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Economic performance of different micronutrients and biofertilizers on okra (*Abelmoschus esculentus* L. Moench) cv. Gao-5

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Abstract
Research work was carried out at Horticultural Instructional Farm of Department of Horticulture, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University (SDAU), Sardarkrushinagar, Gujarat to determine the growth, yield and profit of Okra as influenced by different Micronutrients and Biofertilizer. The study was conducted with four level of micronutrients *viz.*, no application of micronutrients, Zn @ 20 kg/ha, B 20 kg/ha and Zn + B @ 20 kg/ha15th each with four levels of biofertilizers *viz.;* no application of biofertilizers, *Azotobactor* 20 ml/kg seed, PSB @ 20 ml/kg seed and *Azotobactor* + PSB @ 20 ml/kg seed each were tested under the Factorial Randomized Block Design with three replications. All the marketable yield contributing characters were the highest to the plants found with B @ 20 kg/ha was found superior producing number of pods per plant, yield per plant, yield per plot, yield per hectare, length of pod and thickness of pod. On other hand application of PSB @ 20 ml/kg seed recorded maximum number of pods per plant, yield per plant, yield per plot, yield per hectare, length of pod and thickness of pod. Among micronutrient maximum yield (132 qha^{-1}) was found in B whereas in Biofertilizer maximum yield (135.03 qha^{-1}) recorded with PSB (b_2). In the micronutrients highest (4.55) Benefit: Cost Ratio (BCR) was observed in Boron whereas in Biofertilizer highest (4.54) Benefit: Cost Ratio (BCR) was recorded in PSB.

Keywords: Okra, Micronutrient, Biofertilizer, Zn, B

Introduction
Okra (*Abelmoschusesculentus*L. Moench) popularly known as bhindi orlady's finger is one of the important vegetable grown extensively throughout India in summer and rainy seasons. It is native of tropical and subtropical Africa (Yawalkar, 1980). Among all the vegetables grown in the country, okra ranks 8th with the total production of 66.09 lakh tonnes from 5.41 lakh ha area. It is cultivated in almost all the states, but main growing states are Bihar, Orissa, West Bengal, Andhra Pradesh and Assam. In Gujarat, okra covers 65.66 thousand ha area with the production of 7.23 tonnes and contributes 9.14 per cent share of the total okra production (Anonymous, 2013) [2]. In Gujarat, it is grown in almost all districts; Surat ranks first followed by Tapi in area and production (Anonymous, 2013) [2]. In Gujarat, it is grown in rainy and summer seasons, mainly for tender fruits to be used as a vegetable.
Katung, (2007) [3] reported that wet season conditions were most favorable for increased growth, leaf formation and fruit yield as compared to dry season which resulted in less vegetative and reproductive growth. According to Adejoye *et al.* (2009) [1] the rainy season induced the highest values for the seedling performance during the rainy and dry season. The average values of the parameters determined were significantly higher for raining season than that of dry season. However, okra planted during the dry season matured early and produced more fruits.
The availability of nutrients form soil to plants is governed by a number of factors like soil reaction, organic matter status and management practices. In this relation the soil of Banaskantha district is of sandy loam type with high drainage and slightly saline in reaction. Therefore, the deficiency of micronutrients is very common especially of zinc and boron.
Biofertilizers are carrier-based inoculants containing cells of efficient strains of specific microorganisms(namely bacteria) used by farmers for enhancing the productivity of the soil by fixing atmospheric nitrogen or by solubilizing soil phosphate or by stimulating plant growth for synthesis of growthpromoting substances. In recentyears, free living bacteria (*Azotobacter*), associate (*Azospirillum*) and symbiotic (*Rhizobium*) bacteriaand phosphate solubilizing one (*Bacillus megaterium,B. polymyxa*and *Ps. Striata*) are gaining muchpopularity.

Materials and Methods

Field experiments were conducted at Horticultural Instructional Farm of Department of Horticulture, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University (SDAU), Sardarkrushinagar, Gujarat (latitude 24º 19' N longitude 72º 19' E) during the *rabi* season of the year 2014-15 Laboratory works were done at Soil Science Laboratory in C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agriculture University, S. K. Nagar - 385506. The experiment area Sardarkrushinagar is located at a distance of about 27 km away from Palanpur town of Banaskantha district, Gujarat and geographically, situated at 24º 19' N latitude and 72º 19' E longitude with an altitude of 154.42 meters above the mean sea level. It is located in the North Gujarat Agro-climatic Zone AEZ- IV. The soil was loamy sandy in texture having pH 7.8, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potash.

A. Factor: I

i. Micronutrient (M)

m_0 = Control

m_1 = Zn (20 kg/ha)

m_2 = B (20 kg/ha)

m_3 = Zn + B (20 kg/ha) each

B. Factors: II

i. Biofertilizers (B)

b_0 = Control

b_1 = *Azotobacter*

b_2 = PSB

b_3 = *Azotobacter* + PSB

The two factors experiment was laid out in a factorial randomized block Design with three replications. The whole experimental area was 349.32 m^2, which was divided into three blocks is called replication and each replication divide in to two plot and each plot divide in to 4 sub plot hence there were 48 (16×3) unit plots.

The crop was harvested periodically for data collection. Randomly selected ten plants were harvested each time from each unit plot at 10 days interval. The harvesting was started after 50 days from date of planting in Okra. Yield parameters were calculated as follows:

$$\text{Gross yield (kg plot}^{-1}) = \frac{\text{Area of single plot (m x m) x Average yield per plant (g) x 10000}}{\text{Spacing (cm x cm) x 1000}}$$

Gross yield of roots per hectare was calculated by using the following formula-

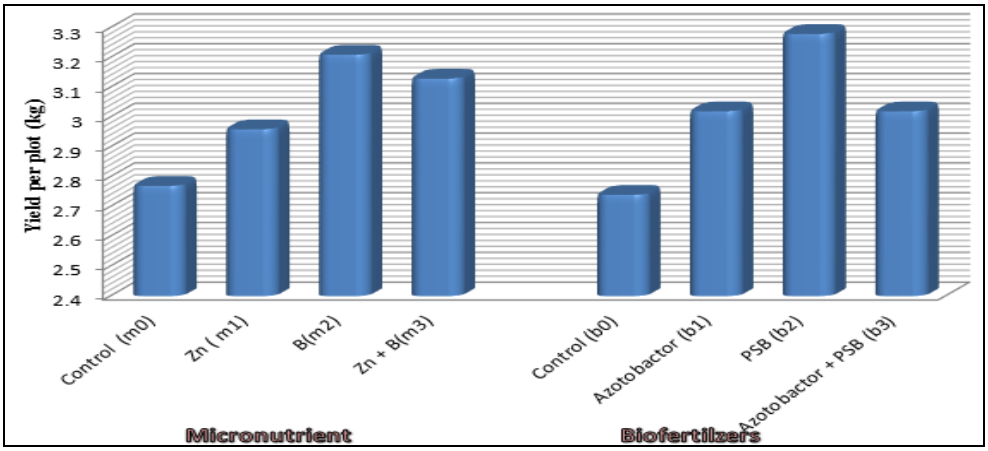
$$\text{Gross yield (t ha}^{-1}) = \frac{\text{Area (ha) x Average yield per plant (g) x 10000}}{\text{Spacing (cm x cm) x 1000 x 1000}}$$

Marketable yield = Gross yield-Non marketable yield

Marketable yield of capsule per hectare was calculated by conversion of the marketable fruit weight per plot and recorded in quintal. The recorded data on different growth and yield parameters were calculated for statistical analysis. The data was statistically analysed using analysis of variance according to the method described by Panse and Sukhatme (1978).

Results and Discussion

Marketable Yield per Plot and Hectare: Marketable yield of okra per plot was statistically significant in respect of micronutrients (Fig. 1). It ranged from 113.85 q ha^{-1} to 132.85 q ha^{-1} (2.77 kg $plot^{-1}$ to 3.21 kg $plot^{-1}$). The highest marketable yield (132.85 q ha^{-1} or 3.21 kg $plot^{-1}$) was found from the treatment of m_2 (B). The second highest marketable yield (3.13 kg $plot^{-1}$ or 128.81 q ha^{-1}) was found from the treatment of m_3 (Zn + B) and the lowest marketable yield (2.77 kg $plot^{-1}$ or 113.85 q ha^{-1}) was obtained from the treatment of m_0 (Control). The Boron performed the highest marketable yield and it was gradually decreased from the treatment of m_3 (15th November) and m_1 (15 October) (Fig. 1). Significant variation was observed among the different biofertilizers of okra production in respect of marketable yield (Fig. 1). It ranged from 112.90 q $ha^{-1}$to 135.02 q ha^{-1} (3.28 kg $plot^{-1}$ to 2.74 kg $plot^{-1}$). The maximum (135.02 q ha^{-1} or 3.28 kg $plot^{-1}$) marketable yield was obtained from the treatment of b_2 (PSB). The highest marketableyield was observed under the treatment b_2 due to PSB produce organic acid like gluconic, guccinic, lactic, oxalic and α-ketogluconic acid which convert the insoluble phosphate to soluble one (Stevenson, 1967). These findings corroborate with the findings of Krishna (2000) [4], Raj and Kumari (2001) [8], Patel *et.al.* (2008) and Mehraj *et al.* (2015) in okra.



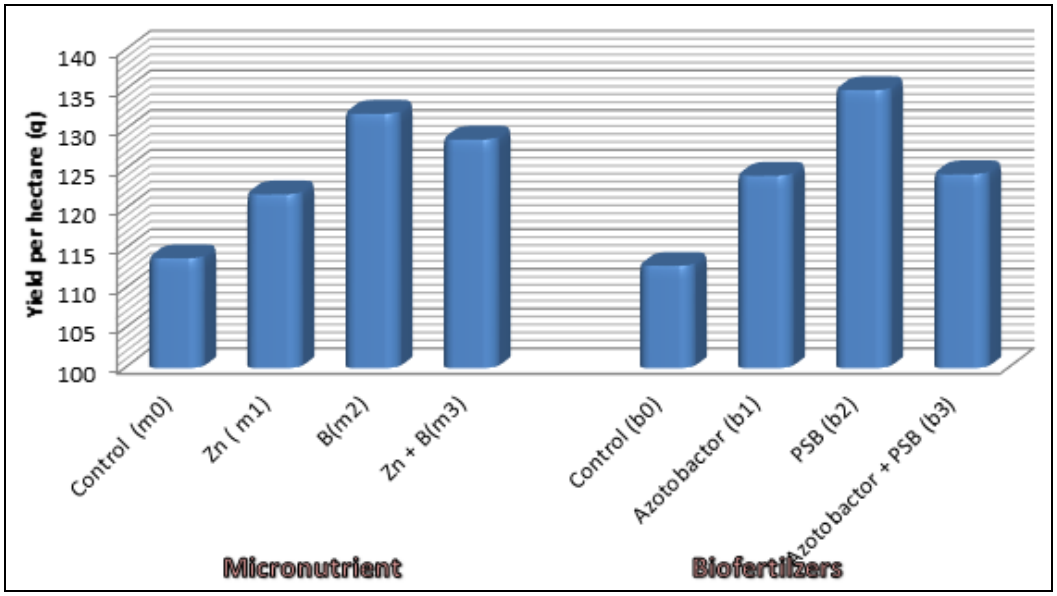


Fig 1: Yield per plot (kg) and Yield per hectare (q) as influenced by date of planting, spacing and beet root cultivars

Cost and Return Analysis: Material, non-material andoverhead costs were recorded for all the treatment for unit plots and calculated per hectare basis. The price of okra at the local market was also noted (Table 1, 2 and 3). The total cost of production ranged between ₹58165 to ₹59885 among the treatments combination. The cost of variation was found for different amount of micronutrient and biofertilizers to be required in several treatments combination. The benefit cost Ratio (BCR) of micronutrients was found to be the highest (4.55) in the treatment combination of Boron and the lowest BCR (3.88) was recorded with Control where as in biofertilizers benefit cost Ratio (BCR) was found to be the highest (4.54) in the treatment combination of PSB and the lowest BCR (3.91) was recorded with Control. Results revealed that maximum yield in micronutrients might be better in the treatment of Boron and Biofertilizer maximum yield might be higher in the treatment of PSB to be considered net-return respectively.

Table 1: Cost of cultivation of okra and other details of cost incurred Fixed Cost

S. No.	Particular		Labour	Frequency	Fixed Cost (₹ ha^{-1})
[A]Pre sowing operation					
	1	Ploughing (8 hrs tractor)	1	1	4950
	2	Planking (4 hrs tractor)	2	1	2700
	3	FYM @20 t/ha	8	1	21200
[B] sowing					
	1	Preparation of seed bed	8	1	1500
	2	Seed cost			2200
	3	Sowing of seed	6	1	900
	4	Fertilizers			
		N @ 100 Kg/ha	1	2	1658.42
		P @ 50 Kg/ha	1	1	2406.25
		K @ 50 Kg/ha	1	1	1450
	5	Micronutrients (As per treatment)	1	1	
	6	Biofertilizers (As per treatment)	1	1	
[C] Post sowing operations					
	1	Gap filling and thinning	4	1	600
	2	Weeding	10	3	4500
	3	Plant protection	2	2	3100
[D]	Irrigation charge		-	-	5000
[E]	Harvesting cost		2	20	6000
Total Fixed cost/ha					58165

Tractor charges @ ₹600 per hours
Labour charges @ ₹150 per day
Urea @ ₹313 per 50 kg bag,
SSP @ ₹361 per 50 kg bag,
MOP @ ₹ 840 per 50 kg bag.
FYM cost @ ₹ 1000 per ton
Biofertilizers @ ₹100 per kg.
Micronutrients (Zn) @ ₹ 24 per kg
Micronutrients (B) @ ₹ 60 per kg

Table 2: Detail of treatment wise cost of beet root crop

Treatments	Common cost / Fixed Cost (₹)	Variable Cost (₹)	Total cost (₹)
m_0b_0	58165	0	58165
m_0b_1	58165	20	58185
m_0b_2	58165	20	58185
m_0b_3	58165	40	58205
m_1b_0	58165	480	58645
m_1b_1	58165	500	58665
m_1b_2	58165	500	58665
m_1b_3	58165	520	58685
m_2b_0	58165	1200	59365
m_2b_1	58165	1220	59385
m_2b_2	58165	1220	59385
m_2b_3	58165	1240	59405
m_3b_0	58165	1680	59845
m_3b_1	58165	1700	59865
m_3b_2	58165	1700	59865
m_3b_3	58165	1720	59885

Table 3: Economics as influenced by different micronutrients and biofertilizers

Treatments	Yield/ha (kg)	Gross returns (₹)/ha)	Total cost of cultivation (₹)/ha)	Net returns (₹)/ha)	Benefit Cost ratio
I. Micronutrients					
m_0	11290	225800	58164	167636	3.88
m_1	12425	248500	58644	189856	4.24
m_2	13503	270060	59364	210696	4.55
m_3	12444	248880	59844	189036	4.16
II. Biofertilizers					
b_0	11385	227700	58164	169536	3.91
b_1	12191	243820	58184	185631	4.19
b_2	13206	264120	58184	205936	4.54
b_3	12881	257620	58204	199416	4.43

The sale price of okra was Rs 20/kg.

Conclusion

Marketable yield significantly influenced by different Micronutrients and Biofertilizers. The highest marketable yield (132.85 q ha^{-1}) was noticed under the treatment of Boron and the lowest (113.85 q ha^{-1}) in Control whereas In Biofertilizer maximum yield (135.02 q ha^{-1}) recorded with PSB and lowest (112.90 q ha^{-1}). In micronutrients highest (4.55) Benefit: Cost Ratio (BCR) was observed in Boron and the lowest (3.88) was in Control whereas in Biofertilizers maximum (4.54) Benefit: Cost Ratio (BCR) was observed in Boron and the lowest (1.91) was in Control. The yield and yield contributing characters were increased with the boron and PSB. In sixteen treatments of combination of four micronutriens and four biofertilizers, the maximum yield and marketable yield were in Boron and PSB.

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