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RESEARCH ARTICLE

OPTIMIZING MICRONUTRIENT MANAGEMENT FOR ENHANCED OKRA (ABELMOSCHUS ESCULENTUS L.) PRODUCTIVITY: A FOCUS ON ZINC AND BORON APPLICATION STRATEGIES

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ABSTRACT

Okra is widely cultivated vegetable crop which has been reducing its quality due to inappropriate utilization of micro-nutrients as well. This research was carried out to investigate the impact of foliar spray of boron and zinc on the growth and yield of the okra 'Arka Anamika' variety. The experiment followed a Randomized Complete Block Design (RCBD) with seven treatments, including control, 0.2%Zn, 0.2%B, 0.3%Zn, 0.3% B, 0.2%Zn+0.2%B, and 0.3%Zn+0.3%B, replicated three times. Data on various parameters such as plant height, stem diameter, leaf number, number of branches, number of buds, number of fruits, length of fruits, girth of fruits, and yield were collected from sampled plants in each plot. Results indicated significant effects of different fertilizer treatments on these parameters. The highest values for plant height, stem diameter, number of branches, number of buds, fruit length, number of fruits, and yield were observed in T_7, which was statistically at par with T_6. Conversely, T1 (control) exhibited significantly lower values. The girth of fruits showed no any significant differences even due to various levels of foliar application of boron and zinc, either separately or in combination. Overall, the study suggests that the application of 0.3%Zn+0.3%B may be the most effective for improving the yield and yield parameters of okra.

KEYWORDS

Okra, Zinc, Boron, Foliar application, Yield

1. INTRODUCTION

Okra (*Abelmoschus esculentus*) popularly known as chiple bhindi in Nepal is one of the most important vegetable crops belonging to the family Malvaceae, cultivated in tropical and sub-tropical regions of Nepal. It originates from Ethiopia and is widely spread all over tropical, sub-tropical, and warm temperate regions of the world (Singh et al., 2014). Okra is famous for its immature pods which are enriched with protein, vitamins A and C, iron, calcium, and dietary fiber (Adom et al., 1996). It is also known as an anti-oxidant as it is used for plasma replacement or blood volume expander (Savello et al., 1980) against gastric and inflammatory diseases (Lengsfeld et al., 2004). Each 100 g green tender okra fruit contains 1.76 g protein, 8.73 g carbohydrate, 1.1 g fiber, 88 IU Vitamin A, 9.8 mg Vitamin C, and 116 mg Ca (Hasan, 1993). The production of okra and its quality mainly depends upon micronutrients particularly Zinc (Zn) and Boron(B). Boron plays a role in the regulation of cellular processes such as maintaining the structural and membrane integrity of the cell wall and plasma membrane, development of roots and shoot meristem (Pereira et al., 2021) facilitating the movement of ions across the membrane, promoting cell division and elongation, supporting reproductive growth, facilitating the synthesis of biomolecules including carbohydrates and proteins, aiding in the metabolism of phenols and auxins, enabling nitrogen fixation, contributing to disease resistance, and assisting in managing abiotic stress. Limited boron supply leads to suppressed leaf expansion, restricted root elongation, and impaired flower development. In contrast, excessive boron has been seen to diminish photosynthetic ability, hinder pollen germination, and inhibit pollen tube expansion (Day and Aasim, 2020). Zinc is an essential component of the enzymes and proteins that are involved in the metabolism of carbohydrates, the synthesis of proteins, the expression of genes, the metabolism of auxin (a growth regulator), the formation of pollen, the maintenance of biological membranes, protection from photo-oxidative damage and heat stress, and resistance to infection by specific pathogens (Das and Green, 2013; Hacisalihoglu, 2020; Tayyiba et al., 2021) .Zinc deficiency impairs one or more of the plant's various physiological activities, affecting plant development. Zinc deficiency can cause plant physiological changes, including stunting, interveinal chlorosis, bronzing of chlorotic leaves, small and abnormally shaped leaves, and stunting and resetting (Alloway, 2008; Suganya et al., 2020). In today's world, the production of okra is decreasing due to haphazard use of nutrient fertilizers. On this, micronutrients (Zn and B) are on veil that only some farmers used it other are unaware about the important and their proper doses. Hence, this study was undertaken to find out the effective foliar spray dose of zinc and boron on quality parameters and yield of okra for maximization of okra production.

2. MATERIALS AND METHODS

2.1 Experiment Site

The experiment was carried out on the horticulture farm of Gokuleswor Agriculture and Animal Science College Gokuleshwor, Baitadi. The latitude and longitude of the research site are 29.6880°N and 80.5494°E respectively. The experiment was conducted from May 8 to August 27, 2023. It is situated at an altitude of 800-950 meters above sea level.

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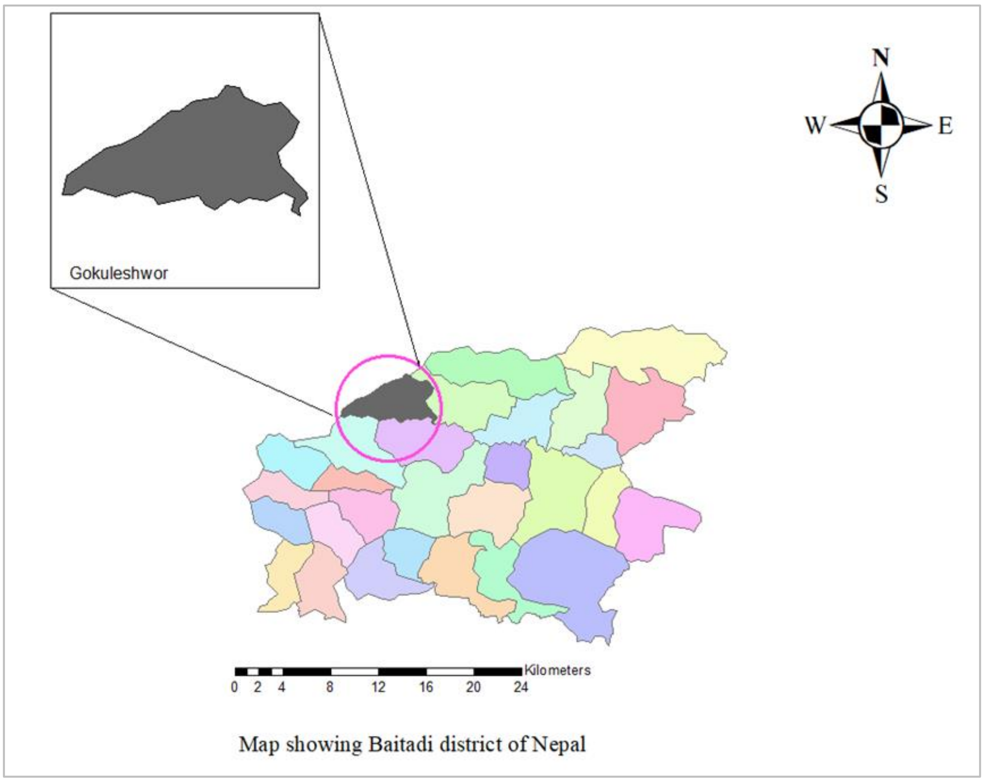

Figure 1: Map showing the study area

2.2 Climate and Weather

The experiment was conducted in the warm sub-tropical climatic zone with average summer and winter temperatures of 21.1℃ and 7.7℃ respectively. The mean annual precipitation is 921.09mm with approximately 65.13% occurring from May to August. The agro-climatic feature of the research field is presented in Figure 1 (Data was made available from the agrometeorological station of Gokuleswor Agriculture and Animal Science College, Baitadi).

2.3 Soil Characteristics of the Experimental Field

Before starting the experiment, initial soil sample(0-15cm) of the experimental field was collected by tube auger from 10 different spots in Z shaped. A representative composite soil sample was tested in the soil and fertilizer testing laboratory, Pokhara for detailed analysis. The result of the analysis is presented in Table 1.

2.4 Experimental Design and Treatment Details

This experiment was carried out in a Randomized Completel Block Design (RCBD) with 7 treatments replicated 3 times. The treatments used in the study were T_1 (Control), T_2 (0.2%Zn), T_3 (0.2%B), T_4 (0.3%Zn), T_5 (0.3%B), T_6 (0.2%Zn+0.2%B) and T_7 (0.3%Zn+0.3%B). The total area of the experimental field was 199.68 sq. m with a standard plot size of 3.6×1.8 m^2. The distance between plot to plot and replication to replication was 0.5 m and 1 m respectively. Row to Row and Plant to Plant distance was maintained at 60×45cm.

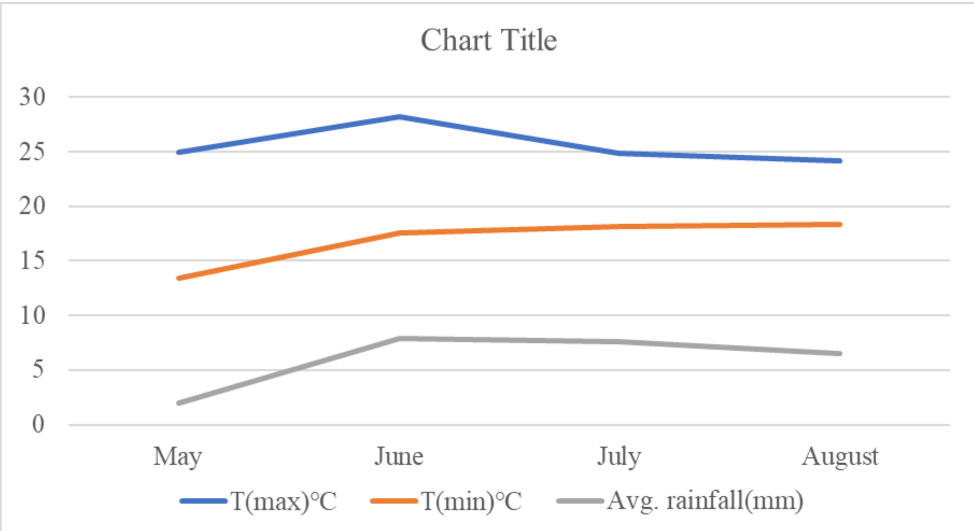

Figure 2: Agro-meteorological status during the study period.

Table 1: Physio-chemical properties of soil before sowing of okra in field

Location	ph.	OM%	Texture	Sand%	Silt%	Clay%	Zn	Cu	Fe	B	N	P_2O_5	K_2O
Gokuleshwor							ppm						
Critical level	5.1	2.39	loam	41.62	48.12	10.26	0.10125	0.7881	160.8467	3.79656	0.12	16.38	60
Interpretation	Acidic	low					Very low	Low	Very high	Very high	medium	low	low

Source: Soil and Fertilizer Testing Laboratory, Pokhara

2.5 Land Preparation and Agronomic Practices

At first, to open the land tractor operated disc plough was used followed by levelling the field. Then after, recommended dose of organic manure was applied on field (@20t/ha) prior to about 1 month of seed sowing. Seeds were soaked for about 16hrs and kept dry in muslin cloth to absorb moisture for facilitation of proper sprouting. Before 2 days of sowing, experimental field was designed into planned treatments which were raised 2m above ground surface. Then, as per recommendation of NARC, the synthetic fertilizer (NPK@200:180:60kg/ha) were applied in such a way that full dose of Phosphorous and Potassium were applied at basal dose and Nitrogen was applied in split dose as ½ part in basal dose and ½ part in 30DAS.

Table 2: Treatments Application Details

Treatments number	Treatments used
T_1	Control
T_2	0.2%Zn
T_3	0.2%B
T_4	0.3%Zn
T_5	0.3%B
T_6	0.2%Zn+0.2%B
T_7	0.3%Zn+0.3%B

As per treatment details, 2gm of zinc sulphate was dissolved in 1ltr of water to make 0.2% zinc sulphate solution. 2gm of borax was dissolved in 1ltr of water to make 0.2% borax solution. Likewise, 3 gm of zinc sulphate and 3 gm of borax were dissolved in 1ltr of water separately to make 0.3% zinc sulphate and 0.3% borax respectively. For combination, 2gm of zinc sulphate and 2gm of borax were dissolved in 1ltr of water to make 0.2%Zn+0.2%B. Similarly, 3gm of zinc sulphate and 3gm of borax were dissolved to make 0.3%Zn+0.3%B. Then, all micronutrient solutions were used to spray after mixing to tipol for facilitation of adherence of micronutrient to leaf. The foliar spray was given for 3 times first before flowering at 35DAS, second at 60DAS and third at 25days after second spraying i.e. 85DAS

2.6 Seed Sowing

The crop variety was Arka Anamika. Healthy seeds were sown with row-to-row distance of 60cm and plant to plant distance of 45cm and three seeds were sown per pit. After 10 days of sowing at 4-5 leaf stages, comparatively weak seedlings were removed from the pit and finally one seedling was remained in each pit which was seems vigorous. Manual weeding was done at 25 and 55 DAS. Irrigation was applied as per the analysis of moisture present in soil.

2.7 Data Collection Procedure

There were altogether 24 plants in each plot. Five plants were randomly selected in each plot leaving the border plants and tagged accordingly

- **Plant height:** The height of plant was measured by using meter scale taking 5 plants randomly from each plots excluding border plant. Average height was calculated by adding the height of all 5 plants and divided it by five.
- **Girth length:** The length of girth was measured by using meter tape. Average girth of stalk was calculated by adding girth of all 5 plants and divided it by five.
- **Number of leaves:** Number of leaves were counted by manually. Average leaves were calculated by adding leaves of all 5 plants and divided it by five.
- **Number of branches:** Number of branches were determined by counting manually. Average branches were calculated by adding branches of all 5 plants and divided it by five.
- **Number of buds:** Number of buds were recorded by counting manually of each 5 tagged plants from each plot. Average buds were calculated by adding buds of all 5 plants and divided it by five.
- **Number of fruits:** Number of fruits were determined by counting manually in each harvest and average fruits were calculated by adding fruits of all plants and divided it by five.
- **Fruit length:** Fruit length was recorded by measuring with the help of measuring tape. Average fruit length was determined by adding all the fruit length after harvesting fruit from each 5 tagged plants of each plant and divided by total number of fruits harvested from those selected plants.
- **Fruit girth:** Fruit girth was measured by using vernier caliper and average fruit's girth was recorded by adding all fruit girth of each fruit of tagged plants from each treatment and divided it by total number of fruits.
- **Yield:** Yield was recorded by weighing total harvest of fruits from tagged plants of each treatment plots by the help of weighing balance (Model: WT12002NEJ) and converted it to yield/hectare by using following formula,
  - $$\text{Yield per hectare(ton)} = \frac{\text{Yield plot}^{-1} \times 10000}{\text{Area of plot in m2} \times 1000}$$

2.8 Statistical Analysis

At first, recorded data were entered in excel sheet. The entered data were analyzed with the help of R-studio (version 4.3.0). The mean value of all the recorded parameters was assessed and analysis of variance was done using the F-test. Duncan's Multiple Range Test (DMRT) was done. The least significant difference (LSD) test was used to determine the significance of the difference between treatment means at a 5% level of probability. The final result was interpreted with relevant literature by table and graph.

3. Results and Discussion

The results obtained from research have been presented, compared and discussed through different table and possible interpretation have been given under following headings.

3.1 Plant Height

It was recorded that plant height become significantly variation among used treatments. AT 90DAS, the highest plant height(204.69cm) was recorded from T_7 (0.3%Zn+0.3%B) which was found statistically similar to T_6 (0.2%Zn+0.2%B) whereas T_1 (control) exhibited lower plant height i.e., 143.2cm. Similar results were obtained that higher plant height was obtained by spray of 0.2%Zn+0.3%B which was statistically at par with 0.2%Zn+0.2%B (Jahan et al., 2020).

3.2 Stem Diameter

It was recorded that stem diameter was significantly influenced by various level of foliar application of zinc and boron. The highest stem's diameter i.e., 8.04 was recorded in T_7 which was statistically at par with T_6 whereas control exhibits lower stem's diameter i.e.,6.53. This result was supported that highest stem's diameter was observed in 0.2% Zn + 0.3% B which was at par with 0.2%Zn+0.2%B (Jahir Maliha et al., 2022).

3.3 Number of Leaves

Significant influence was recorded on number of leaves as influenced by various level of foliar application of Zinc and Boron. The highest number of leaves (36.01) was observed in T_7 whereas lower number of leaves (31.53) was observed in control. It was reported that the combination of both Zinc and Boron exhibits highest leaves number compare to alone zinc and boron whereas least number was recorded in control (Ahsan Habib et al., 2018).

3.4 Number of Branches

Significant variation was found in number of branches as influenced by various level of foliar application of zinc and boron. The highest number of branches i.e., 23.39 was found in T_7 whereas lowest number of branches was recorded in control i.e., 19.33 which was also recorded that highest number of leaves was observed in 0.2% Zn + 0.3% B which was at par with 0.2%Zn+0.2%B (Jahir Maliha et al., 2022).

Table 3: Effect of Zn and B on plant height(cm), stem diameter(cm), number of leaves and number of branches of okra

Treatments	Plant height(cm)	Stem diameter(cm)	Number of leaves/ plants	Number of branches/ plants
0	143.2^{c}	6.53^{c}	31.53^{d}	19.33^{d}
0.2%Zn	156.08^{b}	6.62^{bc}	33.88^{bc}	21.12^{c}
0.2%B	163.48^{b}	7.84^{ab}	33.10^{c}	22.18^{b}
0.3%Zn	168.20^{b}	7.34^{abc}	33.94^{bc}	22.34^{b}
0.3%B	165.64^{b}	8.01^{a}	33.62^{bc}	22.26^{b}
0.2%Zn+0.2%B	200.14^{a}	8.21^{a}	34.82^{ab}	22.91^{ab}
0.3%Zn+0.3%B	204.69^{a}	8.04^{a}	36.01^{a}	23.39^{a}
LSD	12.52	1.20	1.27	0.86
SEM	1.54	0.15	0.16	0.11
F-probability	<0.001	<0.01	<0.001	<0.001
CV%	4.10	8.99	2.10	2.21
Grand Mean	171.63	7.51	33.84	21.93

Note: Mean with same letter are non-significant at p=0.05 by DMRT, SEM= Standard Error of the Mean, LSD=Least Significant Difference, CV= Coefficient of Variation, NS= Non-Significant

3.5 Number of Buds

Significant variation was found in number of buds as influenced by various level of foliar application of zinc and boron. The highest number of buds i.e., 11.15 was found in T_7 whereas lowest number of buds was recorded in T_1(control) i.e., 8.57. Zn and B play important roles in chlorophyll formation, cell division, meristematic activity of tissue expansion of cell and formation of cell wall (Souri and Dehnavard, 2018).

3.6 Girth of Fruits

No significant difference was found in girth of fruits with various level of foliar application of zinc and boron. This result was also supported that there was no significant difference by various dose of zinc and boron alone and in combination (Jahan et al., 2020).

3.7 Length of fruits

It was found that various level of foliar application of zinc and boron causes significant impact on length of fruits. The highest fruit's length (14.27) was found in T_7 was followed by T_6 which was statistically at par whereas lower length of fruits was recorded in control i.e.,12.83. this result was also reported that combination of both Zinc and Boron exhibits highest leaves number compare to alone zinc and boron whereas least number was recorded in control (Jahan et al., 2020).

3.8 Number of Fruits

Significant variation was found in number of fruits as influenced by various level of foliar application of zinc and boron. The highest number of fruits i.e., 34.93 were found in T_7 which was followed by T_6 i.e.,32.10 whereas lowest number of fruits were found in T_1 i.e., 18.22. this result was supported that recorded highest number of fruits were found in 0.2%Zn+0.2%B and 0.3%Zn+0.3%B which at statistically at par whereas lowest number of fruits were found in control (Moench et al., 2004; Rahman et al., 2020).

3.9 Yield

It was recorded that the various level of foliar application of Zinc and Boron significantly impact on yield of okra. The data concerning yield/plot(kg) revealed that maximum yield (10.04kg) was recorded in 0.3%Zn+0.3%B was followed by 0.2%Zn+0.2%B (9.76kg) whereas lowest yield was obtained from control i.e., 4.97kg. Data observed from yield(t/ha) found that maximum yield (15.49t) was in 0.3%Zn+0.3%B whereas minimum yield was recorded in control i.e.,7.67t. The previous study also reported that Zn and B foliar application improves the yield of okra (Al-Dulaimi & Al-Jumaili, 2017; Shukla et al., 2018).

Table 4: Effect of Zn and B on number of buds, number of fruits, length of fruits, girth of fruits, yield/plot(kg) and yield(t/ha)

Treatments	Number of buds	Number of fruits	Length of fruits	Girth of fruits	Yield/plot (kg)	Yield (t/ha)
0	8.57^{d}	18.22^{d}	12.83^{c}	1.67	4.97^{c}	7.67^{d}
0.2%Zn	9.68^{c}	23.84^{c}	13.21^{bc}	1.67	6.95^{b}	10.73^{c}
0.2%B	9.50^{c}	23.59^{c}	13.14^{bc}	1.67	7.48^{b}	11.55^{b}
0.3%Zn	10.68^{b}	25.04^{c}	13.44^{abc}	1.7	7.61^{b}	11.74^{b}
0.3%B	9.78^{c}	24.26^{c}	13.28^{bc}	1.67	7.55^{b}	11.65^{b}
0.2%Zn+0.2%B	11.29^{ab}	32.10^{b}	13.8^{ab}	1.83	9.76^{a}	15.06^{a}
0.3%Zn+0.3%B	11.75^{a}	34.93^{a}	14.27^{a}	1.87	10.04^{a}	15.49^{a}
LSD	0.81	1.95	0.82	0.21	0.88	0.47
SEM	0.10	0.24	0.10	0.03	0.11	0.06
F-probability	<0.001	<0.001	<0.05	NS	<0.001	<0.001
CV%	4.49	4.23	3.43	6.97	6.37	2.21
Grand Mean	10.18	25.99	13.42	1.72	7.77	11.98

Note: Mean with same letter are non-significant at p=0.05 by DMRT, SEM= Standard Error of the Mean, LSD=Least Significant Difference, CV= Coefficient of Variation, NS= Non-Significant

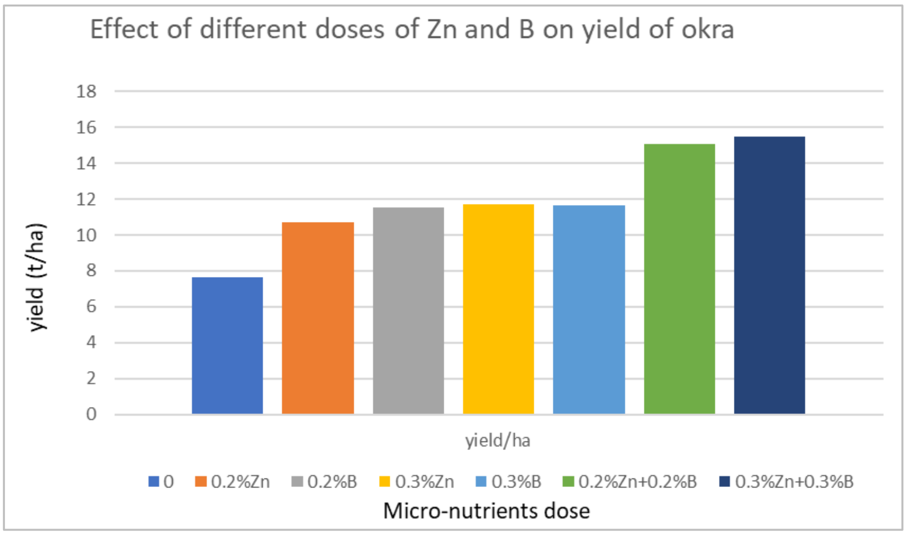

Figure 3: Effect of different doses of Zn and B on yield of okra

4. Conclusion

From the above findings of the research, it can be concluded that combination dose of zinc and boron showed outstanding results on growth, yield and yield components of okra than application of zinc and boron separately. The zinc and boron at highest level 0.3% Zn+0.3%B produced highest plant height, stem diameter, number of leaves, number of buds, number of fruits, length of fruits and yield too which was statistically similar to level 0.2%Zn+0.2%B. only application of zinc or boron separately signifies marginally decreased in growth parameters and yield of okra. So, use of proper dose of combination of zinc and boron is must for maximization of production and productivity of okra var. Arka Anamika.

Conflict of Interest

The authors have declared that no conflict of interest for this work.

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