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Physiological Responses and Cost Benefit Analysis of Tomato (*Solanum Lycopersicon L.*) Seed Crop in Relation to Foliar Application of B and Zn under Temperate Open Field Conditions

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Abstract

Bed planting of *Solanum lycopersicon* with foliar application of B and Zn in temperate open field condition is a new and interestingly technology to enhance the yield. The study revealed that under temperate conditions, the foliar application of B and Zn play significant role on development, fruit characteristics, yield attributes and seed recovery in *Solanum lycopersicon*. Nine treatments were applied in three replicates in the form of Randomised Complete Block Design (RCBD). Highest number of leaves (76.35), branches (10.27), length of roots (37.16cm), seed yield plant^{-1} (6.00g), seed yield hectare^{-1} (445.5kg), 1000 seed weight (3.05g) and seed recovery percentage (13%) was observed at $B_{100}Zn_{100}$. Furthermore, the capital cost investment exhibited variation, net returns of 10,435.25 USD with benefit cost ratio of 3.00 was observed highest at $B_{100}Zn_{100}$. Among all the treatments, $B_{100}Zn_{100}$ proved to be effective concentration for overall development in *Solanum lycopersicon*.

Key words: *Solanum lycopersicon*; Foliar spray; Seed recovery; Physiology; Cost benefit analysis; Seed; Boron; Zinc

Introduction

Micronutrients are required by plants in very small quantities as they are very effective in regulating plant growth, development and reproduction, due to their enhanced enzymatic activities [1]. Different crops require varied quantities of micronutrients at different growth stages. It is being realized that the productivity of crop is being affected in different areas due to deficiencies of micronutrients observed primarily due to intensive cropping and imbalanced fertilization [2]. Deficiencies of micronutrients directly or indirectly affect the growth of plant and accordingly decrease crop yield and quality. Tomato (*Solanum lycopersicon L*) is one of the major vegetable crops grown throughout the world. But due to deficiency of nutrients its quality and quantity has been affected since couple of decades. Moreover, quality of tomato fruits is adversely affected when grown under deficient nutrient conditions especially boron (B) and zinc (Zn). Generally, nutrients can be applied both by conventional or foliar application methods. It is a well-established fact that macro or micro nutrients applied as foliar application become promptly available to crop plants [3]. Therefore, foliar feeding is a valuable asset of nutrient application compared to soil feeding. Tomato being a heavy feeder and exhaustive crop removes substantial amount of micronutrients from soil. To maintain sustainability in its production and nutritive value, it is essential to replenish the depleting reserve of the micronutrients in the soil or apply it through foliar spray to meet the immediate need of the crop. In the present study, an attempt has been made to study the effect of foliar applied micronutrients on physiological parameters and cost benefit analysis of *Solanum lycopersicon L.*

Material and methods

The experiment was carried out in the field under temperate conditions with nine concentration treatments and three replications in randomised complete block design (RCBD) depicted in Table 1. The plants were planted in three rows and five columns. A uniform dose of nitrogen (120kg ha^{-1}) phosphorous (90kg ha^{-1}) potassium (60kg ha^{-1}) and FYM (30t ha^{-1}) were applied to each plot. Foliar applications of micronutrients

(B and Zn) were applied 15 days after transplanting of seedlings and repeated at 15 days interval. A total of three foliar sprays were carried out during the cropping season.

Table 1: Treatment Combinations.

Treatment	Treatment Combinations
B_0Zn_{50}	Zn (50mg L^{-1})
B_0Zn_{100}	Zn (100mg L^{-1})
$B_{50}Zn_0$	B (50mg L^{-1})
$B_{50}Zn_{50}$	B (50mg L^{-1})+Zn (50mg L^{-1})
$B_{50}Zn_{100}$	B (50mg L^{-1}) + Zn (100mg L^{-1})
$B_{100}Zn_0$	B (100mg L^{-1})
$B_{100}Zn_{50}$	B (100mg L^{-1}) + Zn (50mg L^{-1})
$B_{100}Zn_{100}$	B (100mg L^{-1}) + Zn (100mg L^{-1})
B_0Zn_0	Control

Root measurements

Root volume was determined using a calibrated cylinder into which the entire root system was placed and water was added to the height of a mark. The difference between the water quantity required filling the cylinder up to the mark and the cylinder volume below the mark equalled the root system volume.

Seed recovery and cost benefit analysis

A random sample of 1000 seeds from treated was weighed out. The seeds from the fruits obtained from five randomly selected plants from each picking were extracted and added to get total seed yield per plant and their average was worked out. Seed recovery percentage was calculated by using the following relation:

$$\text{Seed Recovery Percentage}(\%) = \frac{(\text{Weight of filled seeds})}{(\text{Total weight of seeds})}$$

Tabular analysis was performed to assess the economics of the crop. Gross returns were worked out by multiplying yield obtained with the average of current market price. The production cost was subtracted from the gross returns and the results obtained were taken as the net profit. The cost benefit ratio of each treatment was also worked out.

Results and Discussion

Table 2: Response of foliar application of B and Zn on physiological parameters, seed yield attributes and seed recovery percentage of *Solanum lycopersiconL.*

Treatment	Number of Leaves Per Plant	Number of Branches Per Plant	Length of Roots (Cm)	1000 Seed Weight (G)	Seed Yield (G) Per Plant	Seed Yield Kg Ha^{-1}
B_0Zn_1	63.57	6.5	32.03	2.55	4.28	317.82
B_0Zn_2	65.98	7.14	33.02	2.83	5.11	379.45
B_1Zn_0	62.98	6.28	31.22	2.49	4.31	320.04
B_1Zn_1	70.06	7.8	33.8	2.77	5.23	388.36
B_1Zn_2	74.14	9.53	32.99	3	5.89	437.37
B_2Zn_0	62.45	5.98	30.21	2.6	4.74	351.98
B_2Zn_1	73.47	9.04	34.18	2.9	5.58	414.35
B_2Zn_2	76.35	10.27	37.16	3.05	6	445.54
B_0Zn_0	54.05	4.13	28.16	2.28	4.05	300.74
C.D($p \leq 0.05$)	0.73	0.42	0.42	0.29	0.19	28.59

There were highly significant differences observed among the treatments in the number of leaves, branches and length of roots per plant. The maximum number of leaves (76.35), branches (10.27) and length of roots (37.16cm) per plant was observed at treatment concentration dose $B_{100}Zn_{100}$ i.e. B (100mg L^{-1}) + Zn (100mg L^{-1}) while minimum number of leaves (54.05), branches (4.13) and length of roots (28.16 cm) per plant was observed was under natural conditions (B_0Zn_0), presented in Table 2.These results confirmed that the foliar application of B and Zn have a significant effect on overall development of plant [4] which directly helped the plant to explore a larger soil volume and thus influences the spatial nutrient availability.

Seed yield per plant and seed yield per hectare depends upon number of mature fruits per plant, seed recovery rate and average seed weight which are considered to be an important component of seed yield. Maximum seed yield (6.00g per plant) and seed yield (445.4Kg per hectare) was determined at $B_{100}Zn_{100}$. The increase in seed yield may be attributed due high production of components such as fruit set, number of seeds per fruit and seed weight. Maximum (3.05g) 1000 seed weight was observed at $B_{100}Zn_{100}$ and minimum (2.28g) at B_0Zn_0. Greater mobilisation of photosynthesis to the developing seeds by application of B and Zn might be the reason for increase in seed weight [1,5].

Highest seed recovery percentage of 13% was observed at $B_{100}Zn_{100}$ and lowest at B_0Zn_0 depicted in Figure 1. This may be attributed to the fact that Zn is essential for many enzymes which are needed for nitrogen metabolism, energy transfer and protein synthesis by influencing the activities of hydrogen and carbonic anhydrase [6]. In addition foliar application of B in tomato improves the internal physiology of developing fruits in terms of better supply of water, nutrients, and other compounds which are vital for proper growth and development [1]. The micronutrients enhancing role in seed set that resulted in improvement in seed recovery. These results are in conformity with the findings of [7].

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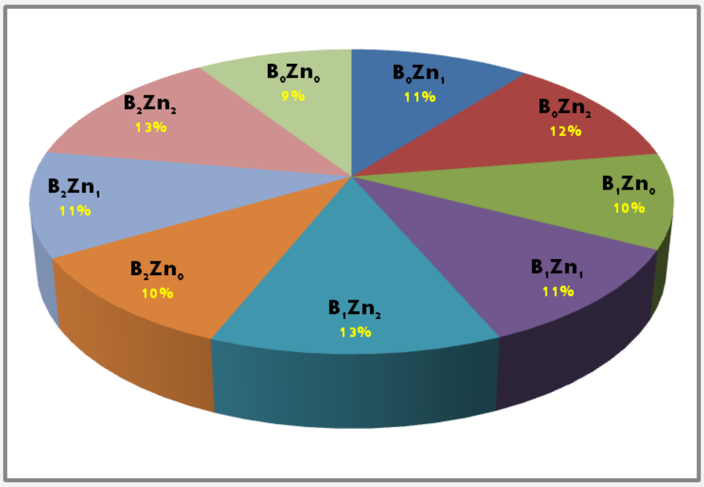

Figure 1: Seed recovery (%) of *Solanum lycopersicon L.* with foliar application of B and Zn at different treatment concentrations.

Cost benefit Analysis

Table 3: Relative economics (hectare basis) of tomato seed as affected by foliar application of B and Zn.

Treatment	Total Cost of Cultivation (USD)	Yield (Q Ha^{-1})	Gross Returns (USD)	Net Profit (USD)	Returns/Dollar Invested
B_0Zn_1	3468.4	317.82	9919.47	6450.67	1.85
B_0Zn_2	3469.44	379.45	11843	8373.9	2.41
B_1Zn_0	3468.86	320.04	9988.76	6519.89	1.87
B_1Zn_1	3469.80.	388.36	12121.09	8651.29	2.49
B_1Zn_2	3470.06	437.37	13650.74	10180.68	2.93
B_2Zn_0	3469.25	351.98	10985.64	7516.38	2.16
B_2Zn_1	3470.03	414.35	13912.25	9462.23	2.72
B_2Zn_2	3470.49	445.54	13905.74	10435.25	3
B_0Zn_0	3468.71	300.74	9386.3	5917.75	1.7

The results depicted in Table 3 revealed that the capital investment cost exhibited variation with different treatments in tomato cultivation and was estimated maximum (3470.49 USD) for seed yield at $B_{100}Zn_{100}$. Maximum net returns 10435.25 (USD) with benefit cost ratio of 3.00 was determined at treatment, $B_{100}Zn_{10}$. These results are in conformity with the findings of [5].

Conclusion

The combined foliar application of micronutrients (B and Zn) enhanced plant growth characteristics, marketable yield, seed recovery percentage and reduces crop duration of *Solanum lycopersicon L.* under the temperate conditions. This upgradation in growth, maturity, yield, and seed recovery might be due to the availability of essential nutrients (B and Zn) and easiness of absorbing them via leaves that fulfil the optimal nutritive requirements of tomato plants.

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