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Effect of Plant Growth Regulators on Morpho-Physiological and Yield Parameters of Some Sesame (*Sesamum indicum* L.) Cultivars

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A B S T R A C T

The present experiment was conducted in the Central farm, OUAT during Rabi season 2014-15 with five sesame varieties viz. Uma, Amrit, Smarak, Prachi and Nirmala to find the efficiency of growth regulators such as NAA, GA_3 and IAA in two Conc. (10 ppm and 20 ppm) sprayed at 30 and 45 DAS. The experiment was laid out in split-plot design with three replications. The Morpho-physiological observations were recorded at different stages of growth of all the varieties due to effect of growth regulators. Significant increase was observed in response to growth regulator on germination of seeds. The highest percentage of seed germination was recorded in GA_3 20 ppm (98.51%). Due to spraying of growth regulators there was increase of plant height, number of branches and leaf area per plant in all the treatments irrespective of varieties and the highest value was exhibited by Nirmala as regards to above characters. The LAI, RGR, NAR, CGR and LAD were found to be increased in PGRs treatments over the control. Among the varieties Nirmala exhibited highest value followed by Amrit. The yield attributing characters such as total dry matter, number of capsules/ plant, number of seeds per capsules and 1000 seed weight were significantly increased among the treatments as well as varieties. Due to the spraying of plant growth regulators the percentage of increase in yield ranged from to a tune of 0.5 % in GA_3 10 ppm conc. to 24 % in GA_3 20 ppm conc. over the control. Among the varieties highest yield was noted in Nirmala (5.60 q/ha) followed by Amrit (5.08 q/ha). In view of the present findings Nirmala was found to be the highest yielder and higher concentrations of plant growth regulators were found to be more significant over the

Introduction

Sesame (*Sesamum indicum* L.) adomed as queen of oil seeds. It is commonly known as Til, Gingeli, Sim and it is the oldest important oil seed crop in the tropics. It has been believed as sesame probably originated in Africa. Sesame was introduced into India by the earliest human migrants from Africa, this crop is grown in a period when atmospheric

evaporative demand is high and availability of irrigation water is low. Under the circumstances there is a need for efficient utilization of water resources or Physiological manipulation of the crop with the growth regulator to overcome the water stress situation (Tian *et al.*, 1993) even through it is grown all over the world for its importance in food, medicine and industries. In the world the major countries producing sesame are china (19.97), Myanmar (16.68), Sudan (9.98) and the countries like Uganda, Nigeria, Pakistan, Ethiopia and Bangladesh contributed less than 5% in Production. It has been observed that the productivity of sesame in India was 6.76 kg/ha as compared to the worlds' average 48.87 kg/ha. India has leading edge over its area (29.3 %) and by production (25 %). Among the oilseed crops sesame ranks 1st for its higher oil content (46-62 %) with 63.35 k.cal /kg of dietary energy in seeds (Kumar and Goel, 1994) the yield of sesame has yield potential of around 20t/ha but low in productivity (346 kg/ha) and hence has tremendous options for management technologies.

Sesame seed provides excellent food nutrition, health care, edible oil and bio-medicine. It is digestive, regenerative, anti-aging and resource of quality oil. It is rich in Vitamin C, Vitamin A, Vitamin B complex, niacin, minerals like calcium, phosphorous, iron, copper, magnesium, zinc, and potassium. From an industrial point of view sesame is used in manufacturing soaps, cosmetics, perfumes, insecticides and Pharmaceutical Products. Sesame cake is a byproduct of the oil milling industry and valued as livestock feed because of its high methane content. It has been observed as the international market of sesame has been increasing in the recent past due to high demand and various uses. In India Gujarat alone contributed 30% of total production followed by West Bengal 17.8 %, Rajasthan 17.6 %.West Bengal ranks 1st with 8.6 kg/ha followed by Gujarat 5.98 kg/ha.

In Odisha sesame is cultivated both in Kharif and Rabi season. The average production of sesame is 70.74 Mt during Kharif season where as in Rabi season it is 23.42 Mt. During Rabi season sesame is cultivated under non-irrigated situation for which water deficit situation in one of the major abiotic stress which adversely affect the crop growth and yield.

Although many reasons have been attributed to explain such low productivity remain hindrance lies in physiological problems associated with hormonal imbalance which leads to a reduction in the yield of the crop plant growth regulators are known as to change the growth and development pattern of growth plants.

Physiological and biochemical process and thereby increase the yield of the crop. The localized application of some plant growth regulators is reported to have profound effects on assimilate partitioning, enhancing the crop productivity plant growth regulators are effective on several crop plants to balance the source sink relationship and thereby increasing them, they used as an aid to enhance in many crops Indole acetic acid (IAA) and Gibberellic acid (GA_3) can manipulate a variety of growth and developmental phenomena in various crops.IAA has been found to increase the plant height, number of leaves per plant with consequent enhancement in seed yield in groundnut (Lee,1990) and cotton (Kepgate *et al.*,1989), it also increases the flowering, fruit set, the total dry matter of crops (Gurudev and Saxena, 1991) likewise GA_3 stimulated stem elongation (Harington *et al.*,1996) increased dry matter accumulation (Hore *et al.*,1988) and enhance total yield (Deotale *et al.*,1998). However studies on the effect of growth

regulators would provide useful information regarding manipulations of growth and yield therefore this experiment was designed to study the effect of IAA, NAA and GA_3 in modifying the morphological changes and the yield contributing characters of sesame.

Materials and Methods

The present experiment entitled "Effect of plant growth regulators on morpho-physiological and yield parameters of some sesame cultivars" was conducted at the Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar, situated at $20^0$15' N latitude and $85^0$52'E longitude of the Department of Plant Physiology, College of Agriculture, OUAT, Bhubaneswar during Rabi 2014-2015. Five sesame varieties viz., Uma, Amrit, Smarak (AVTS-13-9), Prachi, Nirmala (5 Variety) were taken for the study. Breeder seeds of the above varieties were collected from the AICRP on Sesame, OUAT, Bhubaneswar farm for the purpose. A field experiment was conducted with 35 numbers of Field plots which laid out in a complete split-plot Design for 7 treatments and 3 replications (Gomez and Gomez, 1984). The experiment was carried out in the medium land with well drained sandy loam soil and the chemical properties of the soil were analyzed in the Department of Soil Science and Agricultural Chemistry OUAT, Bhubaneswar having pH (5.4) (Table 2). The data on climatic parameters *viz.*, rainfall, maximum and minimum temperature, relative humidity and bright sunshine hours recorded during the period of investigation (2013-14) at the meteorological observatory, OUAT is depicted in table 1.

Seed treatment was done one day before the sowing on field plot. Seed treatment with saffaya on slurry like water and fungicidal solution and shed dried for 3-4 hours. The crop was grown in *Rabi season*, 2014-15 using 5 varieties viz., Uma, Amrit, Smarak, Prachi and Nirmala of sesame in a plot size 5.5 ' × 3.4 ' with spacing of 30 cm ×15 cm. The meteorological conditions were suitable for raising of crop sesame. Fertilizer was applied @ 40kg N, 20kg $P_2O_5$and 20 kg K_2O along with 10 cartloads of FYM per hectare before sowing of seeds. Two hand weeding was done to keep the crop from weeds and prophylactic plant protection measures were adopted to protect the crop from weeds, diseases and pests attack. The field was irrigated as and when required. Sowing was done manually on 18th Nov 2014, the plots of different treatments were harvested at harvestable maturity stage on 5th, 7th and 10th March 2015. Seeds after threshing were sun dried to about nine percent moisture level and stored in small cloth bags under ambient condition. The required pre and post-harvest observations were recorded in the laboratory of the department of Plant Physiology. There were seven treatments involving three plant growth regulators (IAA, NAA and GA_3) applied along with a control. The detail procedures of application of these Plant growth regulators are provided in the following table 1. Foliar application of these plant growth regulators was made at 30 and 45 days after sowing. Observation of the following parameters as per the scheduled before harvesting were recorded at 30, 45, 60 and 90 DAS randomly selected five plants from each plot were collected and the following observations were taken as per the schedule on seed germination and different morpho-physiological characters, i.e., Plant height (cm), Number of Branches per plant, Leaf area per plant, total dry matter, growth analysis parameters [Leaf Area Index (LAI) (Watson, 1952), Crop growth rate (CGR), Relative Growth Rate (RGR) (Leopold and Kriedemann, (1975), Net Assimilation Rate (NAR) (Gregory, 1926), Leaf weight ratio, Specific leaf weight, Leaf Area Ratio (LAR)

(Gregory,1926), Leaf Area Duration (LAD), Leaf Area Index (LAI) (Watson,1937) and Post-harvest observation i.e., Number of seeds per capsule, number of chaffy seeds per Capsule, number of healthy seeds per capsule, number of capsules per plant, 1000-seed weight, yield (q/ ha), oil content, total dry matter.

Results and Discussion

The present investigation was carried out at the experimental station of O.U.A.T to assess the effects of growth regulators such as Indole acetic acid (IAA), Naphthalene acetic acid (NAA) and Gibberellic acid (GA_3) on sesame (*Sesamum indicum* L.) cultivars.

Morphological characters

Germination of seeds

The percentage of germination of seeds as influenced by different growth regulators of different varieties is represented in table 5. Analyzing data it is observed that significant difference on percentage of germination was noted among the different concentration of growth regulator irrespective of varieties. The highest percentage of germination was noted in GA_3 20ppm (98.51) followed by GA_3 10 ppm (95.81) whereas the lowest value of the same was observed in control (87.49) GA_3 20ppm conc. resulted in the maximum increase of germination percentage (12.59) as compared to the control. While examining the effects of growth regulators on germination percentage of different varieties it was observed that highest percentage of germination was noted in Nirmala (95.42) followed by Amrit (93.82). Significant difference among the treatment as well as among the varieties was found as regards to germination percentage. The interaction effect between the variety and the treatment was existed. In the studies of seed germination under different treatments revealed that among all the growth regulators GA_3 at both the concentrations (10 and 20 ppm) resulted higher significant, increases in germination over the control. Besides GA_3 other growth regulators such as NAA and IAA of both concentrations also showed an increase in germination percentage of seeds. Seed germination is the resumption of active growth of the embryo that results in the rupture of the seed coat and the emergence of a young plant. Among the growth regulators gibberellic acid controls the germination of seeds more than other PGRs. Presoaking of GA_3 results the production of hydrolytic enzymes and multiple forms of amylase such as a α-amylase, β-amylase ribonuclease and 1-3-β-d gluconase which rapidly promote cell wall degradation and digest starch and protein leading to release of energy and nutrients which are essential for germination. Secondly application of exogenous above growth regulators are known to modify the influence of cytokinin transport across membranes and is thus able to initiate the biochemical process necessary for germination, the cytokinin probable penetrates the tet and neutralise the inhibitors present in the embryo, thus enables the embryo to rupture the seed coat, besides this over and above GA_3 decreases the total phenol of the seed, so that the percentage of germination was enhanced.(Araby *et al.*, 2009). So the present investigation corroborates the findings of previous workers (Patil and Gaikwad, 2011; Mostafa and Hamd, 2011; Lalitha, 2015).

Plant height

Data presented in the table 6 revealed that there was minor deviation in plant height at the initial stage of growth (30 DAS) among the treatments. The effect of plant growth regulators on plant height is taken at 45 DAS indicated that highest plant height was recorded from NAA 20 ppm conc. (101.71

cm) followed by GA_3 10 ppm conc. (80.87 cm) and IAA 20 ppm conc. (80.83 cm) whereas control contributed lowest value of the same (55.02 cm). The plant height was an increased with increase of growth period. At 90 DAS the highest plant height was observed in T_4 (138.4 cm) followed by T_3 (134.59 cm) with lowest value in T_0 (96.96 cm), similar observation was found among the varieties due to the effect of growth regulators. At 30 DAS highest plant height was recorded from Uma (40.28 cm) which was significantly increased over all the varieties. At 45, 60, 90 DAS similar trend was recorded. At 90 DAS highest plant height was observed in Uma (135.30 cm). The percentage of increase at 90 DAS with respect to 30 DAS by Uma, Amrit, Smarak, Prachi, Nirmala was 235.89, 216.30, 237.84, 238.54 and 240.28 % respectively. Significant difference among the varieties and within the treatments was observed. The interaction effect between variety and the treatment was significant.

In general, the growth of the plant was affected by plant growth regulators. Plant height is a manifestation of genetical potential however as sesame is an indeterminate plant, plant height is a beneficial characters to a increase the yield of the crop. However its expression to same degree modified as was evident from a general increase to a tune of 13.03 % in NAA 10 ppm to 42.73 % in GA_3 20 ppm conc. of plant height at 90 DAS. Due to exogenous application of growth regulators irrespective of varieties. A similar increase of plant height has been reported by this may be due to fact that application growth regulators promote the coleoptiles or stem section in rapid and dramatic within 5 to 10 minutes. It causes wall loosening so that water absorption is increased by acid growth hypothesis due to the application of IAA H^+ ion secrets which lower the pH so that wall loosening and fast growth occur. Again it is thought that it has the remarkable abilities to activate a plasma membrane ATPase that transport H^+ from the cytosol in to the wall, to lower the wall pH so that there will be loosening of cell wall and promote cell growth.it is also thought there will production of protein which involved in growth, the increase of plant height supports the earlier workers (Sontakey *et al.*,1991) in sesame Lee,1990 in ground nut,Kumar *et al.*,1996 in okra and Deotale *et al.*,1998 in soybean, Chauhan *et al.*,2009 ; Agrawal and Dikshit.,2008.

Number of branches

The number of branches per plant due to the effect of growth regulators was recorded in table 7. From the data it was revealed that at 60 DAS highest number of branches per plant was recorded from IAA 20 ppm conc. (3.95) followed by NAA 20ppm conc. (3.65) and GA_3 20 ppm conc. (3.62) whereas the lowest value was shown in control (3.34). The percentage of increase ranged from 3.59 % in $GA_3$10 ppm conc. to 18.26 % in IAA 20 ppm conc. over the control. Significant difference among the treatments was observed. Among the varieties at 60 DAS the highest number of branches per plant was exhibited by Nirmala (4.06) followed by Amrit (3.67) on the contrary the minimum value was observed in Uma (2.88). At 90DAS the same trend was observed among the varieties. The highest number of branches per plant was exhibited by Nirmala (5.90) followed by Amrit (5.58) whereas the minimum value of the same was recorded from Uma (4.65). The interaction effect between variety and the treatment was significant.

A total number of branches per plant increased significantly due to exogenous application of growth regulators at 30 and 45 DAS irrespective of varieties. It was found that the percentage of increase in number of branches per plant was highest in IAA 20 ppm conc. (8.92 %) followed by IAA 10 ppm

conc. (8.13 %) due to the inhibitory effect of apical bud upon lateral bud there was more production of branches, the present findings agreed with the previous workers (Awan and Alizal *et al.,* 1989; Sontakey *et al.,* 1991; Sarkar *et al.,* 2002).

Leaf area

Data on leaf area registered in the table 8 revealed that leaf area recorded at 45 DAS indicated that the highest leaf area (49.76 cm^2) was exhibited by T_4 (IAA 20 ppm) followed by T_2 (48.73 cm^2) and T_5 (48.02 cm^2) whereas the lowest value was recorded from control (41.76 cm^2). A similar trend was recorded in 60 DAS. At 90 DAS the leaf area was decreased irrespective of treatments. The percentage of increase in leaf area ranged from 31.56 % in T_0 to 37.22 % in T_2 at 60 DAS compared to 45 DAS whereas at 90 DAS the reduction was ranged from 27.06 % in T_0 to 37.34 % in T_2 compared 60 DAS.

At 90 DAS the highest leaf area was exhibited by T_4 (42.09 cm^2) whereas the lowest value of the same was recorded from T_0 (40.07 cm^2). Significant difference among the treatments was noted, similar trend was also observed among the varieties. At 45 DAS the maximum leaf area was registered from Nirmala (51.17 cm^2) followed by Prachi (48.50 cm^2) whereas the minimum leaf area was recorded from Uma (44.05 cm^2). As the duration of the crop increased the leaf area increased in the varieties. The percentage of increase of leaf area from 45 DAS to 60 DAS ranged from 33.24 % in Smarak to 37.52 % in Nirmala but at 90 DAS it was 39.98 % in Smarak to 30.53 % in Nirmala as compared 60 DAS. The maximum leaf area was recorded from Nirmala (48.88 cm^2) whereas the lowest value of the same was shown in Uma (36.5 cm^2).The interaction effect between variety and treatment as well as treatment with variety was found significant.

Leaf area was found to increase significantly in all the varieties when sprayed with PGRs up to 60 DAS ranging from 31.56 % to 37.22 % and thereafter there was reduction as recorded at 90 DAS ranging from 27.06 % to 37.34 % due to the shedding of leaf. Application of growth regulators enhanced cell division and cell elongation as stated earlier. Due to the application of hormone the hydrolysis of starch, fructose and sucrose increased to from glucose and fructose molecule for which more energy produced, there will be increased of water potential and cell expansion was caused and cell plasticity increased. it promotes leaf growth, so that leaf area is increased Agrawal and Dikshit, (2008) stated that application of IAA,NAA and GA_3 increased the number of leaves in pea, the present findings are supported by previous workers (Kokare *et al.,* 2006).

Total dry matter

The effect of different growth regulators on total dry matter accumulation is reflected in table 9. It was found that due to the effect of growth regulators the dry matter accumulation varied significantly among the treatments. The total dry matter was higher in 20 ppm conc. of each growth regulator. Highest accumulation at 45 DAS was recorded in NAA 20 ppm conc. (1.94 g/plant) followed by IAA 20 ppm conc. (1.93 g/plant). A similar trend was observed at 60 and 90 DAS. At 90 DAS highest total dry matter was observed in IAA 20 ppm conc. (8.43 g/plant) followed GA_3 20 ppm (8.04 g/plant) and NAA 20 ppm (8.01 g/plant).The highest percentage of increase over the control was shown in 12.85 % in IAA 20 ppm conc. followed by 7.63 % in NAA 20 ppm conc. Significant difference among the treatments was observed. Due to the effect of growth regulator among the varieties the maximum dry matter was exhibited by Nirmala (1.98 g/plant) followed by Amrit (1.89 g/plant) at 45 DAS similarly at

60 DAS and 90 DAS similar trend was recorded. At 90 DAS the highest dry matter was recorded from Nirmala (8.39 g/plant) followed by Amrit (8.12 g/plant) whereas the lowest value was recorded from Uma (7.41 g/plant), significant difference as regards to dry matter accumulation was observed, the interaction effect between the variety and the treatment was significant.

Application of growth regulators significantly increased the total dry matter accumulation irrespective of varieties due to increasing cell division and other physiological activities, due to the increase of leaf area more photosynthesis are produced and the total dry matter of the plant was increased. The increased of dry matter might be due to the accumulation of building units that accompanied by greater saccharides and protein content which is linked with the photosynthetic operator increasing protein content may be due to the increase in the formation of rough endoplasmic reticulum that provides appropriate medium for increasing the polyribosomes and RNA, the present findings correlates the findings of previous workers (Kokare *et al.*, 2006)

Physiological characters

The effect of growth regulators affected the physiological characters of different sesame varieties which ultimately determined the yield and yield attributing characters. The following physiological characters were recorded at 90 DAS of the different varieties due to the effect of growth regulators.

Leaf area index (LAI), Relative growth rate (RGR), Leaf area ratio (LAR)

Data presented on leaf area index (LAI) recorded at 90 DAS is in table 10 which revealed that among the treatments T_6 recorded highest LAI 0.097 followed by T_2 (0.096), on the contrary the lowest value was exhibited by control (0.092).Among the varieties the highest LAI (0.78) was exhibited by Nirmala followed by Amrit (0.072). The leaf area index was positively correlated with yield (r = 0.984) table 16. The interaction effect between variety and treatment was recorded significant.

The relative growth rate as calculated over a period of 30 DAS (60 DAS to 90 DAS) is represented in table 10. During 60 – 90 days of growth the relative growth rate significantly increased in higher concentration of NAA, GA_3, IAA over the control and highest value was recorded from IAA 20 ppm (1.654 g/g/day) followed by GA_3 20 ppm (1.627 g/g/day) and the percentage of increase in relative growth rate (RGR) was maximum in IAA 20 ppm conc. (5.14 %) followed by GA_3 20 ppm 3.43 % over the control respectively. Among the varieties highest RGR was recorded from Nirmala (1.750 g/g/day) whereas the minimum value of the same was exhibited by Uma (1.499 g/g/day). Significant difference among the varieties in respect to RGR was found. The interaction effect between variety and treatment is significant. There was positive correlation between yield and relative growth rate (r = 0.981). Data registered in table 10 indicated that there was increase of LAR in all the treatments irrespective of varieties and maximum value was recorded from IAA 20 ppm conc. (79.70 cm^2/g) followed by NAA 20 ppm conc. (78.66 cm^2/g) which was 5.75 % and 4.71 % increased over the control. Nirmala exhibited highest value of LAR (82.65 cm^2/g) followed by Amrit (80.93 cm^2/g).From the table 10 it was found that there was significant difference among the varieties and treatment was exist. The interaction effect of effect between varieties and treatments was existed. There was positive correlation between yield and LAR (r = 0.927).

Leaf weight ratio (LWR), Specific leaf weight (SLW) Specific leaf area (SLA)

From table 11 it was found that irrespective treatments there was an increase of LWR over the control, highest leaf weight ratio was observed in IAA 20 ppm (0.576 g/g) with an increase of 6.86 % over the control. Among the variety Nirmala recorded highest LWR (0.595 g/g) followed by Amrit (0.567 g/g) due to the effect of growth regulator. Significant difference among the variety and treatments were recorded.From table 16, it was noted that there was a positive correlation (r= 0.897) between yield and LWR. The specific leaf weight (SLW) due to the effect of different growth regulators recorded at 90 DAS is presented in table 11 which showed a significant increase over the control irrespective of varieties. It was found that crop sprayed with higher conc. of growth regulators contributed higher SLW as compared to the respective lower concentration of NAA, GA_3 and IAA. Highest SLW was noted from Nirmala (0.298 g/m^2) followed by Amrit (0.269 g/m^2) with lowest value of the same recorded from Uma (0.149 g/m^2).The interaction effect on SLW between variety and treatment was found to be significant. There was a positive correlation between SLW and yield (r = 0.978) (Table 16). At 90 DAS the effect of different growth regulators of different varieties in specific leaf area (SLA) had been studied which was presented in table 11. It was revealed from the data that higher concentration of different growth regulators showed lower specific leaf area (SLA) as compared to lower concentration of respective growth regulator. The maximum SLA was recorded from control (1.490 dm^2/g) whereas the lowest value was showed in IAA 20 ppm conc. (1.434 dm^2/g) with reduction of 3.75 % compared to the control. Among the varieties the highest value of SLA was recorded from Uma (1.505 dm^2/g) whereas minimum value of the same was observed from nirmala (1.437 dm^2/g) with reduction of 4.51 % to the former. It was found that there was negative correlation (r= - 0.236) between the SLA with yield and yield attributing characters. The interaction effect on SLA between variety and the treatment was found to be significant.

Crop growth rate (CGR) Net assimilation rate (NAR) and Leaf area duration (LAD)

At 90 DAS the effect of growth regulators of different varieties on crop growth rate (CGR) had been studied which is presented in table 12. It was revealed from the data that there was increase of CGR in all the concentration of growth regulators as compared to control. The maximum value of CGR was recorded from IAA 20 ppm conc. (52.09 g/m^2/day) followed by GA_3 20 ppm conc. (51.81 g/m^2/day). The percentage of increase in CGR was ranged from 4.84 % in NAA 10 ppm conc. to 14.76 % in IAA 20 ppm conc. Significant difference among the treatments in respect to CGR was found. Among the varieties the highest value of CGR was found in Nirmala (48.91 g/m^2/day) followed by Amrit (48.60 g/m^2/day). The interaction effect between the variety and treatment was significant. CGR is positively correlated with grain yield. (r = 0.946) (Table 16). Data reflected in table 12 indicated that significant increase in NAR was recorded in all the treatment of PGRs irrespective of varieties. The maximum increase was observed in T_6 (46.19 %) whereas minimum value of the same was shown in T_1 (4.56 %) over the control. The variety Nirmala exhibited highest NAR (97.4 mg/dm2/day) followed by Amrit (95.0 mg/dm^2/day) but the lowest value was recorded from Smarak (67.4 mg/dm^2/day). Significant difference within the treatment as well as within variety was noted. The interaction effect between variety and treatment was found NAR is positively correlated with yield (r = 0.893) on table 16.

Table.1 Meteorological data at the experimental site

Month	Avg. Temp		Avg. Rh (%)		Bright sunshine hours (BSH)	Rain Fall	
	Max.	Min.	Morning	Afternoon		mm	Days
November	30.9	18	90	44	7.2	0.0	-
December	27.7	13.9	88	45	5.8	0.0	-
January	27.8	14.2	91	43	6.7	21.5	2
February	32.5	17	94	39	8.3	18.4	1
March	35.8	21.5	91	40	8	24.8	3

Table.2 Soil properties of the experimental field

Sl. No.	Particular	Percentage of composition
1	Texture	Sandy loam
2	pH	5.4
3	Total nitrogen	0.09
4	Available P	17.8 (kg ha^{-1})
5	Available K	110.3 (kg ha^{-1})

Table.3 Varieties used five

Name of the Varieties	Symbol
UMA	V_1
AMRIT	V_2
SMARAK (AVTS-13-9)	V_3
PRACHI	V_4
NIRMALA	V_5

Table.4 Details of plant growth regulators application

Sl No.	Treatment symbol	Micronutrients	Concentration/ Dose of Application	Mode of application
1	T_0	Control		-
2	T_1	NAA	@10 PPM	Foliar Spray
3	T_2	NAA	@20 PPPM	Foliar Spray
4	T_3	GA_3	@10 PPM	Foliar Spray
5	T_4	GA_3	@20 PPPM	Foliar Spray
6	T_5	IAA	@10 PPM	Foliar Spray
7	T_6	IAA	@20 PPPM	Foliar Spray

Table.5 Effect of NAA, GA_3 and IAA on germination percentage on seeds of different Sesame cultivars

Treatment	Germination percentage
T_0	87.49
T_1	93.18
T_2	93.61
T_3	95.81
T_4	98.51
T_5	93.96
T_6	94.31
Mean	93.84
Varieties	
V_1	93.05
V_2	93.82
V_3	93.17
V_4	93.73
V_5	95.42
Mean	93.83

	SE(m)±	C.D. at 5%	CV%
V	0.017	0.057	0.086
T	0.015	0.044	0.064
VxT	0.028	0.083	
TxV	0.035	0.09	

Table.6 Effect of NAA, GA_3 and IAA on plant height of different sesame cultivars

Treatment	30 DAS	45 DAS	60 DAS	90 DAS
T_0	37.02	55.02	79.9	96.96
T_1	36.9	66.47	92.83	109.6
T_2	37.14	75.96	103.25	125.76
T_3	36.82	80.87	105.98	134.59
T_4	37	101.71	119.51	138.4
T_5	36.61	78.19	96.24	129.06
T_6	37	80.83	95.63	128.41
Mean	36.93	76.80	99.05	123.25
Varieties				
V_1	40.28	85.34	106.25	135.3
V_2	36.54	75.14	93.69	115.58
V_3	35.46	75.78	94.22	119.8
V_4	36.22	77.19	96.47	122.62
V_5	36.14	76.8	104.62	122.98
Mean	36.92	78.05	99.05	123.25
DAS		**SE(m)±**	**C.D. at 5%**	**CV%**
30	V	0.18	0.6	2.28
	T	0.17	0.50	1.87
	VxT	0.32	0.93	
	TxV	0.4	1.13	
45	V	0.29	0.96	1.73
	T	0.16	0.47	0.82
	VxT	0.35	1.05	
	TxV	0.37	1.05	
60	V	0.12	0.40	0.58
	T	0.11	0.33	0.46
	VxT	0.21	0.62	
	TxV	0.26	0.74	
90	V	1.44	4.70	5.37
	T	1.77	5.02	5.57
	VxT	3.05	8.89	
	TxV	3.97	11.22	

Table.7 Effect of NAA, GA3 and IAA on number of branches of different Sesame cultivar

Treatment	60 DAS	90 DAS
T_0	3.34	5.04
T_1	3.54	5.17
T_2	3.65	5.34
T_3	3.46	5.21
T_4	3.59	5.31
T_5	3.62	5.49
T_6	3.95	5.45
Mean	3.59	5.28
Varieties		
V_1	2.88	4.65
V_2	3.67	5.58
V_3	3.05	4.82
V_4	3.52	5.06
V_5	4.06	5.9
Mean	3.43	5.2

DAS		**SE(m)±**	**C.D. at 5%**	**CV%**
60	V	0.021	0.069	2.857
	T	0.024	0.07	2.786
	VxT	0.043	0.124	
	TxV	0.055	0.156	
90	V	0.06	0.198	5.362
	T	0.042	0.121	3.182
	VxT	0.083	0.247	
	TxV	0.095	0.270	

Table.8 Effect of NAA, GA_3 and IAA on leaf area per plant (cm^2) of different sesame cultivars

Treatment		**45 DAS**	**60 DAS**	**90 DAS**
T_0		41.76	54.94	40.07
T_1		47.76	64.12	41.47
T_2		48.73	66.87	41.9
T_3		47.93	64.82	41.43
T_4		49.76	66.93	42.09
T_5		48.02	64.87	40.82
T_6		49.16	66.27	41.87
Mean		47.58	64.11	41.37
Varieties		45 DAS	60 DAS	90 DAS
V_1		44.05	58.92	36.5
V_2		46.9	62.84	41.65
V_3		47.37	63.12	37.88
V_4		48.5	65.31	42.04
V_5		51.17	70.37	48.88
Mean		47.59	54.85	41.39
DAS		**SE(m)±**	**C.D. at 5%**	**CV%**
45	V	0.138	0.449	1.33
	T	0.107	0.302	0.87
	VxT	0.202	0.595	
	TxV	0.239	0.675	
60	V	0.118	0.384	0.84
	T	0.119	0.336	0.72
	VxT	0.211	0.614	
	TxV	0.265	0.751	
90	V	0.132	0.446	1.37
	T	0.103	0.301	0.83
	VxT	0.204	0.593	
	TxV	0.234	0.674	

Table.9 Effect of NAA, GA_3 and IAA on total dry matter per plant (g) of different sesame cultivars

Treatment		**45 DAS**	**60 DAS**	**90 DAS**
T_0		1.64	3.64	7.47
T_1		1.66	3.75	7.74
T_2		1.9	3.92	8.04
T_3		1.77	3.72	7.74
T_4		1.81	3.9	8.01
T_5		1.77	3.78	7.77
T_6		1.93	4.09	8.43
Mean		1.78	3.82	7.88
Varieties		45 DAS	60 DAS	90 DAS
V_1		1.58	3.87	7.41
V_2		1.89	3.98	8.12
V_3		1.68	3.84	7.65
V_4		1.81	3.92	7.86
V_5		1.98	4.16	8.39
Mean		1.78	3.95	7.88
DAS		**SE(m)±**	**C.D.**	**CV%**
45	V	0.026	0.086	6.758
	T	0.017	0.049	3.754
	VxT	0.034	0.103	
	TxV	0.038	0.109	
60	V	0.02	0.06	2.42
	T	0.024	0.07	2.5
	VxT	0.042	0.123	
	TxV	0.055	0.157	
90	V	0.018	0.059	1.06
	T	0.016	0.047	0.828
	VxT	0.03	0.089	
	TxV	0.037	0.106	

Table.10 Effect of NAA, GA_3 and IAA on LAI, LAR, RGR of different sesame cultivars

Treatments	LAI		LAR (cm2/g)	RGR (g/g/day)
T_0	0.092		75.36	1.573
T_1	0.095		77.48	1.596
T_2	0.096		78.66	1.607
T_3	0.093		77.28	1.606
T_4	0.094		78.33	1.627
T_5	0.094		78.91	1.623
T_6	0.097		79.7	1.654
Varieties				
V_1	0.58		77.53	1.499
V_2	0.72		80.93	1.677
V_3	0.60		78.52	1.531
V_4	0.67		78.62	1.601
V5	0.78		82.65	1.750
DAS		**SE(m)±**	**C.D.at 5%**	**CV%**
LAI	V	0.01	0.01	1.09
	T	0.01	0.001	1.23
	VxT	0.001	0.001	
	TxV	0.001	0.002	
LAR	V	0.035	0.115	2.04
	T	0.021	0.06	1.04
	VxT	0.044	0.132	
	TxV	0.048	0.135	
RGR	V	0.009	0.03	2.66
	T	0.02	0.05	4.9
	VxT	0.033	0.095	
	TxV	0.045	0.129	

Table.11 Effect of NAA, GA_3 and IAA on LWR, SLW, SLA of different Sesame cultivars

Treatments	**LWR(g/g)**		**SLW (g/dm^2)**	**SLA (dm^2/g)**
T_0	0.539		0.151	1.490
T_1	0.549		0.151	1.484
T_2	0.559		0.220	1.464
T_3	0.532		0.156	1.488
T_4	0.542		0.226	1.446
T_5	0.545		0.192	1.468
T_6	0.576		0.238	1.434
Varieties				
V_1	0.493		0.149	1.505
V_2	0.567		0.269	1.5457
V_3	0.552		0.159	1.473
V_4	0.538		0.215	1.463
V_5	0.595		0.298	1.437
DAS		**SE(m)±**	**C.D.at 5%**	**CV%**
LWR	V	0.008	0.026	6.833
	T	0.007	0.021	5.41
	VxT	0.013	0.04	
	TxV	0.017	0.048	
SLW	V	0.064	0.211	15.19
	T	0.044	0.124	9.17
	VxT	0.086	0.257	
	TxV	0.098	0.278	
SLA	V	0.096	0.314	3.012
	T	0.089	0.252	2.35
	VxT	0.161	0.471	
	TxV	0.199	0.564	

Table.12 Effect of NAA, GA_3 and IAA on CGR, LAD, NAR of different sesame cultivars

Treatments		**CGR ($g/m^2/day$)**	**LAD (Days)**	**NAR ($mg/dm^2/day$)**
T_0		45.39	32.52	72.3
T_1		47.59	35.85	75.6
T_2		49.85	36.75	92.9
T_3		47.59	37.07	85.9
T_4		51.81	37.11	93.3
T_5		48.52	36.08	93.1
T_6		52.09	36.56	105.7
Varieties				
V_1		46.80	32.27	68.2
V_2		48.60	39.65	95.0
V_3		47.43	35.00	67.4
V_4		47.48	36.45	72.6
V_5		48.91	40.58	97.4
DAS		**SE(m)±**	**C.D.at 5%**	**CV%**
CGR	V	0.005	0.018	5.31
	T	0.002	0.005	16.53
	VxT	0.005	0.016	
	TxV	0.004	0.012	
LAD	V	0.038	0.125	4.91
	T	0.034	0.097	3.721
	VxT	0.063	0.184	
	TxV	0.077	0.218	
NAR	V	0.0001	0.0005	7.94
	T	0.0002	0.0005	7.86
	VxT	0.0003	0.001	
	TxV	0.0004	0.0001	

Table.13 Effect of NAA, GA_3 and IAA on No. of capsules per plant and no. of seeds per capsule of different sesame cultivars

Treatments	No. of capsules/plant		No. of seeds/capsule	
T_0	16.94		40.54	
T_1	17.04		40.88	
T_2	17.22		41.02	
T_3	17.18		40.9	
T_4	17.34		41.14	
T_5	17.26		40.98	
T_6	17.64		41.08	
MEAN	17.23		40.93	
VARIETIES				
V_1	16.84		38.65	
V_2	18.0		43.14	
V_3	16.07		37.8	
V_4	16.87		40.81	
V_5	18.37		44.25	
MEAN	17.23		40.93	
DAS		**SE(m)±**	**C.D. at 5%**	**CV**
No. of capsules/plant	V	0.033	0.107	0.88
	T	0.045	0.126	1.0
	VxT	0.076	0.218	
	TxV	0.1	0.281	
No. of seeds/capsule	V	0.022	0.07	0.24
	T	0.012	0.034	0.12
	VxT	0.026	0.077	
	TxV	0.027	0.077	

Table.14 Effect of NAA, GA_3 and IAA on no. of chaffy seeds per capsule and no. of healthy seeds per capsule of different sesame cultivars

Treatments	No. of chaffy seeds/capsule		No. of healthy seeds/capsule	
T_0	8.1		30.32	
T_1	2.9		34.14	
T_2	2.72		34.54	
T_3	7.46		31.08	
T_4	4.2		33.6	
T_5	6.46		29.48	
T_6	3.56		33.2	
MEAN	5.05		32.33	
VARIETIES				
V_1	5.4		29.82	
V_2	4.8		34.57	
V_3	5.68		29.82	
V_4	5.04		31.11	
V_5	4.35		36.34	
MEAN	5.05		32.33	
DAS		**SE(m)±**	**C.D. at 5%**	**CV**
No. of chaffy seeds/capsule	V	0.037	0.119	3.31
	T	0.029	0.083	2.25
	VxT	0.055	0.162	
	TxV	0.066	0.186	
No. of Healthy seeds/capsule	V	0.533	1.739	7.56
	T	0.695	1.965	8.32
	VxT	1.188	3.422	
	TxV	1.553	4.393	

Table.15 Effect of NAA, GA_3 and IAA on 1000 seed weight, yield and oil content of different sesame cultivars

Treatments	**1000 seed weight**		**Yield**	**Oil content (%)**
T_0	2.92		4.0	46.62
T_1	3.12		4.44	48.13
T_2	3.08		4.78	48.86
T_3	3.16		4.02	48.23
T_4	3.24		4.96	48.43
T_5	3.14		4.36	48.37
T_6	3.12		4.8	48.92
MEAN	3.14		4.48	48.22
Varieties				
V_1	3.01		3.24	54.61
V_2	3.07		5.08	46.03
V_3	2.98		3.84	49.19
V_4	3.2		4.62	45.95
V_5	3.4		5.6	45.33
MEAN	3.14		4.48	48.22
DAS		**SE(m)±**	**C.D. at 5%**	**CV%**
1000 seed weight	V	0.017	0.056	2.5
	T	0.016	0.044	1.91
	VxT	0.028	0.083	
	TxV	0.035	0.098	
Yield	V	0.314	1.023	32.09
	T	0.170	0.482	14.72
	VxT	0.365	1.104	
	TxV	0.38	1.07	
Oil content (%)	V	0.031	0.101	0.295
	T	0.026	0.075	0.215
	VxT	0.049	0.144	
	TxV	0.059	0.169	

Table.16 Correlation coefficient matrix between physiological growth parameters with yield and its attributing characters

	Yield	**No of capsules per plant**	**No of seeds per capsule**	**No of chaffy seeds per capsule**	**No of healthy seeds per capsule**	**1000 seed weight**	**Oil content percentage**	**Plant height (90 DAS)**	**Total dry matter**
Yield	-	0.820	0.936	-0.904	0.924	0.8	-0.904	-0.636	0.990
LAI	0.984	0.898	0.974	-0.959	0.968	0.840	-0.831	-0.514	0.989
CGR	0.946	0.852	0.911	-0.854	0.964	0.667	-0.804	-0.656	0.973
RGR	0.981	0.9	0.969	-0.95	0.978	0.820	-0.822	-0.529	0.993
NAR	0.893	0.956	0.958	-0.909	0.986	0.645	-0.669	-0.489	0.922
SLW	0.978	0.92	0.986	-0.956	0.975	0.784	-0.819	-0.537	0.980
SLA	-0.236	0.038	-0.065	0.208	-0.1001	-0.650	0.264	-0.126	-0.249
LWR	0.897	0.625	0.743	-0.694	0.828	0.648	-0.857	-0.745	0.922
LAR	0.927	0.881	0.915	-0.892	0.980	0.754	-0.733	-0.514	0.968
LAD	0.983	0.821	0.921	-0.862	0.937	0.700	-0.892	-0.709	0.986
Total Chlorophyll content	0.845	0.936	0.918	-0.948	0.960	0.844	-0.565	-0.216	0.893
Plant height (90 DAS)	-0.636	-0.242	-0.421	0.272	-0.447	-0.115	0.812	-	-
Total dry matter	-	0.847	0.939	-0.911	0.956	0.804	-0.868	-0.604	-

The leaf area duration between 60 to 90 DAS was calculated and reflected in table 12. From the data it was revealed that the highest LAD (37.11 Days) was recorded from GA_3 20 ppm conc. which is 14.11 % increase over the control. Among the varieties highest value of LAD was observed in Nirmala (40.58) but the minimum value was shown in Uma (32.27). The interaction effect between the LAD and the yield was found to be significant. LAD is positively correlated with yield (r = 0.983) (Table 16).

The leaf area index (LAI) was increased significantly irrespective of varieties due to foliar spray of plant growth regulators. There was remarkable improvement in LAI with -15.78 % decreases at 90 DAS of the crop on GA_3 20 ppm conc. The findings was close conformity with the result of Barun and wild (1984), similar trend was recorded in relative growth rate (RGR) as the leaf area was increased the photosynthetic rate was increased which enhance the growth rate, higher concentration of PGRs contributed higher RGR. The net assimilation rate is a measure of photosynthesis of leaves in crop community due to optimum LAI net assimilation rate (NAR) was found maximum in IAA 20 ppm conc. (105.7 mg/dm^2/day) so NAR significantly influenced by hormonal manipulation (Briggs *et al.,* 1920). Specific leaf weight a measure of leaf thickness has been reported a strong positive correlation with photosynthesis of several crops as reported by Bowes *et al.,* (1972).

Thicker leaves would have more number of mesophyll cells with a high density of chlorophyll for which they have the greater photosynthetic capacity. PGRs increased leaf area with more chlorophyll content which ultimately more SLW, IAA 20 ppm exhibited more SLW. Higher SLW might be associated with higher cell surface to volume ratio. The foliar spraying of PGRs increased SLW of sesame. The present findings are in close conformity of Dornhoff and Sibles (1970). The product of NAR and LAI resulted in CGR which was found higher in all the treatments of PGRs over the control. CGR has a strong positive correlation with LAI as the LAI was found maximum in PGRs treated plots the CGR was noted highest in IAA 20 ppm conc. (52.09 g/m^2/day) so from the present study concluded that foliar application PGRs significantly expressed the higher values of growth attributes viz. LAI, CGR, NAR and SLW by showing higher accumulation of total dry matter production with increased yield.

Yield and yield attributing characters

The yield of a crop depends upon the yielding potentiality of the variety but it is governed by the environmental factors around the crop. The yield and the yield attributing character affected by growth regulators were recorded, analyzed and presented in the following subheads.

Number of capsules per plant

The number of capsules per plant due to the effect of growth regulators has been computed in table 13. From the data it was revealed that irrespective of varieties there was an increase of number of capsules per plant due to the application of growth regulators. Among the varieties Nirmala exhibited the highest number of capsule per plant (18.37) followed by Amrit (18.0) whereas lowest value was recorded from Smarak (16.07).Among the treatments highest number of capsules was produced (17.64) by the effect of IAA @20 ppm followed by GA_3 @20 ppm (17.34) which is 4.13 % and 2.36 % increased over the control. It was found that significant difference was noted among the varieties and treatments. The interaction effect between treatments and varieties was

not significant. There was positive correlation between the yield and the number of capsules per plant (r = 0.820) (Table 16).

Number of seeds per capsule

Data computed in table 13 revealed that the number of seeds per capsule was not much more affected by growth regulator and the percentage of increase in seed ranged from 0.83 in NAA @10 ppm to 1.48 in GA_3 @20 ppm. Among the treatments GA @20ppm contributed highest number of seeds per capsules per capsule (41.44) followed by IAA @20 ppm treatment (41.08) whereas the lowest value was recorded from control (40.54). Among the varieties the highest number of seeds was contributed by Nirmala (44.25) followed by Amrit (43.14) whereas lowest value of the same was noted from Smarak (37.80) significant difference among the varieties was noted. There was positive correlation between yield and Number of healthy seeds per capsule (r = 0.936) (Table 16).

Number of healthy seeds per capsule

Data recorded in table 14 indicated that application growth regulator increased the filled up grains per capsule in all the varieties. The maximum filled up grains was recorded from NAA @20 ppm (34.54) followed by NAA 10 ppm (34.14) which was (15.80 %) and (17.16 %) increased over the control. Among the varieties Nirmala contributed the highest number of healthy seeds (36.34) followed by Amrit (34.57) whereas the minimum value of the same was exhibited by Uma and Smarak (29.82 kg). Significance difference among the varieties was noted as per the C.V value there was greater variation among the treatment and varieties as recorded to number of healthy seeds. There was positive correlation between yield and number of healthy seeds per capsule (r =0.924) (Table 16).

Number of chaffy seeds/capsules

From the data computed in table 14 revealed that the number of chaffy seeds decreased irrespective of varieties. Highest number of chaffy seeds per capsules was recorded by control (8.1) whereas the minimum value of the same was noted from NAA @20 ppm (2.72) followed by NAA @10 ppm (2.9). It was found that highest number of chaffy seeds were exhibited by Smarak (5.68) followed by Uma (5.40) but minimum value of the same was recorded from Nirmala (4.35).It was noted that significant difference was found among the treatment as well as among the varieties. The interaction effect between the variety and treatment was significant. There was negative correlation between yield and chaffy seed (r = -0.904) (Table 16).

1000 seed weight

One thousand seed weight have been depicted in table 15. From the data it was found that among the cultivars the highest test weight was recorded from Nirmala (3.40 g) followed by Prachi (3.20 g) whereas the lowest value at the same was noted in Smarak (2.98 g) Irrespective of treatment. There was increased of 1000 seed weight on compared to the control. The percentage of increase ranged from 6.84 in NAA 10 ppm to 10.95 in GA_3 20 ppm. A significantly difference among the varieties and treatments were noted. There was positive correlation between yield and 100 seed test weight (r = 0.8) (Table 16).

Yield

The yield data is compared in table 15 which reflected that the highest yield was contributed by Nirmala (5.6 q/ha) followed by Amrit (5.08 q/ha) but the lowest yield was exhibited by Uma (3.24 q/ha) among all the varieties due to the effect of growth regulators. Due to the effect of growth

regulator maximum yield was produced due to spraying IAA @20 ppm (4.80 q/ha) followed by NAA @20 ppm (4.78 q/ha) whereas the minimum yield was exhibited by GA_3 @10 ppm. The percentage of increase of yield ranged from 0.5 in GA_3 @10 ppm conc. to IAA @20 ppm conc. 20 %. A significant difference between the variety and treatment was noted. The interaction effect as regards to yield is non-significant.

Oil content of seeds (%)

Analysis of oil content of seeds table 15 revealed that irrespective of variety the oil content of seeds was increased, ranging from 3.23 % in NAA 10 ppm conc. to 4.93 % IAA 20 ppm conc. In Significant difference among the treatments was noted as regards to oil content of the seeds. Among the varieties Uma contributed highest oil content (54.61 %) followed by Smarak (49.19 %) whereas the lowest value of the same was recorded from Nirmala (45.33 %). Significant difference in respect to oil content among the varieties was noted. The interaction effect between the variety and treatment was found. There was negative correlation between the yield and oil content of the seeds (r = -0.0904) (Table 16).

The response in yield and yield attributing characters were studied under different concentration of NAA, GA3, IAA. Increase in seed yield over the control ranged from 0.5 % in GA_2 10 ppm to 24% in GA_3 20 ppm conc. more or less similar increase in number of capsules number of seeds per capsules and 1000 seed weight was observed in PGRs treatments over the control. Similar effects of growth substances were obtained by Akhtar *et al.*, (1998).

From the present investigation it was concluded that there is a remarkable effect of NAA, IAA and GA_3 improving the oil content of seeds. Both the concentration of all the growth regulators significantly increased the oil content over the control. The oil content of seeds increased to an extent of 3.23 % in NAA 10 ppm to 4.9 % in IAA 20 ppm conc. This finding confirms the findings of previous workers (Akhtar *et al.*, 1998).

It can be concluded that application of Plant growth regulators of different concentration increased plant height irrespective of varieties and the maximum plant height was observed in GA_3 20 ppm (138.4 cm) followed by $GA_3$10 ppm (134.59 cm) Among the varieties the maximum increase in plant height was recorded from Nirmala followed by Prachi. Exogenous spraying of growth regulators significantly increasing the oil content of seeds irrespective of varieties over the control. The percentage of increase ranged from 3.23 in NAA 10 ppm conc. to 4.9 % in IAA 20 ppm conc. whereas among the varieties the highest percentage of oil content was recorded from Uma (54.61 %) followed by Smarak (49.19 %). The application of GA_3 20 ppm concentration contributed highest profit (104.76 %) followed by IAA 20 ppm concentration (20.8 %) whereas NAA in both concentration along with a lower concentration of IAA and GA_3 have no effect on profit.

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