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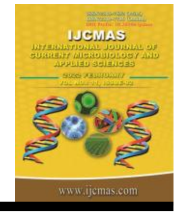

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Growth and Yield of Sesame (*Sesamum indicum* L.) as Influenced by Plant Growth Regulators

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A B S T R A C T

A field experiment was conducted at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal to study the effect of plant growth regulators on growth and yield of sesame (*Sesamum indicum* L.) during summer 2021. The field experiment with thirteen treatments was conducted on loamy sand soil in a randomized block design (RBD) replicated thrice. The treatments included four plant growth regulators at various concentrations (NAA 50 ppm, NAA 100 ppm, CCC 100 ppm, BA 5 ppm and HA 500 ppm) and water spray at two levels of application (one spray – at flowering stage and two sprays – at flowering and capsule formation stages) and an unsprayed control. The results revealed that spraying NAA 100 ppm twice recorded the highest values for plant height, leaf area index, dry matter production and number of branches per plant followed by single spray of humic acid 500 ppm at flowering stage. The highest number of capsules per plant was recorded with application of NAA 100 ppm twice at flowering and capsule formation stages. Application of NAA 100 ppm twice recorded significantly higher seed (633 kg ha^{-1}) and haulm (1296 kg ha^{-1}) yields as compared to other growth regulators.

Introduction

Sesame (*Sesamum indicum* L.) adorned as the “queen of oilseeds” is one of the most important ancient oilseed crops cultivated extensively in the world. Sesame is a traditional healthy food and the seeds are a good source of fibre which aids in lowering the cholesterol and triglycerides which are the main risk factors of heart disease. Sesame seeds consist of 45 to 50 per cent oil, 20 per cent protein and 14.2 per cent carbohydrates and are used as condiments and ingredients in manufacture of paints, soaps, cosmetics, perfumes and insecticides (Langham *et al.,* 2006). Sesame has excellent nutritive value with long shelf life. The high level of antioxidants *viz.* sesamin, sesamolin and sesamol present in sesame inhibit the development of rancidity in the oil. India ranks first in the world sesame production with an output of 8.66 lakh tonnes from an area of 19.47 lakh ha and accounts for one-third of world's sesame production. However, the average yield of sesame in India is low (413 Kg ha^{-1}) as compared to other countries in the world (535 Kg ha^{-1}). The main reasons for low productivity of sesame may be its rainfed cultivation in marginal and sub-marginal lands under poor management and input starved conditions. However, improved varieties and agro production technologies are now developed which are capable of increasing the productivity levels of sesame suitable for different agro ecological conditions.

The yield of sesame may be increased by using numerous technologies and practices such as use of high yielding varieties, proper nutrient management, application of growth regulators and other suitable practices. Of these practices, proper balanced supply of nutrients and application of plant growth regulators are the most important factors to increase yield. The physiological efficiency of a plant can be improved by prolonging photosynthesis, reducing respiration, better partitioning of photo assimilates, improving mineral ions uptake and stimulating nitrogen metabolism. All these processes are inter-linked through several interactions and influence the growth and productivity. Plant growth regulators have been found to influence these processes. Plant hormones which are produced naturally by the plants are essential for regulating their own growth. They act by controlling or modifying plant growth processes, such as formation of leaves and flowers, elongation of stems, development and maturing.

Ewais *et al.,* (2013) reported that foliar application of Benzine Amino purine (BA), ascorbic acid (Asc), paclobutrazol (Pac) caused significant increase in yield components of sesame plants. Sesame yield was increased by application of planofix through increasing the number of flower clusters per plant and reduced percentage of flower drop (Siddik *et al.,* 2015). It was observed that the seed yield of sesame increased with increase in the addition of humic acid (Singaravel *et al.,* 2016). The scientific data on the use of such growth regulators and their effect on the growth, development and yield of sesame are scanty. In this context, this study was taken-up to find the effect of different growth regulators *viz.* Naphthalene Acetic Acid (NAA), cycocel (CCC), Benzine Amino purine (BA) and Humic Acid (HA) at different concentrations on growth and yield of sesame.

Materials and Methods

A field experiment was conducted at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, U.T. of Puducherry during summer (March to June) 2021. The soil was loamy sand in texture and neutral in reaction (pH=6.63).The soil was medium in organic carbon (0.8%), low in available nitrogen (173.6 Kg ha^{-1}), high in available P (34 Kg ha^{-1})and medium in available K (114.6 Kg ha^{-1}) contents. The treatments consisted four plant growth regulators at various concentrations *viz.*, NAA 50 ppm, NAA 100 ppm, CCC100 ppm, BA 5 ppm and HA 500 ppm and water spray, each at two different levels of application (One spray – at flowering stage and Two sprays – at flowering and capsule formation stages) and an unsprayed control. The field experiment involving 13 treatments was laid out in a randomized block design (RBD) with three replications. Sesame seeds (cv. TMV 7) were sown adopting a seed rate of 5 Kg ha^{-1}. The required seeds were mixed with dry sand in 1:4 ratio (seed:sand) and were sown at a depth of three cm in furrows opened at 30 cm spacing and covered with soil. In all the treatments involving plant growth regulators, the plant growth regulators were sprayed according to the treatments at two different times *viz.* at flowering stage (47 DAS) and at flowering and capsule formation stages (47 and 62 DAS). Surface irrigation was given based on the climatic and soil moisture conditions. A total of six irrigations were given during the cropping period. The weeds in the experimental plots were managed by application of pendimethalin @ 1 Kg a.i. ha^{-1} at three DAS followed by hand hoeing at 17 and 29 DAS.

Thinning was done at 19 DAS and at 28 DAS maintaining one healthy plant at a spacing of 30 cm×30 cm.

Observations on various parameters pertaining to growth, yield components and yield of sesame were recorded. The results were statistically analyzed using ANOVA technique and the critical difference (C.D.) values at 5% level of significance were computed to find out the differences between treatment means.

Results and Discussion

Growth attributes

Application of plant growth regulators substantially improved the growth of sesame as indicated by the taller plants, higher leaf area index, greater dry matter production and more number of branches per plant (Table 1).The growth parameters of sesame were not significantly varying at 30 DAS, prior to application of growth regulators.

Application of plant growth regulators enhanced the plant height to the tune of 2.1 to 22.8 per cent at harvest as compared to control. Application of NAA 100 ppm at flowering and capsule formation stages was found to be superior among all the plant growth regulators applied. It was followed by humic acid 500 ppm spray at flowering. Increase in the plant height due to application of plant growth regulators might be attributed to enhancement of several physiological processes like cell division, cell elongation, synthesis of nucleic acids and proteins, thereby leading to enhanced growth and development. The increased plant height due to application of NAA (Siddik *et al.*, 2015) and humic acid (Kandil and Esmail, 2015) has been reported earlier. Due to increased cell division and cell elongation, application of plant growth regulators increased the plant height.

The leaf area index of sesame was increased by 17.6 to 41.2 per cent due to the application of plant growth regulators. Application of NAA 100 ppm at flowering and capsule formation stages was found to register the maximum leaf area index followed by application of humic acid 500 ppm at flowering. The higher leaf area index due to application of plant growth regulators may be attributed to taller plants with more number of leaves. The growth regulators not only increased the number of leaves per plant, but also increased the length and width of the leaves due to enhanced cell expansion. Increase in number of leaves per plant may also be due to the reason that growth hormones might have contributed to enhanced source-sink relationship. Because of more number of leaves and larger size of the leaves, the leaf area index in plant growth regulator treated plants was higher as compared to control. It was observed that application of BA 5 ppm had least influence on leaf area index (17.6 % increase over unsprayed control) when compared to application of other plant growth regulators. Unsprayed control registered the lowest leaf area index due to shorter plants which could not support more number of leaves. Not only the number of leaves, but also the length and breadth of leaves were lower. All these manifested in lower leaf area index in control.

The dry matter production is an indication of utilization of light, nutrients and water by the plants. It is also an indicator of growth over the entire period. Application of plant growth regulators markedly enhanced the dry matter of sesame to the tune of 7.8 to 49.0 per cent at 60 DAS and 18.5 to 49.0 per cent at harvest when compared to control. The higher dry matter production in plant growth regulator applied sesame might be attributed to the increase in plant height and leaf area index which in turn would have helped the plants in harvesting higher amount of solar energy that have imparted a better assimilatory potential of the crop to produce more dry matter. Application of NAA 100 ppm at flowering and capsule formation stages recorded the highest dry matter production. Humic acid 500 ppm spray at flowering was found to be the second best growth regulator in enhancing the dry matter production. Increase in dry matter production of sesame by NAA 100 ppm at flowering and capsule formation stages and humic acid 500 ppm at flowering could be attributed to the higher photosynthetic efficiency and accumulation of photosynthates and further to higher plant height and more leaf production. In the present study, it was observed that NAA 50 ppm applied twice could produce only lesser dry matter production than application of NAA 100 ppm twice, thus indicating it to be the optimum dose for improving the growth of sesame. Application of BA 5 ppm did not have any marked influence on DMP. As BA 5 ppm could not significantly enhance LAI, the dry matter production was not influenced to a great extent Slight wilting of sesame leaves was observed when NAA 100 ppm was applied at flowering stage (Plate 1). However, within two days, the plants recovered from this symptom. This might be due to the increase in stomatal opening caused due to NAA 100 ppm (auxin) application. This in turn resulted in increased transpiration. The stress caused the plants to slightly wilt for two days. This is in agreement with the findings of Xi-Gui Song *et al.,* (2006) and She Xiao-Ping and Song Xi-Gui (2006) wherein they reported auxin induced stomatal opening in broad bean.

Application of plant growth regulators enhanced the number of branches by 10.3 to 41.0 per cent at harvest over control. The increase in plant height supported the increase in number of branches.

Application of NAA 100 ppm at flowering and capsule formation stages registered its superiority over other plant growth regulators by producing the maximum number of branches followed by humic acid 500 ppm at flowering.

Yield attributes

The increase in yield is directly driven by the tremendous hike in number of capsules per plant, since all other yield attributes were found to be not significant (Table 2). Application of plant growth regulators markedly enhanced the number of capsules per plant (32.3 to 116.8 per cent) as compared to control and water spray. This affirms that the plant growth regulators had increased the flower production and retention of flowers produced. Application of NAA 100 ppm at flowering and capsule formation stages was found to be more effective (61.8 capsules plant^{-1}) followed by humic acid 500 ppm at flowering (58.4 capsules plant^{-1}). This increase in the number of capsules per plant may also be attributed to the higher number of branches produced by these growth regulators.

Siddik *et al.,* (2015) were also of the opinion that spraying NAA resulted in higher number of capsules per plant. Kandil and Esmail (2015) had also witnessed increase in number of capsules per plant when sprayed with humic acid.

The number of seeds per capsule was not significantly influenced by the different plant growth regulators. However, application of plant growth regulators increased the number of seeds per capsule by 6.1 to 20.1 per cent. The highest number of seeds per capsule (51.3) was recorded under NAA 100 ppm applied twice and under humic acid 500 ppm applied once. It was observed that the plant growth regulators did not have any significant influence on increasing the length of the capsule. Also, application of plant growth regulators did not exert any significant influence on test weight of sesame.

Yield

Application of plant growth regulators substantially enhanced the seed yield and haulm yield of sesame. A significantly higher seed (633 Kg ha^{-1}) and haulm (1296 Kg ha^{-1}) yields were recorded when NAA 100 ppm was applied at flowering and capsule formation stages.

This might be attributed to the maximum values recorded for various growth and yield attributes. The increase in number of branches made the plants to carry more flowers, pods and seeds. Also marked increase in LAI led to increase in photosynthesis, resulting in greater transfer of assimilates to the seed, causing increase in their weight and finally the seed yield.

Table.1 Effect of plant growth regulators on growth attributes of sesame

Treatment	Plant height at harvest (cm)	LAI at 60 DAS	DMP (Kg ha^{-1})		No. of branches $plant^{-1}$ at harvest
			At 60 DAS	At harvest	
T_1 : NAA 50 ppm at F	90.4	2.3	1294.2	1652.1	5.2
T_2 : NAA 50 ppm at F & CF	86.7	2.1	1107.0	1538.4	4.6
T_3 : NAA 100 ppm at F	88.8	2.1	1242.7	1631.5	4.7
T_4 : NAA 100 ppm at F & CF	97.4	2.4	1315.2	1752.3	5.5
T_5 : CCC 100 ppm at F	82.6	2.2	1211.1	1645.1	5.3
T_6 : CCC 100 ppm at F & CF	81.0	2.1	1173.4	1574.6	4.9
T_7 : BA 5 ppm at F	85.4	2.0	1118.0	1397.9	4.7
T_8 : BA 5 ppm at F & CF	85.3	2.0	1199.0	1393.5	4.7
T_9 : HA 500 ppm at F	91.9	2.4	1329.7	1722.5	5.5
T_{10} : HA 500 ppm at F & CF	88.9	2.1	1265.1	1634.9	4.8
T_{11} : Water Spray at F	83.1	1.8	1074.7	1262.3	4.0
T_{12} : Water Spray at F & CF	83.8	1.9	1106.5	1306.5	4.3
T_{13} : Control (No spray)	79.3	1.7	1026.9	1176.2	3.9
S. Ed.	3.9	0.17	63.1	83.8	0.4
C.D. (P=0.05)	8.01	0.36	130.3	173.0	0.8

F: Flowering CF: Capsule formation

Table.2 Effect of plant growth regulators on yield attributes and yield of sesame

Treatment	No. of capsules per plant	Length of capsule (cm)	No. of seeds per capsule	Test weight (g)	Seed yield (Kg ha^{-1})	Haulm yield (Kg ha^{-1})	Harvest index
T_1 : NAA 50 ppm at F	54.1	2.33	48.3	3.34	620	1207	0.34
T_2 : NAA 50 ppm at F & CF	41.6	2.13	45.7	3.54	582	1038	0.36
T_3 : NAA 100 ppm at F	49.1	2.32	47.0	3.29	595	1173	0.34
T_4 : NAA 100 ppm at F & CF	61.8	2.28	51.3	3.49	633	1296	0.33
T_5 : CCC 100 ppm at F	52.8	2.18	47.0	3.49	615	1204	0.34
T_6 : CCC 100 ppm at F & CF	43.6	2.10	46.7	3.51	589	1085	0.35
T_7 : BA 5 ppm at F	41.2	2.20	45.7	3.41	507	961	0.35
T_8 : BA 5 ppm at F & CF	37.7	2.18	45.3	3.51	490	951	0.34
T_9 : HA 500 ppm at F	58.4	2.31	51.3	3.40	623	1225	0.34
T_{10} : HA 500 ppm at F & CF	49.3	2.31	47.0	3.34	603	1201	0.33
T_{11} : Water Spray at F	35.1	2.23	43.7	3.37	473	862	0.35
T_{12} : Water Spray at F & CF	35.8	2.20	43.7	3.46	480	943	0.34
T_{13} : Control (No spray)	28.5	2.13	42.7	3.38	462	858	0.35
S. Ed.	6.3	0.12	4.7	0.12	27	90	0.02
C.D. (P=0.05)	12.9	NS	NS	NS	55	185	NS

F: Flowering CF: Capsule formation

Plate.1 Temporary wilting of leaves due to application of NAA 100 ppm

Similar observations were recorded by Bharathi *et al.,* (2014), Siddik *et al.,* (2015) and Vinothini *et al.,* (2018). The next best growth regulator in terms of seed and haulm yields was humic acid 500 ppm applied at flowering. The higher seed yield and haulm yield might also be attributed to its more vegetative growth and bearing capacity leading to more yield potentiality. Increase in seed yield (Kandil and Esmail, 2015) and haulm yield (Singaravel *et al.,* 2016) by the application humic acid has also been reported earlier.

The harvest index was not significantly influenced by the plant growth regulators. However, the harvest index was high under NAA 50 ppm applied at flowering and capsule formation stages.

From the results of this study, it is clear that application of plant growth regulators had favourably influenced the growth and yield attributes of sesame leading to increased yield. Application of NAA 100 ppm at flowering and capsule formation stages is found to be a suitable agronomic practice for increasing the yield of sesame.

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