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Response of Sesame (*Sesamum indicum* L.) to Growth Regulator under Dry Farming Condition

G.B. Vekaria, K.D. Rakholiya, V.D. Vora*, J.T. Patel, G.S. Sutaria and P.D. Vekaria

Main Dry Farming Research Station, Junagadh Agricultural University, Targhadia, Rajkot - 360003, Gujarat, India
**Corresponding author*

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A B S T R A C T

A field experiment was conducted during the *kharif* season of 2011 and 2014 to study the response of sesame (*Sesamum indicum* L.) to plant growth regulators. The experiment was conducted in Randomized Block Design with ten treatments and replicated thrice. Among the different treatments T_5 (IAA @ 100 ppm at flowering has recorded maximum value for plan height (131.8 cm) and maximum number of capsules per plant at 70 DAS (55.5). The significantly highest 1000 seed weight (3.38 g) of sesame was recorded due to spraying of IAA @ 100 ppm at flowering + capsules formation stage(T_7) followed by T_5 (IAA @ 100 ppm at flowering stage. The significantly highest harvest index (25.8) was noted under T3 Gibberellic Acid (GA_3 -100 ppm) at capsules formation stage. On the bases of pooled results, the significantly highest seed (947 kg ha^{-1}), stalk (2810 kg ha^{-1}) and biological yield (3757 kg ha^{-1}) were obtained due to foliar spraying of IAA @ 100 ppm at flowering and capsule formation stage (T_7) and statically at par with T_5 and T_6.

Introduction

Sesame (*Sesamum indicum* L.) is one of the oldest oil seed crop cultivated in India. It is called as "Queen of oil seed crop" by virtue of its excellent quality. Sesame is very drought-tolerant crop of semiarid regions. It is superior to other oilseed crop due to adaptability to varied agro-climatic condition and high degree of drought tolerance. It is widely grown in countries such as India, China, Bangladesh, Turkey and also in drier parts of African and Mediterranean countries.

It has been called a survivor crop, with an ability to grow where most crops fail. It is popularly known as gingelly, til, benni, ajanjoli, ellu, goma and simsim in different languages. Sesame ranks first for having oil content of 46-64 per cent and 6355 K cal kg^{-1} dietary energy in seeds (Sanjay Kumar and Goel, 1994). Seed of sesame is also rich source of protein (20-28%), sugar (14-16%) and minerals (5-7%). This oil has 85 percent unsaturated fatty acid is highly stable and has washing effect on cholesterol and prevents coronary heart disease. Sesame as a valued oil seed appears to have numerous industrial applications.

Sesame originated from South West Africa and is botanically termed as *Sesamum indicum* L. of family Pedaliaceae. Among top ten oil seed producing countries Mayammar

ranks first in production of 0.72 million tonnes with productivity of 0.46 tonnes ha^{-1} fallowed by India which having production of 0.62 metric tonnes and productivity of 0.34 tonnes ha^{-1}. It is clearly indicated that, it is not matching with the increasing demand. The country continues to experience edible oil deficit (Hedge, 2002). A further increase in production could be achieved by adopting improved agronomic practices like proper nutrient management, application of biofertilizers, micronutrients and growth regulators, reorienting of plant structure, reducing field harvesting losses and storage losses. To achieve this strategy, the field experiment was conducted at Main Dry Farming Research Station, Junagadh Agricultural University, Targhadia with the entitled Response of sesame (*Sesamum indicum* L.) to growth regulator during monsoon period.

Materials and Methods

Experimental site and plant material

Field trials was carried out during the *Kharif* seasons 2011 to 2014 at main dry farming research station, Junaghadh Agriculture University, Targhadia, located at 22.17' N, 70^0 48' E and altitude 137.7 m above mean sea level. The research farm is situated in north Saurashtra agroclimatic zone of Gujarat. Soil of the experimental site was medium black with pH 8.1 and organic carbon status 0.59%. The area was ploughed and harrowed before sowing. Recommended dose of fertilizer was applied before sowing to each plot at 50.0:25.0:0.0 NPK.

The seeds of sesame (*Sesamum indicum* L.) variety "Gujarat Til-3"were sown in eight rows per plot, 5 m length with spacing of 45 cm between rows. After germination, the plants were thinned to obtain optimum plant population. Two inter-culturing and hand weeding were carried out. The three types of growth regulators of different concentration were foliar sprayed at flowering and capsules formation stage as following treatments.

Treatments

The experiment comprised of total 10 treatments viz. T_1[(Absolute control), T_2 (gibberellic acid (GA 3 -100ppm) at flowering stage)], T_3 [(gibberellic acid (GA_3 -100ppm) at capsules formation stage)], T_4[(gibberellic acid (GA_3 -100ppm) at flowering stage and capsules formation)], T_5[(Indole Acetic Acid (IAA -100ppm) at flowering stage)], T_6[(T6 Indole Acetic Acid (IAA -100ppm) at capsules formation stage)], T_7[(Indole Acetic Acid (IAA -100ppm) at flowering stage and capsules formation stage)], T_8[(Benzine Amino purine (BA -5 ppm) at flowering stage)], T_9 [Benzine Amino purine (BA- 5 ppm) at capsules formation stage)] and T_{10} [Benzine Amino purine (BA- 5 ppm) at flowering and capsules formation stage].

Experimental design and layout

The experiment was laid out thrice in Randomized Block Design (R.B.D.) in with the plot size of (a) Gross: 5.0 m x 3.6 m (8 lines) (b) Net: 4.0 m x 2.7 m (6 lines). The row spacing and seed rate were 45 cm x 10 cm and 2.25 Kg\ha respectively. The fertilizer 50.0-25.0-0.0 NPK kg ha^{-1} was applied.

Observations

The plants were harvested at physiological maturity and yield components, such as plant height (cm), number of total capsules per plant at 70 DAS and maturity, 1000 seed weight and harvest index were recorded on five randomly selected plants in each plot. Seed yield was determined by harvesting the middle six rows of each plot.

Harvest index

Harvest index is defined as the yield of grain divided by the total yield of above ground biomass (Stover plus grain).

Harvest index = yield of grain / (yield of Stover + yield grain) x 100

Seed yield (kg ha^{-1})

At the maturity, the sesame crop in each plot was harvested and threshed, and yield ha^{-1} was calculated by the following formula

Seed yield plot kg^{-1} Seed yield kg ha^{-1} = (Seed yield plot kg^{-1} / Plot size m^{-2}) X 10000

Statistical analysis

Statistical analysis of variance was done using SAS computer software package and the mean values were compared with Duncan multiple range test (DMRT) at 0.05 probability level.

Results and Discussion

Effect of growth regulators on growth parameters

Effect of growth regulators on growth parameters of sesame are presented in Table 1. In the results revealed that the growth parameters of sesame were significantly differed during pooled result due to foliar spraying of growth regulator. The highest value of plant height (131.8 cm) was observed with T5 (IAA @ 100 ppm at flowering stage) (Table 1a) which was at par with treatments T_3, T_4 and T_6 to T_{10}. Pooled results indicated that the highest number of branches per plant (2.81) of sesame was recorded under spraying of IAA @ 100 ppm at flowering stage + capsules formation stage(T7) followed by T5 (IAA @ 100 ppm at flowering stage) (Table 1b).The minimum plant height(123.7 cm) and minimum number of branches (1.89) were observed under control plot.IAA induced higher plant height was reported earlier in grasspea (Rahman *et al*., 1989), soybean (Reena *et al*., 1999), groundnut (Lee, 1990), Mungbean (Quaderi *et al*., 2006), *Jatropha curcas* (Joshi *et al*., 2011) and tomato (Khaled *et al*., 2015). The stimulatory effects of IAA on plant height in the present experiment agreed well with the above findings.

Effect of foliar spraying of growth regulator on number of capsules plant^{-1} at 70 DAS and maturity as well as capsule growth rate was found significant. In pooled result significantly highest number of capsules per plant at 70 DAS (55.5) was observed with T_5 (IAA @ 100 ppm at flowering stage) (Table 2a)which was at par with treatments T_3, T_4, T_6, T_7,T_9 and T_{10}. While at maturity treatment T_7 (IAA @ 100 ppm at flowering + capsules formation stage Table 2b) recorded significantly highest number of capsules per plant (65.4) followed by T_5(IAA @ 100 ppm at flowering stage), T_6(T6 IAA -100ppm at capsules formation stage)and T_{10} (BA- 5 ppm at flowering and capsules formation stage). The minimum number of capsule per plant at 70 DAS and maturity stage were found under control condition. In sesame crop, spraying of IAA @ 100 ppm at flowering stage (T5) and GA3 @ 100 ppm at capsules formation stage (T3) was recorded significantly higher capsules growth rate. Senthil *et al*., (2003) also investigated the IAA at 100 ppm supplied as foliar spray at 35 and 60 days after sowing on some biochemical and physiological aspects of soybean plant. They reported that all treatments increased the biochemical parameters of soybean and IAA treatment had the highest effects on the plant. Khaled *et al*., (2015) also reported that IAA treated plots showed better performance for growth parameters and yield compared to control condition and 100 ppm IAA was more suitable than the 200 ppm IAA for higher yield for tomato cultivation.

Table.1 Effect of growth regulators on growth parameters of sesame

Sr. No.	Treatment	2011	2013	2014	Pooled	Y	Y x T
1(a) Plant Height(cm)							
T_1	Control	104.7	130.1	136.4	123.7		
T_2	GA3 @ 100ppm at flowering stage	103.2	131.9	137.5	124.2		
T_3	GA3 @ 100ppm at capsule formation stage	105.9	133.8	139.0	126.3		
T_4	GA3 @ 100ppm at flowering stage + capsule formation stage	97.7	135.1	142.7	125.1		
T_5	IAA @ 100ppm at flowering stage	104.5	142.3	148.5	**131.8**		
T_6	IAA @ 100ppm at capsule formation stage	105.7	141.4	147.2	131.4		
T_7	IAA @ 100ppm at flowering stage + capsule formation stage	98.1	144.1	149.5	130.6		
T_8	BA @ 5ppm at flowering stage	106.3	134.3	141.7	127.4		
T_9	BA @ 5ppm capsule Formation Stage	110.6	135.8	142.6	129.7		
T_{10}	BA @5ppm at flowering stage + capsule formation stage	103.5	138.7	143.0	128.4		
	S.Em. ±	3.37	3.64	3.87	2.24	1.23	3.63
	C.D.at 5%	10.01	10.81	11.49	6.67	3.65	10.30
	C.V. %	5.61	4.61	4.69	4.92		
1(b) Number of Branches/plant							
T_1	Control	1.67	2.21	1.80	1.89		
T_2	GA3 @ 100ppm at flowering stage	1.93	2.47	2.00	2.13		
T_3	GA3 @ 100ppm at capsule formation stage	2.00	2.53	2.00	2.18		
T_4	GA3 @ 100ppm at flowering stage + capsule formation stage	2.13	2.67	2.10	2.30		
T_5	IAA @ 100ppm at flowering stage	2.33	3.11	2.57	2.67		
T_6	IAA @ 100ppm at capsule formation stage	2.27	2.99	2.33	2.53		
T_7	IAA @ 100ppm at flowering stage + capsule formation stage	2.53	3.23	2.67	**2.81**		
T_8	BA @ 5ppm at flowering stage	2.10	2.43	2.00	2.18		
T_9	BA @ 5ppm capsule Formation Stage	2.20	2.90	2.10	2.40		
T_{10}	BA @5ppm at flowering stage + capsule formation stage	2.20	2.80	2.00	2.33		
	S.Em. ±	0.15	0.20	0.17	0.05	0.03	0.17
	C.D.at 5%	0.44	0.60	0.49	0.16	0.09	0.49
	C.V. %	12.07	12.77	13.31	12.82		

*Foliar spray at flowering and capsule formation stage.

Table.2 Effect of growth regulators on growth parameters of sesame

Sr. No.	Treatment	2011	2013	2014	Pooled	Y	Y x T
2(a)No. of Capsules/plant at 70 DAS							
T_1	Control	27.07	41.08	53.37	40.5		
T_2	GA3 @ 100ppm at flowering stage	31.40	44.56	54.67	43.5		
T_3	GA3 @ 100ppm at capsule formation stage	35.67	55.78	56.90	49.4		
T_4	GA3 @ 100ppm at flowering stage + capsule formation stage	34.27	50.90	60.33	48.5		
T_5	IAA @ 100ppm at flowering stage	37.67	57.10	71.77	**55.5**		
T_6	IAA @ 100ppm at capsule formation stage	36.07	56.42	70.23	54.2		
T_7	IAA @ 100ppm at flowering stage + capsule formation stage	33.77	51.77	80.00	55.2		
T_8	BA @ 5ppm at flowering stage	32.90	47.67	57.90	46.2		
T_9	BA @ 5ppm capsule Formation Stage	30.07	45.33	66.90	47.4		
T_{10}	BA @5ppm at flowering stage + capsule formation stage	33.53	54.02	63.57	50.4		
	S.Em. ±	1.89	3.54	4.59	2.58	1.42	3.52
	C.D.at 5%	5.62	10.51	13.62	7.68	4.21	9.98
	C.V. %	10.86	12.14	12.49	12.41		
2(b)	**No. of Capsules/plant at Maturity**						
T_1	Control	30.67	53.10	57.77	47.2		
T_2	GA3 @ 100ppm at flowering stage	32.00	56.34	58.73	49.0		
T_3	GA3 @ 100ppm at capsule formation stage	37.80	68.43	59.10	55.1		
T_4	GA3 @ 100ppm at flowering stage + capsule formation stage	36.93	63.57	62.00	54.2		
T_5	IAA @ 100ppm at flowering stage	39.10	76.99	74.83	63.6		
T_6	IAA @ 100ppm at capsule formation stage	38.13	73.00	72.97	61.4		
T_7	IAA @ 100ppm at flowering stage + capsule formation stage	35.80	75.00	85.50	65.4		
T_8	BA @ 5ppm at flowering stage	35.70	62.89	60.17	52.9		
T_9	BA @ 5ppm capsule Formation Stage	31.60	57.77	67.23	52.2		
T_{10}	BA @5ppm at flowering stage + capsule formation stage	36.77	69.67	65.30	57.2		
	S.Em. ±	1.88	4.61	4.49	2.79	1.53	3.87
	C.D.at 5%	5.59	13.71	13.34	8.30	4.55	10.99
	C.V. %	10.2	12.17	11.72	12.02		

*Foliar spray at flowering and Capsule formation stage.

Table.3 Effect of growth regulators on yields of sesame

Sr. No.	Treatment	2011	2013	2014	Pooled	Y	Y x T
3 (a) Seed Yield (kg ha^{-1})							
T_1	Control	407	621	1101	710		
T_2	GA3 @ 100ppm at flowering stage	430	614	1194	746		
T_3	GA3 @ 100ppm at capsule formation stage	519	794	1256	856		
T_4	GA3 @ 100ppm at flowering stage + capsule formation stage	461	719	1313	831		
T_5	IAA @ 100ppm at flowering stage	522	814	1458	931		
T_6	IAA @ 100ppm at capsule formation stage	495	807	1414	905		
T_7	IAA @ 100ppm at flowering stage + capsule formation stage	557	784	1502	**947**		
T_8	BA @ 5ppm at flowering stage	452	641	1267	787		
T_9	BA @ 5ppm capsule Formation Stage	443	638	1375	819		
T_{10}	BA @5ppm at flowering stage + capsule formation stage	479	744	1326	850		
	S.Em. $\pm$	29	49	78	32	17	56
	C.D.at 5%	88	145	232	94	51	158
	C.V. %	10.7	11.8	10.2	11.5		
3 (b) Straw Yield (kg ha^{-1})							
T_1	Control	1698	2148	2438	2095		
T_2	GA3 @ 100ppm at flowering stage	1731	2130	2469	2110		
T_3	GA3 @ 100ppm at capsule formation stage	2096	2623	2531	2417		
T_4	GA3 @ 100ppm at flowering stage + capsule formation stage	2052	2593	2809	2485		
T_5	IAA @ 100ppm at flowering stage	2299	2778	3179	2752		
T_6	IAA @ 100ppm at capsule formation stage	2123	2654	3086	2621		
T_7	IAA @ 100ppm at flowering stage + capsule formation stage	2333	2840	3256	**2810**		
T_8	BA @ 5ppm at flowering stage	1796	2099	2623	2173		
T_9	BA @ 5ppm capsule Formation Stage	1914	2284	2901	2366		
T_{10}	BA @5ppm at flowering stage + capsule formation stage	1963	2377	2716	2352		
	S.Em. $\pm$	130	178	189	62	34	167
	C.D.at 5%	385	527	560	184	101	474
	C.V. %	11.2	12.5	11.7	12.0		

*Foliar spray at flowering and Capsule formation stage.

Table.4 Effect of growth regulators on harvest Index

Sr. No	Treatment	2011	2013	2014	Pooled	Y	Y x T
T_1	Control	19.4	22.7	31.2	24.4		
T_2	GA3 @ 100ppm at flowering stage	19.9	22.4	32.5	24.9		
T_3	GA3 @ 100ppm at capsule formation stage	20.7	23.1	33.4	**25.8**		
T_4	GA3 @ 100ppm at flowering stage + capsule formation stage	18.5	21.8	32.0	24.1		
T_5	IAA @ 100ppm at flowering stage	18.8	22.7	31.6	24.4		
T_6	IAA @ 100ppm at capsule formation stage	19.0	23.3	31.4	24.6		
T_7	IAA @ 100ppm at flowering stage + capsule formation stage	19.4	21.8	31.6	24.2		
T_8	BA @ 5ppm at flowering stage	20.4	23.4	32.9	25.5		
T_9	BA @ 5ppm capsule Formation Stage	19.0	21.7	32.6	24.4		
T_{10}	BA @5ppm at flowering stage + capsule formation stage	20.0	24.1	33.0	25.7		
	S.Em. ±	1.3	1.6	2.1	0.3	0.17	1.73
	C.D.at 5%	NS	NS	NS	0.9	0.49	4.91
	C.V. %	11.8	12.4	11.5	12.1		

*Foliar spray at flowering and Capsule formation stage

Table.5 Effect of growth regulators on 1000 seed weight (g) of sesame

Sr. No	Treatment	2011	2013	2014	Pooled	Y	Y x T
T_1	Control	2.38	3.07	3.17	2.87		
T_2	GA3 @ 100ppm at flowering stage	2.71	3.15	3.20	3.02		
T_3	GA3 @ 100ppm at capsule formation stage	2.78	3.31	3.22	3.10		
T_4	GA3 @ 100ppm at flowering stage + capsule formation stage	2.71	3.19	3.27	3.06		
T_5	IAA @ 100ppm at flowering stage	2.84	3.35	3.47	3.22		
T_6	IAA @ 100ppm at capsule formation stage	2.91	3.30	3.43	3.21		
T_7	IAA @ 100ppm at flowering stage + capsule formation stage	3.12	3.51	3.50	**3.38**		
T_8	BA @ 5ppm at flowering stage	2.63	3.17	3.25	3.02		
T_9	BA @ 5ppm capsule Formation Stage	2.64	3.16	3.38	3.06		
T_{10}	BA @5ppm at flowering stage + capsule formation stage	2.71	3.28	3.32	3.10		
	S.Em. ±	0.06	0.07	0.07	0.04	0.02	0.07
	C.D.at 5%	0.19	0.22	0.22	0.12	0.07	0.20
	C.V. %	3.99	3.93	3.82	3.92		

*Foliar spray at flowering and Capsule formation stage.

Effect of growth regulators on yield

Effect of growth regulators on yields of sesame is presented in Table 3.The yields of sesame were significantly differed during all the three year and also in pooled result due to foliar spraying of growth regulator. On the bases of pooled results, maximum seed yield and straw yield were 947 kg ha^{-1} (Table 3a) and 2810 kg ha^{-1} (Table 3b) respectively obtained due to foliar spraying of IAA @ 100 ppm at flowering and capsule formation stage (T7) and statically at par T5 and T6. Results (Table 3) further indicated that around 34 % increase in seeds, stalk and biological yield were recorded with T7 in comparison to their respective control. The lowest seed yield (710 kg ha^{-1}) and straw yield (2095 kg ha^{-1}) were recorded under control treatment. Rastogi *et al.*, (2013) effort done in linseed (*Linumusitatis simum* L.) and get better result with indole acetic acid.

Effect of growth regulators on harvest index and 1000 seed weight (g)

The effect of different treatments on harvest index was found significant and varied from 24.1 to 25.8 (Table 4). The significantly highest harvest index was recorded under treatment T_3 (GA_3 @ 100 ppm at capsule formation stage) followed by T_2. The significantly highest1000 seed weight (3.38 g) of sesame was recorded due to spraying of IAA @ 100 ppm at flowering and capsules formation stage(T7,Table 5). The least harvest index was notedunder control treatment. Maximum result was found in IAA at 100 ppm at flowering and capsules formation may be due to its plays an important role in improving the plant growth, development and yield of crops and affects the physiological processes, hastens maturity and improving the quality of fruits (Rout, 2006; Khaled *et al*., 2015). Growth hormone like Indole acetic acid is naturally occurring auxin that stimulates growth through cell elongation and lateral root formation which probably support more absorption of minerals (Egamberdieva, 2009; Rathod *et al*., 2015).

From the overall results it may be concluded that IAA treated plot at flowering stage showed better performance for growth parameters and yield compared to control condition. Therefore, 100 ppm IAA at flowering stage was more suitable than the other treatments for sesame cultivation.

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