



Influence and Assessment of Elicitor's Application on Black Cumin (*Nigella sativa* L.) for Growth, Phenological and Reproductive Characters

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ABSTRACT: The seed spices comprise of a group which includes all those annuals whose dried fruit or seeds are used as spice. Black cumin is one of the important emerging seed spice/annual spicy herb. In the recent years, the use of elicitors is found to be one of the best possible ways to achieve spectacular progress in increasing production, productivity and quality of seed spices. In this view, a field experiment was carried out with foliar spraying of different elicitors in black cumin. The results of the study inferred that, plants applied with various elicitors exhibited significant differences in growth, phenological and reproductive characters. Application of NAA at 25 ppm recorded maximum plant height (50.6 cm) whereas; the plants treated with ancymidol at 50 ppm manifested the lowest plant height (33.9 cm). Foliar spraying of salicylic acid at 50 ppm recorded maximum stem girth (4.98 mm) at harvest. The maximum fresh and dry weight (42.35 & 8.89 g/plant respectively) of whole plant was noted in plants treated with salicylic acid at 50 ppm. Among the various elicitors tried, application of ancymidol at 50 ppm significantly promoted the synthesis of chlorophyll content (24.33 SPAD value) subsequently by paclobutrazol at 50 ppm (20.50 SPAD value). With respect to reproductive parameters, early flowering and crop maturity was noticed in plants treated with salicylic acid at 50 ppm, which took minimum number of days to first flowering, fifty percent flowering and to reach crop maturity (45.3, 52.2 and 108.1 days respectively).

Keywords: *Nigella sativa* L., Black cumin, Elicitors, Phenological characters, Light intensity ratio, Chlorophyll content, SPAD value, Ancymidol, Days to first flower appearance.

INTRODUCTION

The history of spices in India dates back thousands of years, making it the "Spice Bowl of the World". India is the largest producer, consumer and exporter of spices. Among the 109 spices listed by the International Organization for Standardization (ISO), India produces 63 spices. According to NRCSS out of 63 spices, 20 of them are seed spices. Seed spices are annual herbs, whose dried seeds or fruits are used as spice. Seed spices are the important export oriented commodities which play a significant role in our national economy because of its large domestic consumption and growing demand for export. India is exporting about 14 percent of its production annually and full fills nearly 50 percent of world demand. The total export of seed spice crops is Rs. 3738 crore, out of which cumin alone contributes Rs. 2418 crore annually (Lal, 2018). They

are primarily used for flavouring, seasoning and imparting aroma to variety of food items and beverages. Besides their importance in food industry, the seed spices have medicinal properties and thus, used by various pharmaceutical and cosmetic industries.

The seed spices comprise of a group which includes all those annuals whose dried fruit or seeds are used as spice. The seed spices are aromatic vegetable products of tropical origin and are commonly used in pulverized state, primarily for seasoning or garnishing the foods and beverages. These are also used in preparation of various value-added products viz., spice oils, oleoresins and spice powders. Seed spices possess industrial importance and are used in cosmetic, perfumery and various pharmaceutical preparations medicines. The important among them are coriander, cumin, fennel, fenugreek, ajwain, dill, celery, anise, nigella and caraway. The seed spices constitute an important group

of agriculture commodities and play a significant role in our national economy. Seed spices account for about 51.79 per cent and 19.06 per cent of total area and production of spices in the country. Almost all the seed spices are winter season crops (Rabi), need cool weather conditions for better growth and development. Frost, late winter rainfall, infestation by disease, pests etc., leads to major damage to these crops and also adversely affect the quality and quantity of production. Production of seed spices has critical constraints which need to be tackled on priority basis. The most important constraint adversely affecting the promotion of these crops to farmers for diversification of the existing cropping system is low productivity. The major factors presently contributing to low productivity are very low seed replacement rate, the lack of authentic seeds of improved varieties, growing of these crops in low/marginal soil fertility and drought prone conditions, attack of major pest and diseases and above all unorganized marketing. Rajasthan and Gujarat have emerged as "Seed Spice Bowl" and together contribute more than 80 per cent of the total seed spices production in the country. Other important seed spice growing states are Madhya Pradesh, Orissa, Tamil Nadu, Andhra Pradesh, Karnataka, Bihar, Uttar Pradesh, Punjab and West Bengal. India grows about twenty important seed spices (Anonymous, 2022).

Black cumin (*Nigella sativa* L.) is one of the important emerging seed spice/annual spicy herb, belongs to the Ranunculaceae family and native to Southern Europe, North Africa and Southwest Asia. It is generally short-lived annual typical of disturbed natural communities of semiarid areas with a dominance of therophytes. Plants mature in one year and are between one and two feet tall (60-70 cm). Its leaves are gray-green, its flowers are colored white to blue, and its fruits are capsules containing numerous black aromatic seeds. The seeds contain up to 40% fixed oil and about 1.5% essential oil. It is known as a medicinal plant with extensive pharmaceutical, nutritional, and health applications. Like most herbs, the composition of black cumin varies with geographic distribution, time of harvest and agronomic practices. The dried seeds of black cumin are the commercial products used in food. Seeds contain up to 40% fixed oil and about 1.5% essential oil, which has great demand in the pharmaceutical, food and perfumery industry (Datta *et al.*, 2012). Scientific investigations have depicted its composition of oils, proteins, carbohydrates, fibers, ashes, moisturizers etc. The seed also contains good amount of vitamins and minerals like Cu, P, Zn and Fe. The fixed oil contains linoleic (50-60%), oleic (20-23.4%), palmitic (12.5%), dihomolinoleic (10%), and eicosadienoic (3%) acids as well as arachidonic, stearic and myristic acid, betasitosterol, cycloecalenol, cycloartenol, sterol esters and sterol glucosides along with other minor lipid constituents such as methylnonadeca-15, 17-dienoate, pentylhexadec-12-enoate, and pentylpentadec-11-enoate. Its health enhancing potential has been attributed to the active ingredients that are mainly concentrated in fixed or essential oil (Ramadan, 2007). Black cumin fixed oil is lipid fraction containing fatty

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acids, fat-soluble vitamins and small amounts of volatile constituents, whereas its essential oil comprises of only volatiles. The therapeutic and curative properties are due to the presence of nigellicine, nigellidine, thymoquinone, dithymoquinone, thymol and carvacrol (Gholamnezhad *et al.*, 2016).

The seeds are widely used in the treatment of various diseases like bronchitis, asthma, diarrhoea, rheumatism and skin disorders. It is also used as liver tonic, digestive, antidiarrhoeal, appetizer, stimulant, diuretic, antihypertensive, antidiabetic, anticancerous, emmenagogue, to increase milk production in nursing mothers, to fight parasitic infections, and to support immune system. Most of the therapeutic properties of this plant are due to the presence of thymoquinone (TQ) which is a major active chemical component/ingredient of the essential oil (Ahmad *et al.*, 2013).

Black cumin is cultivated as an aromatic plant in different parts of Asia, Europe, Africa, and the Americas. In India black cumin is grown as winter crop in tropics and spring crop in temperate regions. Its cultivation is mostly restricted to Northern states, where it is grown commercially with suitable elite varieties covering large area. Considering the importance, demand and price offered for this spice cum medicinal crop across the country, farmers in the non-traditional areas are fascinated for the cultivation of black cumin. Physiological growth of black cumin is affected mainly by ecological, genetic and various other factors including the application of elicitors. Originally the term elicitor was used for molecules capable of inducing the production of phytoalexins, but it is now commonly used for compounds stimulating any type of plant defense. Eventually, the induction of defense responses may lead to enhanced resistance. This broader definition of elicitors includes both substances of pathogen origin (exogenous elicitors) and compounds released from plants by the action of the pathogen (endogenous elicitors). Elicitors are classified as physical or chemical, biotic or abiotic, and complex or defined depending on their origin and molecular structure (Hahn, 1996).

Elicitors may be divided into two groups, "general elicitors" and "race specific elicitors". While general elicitors are able to trigger defense both in host and non-host plants, race specific elicitors induce defense responses leading to disease resistance only in specific host cultivars. A complementary pair of genes in a particular pathogen race and a host cultivar determines this cultivar specific (gene-for-gene) resistance. Thus, a race specific elicitor encoded by or produced by the action of an avirulence gene present in a particular race of a pathogen will elicit resistance only in a host plant variety carrying the corresponding resistance gene. The absence of either gene product will often result in disease (Nurnberger and Scheel 2001). In contrast, general elicitors signal the presence of potential pathogens to both host and non host plants. The nonspecific nature of general elicitors is relative, however, and some of these are only recognized by a restricted number of plants. Recent studies have indicated remarkable similarities between the defense

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mechanisms triggered by general elicitors and the innate immunity of animals, and it is tempting to speculate that the recognition of general elicitors subsequently leads to plant innate immunity. Elicitors act as signal compounds at low concentrations, providing information for the plant to trigger defense, distinguishing elicitors from toxins, which may act only at higher concentrations and/or affect the plant detrimentally without active plant metabolism (Thakur and Sohail 2013).

In the recent years, the use of elicitors is found to be one of the best possible ways to achieve spectacular progress in increasing production, productivity and quality of seed spices. Elicitors are the substances which induce physiological changes in the plant. Plants respond to these elicitors by activating an array of mechanisms, similar to the defense responses to pathogen infections or environmental stimuli, affecting the plant metabolism and enhancing the synthesis of phytochemicals (Baenas *et al.*, 2014). These elicitors enhance the plant secondary metabolite synthesis and could play an important role in biosynthetic pathways for enhanced production of commercially important compounds that contribute for the quality of raw material (Angelova *et al.*, 2006) and (Elyasi *et al.*, 2016). The trials of elicitors application on seed spice crops are very limited and the literature available is also very less in this work. Considering this a study has been conducted to assess the effect of different elicitors on growth, yield and quality of black cumin.

MATERIAL AND METHODS

The field experiment was carried out during rabi season at the Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, UHS Campus, GKVK, Bengaluru. The location is situated at an altitude of 930 m above Mean Sea Level (MSL), positioned at 12° 58' North Latitude and 77°35' East Longitude, falling within the Eastern Dry Zone (zone-5) of Karnataka. The experiment was laid out in a randomized complete block design with three replications and twelve treatments. The treatments included T₁ – Control, T₂ - Pinching at 50 days after sowing, T₃ - Salicylic acid - 50 ppm, T₄ - Chitosan - 100 ppm, T₅ - Dry yeast - 5000 ppm, T₆ - Potassium silicate - 200 ppm, T₇ - NAA - 25 ppm, T₈ - Kinetin - 25 ppm, T₉ - Humic acid - 500 ppm, T₁₀ - PGPR - 5000 ppm, T₁₁ - Ancymidol - 50 ppm, T₁₂ - Paclobutrazol - 50 ppm. The elicitors were applied 50 days after sowing, primarily through foliar spray. Five plants in each treatment and in each replication were selected randomly and tagged for recording observations for plant characters and yield attributes.

The experimental area was brought to a fine tilth by ploughing. The clods were crushed and weeds removed. Then, the plots of 3.0 m length and 1.5 m width were prepared with each plot separated by bunds of 0.75 m width all round. The blocks/replications were laid out at a distance of 2 m from each other to prevent flow/percolation of rain water and nutrients. Each plot was thoroughly levelled and shallow furrows were made for sowing of seeds. Plots measuring 3m x 1.5m

(4.5 m²) were laid out, and farmyard manure at a rate of 5 tons per hectare, along with the full dose of NPK (40:20:20 kg/ha), was applied. Seeds of black cumin variety Ajmer Nigella-1 were procured from National Research Centre on Seeds Spices, Ajmer, Rajasthan and sown at a depth of 1-1.5 cm in shallow furrows spaced at 30 X 10 cm. Germination occurred within 12 days of sowing, with the entire process completed within 15 days. The plots were irrigated immediately after sowing and irrigation was given through drip system with 16 mm inline laterals with a discharge of 8 LPH (liters per hour). Thinning was done at 25 days after sowing. The plots were kept completely free from weeds by regular hand weeding at 20 days interval till crop maturity. Root rot was the only serious disease noticed throughout the growth period. Control measures were taken by drenching Ridomil M gold at 2 g/l and SAAF at 2g/l alternatively when disease was noticed as a spot application. The crop was harvested when capsules attained full maturity and turned brownish from immature green colour. The plants were cut at ground level by using secateurs and tied into small bundles and stacked in threshing yard for drying with frequent up turnings till moisture level was reduced. Seeds were separated by threshing and cleaned by winnowing.

Observations on growth parameters were recorded on five randomly selected plants in each plot under each replication. Plant height was measured in five tagged plants from the ground level to the growing tip of the main stem at harvest in each treatment and the mean values were computed and expressed in centimeter. The total number of primary and secondary branches arising from the main stem and primary branches respectively above the ground level in all the five tagged plants was counted at harvest and their mean value per plant for each treatment was calculated and expressed as number of primary and secondary branches per plant. Main stem girth was measured at harvest using digital Vernier calipers. The stem diameter was measured by placing the plant stem between the calipers jaws. Mean was recorded and expressed in millimeter. Five plants in each net plot were randomly uprooted and immediately their total fresh weight was recorded. Further they were kept in oven for drying. Their dry weight was recorded after complete drying when the plants recorded same weight for two consecutive days and mean was computed and expressed in grams. Chlorophyll content was recorded by using Soil Plant Analysis Development (SPAD) chlorophyll meter at 60 days after sowing. SPAD value was recorded for 5 leaves in each tagged plant and mean was expressed as SPAD values. Harvest index is calculated as the ratio of economical yield to biological yield and is expressed in percentage. Light intensity ratio (LTR) was recorded in five tagged plants at the top, middle and bottom of plant canopy and LTR was calculated by using the following formula.

$$\text{LTR (middle)} = \frac{\text{Light intensity at the middle of the canopy} \times 100}{\text{Light intensity at the top of the canopy}}$$

$$\text{LTR (bottom)} = \frac{\text{Light intensity at the bottom of the canopy} \times 100}{\text{Light intensity at the top of the canopy}}$$

Statistical Analysis

The data collected during the experimentation was analyzed by randomized completely block design (RCBD). Statistical analysis was performed using Web Agri Stat Package (WASP) Version 2 (Jangam & Thali 2010). The level of Significance used in 'F' was $p=0.05$. Critical difference values were calculated whenever F-test was found significant.

RESULTS AND DISCUSSION

A. Growth parameters

The results of the experiment on the growth attributes of black cumin (*Nigella sativa* L.) are summarized in Table 1. Plant height at harvest differed significantly due to various elicitor treatments. Foliar spraying of NAA at 25 ppm (T₇) recorded highest plant height (50.6 cm) followed by salicylic acid at 50 ppm (49.1 cm) which were at par and differed significantly from rest of the treatments. Whereas, the plants treated with ancymidol at 50 ppm (T₁₁) manifested the lowest plant height (33.9 cm) followed by paclobutrazol at 50 ppm (36.0 cm). The increase in plant height might be due to the stimulatory effect of NAA that promotes cell elongation and cell enlargement at growing points. The suppression of plant height due to the application of ancymidol could be due to suppressed internodal elongation due to reduction in cell elongation, rather than reduction in cell number. The reduction or stagnation in plant height with paclobutrazol application may be due to the mode of action of this chemical as a suppressor of GA biosynthesis, thereby altering the endogenous profile of these compounds within the plant. These results found clear support in the similar studies for the increase in plant height by (Pariari *et al.*, 2012) wherein, they reported that, GA₃ at 100 ppm registered maximum plant height in black cumin. (Pavankumar *et al.*, 2018) reported increased plant height with treatment of GA₃ at 50 ppm in black cumin. (Rahimi *et al.*, 2013) propounded that, salicylic acid at 0.01 mM significantly promoted plant height in cumin. Similar pattern of results were also obtained by (Banu *et al.*, 2023) in black cumin, (Mostafa, 2015) in fennel, (El-Gamal and Ahmed 2016) in coriander and (Ahmed *et al.*, 2018) in celery. The supporting results pertaining to reduction in plant height were reported by (Setia *et al.*, 1995) in *Brassica carinata*.

Elicitors had a profound impact on number of primary and secondary branches per plant at all the stages of crop growth till harvest. The application of elicitors caused significant differences in number of primary and secondary branches per plant, though maximum number of primary and secondary branches per plant was registered in plants pinched at 50 days after sowing (8.40 & 16.38) followed by the application of salicylic acid at 50 ppm (8.20 & 15.17) and NAA at 25 ppm (7.17 & 14.38) which were on par with each other and significantly different from rest of the treatments. On the other hand, the minimum number of primary and secondary branches per plant was observed in plants applied with ancymidol at 50 ppm (3.19 & 7.38) and paclobutrazol at 50 ppm (3.83 & 8.81) was the next minimum, which were at par. Increase in the number of

primary and secondary branches per plant can be attributed to pinching of the apical bud, which overcomes apical dominance, an important role in longitudinal growth. Therefore, removing the apical buds leads to an increase in lateral buds and thereby, increases the number of primary and secondary branches. The beneficial effects of pinching may be increased number of flowers because of an increase in primary branches and reduced plant height by removing apical dominance. Pinching temporarily reduces auxin which takes away the apical dominance and it increases cytokinin concentration that promotes cell division in plants. The results are in concurrence with the earlier findings of (Bairagi, 2016), wherein, they reported that, pinching at 30 DAS resulted in production of maximum number of primary and secondary branches in fenugreek. (Abbasi *et al.*, 2019) reported that, salicylic acid increases some growth regulators including cytokinin, which stimulates the growth of lateral buds in cucumber. Likewise, (Shah and Samiullah 2006) in black cumin, (El-Gamal and Ahmed 2016) in coriander, (Rezazadeh and Harkess 2015) in purple firespike, (Mutlu and Agan 2015) in ornamental pepper and (Ahmad *et al.*, 2014) in potted ornamental plants and plugs have also concluded with similar results. Whereas, the decreased number of primary and secondary branches in ancymidol treatment might be due to inhibition of gibberellin (GA) in plants, which is known to stimulate cell division, cell elongation and development of lateral buds. The results of the present study are in line with previous studies of (Ahmad, 2012) in *Hibiscus rosa-sinensis*.

Main stem girth at harvest varied significantly due to various elicitors used. Foliar spraying of salicylic acid at 50 ppm resulted in maximum stem girth at harvest (4.98 mm), closely followed by NAA at 25 ppm (4.78 mm) and pinching plants at 50 days after sowing (4.62 mm), which were significantly different from the other elicitors tried. The minimum stem girth at harvest was registered in plants applied with ancymidol at 50 ppm (3.45 mm), followed by paclobutrazol at 50 ppm (3.62 mm) which were at par. The increase in main stem girth may be due to salicylic acid increases the amount of lignin in the cell wall structure, which can be an influencing factor in increasing the stem girth of the plants. These results are consistent with the findings of (Seyed and Aliloo 2013) who reported that, the use of salicylic acid at 50 ppm increased the diameter of the liliium stem and higher concentrations had a negative effect. It seems that the positive effect of salicylic acid on growth traits is also the result of an increase in CO₂ absorption and the relative chlorophyll concentration and photosynthesis ratio (Karlidag *et al.*, 2009). However, the application of ancymidol resulted in shorter more rigid stems which might be due to reduced cell enlargement and cell division. A similar conclusion was drawn by (Warner and Erwin 2003) in hibiscus. Plants applied with elicitors manifested significant differences in fresh and dry weight of whole plant. The maximum fresh and dry weight (42.35 & 8.89 g/plant respectively) of whole plant was noted in plants treated with salicylic acid at 50 ppm (T₃) followed by NAA at

25 ppm (38.03 & 7.99 g/plant respectively) and potassium silicate at 200 ppm (36.23 & 7.61 g/plant respectively) which were on par and significantly different from rest of the treatments. But, the lowest fresh and dry weight of whole plant was recorded in plants applied with ancymidol at 50 ppm (18.68 & 3.92

g/plant respectively), followed by paclobutrazol at 50 ppm (21.60 & 4.54 g/plant respectively) which were at par with one another. The variation in fresh and dry of whole plant may be due to environmental conditions that prevailed during the crop growth period.

Table 1: Influence of elicitors on mean values of different growth parameters of black cumin (*Nigella sativa* L.).

Treatments	Plant height (cm) at harvest	No. of primary branches per plant	No. of secondary branches per plant	Main stem girth (mm)	Fresh weight of whole plant (g/plant)	Dry weight of whole plant (g/plant)
T ₁ - Control	41.0 ^{cd}	4.60 ^{de}	10.03 ^b	3.84 ^{cde}	31.48 ^{bcd}	6.61 ^{bcd}
T ₂ - Pinching at 50 DAS	39.6 ^{de}	8.40 ^a	16.38 ^a	4.62 ^{abc}	27.10 ^{cdef}	5.69 ^{cdef}
T ₃ - Salicylic acid 50 ppm	49.1 ^{ab}	8.20 ^a	15.17 ^a	4.98 ^a	42.35 ^a	8.89 ^a
T ₄ - Chitosan 100 ppm	40.1 ^{de}	5.12 ^{cde}	10.25 ^b	3.70 ^{de}	29.15 ^{bcd}	6.12 ^{bcd}
T ₅ - Dry yeast 5000 ppm	45.0 ^{bc}	5.22 ^{bcd}	10.32 ^b	4.36 ^{abcd}	29.78 ^{bcd}	6.25 ^{bcd}
T ₆ - Potassium silicate 200 ppm	42.0 ^{cd}	5.98 ^{bcd}	9.90 ^b	4.00 ^{bcd}	36.23 ^{abc}	7.61 ^{abc}
T ₇ - NAA 25 ppm	50.6 ^a	7.17 ^{ab}	14.38 ^a	4.78 ^{ab}	38.03 ^{ab}	7.99 ^{ab}
T ₈ - Kinetin 25 ppm	42.4 ^{cd}	6.73 ^{abc}	10.92 ^b	3.80 ^{cde}	33.28 ^{abcd}	6.99 ^{abcd}
T ₉ - Humic acid 500 ppm	39.1 ^{de}	4.85 ^{cde}	9.80 ^{bc}	4.27 ^{abcde}	27.13 ^{cdef}	5.70 ^{cdef}
T ₁₀ - PGPR 5000 ppm	41.9 ^{cd}	4.69 ^{cde}	10.13 ^b	4.38 ^{abcd}	24.67 ^{def}	5.18 ^{def}
T ₁₁ - Ancymidol 50 ppm	33.9 ^f	3.19 ^e	7.38 ^c	3.45 ^e	18.68 ^f	3.92 ^f
T ₁₂ - Paclobutrazol 50 ppm	36.0 ^{ef}	3.83 ^e	8.81 ^{bc}	3.62 ^{de}	21.60 ^{ef}	4.54 ^{ef}
F - test	**	**	**	*	**	**
S. Em ±	1.6	0.70	0.84	0.30	3.51	0.74
CD at 5%	4.8	2.04	2.46	0.87	10.30	2.16

* Significant at 5%

** Significant at 1%

NS - Non significant

Means of the same category followed by different letters are significantly different as per DMRT test

The positive effect of salicylic acid might be due to its modulating effect on the expression of numerous genes and influences specific aspects of plant growth and development. Since salicylic acid improves the plant-water relationships and plays an important role in the absorption and transportation of ions, it seems that, it had maintained sufficient water in the plant system thereby increased fresh weight of different plant parts as compared to other treatments (Hayat *et al.*, 2010). Salicylic acid is also effective on nutrients absorption, which seems to contribute to the nutrient elements absorption in the root due to its high proton activity. In addition, it improves photosynthesis along with increased photosynthetic products and dry weight of different plant parts (Hamada and Al-Hakimi 2001). Overall, these findings are in accordance with the findings reported by (Abbasi *et al.*, 2019) wherein, significant increase in fresh and dry weight of leaves, stem and fruits was observed in cucumber with foliar spraying of salicylic acid at 0.01 mM. Similarly, (Fariduddin *et al.*, 2003) reported that, foliar application of 10.00 µmol of salicylic acid resulted in more dry matter than the control in rapeseed. Likewise, (Ahmed *et al.*, 2018) in celery and (Mondal *et al.*, 2011) in Indian spinach. The decrease in fresh and dry weight of whole plant in black cumin might be due to lowered water use efficiency with increased ancymidol concentration. This is consistent with what has been found in previous study by (Ahmad *et al.*, 2014) in ornamental plants and zinnia plugs.

B. Phenological parameters

The data in respect of phenological parameters of black cumin as influenced by various elicitors is presented in Table 2. Among the various elicitors tried, application of ancymidol at 50 ppm significantly promoted the synthesis of chlorophyll and recorded maximum chlorophyll content (24.33 SPAD value) subsequently by paclobutrazol at 50 ppm (20.50 SPAD value), which were at par with each other and significantly different from the other elicitors. While, the control plants (T₁) recorded the least chlorophyll content (8.88 SPAD value) followed by foliar spraying of PGPR at 5000 ppm (and 9.97 SPAD value) which were at par with one another. Increased chlorophyll content due to ancymidol may be attributed to an indirect role in increasing the chlorophyll content by regulating the uptake of nutrient elements required for chlorophyll synthesis and also by increasing IAA and cytokinin, thereby delaying the senescence of the leaves. The darker green foliage might also be due to the function of ancymidol in increasing chlorophyll biosynthesis and reducing leaf expansion along with normal chlorophyll biosynthesis. This may be also due to the fact that, ancymidol protects photosynthetic apparatus through increasing the ability of cell anti-oxidation and new proteins synthesis. The results are in agreement with the findings of (Starman *et al.*, 1990), who reported that, ancymidol at 130 ppm increased the chlorophyll content regardless of stage of leaf development in *Helianthus annuus* L. Similarly, (Mutlu and Agan 2015) reported that, paclobutrazol increased

chlorophyll SPAD value in ornamental pepper. (Yildrium and Dursan 2009) and (Kazemi, 2014) recorded similar findings in tomato and (Gharib, 2006) in sweet basil and marjoram. However, application of

elicitors did not bring about any significant change in light transmission ratio at middle and bottom of the canopy. The non-significant differences might be due to uniform dense canopy of the plants.

Table 2: Influence of elicitors on mean values of phenological parameters of black cumin (*Nigella sativa* L.).

Treatments	Chlorophyll content (SPAD values)	Light transmission ratio (%)	
		Middle	Bottom
T ₁ - Control	8.88 ^h	16.1	2.1
T ₂ - Pinching at 50 DAS	16.81 ^{cd}	16.1	2.5
T ₃ - Salicylic acid 50 ppm	14.19 ^{def}	18.0	2.4
T ₄ - Chitosan 100 ppm	18.25 ^{bc}	18.6	2.4
T ₅ - Dry yeast 5000 ppm	13.66 ^{ef}	15.6	1.5
T ₆ - Potassium silicate 200 ppm	18.57 ^{bc}	14.9	1.7
T ₇ - NAA 25 ppm	14.85 ^{de}	16.1	1.5
T ₈ - Kinetin 25 ppm	12.67 ^{efg}	17.5	2.1
T ₉ - Humic acid 500 ppm	11.24 ^{fgh}	16.5	2.0
T ₁₀ - PGPR 5000 ppm	9.97 ^{gh}	16.0	2.1
T ₁₁ - Ancyimidol 50 ppm	24.33 ^a	15.3	1.8
T ₁₂ - Paclobutrazol 50 ppm	20.50 ^b	16.1	2.3
F - test	**	NS	NS
S. Em ±	1.05	1.7	0.3
CD at 5%	3.07	-	-

* Significant at 5%

** Significant at 1%

NS - Non significant

Means of the same category followed by different letters are significantly different as per DMRT test

C. Reproductive parameters

The data recorded on reproductive characters like days to first flower appearance, days to 50 per cent flowering and days to crop maturity as influenced by various elicitor treatments are presented in Figure 1. Number of days taken for first flower appearance differed significantly due to different elicitor treatments imposed during the course of investigation. Early flowering was noticed in the control plants, which recorded minimum days to first flowering (45.7 days) followed by the application of salicylic acid at 50 ppm (45.3 days) which were at par with each other and differ significantly from the rest of elicitor treatments. While, delayed flowering was noticed in plants pinched at 50 days after sowing (T₂) which took maximum number of days to first flowering (48.5 days), followed by the application of humic acid at 500 ppm (48 days) and ancymidol at 50 ppm (48.2 days). Days to 50 per cent flowering also clearly indicates the significant influence of elicitor's application in black cumin. Minimum number of days was recorded for 50 per cent flowering (52.2 days) in plants applied with salicylic acid at 50 ppm (T₃), followed by T₁₂ (53.8 days). In contrast, maximum number of days was registered for 50 per cent flowering (59.7 days) in plants pinched at 50 days after sowing, which differed significantly from rest of the treatments. This might be due to the fact that, pinching prolonged the vegetative growth of plants by diverting the photosynthates from apical meristem to the lateral buds thereby, keeping the plants in vegetative phase for long time and restricting the plants from entering into early reproductive stage. These results are in line with the findings of (Arora & Khanna 1986), who suggested that, pinching delayed the flowering in marigold by 10 to 12 days under Ludhiana conditions. Similarly, (Phetpradap *et al.*, 1994)

observed the effect of pinching in hybrid dahlia and suggested that, pinching increases days to first flowering (81 days), as compare to without pinching (67 days) and (Kumar *et al.*, 2002) reported that, pinching in carnation resulted in delayed bud initiation, flower opening and peak flowering in comparison to control. Days taken for crop maturity due to various elicitors application clearly showed significant impact on crop maturity. The plants pinched at 50 days after sowing (T₂) took maximum number of days to reach maturity (112.7 days), which is a significant delay compared to other treatments under study. Whereas, the other elicitor treatments such as T₃ (108.1 days), T₆ (108.1 days), T₈ (108.3 days), T₄ (108.6 days), T₁₀ (108.6 days), T₇ (108.8 days), T₅ (109.3 days), T₁₁ (109.4 days), T₁₂ (109.7 days) and T₁ (109.8 days) resulted in early crop maturity, which were on par with each other. The delayed maturity in plants pinched manually at 50 DAS may be due to delay in first flower appearance and flowering in fifty per cent of the plants. It might also be due to prolongation of vegetative and reproductive phase by diverting the photosynthates from apical meristem to the lateral buds which could be attributed to maximum days taken for maturity. In contrary, the early maturity of the crop due to various elicitors application may be due to their interaction with various phytohormones, which resulted in advancement of reproductive phase from vegetative growth by early initiation and completion of flowering period that promoted synthesis of ethylene and enhanced senescence of the plant. Similar conclusion has been drawn by (Arpitha *et al.*, 2024) in black cumin, (Gaash and Lavee 1972) in peach and apricot, (Rotbaum *et al.*, 2005) in sweet cherry, wherein harvesting was delayed by 7 days due to GA₃ application regardless of concentration.

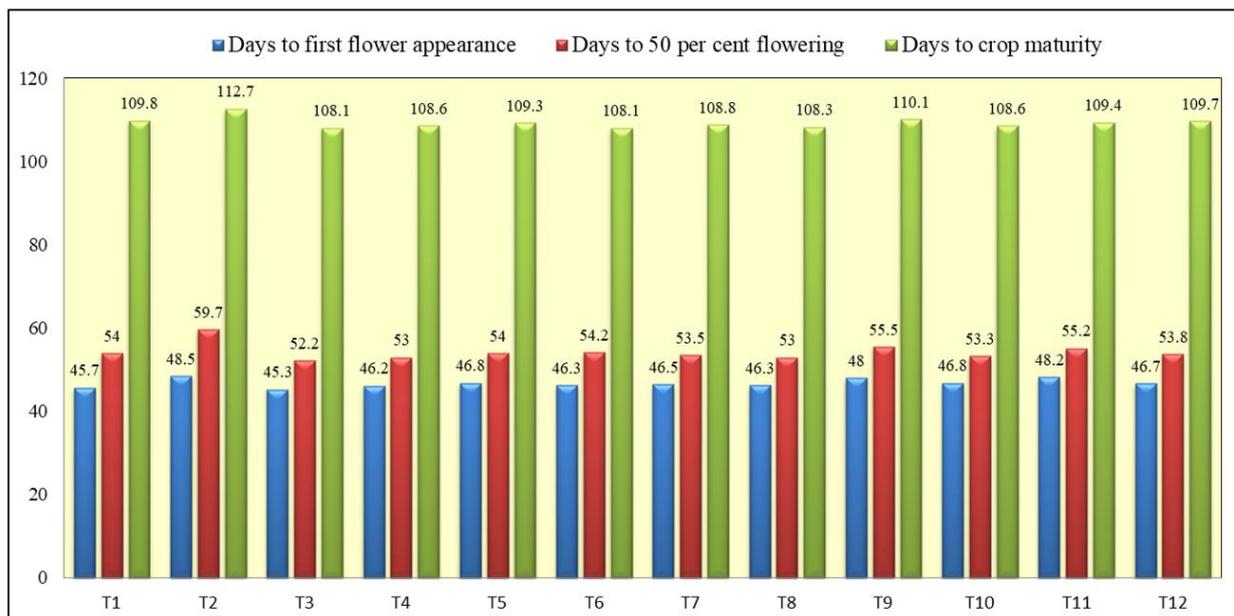


Fig. 1. Influence of elicitors on reproductive parameters in black cumin (*Nigella sativa* L.).

- | | | |
|--|---|---------------------------------------|
| T ₁ - Control | T ₅ - Dry yeast 5000 ppm | T ₉ - Humic acid 500 ppm |
| T ₂ - Pinching at 50 DAS | T ₆ - Potassium silicate 200 ppm | T ₁₀ - PGPR 5000 ppm |
| T ₃ - Salicylic acid 50 ppm | T ₇ - NAA 25 ppm | T ₁₁ - Ancymidol 50 ppm |
| T ₄ - Chitosan 100 ppm | T ₈ - Kinetin 25 ppm | T ₁₂ - Paclbutrazol 50 ppm |



Fig. 2. Experimental filed at thirty days after sowing before spraying of elicitors.



Fig. 3. Experimental filed at sixty days after sowing after spraying of elicitors.

CONCLUSION

Black cumin plants applied with various elicitors exhibited significant differences in growth, phenological and reproductive characters. Application of NAA at 25 ppm recorded maximum plant height (50.6 cm) whereas; the plants treated with ancymidol at 50 ppm manifested the lowest plant height (33.9 cm).

Manual pinching of black cumin plants at 50 days after sowing recorded highest number of primary and secondary (8.40 and 16.38) branches at harvest, followed by the application of salicylic acid at 50 ppm (8.20 & 15.17). Foliar spraying of salicylic acid at 50 ppm recorded maximum stem girth (4.98 mm) at harvest. There was also a significant difference in fresh and dry weight of whole plant when the elicitors were

applied. The maximum fresh and dry weight (42.35 & 8.89 g/plant respectively) of whole plant was noted in plants treated with salicylic acid at 50 ppm. Among the various elicitors tried, application of ancymidol at 50 ppm significantly promoted the synthesis of chlorophyll and recorded maximum chlorophyll content (24.33 SPAD value) subsequently by paclobutrazol at 50 ppm (20.50 SPAD value). With respect to reproductive parameters, early flowering and crop maturity was noticed in plants treated with salicylic acid at 50 ppm, which took minimum number of days to first flowering, fifty per cent flowering and to reach crop maturity (45.3, 52.2 and 108.1 days respectively) as against delayed flowering and crop maturity in plants pinched at 50 DAS (48.5, 59.7 and 112.7 days respectively).

FUTURE SCOPE

Explore the other commercial elicitors like methyl jasmonate, hydrogen peroxide, boric acid, GA₃ etc., and need to standardize the method and time of elicitors application. Further studies are required to accomplish uniformity in flowering and maturity using growth regulating compounds.

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REFERENCES

- Abbasi, F., Khaleghi, A. and Khadivi, A. (2019). The effect of salicylic acid on physiological and morphological traits of cucumber (*Cucumis sativus* L. cv. Dream). *Gesunde Pflanzen*, 72(2), pp.155-162.
- Ahmad Nazarudin M. R. (2012). Plant growth retardants effect on growth and flowering of potted *Hibiscus rosa-sinensis* L. *Journal of Tropical Plant Physiology*, 4, pp.29-40.
- Ahmad, A., Husain, A., Mujeeb, M., Khan, S. A., Najmi, A. K., Siddique, N. A., Zoheir, A. Damanhour. and Anwar. F. (2013). A review on therapeutic potential of *Nigella sativa*: A miracle herb. *Asian Pac. J. Trop. Biomed.*, 3(5), 337-352.
- Ahmad, I., Whipker, B. E., Dole, J. M. and McCall, I., (2014). Paclobutrazol and ancymidol lower water use of potted ornamental plants and plugs. *European Journal of Horticultural Science*, 79(6), pp.318-326.
- Ahmed, A. M., Elkady, F. M. and Khalid, K. A. (2018). Comparison between salicylic acid and selenium effect on growth and biochemical composition of celery. *Asian Journal of Plant Science*, 17(3), pp.1150-159.
- Angelova, Z., Georgiev, S. and Roos, W. (2006). Elicitation of plants. *Biotechnology & Biotechnological Equipment*, 20(2), pp.72-83.
- Anonymous (2022). Innovative technologies in seed spices for commercialization. ICAR-National Research Centre on Seed Spices, Tabiji, Ajmer, Rajasthan.

<https://nrccs.icar.gov.in/Upload/637950434127582770.pdf>

- Arora, J. S. and Khanna, K. (1986). Effect of Nitrogen and Pinching on Growth and Flower Production of Marigold (*Tagetes Erect* A). *Indian Journal of Horticulture*, 43(3&4), pp.291-294.
- Arpitha, H.S., Umsha, K. and Anilkumar, G. S. (2024). Influence of elicitors on growth and yield of black cumin (*Nigella sativa* L.) varieties. *Asian Journal of Soil Science and Plant Nutrition*, 10(2), pp.182-189.
- Baenas, N., García-Viguera, C. and Moreno, D. A. (2014). Elicitation: a tool for enriching the bioactive composition of foods. *Molecules*, 19(9), pp.13541-13563.
- Bairagi, S. (2016). Effect of pinching of apical buds and chemical sprays on yield and quality of fenugreek seed. *Annals of Horticulture*, 9(2), pp. 177-181.
- Banu, M. K., Mostarin, T., Khatun, K., Kabir, S., Akter, M. S., Hashi, S. N., Roy, S., Akter, A. and Samad, M. A. (2023). Influence of elicitors and seed rate on enhancing growth and seed yield of black cumin (*Nigella sativa*). *Asian Plant Research Journal* 11(1), pp. 10-19.
- Datta, A. K., Saha, A., Bhattacharya, A., Mandal, A., Paul, R. and Sengupta, S. (2012). Black cumin (*Nigella sativa* L.) - A review. *J. Plant Dev. Sci.*, 4(1), pp.1-43.
- El-Gamal., S. M. A and Ahmed, H. M. I. (2016). Optimization coriander production for fruit and essential oil B: yield improvement by chitosan and salicylic acid foliar application. *J. Pl. Production, Mansoura Univ.*, 7(12), pp.1481 -1488.
- Elyasi, R., Majdi, M., Bahramnejad, B. and Mirzaghaderi, G. (2016). Spatial modulation and abiotic elicitors responses of the biosynthesis related genes of mono/triterpenes in black cumin (*Nigella sativa*). *Industrial Crops and Products*, 79, pp.240-247.
- Fariduddin, Q., Hayat, S. & Ahmad, A. (2003). Salicylic acid influences the net photosynthetic rate, carboxylation efficiency, nitrate reductase activity and seed yield in *Brassica juncea*. *Photosynthetica*, 41(2), pp.281-284.
- Gaash, D. and Lavee, S. (1972). The effect of growth regulators on maturation, quality and pre-harvest drop of stone fruits. *Acta Hort.*, 34, pp.449-456.
- Gharib, F. A. E. (2006). Effect of salicylic acid on the growth, metabolic activities and oil content of basil and marjoram. *Int. J. Agri. Biol.*, 8(4), pp.485-492.
- Gholamnezhad, Z., Havakhah, S. and Boskabady, H. M. (2016). Preclinical and clinical effects of *Nigella sativa* and its constituent, thymoquinone, A review. *Journal of Ethnopharmacology*, 190, pp.372-386.
- Hahn, M. G. (1996). Microbial elicitors and their receptors in plants. *Annual review of phytopathology*, 34(1), pp.387-412.
- Hamada, A. M. and Al-Hakimi, A. M. A. (2001). Salicylic acid versus salinity drought induced stress on wheat seedlings. *Rostlina Vyroba.*, 47, pp.444-450.
- Hayat, Q., Hayat, S., Irfan, M. and Ahmad, A. (2010). Effect of exogenous salicylic acid under changing environment: a review. *Environ. Exp. Bot.*, 68, pp.14-25.
- Jangam A. K., and Thali P. (2010). WASP 2.0, ICAR Research Complex, Goa, India.
- Karlidag, H., Yildirim, E. and Turan, M. (2009). Exogenous application of salicylic acid affects quality and yield of strawberry grown under antifrost heated greenhouse

- conditions. *Journal of Plant Nutrition and Soil Science*, 172(2), pp.270-276.
- Kazemi, M. (2014). Effect of foliar application with salicylic acid and methyl jasmonate on growth, flowering, yield and fruit quality of tomato. *Bull. Environ. Pharmacol. Life Sci.*, 3(2), pp.154-158.
- Kumar, R., Singh, K. and Reddy, B. S. (2002). Effect of planting time, photoperiod, GA₃ and pinching in carnation. *J. Ornamental Hort.*, 5(2), pp.20-23.
- Lal, G. (2018). Scenario, importance and prospects of seed spices: A review. *Current Investigations in Agriculture and Current Research*, 4(2), pp.491-498.
- Mondal, M. M. A., Rana, M. I. K., Dafader, N. C. and Haque, M. E. (2011). Effect of foliar application of chitosan on growth and yield in Indian spinach. *J. Agrofor. Environ.*, 5(1), pp.99-102.
- Mostafa, G. G. (2015). Improving the growth of fennel plant grown under salinity stress using some biostimulants. *American J. Plant Physiology*, 10(2), pp.77-83.
- Mutlu, S. S. and Agan, E. (2015). Effects of paclobutrazol and pinching on ornamental pepper. *Hort. Technol.*, 25(5), pp.657-664.
- Nurnberger, T. and Scheel, D. (2001). Signal transmission in the plant immune response. *Trends in plant science*, 6(8), pp.372-379.
- Pariari, A., Chatterjee, V. and Khan, S. (2012). Effect of GA₃ and NAA on growth and yield of black cumin (*Nigella sativa* L.). *J. Crop and Weed.*, 8(1), pp.165-166.
- Pavankumar, D. S., Maruthiprasad, B. N., Umesha, K., Shivanna, M., Shankarappa, T. H. and Halesh, G. K. (2018). Influence of plant growth promoting rhizobacteria and plant growth regulators on growth and yield of black cumin (*Nigella sativa* L.) Var. NS-44. *J. Pharma. and Phytochemistry*, 7(3), pp.01-04.
- Phetpradap, S., Hampton, J. G. and Hill, M. J. (1994). Studies on the effect of hand pinching and plant growth regulators on seed production of field grown hybrid dahlia. *New Zealand journal of crop and horticultural science*, 22(3), pp.313-320.
- Rahimi, A. R., Rokhzadi, A., Amini, S. and Karami, E. (2013). Effect of salicylic acid and methyl jasmonate on growth and secondary metabolites in *Cuminum cyminum* L. *Journal of Biodiversity and Environmental sciences*, 3(12), pp.140-149.
- Ramadan, M. F. (2007). Nutritional value, functional properties and nutraceutical applications of black cumin (*Nigella sativa* L.): an overview. *International journal of food science & technology*, 42(10), pp.1208-1218.
- Rezazadeh, A. and Harkess, R. L. (2015). Effects of pinching, number of cuttings per pot, and plant growth regulators on height control of purple firespike. *HortTechnology*, 25(1), pp.71-75.
- Rotbaum, A., Faingersh, E., Lurie, S., Weksler, A., Zilkah, S. and David, I. (2005), June. Effect of Plant Growth Regulators on Extending the Marketing Season of Sweet Cherry. In *V International Cherry Symposium* 795 (pp. 699-702).
- Setia, R. C., Bhathal, G. and Setia, N. (1995). Influence of paclobutrazol on growth and yield of Brassica carinata A. Br. *Plant growth regulation*, 16(2), pp.121-127.
- Seyed, H. H. and Aliloo, A. A. (2013). The effectiveness of pre-harvest salicylic acid application on physiological traits in liliun (*Lilium longiflorum* L.) cut flower. *Int. J. Sci. Environ.*, 1(12), pp.344-350.
- Shah, S. H. and Samiullah (2006). Effect of phytohormones on growth and yield of black cumin (*Nigella sativa* L.). *Ind. J. Pl. Physiol.*, 11(2), pp.217-221.
- Starman, T. W., Kelly, J. W. and Pemberton, H. B. (1990). The influence of ancymidol on morphology, anatomy, and chlorophyll levels in developing and mature *Helianthus annuus* leaves. *Pl. growth regulation*, 9(3), pp.193-200.
- Thakur, M. and Sohal, B. S. (2013). Role of elicitors in inducing resistance in plants against pathogen infection: a review. *International Scholarly Research Notices*, 2013(1), pp.762412.
- Warner, R. M. and Erwin, J. E. (2003). Effect of plant growth retardants on stem elongation of Hibiscus species. *HortTechnology.*, 13(2), pp.293-296.
- Yıldırım, E. and Dursun, A. (2008). April. Effect of foliar salicylic acid applications on plant growth and yield of tomato under greenhouse conditions. In *International Symposium on Strategies Towards Sustainability of Protected Cultivation in Mild Winter Climate* 807 (pp. 395-400).

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