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EFFECT OF FOLIAR SPRAY OF ZINC AND BORON ON PERFORMANCE OF TOMATO (SOLANUM LYCOPERSICUM) CV. MANISHA UNDER NET HOUSE CONDITION

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ABSTRACT
This experiment was carried out to investigate the plant performance of tomato var. Manisha under foliar spray of zinc and boron in Randomized Complete Blocked Design with five treatments and four replications. The treatments were control (T_0), two levels of chelated zinc (T_1:30 ppm and T_2:60 ppm), and the two levels of borax (T_3:30 ppm and T_4:60 ppm) applied in two installments (15 and 35 DAT by foliar spray). The results showed significance increase in parameters such as plant height (86 cm), plant leaves number (52.47), branches number (8.21), clusters number (19.32), fruits number (22.73), fruit diameter (5.58 cm), fruit weight (59.71 gm) and yield (56.56 t/ha) with the foliar application of chelated zinc at the dose of 30 ppm. Furthermore, early flowering (23.70 days) was observed at borax 30 ppm concentration. The results can recommend the tomato growers to apply chelated zinc and borax at the dosages of 30 ppm which denotes use of 30 mg per liter. The results clearly depict the potential increase in yield and other parameters of tomato cv. Manisha, using easily available source of zinc and boron, i.e. chelated zinc and borax.

KEY WORDS
Deficiency, foliar spray, micronutients, net house, tomato.

Agriculture is the backbone of the Nepalese economy and it consist 31.7% of total GDP (Mandal *et* al 2021). The country is lagging in the commercial production of vegetables and still, the traditional methods of farming are widely practiced. As a result, the production is low compared to nation-wide demand and we have to import from the neighboring country. The data shows that vegetables were grown in the area of 297,195 ha and the total production was around 4,271,270 Mt (MoAD, 2019). This reveals that the production was quite low compared to area. The majority people of this district are closely bounded with agriculture (89.5%) and the area is reputed for the production of vegetables seed (PMAMP, Annual Progress Report, 2019/20).

Tomato (*Solanum lycopersicum)* is an important vegetable crop that is widely grown in the terai, mid-hills, and high hills of Nepal. It has a huge role in the economics of farmers of the hilly region. Tomato is the most consumed and widely cultivated vegetables crop after potato in Nepal. Tomatoes are grown almost all period during the year, mainly in the mid-hills and terai area. The most commonly cultivated varieties of tomato in Nepal are Srijana, Manisha, Snehalta, Thimps-1, Bishesh, and Surakshya. The application of lime has an adverse effect on the availability of micronutrients such as Zn, B, Cu, Mn (Tadeusz, 2011). Nutrients are quickly available by foliar application than soil application (Mehdizadeh, Darbandi, Naseri-Rad, & Tobeh, 2013, Basavarajeswari, et al., 2008). The physiological role of boron was found in strengthen the cell wall, sugar transport, RNA Metabolism, and also part of cell membranes. Zinc is a constituent of an enzyme (Carbonic Anhydrase) which is essential for nutrients metabolism and play role in biomass production (Cakmak, 2008). Zinc is required for chlorophyll formation, pollen function, and fertilization (Kaya & Higgs, 2002). About 30% of the cultivable soils of the world contain low levels of plant available Zn (Hafeez, Khanif, & Saleem, 2013). About 80 to 90% of soil samples were deficient in Boron, 20 to 50% in Zn, and 10 to 20% in Molybdenum (Anderson, 2007). Boron unavailability is major problem in Nepal and affects about 80-90% of agricultural soils. It can adversely affect tomato flowering and fruiting reducing not only yield but the product quality (Bele & Thakur, 2019).

The productivity of tomato in Nepal is around 19 t/ha but in the Rukum West the productivity is only around 12 Mt/ha which shows huge gap in productivity. The reasons for this gap may be because of various factors but negligence of micronutrients application is one of them. The farmers of Rukum west district have less or no knowledge about the application of micronutrients and their value on production. Realizing the scenario of this district, the present experiment has been undertaken to know the overall effect of Zn and B on tomatoes. This study will be beneficial to farmers in considering the choice of micronutrients as well as to know the optimum dose for foliar application on tomato farming. The outcome will also provide knowledge of the importance of micronutrients on vegetables to the farmers.

MATERIALS AND METHODS OF RESEARCH

The research was carried out at Chaurjahari Municipality Ward No. 5, Lahare Simal village, Rukum West. Subtropical climate dominates the Chaurjahari municipality due to moderate elevation of the location. In the context of Rukum West, the average maximum temperature was found around 34.4^0C and average minimum temperature was recorded 0.4^0C. Similarly, the average maximum precipitation was recorded 2200 mm and the lowest was recorded 1600 mm. The research was started during spring period.

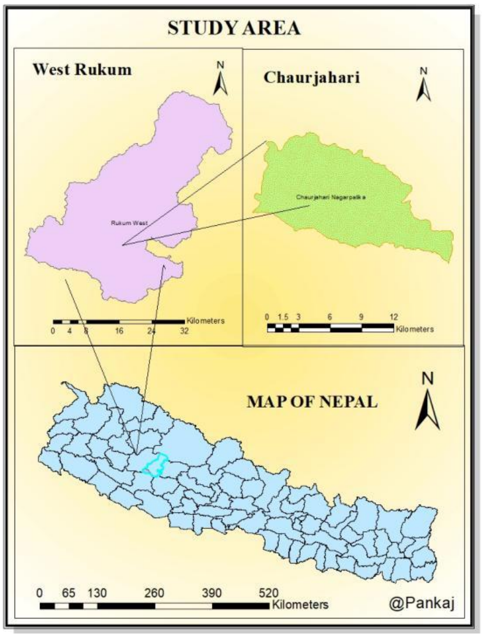

Figure 1 – Map showing the experimental site in West Rukum

The experiment was conducted under net house using variety Manisha of Tomato. Two foliar applications of Zn and Boron were done. The first application was done after 15 days of seedlings transplantation and second followed 35 days after transplantation (DAT).

Table 1 – Dosage of micronutrients that was used during the experiment

Treatment Details	Dose of micronutrients per spray (mg)	Application Rate	Solutions used per spray (liter)
Control	0	2	2
30 ppm Zn	61.12	2	2
60 ppm Zn	121.33	2	2
30 ppm B	60.65	2	2
60 ppm B	120.89	2	2

Note: T_1= Control Treatment (Water), T_2= 30 ppm of Zn, T_3= 60 ppm of Zn, T_4= 30 ppm of B, T_5= 60 ppm of B.

The study was conducted using five treatments. There were two doses of Zn and also two doses of B. One of treatments was under control conditions where only water applied. Each of micronutrients was studied at the concentration of 30 ppm and 60 ppm. The field of the experimental site was small for the large number of treatments.

The experiment was conducted under Randomized Complete Block Design (RCBD) which is suitable design for heterogeneous field condition. The five treatments were replicated four times with block formation in the field. The size of each plot was 2*1.2 m^2.

Morphological Characters Considered, Plant height (cm), Number of leaves, Number of branches/Plant, Number of Clusters/Plant, Flowers and Fruits Characters, Days to first flowering, Number of Fruits/Plant, Average diameter of fruit, Yield Characters, Fruit weight (g), Fruit yield (kg/plant), Fruit Yield (kg/Plot)Fruit yield (t/ha)

RESULTS AND DISCUSSION

The study revealed that the height of the plant was influenced significantly by the application of plant micronutrients at 60 DAT as shown in table 2. The mean plant height of the tomato was found to be 81.08 cm. The maximum height of the tomato (86.00 cm) was recorded in chelated zinc at the dose of 30 ppm which was followed by Borax 30 ppm (84.77cm) and chelated zinc 60 ppm (81.49 cm). Similarly, minimum plant height was recorded at borax in the concentration of 60 ppm (76.57 cm) and also in the control treatment (76.60 cm). Zinc is believed to have positive correlation with the height of the plant. But many other factors have found to affect proper assimilation and usage of applied zinc source. The factors may be soil type, radiation, moisture etc (Javadimoghadam, Ladan Moghadam, & Danaee, 2015). Cell division and Cell elongations mechanisms were responsible for the increase in length of tomato. Zinc is significant fundamental micronutrient which helps in the development of tryptophan, an antecedent of IAA liable for growth incitement (Malliick & Muthukrishnan, 1980; Patil, et al., 2008) and has an indispensable part in formulation of carbonic anhydrase catalyst which helps in transport of CO_2 in photosynthesis (Alloway, 2008). Furthermore, it was also found that in addition with boron, zinc helps in growth of cell walls and cellular proliferation in plants (Patil, et al., 2008).

Table 2 – Plant height of Tomato cv. Manisha influenced by foliar application of Micronutrients

Treatments	Plant height at 60 DAT
Control Water (no treatment)	76.60^{c}
Chelated Zinc(30ppm)	86.00^{a}
Chelated Zinc(60ppm)	81.49^{b}
Borax (30ppm)	84.77^{ab}
Borax (60ppm)	76.57^{c}
LSD(0.05)	3.43
$SE_m(\pm)$	0.49
F- Probability	< 0.001
CV, %	2.74
Grand Mean	81.08

Note: 0.001, 0.01 and 0.05 indicate the level of significance at 0.1%,, 1% and 5% respectively, and Treatment means in columns followed by common letters are not significantly different from each other based on DMRT TEST at 5% level of significance.

With the application of plant micronutrients, a significant difference was observed on the plant leaves number after 60 days of transplantation (table 3). Plant leaves number (52.47/plant) at chelated zinc 30 ppm was found higher than others and is followed by leaves number (47.67/plant) at borax 30 ppm. Lowest leaves number (40.65/plant) was recorded under control condition which was followed by borax 60 ppm (44.97/plant) and chelated zinc 60 ppm (46.74/plant) based on DMRT analysis at 5% level of probability. The grand mean of leaves number of tomato plant at 60 DAT was found as 46.78/plant.

All the treatment dosages of zinc source and boron source have shown the positive influence on the leaves number of tomato plant under the protected system. Leaves number found to be increased in many researches with application of zinc and boron. It may be due to zinc association in the chlorophyll formation which might have favored the cell wall development, cell enlargement and cell division. The result is in harmony with the result obtained by (Ali, Mehraj, & Uddin, 2015), who also reported that plant leaves number (68.9/plant) of BARI tomato was increased with the combined application of zinc and boron than control treatment (50.5/plant). Low Boron supply (deficiency) led to a significant (p <0.05) decrease in total leaf number, maximum leaf width and length by around 40, 46 and 59%, respectively, when compared with those of B-sufficient (0.5 mg $B \cdot L^{-1}$) cabbage at 32 days after transplantation (DAT) (Choi, Jeon, Choi, & Stangoulis, 2016). Likewise, (Gopal & Sarangthem, 2018) have found that Zn @10kg/ha showed higher number of leaves number (20.07) per plant at 20 DAT. (Shnain, Prasad, & Saravanan, 2014), obtained a higher number of leaves in tomatoes at a combined concentration application of Zn (1250 ppm) and B (1250 ppm).

Table 3 – Plant leaves number of Tomato cv. Manisha influenced by foliar application of Plant Micronutrients and their concentration at 60 DAT

Treatments	Leaves number at 60 DAT
Control Water (no treatment)	40.65[d]
Chelated Zinc (30 ppm)	52.47[a]
Chelated Zinc (60 ppm)	46.74[bc]
Borax (30 ppm)	47.65[b]
Borax (60 ppm)	44.97[c]
LSD(0.05)	2.28
$SE_m(\pm)$	0.33
F- Probability	< 0.001
CV, %	3.18
Grand Mean	46.49

Note: 0.001, 0.01 and 0.05 indicates level of significance at 0.1%, 1% and 5% respectively, and Treatment means in columns followed by common letters are not significantly different from each other based on DMRT TEST at 5% level of significance.

Table 4 – Plant branches number of Tomato cv. Manisha influenced by foliar application of Plant Micronutrients and their concentration at 60 DAT

Treatments	Branches number at 60 DAT
Control Water (no treatment)	7.12[b]
Chelated Zinc (30 ppm)	8.21[a]
Chelated Zinc (60 ppm)	7.83[a]
Borax (30 ppm)	8.10[a]
Borax (60 ppm)	7.35[b]
LSD(0.05)	0.47
$SE_m(\pm)$	0.068
F- Probability	< 0.01
CV, %	3.97
Grand Mean	7.72

Note: 0.001, 0.01 and 0.05 indicates level of significance at 0.1%, 1% and 5% respectively, and Treatment means in columns followed by common letters are not significantly different from each other based on DMRT TEST at 5% level of significance.

Number of branches per plant of Manisha variety of tomato showed significant variation among the treatments at 60 days after transplantation as shown in table 4. The grand mean for the number of branches among the treatments was 7.72/plant. The result showed that significantly higher number of branches (8.21/plant) was found in case of chelated zinc 30 ppm. However, it was statistically at par with other two treatments which were borax at 30 ppm (8.10/plant) and zinc at 60 ppm (7.83/plant). The lowest number of branches (7.12/plant) was recorded in control condition and this was followed by borax at 60 ppm (7.35/plant). From the experiment, it was discovered that there was positive impact of zinc and boron to increase the branches number in tomato. (Harris & Mathuma, 2015), found that zinc is responsible for RNA metabolism encouraging formation of Carbohydrates, Proteins and DNA. Thus, branches number might have got increased due to sufficient production of energy sources within plants. Energy might be utilized by plants in making the higher number of branches. Beside maintaining structural stability in plants, the role of boron is also found in transport of sugars across the membrane (Seth & Aery, 2017) which is also seems helpful in branch formation. This result was also in accordance with result of (Basavarajeswari, et al., 2008), who also found to increase branch number with application of zinc and boron. Likewise, same kind of result was also obtained by (Ali, Mehraj, & Uddin, 2015).

Table 5 – Clusters number of Tomato cv. Manisha influenced by foliar application of Plant Micronutrients and their concentration at 60 DAT

Treatments	Clusters number at 60 DAT
Control Water (no treatment)	15.21[d]
Chelated Zinc (30 ppm)	19.32[a]
Chelated Zinc (60 ppm)	17.31[c]
Borax (30 ppm)	18.34[b]
Borax (60 ppm)	16.81[c]
LSD(0.05)	0.59
$SE_m(\pm)$	0.08
F- Probability	<0.001
CV, %	2.21
Grand Mean	17.40

Note: 0.001, 0.01 and 0.05 indicates level of significance at 0.1%, 1% and 5% respectively, and Treatment means in columns followed by common letters are not significantly different from each other based on DMRT TEST at 5% level of significance.

There was significant variation in responses among the treatments influenced by different level of micronutrients in clusters number of tomato variety Manisha as shown in table 5. The number of clusters (19.32/plant) was found maximum in chelated zinc 30 ppm which is superior in comparison with others. After that high number of clusters (18.34/plant) was found in borax 30 ppm which was followed by two statistically same results i.e. borax 60 ppm (16.81/plant) and chelated zinc 60 ppm (17.31/plant). Minimum number of clusters (15.21/plant) was obtained in case of control condition. The mean of the clusters was found to be 17.40/plant.

Table 6 – Early flowering days of Tomato cv. Manisha influenced by foliar application of Plant Micronutrients and their concentration at 60 DAT

Treatments	Days of Flowering after transplantation
Control Water (no treatment)	27.23[a]
Chelated Zinc (30 ppm)	24.66[bc]
Chelated Zinc (60 ppm)	25.83[ab]
Borax (30 ppm)	23.70[c]
Borax (60 ppm)	25.06[bc]
LSD (0.05)	1.49
$SE_m(\pm)$	0.217
F- Probability	<0.01
CV, %	3.84
Grand Mean	25.29

Note: 0.001, 0.01 and 0.05 indicates level of significance at 0.1%, 1% and 5% respectively, and Treatment means in columns followed by common letters are not significantly different from each other based on DMRT TEST at 5% level of significance.

We can conclude that use of plant micronutrients promote in the cluster number of tomato and it was found that foliar application of zinc at the rate of 30 ppm concentration is much better for number of tomato flower clusters. Foliar application zinc 0.4% has resulted in the maximum outcomes of flower-bunches per plant (27.45) (Ullah, et al., 2015) and also the greatest number of clusters (21.6) was also reported in tomato plants in which foliar application of $ZnSO_4$ was done in the concentration of 12.55 ppm (Ali, Mehraj, & Uddin, 2015). The same fact was also reported by the findings of many other researchers.

The number of days required for first flowering showed significantly influenced by the application of plant micronutrients (table 6). The variation among the different treatments can be observed from the table 5. Early flowering (23.70 days) was found in borax at the foliar concentration of 30 ppm. Late flowering (27.23 days) occurred in case of control treatment. Likewise, statistically same data were recorded in treatments chelated zinc 30 ppm (24.66

days) and borax 60 ppm (25.06 days). The mean days to early flowering was found to be 25.29 days.

All the treatment of plant micronutrients showed positive results for days to early flowering than without application of micronutrients. The early flowering found in the boron 30 ppm might be associated with proper influx of required ions in the plants. Boron has been found to enhance the photosynthesis and hormonal metabolism (Coulter, 2001). Hormonal mechanisms of plant get activated in presence of various ions and cell expansion resulting formation of flowers. Early flowering was found from application of boron and zinc (49.3 days) while without application showed late flowering (55.5 days) (Ali, Mehraj, & Uddin, 2015). Also boron has significant effect on pollen germination and pollen tube growth (Allah, 2006).

Table 7 – Number of fruits on Tomato cv. Manisha influenced by foliar application of Plant Micronutrients and their concentration

Treatments	Number of fruits per plant
Control Water (no treatment)	15.27[d]
Chelated Zinc (30 ppm)	22.73[a]
Chelated Zinc (60 ppm)	17.70[c]
Borax (30 ppm)	20.84[b]
Borax (60 ppm)	17.27[c]
LSD(0.05)	0.90
$SE_m(\pm)$	0.13
F- Probability	<0.001
CV, %	3.13
Grand Mean	18.76

Note: 0.001, 0.01 and 0.05 indicates level of significance at 0.1%, 1% and 5% respectively, and Treatment means in columns followed by common letters are not significantly different from each other based on DMRT TEST at 5% level of significance.

From the experiment, it was found that plant micronutrients had significantly influenced the fruits number of tomato cv. Manisha as seen in table 7. The grand mean of the fruits number among the treatment was found to be 18.76 per plant. Fruits number (22.73) was found superior at the chelated zinc dose of 30 ppm which was followed by borax at the dose of 30 ppm (20.84/plant), chelated zinc 60 ppm (17.70/plant) and borax 60 ppm (17.27/plant). The treatment with no application of micronutrients showed lower number of fruits (15.27/plant) in tomato.

Table 8 – Fruit diameter of Tomato cv. Manisha influenced by foliar application of Plant Micronutrients and their concentration

Treatments	Fruit diameter (cm)
Control Water (no treatment)	5.06[b]
Chelated Zinc (30 ppm)	5.58[a]
Chelated Zinc (60 ppm)	5.40[a]
Borax (30 ppm)	5.46[a]
Borax (60 ppm)	5.18[b]
LSD(0.05)	0.21
$SE_m(\pm)$	0.031
F- Probability	<0.01
CV, %	2.66
Grand Mean	5.34

Note: 0.001, 0.01 and 0.05 indicates level of significance at 0.1%, 1% and 5% respectively, and Treatment means in columns followed by common letters are not significantly different from each other based on DMRT TEST at 5% level of significance.

Basically, zinc being the essential micronutrients enhances the many enzymatic reactions like manganese and magnesium. It plays role in RNA metabolism, carbohydrate and protein synthesis, fruit setting, and finally increasing the number of fruits in the plant (Harris & Mathuma, 2015). Similar result was obtained in my experiment at chelated zinc at the dose of 30 ppm. Furthermore, this result was also supported by (Gopal & Sarangthem, 2018), in which they found maximum number of tomato (28.33/plant) fruits by the application of zinc at the dose of 10 kg/ha. Application of NPK along with the 100 ppm of Zn had shown the highest number of fruits per plant (34.43/plant) in the Gujarat Tomato 2 (Singh, et al., 2017).

As described in table 8, the responses of different doses of plant micronutrients showed significant variation. Higher value for the diameter of fruits (5.58 cm/fruit) was obtained in chelated zinc at the concentration of 30 ppm but this was statistically at par with other two treatments, chelated zinc at 60 ppm (5.40 cm/fruit) and borax 30 ppm (5.46 cm/fruit) respectively. The diameter of the fruits was the lowest in case of control treatment (5.06 cm/fruit) which is also statistically similar with borax at the dose of 60 ppm (5.18 cm/fruit). The mean of the fruit diameter in all the treatments was measured as 5.34 cm/fruit.

It was found that there was positive correlation between the diameter of fruits and application of plant micronutrients. Fruits diameter of tomato was reduced when there was lack of enough micronutrients in the plants, which was shown under control condition in table 11. The maximum value of fruit length and diameter (5.1 cm/fruit) was obtained through combined foliar application of zinc and boron in considering to no application of micronutrients (Ali, Mehraj, & Uddin, 2015). Similarly, higher value of tomato diameter was also obtained with combined application of boron 0.1% and zinc 0.2% with other nutrients (Dixit, Sharma, & Bairwa, 2018). The measurement of tomato may have expanded as zinc and boron favor the course of cell division and cell development.

Table 9 – Fruits weight of Tomato cv. Manisha influenced by foliar application of Plant Micronutrients and their concentration

Treatments	Fruit weight (gm)
Control Water (no treatment)	53.82[d]
Chelated Zinc (30 ppm)	59.71[a]
Chelated Zinc (60 ppm)	57.62[b]
Borax (30 ppm)	58.75[a]
Borax (60 ppm)	55.13[c]
LSD(0.05)	1.06
$SE_m(\pm)$	0.15
F- Probability	<0.001
CV, %	1.21
Grand Mean	57.00

Note: 0.001, 0.01 and 0.05 indicates level of significance at 0.1%, 1% and 5% respectively, and Treatment means in columns followed by common letters are not significantly different from each other based on DMRT TEST at 5% level of significance.

Table 9 showed the averaged single fruit weight of the tomato as influenced by the level of plant micronutrients and their concentration. Fruit weight varied significantly among the treatments. The highest fruit weight (59.71 gm/fruit) was recorded at chelated zinc 30 ppm concentration which was statistically at par with the borax 30 ppm (58.75 gm/fruit). The lightest fruit weight (53.82 gm/fruit) was found in the control condition. The treatment, chelated zinc 60 ppm (57.62 gm/plant) and borax 60 ppm (55.13 gm/plant) were followed after two superior treatments. The grand mean among the treatments was found to be 57.00 gm per fruit. The positive impact of foliar application of plant essential micronutrients can be observed from the table 8. Zinc 30 ppm showed superior result than any other treatment for maintaining proper weight of tomato based on DMRT test at 5% level of probability. Boron and Zinc play roles in higher and upgraded translocation, and accumulation of photosynthates from source to sink of the plants as developing fruits acts extremely as metabolic sink (Muhammad & Laghari, 2014). Zinc source however helps in endogenous auxins and productions of other stimulatory compounds, it regulates the permeability of cell wall and allows the mobilizations of water in fruits that contribute to greater fruit length and weight. In accordance to my result, significantly higher fruit weight was also obtained by (Dixit, Sharma, & Bairwa, 2018) with the combine application of zinc and boron. Similarly, Sindhu et. Al (1999) found that zinc and boron increases the fruit weight of tomato.

Table 10 – Yield of Tomato cv. Manisha influenced by foliar application of Plant Micronutrients and their concentration

Treatments	Yield per Plant (kg/plant)	Yield per Plot (kg/plot)	Yield per Hectare (t/ha)
Control Water (no treatment)	0.82[e]	8.22[e]	34.26[e]
Chelated Zinc (30 ppm)	1.35[a]	13.57[a]	56.56[a]
Chelated Zinc(60 ppm)	1.01[c]	10.19[c]	42.48[c]
Borax (30 ppm)	1.22[b]	12.24[b]	51.01[b]
Borax (60 ppm)	0.95[d]	9.52[d]	39.68[d]
LSD(0.05)	0.051	0.51	2.13
$SE_m(\pm)$	0.0074	0.074	0.30
F- Probability	<0.001	<0.001	<0.001
CV, %	3.09	3.09	3.09
Grand Mean	1.07	10.75	44.80

Note: 0.001, 0.01 and 0.05 indicates level of significance at 0.1%, 1% and 5% respectively, and Treatment means in columns followed by common letters are not significantly different from each other based on DMRT TEST at 5% level of significance.

There was significant difference between yield per plant and yield per hectare among the treatments treated with varied concentration of plant micronutrients (table 10). Yield per plant was highest for the treatment of zinc 30 ppm (1.35kg) and this was followed by borax 30 ppm (1.22 kg), chelated zinc 60 ppm (1.01 kg) and borax 60 ppm (0.95 kg) respectively. The low value of yield per plant was recorded in control condition where no any micronutrients solution was applied. The grand mean of the yield per plant was measured to be 1.07 kg as shown in table 9. The yield, in context of hectare, was found maximum (56.56 t/ha) in case of chelated zinc 30 ppm and the lowest yield (34.26 t/ha) was observed in control treatment (table 10). The grand mean of the yield per hectare was measured as 44.80 t/ha.

From the above result, it was observed in all context application of micronutrients showed better result than under control treatment. Yield was important parameter for evaluating treatments used in any experiment. Although there was similar climatic condition and growing period, application of chelated zinc at the concentration of 30 ppm have got superior result. That could be due to the maximum expression of all the physiological activities by plants at required concentration of zinc. Zinc becomes necessary for the synthesis of enzyme carbonic anhydrase which supports the transport of CO_2 throughout photosynthesis (Alloway, 2008) and thus zinc can improve the effectiveness of photosynthesis and also enhance antioxidant system of tomato plants (Faizan & Hayat, 2019). The fruit yield of two tomato variants, VCT-1 and Rio Grande, was improved by 39% and 54% over the control variant with the application of Zn at 10 mg/kg soil, whereas the yield of tomatoes was improved by 34 and 48%, respectively, at 15 mg kg^{-1} of soil application (Gurmani, et al., 2012). Similarly, the highest value of yield (23.40 t/ha) was obtained by the foliar application of 0.4% of zinc (Ullah, et al., 2015). (Kazemi, 2013), found that Zinc (100 mg/l) with combination to iron had also shown high value of yield (25.14 t/ha). These all aforementioned result might be true for the experiment conducted because we got to see the significant positive difference in treatments than in control.

CONCLUSION

The result clearly revealed that use of zinc and borax in tomato plant can solve the sloppy production of it. The parameters such as plant height, leaves number, branches number, flower clusters number, days to early flowering, number of fruits, diameter of the fruits, fruits weight and yield were significantly influenced by the use of chelated zinc and borax. Among all the five treatments chelated zinc at the dose of 30 ppm showed the superior result in most of the parameters excluding days to early flowering. At zinc 30 ppm; highest plant height (86 cm), leaves number (52.47), branches (8.21) and cluster number (19.32), highest fruit number (22.73) and diameter (5.58 cm), highest fruit weight (59.71gm) and yield (56.56 t/ha) were obtained. Borax at 30 ppm also showed high performance in case of leaves number, branches number, days to early flowering (23.70 days), fruits diameter and fruits weight. At all condition there was positive influenced of zinc and borax application than in control. It has been confirmed that for optimizing tomato productivity foliar application of plant micronutrients (zinc and boron) becomes crucial. Zinc and Boron have role in physiological and metabolic activities within the plants. Their minute concentration significantly affects the production. The above result suggests that there is almost 20 t/ha gap in the productivity between the application of zinc 30 ppm and no application of micronutrients. Also result showed application of chelated zinc and borax at higher dosages was also not much beneficial to the tomato plants. Thus, the lower concentration (30ppm) should be maintained to get the optimum production.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this paper.

REFERENCES

1. ADS. (2015). Agriculture Development Strategy 2015 to 2035 Main Document Part 1. Singhadurbar, Kathmandu, Nepal: MoAD, Goverment of Nepal.
2. Ali, M., Mehraj, H., & Uddin, A. J. (2015). Effects of foliar application of zinc and boron on growth and yield of summer tomato. J. of Biosc. and Agr. Research, 06(01), 512-517.
3. Allah, A. (2006). Effect of spraying some macro and micro nutrients on fruit set, yield and fruit quality of Washington navel trees.
4. Alloway, B. (2008). Fundamental aspects of Zinc in soils and Plants. Zinc in Soils and Crop Nutrition. 2nd Edi, Published by IZA and IFA, Brussels, Belgium and Paris, France.
5. Anderson, P. (2007). A review of Micronutrient problems in the cultivated soils of Nepal. 27(4), 331-335.
6. Basavarajeswari, C., Hosamni, R., Ajjappalavara, P., Naik, B., Smitha, R., & Ukkund. (2008). Effect of foliar application of micronutrients on growth and yield components of tomato. Karnataka journal of Agricultural Sciences, 21(3), 428-430.
7. Bele, P., & Thakur, R. (2019). Boron nutrition of crops in relation to yield and quality :a review. 430-433.
8. Cakmak, I. (2008). Enrichment of cereal grains with zinc:Agronomic or genetic biofortification. Plants and Soils 302, 1-17.
9. Choi, F.-Y., Jeon, Y.-A., Choi, K.-Y., & Stangoulis, J. (2016). Physiological and Morphological responses to boron deficient chinese cabbage. Horticulture, Encironment, and Biotechnology.
10. Coulter, D. (2001). Nutritional disorders in cucumbers and gherkins in Glass. Centre for Agricultural Publishing and Documentation.
11. Dixit, A., Sharma, T., & Bairwa, P. (2018). Effect of foliar application of some macro and micronutrients on growth and yield of tomato cv. ArkaRakshak. Int.J.Curr. Microbio. App. Sci., 6, 197-203.
12. Faizan, M., & Hayat, S. (2019). Effect of foliar spray of ZnO-NPs on the physilogical parameters and antioxidant systems of Lycopersicum esculentum. Pol.J. Natural Science, 34, 87-105.
13. Ghimire, N., Mandal, M., Aryal, M., & Bhattarai, D. (2018, may). Assessment of Tomato consumption and demand in Nepal. Journal of Agriculture and Environment.
14. Gopal, D., & Sarangthem, I. (2018). Effect of Zinc on Growth and Yield of tomato (Lycopersicum esculentum cv. pusa ruby). International Journal of Current Research, 10, 73616-73620.
15. Gurmani, A., Din, J., Khan, S., Andaleep, R., Waseem, K., Khan, A., Ullah, H. (2012). Soil application of zinc improves growth and yield of tomato. Int. J. Agric. Bio., 14, 91-96.
16. Hafeez, B., Khanif, Y., & Saleem, M. (2013). Role of zinc in plant nutrition-A review. American Journal of experimental agriculture, 3(2), 374-391.

17. Harris, K., & Mathuma, V. (2015). Effect of foliar application of boron and zinc on growth and yield. Asian J.Pharm. Sci. Technology, 5, 74-78.
18. Javadimoghadam, A., Ladan Moghadam, A., & Danaee, E. (2015). Response of Growth and Yield of Cucumber Plant to different foliar application of Nano- Iron and zinc . International Research Journal of Applied and Basic Sciences, 1477-1478.
19. Kaya, C., & Higgs, D. (2002). Response of tomato (Lycopersicon esculentum L.) cultivars to foliar application of zinc when growth in sand culture at low zinc. Scientia Horticulturae 93, 53-64.
20. Kazemi, M. (2013). Effects of Zn, Fe and their combination treatments on the growth and yield of tomato. Bull. Eny. Pharmacol.Life Sci., 3, 109-114.
21. Knapp, S. (2002). Tobacco to Tomatoes: A phylogenic perspective on fruit diversity in the Solanaceae. Journal of Experimental Botany, 53/377, 2001-2022.
22. Malliick, M., & Muthukrishnan, C. (1980). Effect of Micronutrients on tomato (Lycopersicum esculentum),II.Effect on flowering, fruit-set and yield. South Indian Hort., 28(1), 14-20.
23. Mandal, Anuj Kumar, Yadav, Pankaj Kumar and Dhakal, Krishna Hari (2021). Comparative Study of Evaluation of Soil Fertility Status in Rice Zone, Morang. Tropical Agroecosystem, 2(1): 12-25.
24. Mehdizadeh, M., Darbandi, E., Naseri-Rad, H., & Tobeh, A. (2013). Growth and Yield of tomato(Lycopersicon esculentum Mill) as influenced by different organic fertilizers. International Journal of Agronomy and Plant Production, 4(4), 734-738.
25. Micronutrients. (n.d.). Retrieved from Mosaic: Cropnutrition.com
26. MoAD. (2073/074). Statistical Information on Neplese Agriculture. Kathmandu, Nepal: Agribusiness Promotion and Statistics Division, Minstry of Agriculture Development.
27. MoAD. (2075/076). Statistical Information on Nepalese Agriculture. Kathmandu, Nepal: Agribusiness Promotion and Statistics Division, Ministry of Agriculture Development.
28. Muhammad, W., & Laghari, A. (2014). Impact of foliar spray of Zinc on fruit yield of chillies capsicum. Umerkot: Arid Zone Research Instute, (PARC).
29. Patil, B., Hosami, R., Ajjappalavara, P., Naik, B., Smitha, R., & Ukkund, K. (2008). Effect of foliar application of micronutrients on growth and Yield components of Tomato (Lycopersicum esculentum Mill.). Journal of Agr. Sciences, 21, 3.
30. Pattidar, D. (2017). Effect of Boron, Zinc, Iron and their Treatment.
31. Paul. (2013). Are there different types of tomato leaves? Retrieved: gardenweb.com
32. Peet, M. (2007). Tomato Botany Sustainable practices for Vegetable production in South Crop Profiles- Tomato.
33. PMAMP. (2019/020). Annual Progress Report. West Rukum: Goverment of Nepal, Ministry of Agriculture and Livestock Department, Program Implementation Unit.
34. PMAMP. (2020/21). Annual Progress Report. West RUKUM: Nepal, MoAD.
35. Seth, K., & Aery, N. (2017). Boron induced changes in biochemical constituents, enzymatic activities, and growth performance of wheat. Acta Phsiology Plant.
36. Shnain, R., Prasad, V., Saravanan, S. (2014). Effect of zinc and boron on growth, yield and quality of tomato cv. HeemSohma under protected condition. Eur.Acad.Res., 4573-4597.
37. Singh, B., Kasera, S., Mishra, S., Roy, S., Rana, S., & Singh, D. (2017). Growth, Yield and quality of cherry tomato var. cerasiforme as influenced by foliar application of Zinc and Boron. J.Pharmacogn. phytochem., 911-914.
38. Tadeusz, F. (2011). Liming effects on Soil properties.Encylopedia of Agrophysics(Eds). Springer, Dordrecht. doi:https://doi.org/10.1007/978-90-481-3585-1_84
39. TEPC. (2018). Export Import Data Bank. Pulchowk, Lalitpur, Nepal: Trade and Export Promotion Centre, Ministry of Commerce and Supply.
40. TEPC. (2019). Export and Import Data Bank. Pulchowk,Lalitpur: Trade and Export Promotion Center, Ministry of Commerce and Supply.
41. Ullah, R., Ayub, G., Ilyas, M., Ahmad, M., Umar, M., Mukhtar, S., & Farooq, S. (2015). Growth and Yield of tomato as influenced by different levels of Zinc and Boron as Foliar application. Am.-Eurassian J. Agric. Environ.Sci., 15, 2495-2498.