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Yield and Economics of Okra Seed Production Influenced by Growth Regulators and Micronutrients

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A B S T R A C T

To know the effect of growth regulators and micronutrient on seed production of okra a two year field experiment was conducted in vegetable research farm, college of horticulture and forestry, Pasighat during 2018 and 2019. Two growth regulators (NAA and GA_3) and micronutrients (Zn and B) were used at different concentration individually and also in combinations. Pooled data of two year experiment showed that the highest green fruit yield (1007.33 kg ha^{-1}) and seed yield (18.84 q ha^{-1}) were reported in the treatment P_4M_5 (GA_3- 100 ppm + borax-1.0%). In case of economics of cultivation similar treatment recorded the highest net income (Rs.297631.43 ha^{-1}) and B:C Ratio (3.34). All the observation parameters recorded significantly lowest value under control treatments.

Introduction

Okra or Bhindi (*Abelmoschus esculentus* (L.) Moench) commonly known as lady's finger, belong to the family Malvaceae. It is one of the important summer vegetable grown widely in sub-tropical region of the world for its tender pods. Okra is one of the most important vegetable crops grown extensively thought the country during summer and rainy seasons due to high adaptability over a wide range of environmental conditions. It is one of the economically important vegetable crops grown in India. As a vegetable in tender stage, okra is nutritious and it finds an important place in the Indian dietary. Besides the utility of its tender green fingers as vegetables, it is used in soups and curries. Green pods are rich source of Iodine, vitamin A, B and C. The stems and roots of okra can also be used in paper industry.

Plant hormones are a group of naturally occurring, organic substances which influence physiological processes at low concentrations. Physiological and bio-chemical role of plant growth regulators in crop production is well-known phenomenon which enables a rapid change in the phenotype of the plant with one season to achieve desirable results. The use of plant growth regulator promotes growth along the longitudinal axis, increase the number of leaves, initiate early flowering, fruit set and subsequently contribute towards higher production and productivity at various concentrations.

Similarly, micro-nutrients are inorganic substances necessary for the normal growth and development of plants and have important role in various enzymatic processes, assimilation, oxidation and reduction reactions and help in increasing the biomass and pod yield. Plant absorbs these elements in minor quantity but they are essential for proper growth of the plants. Horticultural crops suffer widely by zinc deficiency followed by boron, manganese, copper, iron and Mo deficiencies (Kumari, 2012). The micronutrient deficiencies in soil not only hamper vegetable productivity but also deteriorate the produce quality. Hence, there is scope for use micronutrients to overcome the ever increasing micronutrients deficiency.

Seed is the important input in a crop production system. Seed production is a profitable enterprise. Nowadays only 20% quality has been produced in India and it should be increased by increasing the seed production area. With these ideas in view, field experiments were planned to find out the effect of different growth regulators and micronutrients and their combinations on seed production of okra and also find out the economics of cultivation

Materials and Methods

The experiment was conducted at Vegetable Research Farm, College of Horticulture and Forestry, Central Agricultural University, Pasighat, East Siang, Arunachal Pradesh. The experiment was laid in factorial randomized block design (FRBD) with three replications in which the treatments comprised of two levels each of NAA (50 and 100 ppm), GA_3 (50 and 100 ppm) and three levels of micronutrients *i.e.* Zinc sulphate (0.5. 1.0 and 1.5%) and Borax (0.5. 1.0 and 1.5%).

The experimental field was prepared by three ploughing with the help of tractor drawn implement followed by harrowing and planking. Farm yard manure was applied at the rate of 10 t ha^{-1} along with recommended dose of NPK ((120:60:60 kg ha^{-1}). In all cases, half of the of nitrogen dose in form of urea was applied as basal dose at the time of sowing and remaining half dose was applied in two equal splits as top dressing of 30 kg ha^{-1} at 30 and 60 days after sowing. The entire dose of phosphorus and potassium was applied uniformly to all the plots in form of single super phosphate and muriate of potash before sowing. Healthy uniform seeds were collected and soaked for 12 hours in water before sowing.

The growth regulators and micro-nutrients were sprayed on foliage in aqueous form by using fresh solution at each spray. Spraying was done with knapsack sprayer and the leaves were wetted thoroughly with fine mist. First foliar spray was applied at 30 days after sowing and second sprays at 60 days after sowing. For better absorption of spray solution by okra leaves, a pinch of sticker (Tipol) was added to the spray solution before spraying. The spraying was done during evening hours.

The green pods were harvested at edible pod stage for vegetable purpose. In total, 2 pickings were done in month of August during both the years. Green pods were weighed treatment-wise and were computed on plot basis. The dry pods were harvested when observed brown coloured. They were sun-dried before seed shattering stage. In total, 5 pickings were done. Seeds were separated by hand twisting. Collected seeds were weighed and were computed on hectare basis.

Results and Discussion

The data on green fruit yield and seed yield were represented in the table 1 and 2 showed that application of growth regulators and micronutrients significantly affect the yield parameters of okra. In case of growth regulators among the treatments pooled data of two year experiment showed that the highest green fruit yield and seed yield (356.83 g $plot^{-1}$ and 18.11 q ha^{-1}) were recorded with treatment P_4 (GA_3- 100 ppm). The increase in yield characters due to application of gibberellins might be due to more accumulation of carbohydrates as the result of photosynthesis and efficient translocation of these food reserves from source to sink (Hussaini and Babu, 2004). Similar results were also reported by Baraskar *et al.*, (2018) and Tahir *et al.*, (2019) in okra.

Table.1 Effect of growth regulators and micronutrients on green fruit yield

Treatments	Green fruit yield (g $plot^{-1}$)		
	2018	2019	Pooled Mean
Growth Regulators			
P_0: Control	333.88	324.58	329.23
P_1: NAA- 50 ppm	346.52	336.03	341.27
P_2: NAA- 100 ppm	354.54	344.95	349.74
P_3: GA_3- 50 ppm	348.32	339.03	344.15
P_4: GA_3- 100 ppm	361.21	352.45	356.83
SE (m) ±	**0.46**	**0.46**	**0.33**
CD at 5%	**1.30**	**1.31**	**0.91**
Micronutrients			
M_0: Control	344.38	334.84	339.61
M_1: Zinc Sulphate- 0.5%	347.46	337.92	342.69
M_2: Zinc Sulphate- 1.0%	350.36	341.15	345.76
M_3: Zinc Sulphate- 1.5%	345.24	335.70	340.47
M_4: Borax- 0.5%	350.28	340.74	345.51
M_5: Borax- 1.0%	353.67	344.16	348.92
M_6: Borax- 1.5%	350.86	341.32	346.09
SE (m) ±	**0.55**	**0.55**	**0.38**
CD at 5%	**1.54**	**1.55**	**1.08**
Treatment Combinations			
(Growth Regulators × Micronutrients)			
P_0M_0: Control	325.62	316.08	320.85
P_0M_1: Zinc Sulphate- 0.5%	334.24	324.70	329.47
P_0M_2: Zinc Sulphate- 1.0%	336.42	328.54	332.28
P_0M_3: Zinc Sulphate- 1.5%	328.44	318.90	323.67
P_0M_4: Borax- 0.5%	336.54	327.00	331.77
P_0M_5: Borax- 1.0%	340.26	330.72	335.49
P_0M_6: Borax- 1.5%	335.64	326.10	330.87
P_1M_0: NAA- 50 ppm	342.42	332.88	337.65
P_1M_1: NAA- 50 ppm + Zinc Sulphate- 0.5%	344.54	335.00	339.77
P_1M_2: NAA- 50 ppm + Zinc Sulphate- 1.0%	348.64	339.10	343.87
P_1M_3: NAA- 50 ppm + Zinc Sulphate- 1.5%	343.46	333.92	338.69
P_1M_4: NAA- 50 ppm + Borax- 0.5%	347.68	338.14	342.91
P_1M_5: NAA- 50 ppm + Borax- 1.0%	350.52	334.34	342.43
P_1M_6: NAA- 50 ppm + Borax- 1.5%	348.36	338.82	343.59
P_2M_0: NAA- 100 ppm	350.64	341.10	345.87

P_2M_1: NAA- 100 ppm + Zinc Sulphate- 0.5%	352.82	343.28	348.05
P_2M_2: NAA- 100 ppm + Zinc Sulphate- 1.0%	356.94	347.40	352.17
P_2M_3: NAA- 100 ppm + Zinc Sulphate- 1.5%	353.12	343.58	348.35
P_2M_4: NAA- 100 ppm + Borax- 0.5%	355.34	345.80	350.57
P_2M_5: NAA- 100 ppm + Borax- 1.0%	358.26	348.32	353.29
P_2M_6: NAA- 100 ppm + Borax- 1.5%	354.68	345.14	349.91
P_3M_0: GA_3- 50 ppm	344.74	335.20	339.97
P_3M_1: GA_3- 50 ppm + Zinc Sulphate- 0.5%	346.48	336.94	345.03
P_3M_2: GA_3- 50 ppm + Zinc Sulphate- 1.0%	347.34	337.80	342.57
P_3M_3: GA_3- 50 ppm + Zinc Sulphate- 1.5%	342.64	333.10	337.87
P_3M_4: GA_3- 50 ppm + Borax- 0.5%	350.38	340.84	345.61
P_3M_5: GA_3- 50 ppm + Borax- 1.0%	354.64	346.82	350.73
P_3M_6: GA_3- 50 ppm + Borax- 1.5%	352.04	342.50	347.27
P_4M_0: GA_3- 100 ppm	358.48	348.94	353.71
P_4M_1: GA_3- 100 ppm + Zinc Sulphate- 0.5%	359.24	349.70	354.47
P_4M_2: GA_3- 100 ppm + Zinc Sulphate- 1.0%	362.46	352.92	357.69
P_4M_3: GA_3- 100 ppm + Zinc Sulphate- 1.5%	358.54	349.00	353.77
P_4M_4: GA_3- 100 ppm + Borax- 0.5%	361.48	351.94	356.71
P_4M_5: GA_3- 100 ppm + Borax- 1.0%	364.66	360.62	362.64
P_4M_6: GA_3- 100 ppm + Borax- 1.5%	363.58	354.04	358.81
SE (m) ±	**1.22**	**1.23**	**0.54**
CD at 5%	**3.45**	**3.46**	**1.52**

Table.2 Effect of growth regulators and micronutrients on seed yield

Treatments	**Seed yield per hectare (q ha^{-1})**		
	2018	**2019**	**Pooled Mean**
Growth Regulators			
P_0: Control	12.24	10.93	11.58
P_1: NAA- 50 ppm	14.06	12.36	13.21
P_2: NAA- 100 ppm	16.94	14.78	15.86
P_3: GA_3- 50 ppm	16.63	14.44	15.56
P_4: GA_3- 100 ppm	19.34	16.88	18.11
SE (m) ±	**0.13**	**0.09**	**0.08**
CD at 5%	**0.37**	**0.25**	**0.22**
Micronutrients			
M_0: Control	14.89	13.11	14.00
M_1: Zinc Sulphate- 0.5%	15.68	13.69	14.69
M_2: Zinc Sulphate- 1.0%	15.97	13.94	14.96
M_3: Zinc Sulphate- 1.5%	15.67	13.70	14.69
M_4: Borax- 0.5%	15.98	14.02	15.00
M_5: Borax- 1.0%	16.44	14.40	15.42
M_6: Borax- 1.5%	16.25	14.28	15.26
SE (m) ±	**0.16**	**0.10**	**0.09**
CD at 5%	**0.44**	**0.29**	**0.26**
Treatment Combinations			
(Growth Regulators × Micronutrients)			
P_0M_0: Control	9.47	8.99	9.23
P_0M_1: Zinc Sulphate- 0.5%	12.37	10.87	11.62
P_0M_2: Zinc Sulphate- 1.0%	12.79	11.17	11.98
P_0M_3: Zinc Sulphate- 1.5%	12.36	10.87	11.62

P_0M_4: Borax- 0.5%	12.59	11.23	11.91
P_0M_5: Borax- 1.0%	13.15	11.74	12.44
P_0M_6: Borax- 1.5%	12.93	11.64	12.29
P_1M_0: NAA- 50 ppm	13.71	12.00	12.85
P_1M_1: NAA- 50 ppm + Zinc Sulphate- 0.5%	13.90	12.18	13.04
P_1M_2: NAA- 50 ppm + Zinc Sulphate- 1.0%	14.14	12.42	13.28
P_1M_3: NAA- 50 ppm + Zinc Sulphate- 1.5%	13.84	12.16	13.00
P_1M_4: NAA- 50 ppm + Borax- 0.5%	14.05	12.41	13.23
P_1M_5: NAA- 50 ppm + Borax- 1.0%	14.42	12.70	13.56
P_1M_6: NAA- 50 ppm + Borax- 1.5%	14.35	12.61	13.48
P_2M_0: NAA- 100 ppm	16.48	14.38	15.43
P_2M_1: NAA- 100 ppm + Zinc Sulphate- 0.5%	16.75	14.60	15.68
P_2M_2: NAA- 100 ppm + Zinc Sulphate- 1.0%	17.10	14.78	15.94
P_2M_3: NAA- 100 ppm + Zinc Sulphate- 1.5%	16.75	14.60	15.67
P_2M_4: NAA- 100 ppm + Borax- 0.5%	16.98	14.86	15.92
P_2M_5: NAA- 100 ppm + Borax- 1.0%	17.33	15.20	16.27
P_2M_6: NAA- 100 ppm + Borax- 1.5%	17.21	15.06	16.14
P_3M_0: GA_3- 50 ppm	16.10	13.95	15.03
P_3M_1: GA_3- 50 ppm + Zinc Sulphate- 0.5%	16.45	14.24	15.52
P_3M_2: GA_3- 50 ppm + Zinc Sulphate- 1.0%	16.70	14.42	15.56
P_3M_3: GA_3- 50 ppm + Zinc Sulphate- 1.5%	16.44	14.24	15.34
P_3M_4: GA_3- 50 ppm + Borax- 0.5%	16.70	14.55	15.63
P_3M_5: GA_3- 50 ppm + Borax- 1.0%	17.09	14.88	15.99
P_3M_6: GA_3- 50 ppm + Borax- 1.5%	16.95	14.78	15.87
P_4M_0: GA_3- 100 ppm	18.69	16.25	17.47
P_4M_1: GA_3- 100 ppm + Zinc Sulphate- 0.5%	18.96	16.54	17.75
P_4M_2: GA_3- 100 ppm + Zinc Sulphate- 1.0%	19.14	16.90	18.02
P_4M_3: GA_3- 100 ppm + Zinc Sulphate- 1.5%	18.98	16.62	17.80
P_4M_4: GA_3- 100 ppm + Borax- 0.5%	19.58	17.05	18.32
P_4M_5: GA_3- 100 ppm + Borax- 1.0%	20.20	17.47	18.84
P_4M_6: GA_3- 100 ppm + Borax- 1.5%	19.82	17.28	18.55
SE (m) ±	**0.35**	**0.23**	**0.13**
CD at 5%	**0.99**	**0.66**	**0.37**

Table.3 Economics of cultivation

Treatment Combinations	**Cost of cultivation (Rs.)**	**Seed Yield (q ha^{-1})**	**Green Fruit Yield (Kg ha^{-1})**	**Gross income (Rs.)**	**Net income (Rs.)**	**B:C Ratio**

P_0M_0: Control	76624.87	9.23	891.25	193512.50	116887.63	1.53
P_0M_1: Zinc Sulphate- 0.5%	77998.50	11.62	915.19	241551.90	163553.40	2.10
P_0M_2: Zinc Sulphate- 1.0%	78761.62	11.98	923.00	248830.00	170068.38	2.16
P_0M_3: Zinc Sulphate- 1.5%	79524.75	11.62	899.08	241390.80	161866.05	2.04
P_0M_4: Borax- 0.5%	77845.87	11.91	921.58	247415.80	169569.93	2.18
P_0M_5: Borax- 1.0%	78456.37	12.44	931.92	258119.20	179662.83	2.29
P_0M_6: Borax- 1.5%	79066.87	12.29	919.08	254990.80	175923.93	2.23
P_1M_0: NAA- 50ppm	77642.37	12.85	937.92	266379.20	188736.83	2.43
P_1M_1: NAA- 50 ppm + Zinc Sulphate- 0.5%	79016.00	13.04	943.81	270238.10	191222.10	2.42
P_1M_2: NAA- 50 ppm + Zinc Sulphate- 1.0%	79779.12	13.28	955.19	275151.90	195372.78	2.45
P_1M_3: NAA- 50 ppm + Zinc Sulphate- 1.5%	80542.25	13.00	940.81	269408.10	188865.85	2.34
P_1M_4: NAA- 50 ppm + Borax- 0.5%	78863.37	13.23	952.53	274125.30	195261.93	2.48
P_1M_5: NAA- 50 ppm + Borax- 1.0%	79473.87	13.56	951.19	280711.90	201238.03	2.53
P_1M_6: NAA- 50 ppm + Borax- 1.5%	80084.37	13.48	954.42	279144.20	199059.83	2.49
P_2M_0: NAA- 100 ppm	78049.37	15.43	960.75	318207.50	240158.13	3.08
P_2M_1: NAA- 100 ppm + Zinc Sulphate- 0.5%	79423.00	15.68	966.81	323268.10	243845.10	3.07
P_2M_2: NAA- 100 ppm + Zinc Sulphate- 1.0%	80186.12	15.94	978.25	328582.50	248396.38	3.10
P_2M_3: NAA- 100 ppm + Zinc Sulphate-1.5%	80949.25	15.67	967.64	323076.40	242127.15	2.99
P_2M_4: NAA- 100 ppm + Borax- 0.5%	79270.37	15.92	973.81	328138.10	248867.73	3.14
P_2M_5: NAA- 100 ppm + Borax- 1.0%	79880.87	16.27	981.36	335213.60	255332.73	3.20
P_2M_6: NAA- 100 ppm + Borax- 1.5%	80491.37	16.14	971.97	332519.70	252028.33	3.13
P_3M_0: GA_3- 50 ppm	82322.87	15.03	944.36	310043.60	227720.73	2.77
P_3M_1: GA_3- 50 ppm + Zinc Sulphate- 0.5%	83696.50	15.52	951.58	319915.80	236219.30	2.82
P_3M_2: GA_3- 50 ppm + Zinc Sulphate- 1.0%	84459.62	15.56	958.42	320784.20	236324.58	2.80
P_3M_3: GA_3- 50 ppm + Zinc Sulphate- 1.5%	85222.75	15.34	951.58	316315.80	231093.05	2.71
P_3M_4: GA_3- 50 ppm + Borax- 0.5%	83543.87	15.63	960.03	322200.30	238656.43	2.86
P_3M_5: GA_3- 50 ppm + Borax- 1.0%	84154.37	15.99	974.25	329542.50	245388.13	2.92
P_3M_6: GA_3- 50 ppm + Borax- 1.5%	84764.87	15.87	964.64	327046.40	242281.53	2.86
P_4M_0: GA_3- 100 ppm	87410.37	17.47	982.53	359225.30	271814.93	3.11
P_4M_1: GA_3- 100 ppm + Zinc Sulphate- 0.5%	88784.00	17.75	984.64	364846.40	276062.40	3.11
P_4M_2: GA_3- 100 ppm + Zinc Sulphate- 1.0%	89547.12	18.02	993.58	370335.80	280788.68	3.14
P_4M_3: GA_3- 100 ppm + Zinc Sulphate- 1.5%	90310.25	17.80	982.69	365826.90	275516.65	3.05
P_4M_4: GA_3- 100 ppm + Borax- 0.5%	88631.37	18.32	990.86	376308.60	287677.23	3.25
P_4M_5: GA_3- 100 ppm + Borax- 1.0%	89241.87	18.84	1007.33	386873.30	297631.43	3.34
P_4M_6: GA_3- 100 ppm + Borax- 1.5%	89852.37	18.55	996.69	380966.90	291114.53	3.24

In case of micronutrients application the highest green fruit yield and seed yield (348.92 g $plot^{-1}$ and 15.42 q ha^{-1}) were recorded with treatment M_5 (Borax- 1.0%). This might be due to fact that boron involve in protein metabolisms, pectin synthesis, maintain correct water balance in the plant which help in efficient absorption of nutrients from soil. The results were supported with the findings of Kumar *et al.*, (2019) and Rahman *et al.*, (2020) in okra.

Interactions of different treatment combinations also significantly influenced the yield characters of okra. The highest green fruit yield and seed yield (362.64 g $plot^{-1}$ and 18.84 q ha^{-1}) were recorded with treatment P_4M_5 (GA_3- 100 ppm + Borax- 1.0%).

This might be due to synergistic effect of both growth regulators and micronutrients which helped the plant to remain physiologically active for longer duration as suggested by Kiranmayi *et al.*, (2017) in chilli. All the observation parameters found significantly lowest with control.

Pooled data of the two year experiment

showed that amongst the different treatment combinations the highest highest B:C ratio (3.34) was observed with the treatment combination with GA_3- 100 ppm + Borax-1.0% (P_4M_5). This might be due to application of growth regulators and micronutrients resulted in good growth and yield. It was observed that combine application of treatments improve the yield parameters as compared to individual treatment. Therefore, treatment P_4M_5 (GA_3- 100 ppm + Borax-1.0%) is considered to be the best treatment that can be adopted under field cultivation.

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