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Effect of Gibberellic Acid Spray on Growth, Nutrient Uptake and Yield Attributes During Various Growth Stages of Black Cumin (*Nigella sativa* L.)

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Abstract: Field trials were conducted on black cumin (*Nigella sativa* L.), sprayed with either deionized water (control) or 10^{-5} M GA_3 at 40 (vegetative stage) or 60 (flowering stage) Days after Sowing (DAS) to characterize the effects of hormone treatment on the mentioned parameters and select the suitable growth stage for spray in order to achieve desired results. Shoot length/plant, leaf number/plant, leaf area/plant, branch number/plant, dry weight/plant and accumulations of N, P and K were assayed at 70 DAS. Capsule number/plant, seeds capsule^{-1}, 1000 seed weight, seed yield q ha^{-1}, harvest index and Seed Yield Merit (SYM) were analyzed at harvest (130 DAS). It was noted that growth, NPK accumulation and seed yield were maximal when spraying of GA_3 was carried out at 40 DAS. However, spraying at 60 DAS was not much effective in terms of the parameters studied. Moreover, there was a significant difference in spray treatments at various growth stages only when GA_3 was sprayed and not when water was sprayed.

Key words: Dry matter production, gibberellic acid, *Nigella sativa*, NPK uptake, yield

INTRODUCTION

Nigella sativa L. is an important herb, used extensively in medicinal as well as in food formulations (Babayan *et al*., 1978; Takruri and Dameh, 1998). The extract of its seeds shows anticancerous activity and has been found much effective against Dalton's lymphoma ascites cells (Salomi *et al*., 1989). Moreover, the black seed oil has also been reported to increase the flow of bile experimentally and is of great use in paralysis, particularly facial paralysis, back pain and rheumatism (Riaz *et al*., 1996; Saeed *et al*., 1996). However, the supply of this medicinal plant through collection from forests, is not keeping pace with its continuous increasing demand in the domestic as well as international markets. As such there is an excellent scope for the promotion and extension of its cultivation to a commercial level. In this context, the use of growth regulators, particularly Gibberellic acid (GA_3) is thought to be trendsetting, as it addresses the improper source-sink relationship and internal hormonal imbalance occurring during growth. GA_3 is an essential growth hormone known to be actively involved in various physiological activities such as growth, flowering and ion transport (Wareing and Phillips, 1981; Takei *et al*., 2002; Khan and Samiullah, 2003), besides stimulating leaf area expansion (Brock, 1993) and inducing elongation and osmoregulation in internodes (Azuma *et al*., 1997), in addition to increasing dry matter and biomass production (Bhaskar *et al*., 1997; Gupta and Dutta, 2001).

Given the potential beneficence of these effects, along with the fact that hormone requirement, relative concentrations and responses are different at different growth stages (Robert, 1999) therefore, the present study was aimed at characterizing the effect of GA_3 on *Nigella sativa* L., sprayed during various growth phases.

MATERIALS AND METHODS

Field experiments were carried out during 1999-2000 and 2000-2001 at the Agricultural Farm, Aligarh Muslim University, Aligarh, India (27° 53′ N, 78° 54′ E and 187.45 m altitude) to select the most appropriate growth stage of *N. sativa* for GA_3 spray for augmenting productivity. The spraying of 10^{-5} M GA_3 was performed at 40 (vegetative stage) and 60 (flowering stage) Days after Sowing (DAS) of crop growth. GA_3 (10^{-5} M) was sprayed at the rate of 600 L ha^{-1} and the control set was applied with deionized water. The soil of the experimental plots was sandy loam and available N, P and K was 195.6, 21.7 and 229.6 kg ha^{-1}, respectively. Seeds were procured from the Regional Research Institute of Unani Medicine, Aligarh, India. They were surface sterilized with 0.01% mercuric chloride solution, followed repeated washings with double distilled water. The seeds were then sown in 24 m^2 plots and at the seedling stage at a distance of 30 cm between rows and 15 cm between plants in a row. Each treatment was replicated thrice.

Shoot length/plant, leaf number/plant, leaf area/plant, dry weight/plant and N, P, K uptake in plants were

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recorded at 80 DAS. Leaf area was calculated gravimetrically. The leaf area of 10% of total leaves in each treatment was determined by outlining on graph paper and the dry weight of these leaves was recorded. The leaf area/plant was computed using the leaf dry weight/plant and dry weight of those leaves for which the area was estimated (Watson, 1958). Dry weight/plant was recorded by drying the plants at 80°C for 24 h. The concentration of N and P in the plant was estimated, adopting the methods of Lindner (1944) and Fiske and Subba Row (1925), respectively. Content of K was analysed by flame photometer. The uptake of N, P and K were the product of their concentration in the plant and dry weight of plant. At maturity (130 DAS), capsules/plant, seeds/capsule, 1000 seed weight, seed yield ha^{-1} and Harvest Index (HI) were determined. Twenty plants from each plot were removed and the capsule number $plant^{-1}$ was recorded. Random samples were taken from threshed seeds for determination of the 1000 seed weight. The seed yield from three randomly selected plants was noted after threshing the seeds. Harvest index was determined by dividing the seed yield by the biological yield. Moreover, SYM was obtained by using the method given by Imsande (1992). Analysis of variance was carried out on the data obtained and LSD ($p = 0.05$) was calculated (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The effect of GA_3 administration on growth, nutrient uptake and yield was found to be significantly promotive, except for seeds/capsule, 1000 seed weight and HI (Table 1-3). It was also found that spraying of GA_3 at 40 DAS proved more stimulatory for the parameters studied in comparison to the 60 DAS spray. In context of the 40 DAS spray, promotion of growth in the crop may probably be because the spray was available at a stage when the plant was in the phase of maximum cell division and expansion at apical, lateral and intercalary regions through meristems and hence it enhanced the key constituents of the building blocks (organs) of the infrastructure of the plant maximally. At the time of division, these decisive cells need more nutrients, which are made available by the efficient manipulation, absorption and utilization of the available nutrients, triggered by the GA_3 spray (Shah, 2004). This ultimately may be the cause for more plant height, leaf number, leaf area and branch number (Table 1). Moreover, the GA_3 induced wall extensibility (Huttly and Phillips, 1995) leading to cell expansion may be assigned as another possible reason for the elongation of internodes (increase in plant height) (Moore, 1989; Taiz and Zeiger, 1998) and expansion of leaf area (Sarma, 1985; Khan, 1996; Khan *et al*., 1998), which inturn manifests itself in the form of more dry matter as observed (Table 1). This stance is further supported by the strong positive correlation between maximum leaf area and dry matter ($r = 0.925^{**}$). On the contrary, spraying at 60 DAS did not show such marked effects due to the inappropriate phase of stimulation, as by then the vegetative phase was already over.

Similarly, there was observed an increase in the nutrient uptake (Table 2) of the test plants due to the GA_3 spray, more prominent in the 40 DAS stage than in the 60 DAS stage. It is known that the application of GA_3 invokes the inherent genetic potential of the crop for maximum performance (Moore, 1989; Taiz and Zeiger, 1998). Also, as aforesaid, the spray of GA_3 during the active growth phase of the crop triggers judicious utilization of resources and results in a better source-sink relationship. Hence, the cause of increased nutrient uptake may be the increased assimilation of all nutrients effectively during the vegetative phase, under maximal uptake potential. Similar results have been obtained for GA_3 application on *N. sativa* and other crops by Stopkinska (1986), Khan *et al.* (1998), Mousa *et al.* (2001)

Table 1: Effect of 10^{-5} M GA_3 spray at different growth stages of black cumin (*Nigella sativa* L.) on shoot length/plant, leaf number/plant, leaf area/plant, dry weight/plant and branch number/plant at 70 DAS (average of 1999-2000 and 2000-2001)

Spray treatment	Spray stages (days after sowing)	Shoot length (cm)	Leaf No.	Leaf area (cm^2)	Drey weight (g)	Branch No.
Water	40 (vegetative)	46.51	29.10	295.10	1.78	7.55
	60 (flowering)	41.12	25.01	285.23	1.30	6.64
GA_3	40 (vegetative)	78.51	42.15	430.16	2.85	10.90
	60 (flowering)	61.41	35.94	370.25	2.24	9.05
LSD at 5%		12.05	5.120	22.160	0.16	1.61

Table 2: Effect of 10^{-5} M GA_3 spray at different growth stages of black cumin (*Nigella sativa* L.) on N, P and K uptake at 70 DAS (average of 1999-2000 and 2000-2001)

Spray treatment	Spray stages (days after sowing)	N uptake (mg/plant)	P uptake (mg/plant)	K uptake (mg/plant)
Water	40 (vegetative)	34.45	3.73	38.73
	60 (flowering)	33.30	3.41	34.42
GA_3	40 (vegetative)	60.41	6.01	64.50
	60 (flowering)	48.18	4.37	47.50
LSD at 5%		10.12	0.63	12.12

Table 3: Effect of 10^{-5} M GA_3 spray at different growth stages of black cumin (*Nigella sativa* L.) on capsule number/plant, seed number/capsule, 1000 seed weight, seed yield q ha^{-1}, harvest index and seed yield merit (SYM) at harvest 130 DAS (average of 1999-2000 and 2000-2001)

Spray treatment	Spray stages (days after sowing)	Capsule number/plant	Seeds/capsule	1000 seed weight (g)	seed yield (q ha^{-1})	Harvest Indes (%)	SYM
Water	40 (vegetative)	16.50	52.01	2.50	8.31	30.21	251.04
	60 (flowering)	15.26	52.17	2.45	8.07	30.01	242.18
GA_3	40 (vegetative)	23.75	55.21	2.55	11.12	31.36	348.72
	60 (flowering)	19.60	54.91	2.50	9.92	31.45	311.98
LSD at 5%		3.210	NS[1]	NS[1]	1.03	NS[1]	14.210

[1]Not significant

and Hashmi (2003). Further the nutrient uptake did not show marked increase during the 60 DAS stage, which may have been because, as the plant ages, there is reduced influx of nutrient by the old and suberized roots (Barbar, 1980). Moreover, the translocation of nutrient to sinks (seeds) during their formation and subsequent development of fruit can also be reasonably considered to be responsible for nutrient depletion at later stages of growth.

With regard to various yield attributes taken under study, the treatment with GA_3 proved more effective at the 40 DAS stage in increasing the number of capsules/plant, seed yield and seed yield merit, than at the 60 DAS stage. However, either treatment did not show much effect on HI, number of seeds/capsule or the 1000 seed weight, which may be attributed to the dilution with growth effect, arising due to the voluminous sink (Table 3). As per Thorne (1966), vegetative growth before flowering has considerable influence on the yield of the crop. Synchronously, in our research, spraying at a phase that coincides with intense vegetative growth resulted in higher demand for absorption of nutrients and water to bring the best out of the crop, in the form of enhanced number of capsules and subsequently, seed yield and seed yield merit. In other words, the ample availability of nutrients, efficient re-directed mobilization of metabolites and the modification of the rate or duration of dry mass accumulation at the critical growing phase induced by the hormone treatment (Davies, 1995; Naidu and Swamy, 1995), coupled with the delayed senescence and prevented abortion of plant organs under GA_3 administration (Noden and Leopold, 1978), Saks and Vanstaden (1992) can be said to be responsible for the observed increase in yield of the crop. Such findings gain support from those of Saran and Mehta (1985), Khan *et al.* (1998) and Mousa *et al.* (2001).

Simultaneously, it is assumed that seed yield and harvest index frequently do not provide satisfactory measures of plant yield efficiency, because a large plant may have high yield and low harvest index and a small plant may have vice-versa. Seed yield merit which combines the merits of these two traits (Imsande, 1992), was also found to be influenced by the GA_3 spray in our study. It would hence be safe to conclude that spray of GA_3 at the vegetative phase (40 DAS) holds promising potential for the productivity and overall performance of *N. sativa* L.

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