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Effect of zinc on growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract
A field experiment was conducted to study the "Effect of Zinc on Growth, Yield and Quality of okra [*Abelmoschus esculentus* (L.) Moench]" at Horticulture farm, S.K.N. College of Agriculture, Jobner. The experiment consisted of four zinc levels (control, 2.5 kg/ha, 5.0 kg/ha and 7.5 kg/ha) in Randomized Block Design with three replications. Results indicated that soil application of 7.5 kg zinc per ha. significantly enhanced the plant height (118.23 cm), number of branches per plant (2.58), leaf area (116.80 cm), chlorophyll content (1.60 mg/g), fruit length (11.70 cm), number of fruit per plant (22.33), fruit yield per plant (233.67 g), per plot (5.61 kg), per hectare (129.81 q), protein (1.40%) and crude fiber content in fruits (1.40 %), net return (252360 Rs) and B: C ratio (4.43) also proved at par However application of 5.0 kg zinc per ha also proved at par with all parameters.

Keywords: okra, growth, quality, yield, zinc

Introduction
Okra [*Abelmoschus esculentus* (L.) Moench] commonly known as lady's finger or that, belongs to the family Malvaceae. It is widely adopted and popular vegetable in Indian kitchens and can be grown in summer and rainy seasons throughout India. India is the highest producer in the world and exported there by helping in earning foreign exchange. Okra is an important vegetable grown for its tender fruits which are used as a vegetable in various ways. Matured fruits and stem containing crude fibers are used in the paper industry, roots and stems are used for clarification of sugar cane juice in preparation of jaggary. High iodine content of fruit helps to control goiter. Okra is said to be very useful against genitor-urinary disorders, spermetorrhoea and chronic dysentery (Nadkarni, 1927) [7].

Crop performance, yield and quality are the results of genotypic expression, which is modulated by continuous interaction with the environment and other factors. Among them nutrients are more important factors, which limit the growth and development of the plant. Nutrients are directly affect the vegetative growth and yield of the crop.

Vegetables and vegetable based cropping system show that vegetable crops respond well to nutrient supply through organic manures and chemical fertilizers (Kale *et al*., 1991) [5]. Besides the macro nutrients, micro nutrients have great importance for development of plant growth, yield and quality of okra vegetable crop. Among them zinc is essential micro nutrient. Zinc also plays an important role in oxidation-reduction processes and help in the formation of chlorophyll. Deficiency of zinc produces changes in leaf morphology and cell histology, which causes several-known disorders "little leaf" or "rosette mottled leaf" *etc.* its deficiency also causes interveinal chlorosis, reduce root growth, blossoming and fruiting. Similarly, shortened internodes and chlorotic areas on the older leaves and yellowing of younger leaves due to its deficiency were reported by Shanmugavelu (1989) [10].

Materials and Methods
A field study was conducted during kharif 2016 at Department of Horticulture of S.K.N. college of Agriculture, Jobner. The experiment was laid out in randomized block design with 3 replications. Altogether 12 plots, 4.32 m^2 each were prepared for the experiment. The weighed quantity of Zinc as per treatment combination was applied before sowing through fertilizer grade zinc sulphate ($ZnSO_4$, 21% Zn) and mixed with soil and incorporated as per treatment. The treatments comprised four levels of zinc viz. 0 kg zinc (Zn_0), 2.5 kg zinc (Zn_1), 5.0 kg zinc (Zn_2) and 7.5 kg zinc (Zn_3). Which wide trieds is randomized block design and replicated thrice. Parbani kranti variety of okra was used for sowing at the rate of 12 kg/ha. The distance was kept 30 cm row to row and 15 cm plant to plant. The zinc was applied as per treatment combination through zinc sulphate as soil application one month before sowing.

The data on plant height, leaf area, number of branch, chlorophyll content, fruit length, number of fruit per plant and yied per ha. were recorded. Leaf area was measured with the help of leaf area meter (LA-3100)

Crude fiber content in fruits (%) crude fiber content was determined by the method suggested A.O.A.C., 1960 [1]. The sample was dried out, weighed and ignited in muffle furnace. Loss in weight was considered as crude fiber content and expressed on the basis of using following relationship:

$$\text{Crude fiber (\%)} = \frac{W_2 - W_3}{W_1} \times 100$$

Where,

W_1 = Initial weight of sample

W_2 = Weight of refluxed sample

W_3 = Weight of ignited sample

Protein content was calculated by multiplying nitrogen per cent in fruit by the factor 6.25 as suggested by Snell and Snell, (1949) [11].

Results and Discursion

There was significant increase in the plant growth parameter viz. plant height at 45 DAS and at harvest, number of branches per plant and chlorophyll content of okra with application of 7.5 kg zinc per ha but remained at par 5.0 kg zinc per ha as per table number 1. These findings clearly indicated that zinc played a significant role and enhancing the growth of okra. Improvement in plant height at 45 DAS (95.46 cm) and at harvest (118.23 cm), number of branches per plant (2.58) and chlorophyll content (1.60 mg/g) with the application of zinc might be due to supply of micro nutrients, availability and uptake nutrients from soil due to favorable conditions (Kumar *and Sen*., 2004) [6].

The physiological parameters pertaining to photosynthesis, stomatal conductance and transpiration also exhibited significant increment with zinc supplied through zinc sulthate in soil. It also influenced cell division, meristematic activity of tissues and expansion of cell and formation of cell wall, similar results were also reported by Chhipa (2005) [2] in cauliflower and Sammauria and Yadav (2008) [8] in fenugreek and Dubey *et al*. (2003) [4] in tomato.

Table 1: Effect of zinc on growth, yield and Yield attributes of okra.

S. No.	Characters	Zinc levels (kg/ha)					
		0 kg zinc (Zn_0)	2.5 kg zinc (Zn_1)	5.0 kg zinc (Zn_2)	7.5 kg zinc (Zn_3)	SEm±	CD (P=0.05)
1	Plant Height (cm) at 45 DAS	87.29	89.05	92.09	95.46	1.85	5.29
2	Plant Height at Harvest (cm)	102.57	105.05	113.09	118.23	2.26	6.46
3	Leaf area $(cm)^2$	98.31	105.77	113.97	116.80	1.76	5.04
4	No. of Branches	2.31	2.36	2.50	2.58	0.03	0.10
5	Chlorophyll content(mg/g)	1.40	1.48	1.53	1.60	0.03	0.09
6	Fruit Length (cm)	8.15	10.05	11.13	11.70	0.15	0.42
7	No. of fruit per plant	19.35	20.91	21.90	22.33	0.43	1.23
8	Fruit yield per plant (g)	60.07	187.40	224.84	233.67	3.60	10.30
9	Fruit yield per plot (kg)	1.44	4.50	5.40	5.61	0.09	0.25
10	Fruit yield per ha (q)	33.37	104.11	124.91	129.81	2.00	5.72

Data on various yield attributes and yield revealed that application of different levels of zinc increased the fruit length and fruit diameter fruit yield per plant, per plot, per ha. Application of 7.5 kg zinc per ha enhanced yield attributes and yield parameters significantly but at par with 5.0 kg zinc per ha. The beneficial effect of zinc on yield attributes and yield might be due to enhanced supply of micro nutrients during entire growing season. Significant increase in yield under the reference of zinc was largely a function of improved growth and the consequent increase in different yield attributes and yield.

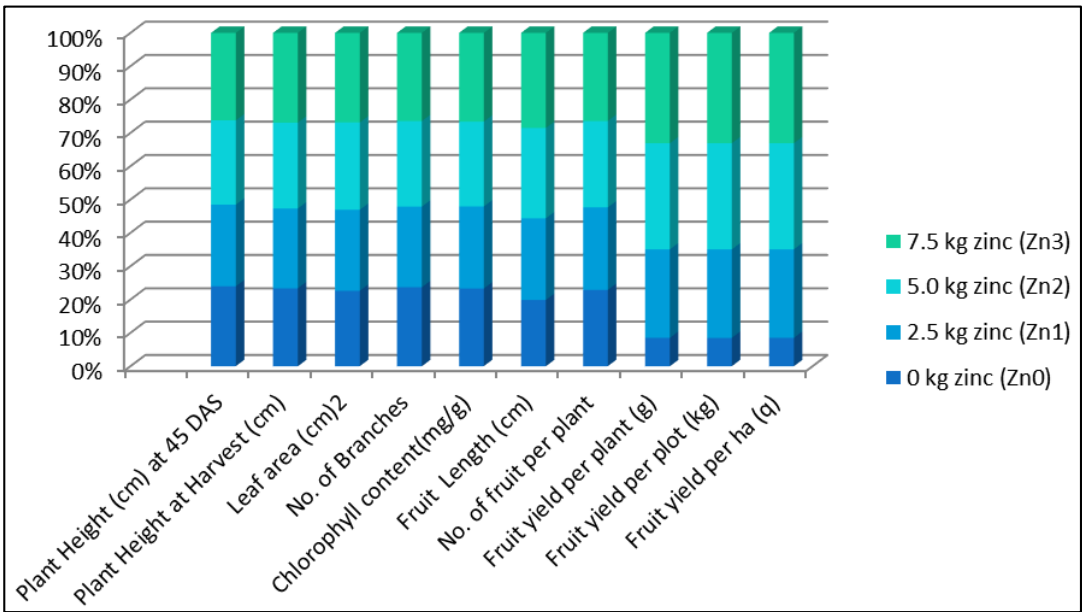

Fig 1: Effect of zinc on growth, yield and Yield attributes of okra.

Table 2: Effect of zinc level on economics and quality parameters of okra

S. No.	Characters	Zinc levels (kg/ha)					
		0 kg zinc (Zn_0)	0 kg zinc (Zn_1)	0 kg zinc (Zn_2)	0 kg zinc (Zn_3)	SEm±	CD (P=0.05)
1	Protein content (%)	1.28	1.32	1.37	1.40	0.01	0.03
2	Crude fiber content (%)	1.31	1.34	1.39	1.40	0.02	0.05
3	B:C Ratio	1.18	3.59	4.30	4.43	0.07	0.19
4	Net return	13350	189455	240850	252360	3910	11195

Further, zinc might have increased the efficiency of added chemicals fertilizer in soil and increase the rate of humification of zinc enhances the availability of both native and added nutrients in soil and thus yield of okra increased. These results are accordance with the finding of Dube *et al*. (2003) [4] in tomato and, Dadhich *et al*. (2016) [3] in knol-khol. Protein content and crude fiber content were found maximum in 7.5kg zinc zinc ha and minimum in control (table-2). Thus, the application of zinc in soil increased the availability of zinc in the rizosphere. The beneficial role of zinc in increasing cation exchange capacity (CEC) of roots helped in increasing absorption of nutrients from the soil. Futher, the beneficial role of zinc in chlorophyll formation, regulating auxin concentration and its stimulatory effecton most of the physiological and metabolic processes of plant, might have helped plants in absorption of greater amount of nutrients from soil. Thus, the favorable effect of zinc on photosynthesis and metabolic process augmented the production of photosynthates and their translocation to different plant parts, which ultimately increased the concentration of nutrients in the plant. Similar results were also reported by Chhipa (2005) [2] in cauliflower, Shah *et al*. (2010) [9] in knol-khol.

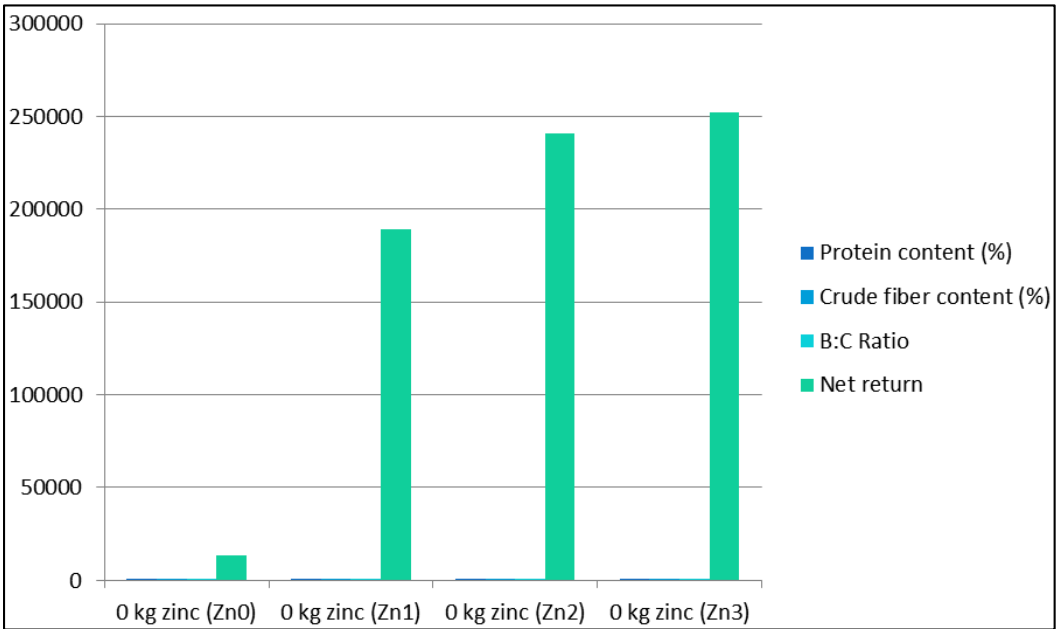

Fig 2: Effect of zinc level on economics and quality parameters of okra

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