growth and yield of black cumin at Horticulture Research Field, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh in *Rabi* season of 2012. The experiment consisted of 7 levels of GA_3 (0, 25, 50, 75, 100, 125 and 150 ppm) with three replications. Different doses of GA_3 were sprayed both at vegetative (40 days) and flowering stage (60 days). The results indicated that, growth and yield of black cumin were increased due to enhanced application of GA_3 up to 100 ppm. Application of GA_3 at vegetative stage was more effective than that of flowering stage. The maximum number of branches/plant, plant height, weight/plant, capsule/plant, 1000 seed weight, seed yield and stover yield were observed with application of GA_3 100ppm at vegetative stage. The highest yield (2. 09 t/ha) was obtained by the application of GA_3 at vegetative stage. The results suggest that for higher seed production of black cumin, GA_3 should be applied at vegetative stage with concentration of 100 ppm.

Keyword : Black cumin, GA_3, vegetative stage, flowering stage, yield.

Introduction

Black cumin (*Nigella sativa* L.) is an annual herbaceous plant belonging to the family Ranunculaceae. It is widely cultivated throughout South Europe, Syria, Egypt, Saudi Arabia, Iran, Pakistan, India and Turkey (Riaz *et al.*, 1996). Though we use it mainly as spices, it has been used as herbal medicine for more than 2000 years. *N. sativa* volatile oil has recently beenshown to possess 67 organic constituents, many of which are capable of inducing beneficial pharmacological effects in humans (Aboutabl *et al.* , 1986).

In Bangladesh, it is rarely produced in some parts of the country, even though most of the soil and climatic condition of Bangladesh are suitable for black cumin cultivation (Anonymous1). Probably the crop did not show its yield potential due to lake of proper practices. Like other crops, plant growth regulator

GA_3 can be used to maximize yield of black cumin seed. Gibberellic acid (GA_3) is the first highly active and commercially available gibberellin to be purified from a culture medium of *Gibberella fujikuroi* (Sponsel, 1990). Gibberellins (GA_3) are a class of endogenous plant growth substances actively involved in the control of a number of key developmental processes including endosperm mobilization and stem elongation, as well as flower and fruit development (Huttly and Phillips, 1995). Plants subjected to exogenous application of GA_3 have been found to exhibit increased activities of carbonic anhydrase, nitrate reductase (Khan, 1996; Hayat *et al.*, 2001; Afroz *et al.*, 2005), CO_2 fixation, stomatal conductance (Bishnoi and Krishnamoorthy, 1992), and ribulose-1, 5-biphosphate carboxylase/ oxygenase (Rubisco) (Arteca and Dong , 1981;Yuan and Xu, 2001). Besides, GA_3 are also known to alter membrane permeability to ions (Manuel and Guardia, 1980; Gilroy and Jones, 1992), induce fruit set (Arteca, 1996) and greatly enhance the translocation potential of the sink (Peretó and Beltrán, 1987). To achieve these, the black cumin may be manipulated in order to enable the utilization of the maximum possible available resources and exploitation of its inherent genetic potential. Hence, even though the hormone itself may be metabolized, its effects remain apparent due to sustained activity of these enzymes. To realize the full yield potential of black cumin agricultural practices will have to be optimized for its production. Optimum GA_3 in appropriate plant stage of black Cumin in Bangladesh has rarely investigated. This study aimed to find out the effect of GA_3on seed production of black cumin.

Materials and Methods

The experiment was conducted at the Horticulture Research Field, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during the winter season of 2012-13. The experiment consisted of 7 levels of foliar application of GA_3 (0, 25, 50, 75, 100, 125 and 150 ppm), both in vegetative (T_1, T_3, T_5, T_7, T_9, T_{11} and T_{13} respectively) and flowering stages (T_2, T_4, T_6, T_8, T_{10}, T_{12} and T_{14} respectively). The experiment was laid out in a randomized complete block design with three replications. Each block consisted of 14 plots and the dimension of each plot was 1.2 m×1.2 m (1.44 m^2) with a plot to plot and block to block distance 0.5 m and 1.0 m respectively.

Genotypeof black cumin was used in

the experiment as exotic, Iran. The seeds were soaked in water for 24 hours to facilitate germination. They were dried and treated by Bavistin @ 2 g/kg of seed to minimize the primary seed-borne diseases (BARI, 2007). The land was well prepared by deep and cross ploughing with a tractor disk harrow followed by laddering. Weeds and stubbles of the previous crops were collected and removed from the field during land preparation. Soil clods were broken and plots were prepared as 10 cm raised so that irrigation and rain water easily could drain out and seeds could easily be germinated. The experiment plots were manured and fertilized with cowdung, urea, TSP and MP at the rate of 10 t, 125, 95 and 75 kg/ha respectively (BARI, 2007). The total amount of cow dung, half of N, full dose of TSP and MP were applied at the time of final land preparation. The remaining N was applied at 40 days after sowing (DAS) of seeds as top dress followed by irrigation. The seeds were mixed with some loose soil to allow uniform sowing in rows. Then, seeds were sown in rows 15 cm apart continuously by hand @ 10 kg/ha (BARI, 2007), maintaining a depth of one cm. Continuous line sowing was done to maintain plant to plant distance 10 cm by thinning later on (BARI, 2007). The seeds were covered with loose soil properly just after sowing and gently pressed by hands. The field was kept free by hand weeding. Weeding cum thinning was done in installments at 25, 40 and 60 days after sowing (DAS). To keep spacing 10 x 15 cm^2, properly thinning was done at 25 days after sowing. Fungicide Bavistin @ 2 g/L was sprayed to control damping off. The spray was done twice at the 10 days interval from 25 DAS. The crop was harvested when 50% of the capsules changed color from green to straw. Seeds from capsule were separated by beating with sticks and cleaned by winnowing and dried properly (8% moisture of seed). Parameters were taken as plant height, length and breath of leaf, number of branches per plant, fresh and dry weight per plant, number of capsule per plant, 1000 seed weight, seed yield per plant and per hectare, stover yield per hectare and harvest index. The data on various parameters under study were statistically analyzed using MSTAT-C computer package program. The means for all the treatments were calculated and analysis of variance for all characters was performed by F- variance test. The significance of the difference among the treatment means was evaluated by Least Significant Difference Test (LSD) at 5% level of probability.

Results and Discussion

Plant height (cm)

Plant height significantly varied with different treatments (Fig. 1). It ranged from 47.30 cm (T_2) to 57.80 cm (T_9). Up to 100 ppm, application of GA_3, plant height gradually raised in sprayed both vegetative and flowering stage, and then decreased. T_9 was statistically similar to T_7 and T_{11}. T_2 was statistically similar to T_1, T_4, T_6, T_8 and T_{14}. It may be due to higher response to GA_3 at vegetative stage and lower response at flowering stage. The finding was supported by Shah *et al.* (2006) who reported that, application of GA_3 in vegetative stage was more effective than flowering stage in plant height. In both, vegetative and flowering stage, application of GA_3 increased shoot length. Upper plant height was obtained with spraying 10-4 M GA_3 by Shah and Tak (2011), which mostly supported the finding. Ali (2012) found upper scape length with 100 ppm GA_3 in onion, which support the finding.

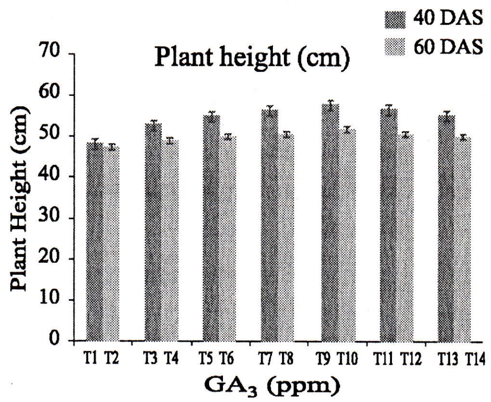

Fig. 1. Effect of GA_3 on plant height in black cumin.

Vertical bars represent standard error of treatment means.

T_1, T_2 (control); T_3, T_4 (25ppm); T_5, T_6 (50 ppm), T_7, T_8 (75 ppm);T_9, T_{10} (100 ppm); $T_{11}T_{12}$ (125 ppm); T_{13}, T_{14} (150 ppm)

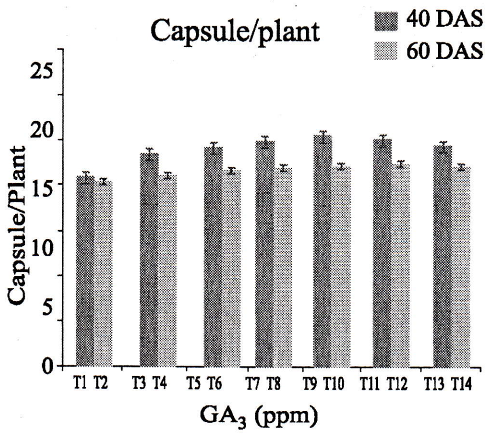

Fig. 2. Effect of GA_3 on number of capsule per plant in black cumin.

Vertical bars represent standard error of treatment means.

T_1, T_2 (control); T_3, T_4 (25 ppm); T_5, T_6 (50 ppm), T_7, T_8 (75 ppm); T_9, T_{10} (100 ppm); T_{11} T_{12} (125 ppm); T_{13}, T_{14} (150 ppm)

Table 1. Effect of GA_3 on leaf length and breath and branching characteristics in black cumin

Treatment	LeafNo. of branches per plant			
	Length (cm)	Breath (cm)	Primary	Tertiary
T_1 (0 ppm at 40 DAS)	2.80 e	2.35 f	4.25 g	16.20 f
T_2 (0 ppm at 60 DAS)	2.65 e	2.25 f	4.16 g	15.80 f
T_3 (25 ppm at 40 DAS)	3.14 a-d	2.63 cd	4.76 d	18.14 d
T_4 (25 ppm at 60 DAS)	2.90 de	2.43 ef	4.40 f	16.77 ef
T_5 (50 ppm at 40 DAS)	3.25 a-c	2.72 bc	4.93 c	18.79 c
T_6 (50 ppm at 60 DAS)	2.94 c-e	2.47 ef	4.46 ef	17.01e
T_7 (75 ppm at 40 DAS)	3.33 a	2.80 ab	5.06 a-c	19.28 a-c
T_8 (75 ppm at 60 DAS)	2.97 b-e	2.49 e	4.51ef	17.17e
T_9 (100 ppm at 40 DAS)	3.42 a	2.87 a	5.19 a	19.76 a
T_{10} (100 ppm at 60 DAS)	3.00 b-e	2.51de	4.55 e	17.33 e
T_{11} (125 ppm at 40 DAS)	3.36 a	2.82 ab	5.10 ab	19.44 ab
T_{12} (125 ppm at 60 DAS)	2.98 b-e	2.50 de	4.53 ef	17.25 e
T_{13} (150 ppm at 40 DAS)	3.28 ab	2.75 a-c	4.97 bc	18.95 bc
T_{14} (150 ppm at 60 DAS)	2.95 c-e	2.48 ef	4.48 ef	17.09 e

Means followed by the same letter (s) in a column are not significantly different at 0. 05 level of significance

Length andbreath of leaf (cm)

There were significant differences among the treatments in leaf length and leaf breath (Table 1). The highest leaf length (3.42 cm) as well as leaf breath (2.87 cm) were obtained from T_9, and the lowest leaf length (2.65 cm) and leaf breath (2.25 cm) from control at 60 DAS (T_2), which were statistically similar to control T_1. In all cases of leaf length sprayed GA_3 in flowering stage was statistically similar to control. On the other hand, all leaf length sprayed GA_3 at vegetative stage were statistically similar to T_9. In case of leaf breath, T_4, T_6 and T_{14} were statistically similar to control (T_1 and T_2). T_7, T_{11} and T_{13} were statistically similar to T_9. Shah and Tak (2011) found higher leaf area with spraying GA_3 with concentration of 10-4 M. Shah *et al.* (2006) found greater leaf area with spraying GA_3, both in vegetative and flowering stage. According to his result, vegetative stage was more effective, which support current finding. Also Shah and Samiullah (2007) observed higher leaf area at spraying GA_3 10-5 M with N100.

Number of branches per plant

Number of primary and tertiary branches were statistically different in various treatments (Table 1). Primary branches was the highest (5.19) in T_9, which was statistically similar to T_7 and T_{11}. The lowest primary branches (4. 16) were found in control (T_2), which were similar to T_1. Also tertiary branches were the highest (19. 76) in T_9, and the lowest (15. 80) was observed in T_2. According to Shah *et al.* (2006), the highest branches were obtained by spraying GA_3 at vegetative stage, which support the current finding. Shah and Samiullah (2007) observed higher number of branches in black cumin at spraying GA_3 10-5 M with N100.

Fresh and dry weight per plant (g)

A significant difference was found both in fresh and dry weight per plant in different treatments (Table 2). Fresh weight per plant ranged from 11. 76 g (T_2) to 14.64g (T_9). Also dry weight was the lowest (7.45g) in T_2, and the highest (9.52g) was observed in T_9. All treatments sprayed GA_3 at vegetative stages except T_3 were statistically similar both in fresh and dry weight. Also, except T_{10}, all treatments of sprayed GA_3 at flowering stage were statistically similar in both fresh and dry weight per plant. The finding was supported by Shah *et al.* (2006) who reported higher dry weight by spraying GA_3 at vegetative stage. Upper level of total dry matter was found by application of GA_3 at concentration of 10-4M (Shah and Tak, 2011). Also Shah and Samiullah (2007) observed higher total dry matter at spraying GA_3 10-5 M with N100 in black cumin.

Number of capsule per plant

Number of capsule per plant is an important character for determination seed yield. Application of GA_3 implies T_9 produced the highest capsule per plant. It was the highest 19.52, which was statistically similar to T_7 and T_{11} (Fig. 2). On the other hand, it was the lowest (15.56) in control (T_2), which was statistically similar to T_1, T_4 and T_6. The result was similar to finding of Shah *et al.* (2006). With spraying 10∝M GA_3, Shah *et al.* (2007) observed higher capsule per plant in black cumin. Number of capsule per plant was obtained with 10-4 M GA_3 by Shah and Tak (2011). These results are almost similar to current finding. Ali (2012) found more umbles per plant with 100 ppm GA_3 in onion, which support the finding.

Table 2. Effect of GA_3 on plant weight and seed characteristics in black cumin

Treatment	Fresh weight per plant (g)	Dry weight per plant (g)	1000 seed weight (g)
T_1 (0 ppm at 40 DAS)	12.00 e	7.80 e	2.15
T_2 (0 ppm at 60 DAS)	11.76 e	7.45 e	2.10
T_3 (25 ppm at 40 DAS)	13.44 bc	8.74 bc	2.16
T_4 (25 ppm at 60 DAS)	12.42 de	8.07 de	2.10
T_5 (50 ppm at 40 DAS)	13.92 ab	9.05 ab	2.20
T_6 (50 ppm at 60 DAS)	12.60 de	8.19 de	2.12
T_7 (75 ppm at 40 DAS)	14.28 a	9.28 a	2.18
T_8 (75 ppm at 60 DAS)	12.72 c-e	8.27 c-e	2.10
T_9 (100 ppm at 40 DAS)	14.64 a	9.52 a	2.20
T_{10} (100 ppm at 60 DAS)	12.84 cd	8.35 cd	2.19
T_{11} (125 ppm at 40 DAS)	14.40 a	9.36 a	2.08
T_{12} (125 ppm at 60 DAS)	12.78 c-e	8.31c-e	2.13
T_{13} (150 ppm at 40 DAS)	14.04 ab	9.13 ab	2.10
T_{14} (150 ppm at 60 DAS)	12.66 c-e	8.23 c-e	2.14

Means followed by the same letter(s) in a column are not significantly different at 0. 05 level of significance

1000 seed weight (g)

Application of GA_3 did not show any effect on the size of seeds (Table 2). All the treatments showed similar 1000 seed weight. However, 1000 seed weight ranged from 2.08 to 2.20g. Also Shah *et al.* (2006) found no significant different between control and GA_3 spraying both in vegetative and flowering stage.

Seed yield per plant (g)

Seed yield per plant directly effect on total seed yield. It ranged from 3. 15g (T_2) to 4.03g (T_9) (Table 3). T_9 was statistically similar to all treatment sprayed GA_3 in vegetative stage, also with T_8, T_{10} and T_{12}. On the other hand, T_2 was statistically similar to all treatments sprayed GA_3 at flowering stage. Shah *et al.* (2006) obtained higher yield with spraying GA_3 at vegetative stage, than flowering stage. Shah *et al.* (2007) observed upper seed yield per plant with 10 ∝M GA_3. Also Ali (2012) found higher seed yield per plant with 100 ppm GA_3 in onion, which support the finding.

Seed yield per hectare (t)

Seed yield per hectare is the ultimate goal (Fig. 3). It ranged from 1.66 t to 2. 09 t. The highest seed yield per hectare was obtained from T_9, which was statistically similar to T_7 and T_{11}. The lowest yield was found in control (T_2). Fig. showed that, up to a certain level of GA_3 (100 ppm), yield gradually increased, than decreased. The result was supported by finding of Shah *et al.* (2006) who found higher yield with spraying GA_3 at vegetative stage in black cumin than flowering stage. Shah and Tak (2011) found upper seed yield with application of GA_3 at concentration of 10-5 M.

Table 3. Effect of GA_3 on yielding characteristics in black cumin

Treatment	Seed yield per plant (g)	Stover yield per hectare (t)
T_1 (0 ppm at 40 DAS)	3.30 c	3.88
T_2 (0 ppm at 60 DAS)	3.15 c	3.82
T_3 (25 ppm at 40 DAS)	3.70 a-c	3.89
T_4 (25 ppm at 60 DAS)	3.42 bc	3.89
T_5 (50 ppm at 40 DAS)	3.83 a-c	3.88
T_6 (50 ppm at 60 DAS)	3.30 c	3.88
T_7 (75 ppm at 40 DAS)	3.93 ab	3.90
T_8 (75 ppm at 60 DAS)	3.50 a-c	3.91
T_9 (100 ppm at 40 DAS)	4.03 a	3.92
T_{10} (100 ppm at 60 DAS)	3.53 a-c	3.90
T_{11} (125 ppm at 40 DAS)	3.96 ab	3.91
T_{12} (125 ppm at 60 DAS)	3.51 a-c	3.89
T_{13} (150 ppm at 40 DAS)	3.86 ab	3.90
T_{14} (150 ppm at 60 DAS)	3.48 bc	3.90

Means followed by the same letter (s) in a column are not significantly different at 0.05 level of significance

Stover yield per hectare (t)

There was no significant different among treatments in stover yield per plant (Table 3). It ranged from 3.82 t (T_2) to 3.92 t (T_9). It showed that, there was no significant effect of various doses of GA_3 and stages of spray.

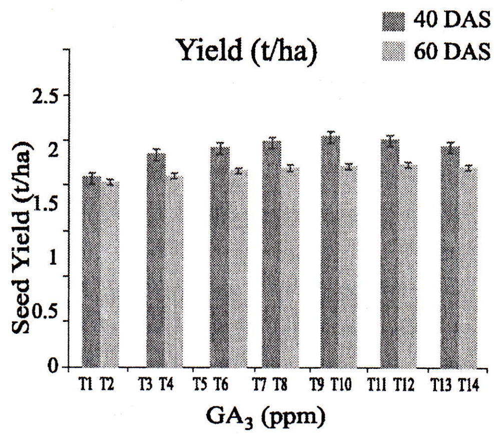

Fig. 3. Effect of GA_3 on seed yield (t/ha) in black cumin.

Vertical bars represent standard error of treatment means.

T_1, T_2 (control); T_3, T_4 (25 ppm); T_5, T_6 (50 ppm), T_7, T_8 (75 ppm); T_9, T_{10} (100 ppm); T_{11} T_{12} (125 ppm); T_{13}, T_{14} (150 ppm)

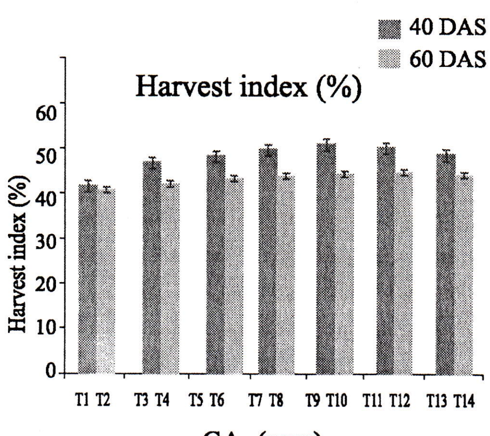

Fig. 4. Effect of GA_3 on harvest index (%) in black cumin.

Vertical bars represent standard error of treatment means.

T_1, T_2 (control); T_3, T_4 (25 ppm); T_5, T_6 (50 ppm), T_7, T_8 (75 ppm); T_9, T_{10} (100 ppm); T_{11} T_{12} (125 ppm); T_{13}, T_{14} (150 ppm)

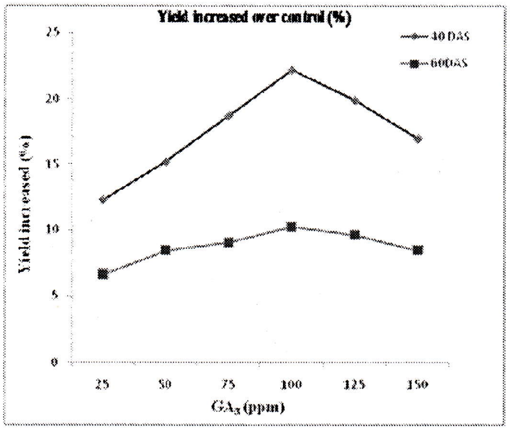

Fig. 5. Effect of GA_3 on seed yield increased over control

Harvest index (%)

A significant different was observed in harvest index (Fig. 4). T_9 showed the highest harvest index 53.32%, which was statistically similar to T_7 and T_{11}. On the other hand, the lowest harvest index was observed in T_2 (43.52%), which was statistically similar to T4.

Seed yield over control (%)

There was significant different in seed yield over control in various treatments (Fig. 5). It was the highest (22.22%) in T_9, which was statistically similar to T_7 and T_{11}. The lowest seed yield over control (6.63%) was observed in T_4. It was found that, with foliar application of GA_3 at concentration of 100 ppm both in vegetative and flowering stages, yield increased 22.22 and 10.00%

respectively over control. Shah *et al.* (2006) found, increasing yield 33% and 22% in vegetative and flowering stage respectively with foliar application of GA_3 at concentration of 10 -5 M.

It could be concluded that, foliar application of GA_3 with concentration of 100 ppm at vegetative stage enhanced the seed production of black cumin.

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