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The Effect of Plant Growth Hormones and Bio-fertilizers on Growth and Economics of Summer Sesame (*Sesamum indicum* L.)

Kadamandla Jerusha[1*], Vikram Singh[2] and Dhananjay Tiwari[3]

[1]M.Sc. Scholar, Department of Agronomy, NAI, SHUATS, Prayagraj, (Uttar Pradesh), India.
[2]Associate Professor, Department of Agronomy, NAI, SHUATS, Prayagraj, (Uttar Pradesh), India.
[3]Ph.D. Scholar, Department of Agronomy, NAI, SHUATS, Prayagraj, (Uttar Pradesh), India.
[1]Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj-211007, (Uttar Pradesh), India.

(Corresponding author: Kadamandla Jerusha)*
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ABSTRACT: A field experiment was conducted during the *Zaid* season of 2020 at the experimental field of the Crop Research Farm, Department of **Agronomy, Sam Higginbottom University of Technology and Sciences, Prayagraj, Uttar Pradesh, India to determine the "Effect of Plant growth hormones and Bio-fertilizers on Growth and yield of Sesame (*Sesamum indicum* L.)". The experiment consisted of 2 levels of two plant growth hormones 1. Gibberellic acid (50mg/l, 100mg/l) 2. Indole Acetic acid (50mg/l, 100mg/l) and two bio-fertilizers Azospiriluum and Azotobacter at 20g/kg seed. The experiment was carried out through a statistical design of Randomized Block Design (RBD) with three replications. Variety used was Gujarat till 4. Report of the study indicates that, among different levels of plant growth hormones and bio-fertilizers the application of 100 mg/l of GA_3 to the Azotobacter treated plots produced significantly highest Leaf area (36.2cm^2), Plant Dry weight (13.40g) at 60 DAS and Crop Growth Rate (14.20g/m^2/day) at 45-60 DAS. The application of GA_3 at 100 mg/l and Azotobacter was found to be effective because it also fetched highest Gross returns (63,916 INR/ha), Net returns (42,109 INR/ha) and B:C ratio (1.93) when compared to the control (RDF). The challenges faced during the research work were a little bit of fungus attack during the maturity of the capsule but it did not show any greater effect on the yield.**

Keywords: Plant growth hormones, Bio-fertilizers, Gibberellic acid (GA_3), Indole acetic Acid (IAA), Azospirillum, Azotobacter.

INTRODUCTION

Sesame (*Sesamum indicum*) is a broad leaf summer crop similar to cotton, sunflower, soy beans, black eyed peas, mung beans or guar. When planted early and under high moisture and fertility conditions, it is generally 3-5 feet, depending on rainfall. Some varieties are single stemmed and others have branches. The fruiting form of sesame is a capsule, often called pods. They have divided sections much like a cotton boll. Some varieties have a single capsule per leaf axil and others have triple capsule per leaf. Branched, single capsule varieties are best adapted to the present growing areas.

The oil of sesame is being used for cooking in south India. The oil cake is an edible. Worldwide, sesame is grown on6.57 million hectares with production of 0.72 million tones and productivity of 0.46 tonnes/ha. India is the largest producer and acreage holder (26%) of sesame in the world. It is cultivated on 17 lakh hectares with total production of 0.62 metric tonnes and productivity of 0.34 tonnes/ha (Vekaria, 2017).

In Uttar Pradesh sesame is cultivated in districts of Jhansi, Mahoba, Jalaun, Hamirpur, Banda, Hardoi, Unnao, Sitapur, Fatehpur, Shahjahanpur, Kheri and Raebareli in an area of 3,31,438 ha with the total production of 41654 MT. Indole acetic acid (IAA) and Gibberellic acid (GA_3) can manupulate a variety of growth and development phenomenon in various crops. IAA has been found to increase the plant height, the number of leaves per plant with consequent enhancement in seed yield in groundnut and cotton. It also increases flowering, fruit set, total dry matter of crop likewise GA_3 stimulated stem elongation increased dry matter application and enhance total yield. The Application of growth regulators also enhances cell division and cell elongation. Due to the application of hormones the hydrolysis of starch, fructose and sucrose increased to form glucose and fructose molecule for which there will be increased water potential, cell expansion and cell plasticity thus promotes leaf growth and increases leaf area (Agarwal and Dikshit 2008).

Role of bio-fertilizers is well recognized in agriculture, particularly in pulses. Application of Azotobacter or Azospirillum provides nitrogen to the crop which is the most essential plant nutrient for plant growth and crop yield. It is reported that bio-fertilizers application stimulated the germination and growth by excreting phytohormones and enhancing the nutrient mobilization from the seed. Considering the above points, the present investigation was conducted.

Sahoo *et al*. (2010) concluded that in sesame *Azotobacter* at 600g/ha + 30kg N /ha increased the plant height (136.18cm), dry matter (8.747 g) at harvest, leaf area index (1.473)at 60DAS, number of seeds/capsule (65.56), width of capsule (0.887 cm) and

seed yield (1157.66 kg/ha) whereas application of 600g of *Azospirillum* per hectare increased the length of capsules (2.340cm)and stalk yield (22.410 q/ha) when compared to control.

Kushwaha (2011) concluded that in sesame the seed treatment with 10g/kg seed of Azotobacter increased the shoot length (2.07cm), organic carbon (0.63%), available N (322.44 kg/ha), available p(20.41kg/ha) which was 0.43%, 189.10kg/ha,14.89kg/ha respectively in control.

Venkaria *et al.,* (2017) concluded that in sesame application of IAA at 100ppm at flowering and capsule formation stage in sesame has recorded maximum value for 1000 seed weight (3.38g), the highest harvest index (25.8) was noted under application of GA_3 at 100ppm at capsule formation stage. On basis of pooled results the significantly highest seed yield (947 kg/ha), stalk yield (2810kg/ha) and biological yield (3757kg/ha) were obtained due to foliar application of IAA @ 100ppm at flowering and capsule formation stage.

Senthilkumar and Sivagurnathan (2012) reported that the comparative effect of bacterial bio-fertilizers such as *Rhizobium*, *Phosphobacteria* and *Azospirillum*on growth and yield of green gram and cowpea showed that in cowpea the highest number of leaves/ plant (10.6), length of leaves (6.8 cm), breadth of leaves (4 cm), shoot length (31cm), root length (17.2 cm) and also in green gram number of leaves (9.0), length of leaves (6.6cm), breadth of leaves (2.4cm), shoot length (25.2cm) an root length (7.9cm) in the treatment with application of *Rhizobium* + *phosphobacteria* + *Azospirillum* when compared to control.

Ahiwar (2013) reported that during the study of IBA in Akola the highest shoot height (38.38cm) and root length (39.55cm) is observed in the treatment with IBA (100ppm). The average maximum dry weight of leaves (0.480g) was noted in 100ppm followed by 50PPM (0.372g) and in 25ppm (0.272g) of IBA application as compared to control (0.158g), dry weight of shoot is also maximum (0.815) in treatment with 100 ppm of IBA when compared to control.

Lakhran *et al.* (2015) reported that in summer sesame significantly highest oil content (48.48%) and oilyield (574.1 kg/ha) were observed under the application of 75% RDF+5t FYM/ha + bio-fertilizer (*Azospirillum* + PSB) over the remaining treatments.

Subash and Rafath (2016) reported that the seed of sesame variety TMV-7 when treated with different concentrations of Gibberllic acid (1.0mg/l, 2.0mg/l, and 2.5mg/l) and the bio-fertilizer Azospirillum was mixed with rice starch and applied to the seeds the biofertilizer has regulator effect on seed germination (98%), root length (7.23cm), shoot length(10.11cm) while in plant growth hormones treated plants 2.0mg/l of GA_3 shows maximum effect compared to IAA.

Behera *et al*., (2017) reported that in sesame the highest percentage of seed germination was recorded in GA_3 20ppm (98.51%) compared to control. IAA (10ppm) showed highest plant height (134.59cm), number of branches (5.49), leaf area was highest (42.09cm^2) in treatment with GA_3 (20ppm), dry weight per plant was highest (8.43g) in treatment with IAA (20ppm) the foliar spray of IAA 20ppm at 30 and 45 DAS showed highest LAI (0.097), RGR (1.654g/g/day), CGR (52.09g/m^2/day), NAR (105.7mg/dm^2/day) when compared to the control.

(Das and Biswas (2019) reported that in sesame the highest plant height (73.83cm), available nitrogen (200kg/ha), available phosphorus (77.65kg/ha), available potassium (63.46kg/ha), available sulfur (33.77kg/ha) at harvest are found in treatment with S@45kg/ha + PSB+ Azotobacter when compared to control.

Shalinee *et al.,* (2019) reported that in sesame significant variation was found among the treatments with spraying of GA_3 and IAA. GA_3 (300ppm) showed the highest germination percentage in contrast to other treatments. Highest germination percentage (92.63%) was found while compared to control (56.20%). It also showed highest shoot length of seedlings (5.73cm), while highest seedling root length (6.19cm), seedling dry weight (0.040g) and seed vigour index (3.17) was reported to be highest in seeds treated with IAA (300ppm).

MATERIAL AND METHODS

The experiment was conducted during the *zaid* season of 2020 at the Crop Resarch Farm, Department of Agromomy, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India. The Crop Research Farm is situated at25.57^o N latitude, 87.19^o E longitude and at an altitude of 98m above mean sea level. The experiment consists of 2 levels of two plant growth hormones Gibberellic acid (50mg/l, 100mg/l) Indole Acetic acid (50mg/l, 100mg/l) and two bio-fertilizers Azospiriluum and Azotobacter.

It was carried out through a statistical design of Randomized Block Design (RBD) with three replications consisted of 'nine treatments' *viz*., T_1: control (RDF), T_2: GA_3 at 50mg/l + Azospirillum, T_3: GA_3 at 50mg/l + Azotobacter, T_4: GA_3 at 100 mg/l + Azospirillum, T_5: GA_3 at 100mg/l + Azotobacter, T_6: IAA at 50 mg/l + Azospirillum, T_7: IAA at 50 mg/l + Azotobacter, T_8: IAA at 100 mg/l + Azospirillum, T_9: IAA at 100 mg/l + Azotobacter. During the growing season, the mean weekly maximum and minimum temperate, relative humidity and rainfall were 29.94°C, 10.84°C, 91.9 %, 32.5 % and 2.79 mm respectively. Sesame was sown at a spacing of 30cm × 10cm using the seed rate of 4kg/ha.

The field was uniformly irrigated before two days of sowing and further irrigated based on critical periods. The RDF i.e Nitrogen (50 kg/ha) was applied through urea and DAP in three equal splits, first as basal and remaining two doses at 30 DAS and 60 DAS (days after sowing), full dose P_2O_5 (40kg/ha) where as the full dose of K_2O (30kg/ha) were applied through DAP and MOP. Observations on growth parameters, yield attributes, yield and oil content of sesame to be recorded and their significance to be tested by the variance ratio. (F-value) at 5% level (Gomez and Gomez, 1984). Relative economics was calculated as per prevailing market prices of inputs and produced during *Zaid* season.

RESULT AND DISCUSSION

A. Growth attributes

Growth parameters of Sesame *viz*, Plant height (cm), Leaf area (cm^2), Leaf Area Index, Plant dry weight (g/plant), Crop growth rate ($g/m^2/day$), Relative growth rate (g/g/day) varied due to different treatments and are presented in Table 1.

Table 1: The Effect of Plant Growth Hormones and Bio-fertilizers on Growth attributes of sesame.

S.No.	Treatments	Plant Height (cm) at 60 DAS	Leaf Area (cm^2) at 60 DAS	Dry weight (g/plant) at 60 DAS	Leaf Area Index (LAI) at 60 DAS	CGR ($g/m^2/day$) 45-60 DAS	RGR (g/g/day) 45-60 DAS
1.	Control	64.00	29.50	8.20	3.14	13.40	0.089
2.	GA_3 at 50 mg/l + Azospirillum	73.80	31.40	8.60	3.56	13.40	0.081
3.	GA_3 at 50 mg/l + Azotobacter	72.90	31.60	8.50	3.85	13.20	0.080
4.	GA_3 at 100 mg/l + Azospirillum	76.40	32.20	8.90	4.65	11.30	0.057
5.	GA_3 at 100 mg/l + Azotobacter	78.90	36.20	13.40	5.14	14.20	0.043
6.	IAA at 50 mg/l + Azospirillum	73.10	32.70	9.10	3.49	13.20	0.071
7.	IAA at 50 mg/l + Azotobacter	78.30	31.70	9.40	4.33	13.30	0.068
8.	IAA at 100 mg/l + Azospirillum	78.40	32.80	10.00	4.58	13.50	0.062
9.	IAA at 100 mg/l + Azotobacter	80.70	35.70	10.20	5.46	12.90	0.057
	SEm(±)	1.42	0.39	0.24	0.15	0.38	0.003
	CD(p=0.05)	4.26	1.18	0.73	0.45	1.14	—

At 60 DAS the treatment combination T_5: GA_3 at 100 mg/l + Azotobacter resulted in the highest leaf area (36.2 cm^2), dry weight/plant (13.40g), CGR (14.20g) at 45-60 DAS. Whereas treatment combination T_9: IAA at 100 PPM + Azotobacter shows leaf area (35.7cm^2), which were statistically par with treatment T_5.However, T_9: IAA at 100 PPM + Azotobacter showed the highest plant height (80.7cm) and T_5: GA_3 at 100 mg/l + Azotobacter showed statistically at par with T_9 in respect to the plant height of (78.9 cm). The Application of growth regulators significantly increased the number of branches per plant, leaf area, total dry matter accumulation due to increase in cell division and other physiological activities. Due to the increase in leaf area more photosynthates are produced and the total dry matter of the plant was increased. While Azotobacter also helped in the increase of the photosynthesis rate which indirectly showed effect on the dry matter. The present findings correlate the findings of previous workers (Dhoran & Gudadehi, 2012; Ahirwar *et al*., 2012; Kokare *et al*., 2006).

B. Economics

The highest gross returns (63916.00 INR/ha), net returns (42109.00 INR/ha) and benefit cost ratio (1.93) was recorded in the treatment which has GA_3 at 100 mg/l + Azotobacter, as it had reported highest grain yield and stover yield. The lowest gross returns (44608.00 INR/ha), netreturns (22931.00 INR/ha) and B:C ratio (1.05) was reported in control, as it had reported lowest seed yield and stover yield (Table 2). Application plant growth hormones and bio-fertilizers brought about a significant increase in net returns and B:C ratio. This might be due to increased growth and yield by Plant growth hormones and bio-fertilizers.

Table 2: The Effect of Plant Growth Hormones and Bio-fertilizers on Growth of Sesame at Harvest.

Sr. No.	Growth attributes							
	Treatments	Plant Height (cm) at 90DAS	Branches/ Plant (No.) at 90 DAS	Leaf Area (cm^2) at 90 DAS	Dry weight (g/plant) at 90 DAS	Leaf Area Index (LAI) at 90 DAS	CGR ($g/m^2/day$) 75-90 DAS	RGR (g/g/day) 75-90 DAS
1.	Control	98.10	4.67	39.90	12.10	4.70	5.60	0.017
2.	GA_3 at 50 mg/l + Azospirillum	104.8	4.67	42.00	12.80	5.90	6.70	0.018
3.	GA_3 at 50 mg/l + Azotobacter	107.2	5.33	40.80	12.70	5.80	7.00	0.019
4.	GA_3 at 100 mg/l + Azospirillum	110.8	4.67	41.40	13.30	6.50	7.40	0.019
5.	GA_3 at 100 mg/l + Azotobacter	111.7	6.00	43.40	18.90	6.80	9.00	0.015
6.	IAA at 50 mg/l + Azospirillum	105.1	4.67	40.50	13.50	5.20	6.70	0.017
7.	IAA at 50 mg/l + Azotobacter	110.6	5.33	40.90	13.80	5.80	7.60	0.019
8.	IAA at 100 mg/l + Azospirillum	105.8	4.67	41.90	14.90	6.40	7.80	0.018
9.	IAA at 100 mg/l + zotobacter	112.7	5.33	43.20	15.20	7.50	7.60	0.017
	SEm(±)	1.46	0.65	0.63	0.58	0.25	0.91	0.002
	CD(p=0.05)	4.38	—	1.88	1.75	0.75	—	—

Table 3: The Effect of Plant Growth Hormones and Bio-fertilizers on Economics of Sesame.

Sr. No.	Treatments	Cost of Cultivation (INR/ha)	Gross Returns (INR/ha)	Net Returns (INR/ha)	B:C Ratio
1.	Control	21,677.00	44,608.00	22,931.00	1.05
2.	GA_3 at 50 mg/1 + Azospirillum	21,902.00	45,640.00	23,738.00	1.08
3.	GA_3 at 50 mg/1 + Azotobacter	21,782.00	48,630.00	26,848.00	1.23
4.	GA_3 at 100 mg/1 + Azospirillum	21,927.00	56,536.00	34,609.00	1.57
5.	GA_3 at 100 mg/1 + Azotobacter	21,807.00	63,916.00	42,109.00	1.93
6.	IAA at 50 mg/1 + Azospirillum	21,912.00	51,000.00	29,088.00	1.32
7.	IAA at 50 mg/1 + Azotobacter	21,792.00	51,430.00	29,638.00	1.36
8.	IAA at 100 mg/1 + Azospirillum	21,947.00	61,158.00	39,211.00	1.78
9.	IAA at 100 mg/1 + Azotobacter	21,827.00	62,546.00	40,719.00	1.86

Land Preparation

Sowing

Germination

Weeding & Thinning

Irrigating the Plots

GA_3 & IAA Spraying

Sesame Crop Ready to Harvest

The value of increased yield was much more than the cost of GA_3 and Azotobacter application which increased the net returns and the B:C ratio. On the basis of the result, 100 mg/lGA_3 and Azotobacter earned maximum net returns which was found higher than other treatments. Due to the yield in the treatments with GA_3 at 100 mg/l + Azotobacter is more which directly reflect the net returns and the B:C ratio. These results related to the findings of Behara *et al*., (2015).

CONCLUSION

Among all treatments, T_5 (GA_3 at 100 mg/l + Azotobacter) was found to be the best by obtaining highest growth and also the better B: C ratio. Thus, Treatment T_5 is more productive, when compared to other treatments and control.

FUTURE SCOPE

Based on research work done, it can be used as reliable work for further reference. The findings of the present study is based on only one season. Hence, further trails are needed to confirm the findings of the present experiment. Higher levels of plant growth hormones would be tested along with different bio-fertilzers.

Conflict of interest. None of the authors of this paper features a financial or personal relation with people or organizations that would inappropriately influence or bias the content of the paper. We assure you that the content of the paper is never been published.

Research gap. The experiment was conducted during *zaid* season 2020 but due to the pandemic COVID-19 there is a delay in publishing it .

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