International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(8): 1439-1442
www.biochemjournal.com
Received: 07-06-2025
Accepted: 11-07-2025

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Effect of growth regulators on okra

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DOI: https://www.doi.org/10.33545/26174693.2025.v9.i8St.5389

Abstract
The present investigation effect of growth regulators on growth and yield of okra was carried out at Krishi Vigyan Kendra, Navsari Agricultural University, Surat (Gujarat) during *Kharif*-2022 and 2023. The experiment was conducted in Randomized Block Design in Factorial concept with three replications. Significantly maximum number of branches per plant (4.06), plant height (28.54, 34.78, 50.83, 59.16 and 66.75 cm at 30, 45, 60, 75 and 90 DAS, respectively), leaf area per plant (965.03 cm^2), number of nodes per plant (15.04), number of leaves per plant (9.92, 30.23, 33.47, 39.88 and 46.27 at 30, 45, 60, 75 and 90 DAS, respectively), maximum number of pods per plant (16.66), yield per plant (201.56 g) and pod weight (12.10 g) were obtained with the treatment G_4-GA_3 @ 200 ppm at 25 and 45 days after sowing in growth characters. Whereas, days to first flowering and days to 50% flowering were noted non-significant.

Keywords: Growth regulators, GA_3, NAA, Okra, yield, pods per plant

Introduction
Okra [*Abelmoschus esculentus* (L.) Moench], a member of the Malvaceae family, is an annual fruit vegetable crop and having chromosome no. 2n = 130, has captured a prominent position among vegetables. Okra is commonly referred to as *Gumbo* in the US, lady's finger in the UK, *Bhindi* in India and *Bhinda* in Gujarat. The crop was originated from Tropical Africa and first cultivated by the Egyptians in the 12^{th} AD (Thompson and Kelly, 1979) [10]. It is widely grown throughout the world's tropical and subtropical regions. It is popular among vegetable growers throughout India due to adaptability to a wide range of growing conditions. The response with growth regulators depends upon the amount of particular compound absorbed by the seed or plant and ability of seed or plant to respond to the stimulus of the chemical applied. Scientists have given due attention to the idea of regulating plant growth as an important factor in improving the growth, yield and quality parameters with the application of plant growth regulators in various ways. Its use in crop promotes growth along the longitudinal area, increase number of branches, early flower initiation, fruit set, fruit quality and subsequently contributes towards higher production when applied at various concentrations.

Materials and Methods
The present investigation was carried out at Krishi Vigyan Kendra, NAU, Surat (Gujarat, India). Geographically Surat is situated on the bank of the perennial river Tapi which flow into the Arabian ocean. The location of Surat is 21°15' N Latitude and 72°52' E Longitude. The Arabian Sea is to its west at a distance of about 22 kilometres along the Tapi and about 16 kilometres by road. The experiment was conducted in Randomized Block Design in Factorial concept with three replications. Growth regulators was foliar sprayed at 25 DAS and 45 DAS. The treatments consisting of growth regulators with five concentrations (G_0: control, G_1: NAA-100 ppm, G_2: NAA-200 ppm, G_3: GA_3-100 ppm and G_4: GA_3-200 ppm).

Preparation and application of growth regulators
Gibberellic Acid (GA_3): The solution was prepared by dissolving 100 mg and 200 mg of gibberellic acid in small quantity of ethyl alcohol for dissolving all particles of GA_3 and stirred it, when complete GA_3 granules dissolved in ethyl alcohol the volume was made to one litre by adding water to obtain 100 and 200 ppm concentration respective.

Naphthalene Acetic Acid: The 100 and 200 ppm solution of NAA was prepared by dissolving 100 mg and 200 mg NAA in 1000 ml of water and sprayed.

Results and Discussion

Different growth regulators had significant effect on number of branches per plant during experimental years and in pooled analysis. It was concluded that through the maximum number of branches per plant produced in treatment G_4-GA_3 200 ppm spraying @ 25 and 45 DAS (3.95 in the year 2022 and 4.17 in the year 2023) and none of the treatments statistically at par with it in both studied years. It means that growth hormone GA_3 increase the number of branches reduces the apical dominance in okra plant in both years. Whereas, in G_0-Control measured the minimum number of branches per plant (2.36 in the year 2022 and 2.44 in year 2023) in okra. This variation in branching with the time of apical loss reflects differences in stem height and the number of axillary buds developed before de-budding and consequently the number of lateral buds on the main stem that develop when apical dominance is lost (Olasantan, 1986) [7]. Maximum leaf area per plant was recorded in G_4-GA_3 200 ppm spraying @ 25 and 45 DAS (962.99 cm^2 in the year 2022 and 967.07 cm^2 in the year 2023) and none of the treatments statistically at par with it in both years and during pooled analysis also. While, the minimum leaf area per plant recorded in G_0-control (838.80 cm^2 in the year 2022 and 824.15 cm^2 in the year 2023) in okra.

Table 1: Effect of growth regulators on number of branches per plant, leaf area per plant (cm^2) and number of nodes per main shoot in okra

Treatments	Number of branches per plant		Leaf area per plant (cm^2)		Number of nodes per main shoot	
	2022	2023	2022	2023	2022	2023
G_0	2.36^b	2.44^c	838.80^e	824.15^e	12.61^{bc}	13.08^c
G_1	2.66^b	2.60^{bc}	861.63^d	858.85^d	13.66^{ab}	15.83^a
G_2	2.55^b	2.64^{bc}	895.43^c	894.51^c	13.33^{bc}	14.33^{bc}
G_3	2.32^b	2.75^b	925.25^b	928.10^b	11.75^c	13.41^c
G_4	3.95^a	4.17^a	962.99^a	967.07^a	15.08^a	15.00^{ab}
SEm (±)	0.12	0.10	4.55	4.00	0.56	0.48
CD at 5%	0.35	0.29	13.04	11.45	1.62	1.40
CV (%)	15.37	12.04	1.75	1.54	14.76	11.83

During both years of experimentation, the number of nodes per main shoot was recorded in G_4-GA_3 200 ppm spraying @ 25 and 45 DAS (15.08 and 15.00 in the year 2022 and 2023, respectively) which was statistically at par with treatments G_1-100 ppm NAA @ 25 and 45 DAS (13.66 in the year 2022 and 15.83 in the year 2023). While, the minimum number of nodes per main shoot recorded in G_0-control (12.61 in the year 2022 and 13.08 in the year 2023) in okra. The number of nodes per main shoot remains higher in treatment G_4-GA_3 200 ppm spraying at 25 and 45 DAS. Development of more nodes was significantly encouraged by the removal of the apical bud. Similar results were obtained by Aikins *et al.* (2017) [1] in okra.

The plant height measured on 30 (28.54 cm), 45 (34.78 cm), 60 (50.83), 75 (59.16 cm) and 90 (66.75 cm) DAS remains higher in treatment G_4-GA_3 200 ppm spraying at 25 and 45 DAS. The significant increasing effect of GA_3 was observed on the plant height might be due to its rapid cell elongation in meristematic zone of vegetative plant organs. Height is visible measure of plant growth and is a function of internodal elongation and increasing nodes per plant. Since leaves are born on the stem, leaf development and biomass show close relationships with plant height (Baraskar *et al.* 2018) [3]. The number of leaves per plant (9.92, 30.23, 33.47, 39.88 and 46.27 at 30, 45, 60, 75 and 90 DAS, respectively) remains higher in treatment G_4-GA_3 200 ppm spraying at 25 and 45 DAS. This might be due to GA_3 which increased the rate of cell division and cell elongation and ultimately increased the better vegetative growth. These results are in line with the findings of Olasantan (1986) [7], Olasantan and Salau (2008) [8], Aliyu *et al.* (2015) [2], Sahu and Biswal (2017) [9] in okra.

Table 2: Effect of growth regulators on plant height (cm) in okra

Treatments	Plant height (cm)									
	2022					2023				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
G_0	23.47^c	31.04^{cd}	42.50^{bc}	49.25^b	56.75^{bc}	23.39^d	30.50^b	48.25^a	54.08^a	63.25^a
G_1	25.11^b	29.69^d	41.66^c	48.83^b	54.16^c	24.77^c	31.80^b	48.75^a	55.00^a	64.25^a
G_2	25.12^b	33.17^b	43.16^{bc}	49.10^b	56.50^{bc}	25.54^{bc}	31.66^b	49.50^a	54.58^a	64.16^a
G_3	24.66^b	31.19^c	44.66^b	50.66^b	57.75^b	25.67^b	31.87^b	49.08^a	54.25^a	63.00^a
G_4	27.80^a	35.34^a	52.75^a	62.33^a	69.41^a	29.29^a	34.22^a	48.91^a	56.00^a	64.08^a
SEm (±)	0.27	0.49	0.95	0.89	1.06	0.27	0.54	1.00	1.32	1.38
CD at 5%	0.79	1.42	2.72	2.54	3.03	0.77	1.55	2.86	3.78	3.95
CV (%)	3.80	5.37	7.32	5.92	6.23	3.66	5.87	7.09	8.35	7.51

Table 3: Effect of growth regulators on number of leaves per plant

Treatments	number of leaves per plant									
	2022					2023				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
G_0	6.37^b	27.37^b	30.87^b	37.67^b	44.37^b	8.33^b	29.34^b	32.33^b	38.33^b	44.58^b
G_1	6.94^b	27.94^b	31.44^b	38.24^b	44.94^b	9.00^b	30.00^b	33.00^b	39.00^b	45.28^{ab}
G_2	6.52^b	27.52^b	31.02^b	37.82^b	44.52^b	8.77^b	29.77^b	32.77^b	38.77^b	45.05^b
G_3	6.73^b	27.73^b	31.23^b	38.03^b	44.73^b	8.38^b	29.38^b	32.38^b	38.38^b	44.54^b
G_4	8.54^a	29.54^a	33.04^a	39.83^a	46.54^a	9.91^a	30.91^a	33.90^a	39.91^a	46.01^a
SEm (±)	0.20	0.20	0.20	0.20	0.20	0.29	0.29	0.29	0.29	0.29
CD at 5%	0.61	0.55	0.57	0.58	0.58	0.84	0.84	0.83	0.84	0.84
CV (%)	10.02	2.51	2.23	1.83	1.56	11.45	3.40	3.09	2.62	2.27

The number of pods per plant (16.66) and yield per plant (201.56 g) remains higher in treatment G_4-GA_3 200 ppm spraying at 25 and 45. This effect of GA_3 in increasing the number of pods per plant might be due to the presence of good vegetative growth in GA_3 treated plants which accumulated higher amount of assimilates and a greater number of fruits. The spray of GA_3 during the active growth phase of the crop triggers judicious utilization of resources and results in a better source-sink relationship. These results are in line with Kokare *et al.* (2006) [5], Maity *et al.* (2016) [6] and Baraskar *et al.* (2018) [3]. This could be due to the increase in the number of branches and leaves and improvement in light interception that possibly resulted in an increase in vegetative development and fruiting sites at different positions on the branches (Olasantan and Salau 2008) [8]. The report from the Khandaker *et al.* (2018) [4] indicated that yield obtained from the control showed significantly lower yields than growth regulator spray which indirectly increase the morphological, physiological and growth parameters of the plants. GAs is used commercially to enhance morpho-physiological and yield characteristics of many vegetable and ornamental crops. This effect of GA_3 is due to increase in yield attributing components *viz.*, total number of flowers, fruits per plant, fruit length, fruit diameter, fruit weight, seed number per fruit. An increase in the yield might be due to the fact that, gibberellic acid treated plants produced more vegetative growth in terms of plant height and leaf area. This might have resulted in the production and accumulation of more photosynthates which would have diverted to the sink resulting into more yield per hectare. The trend in result of pod weight (g) showed increase pod weight was increase the yield per plant. The effect of growth regulators treatment showed significant effect on pod weight (g) both the consecutive years. Significantly the highest pod weight was recorded in G_2-NAA 100 ppm spraying @ 25 and 45 DAS (12.25 g during 2023). While, the minimum pod weight recorded in G_0-Control (11.56 g in the year 2023) in okra.

Table 4: Effect of growth regulators on number of pods per plant, pod yield per plant (g) and pod weight (g) in okra

Treatments	Number of pods per plant		Pod yield per plant (g)		Pod weight (g)	
	2022	2023	2022	2023	2022	2023
G_0	14.14^b	14.85^b	159.25^{bc}	171.54^b	11.20^b	11.56^b
G_1	12.57^{cd}	11.75^c	150.99^{bc}	140.22^c	11.98^a	11.94^{ab}
G_2	12.28^d	11.91^c	143.40^c	145.75^c	11.90^a	12.25^a
G_3	13.63^{bc}	14.39^b	164.32^b	165.49^b	12.15^a	11.83^{ab}
G_4	16.55^a	16.76^a	206.33^a	196.80^a	12.11^a	12.09^{ab}
SEm (±)	0.44	0.46	5.57	6.00	0.17	0.18
CD at 5%	1.28	1.32	15.95	17.17	0.50	0.53
CV (%)	11.22	11.52	11.71	12.67	5.19	5.47

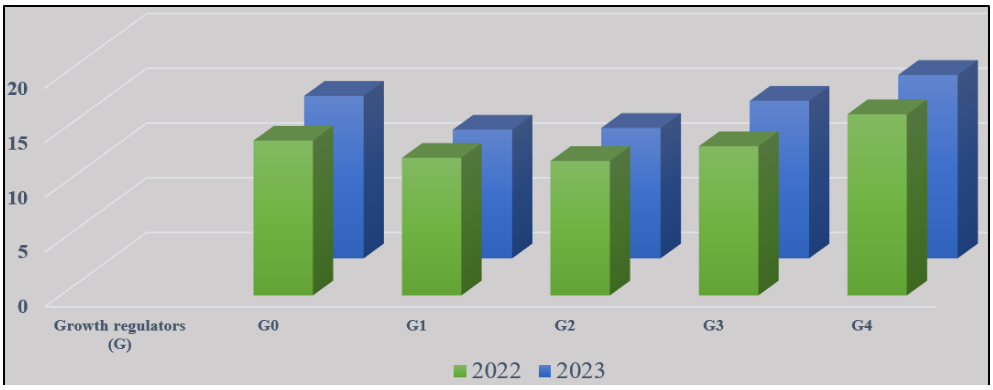

Fig 1: Effect of growth regulators on number of pods per plant

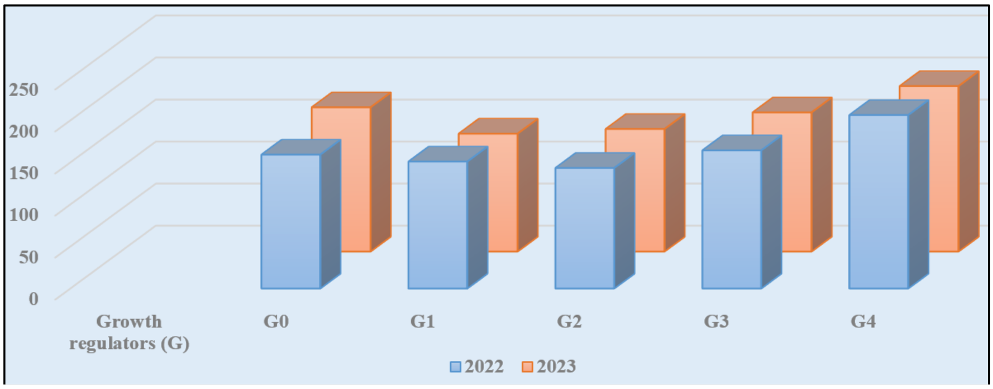

Fig 2: Effect of growth regulators on pod yield per plant (g)

Conclusion

From the two years study it can be concluded that in okra application of GA_3 @ 200 ppm at 25 and 45 days after sowing resulted in better growth and yield of plants. Significantly maximum number of branches per plant (4.06), plant height (28.54, 34.78, 50.83, 59.16 and 66.75 cm at 30, 45, 60, 75 and 90 DAS, respectively), leaf area per plant (965.03 cm^2), number of nodes per plant (15.04), number of leaves per plant (9.92, 30.23, 33.47, 39.88 and 46.27 at 30, 45, 60, 75 and 90 DAS, respectively), maximum number of pods per plant (16.66), yield per plant (201.56 g) and pod weight (12.10 g) were obtained with the treatment GA_3 @ 200 ppm at 25 and 45 days after sowing in growth characters.

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