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SB Gadade
Department of Crop Physiology
D P College of Agriculture,
Dahegaon, Affiliated to
VNMKV, Parbhani,
Maharashtra, India

NS Kahate
Department of Genetics & Plant
Breeding, D P College of
Agriculture, Dahegaon,
Affiliated to VNMKV, Parbhani,
Maharashtra, India

SB Bade
Department of Agronomy
D P College of Agriculture,
Dahegaon, Affiliated to
VNMKV, Parbhani,
Maharashtra, India

Corresponding Author:
SB Gadade
Department of Crop Physiology
D P College of Agriculture,
Dahegaon, Affiliated to
VNMKV, Parbhani,
Maharashtra, India

Study the effect of various concentrations of GA and NAA on different growth parameters of okra (*Abelmoschus esculentus* L.)

SB Gadade, NS Kahate and SB Bade

Abstract
The field experiment was conducted on field of Department of Agril. Botany, College of Agriculture, Parbhani, Maharashtra during *kharif*, 2015 for "Effect growth regulators on different growth parameters of Ladys Finger (*Abelmoschus esculentus* L.)." The experiment was laid out in randomized block design with nine treatments with three replications. The treatments consisted of two growth regulators *viz*., gibberellic acid (50,100,150 and 200 ppm) and naphthalene acetic acid (50,100,150 and 200 ppm). Experimental results revealed that the due to application of plant growth regulators, growth parameters *viz*., RGR, CGR, NAR, were influenced by the application of plant growth regulators. Number of flowers per plant, number of pod per plant and pod yield also increased significantly due to plant growth regulators.

Keywords: GA, NAA, growth parameters, okra

Introduction
Okra is a tall growing, annual, semi woody and warm season crop. It is self- pollinated, but occasionally up to 20% cross pollination happens by insects. The okra flowers blossoms only one day. Okra pods are harvested when they reach the maximum size but still tender (may be 60-180 days from sowing) around 5-10 days after opening of flower depending on the cultivar grown [1].

Okra pods are considered nutritious, providing some human supplementary vitamins such as vitamin C, A, B- complex, calcium, potassium, iron and other minerals [2].

The application of plant growth regulators is known as one of the most important treatments used nowadays in agriculture. Some horticulture crop productions were increased by application of different growth regulators. Growth regulators mainly regulate the plant physiological and biochemical processes. There are some reports, which indicate that application of growth regulators improved the growth and yield of vegetables [3].

Plant growth regulators could manage vegetative and reproductive growth balance. PGRs are known as chemical messengers because they are produced in one part of plant and affect on another part. Exogenous of plant growth regulators improved the yield production and fruit quality of horticulture crops [4].

The overall objective of the experiments was to improve the productivity and quality of okra (*Abelmoschus esculentus*) which will benefit our local farms. Vegetables are high yielding and provide nutritional security, more employment, more cash and more foreign exchange.

West Bengal is the leading state of okra production cultivation in 75.5 thousand ha. Area, 882.4 thousand MT production and 15 MT per ha productivity and sharing 18 percent of total production, Followed by Gujarat 73.08. Thousand ha. Area, 857.05 thousand MT production and 11 MT per ha productivity and sharing 14 percent of total okra production. In Maharashtra okra cultivation with 11.3 thousands ha area with annual production of 84.06 thousand MT and its productivity is of 14.9 MT per ha and sharing 5 percent of the total okra production.

The Area and Production of Maharashtra is low as compare to other leading Okra Producing States. About 60 per cent of okra is grown for the fresh fruit for market and the remaining is used for processing. (Indiastat.com 2015-16 with this background, the present investigation was aimed to "study the effect of various concentrations of GA and NAA on different growth parameters of okra (*Abelmoschus esculentus*)".

Material and Methods

The experiment entitled "study the effect of various concentrations of GA and NAA on different growth parameters of okra**"** were conducted at Department of Agriculture Botany, Vasantarao Naik Marathwada Krishi Vidyapeeth, Prabhani (M.S.), India during kharif season of the year 2015-2016. Okra variety 'Parbhani ok' was sown at 45cm × 30cm spacing during Kharif season with a net plot size of 2.6m2. The experiment was laid out in Randomized Block Design with three replications and eight treatments including plant growth regulators as GA3 (50, 100, 150, 200 ppm), NAA (50, 100, 150, 200 ppm) and one control (foliar spray)

Preparation and application of growth regulators

Gibberellin acid: The Solution was prepared by dissolving 50mg, 100mg, 150mg and 200mg of gibberellic acid in small quantity of ethyl alcohol. For dissolving all particle of GA and stirred. When complete GA granules dissolved in ethyl alcohol the volume was made to one liter by adding double distilled water to obtain 50,100,150,200ppm concentration solution respectively.

Napthalene acetic acid: The 50,100,150,200 ppm solution of NAA was prepared by dissolving 50mg, 100mg, 150mg and 200mg of NAA is small quantity of ethyl alcohol and the volume was made to one liter by adding double distilled water to obtained 50,100,150 and 200 ppm concentration and Control (unsprayed plants).

Foliar spray: All the growth regulators were sprayed on the entire plant. While spraying proper care was taken regarding spraying according to layout.

The spraying of plant growth regulators was done 30 days after sowing i.e.15 August 2015.

Biometric observations: Five plants from each plot were randomly selected and used for the recording all morphological observations at 15 days interval. First observation was recorded 30 days after sowing and after that repeated at 15 days interval up to 90th days

Days to 50 per cent flowering: Number of days required from sowing to flowering approximately 50 per cent plants flowered in each treatment were recorded.

Growth parameters

a. **Relative growth rate (RGR):** The relative rate of which plant incorporate the new material into its substance is measured by relative growth rate (RGR) of dry matter accumulation. It is worked out as per the formula given by Fisher (1919) [19].

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1} \ (g\ g^{-1}\ day^{-1})$$

Where

Log e = Natural logarithm to the base (e = 2.3026)

W_1 and W_2 = Weight of total dry matter at t_2 and t_1 time respectively.

b. **Net assimilation rate (NAR) (g/dm^2 /day):** Net assimilation rate was calculated by using formula given by Gregory (1926) [20].

$$RGR = \frac{\log_e A_2 - \log_e A_1}{A_2 - A_1} \times \frac{W_2 - W_1}{t_2 - t_1}$$

Where

A_1 and A_2 are the leaf area at time t_1 and t_2, respectively.

W_1 and W_2 are the dry weights of plant at time t_1 and t_2, respectively.

c. **Crop growth rate (CGR) (mg/ dm^2/day):** Crop growth rate (CGR) is the absolute growth and is expressed unit area of ground and is expressed as mg/dm2/day.

This was worked out by adopting the formula developed by Watson (1952) [21].

CGR = NAR x LAI

Where

1. NAR= Net Assimilation Rate.
2. LAI= Leaf Area Index

Statistical analysis: Fisher's method of analysis of variance was applied & analysis conducted as suggested by Panse and Sukhatme (1967) [18].

Result and Discussion

Growth parameters

Relative growth rate (RGR) (g/g/day): The Table 1 data revealed that RGR was higher during early stages of the plant growth and thereafter it was decreased. The data showed that relative growth rate (RGR) was comparatively higher during 31-60 DAS and 61-90 DAS decreased.

All the concentration of GA and NAA were found to be effective to increase relative growth rate over control at all growth stages except 76-90 DAS. There is no consistent trend within concentration of GA and NAA in respect of growth stages. At 46-60 DAS the treatment T_4 (GA 200 ppm) and treatment T_7 (NAA150 ppm) concentration was most effect to increase the relative growth rate over all treatments.

Table 1: Mean relative growth rate (RGR) (g/g/day).

Sr. No.	Treatments	30-45 DAS	46-60 DAS	61-75 DAS	76-90 DAS
T_1	GA 50 ppm	0.027	0.021	0.017	0.005
T_2	GA 100 ppm	0.037	0.024	0.020	0.005
T_3	GA 150 ppm	0.033	0.023	0.021	0.004
T_4	GA 200 ppm	0.019	0.025	0.022	0.006
T_5	NAA 50 ppm	0.033	0.021	0.018	0.005
T_6	NAA 100 ppm	0.025	0.024	0.019	0.004
T_7	NAA 150 ppm	0.033	0.025	0.020	0.005
T_8	NAA 200 ppm	0.029	0.023	0.019	0.004
T_9	Control	0.017	0.019	0.016	0.003

Mean net assimilation rate (NAR) (g/dm^2/day)

The table 2 data revealed that the net assimilation rate was maximum in 31-60 DAS and 61-90 DAS decreased rapidly. The treatment T_4 (GA 200 ppm) and treatment T_7 (NAA 150 ppm) concentration were to be most effective to increase NAR at stages of 46-60 and 61-75 DAS over T_9 (Control) and at respective concentration of GA and NAA.

Table 2: Mean net assimilation rate (NAR) (g/dm^2/day)

Sr. No.	Treatments	30-45 DAS	46-60 DAS	61-75 DAS	76-90 DAS
T_1	GA 50 ppm	0.014	0.013	0.012	0.004
T_2	GA 100 ppm	0.022	0.014	0.013	0.005
T_3	GA 150 ppm	0.012	0.015	0.014	0.004
T_4	GA 200 ppm	0.011	0.016	0.015	0.004
T_5	NAA 50 ppm	0.020	0.014	0.013	0.005
T_6	NAA 100 ppm	0.017	0.017	0.015	0.003
T_7	NAA 150 ppm	0.021	0.020	0.016	0.004
T_8	NAA 200 ppm	0.019	0.019	0.015	0.004
T_9	Control	0.012	0.012	0.013	0.002

Mean crop growth rate (CGR) (mg/dm^2/day): The table 3 data revealed that the CGR was more up to 61-75 DAS. The treatmentT_2 (GA 100 ppm) and treatment T_7 (NAA 150 ppm) concentration were to be most effective to increase CGR at stages of 46-60 and 61-75 DAS over T_9 (control) respective concentration of GA and NAA. All the concentration of GA and NAA were found to be more effective to increase crop growth rate over control except 76-90 DAS.

Table 3: Mean crop growth rate (CGR) (mg/dm2/day)

Sr. No.	Treatments	30-45 DAS	46-60 DAS	61-75 DAS	76-90 DAS
T_1	GA 50 ppm	0.016	0.021	0.020	0.006
T_2	GA 100 ppm	0.027	0.023	0.022	0.007
T_3	GA 150 ppm	0.012	0.020	0.020	0.006
T_4	GA 200 ppm	0.013	0.021	0.021	0.006
T_5	NAA 50 ppm	0.015	0.015	0.022	0.004
T_6	NAA 100 ppm	0.017	0.017	0.022	0.004
T_7	NAA 150 ppm	0.023	0.023	0.023	0.006
T_8	NAA 200 ppm	0.018	0.018	0.020	0.004
T_9	Control	0.011	0.015	0.013	0.003

In growth parameter *viz.* RGR, NAR and CGR were not statistically analyzed it can be noted from the present data that indicate there was very little increased or decreased effect on growth function. In general all those growth parameter were increased by T2 (GA 100) and T7 (NAA 150 ppm). This might be due to increase in dry matter and leaf area on which these parameters depend. In case of GA might be result cell rapidly cell division leading to large leaf area and ultimately increasing the biomass of the crop. Same resulted were reported by Sharma and Singh (2015) [22].

Mean number of days for 50 per cent flowering

The table 4 data & figure 1 revealed that almost all the treatments had reduced the days to 50% flowering as compare to control. The treatment T_2 (GA 100ppm) was significantly superior than all other treatments and it was at par with T_1 (GA 50ppm), T_3 (GA 150 ppm) and T_4 (GA 200 ppm) and T_5 (NAA 50 ppm), T_6 (NAA 100 ppm) and T_8 (NAA 200 ppm) respectively. The treatment differences were significant.

All the concentration of GA and NAA were resulted in earlier production of 50 per cent flowering significantly at earlier DAS as compared to control.

Almost all the treatments had reduced the days to 50% flowering as compare to control. The data recorded on number of days required for 50 per cent flowering in treatment the treatment T2 (GA 100 ppm) was significantly superior than all other treatments and it was at par with T1 (GA 50 ppm), T3 (GA 150 ppm) and T4 (GA 200 ppm) and T5 (NAA 50 ppm), T6 (NAA 100 ppm) and T8 (NAA 200 ppm) respectively. All the concentration of GA and NAA were resulted in earlier production of 50 per cent flowering significantly at earlier DAS as compared to treatment T9 (control).

In general, the earlier flowering was observed by the NAA 150 ppm concentration than other experimental treatments. The growth substance T7 (NAA 150 ppm) observe earlier 50% flowering. Earlier flowering might be helps to earlier development of pod on plant. Similar result was reported by Gulshan and lal (1997) [5], Chhonkar and Singh (1959) [6], Singh *et al*. (1998) [7] and Ravat *et al.* (2015) [17].

Table 4: Mean number of days to 50% flowering

Sr. No.	Treatments	Days after sowing
T_1	GA 50 ppm	46.00
T_2	GA 100 ppm	44.26
T_3	GA 150 ppm	46.10
T_4	GA 200 ppm	48.50
T_5	NAA 50 ppm	46.00
T_6	NAA 100 ppm	47.00
T_7	NAA 150 ppm	40.26
T_8	NAA 200 ppm	48.93
T_9	Control	50.00
	S.E.±	0.53
	C.D.at 5%	1.61

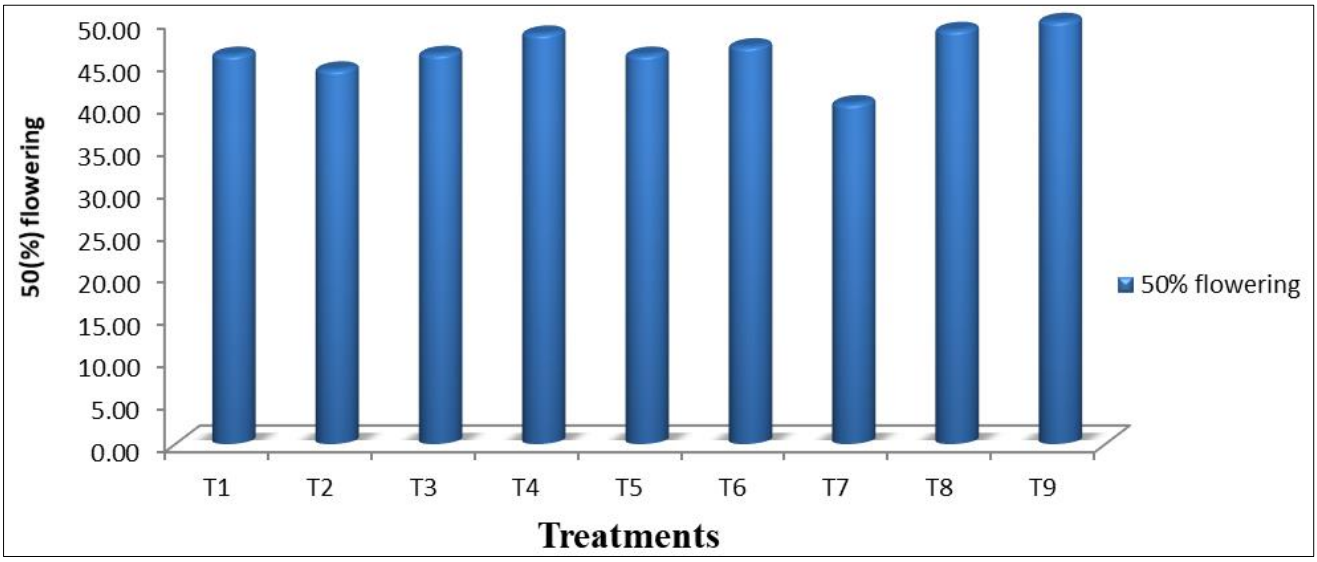

Fig 1: Number of days for 50% flowering

Mean number of flower per plant: The table 5 data revealed that almost all the treatments had increased the number of flower per plant as compare to control. At 45 DAS number of flower was highest in the treatment T_2 (GA 100 ppm) and T_7 (NAA 150 ppm). Significantly superior over treatment T_9 (control) and it was at par with T_1 (GA 50 ppm) only. At 60 DAS number of flower was highest in treatment T_2 (GA 100 ppm) and treatment T_7 (NAA 150 ppm) and statistically significantly superior over treatment T_9 (Control)

At 75 days number of flower per plant was highest in the treatment T_2 (GA 100 ppm) and T_7 (NAA 150 ppm) and statistically superior over the treatment T_9 (control) and at par withT_1 (GA 50 ppm) and treatment T_8 (NAA 200 ppm) respectively. At 90 days number of flowers per plant was highest in treatment T_2 (GA100 ppm) and T_7 (NAA 150 ppm) and statistically superior over the treatment T_9 (control) and at par with T_3 (GA150 ppm) and T_8 (NAA 200ppm) respectively.

The maximum number of flower appears was recorded by treatment T2 (GA 100 ppm) it was followed by treatment T1 (GA 50 ppm) where as in case of NAA, T7 (NAA 150 ppm) were found satisfactory flowering and it was followed by T8 (NAA 100 ppm) it might be NAA are impart role in anthesis of flower and these findings are in agreement with those of Similar study were reported by Chhonkar and Singh (1959) [6], Rattan *et al.* (1987) [8], P Surendra *et al*., (2006) [9], Ghadir Mohammadi *et al.* (2014) [10] and Bhagure and Tambe (2015) [11].

Table 5: Mean number of flower per plant

Sr. No.	Treatments	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
T_1	GA 50 ppm	1.00	2.94	2.93	3.71	2.98
T_2	GA 100 ppm	1.27	3.41	4.33	4.47	3.93
T_3	GA 150 ppm	1.23	1.86	3.84	2.90	3.70
T_4	GA 200 ppm	1.00	1.36	2.53	3.27	2.31
T_5	NAA 50 ppm	1.00	1.06	2.27	2.57	2.25
T_6	NAA 100 ppm	1.00	1.04	3.77	2.60	1.51
T_7	NAA 150 ppm	1.50	3.20	4.23	4.27	2.95
T_8	NAA 200 ppm	1.07	2.15	2.43	3.73	2.37
T_9	Control	0.33	1.2	1.63	1.20	1.38
	S.E.±	N.S	0.16	0.17	0.25	0.17
	C.D.at 5%	0.39	0.48	0.51	0.77	0.51

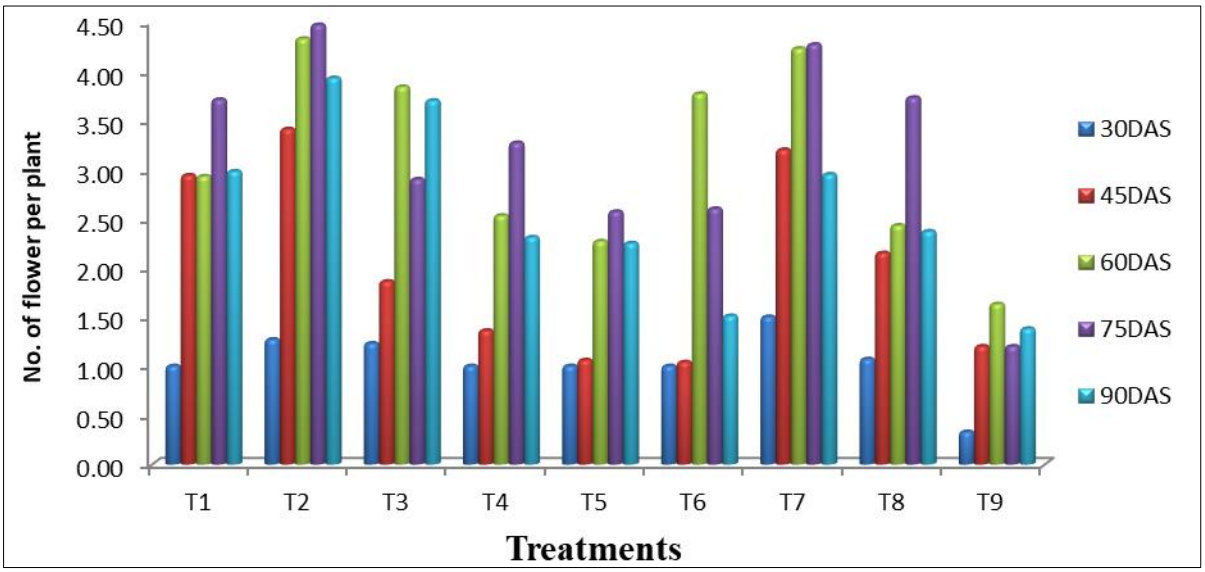

Fig 2: Number of flower per plant

Mean number of pod per plant: The Table 6 data and figure 3 revealed that almost all the treatments had increased the number of pod per plant as compare to control up to 75 DAS. At 45 days number of pod per plant was highest in treatment T_2 (GA 100) and treatment T_7 (NAA 150 ppm) and statistically superior over T_9 (control). At 60 days number of pod per plant was highest in the treatment T_2 (GA 100 ppm) and T_7 (NAA 150 ppm) and statistically superior over T_9 (control) and it was at par with T_3 (GA 150 ppm) and T_8 (NAA 200 ppm) respectively.

At 75 days number of pod per plant was highest in treatment T_2 (GA 100 ppm) significantly superior over the T_9 (control) and at par with T_1 (GA 50 ppm), T_3 (GA 150 ppm), T_4 (GA 200 ppm) and T_7 (NAA 150) and T_8 (NAA 200 ppm) respectively. At 90 days T_2 (GA100 ppm) and T_7 (NAA 150) significantly superior over T_9 (Control) and at par with T_8 (NAA 200 ppm).

Almost all the treatments had increased the number of pod per plant as compare to T9 (control) up to 75 DAS. At 75 days T2 (GA 100 ppm) significantly superior over the T9 (control) and at par with T3 (GA 150 ppm), T4 (GA 200ppm), T1 (GA 50 ppm) and T7 (NAA 150 ppm) found at par with T8 (NAA 200 ppm). Similar result were observed by P. surendra *et al*., (2006) [9] Patil *et al*. (2010) [12], Mandal *et al*. (2012) [13], Usha Rani *et al.* (2012) [14], Muhammad *et al*. (2013) [16], Mehraj, *et al.* (2015) [15].

Table 6: Mean number of pod per plant

Sr. No.	Treatments	45 DAS	60 DAS	75 DAS	90 DAS
T_1	GA 50 ppm	2.73	2.93	3.03	2.97
T_2	GA 100 ppm	3.70	4.57	4.03	3.87
T_3	GA 150 ppm	1.83	3.57	3.23	2.87
T_4	GA 200 ppm	1.57	2.53	3.23	2.29
T_5	NAA 50 ppm	1.67	3.23	2.53	2.33
T_6	NAA 100 ppm	1.60	3.33	2.50	2.38
T_7	NAA 150 ppm	3.33	4.20	4.23	2.97
T_8	NAA 200 ppm	2.00	3.37	3.23	2.33
T_9	Control	1.03	1.23	1.19	1.47
	S.E.±	0.12	0.34	0.36	0.16
	C.D.at 5%	0.37	1.04	1.09	0.49

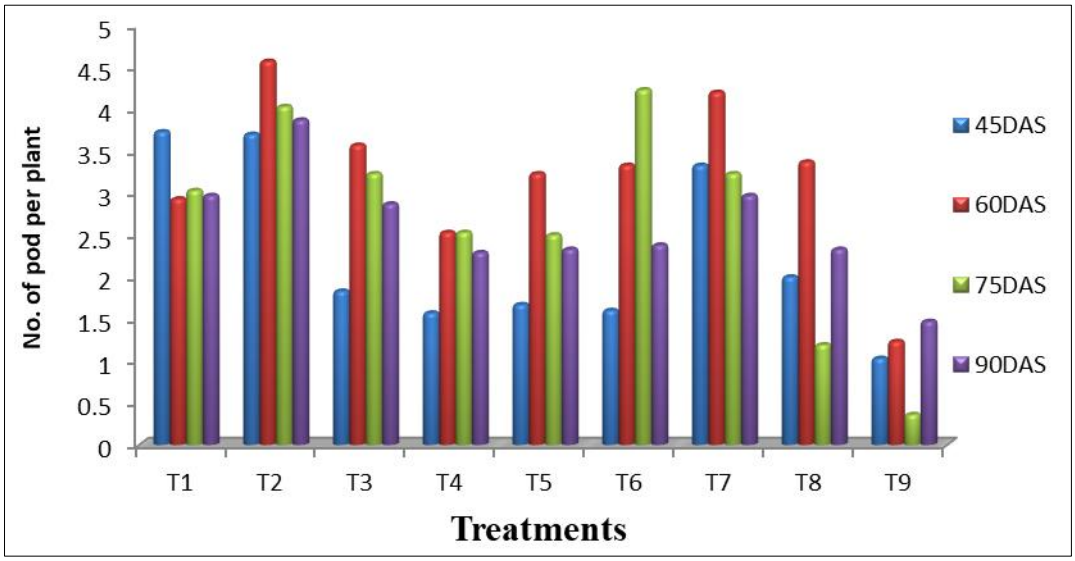

Fig 3: Number of Pod per Plant (gm)

Conclusion

In conclusion**,** PGRs showed significant effect on days to 50% flowering and GA (100 ppm) hastened the days for flower initiation followed by GA (50 ppm). In case of NAA, (150 ppm) was significantly superior as compared to control. Important growth parameters *viz*., CGR, RGR, NAR were significantly influenced by the application of PGRs and were found to be lower in control. GA (100 ppm) was found to be superior to other treatments in most of the parameters followed by NAA (150 ppm).

Conflict of Interest

The authors declare that there is no conflict of interest regarding publication of this paper**.**

Ethical standard

The experiment conducted complies with laws.

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