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NK Lakhnotra
M.Sc. (Agri.) in Agronomy, Department of Agronomy, Junagadh Agricultural University, Junagadh, Gujarat, India

BB Ramani
Associate Research Scientist, Directorate of Research, Junagadh Agricultural University, Junagadh, Gujarat, India.

RR Mushar
Ph.D. Scholar, Department of Agronomy, Junagadh Agricultural University, Junagadh, Gujarat, India.

BS Gohil
Assistant Professor, Department of Agronomy, Junagadh Agricultural University, Junagadh, Gujarat, India

Corresponding Author:
NK Lakhnotra
M.Sc. (Agri.) in Agronomy, Department of Agronomy, Junagadh Agricultural University, Junagadh, Gujarat, India

Response of summer sesame [*Sesamum indicum* (L.)] to plant growth regulators in relation to growth and yield parameters, yield and economics

NK Lakhnotra, BB Ramani, RR Mushar and BS Gohil

Abstract
A field experiment was conducted on medium black calcareous soil at the Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) during the summer season of 2019 in randomized block design with three replications, comprised with 10 treatments of three plant growth regulators spray at single stage as well as double stage. Foliar application of 100 ppm IAA at flowering as well as capsule formation stage recorded significantly higher values of growth parameters *viz*., plant height, number of branches/plant, dry matter accumulation, crop growth rate, early maturity and yield attributes *viz*., number of capsules/plant, number of healthy seeds/capsule, less number of chaffy seeds/capsule and test weight along with higher seed and stover yields as well as higher value of economics over rest of the treatments including Control.

Keywords: Plant growth regulators, summer sesame, GA_3, IAA, NAA, yield

Introduction

In India, sesame (*Sesamum indicum* L., 2n = 26) is a very old oilseed crop that is planted close to mustard, rapeseed, and peanut. It is a member of the family Pedaliaceae and order Tubiflorae. It goes by several names, including gingelly, gergelim, simsim, and til. Owing to the significance of its oil, sesame seeds are given nicknames like "poor man's ghee." Sesame is also known as the "survival crop" since it can withstand weather fluctuations among other things. Sesame is known as the “Queen of Oilseeds” because of the exceptional properties of the seed, oil, and meal, as well as the oil's exceptional qualities for cosmetics and skin care. Sesame oil typically contains between 34 to 63% of oil (Were *et al*., 2006) [14]. Sesame is extremely nutritious (Oil 50% and protein 25%) and its oil is a great vegetable oil because of its high concentrations of antioxidants such as sesamin, sesamol and sesamolin and its fatty acid composition (Suja *et al*., 2004) [10]. With 85% unsaturated fatty acids, the oil is very stable, lowers cholesterol, and guards against coronary heart disease. Among India's edible oilseeds, sesame has emerged as a silver line in agri-export, contributing the most to export profits.

Today, sesame is grown profitably in the summer season in every district of Gujarat except Dang, Valsad and other parts of the state. Sesame is usually grown as a sole crop or as a mixed crop during *Kharif*, Semi-*Rabi* and summer as a short-duration crop. The summer season offers good weather parameters in terms of photoperiods and temperature and bad weather conditions in terms of diseases and attack by insects. Because of these factors and due to the availability of moisture, sesame gives higher yield in summer than in *kharif*. Today in Gujarat, the area of summer sesame is increasing due to low input cost and short life span as compared to other crops.

Part of the reason for low productivity is that the crop is grown on a large scale under rainfed, low input conditions, and high yielding varieties are not available. In order for the crop to grow and develop normally, it needs to have the proper amounts of hormones such as auxins, gaberellins and ethylene, as well as Cytokinins and Abscisic Acid. If the hormones are not in the correct proportions, the reproductive organs are shed. When the growth regulators are applied in the correct amounts, these substances affect the structure of the plant in a typical way and increase the yield potential of the crop. In recent years, the use of Plant Growth Regulators (PGR) may have been one of the most effective ways to make great strides in crop growth and productivity.

Materials and Methods

The field experiment entitled "Response of summer sesame (*Sesamum indicum* L) to plant growth regulators in relation to growth and yield parameters, yield and economics" was conducted during summer season of the year 2019. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction with pH 7.9 and EC 0.33dS/m. The soil was low in available nitrogen (278 kg/ha), high in available phosphorus (38 kg/ha) and medium in available potash (252 kg/ha). The field experiment was comprised with 10 treatments including Control (T_1) and three plant growth regulators spray at single stage as well as double stage *viz.*, T_2: GA_3 - 50 ppm at flowering stage, T_3: GA_3 - 50 ppm at capsule formation stage, T_4: GA_3 - 50 ppm at flowering and capsule formation stage, T_5: IAA - 100 ppm at flowering stage, T_6: IAA - 100 ppm at capsule formation stage, $T_{7:}$ IAA - 100 ppm at flowering and capsule formation stage, T_8: NAA - 50 ppm at flowering stage, T_9: NAA - 50 ppm at capsule formation stage, T_{10}: NAA -50 ppm at flowering and capsule formation stage which were tried under randomized block design with three replications. Summer Sesame variety Gujarat Junagadh Til-5 was used for sowing with seed rate of 5 kg/ha on 20th February during 2019. Seeds were dropped manually in opened furrows at depth 2-3 cm with inter row spacing 30 cm and gently covered with the soil. The fertilizer dose 50-25-0kg N-P_2O_5-K_2O/ha in form of urea and diammonium phosphate was applied to the crop just before sowing. Thinning operation were undertaken 15 days after sowing to maintain intra-row spacing of 10 cm. Spraying of plant growth regulators was done at flowering and capsule formation stage.

Results and Discussion

Effect on growth parameters

Plant height at 40 & 60 DAS and at harvest

Effect of growth regulators treatments on growth parameters of sesame are presented in Table 1. Significantly higher value of plant height at 60 DAS (62.02 cm) and at harvest (70.33 cm) was observed with application of IAA 100 ppm at flowering and capsule formation stage (T_7) but it was statistically at par with treatments (T_5) and (T_6) at both the stages. The increase of plant height supports the earlier workers findings of Behera *et al.* (2017) [3], Sarkar *et al.* (2002b) [8] and Vekaria *et al.* (2017) [13] in sesame, Sao and Sahu, (2013) [6] in groundnut.

The highest value of branches/plant (3.00) was observed under spraying of IAA 100 ppm at flowering and capsule formation stage (T_7). It was statistically at par with treatments (T_5), (T_6), (T_4) and (T_2). The finding are in accordance with the findings of Behera *et al.* (2017) [3] and Vekaria *et al.* (2017) [13] in sesame. Dry matter accumulation at 40 & 60 DAS and at harvest furnished in Table 1 revealed that plant growth regulators had no any effect on dry matter production at 40 DAS but they are significantly influenced dry matter production at 60 DAS (6.94 (g/plant)) and at harvest (13.98 (g/plant)). Comparing the dry matter/plant at 60 DAS and harvest to the control, it was significantly higher under the application of IAA 100 ppm at flowering and capsule formation stage (T_7) but found statistically at par with treatments (T_5) and (T_6). Lower dry matter accumulation recorded under Control (T_1). This might be as a result of increase cell division and other physiological activities. Due to the increase in number of branches and there by leaf area more photosynthates are produced and the total dry matter of the plant was increased. These findings are in close agreement with Behera *et al*. (2017) [3] in sesame.

The data in Table 1 clearly indicated that different treatment of plant growth regulators did not exert their significant effect on relative growth rate recorded during 40 to 60 DAS and at 60 DAS to harvest of crop. The data given in Table 1 revealed that the application of IAA 100 ppm at flowering and capsule formation stage (T_7) in sesame had significant effect on days to maturity and gave early maturity than other treatments of plant growth regulators. Late maturity observed under Control (T_1 water spray) treatment. This might be due to the favorable growth and more number of capsule which promotes earliness as compare to Control (T_1).

Effect on yield attributes and yields

Number of capsule/plant

Of the different treatments, a significantly higher number of capsules/plant was recorded at the flowering and capsule formation stage (T_7) when IAA 100 ppm was applied (Table 2), which remained statistically at the same level as the IAA 100 ppm treatment. flowering stage (T_5), IAA 100 ppm at capsule formation stage (T_6), GA_3 50 ppm at flowering and capsule formation stage (T_4) and GA_3 50 ppm at capsule formation stage (T_3). Treatment control (T_1) recorded a significantly lower number of capsules/plant and was observed at flowering stage at the same level as all three NAA and GA_3 treatments. The increase in the number of capsules/plant may be due to the increase in the number of branches/plant in the IAA treatment. Similar results were reported by Behera *et al*. (2017) [3] and Vekaria *et al*. (2017) [13] in sesame. Azizi *et al.* (2012) [2], Agawane ja Parhe (2015) [1], Sarkar *et al*. (2002a) [7] Sudadi (2012) [9] in soyabean. Vasudevan *et al*. (2008) [12] in fenugreek.

Number of seeds/capsule

The data in Table 2 showed that different treatments with plant growth regulators did not significantly affect the number of seeds/capsule. This may be due to genetic control.

Number of chaffy seeds/capsule

The number of chaffy seeds/capsule was reduced significantly due to the use of different plant growth regulators. The minimum value of the chaffy seeds/capsule (Table 2) was recorded with as recorded with 100 ppm IAA at flowering and capsule formation (T_7). Higher photosynthetic activity resulted in more nutrient uptake, which caused the least seed damage and yielded healthy seeds in the IAA treatment. On the other hand, the control (T_1) recorded the highest number of chaffy seeds/capsule. Similar results were reported by Behera *et al*. (2017) [3], in sesame.

Number of healthy seeds/capsule

The number of healthy seeds/capsule was increased significantly due to application of different plant growth The number of healthy seeds/capsules has significantly increased due to the use of different plant growth regulators. The highest number of healthy seeds per capsule (Table 2) was recorded with IAA 100 ppm at flowering and capsule formation (T_7), which was statistically at the same level as treatment IAA 100 ppm at flowering (T_5), IAA 100 ppm at the capsule formation stage (T_6), GA_3 50 ppm at the flowering and capsule formation stage (T_4) and GA_3 50 ppm at the capsule formation stage (T_3). This was due to higher photosynthetic activity and more nutrients in the sinking direction, resulting in healthier seeds/pods. A lower number of intact seeds/capsules was recorded in the control (T_1) and was observed at the same level as all NAA and GA_3 treatments in the flowering stage (T_2). Similar results were reported by Behera *et al*. (2017) [3] in sesame.

Test weight (1000 seed weight)

Test weight (Table 2) was significantly increased by IAA 100 ppm at the flowering and capsule formation stage (T_7), but was statistically the same as the treatment with IAA 100 ppm at the flowering stage (T_5), IAA 100 ppm at the capsule formation stage (T_6)), GA_3 50 ppm in the flowering and capsule formation phase (T_4), GA_3 50 ppm in the capsule formation phase (T_3) and GA_3 50 ppm in the flowering phase (T_2). Although a significantly lower test weight was recorded in the Control (T_1), which remained at the same level as all three treatments with NAA and GA_3 in the flowering period. Test mass was significantly higher in indoleacetic acid, which may have been due to increased crop photosynthesis, which was facilitated by both improved photosynthetic efficiency and the source-to-sink ratio. The above results are consistent with Behera *et al*. (2017) [3] and Vekaria *et al*. (2017) [13] in sesame, Agawane and Parhe (2015) [1], Sudadi (2012) [9], Upadhyay and Ranjan (2015) [11] in soybean, Yakubu *et al*. (2013) [15] in peanut, Vasudevan *et al.* (2008) [12] for fenugreek.

Effect on yield

Seed and stover yields

Application of plant growth regulators resulted in significant differences in seed and stover yield (Table 2). Application of plant growth regulators in sesame IAA at 100 ppm at flowering and capsule formation stage (T_7) resulted in significantly higher seed yield (1524 kg/ha) and stover yield (1768 kg/ha) which were about 97% and 27% higher overcontrol (T_1), respectively. Improved vegetative growth resulting from the use of plant growth regulators with increased photosynthesis on the one hand and enhanced mobilization of photosynthesis to reproductive sites on the other may have increased growth and yield.

The cumulative effect of these yield attributes led to a significant increase of stover yield. Since yield of a crop is a combination of several components that are dependent on a complementary interaction between the vegetative and reproduction growth of the crop, the growth and yield attribute clearly led to higher yields under various crop growth regulators. The significant increase of seed yields and stover yield under the various plant growth regulators appear to be due to their significant impact on the number of capsules/plants (Table 2), test weight (Table 2), number/capsules of healthy seeds (Table 2), and increase in growth parameters (Table 1) such as plant height/branches/plants, dry matter accumulation, crop growth rate, relative growth rate, etc. These findings are in line with Behera *et al*. (2017) [3] and Vekaria *et al.* (2017) [13] in sesame, Sarkar *et al.* (2002a) [7] and Sudadi (2012) [9] in soybean, Khalil *et al*. (2006) [4] in Lentil and Lee (1990) [5] in groundnut.

On the other hand, the seed and stover yield recorded under Control (T_1) showed significantly lower yields, which were comparable to single dose NAA for seed yield and all three NAA levels and GA_3 for stover yield (see Table 1). Therefore, the application of NAA & GA_3 showed poor performance on summer sesame yields.

Table 1: Effect of different treatments on plant height, branches/plant, dry matter accumulation, CGR, RGR and days to maturity of summer sesame (*Sesamum indicum* L).

Treatments	Plant height (cm)			No of branches/plant	Dry matter accumulation (g/plant)			CGR (g/day/m^2)		RGR(g/g/day)		Days to maturity
	40 DAS	60 DAS	Harvest		40 DAS	60 DAS	Harvest	40 to 60 DAS	60 DAS to Harvest	40 to 60 DAS	60 DAS to Harvest	
T_1	21.17	51.03	55.20	2.20	1.80	5.30	10.05	0.17	0.15	0.054	0.032	90.67
T_2	24.50	56.05	59.80	2.67	1.89	5.79	11.24	0.20	0.17	0.056	0.033	88.33
T_3	25.50	58.01	61.33	2.60	1.93	5.82	11.30	0.19	0.17	0.055	0.033	87.67
T_4	24.53	59.01	61.53	2.80	1.90	5.82	11.30	0.20	0.17	0.056	0.033	87.33
T_5	28.50	61.51	64.53	2.93	2.00	6.48	12.88	0.22	0.20	0.059	0.034	86.33
T_6	27.50	60.04	64.33	2.87	1.96	6.28	12.40	0.22	0.19	0.058	0.034	86.67
T_7	26.50	62.02	70.33	3.00	1.99	6.94	13.98	0.25	0.22	0.062	0.035	85.33
T_8	21.20	52.03	57.07	2.33	1.83	5.36	10.21	0.18	0.15	0.053	0.032	90.33
T_9	24.06	53.03	57.47	2.40	1.84	5.46	10.44	0.18	0.16	0.054	0.032	89.67
T_{10}	23.50	54.04	57.87	2.47	1.80	5.68	10.98	0.19	0.17	0.057	0.032	88.67
S.Em.+	1.56	2.49	2.76	0.12	0.08	0.32	0.49	0.02	0.01	0.003	0.001	0.35
C.D. at 5%	NS	7.39	8.19	0.36	NS	0.95	1.46	NS	0.04	NS	NS	1.03
C.V. %	10.92	7.62	7.84	7.88	7.25	9.38	7.43	14.59	11.68	11.11	10.07	6.8

Table 2: Effect of different treatments on number of capsule/plant, number of seeds/capsule, number of chaffy seeds/capsule, number of healthy seeds/capsule, 1000-seed weight (g) and yield (kg/ha) of summer sesame (*Sesamum indicum* L)

Treatments	Number of capsule/ plant	Number of seeds/capsule	Number of chaffy seeds /capsule	Number of healthy seeds/ capsule	1000-seed weight (g)	Yield (kg/ha)	
						Seed yield (kg/ha)	Stover yield(kg/ha)
T_1	42.60	62.60	5.80	57.53	2.93	777	1286
T_2	48.40	73.07	3.20	64.40	3.49	945	1414
T_3	52.33	73.10	3.00	68.73	3.52	954	1418
T_4	53.40	73.34	2.73	69.47	3.70	1107	1435
T_5	56.27	76.03	2.27	72.27	3.80	1299	1554
T_6	55.80	73.45	2.33	71.13	3.71	1231	1528
T_7	58.13	77.27	1.77	76.73	4.02	1524	1768
T_8	42.93	68.00	3.67	58.60	2.97	915	1298
T_9	47.27	68.60	3.53	62.60	3.29	919	1323
T_{10}	48.33	70.93	3.33	64.13	3.37	925	1369
S.Em.±	2.29	2.94	0.13	3.14	0.20	47	62
C.D. at 5%	6.80	NS	0.40	9.32	0.58	142	185
C.V. %	7.84	7.11	7.33	8.16	9.76	7.81	7.48

Table 3: Effect of different treatments on economics of summer sesame (*Sesamum indicum* L)

Treatments	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
T_1	27070	51267	20457	1.89
T_2	30095	62278	25231	2.07
T_3	30095	62873	25826	2.09
T_4	33120	72827	32336	2.20
T_5	31290	85343	46936	2.73
T_6	31290	80928	42520	2.59
T_7	35510	100109	56897	2.82
T_8	29595	60258	23781	2.04
T_9	29595	60507	24029	2.04
T_{10}	32120	60918	21566	1.90

Conclusion

On the basis of results of one year experiment, it can be concluded that the foliar spray of 100 ppm IAA (Indole acetic acid) as plant growth regulator at flowering and capsule formation stages was found effective for securing higher yield of sesame (GJT-5) along with higher net returns and B: C ratio in medium black calcareous soil of south Saurashtra Agro-climatic Zone of Gujarat.

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