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Effect of Integrated Nutrient Management and Foliar Spray of Bioregulators on Growth and Yield of Okra

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An experiment was conducted to examine the effect of integrated nutrients and foliar spray of brassinoides and salicylic acid on growth and yield of okra at HRC of SVPUAT, Meerut during the year 2019-20. The experiment was laid out in a factorial randomized block design with 9 treatments, three replications and 27 combinations. Among the treatments, plants fortified with 50 per cent RDF through inorganic fertilizer, 12.0 t/ha FYM, foliar application of brassinoids at 5 ppm and salicylic acid 150 ppm as bio-regulators was found most suitable in terms of yield and quality parameters of okra. However, nutrients supplied with 75 per cent RDF through inorganic fertilizer and 6.0 t/ha FYM, foliar spray of brassinoides 5 ppm and salicylic acid 150 ppm showed better performance in regarding the vegetative growth of okra.

Introduction

Okra is also known as Lady's finger, Bhindi in India and Gumbo in United States belongs to genus Abelmoscus on the basis of distinguished features of caduceus calyx and family Malvaceae. Okra said to be native of South Africa but widely cultivated in Tropical and Sub tropical regions of the world. It is an important vegetable grown for its tender fruits which are used as a vegetable in various ways. Nutritionally, okra is a good source of protein 2.10 g, carbohydrate 8.20 g, fat 0.20 g, fiber 1.70 g, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, β-carotene 185.00 µg, riboflavin 0.08 mg, thiamin 0.04 mg, niacin 0.60 mg, ascorbic acid 47.00 mg Varmudy, (2011). Okra fruit is an excellent source of iodine which is necessary for the resistance against throat disease like goiter Chavan *et al.*, (2007). Among the various factors affecting the growth and quality of okra, supply of balanced nutrition is very important. It is well reported that the growth and development of a plant, generally, depends on their judicious feeding and right time of application. Continuous application of imbalanced and excessive nutrients had led to decline in nutrient-use efficiency making fertilizer consumption uneconomical and producing adverse effects on atmosphere and groundwater quality, causing health hazards. Integrated nutrient management have been very useful approaches for increasing growth and yield of various horticultural crops (Kumar *et al.,* 2013, Singh *et al.,* 2013, Kumar, 2014 and 2014a, Phonglosa *et al.*, 2015, Singh *et al.*, 2014, Kumar, 2015, Singh *et al.,* 2015, Kumar and Chaudhary, 2018, Singh *et al.*, 2018, Tiwari *et al.*, 2018 and 2018a Mohit *et al.*, 2019, Priyanshu *et al.*, 2019). INM approaches can increase crop yields as compared with conventional practices, increases water and nutrients use efficiency, economic returns to farmers and also improve vegetable quality and soil health (Kumar *et al.,* 2018).

Plant growth regulators considered as natural or synthetic compounds and its low concentration can influence developmental and metabolic processes in plants Rademacher (2016). In crop production plant growth regulators promotes growth along with the longitudinal area, increase the number of branches, early flower initiation, fruit set, fruit quality and subsequently contributes towards higher production when applied at various concentration. Brassinoides are a class of polyhydroxy steroids that have been recognized as the sixth class of plant hormone which improve the resistance power in the plants against environmental stresses *viz*., water stress, salinity stress, low and high-temperature stress Rao *et al.,* (2002) and crop productivity Vardhini *et al.,* (2006) whereas, salicylic acid play an important role in plant growth, photosynthesis, transpiration, ion uptake, and transport in plants Popova *et al., (*1997) and Hayat *et al.,* (2010). Earlier studies have demonstrated that a exogenous salicylic acid application, showed variable effects in various crops including an increase in yield of barley (El-Tayeb, 2005; Khodary, 2004; Yildirim *et al.,* 2008;), more photosynthetic activity in wheat (Singh and Usha, 2003), higher total anthocyanin contents in *Catharantus roseus* (Hernandez and Vargas, 1997), inhibition of ethylene biosynthesis in rice leaves (Huang *et al.,* 2004), and protection against biotic and abiotic stresses (Doares *et al.,* 1995). Since limited information on the use of integrated sources of nutrients along with foliar applications of bio-regulators is available, and okra crops being the source of more income for many farmers of peri-urban areas, the present investigation was undertaken to optimize integrated doses of nutrients and foliar applications of bio-regulators for okra crop, through the evaluation of growth and fruit yield.

Materials and Methods

The experiment was conducted during the year 2019-20 at Horticultural Research Center (HRC) of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut to study the effect of integrated nutrients and foliar spray of brassinoides and salicylic acid on growth and yield of okra. The experiment was laid out in a factorial randomized block design with 9 treatments and replicated thrice with 27 treatment combinations. Three levels of integrated nutrients like R_0 as a Control, R_1 (75% RDF+6.0 t FYM/ha), R_2 (50% RDF+12.0 t FYM/ha) and three foliar applications of each growth regulators like Brassinoides viz. B_0- 0 ppm, B_1- 5 ppm, B_2- 10 ppm and Salicylic acid viz. S_0- 0 ppm, S_1 100 ppm and S_2- 150 ppm. Before sowing of seeds, seeds were soaked in water overnight for early germination. During the experimentations, data were recorded in terms of growth and yield parameters by using standard methods. The data were statistical analysis as suggested by Gomez and Gomez, (1983).

Results and Discussion

Effect of integrated nutrients and foliar spray of brassinoides and salicylic acid on vegetative growth of okra are presented (Table 1). The results showed that plants fortified with 75% RDF and 6.0 tonne FYM/ha exhibited maximum plant height (114.32 cm), number of branches/plant (2.75), leaf area (114.52 cm^2) and chlorophyll content (1.69 mg/g) which was statistically at par with application of 50% RDF and 12.0 tonne FYM/ha whereas, minimum plant height (107.69 cm), number of branches/plant (1.55), leaf area (91.03 cm^2) and chlorophyll content (1.02 mg/g) was recorded under control. The increase in growth parameters might be due to the application of organic manures along with chemical fertilizer increased the content of organic matter, maintain the nutrients balance and improve the physical and chemical properties of the soil. Application of integrated nutrients in soil resulted in better physical and biological properties of soil in respect of texture, granulation, fertility, porosity, water holding capacity and soil reactions, increased micro flora and fauna which may be helpful to the crop for utilization of nutrients and water absorption. Similar results were earlier found by Nath and Singh (2011) in cauliflower, Kumar *et al.,* 2013 and Abha *et al.,* (2019) in okra

The foliar application of Brassinoides also showed significant difference among the treatments in terms of growth parameters of okra (Table 1). The maximum plant height (112.58 cm), number of branches/plant (2.50), leaf area (111.97 cm^2) and chlorophyll content (1.52 mg/g) noted with foliar application of Brassinoides at 5 ppm (B_1) which was statistically at par with application of Brassinoides 10 ppm (B_2), whereas minimum plant height (110.23 cm), number of branches/plant (1.86), leaf area (93.96 cm^2) and chlorophyll content (1.27 mg/g) registered with control. It is due to stimulating effect of brassinoides in cell division and cell elongation. Another possible reason might be due to increase secretion of other PGRs in plant body like auxin and gibberalic acid which enhanced vegetative growth due to their synergistic action in plant body which ultimately increased the growth. Similar results were also reported by Bhadala (2017) in vegetable cluster bean and Ola *et al.,* (2018) in broccoli.

Salicylic acid had also exhibited significant effect on growth parameters of okra (Table-1). The foliar application of 150 ppm Salicylic acid (S_2) resulted in maximum plant height (112.08 cm), number of branches/plant (2.38), leaf area (111.69 cm^2) and chlorophyll content (1.48 mg/g), whereas minimum plant height (110.98 cm), number of branches/ plant (2.10), leaf area (94.69 cm^2) and chlorophyll content (1.34 mg/g) had been found under control. It is due to higher concentration of salicylic acid enhanced photosynthetic rate and biochemical parameters. Foliar spray of salicylic acid at higher concentration leads to synthesis of more carbohydrate in plants. Chlorophyll pigments viz. Chlorophyll a, b and light harvesting complex which play a key role in light capturing during photosynthesis which increases intensity of light and dark reactions as well as other photosynthetic reactions. Salicylic acid at higher concentration can also stimulate the growth through increasing the activities like antioxidant enzymes, preventing protein loss and enhancing photosynthetic pigment thereby increasing overall growth parameter of the plant. Similar results were also reported by Maniram *et al.,* (2012 a and Pal *et al.,* 2015 in gladiolus, Aashutosh *et al.,* 2019 in chrysanthemum, Mirdad (2015) in broccoli, Meena *et al.,* (2016) in cluster bean and Yadav *et al.,* (2019) in okra.

Table.1 Effect of integrated nutrients and bio-regulators on plant height, number of branches/plant, leaf area (cm^2) and chlorophyll content (mg/g) of Okra

Treatment	Plant height (cm)	Number of branches/plant	Leaf area (cm^2)	Chlorophyll content (mg/g)
R_0	107.69	1.55	91.03	1.02
R_1	114.32	2.74	114.52	1.69
R_2	113.01	2.52	112.08	1.58
SEm±	**1.31**	**0.03**	**1.25**	**0.02**
CD (P=0.05)	**3.77**	**0.08**	**3.59**	**0.05**
B_0	110.23	1.86	93.96	1.27
B_1	112.58	2.50	111.97	1.52
B_2	112.21	2.45	111.70	1.50
SEm±	**1.30**	**0.03**	**1.25**	**0.02**
CD (P=0.05)	**3.75**	**0.08**	**3.59**	**0.05**
S_0	110.98	2.10	94.69	1.34
S_1	111.96	2.33	111.25	1.47
S_2	112.08	2.38	111.69	1.48
SEm±	**1.30**	**0.03**	**1.25**	**0.02**
CD (P=0.05)	***3.75**	**0.08**	**3.59**	**0.05**

Table.2 Effect of integrated nutrients and bio-regulators on fruit length, fruit diameter (cm), fruit diameter (cm), number of fruits/plant, fruit yield/plant (g), fruit yield/plot (kg) and fruit yield (q/ha) of Okra

Treatment	Fruit length (cm)	Fruit diameter (cm)	Number of fruits /plant	Fruit yield/plant(g)	Fruit yield/plot (kg)	Fruit yield (q/ha)
R_0	7.99	1.64	19.10	102.00	2.49	56.67
R_1	11.20	2.01	22.41	195.36	4.67	108.53
R_2	11.47	2.14	22.92	198.62	4.75	110.34
SE(m)±	**0.13**	**0.02**	**0.26**	**2.13**	**0.05**	**1.17**
CD(P=0.05)	**0.36**	**0.07**	**0.74**	**6.11**	**0.15**	**3.35**
B_0	8.02	1.77	19.25	106.63	2.59	59.24
B_1	11.63	2.06	22.83	195.09	4.67	108.38
B_2	11.01	1.96	22.35	194.26	4.65	107.92
SE(m)±	**0.13**	**0.02**	**0.26**	**2.13**	**0.05**	**1.17**
CD (P=0.05)	**0.36**	**0.07**	**0.74**	**6.11**	**0.15**	**3.35**
S_0	8.95	1.89	19.97	108.23	2.60	60.13
S_1	10.77	1.93	22.16	193.56	4.65	107.53
S_2	10.94	1.97	22.30	194.19	4.66	107.88
SE(m)±	**0.13**	**0.02**	**0.26**	**2.13**	**0.05**	**1.17**
CD (P=0.05)	**0.36**	**0.07**	**0.74**	**6.11**	**0.15**	**3.35**

Table.3 Interaction effect of integrated nutrients with bio-regulators on fruit parameters of okra

Treatment	Fruit length (cm)	Fruit diameter (cm)	Number of fruits /plant	Fruit yield/plant (g)	Fruit yield/plot (kg)	Fruit yield (q/ha)
$R_0B_0S_0$	5.49	1.47	15.92	43.07	1.07	23.93
$R_0B_0S_1$	6.61	1.50	17.66	77.02	1.91	42.79
$R_0B_0S_2$	6.71	1.54	17.78	77.27	1.91	42.93
$R_0B_1S_0$	7.96	1.71	18.88	78.79	1.92	43.78
$R_0B_1S_1$	9.58	1.75	20.95	140.92	3.43	78.29
$R_0B_1S_2$	9.73	1.79	21.08	141.38	3.44	78.54
$R_0B_2S_0$	7.54	1.63	18.48	78.46	1.91	43.59
$R_0B_2S_1$	9.07	1.67	20.51	140.32	3.42	77.96
$R_0B_2S_2$	9.21	1.70	20.64	140.77	3.43	78.21
$R_1B_0S_0$	7.70	1.81	18.68	82.49	2.00	45.83
$R_1B_0S_1$	9.26	1.84	20.73	147.52	3.57	81.95
$R_1B_0S_2$	9.41	1.88	20.86	148.00	3.58	82.22
$R_1B_1S_0$	11.16	2.10	22.15	150.92	3.60	83.84
$R_1B_1S_1$	13.43	2.15	24.58	269.90	6.43	149.93
$R_1B_1S_2$	13.64	2.19	24.74	270.78	6.44	150.42
$R_1B_2S_0$	10.57	2.00	21.69	150.27	3.58	83.49
$R_1B_2S_1$	12.72	2.04	24.06	268.75	6.40	149.30
$R_1B_2S_2$	12.92	2.08	24.22	269.62	6.42	149.78
$R_2B_0S_0$	7.88	1.92	19.10	83.86	2.03	46.59
$R_2B_0S_1$	9.49	1.96	21.20	149.98	3.63	83.32
$R_2B_0S_2$	9.64	2.00	21.33	150.47	3.64	83.59
$R_2B_1S_0$	11.43	2.24	22.66	153.43	3.66	85.24
$R_2B_1S_1$	13.75	2.28	25.14	274.40	6.54	152.44
$R_2B_1S_2$	13.97	2.33	25.30	275.30	6.55	152.93
$R_2B_2S_0$	10.82	2.13	22.18	152.78	3.64	84.88
$R_2B_2S_1$	13.02	2.17	24.61	273.23	6.51	151.79
$R_2B_2S_2$	13.23	2.22	24.77	274.12	6.53	152.28
SE(m)±	**0.38**	**0.07**	**0.772**	**6.38**	**0.153**	**3.49**
CD at 5 %	**1.08**	**0.20**	**2.2**	**18.34**	**0.44**	**10.047**

Data presented in (Table -2) showed that application of different integrated nutrient sources and foliar application of bio-regulators had significant effect on yield parameters of okra. Plant receiving 50% RDF and 12.0 tonne FYM/ha (R_2) showed maximum fruit length (11.47 cm), fruit diameter (2.14 cm), number of fruit per plant (22.92), fruit yield per plant (198.62 g), fruit yield per plot (4.75 kg) and fruit yield (110.34 q/ha) whereas, control (R_0) produced minimum fruit length (7.99 cm), fruit diameter (1.64 cm), number of fruits per plant (19.10), fruit yield per plant (102.00 g), fruit yield per plot (2.49 kg) and fruit yield (56.67 q/ha). It might be due to integrated approaches of fertilizers and manures which may help to improve the availability of nutrients to the plants. Plant nutrient uptake increased cellular activity of plant like multiplication and elongation while, phosphorous would have increased all yield attributes by increase the plant tissues. The results are in line with the findings of Sharma *et al.,* (2018) in broccoli and Singh *et al.,* (2020) in okra.

Plant sprayed with brassinoides showed various effects on yield of okra (Table-2). The maximum fruit length (11.63 cm), fruit diameter (2.06 cm), number of fruits per plant (22.83), fruit yield per plant (195.09 g), fruit yield per plot (4.67 kg) and fruit yield (108.38 q/ha) noted on plants sprayed with 5 ppm (B_1) brassinoides which was significantly at par with application of 10 ppm (B_2) brassinoides however, minimum fruit length (8.02 cm), fruit diameter (1.77 cm), number of fruits per plant (19.25, fruit yield per plant (106.63 g), fruit yield per plot (2.59 kg) and fruit yield (59.24 q/ha) produced under control (B_0). It could be attributed to the stimulatory effect of brassinoides on cell expansion and development of plant with better utilization of resources. Application of brassiniodes increased the total biomass and then might have resulted in an increase in assimilate transport from source to sink and their ultimate conversion into final reserved food which may help to improve the yield. Similar results were also reported by Matwa *et al.,* (2017) in green gram and Netwal (2018) in Indian bean.

Foliar application of salicylic acid also influenced the yield of okra (Table-2. Foliar application of 150 ppm salicylic acid resulted in maximum fruit length (10.94 cm), fruit diameter (1.97 cm), number of fruits per plant (22.30), fruit yield per plant (194.19 g), fruit yield per plot (4.66 kg) and fruit yield (107.88 q/ha) which was statistically at par with foliar application of 100 ppm salicylic acid (S_1), while control plants (S_0) produced minimum fruit length (8.95 cm), fruit diameter (1.89 cm), number of fruits per plant (19.97), fruit yield per plant (108.23 g), fruit yield per plot (2.60 kg) and fruit yield (60.13 q/ha). The foliar application of salicylic acid play a vital role in plant growth and development, photosynthetic reactions, transpiration, ion uptake, transport and protein synthesis. Salicylic acid also induced in leaf anatomy and chloroplast structure in plants and regulates source sink relationship ultimately increased the yield Gharib (2007) and Bartoli *et al.,* (1999). Salicylic acid increased immunity of plant against biotic and abiotic stresses and it also increased the supply of nutrients to the plants and improved tolerance of plants. The present results are in line with Kumar *et al.,* (2014) on cowpea, Mirdad (2015) in broccoli, Kazmi (2015) in tomato, Rady *et al.,* (2015) in moringa, Netwal (2018) in Indian bean and Yadav *et al.,* (2019) in okra.

The combination of treatments also influenced the yield of okra (Table-3). The maximum fruit length (13.97 cm), fruit diameter (2.33 cm), number of fruits per plant (25.30), fruit yield per plant (275.30 g), fruit yield per plot (6.55 kg) and fruit yield (152.93 q/ha) had been registered with the treatment combination of 50% RDF and 12.0 tonne FYM/ha+ Brassinoides @ 5ppm+Salicylic acid @ 150 ppm ($R_2B_1S_2$) which was statistically at par with treatment combinations viz: $R_2B_1S_1$, $R_1B_1S_2$, $R_1B_1S_1$, $R_2B_2S_2$ etc. whereas, the minimum fruit length (5.49 cm), fruit diameter (1.47 cm), number of fruits per plant (15.92), fruit yield per plant (43.07 g), fruit yield per plot (1.07 kg) and fruit yield (23.93 q/ha) registered with control combination ($R_0B_0S_0$). It might be due to synergistic effect of integrated sources of nutrients with bio-regulators on above treatment combinations. Similar results were also reported by Ola *et al.*, (2018) in broccoli.

On the basis of results obtained from the present investigation, it may be concluded that integrated application of nutrients viz. 50 per cent RDF through inorganic fertilizer, 12.0 t/ha FYM and foliar spray of brassinoides @ 5 ppm and salicylic acid @ 150 ppm as bio-regulators was found most suitable in terms of yield parameters of okra. However, nutrient supplied with 75 per cent RDF through inorganic fertilizer and 6.0 t/ha FYM, foliar spray of brassinoides 5 ppm and salicylic acid 150 ppm showed better performance in regarding the vegetative growth of okra.

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