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Effect of foliar application of GA_3 on growth, fruit yield and seed quality parameters in okra [*Abelmoschus esculentus* (L.) Moench].

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Abstract

The present investigation entitled "Effect of foliar application of GA_3 on flowering, fruiting, yield and seed quality parameters in okra [*Abelmoschus esculentus* (L.) Moench]" was carried during Kharif season of 2018-19. The field experiment was laid out in Randomized Complete Block Design factorial with one additional treatment replicated three times while laboratory experiment was conducted in Completely Randomized Design factorial done with one additional treatment having four replications. Various concentrations of growth regulator GA_3 i.e. 25, 50, 100 and 150 ppm were applied as foliar spray after 30, 45 and 60 days of germination on okra plants and observations were recorded on days taken to 50% flowering, days taken to fruit maturity, number of fruits per plant, fruit length (cm), fruit yield (g/plant and q/ha), number of seeds per pod, 100 seed weight (g), seed yield (kg/plot and q/ha), germination percent, speed of germination, seedling length (cm), seedling dry weight (mg), seed vigour index-I and seed vigour index-II. Recorded data revealed that foliar spray of GA_3 150 ppm at 45 days after germination gave significantly superior results for obtaining maximum fruit yield and component traits of okra whereas, the treatment of GA_3 150 ppm at 60 days after germination was significantly superior for seed yield and component traits which can be adopted for commercial cultivation of okra as well as its seed production.

Keywords: Growth regulators, GA_3, seed quality, seed vigour, okra

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is an important vegetable which belongs to the family Malvaceae and is native to Tropical Africa (Jain et al. 2012). It is grown for its tender green fruits which are generally marketed in fresh state and sometimes canned, dehydrated or frozen for off-season consumption (Neeraja et al. 2004). Besides, it also has medicinal and industrial importance. The fruits are very useful against genito-urinary disorders, spermatorrhoea and chronic dysentery (Nandkarni 1972). Its ripe seeds are also roasted, ground and used as a substitute for coffee (Martin, 1982). Its fruits have high nutritive value in which on an average 36 calories energy, 2.4 g protein, 89 per cent moisture, 0.3 g fat, 7.6 g carbohydrates, 92 mg Ca, 51 mg P, 1.5 mg Fe, 3 mg Na and 103 mg K are from 100 g of edible portion (Bose and Mitra 1985). Above all, it is very popular among the farmers because of easy in growing and having wider adaptability. Okra is a heavy yielder and high remunerative crop but sometimes suffer with recurring economic loss due to poor, sparse, uneven fruiting and pod setting, small pod size and low plant vigour which also produce poor quality seeds. The chemical substances like plant growth regulators can bring changes in the phenotype of plants and affect growth either by enhancing or by stimulating the natural growth regulatory systems from seed germination to plant senescence and may results in of these characters (Das and Das 1995). Plant growth regulators are the organic substances which are produced naturally in plants, synthesized in one part and usually translocated to other part where every small quantity influence the growth and other physiological function of the plants and it is a key factor in vegetative growth, flowering, pod setting and high yield in okra (Singh et al. 2012). The growth regulators and their uses are considered to be the most technical and scientific in crop production. The selection of right hormones, their appropriate concentration and their time and method of application are most essential. Even the same growth regulator in different concentrations brings about the different results. Gibberellic acid (GA_3) has potential to control growth and flowering process, also it increases the petiole length, leaf area (Mehraj et al. 2015), fruit yield (Islam et al. 2014) and delayed petal abscission (Khan et al. 2006). Gibberellin induces cell elongation,

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development of fruit and flowering. It increases the size and number of fruit and break the dormancy of seed, buds and underground organ like bulb, tuber, corm, etc. Keeping this in view, present study has been undertaken to determine the effect of foliar application on vegetative and reproductive growth of plant including yield and seed quality attributes using various concentrations of GA_3 at different stages of crop growth in okra.

Materials and Methods

Location and climate: Field experiment was conducted during kharif season in 2018 at the experimental farm of Department of Seed Science and Technology, Dr YS Parmar university of Horticulture and Forestry, Nauni, Solan HP, which is located at an altitude of 1250 meters above mean sea level. Geographically it is situated between 35.5^{0}N latitude and 77.8^{0}E longitude. The area falls under sub-humid, sub-temperate and mid-hill zone of Himachal Pradesh where climate is characterized by mild summers and cold winters. However, during the cropping season, mean maximum temperature was recorded in the month of August i.e. 27.6^{0}C and mean minimum temperature 6.54^{o}C in the month of November. The relative humidity ranged from 81 percent (in the month of July) to 52.9 percent (in the month of October) with minimum rainfall (1 mm) in the month of October and maximum rainfall (110 mm) in the month of July. The soil of experimental field was loam to clay loam having pH ranging from 6.85-7.05.

Materials and treatments: The field experiment was laid out in Randomized Complete Block Design (Factorial) having three replications with thirteen treatments each having two factors (different concentrations of GA_3 , different stages of GA_3 application) with additional treatment (control) while laboratory experiment was conducted in Completely Randomized Design (Factorial) with additional treatment having four replications. Treatments details and treatments combinations are given in Table 1. The seeds of okra cultivar P-8 were sown as treatments in a plot having size of 2.4 m X 1.2 m at a 5 cm depth in rows respectively. FYM and basal application of fertilizers was applied during field preparation. The recommended doses of FYM @ 100 q/ha, CAN @ 300 kg/ha, SSP @ 315/ha and MOP @ 90 kg/ha were applied through 12:32:16 and remaining nitrogen and potassium were provided by urea and murate of potash. The remaining nitrogen was applied in two split doses. All the packages of practices recommended for okra production were followed from time to time to ensure a good crop stand. Experimental plots were irrigated as and when required. Other plant protection practices were also taken up for the control of insect pest and decreases during investigation period. The observations for growth and yield parameters were recorded during field experiment and for seed quality parameters during laboratory experiment. All the data obtained from experiment was statistically analyzed by using the F-test as per the procedure given by Gomez and Gomez (1984).

Results and Discussion

The results obtained from the present research as well as relevant discussion have been summarized under following heads:

Effect of foliar spray of GA_3 on different growth and fruit yield parameters: The data recorded on effect of different concentrations and stages of GA_3 as foliar application on flowering, fruiting and yield contributing characters are presented in Table 2 which revealed that all the treatments are significantly superior over control. In case of earliness, minimum days to 50% flowering (38.33) and fruit maturity (48.56 days) were recorded in treatment T_{10} in which 150 ppm of GA_3 sprayed at 30 days after germination in okra. Early flowering might be due to the increase in the endogenous GA_3 level in the okra which influence the physiological regulation of flower formation of the plants and possibly influenced the timing of anthesis mechanism. Further

Table 1 Description of treatments

Treatment combinations		Details
T_1	C_1D_1	Application of 25 ppm of GA3 at 30 days after germination
T_2	C_1D_2	Application of 25 ppm of GA3 at 45 days after germination
T_3	C_1D_3	Application of 25 ppm of GA3 at 60 days after germination
T_4	C_2D_1	Application of 50 ppm of GA3 at 30 days after germination
T_5	C_2D_2	Application of 50 ppm of GA3 at 45 days after germination
T_6	C_2D_3	Application of 50 ppm of GA3 at 60 days after germination
T_7	C_3D_1	Application of 100 ppm of GA3 at 30 days after germination
T_8	C_3D_2	Application of 100 ppm of GA3 at 45 days after germination
T_9	C_3D_3	Application of 100 ppm of GA3 at 60 days after germination
T_{10}	C_4D_1	Application of 150 ppm of GA3 at 30 days after germination
T_{11}	C_4D_2	Application of 150 ppm of GA3 at 45 days after germination
T_{12}	C_4D_3	Application of 150 ppm of GA3 at 60 days after germination
T_{13}	Control	No spray

Table 2: Effect of growth regulator on growth and fruit yield parameters in okra cv. P-8

Treatments	Days taken to 50% flowering	Days taken to fruit maturity	Number of fruits per plant	Fruit length (cm)	Fruit yield (g/plant)	Fruit yield (kg/plot)	Fruit yield (q/hectare)
T_1	42.00	60.81	11.73	14.78	120.11	2.16	67.50
T_2	48.67	77.28	11.67	14.03	123.73	2.23	69.59
T_3	50.00	87.67	11.40	12.65	114.12	2.05	64.17
T_4	40.67	53.57	13.07	15.98	124.21	2.24	69.90
T_5	48.00	68.44	13.60	16.31	127.83	2.30	71.88
T_6	50.67	85.97	11.60	13.97	117.65	2.12	66.15
T_7	39.33	50.10	13.73	16.00	130.25	2.34	73.23
T_8	46.47	61.13	14.20	16.64	137.80	2.48	77.50
T_9	51.33	83.50	12.53	15.60	118.41	2.13	66.56
T_{10}	38.33	48.56	13.73	16.25	136.65	2.46	76.77
T_{11}	45.67	54.66	14.47	16.83	141.47	2.55	80.25
T_{12}	50.67	84.01	13.13	15.38	119.41	2.15	67.19
T_{13} (NF)	51.67	86.94	8.40	11.41	108.80	1.96	61.15
Source of variation	CxD FvsNF	CxD FvsNF	CxD FvsNF	CxD FvsNF	CxD FvsNF	CxD FvsNF	CxD FvsNF
CD $_{(0.05)}$	1.79 1.32	7.37 5.43	0.64 0.47	0.84 0.61	5.39 3.96	0.09 0.07	3.04 2.24

Table 3: Effect of growth regulator on seed yield parameters in okra cv. P-8

Treatments	Number of seeds per pod	Seed yield (g/plant)	Seed yield (kg/plot)	Seed yield (q/hectare)	100 seed weight (g)
T_1	48.88	21.77	0.39	12.19	5.60
T_2	49.71	21.61	0.39	12.08	6.17
T_3	56.21	24.28	0.44	13.65	6.60
T_4	52.43	22.30	0.40	12.50	6.00
T_5	53.75	22.64	0.40	12.61	6.17
T_6	59.56	26.85	0.48	15.00	6.53
T_7	53.02	22.19	0.40	12.40	6.73
T_8	57.90	23.00	0.41	12.92	6.50
T_9	60.17	29.71	0.54	16.77	7.30
T_{10}	55.44	25.91	0.47	14.58	6.10
T_{11}	57.68	26.08	0.47	14.69	6.93
T_{12}	63.00	33.82	0.61	19.06	7.33
T_{13} (NF)	48.51	15.24	0.27	8.54	5.47
Source of variation	CxD FvsNF	CxD FvsNF	CxD FvsNF	CxD FvsNF	CxD FvsNF
CD $_{(0.05)}$	1.73 1.27	2.58 1.90	0.04 0.03	1.44 1.06	0.44 0.32

Table 4: Effect of growth regulator on seed quality parameters in okra cv. P-8

Treatments	Percent seed germination	Speed of germination	Seedling length (cm)	Seedling dry weight (mg)	Seed vigour index-I	Seed vigour index-II
T_1	74.00	8.45	18.31	20.84	1355.72	1550.21
T_2	84.00	9.80	18.05	21.23	1517.05	1782.71
T_3	81.67	9.85	18.61	21.75	1519.28	1776.91
T_4	81.00	9.38	17.40	20.73	1408.81	1678.75
T_5	85.00	9.55	18.21	22.19	1547.43	1886.39
T_6	86.67	9.66	19.74	25.60	1710.97	2219.27
T_7	84.33	9.19	18.27	21.44	1541.20	1808.27
T_8	86.67	9.79	18.72	23.28	1622.16	2017.32
T_9	85.33	9.78	19.90	26.62	1698.42	2270.96
T_{10}	84.67	9.54	19.98	24.24	1692.37	2052.29
T_{11}	88.33	9.90	22.21	24.34	1963.45	2152.14
T_{12}	93.00	10.32	22.79	28.60	2119.10	2660.84
T_{13} (NF)	65.67	8.78	15.13	19.07	993.66	1252.19
Source of variation	CxD FvsNF	CxD FvsNF	CxD FvsNF	CxD FvsNF	CxD FvsNF	CxD FvsNF
CD $_{(0.05)}$	3.47 2.55	0.53 0.39	0.86 0.63	1.97 1.45	122.8 90.42	205.2 151.0

this might have contributed to slower down the vegetative growth and builds up suitable carbohydrate which transmitted from vegetative parts towards the reproductive organs at early stages leading to early fruit maturity. These results are in conformity with the earlier findings of Dhage *et al.* (2011), who recorded minimum number of days to first flowering (39.67 days) and first harvesting (44.67 days) with foliar application of GA_3 at 150 ppm. Similar results were also recorded by Deepak *et al.* (2007) and Das and Prusty (1969) in okra with application of GA_3 @ 150 ppm.

The interactive effect of different concentrations and stages of application of GA_3 on number of fruits per plant and fruit length was also statistically significant with maximum number of fruits (14.47) and maximum fruit length (16.83 cm) obtained in treatment T_{11} i.e. with application of 150 ppm GA_3 at 45 days after germination. The results obtained can be explained on the basis that GA_3 treated plants became physiologically more active, resulting in increased number of branches and fruiting points which led to better utilization of sunlight for formation of more photo assimilates. Because of better accumulation and distribution of these photo assimilates, the maximum number of fruits and fruit length were obtained in GA_3 treated plants. The similar studies have been reported by Patil and Patel (2010) and Ayyub *et al.* (2013) in okra, where they also opined that the increase in fruit length through GA_3 treatment may be due to the increase in number of leaves resulting in increased photosynthesis and maximum distribution of assimilates. Singh *et al.* (2004) also reported from his experiment that the GA_3 up to 150 ppm increases the fruit length and number of fruits per plant in okra.

Similarly, effect of different concentrations and time of foliar application of GA_3 and their interaction on fruit yield (per plant (g), per plot (kg) and per hectare (q) was also found significantly maximum in T_{11} (141.47 g/ per plant, 2.55 kg/plot and 80.25 q/ha). The positive influence of PGR_s on growth and yield of okra was in agreement of Kokare *et al.* (2006) who explained that, spray of GA_3 leads to the higher rate of photosynthesis and reduced respiration which results into higher accumulation of photosynthates i.e. photosynthetic efficiency was increased and increase in photosynthetic activity produces more carbohydrates which directly influenced the fruit size, number of fruits and ultimately final yield. Dhage *et al.* (2011) in their studies also found that the significantly maximum fruit set and more fruit yield per hectare were observed in treatment GA_3 at 150 ppm. The increased number of fruits, fruit length and fruit girth, resulted in the increased fruit yield per plot and fruit yield per ha.

Effect of foliar spray of GA_3 on different seed yield parameters: The data recorded on seed yield parameters was significantly influenced by different concentrations, stages of application of GA_3 and their interaction which have been presented in the Table 3. The effect of different concentrations and stages of application of GA_3 in okra plant on number of seeds per pods was recorded significant with maximum (63.00) in T_{12}. The results obtained are in line with the findings of Kumar and Sen (2005) who also studied that numbers of seeds per pod were highest in treatment of GA_3 100 ppm (50.13) as compare to the 75-ppm concentration and this increase in number of seeds per increase in concentration is due to increase translocation and assimilation of photosynthates from source to the sink (seeds). GA_3 also stimulates nitrogen assimilation which affects the raw protein accumulation in okra seeds which is important and considered for crops and their seeds production (Ayyub *et al.*, 2013).

Similarly, the effect of different concentrations and time of applications in okra on seed yield (33.82 g/plant, 0.61 kg/plot and 19.06 q/hectare) was significant in treatment T_{12} (150 ppm GA_3 sprayed at 60 days of germination). This increase is obtained due to production of higher percentage of bolder seeds coupled with the heavier seed weight and increased translocation and assimilation of photosynthates from source to the sink (seeds) reported by Balakumar and Balsubramanian (1988) and Bhatt and Singh (1997). These findings were in line with the findings of Singh and Kumar (2005) that also revealed that the highest number of seeds per fruit and seed yield q/ha were recorded with 150 ppm GA_3 application. Similarly, maximum (7.33 g) seed weight was observed in treatment T_{12} which can be due to heavier buildup of sufficient food reserves diversified towards the developing pods and seeds due to spraying of growth regulators (Bhatt and Singh 1997). The above results indicated that foliar application of 150 ppm GA_3 was significantly effective then other concentrations of GA_3 in okra.

Effect of foliar spray of GA_3 on different seed quality parameters: The data recorded on seed quality parameters are presented in Table 4 which reveals that all the treatments are significantly superior over control. The T_{12} treatment recorded maximum germination percent (93.00), speed of germination (10.32), seedling length (22.79cm), seedling dry weight (28.60 mg), seed vigour index-I (2119.10) and seed vigour index-II (2660.84). These results show that foliar application of 150 ppm GA_3 at 60 days after germination was significantly superior to other treatments which can be attributed to the effect of foliar application of GA_3 on flowering, fruiting, yield and seed production attributes in okra. Finally, in the present investigation, it is concluded that amongst various treatment combinations, T_{11} i.e. GA_3 150 ppm sprayed at 45 days after germination was significantly superior for fruit yield and component parameters whereas, T_{12} i.e. GA_3 150 ppm sprayed at 60 days after germination was superior for seed yield and seed quality parameters. Hence, these treatments can be adopted for commercial cultivation by the okra seed producers in different regions of Himachal Pradesh.

सारांश

वर्तमान परीक्षण 'भिंडी में फूल, फल, उपज और बीज की गुणवत्ता के मापदण्डों पर जी.ए.$_3$ के छिड़काव के अनुप्रयोग का प्रभाव को खरीफ मौसम के दौरान डॉ. यशवन्त सिंह परमार विश्वविद्यालय बागवानी एवं वानिकी, नौणी, सोलन की बीज विज्ञान और प्रौद्योगिकी विभाग के अनुसंधान क्षेत्र व प्रयोगशाला में किया गया। परीक्षण को पूरी तरह यादषच्छिक खण्ड अभिकल्पी और पूरी तरह यादषच्दिक डिजाइन क्रमगुनीत में, अतिरिक्त उपचार के साथ तीन प्रतिकषतियां दी गई। वषद्धि नियामक जी.ए.$_3$ को पौधें पर अंकुरण के 30, 45 और 60 दिनों के पश्चात् विभिन्न सांद्राता यानी 50, 100 और 150 पी.पी.एम से छिड़काव किया गया और विभिन्न मापदंडों का निरीक्षण किया गया कि 50 प्रतिशत फूलों की खिलना, फल की परिपक्वता तक दिन, फल की लंबाई की पैदावार, किलोग्राम/प्लाट और कुन्तल/हेक्टेयर प्रति फली, बीज की संख्या, 100 बीजों का वजन, बीजों की पैदावार; किलोग्राम/प्लाट औरन कुन्तल/हेक्टेयर अंकुरण प्रतिशत, अंकुरण गति, अंकुर लंबाई; सेंटीमीटर, सूखे अंकुर का वजन, मिलीग्राम, बीज शक्ति सूचकांक–1 और बीज शक्ति सूचकांक–11 रिकॉर्ड किए गये। आंकड़ों से पता चला है कि जी.ए.$_3$ 150 पी.पी.एम का अंकुरण के 45 दिनों के बाद पर छिड़काव भिंडी में अधिकतम फलों के उत्पादन व घटक गुणों के लिए उत्कृष्ट है जबकि जी.ए.$_3$ 150 पी.पी.एम का अंकुरण के 60 दिनों के बाद का छिड़काव बीज की उपज और घटक विशेषताओं के लिए सर्वोत्तम है और इसे भिंडी की व्यवसायिक व बीज उत्पादन खेती के लिए अपनाया जा सकता है।

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