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Effect of plant growth regulators on growth, yield and yield attributing characters of okra (*Abelmoschus esculentus* L.)

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Abstract
The field experiment was conducted at the research farm, J.N.K.V.V., College of Agriculture, Tikamgarh (M.P.), India; during *kharif* season of 2016-2017 to study the Effect of plant growth regulators on growth, yield and quality of Okra (*Abelmoschus esculentus* L.) *cv.* VRO-6. The experiment was laid out in Randomized Block Design with three replication accommodating ten treatments in each replication. The treatments consists of GA_3 (25, 50 and 100 ppm), NAA (100, 150 and 200 ppm), Cycocel (250, 500 and 750 ppm) and Control. The result revealed that foliar spray of GA_3 was found beneficial for increasing maximum plant height (96.17 cm), maximum number of leaves (23.79) and minimum number of days to 50% of flowering (36.25 days) while the maximum numbers of branches (5.77) were recorded in cycocel 750 ppm. The highest number of fruit (22.05), highest fruit yield plant^{-1} (301.19 g) and fruit yield ha^{-1} (167.38 q) was recorded with GA_3 100 ppm in comparison to the rest of the treatments. Therefore, it can be concluded that the treatment GA_3 is the best treatment to enhancing okra productivity.

Keywords: Okra, plant growth regulators GA_3, NAA, Cycocel (CCC)

Introduction
Okra (*Abelmoschus esculentus* L.) belongs to the Malvaceae. Okra is a warm-season as well as rainy season of both tropical and subtropical regions of the world. India ranks first in the world with a total area under okra crop is 509.0 thousand hectare which produces 6094.9 thousand MT with average productivity 12 MT ha^{-1}. In madhya Pradesh okra is grown in 43.76 thousand hectare area with a production of 638.34 thousand MT and 14.59 MT ha^{-1} productivity. In tikamgarh district okra is grown in 1.24 thousand hectare area with a production of 15.44 thousand MT (Horticulture statistics, 2017-18).

Okra pod contains many nutritional contents which important for human health. It contains good amount of potassium, calcium, magnesium, phosphorus, vitamin 'A' and 'C'. The edible fruit of okra one hundred gram of fresh pod has around; 1.9 g of protein, 0.2 g fat, 6.4 g carbohydrate, 0.7 g minerals and 1.2 g fiber (Tiwari *et al*, 1998) [15]. The discovery of plant growth regulator has been proved revolutionary in increasing production of horticultural crops. Plant growth regulators are the chemical substance, when applied in small amounts modify the growth of plants by stimulating or inhibiting part of the natural growth regulatory system. Among the different plant growth regulators GA_3 is found very promising substance. GA_3 may play a key role in many metabolic pathways affecting these characteristics such as chlorophyll production and degradation, translocation of assimilates, stem elongation by increasing the length of internodes, parthenocarpic fruit formation, increase the size of leaves and fruits and also enhance cell division and cell size. NAA is a potential antifungal agent and it is commonly used in horticulture crops. The effect of NAA has been observed mainly as cell elongation, improved phototropism, respiration, flower bud initiation, vascular tissue differentiation, root initiation, apical dominance, leaf senescence, leaf and fruit abscission, fruit setting ratio, prevent fruit dropping, promote flower sex ratio and flowering. Moreover, Varietal response to plant growth regulators is also different. Therefore, the present experiment was planned to study the effect of Plant Growth Regulators on growth, yield and quality of Okra, cultivar, VRO-6.

Materials and Methods

The experiment entitled "To study the effect of plant growth regulators on growth, yield and quality of Okra (*Abelmoschus esculentus* L.) was conducted at the research farm of College of Agriculture, Tikamgarh, India; during *kharif* season of the year 2016-2017. The experimental site was situated at 24°43' N latitude and 78°49' E longitude having an elevation of 358 m above mean sea level. The soil of the experiment field was clay loam in texture with pH 6.9. The experiment was laid out in a Randomized Block Design with three replications accommodating ten treatments in each replication. Okra variety VRO-6 was sown at 60 x 60 cm spacing with a net plot size 3.00 m x 3.6 m. The crop was fertilized with 12 ton/ha FYM along with NPK@ 120:60:60 kg/ha. The treatments comprised of T_1- GA_3 25 ppm, T_2- GA_3 50 ppm, T_3 GA_3 100 ppm, T_4-NAA 100 ppm, T_5-NAA 150 ppm, T_6-NAA 200 ppm, T_7-CCC 250 ppm, T_8- CCC 500 ppm, T_9-CCC 750 ppm and T_{10}-control respectively. Each growth regulators was used at 30, 60 and 90 DAS. During the course of experiment the observation were recorded from five selected plants in each replication for each treatment. Observation recorded during field experimentation was subjected to the statistical analysis of variance by Randomized Block Design (RBD). Significance and non-significance of the variance due to different treatments were determined by calculating the respective 'F' value as the method described by Panse and Sukhatme (1985) [9].

Result and discussion

Growth attributes

The data presented in table-1, revealed that foliar application of GA_3 Significantly increased the plant height. At 30, 60 and 90 DAS, the maximum plant height (28.62, 78.40 and 96.17 cm) was recorded by GA_3 100 ppm respectively followed by GA_3 50 ppm whereas, the minimum plant height (19.57, 50.17 and 71.42) was recorded by CCC 750 ppm. Significantly increase in plant height because Gibberellins promote stem elongation which might be due to that GA_3 could be involved in cell enlargement, intermodal elongation, stimulate RNA and protein synthesis and there by leading to enhanced growth and development. These results are in conformity with the finding of Ravat and Makani (2015) [12], Surendra *et al*. (2006) [14]. Reduction in plant height with CCC application could be due to its effect in reducing cell division, cell expansion in the sub-apical meristem and synthesis of diffusible endogenous growth substances (Cathey, 1964) [3]. Similar results were reported by Bhagure and Tambe (2013) [2] in okra crop.

A number of leaves plant^{-1} showed significant difference with various treatments. At 30, 60 and 90 DAS, the maximum number of leaves plant^{-1} (9.11, 19.76 and 23.79) were counted by GA_3 100 ppm respectively which was superior over the rest of the treatments. The production of more number of leaves plant^{-1} by GA_3 might be due to rapid growth and differentiation. Similar findings were also reported by Mehraj *et al*. (2015) [7] in okra crop and Sharma and Lashkari (2009) [13] in cluster bean.

The significant variation in the number of branches plant^{-1} was noted for varying treatments. At 30, 60 and 90 DAS, The maximum numbers of branches plant^{-1} (1.96, 4.82 and 5.77) were recorded by the cycocel 750 ppm respectively followed by cycocel 500 ppm whereas, minimum was recorded by the control. The increase in number of branches with the application of Cycocel might be due to its effectiveness in suppressing the apical dominance, thereby promoting growth and axillary buds into new shoots (Narse Gowda and Mundappa Gowda, 1980) [8]. These results are also in accordance with the finding of Prasad and Srihari (2008) [10].

The data revealed that foliar spray of GA_3 100 ppm was recorded significantly minimum number of days (36.25) for 50% of flowering followed by GA_3 50 ppm (36.47). The maximum number of days to 50% of flowering (41.20) was recorded by control. The growth regulators might have influenced the physiological regulation of flower formation of the plants possibly influencing the timing of anthesis mechanism (Das and Prusty, 1969) [4]. Similar results were also reported by the Mehraj *et al*. (2015) [7], Ravatand Makani (2015) and Tyagi *et al*. (2008) [16].

Table 1: Effect of plant growth regulators on growth parameters

Treatments	Plant height (cm)			Number of leaves			Number of branches			50% flowering
	30 DAS	60 DAS	90 DAS	30 Das	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	
T_1- GA_3 25 ppm	27.16	73.44	91.22	8.58	18.63	22.30	1.42	2.99	4.11	36.88
T_2 - GA_3 50 ppm	27.80	75.29	93.63	8.90	19.20	23.32	1.52	3.20	4.35	36.47
T_3- GA_3 100 ppm	28.62	78.40	96.17	9.11	19.76	23.79	1.60	3.50	4.71	36.25
T_4- NNA 100 ppm	25.15	65.27	83.31	7.21	17.49	21.29	1.30	2.34	3.52	37.74
T_5- NNA 150 ppm	25.67	68.70	85.11	7.72	17.89	21.66	1.34	2.63	3.73	37.45
T_6- NNA 200 ppm	26.53	70.36	89.33	8.21	18.24	22.11	1.39	2.75	3.81	37.22
T_7- CCC 250 ppm	21.46	55.12	75.81	6.11	16.40	19.48	1.65	4.38	5.20	39.81
T_8- CCC 500 ppm	20.31	53.51	73.19	6.50	16.74	19.81	1.75	4.62	5.49	39.50
T_9- CCC 750 ppm	19.57	50.17	71.42	6.84	17.02	20.03	1.96	4.82	5.77	39.33
T_{10}- Control	23.27	58.15	79.60	5.10	13.60	17.52	1.27	1.90	2.12	41.20
SE m	0.73	0.86	0.84	0.66	0.37	0.46	0.08	0.39	0.61	0.82
C.D. (5%)	2.19	2.58	2.53	1.99	1.12	1.39	0.26	1.17	1.83	2.46

Yield attributes

The data presented in table-2 revealed that significantly maximum number of fruits Plant^{-1}, fruit yield plant^{-1} and yield ha^{-1} (22.05, 301.19 g and 167.38 q) was recorded by the GA_3 100 ppm respectively, however the minimum number of fruits plant^{-1}, fruit yield plant^{-1} and yield ha^{-1} was recorded in treatment control. The increase in yield by the application of GA_3 over rest of the treatments might be due to the plant growth regulator enters into the plant system and increase the net photosynthetic rate by increasing number of leaves, increasing number of branches Ultimately, the increased number of fruits, fruit length and fruit girth, resulted in the increased fruit yield plant^{-1} and fruit yield ha^{-1}. These results are in conformity with the Hussain and babu (2004) [6] and Ayyub *et al*. (2013) [1] in okra.

Conclusion

From the above results it may be concluded that foliar spray

of GA_3 100 ppm established its superiority as it recorded better in growth and higher yield contributing characters except number of branches plant^{-1} which was found maximum by CCC 750 ppm, hence can be plasticized to harvest better productivity from okra.

Table 2: Effect of plant growth regulators on yield attributes

Treatments	Number of fruits plant^{-1}	Fruit yield plant^{-1} (g)	Fruit yield ha^{-1} (q)
T_1- GA_3 25 ppm	20.35	264.55	146.97
T_2 - GA_3 50 ppm	21.10	278.52	154.73
T_3- GA_3 100 ppm	22.05	301.19	167.38
T_4- NNA 100 ppm	18.61	230.38	127.99
T_5- NNA 150 ppm	19.34	243.67	135.37
T_6- NNA 200 ppm	20.00	258.10	143.39
T_7- CCC 250 ppm	17.15	192.41	106.90
T_8- CCC 500 ppm	17.42	202.24	112.35
T_9- CCC 750 ppm	18.01	212.04	117.80
T_{10}- Control	14.72	150.13	83.41
SE m	0.56	0.93	0.72
C.D. (5%)	1.69	2.80	2.17

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