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Effect of Foliar Application of NAA and GA_3 on Growth and Yield of Okra [*Abelmoschus esculentus* (L.) Moench] cv. Arka Anamika

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ABSTRACT

A field experiment was conducted at Department of Horticulture, MJRP College of Agriculture and Research Achrol, Jaipur, During Zaid Season, 2015. The eight treatment consisting of three levels of GA_3 (10, 20, 30 ppm), three levels of naphthalene acetic acid (10, 20, 30 ppm), were tested in randomized block design with three replications. Results showed that spray of naphthalene acetic acid, gibberellic acid significantly influenced the performance of growth attributes viz., plant height, fruit length, fruit diameter, number of fruits per plant, average weight of fruits per plant, yield per plot as well as per hectare. The best treatment for growth parameter and yield attributes was found at 20-ppm naphthalene acetic acid (T_6) 40 days after sowing. The maximum net profit of Rs. 152344.3 per hectare was obtained when the crop was treated with 20-ppm naphthalene acetic acid with benefit: cost ratio 2.68:1

Key words: *Okra, GA_3 NAA, fruit set and fruit yield*

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is an annual vegetable crop grown in the tropical and sub tropical parts of the world. It is originated from Abyssinian center of origin. It belongs to family *Malvaceae*. It is known by many local names in different parts of the world. It is called ladyfinger in England, gumbo in the United States of America and Bhindi in India. In the northern plains of India, the it is grown mainly in two seasons *i.e.* rainy and summer. It is now cultivated throughout the country in different agro-climatic regions. During raining season, plants grow tall, vigorous and bear a large number of fruits, which contributes to the higher yield per unit area over the summer season crop. In India total area under okra crop is 507.0 thousand hectare which produces 5853.0 thousand tonnes with average productivity 11.5 tonnes per hectare[1] in our country. The major okra growing states are West Bengal, Bihar, Gujrat, Odisha, Jharkhand and Andhra Pradesh. In Rajasthan, okra occupies 4.02 thousand hectare area having an annual production of 12.88 thousand tonnes with average productivity of 3.95 tonnes per hectare[1].

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Okra is nutritious vegetable. It contains good amount of potassium, calcium, magnesium, phosphorus, vitamin 'A' and 'C'. The edible fruit of okra (100 g) contains moisture (89.6%), (88.01 I.U.), Vitamin A, Thiamine (0.07 mg), Vitamin C (13 mg), Riboflavin (0.1mg) with the little amount of iron (1.5 mg) and other nutrients[2]. The mucilage powder of roots and stems of okra is effective as that of fresh stem extract in the clarification of sugarcane juice, which is used in the preparation of gur or jaggary[3]. Fully ripen fruits and stem containing crude fiber, which is used in the paper industry.

A good number of high yielding and resistant varieties have been developed but the productivity potential is not fully achieved in various agro-climatic conditions. Therefore, we need to look for other means in production system management which could help in achieving high productivity. There are several factors *i.e.,* suitable varieties, nutrition management, water management, plant protection etc. responsible for productivity of the crop. The discovery of plant growth regulator has been proved revolutionary in increasing production of horticultural crops. GA_3 has been reported beneficial in okra because it is involved in the regulation of growth and development of the crop[5]. NAA is also being used in many vegetable crops at various stages of development for increasing growth and yield by way of cell elongation, enlargement and differentiation. Artificial foliar spray of growth regulators has been found effective in increasing vegetative growth, early fruiting, total yield and quality of fruits in many vegetables[4].

To obtain the précised recommendations regarding growth regulators (GA_3 and NAA) application through foliar spray in okra crop during *zaid* season, a field experiment entitled with the objectives, to assess response of foliar application of NAA & GA_3 on growth and yield of okra and to evaluate the economic feasibility of the treatments.

MATERIALS AND METHODS

The present study was conducted during the *zaid* season, 2015 at MJRP College of Agriculture and Research, Achrol, Jaipur (Rajasthan). Jaipur is situated at 26.92^0 N North latitude, 75.82^0 E East longitudes and an altitude of 427 meters above mean sea level. This region falls under agro climatic zone- III A (Semi-Arid eastern Plain) of the state. The soil of experimental site was clay loam in texture, slightly alkaline in reaction, low in available nitrogen, medium in available phosphorus and potassium. The experiment was conducted in "Randomized Block Design" replicated three times. Okra cv. Arka Anamika planted at spacing of 45 X 30 cm (P-P x R-R). Detail of treatments with their symbols given in Table 1.

The growth regulator (GA_3 and NAA) solutions of different concentrations were applied to whole plants of respective treatments with a Knapsack sprayer at 40 days after sowing. The fruits were harvested by hand when they were still green tender and in marketable size. The harvested fruits were weighed and subjected to take other observations immediately after each picking.

The plant height to the plants was measured from ground surface to the growing point at 40, 60 and 80 days after sowing with the help of meter scale. When flowers appeared the days of flowering counted from the sowing in tagged plants in each plot. Total numbers of fruits picked from all selected plants were recorded and average number of fruits per plant was calculated. The total numbers of pickings were counted from first harvesting to last harvesting from all the selected plants. Number of days counted between first to last harvesting from the selected plant and counted as duration of picking (days). The same fruits after recording length were weighed for their weight with the help of a balance and later on their average was calculated. Diameter of fruits was measured with the help of "Vernier caliper" in cm. The mean weight of fruits harvested from tagged plants was used to calculate the yield per plot on the basis of plant population per plot. The mean weight of fruits harvested from tagged plants was used to calculate the yield per hectare on the basis of plant population per hectare. In order to find out the benefit: cost

ratio the net profit from individual treatment was divided by their respective cost of cultivation, which included cost of treatment also.

RESULTS AND DISCUSSION

Growth Parameters

A plant height recorded at 40 days after sowing show significant difference with various treatments. The maximum plant height (25.53 cm) was obtained in the treatment T_6. It increased the plant height significantly over to control and rest of the treatments. The treatment T_6 increased the plant height by 25.71 per cent over control and it was statistically at par with the treatment T_7, T_5, T_4, and T_3 (Table 2). A similar trend in plant height was recorded at 60 and 80 days after sowing. The maximum plant height 74.17 cm and 106.20 cm was obtained with the treatment T_6 (NAA 20 ppm) after 60 and 80 days respectively. It significantly increased the plant height as compared to control and rest of the treatments. The treatment T_6 increased the plant height by 52.83 per cent over control and it was statistically at par with the treatment T_5, T_7, and T_4.

It is clear from the data (Table 2) that, days taken to first flowering marginally reduced with the application of GA_3 and NAA as foliar application, however, these were statistically at par with control. Among all the treatments minimum 38.00 days taken to first flowering was recorded under the treatment T_6 (NAA 20 ppm) and maximum 44. 44 days taken to first flowering was under control.

These above findings clearly indicate that NAA 20 ppm played a very important role on the growth of okra. This might be due to NAA 20 ppm which most important primary site of action as the cell division is stimulated in the shoot apex especially more in basal maristematic cells from which large files of cortex and pith cells develop[5]. These results were in confirmity with those of Patil and Patel[6]. In contrary to these results, stem and leaf dry masses and stem length were significantly enhanced by the application of exogenous GA_3 as reported by Ilias *et al*[7]. Shahid *et al*.[8] reported that, all variables regarding vegetative and reproductive growth were significantly influenced by different concentrations of the growth regulators except number of days taken to flowering. The reason of variation may be due to genetic make-up of the cultivar and adaptation; and variability of the various agro-climatic conditions. More or less similar results have been obtained with respect to variation in growth parameters of various cultivars at different climatic conditions. The effects plant growth regulators vary with the stage of plant development, weather conditions (temperature and light intensity) and time of the year (Wilson *et al*.[9]). For example, GA3 @ 25 and 50 ppm increased specific leaf weight and leaf area duration in okra when applied as foliar spray after 80 days of sowing as compared to application after 40-60 days of sowing[10].

YIELD COMPONENTS AND YIELD

The significant variation in the number of fruits per plant was noted varying treatments (Table 3). The maximum numbers of fruit per plant (28.23) were recorded under the treatment T_6 (NAA 20 ppm). Treatment T_6 recorded 28.31 per cent increase in number of fruits over control. The treatments T_7, T_5, T_1, T_3, and T_2, also recorded significantly higher number of fruits than that of control, but these were at par with each other. There was significant variation in the number of picking due to different treatments. The maximum number of picking (18.27) was recorded in the treatments T_7 followed by T_5 and T_3 respectively. All these treatments showed higher number of pickings than the control but these treatments did not differ significantly from each other. The minimum numbers of picking (14.73) was found in control. The maximum duration of harvesting (36.97 days) was found under the treatment T_6 (NAA 20 ppm), which was found significantly higher than control and rest of the treatments.

There was significant variation in weight of fruits per plant with various treatments (Table 3). The maximum weight of green fruits per plant (251.03 g) was recorded in T_6 (NAA 20 ppm), which was followed by

the treatment T_7 and the minimum (210.53 g) was recorded in control. The maximum fruit diameter (2.63cm) was recorded with the foliar application of T_6 (NAA 20 ppm) which was found to be significantly higher over rest of the treatments including control. The foliar application of NAA 20 ppm increased fruit diameter by 52.02 percent over control. The mean maximum fruit length of (13.93 cm) was obtained with T_6 (NAA 20 ppm) that was at par with T_7, T_5 and T_3 respectively. The treatment T_6 represented a non significant increase in length of fruits by 16.08 per cent control. The maximum yield per plot was recorded with the treatment T_6 (17.57 kg) *i.e.*, NAA 20 ppm, followed by T_7. The lowest yield per plot of fruits was obtained in control (14.73 kg). The treatment T_6 increased the yield by 19.28 per cent over control. The analysis of variance exhibited significant variation among the treatments for yield of fruits per hectare. All the treatments showed significantly higher yield than control. NAA 20 ppm (T_6) obtained higher yield (167.33 q ha^{-1}) that was at par with T_7 and T_5 respectively in the descending order.

Suryanrayana and Rao[11] also reported favorable influence of NAA and GA_3 as well as urea on yield of okra fruits. Earlier results by Kokare *et al.*[12] revealed that maximum plant height was observed in the plots sprayed with GA 200 ppm, while spraying the plants with NAA 200 ppm resulted in increase in number of leaves, leaf area, plant dry weight, number of fruits, fruit girth, fruit yield per plant, fruit yield (t/ha) and ascorbic acid content over the control (sprayed with distilled water). However, increased fruit weight was observed by spraying Marwelstim 2ml per L. Plant growth regulators were foliar sprayed on 30 and 45 days after sowing.

In contrary to this results Patil and Patel[6] in cv. GO-2 recorded that, GA_3 at 15 mg/l recorded the highest percentage of seed germination, stem girth, number of branches, number of leaves per plant, early flowering, fruit girth, fruit length, fruit weight, fruit yield per plant and fruit yield per hectare. However, GA_3 at 30 mg/l produced maximum number of fruits per plant noted earlier by Patil and Patel[6] in cv. GO-2. The number of pods and seed yield per plant was increased in okra by foliar spray of GA_3 @ 50-75 ppm [13]. Present results are in line with the findings of Shahid *et al.*,[8] with same chemicals with different concentrations and combinations. Surendra *et al.*,[10] indicated that among the growth regulators the foliar application of GA3 (25 and 50ppm) at 60 days after sowing (DAS) registered significantly higher fresh fruit yield over other treatments. The increase is due to increase in yield attributing components *viz.*, total number of flowers, fruits per plant, fruit length, seed number per fruit, seed weight and harvest index. The reason of variation may be due to genetic make-up of the cultivar and adaptation; and variability of the various agro-climatic conditions. More or less similar results have been obtained with respect to variation in yield attributes of various cultivars at different climatic conditions.

BENEFIT: COST RATIO

Data presented in (Table-2) indicate that general cost of cultivation of okra was Rs. 56223.2 h^{-1} including labour cost, tractor charge, and cost of plugging, irrigation and plant protection measures. The gross returns from sale of okra fruits were calculated at the average price of Rs. 1250 per quintal. The net profit is inclusive of land rent and management. The yield from T_4 to T_8 exhibited no significant difference so yield was taken account on calculation economics. The maximum yield 167.33 q ha^{-1} and net profit (Rs. 152344.3 per hectare) was recorded under the treatment T_6 (NAA 20 ppm) spray with benefit cost ratio of 2.68:1. Similarly, from the economics point of view, NAA was found to be profitable as compared to rest of treatments reported by Patil and Patel[6] in cv. GO-2 with variable concentration. Mandal *et al.*,[14] earlier found that, concentrations of plant growth regulators caused an increased in net return over the control, but the differences were much narrower. Benefit cost ratio exhibited a marked variation among the treatments. Plant spray with NAA at 75 ppm having a benefit: cost ratio of 1:2.67 scored

over all other treatments in this regard which corroborate with the current findings with diferent concentration. Plant spray with 10 ppm 2, 4-D, which was next to 75 ppm NAA had a benefit: cost ratio of 1:2.56 and was superior to plant spray with 800 ppm CCC showing benefit cost ratio of 1:2.52. In comparison to CCC the spraying with 2, 4-D or NAA gained better benefit cost ratio.

Table 1: Detail of treatments with their symbols

S. No.	Symbols	Treatments
1.	T_0	Control
2.	T_1	Only water
3.	T_2	GA_3 10 ppm
4.	T_3	GA_3 20 ppm
5.	T_4	GA_3 30 ppm
6.	T_5	NAA 10 ppm
7.	T_6	NAA 20 ppm
8.	T_7	NAA 30 ppm

Table 2: Effect of foliar application of NAA and GA_3 on growth of Okra

Treatments	Plant height (cm)			Days taken to flower initiation	No. of fruits per plant	No. of picking	Duration of picking (Days)
	40 DAS	60 DAS	80 DAS				
T_0	20.07	48.53	67.13	44.44	22.00	14.73	23.33
T_1	21.83	57.07	76.47	40.99	25.53	15.53	33.73
T_2	23.83	65.47	85.33	42.72	22.90	16.27	34.77
T_3	23.93	65.77	92.57	42.60	24.57	17.17	34.77
T_4	24.23	67.07	93.97	40.97	25.37	16.83	32.00
T_5	24.73	68.03	96.33	41.28	25.77	17.23	34.93
T_6	25.53	74.17	106.20	38.00	28.23	18.27	36.97
T_7	25.23	67.27	97.40	42.90	27.07	17.46	35.33
S.E m ±	1.36	3.77	4.68	2.34	0.57	0.66	1.58
CD (P=0.05)	4.14	11.43	14.20	7.08	1.65	1.99	4.78

Table 3: Effect of foliar application of NAA and GA_3 on growth, yield and economic of Okra

Treatments	Fruit length (cm)	Fruit diameter (cm)	Av. Wt. of fruits per plant (g)	Yield per plot (kg)	Yield of fruits per ha (q)	Net profit	B:C ratio
T_0	12.00	1.73	210.53	14.73	140.28	119126.8	2.11
T_1	13.87	1.97	215.91	15.11	143.90	123651.8	2.19
T_2	13.87	1.97	223.18	15.62	148.36	129156.8	2.94
T_3	13.87	1.97	225.40	15.77	150.19	131374.3	2.33
T_4	13.83	2.37	234.14	16.38	155.99	138484.3	2.45
T_5	13.73	2.13	242.11	16.96	161.92	145581.8	2.56
T_6	13.93	2.63	251.03	17.57	167.33	152344.3	2.68
T_7	13.67	2.24	244.71	17.12	163.04	146666.8	2.56
S.E m ±	1.16	0.10	10.34	0.72	6.89		
CD (P=0.05)	3.53	0.31	31.37	2.20	20.91		

CONCLUSION

Foliar spray of NAA 20 ppm 40 days after sowing gives the best response with respect to growth parameters, yield of fruits per hectare, number of picking and duration of harvesting and followed by the plants treated with NAA 20 ppm spray. The maximum benefit: cost ratio 2.68:1 was obtained when the crop was

treated with the same 20-ppm naphthalene acetic acid treatment.

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