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Effect of Micronutrients on Tomato Productivity During Monsoon Season Under Plastic House in Kavre, a Midhills District of Nepal

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Abstract

In Nepal, tomato production in plastic houses is getting popular. Plastic houses helps to enhance the production through protecting the tomato plants from rain, temperature, pests and diseases. However, micronutrient deficiencies have been causing productivity decline and low quality yields. This experiment was carried out to evaluate the effect of soil and foliar application of zinc and boron along with other essential nutrients with organic sources in tomato production. The experiment was conducted at Nala village of Kavre district Nepal. The research was conducted in a Single Factor Randomized Complete Block Design (RCBD). There were eight treatments with three replications. The field data on phenology, crop growth, yield attributes and yield were recorded. The highest yield of tomato was recorded from the plot treated with the NPK chemical fertilizers 200:180:100 kg ha $^{-1}$ N: P_2O_5 : K_2O with doses of 2.5 kg ha^{-1} boron (B) and 2 kg ha^{-1} zinc (Zn). The micronutrient application enhanced economic yield by a margin of 4 to 19 t ha^{-1} with partial productivity signifying Zn and B use efficiencies (ZUE and BUE) of between 160% and 950% and potential profitability gains. The results clearly indicate the beneficial effects of the application of zinc, boron, calcium and magnesium in combination with NPK fertilizer and farmyard manure (FYM).

INTRODUCTION

The agriculture sector plays a vital role in the Nepalese economy contributing of 23.9% to national GDP [1], and tomato is ranked among the top three economically significant vegetable crop with an average productivity of 18.43 t ha^{-1} in Nepal [2]. Considering the nutrition value, it has great source of vitamins and minerals like vitamin A, vitamin C, calcium, iron, protein, potassium, magnesium as well as antioxidants and carotenoids [3]. During monsoon, production is constrained by biotic and abiotic pressures including pests and diseases and logging from heavy rainfall. Plastic houses are the protected structures which provide shade to crops during heavy rainfall, intense temperatures and prevent insects and pests [4] thereby increasing yield in monsoon season [5, 6]. It has high market potential due to improved fruit size and shining appearance and increased demand during off-season [7].

With improved protection from pests and disease, increasing productivity through fertilizer is essential. Although the government focuses on major plant nutrients, most soils in Nepal are deficient in micro-nutrients [8], resulting in inefficiencies. Balanced fertilization is crucial to increase crop productivity and soil fertility which includes application of optimum amount of both macro as well as micronutrients [9]. Micronutrients are the trace elements which are required in small quantities but essential for crop growth and development [10]. Application of Calcium (Ca) and Magnesium (Mg) increases both yield and quality of tomato by involving in photosynthetic activity and activation of various enzymes and also increases the concentration of lycopene [11]. Boron is a crucial element for fruit setting as it enhances pollen formation. Deficiency of B may result in poor pollination and sterility, reduced flowering, wilting and leaf and fruit drop of tomato [3]. Zinc deficiency in vegetable crops can lead to interveinal chlorosis,

reduction in root and shoot growth as well as decrease fruiting [12]. About one-third of the arable soils in the world are deficient in micronutrients particularly Zn [13] .

Micronutrients deficiency is worsened by a frequent intensive cropping and unbalanced use of fertilizers [14]. In various regions of Nepal, micronutrients particularly Zn, B, and Mo are found to be deficient in soils [15]. However, limited studies have been carried out to analyze the effects of micronutrients specially Zn and B on yield and yield related parameters of tomato under plastic house conditions.

MATERIALS AND METHODS

Site selection

The experiment was conducted at Nala village of Kavrepalanchowk district of Nepal, in the year of 2023 and 2024. It is located at an altitude of 1400 masl with latitude and longitude of 27.6543°N and 85.5157°E respectively. The monthly total rainfall, average temperature and relative humidity of the experiment site is shown in (Fig. 1).

Application of fertilizers

The chemical fertilizers 200:180:100 t ha^{-1} N: P_2O_5: K_2O were applied as Urea, Diammonium Phosphate (DAP) and Muriate of Potash (MOP) respectively. Phosphorus and potash were applied as basal doses at the time of land preparation and N was applied in 3 split doses. The application of micronutrients in soil was carried out during land preparation using doses of 2.5 kg ha^{-1} of B as borax, 2 kg ha^{-1} of Zn as zinc sulphate, 80 kg ha^{-1} of Calcium oxide (CaO) and 50 kg ha^{-1} of Magnesium oxide (MgO). The foliar spray containing Zn, B, Ca and Mg at a concentration of 100 ppm was sprayed at every 15 days interval 30 days after transplanting. Biometric observation was done every 15 days interval until harvest.

Treatment details

The different combinations of micro and macronutrients applied during the experiment are given in (Table 1).

Table 1
Treatments

Treatments	Details
T1	200:180:100 kg/ha N: P_2O_5: K_2O
T2	200:180:100 kg/ha N: P_2O_5: K_2O + FYM+Foliar spray of Multiplex
T3	200:180:100 kg/ha N: P_2O_5: K_2O + B
T4	200:180:100 kg/ha N: P_2O_5: K_2O + Zn
T5	200:180:100 kg/ha N: P_2O_5: K_2O + Zn+B
T6	200:180:100 kg/ha N: P_2O_5: K_2O + Zn+Ca
T7	200:180:100 kg/ha N: P_2O_5: K_2O + Zn+Ca + Mg
T8	200:180:100 kg/ha N: P_2O_5: K_2O + FYM+ Zn + Ca+ Mg + B

Experimental design

The research was conducted in a Single Factor Randomized Complete Block Design (RCBD). There were eight treatments with three replications. The size of each experimental plot was 4.8 m^2 with net area of 672.3m^2. A hybrid tomato variety Srijana-popular for producing in plastic house condition during the rainy season (Babu et al., 2016), was selected. Tomato seedlings of 21 days old were transplanted at a distance of 75×45 cm.

Data collection

Data was collected at the interval of 15 days in the early stage, then at 30 days interval in the reproductive stage. Five plants were randomly selected to take the measurements of plant height, and leaf SPAD value. The yield was calculated at the time of the harvest.

SPAD value measurement

SPAD-502 chlorophyll meter was used for SPAD value measurement. The wave length 600–700 nm for the leaf transmittance value in SPAD − 502. Each leaf SPAD value was measured on average of five upper mature leaves of tomato.

Statistical analysis

Data collected from the experiment were recorded on MS-Excel and analyzed using R-stat version 4.5.0. To identify the difference between each means, Duncan's multiple range test was used as a mean

separation. Analysis of variance (ANOVA) was applied to test the significance of differences among treatments at 5% level of significance. The magnitude of difference and significance was explained in terms of mean yield differences.

RESULTS

Chlorophyll Content

Application of micronutrients had a significant effect on the chlorophyll content of the tomato. At 15 days, the highest chlorophyll content was found from the plants treated with the NPK fertilizer containing B (Table 2). There is significant relation with SPAD value 502 and chlorophyll content [16].

At 60 days, plants treated with the NPK fertilizer combined with Zn, Ca and Mg had the highest chlorophyll content which was statistically similar to the results of plants treated with the NPK fertilizer with Zn and B followed by application of NPK fertilizer with B. The lowest chlorophyll content was recorded from the plants with sole application of the NPK fertilizer (Table 2).

Table 2
SPAD values in tomato leaves as influenced by B and Zn and combined application at Nala, Kavrepalanchowk, in 2023 and 2024.

Treatments	**SPAD value measurement**		
	15 days	**30 days**	**60 days**
NPK	44.73^{b}	36.02^{c}	35.07^{c}
NPK + FYM + Foliar spray of micronutrients	52.00^{a}	47.46^{a}	42.43^{b}
NPK + B	52.21^{a}	44.68^{ab}	42.91^{ab}
NPK + Zn	49.76^{a}	45.23^{ab}	41.20^{b}
NPK + Zn + B	51.25^{a}	45.97^{ab}	43.98^{a}
NPK + Zn + Ca	50.67^{a}	44.28^{b}	42.84^{ab}
NPK + Zn + Ca + Mg	51.19^{a}	45.33^{ab}	44.07^{a}
NPK + Zn + Ca + Mg + B + FYM	50.07^{a}	45.90^{ab}	40.16^{b}
P-value	0.001	< 0.001	< 0.001
CV (%)	5.43	5.12	6.40
LSD	3.21**	2.68***	3.14***
SEm(±)	0.55	0.46	0.53

SEm (±) = Standard Error of the mean, LSD = Least Significant Difference, CV = Coefficient of Variation. Treatment means followed by the same letter (s) within a column are not significantly different among each other by DMRT (Duncan Multiple Range Test) at 5% level of significance.

Yield and yield attributes of tomato

The NPK fertilizer with Zn and B enhanced the plant height in vegetative stage. The lowest plant height was observed from the plot treated with the NPK fertilizer only (Table 3). At 60 days, the result was similar to earlier stages where the highest plant height was recorded from NPK fertilizer combined with Zn and Ca followed by NPK fertilizer with Zn, Ca, and Mg.

Similarly, the application of NPK fertilizer combined with Zn and B resulted in the highest crop yield (119 t ha^{-1}) and highest plant growth (143cm) in 30 days while combining Zn and Ca with NPK fertilizer had the maximum plant height at 60 days of planting (Table 3).

Table 3
Plant height and yield influenced by micronutrients in tomato at Nala, Kavrepalanchowk Nepal in 2023 and 2024.

Treatments	**Plant height (cm)**			**Yield (t ha^{-1})**
	15 days	**30 days**	**60 days**	
NPK	64.22^{c}	124.46^{ab}	175.75^{b}	100.58^{a}
NPK + FYM + Foliar spray of micronutrients	69.21^{bc}	125.13^{b}	179.72^{b}	107.96^{a}
NPK + B	78.17^{a}	140.79^{a}	164.07^{b}	104.75^{a}
NPK + Zn	69.46^{bc}	131.46^{ab}	181.13^{b}	112.82^{a}
NPK + Zn + B	75.13^{ab}	143.00^{a}	196.85^{a}	119.69^{a}
NPK + Zn + Ca	81.17^{a}	140.61^{a}	202.13^{a}	109.77^{a}
NPK + Zn + Ca + Mg	75.21^{ab}	137.67^{ab}	201.11^{a}	113.91^{a}
NPK + Zn + Ca + Mg + B + FYM	78.88^{a}	139.46^{a}	200.17^{a}	115.41^{a}
P-value	0.004	0.018	0.04	0.40
CV (%)	9.03	7.76	7.56	13.06
LSD	7.87*	12.39*	17.26*	17.03
SEm(±)	1.36	2.14	2.98	2.94

SEm(±)= Standard Error of the mean, LSD = Least Significant Difference, CV = Coefficient of Variation. Treatment means followed by the same letter (s) within a column are not significantly different among

each other by DMRT (Duncan Multiple Range Test) at 5% level of significance.

Micronutrients enhanced the tomato yield, hence it also increases the economic profit. Result indicated that application of micronutrients showed a positive effect on yield and yield attributes of tomato. It increases yield up to 20 t ha^{-1} and economic return NRs 708840 (USD 4650.06) per hectare (Table 4). The partial factor of productivity signifying Zn and B use efficiencies (ZUE and BUE) of between 160% and 950%.

Table 4
Partial budget analysis with application of B and Zn on the tomato at Nala, Kavrepalanchowk, Nepal in 2023 and 2024.

Treatments	Yield (t ha^{-1})	Yield increment (t ha^{-1})	% increase of yield	Monetary gain due to micronutrient application (NPR (USD) ha^{-1})
RDF	100.58	-	-	-
RDF + B	104.75	4.14	4.14	150120 (984.80)
RDF + Zn	112.82	12.16	12.82	440640 (2890.64)
RDF + Zn + B	119.69	19.69	18.99	708840 (4650.06)
Note: Exchange rate 1$=152.44 NPR (26.08.2026)				

DISCUSSION

Chlorophyll Content

Increase in chlorophyll content in plants with the application of B may be due to its immediate effect on plant physiology involving in cell wall stability which ensures proper transport of nutrients and water and also translocation of sugars in different parts of the plant essential for chlorophyll synthesis as supported by [17]. At 30 days, the plants receiving NPK fertilizer with FYM and Foliar spray of micronutrients showed maximum chlorophyll content followed by the plants treated with the NPK fertilizer with Zn and B.

The application of magnesium can increase the chlorophyll content in crops as it is considered as a structural element of chlorophyll molecules [18]. Moreover, the application of Zn combined with other micronutrients also helps to enhance chlorophyll content in plants as it serves as a cofactor for enzymes involved in chlorophyll synthesis and stabilizing membranes of chloroplast [19]. Similarly, application of Ca improves shoot and root growth of crops which enhances macronutrients absorption leading to healthy crops and it also plays a vital role in stabilizing cell wall structures and plant membranes which are essential for chlorophyll formation [20].

Yield and yield attributes of tomato

Micronutrients, particularly Zn and B, are essential for growth and development of crops. Boron is involved in functions like cell wall formation, membrane integrity, carbohydrate metabolism and nutrient transportation while Zn enhances protein synthesis and is an activator of various enzymes [21]. The application of optimum dose N, P, K fertilizers when combined with Zn and B increased plant height and yield which may be the result of improved translocation of food and water which provides favorable conditions for the growth and development of crops.

Application of micronutrients including Zn increased yield of crop by increasing carbohydrate concentration through acceleration of enzyme carbonic anhydrase, synthesis of chlorophyll and starch formation [22]. There are no significant differences ($p = 0.4$) in terms of yield seen between the treatments however, the application of micronutrients and FYM showed a positive effect on the economic yield of crops. The NPK fertilizers applied with Zn and B observed the highest yield (Table 3) which was followed by NPK fertilizer with Zn, Ca, Mg, B and FYM. Integrating Zn and B with the NPK fertilizer have increased the availability and uptake of nutrients which resulted in better growth and productivity of crops [23].

Increased yield and growth parameters from the combined application of Zn and B might be due to their positive effect on physiological functions of crops which ultimately improved the yield. Increase in height, with application of Zn could be due to its contribution on formation of amino acids like tryptophan as well as auxin synthesis[3]

CONCLUSION

Micronutrients are trace elements crucial for enhancing crop growth and yield. Application of micronutrients like zinc, boron in combination with NPK fertilizer and other nutrients with application of FYM is a beneficial approach that helps increase the rate of photosynthesis through enhancing chlorophyll content and ultimately contributes to tomato productivity.

DECLARATIONS

CONFLICT OF INTEREST

The authors declare no conflict-of-interest regarding the publication of this paper.

ETHICS, CONSENT TO PARTICIPATE, AND CONSENT TO PUBLISH DECLARATIONS

Not applicable.

PLANT GUIDELINES

Not applicable

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Author Contribution

Shova Shrestha: Conceptualization, Investigation, Formal Analysis, Data Curation, Methodology, Writing original draft, reviewing & editing. Benju Adhikari: Data analysis, Literature review and drafting. Somap Silwal : Methodology, Data Analysis

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Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request

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Figures

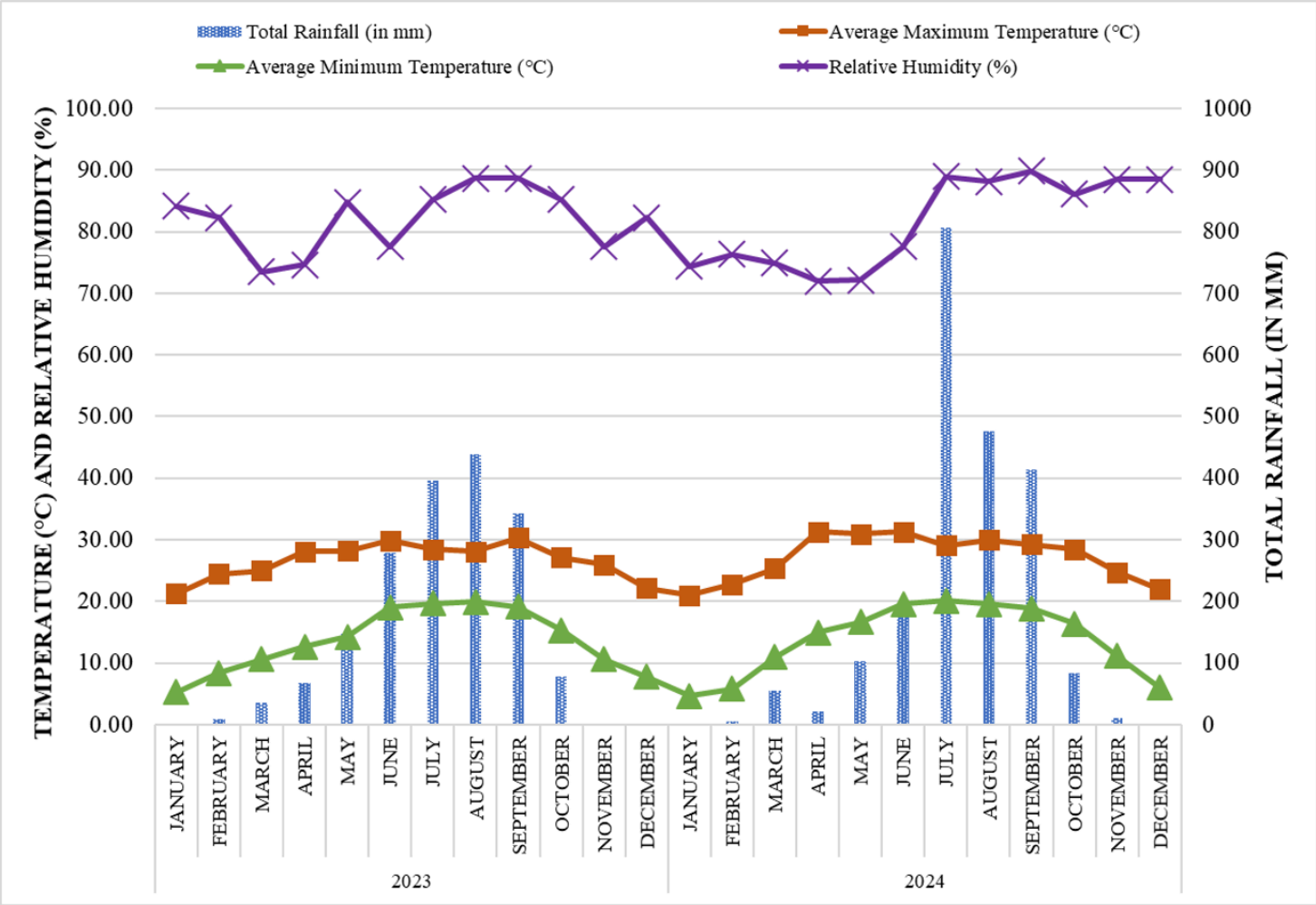


Figure 1

Monthly record of total rainfall, average maximum and minimum temperature and relative humidity of Nala, Kavre Nepal