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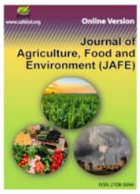

Original Article

Effects of micronutrients on growth and yield of potato

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ABSTRACT

A field experiment was carried out at the Horticulture Farm of the Bangladesh Agricultural University, Mymensingh to evaluate the effects of micronutrients and their methods of application on growth and yield of potato cv. Diamant during the period from November 2019 to March 2020. The experiment consisted of two factors, Factor A: Two methods of micronutrient application *viz.*, M_1= Basal and M_2= Foliar, and Factor B: Four levels of micronutrients viz., T_0= control treatment, T_1= Boron (B) @ 2 kg/ha, T_2= Zinc (Zn) @ 3 kg/ha, T_3= B @ 2 kg/ha + Zn @ 3 kg/ha. The experiment was laid out in split plot design with three replications. Result of the experiment revealed that application method and different levels of micronutrients alone or in combination significantly influenced all the parameters studied. The highest tuber yield (3.53 t/ha) was obtained with foliar application and the lowest was found from basal application. On the other hand the highest tuber yield (4.56 t/ha) was obtained when B + Zn @ 2 kg B/ha + 3 kg Zn/ha was applied and the lowest was recorded from control treatment. Among the treatment combinations, foliar application of micronutrients along with combined treatment of B + Zn @ 2 kg/ha + 3 kg/ha produced the maximum tuber yield (4.89 t/ha) while the lowest was obtained from the control treatment. Therefore, foliar application method along with the combined treatment of boron plus zinc was found to be better in respect of growth and yield of potato.

Introduction

Potato (*Solanum tuberosum* L.) is a leading staple food in the diet of the world's population which is also used as animal feed (Eleiwal *et al.*, 2012). Potato provides a part of daily caloric needs of human and delivers many essential nutrients and vitamins including potassium, phosphorus, manganese, magnesium, folate, vitamin C and vitamin B-6 (Haynes *et al.*, 2012). Potatoes provide a bulk dry matter and yield per unit area in comparison with other crops such as cereals, therefore potato is considered as a heavy nutrient requiring crop (Bari *et al.*, 2001).

Potato is one of the major food security and cash crops in Bangladesh. It is a nutritious, high-value, short production cycle crop. Potato produces more food per time, area and other resources than most major crops. Over a century and two decades, potato in Bangladesh grew from a garden crop in few regions to a staple crop produced in many regions and under different agro-ecological conditions. In the last few years, potato has continued to grow rapidly in importance for food security and income generation. Current potato production in Bangladesh is 9655000 tons from the 468835.91 hectares of land with an average yield of 8.34 tons per ha which is considered to be low compared to other potato growing countries of the world (BBS, 2020).

There are many factors that have been identified as the causes for this low yield in Bangladesh such as lack of proper nutrient management seems to explain most of the differential with the potential yields of the existing potato varieties. Most of the agroecologies in Bangladesh have favorable climatic and edaphic conditions having a huge potential to produce high quality potatoes (Sarker *et al.*, 2018). Agronomic practices like fertilizer application remarkably influence potato crop emergence, the onset and area increase of leaves, canopy development and subsequent performance and tuber production. Potato as a high yielding crop, consumes more nutrients from the soil at a given time for better tuber production because the food produced through photosynthesis in plant leaves needs in translocation and synthesis of carbohydrates to form tuber.

The agro-based economy of Bangladesh has two main challenges, which are vast population to feed, and small arable land area. To produce more food for the ever-increasing population the arable land is being intensively used. Cropping intensity of this country in 1983-84 was 171%, which has become 198%, in 2015-16 (BBS, 2020). Moreover, cultivation of HYV and hybrid varieties of different crops is deteriorating soil fertility day by day due to exhaustive nature of those varieties. As a consequence new nutrient deficiency in soil is emerging. Chronologically N, P, K, S, Zn and B deficiencies have arisen in this country's soils. Fertilizer use in Bangladesh has focused mainly on the use and application of nitrogen and phosphorous fertilizers in the form of di-ammonium phosphate (DAP) and Urea for almost all cultivated crops for both market and food security purposes for the last several years. Such unbalanced application of plant nutrients may aggravate the depletion of other important nutrient elements in soils such as K, Mg, Ca, S and micronutrients. Although nitrogen, phosphorus and potassium are the three major nutrient elements required in large quantities for normal growth and development of potato tubers, some reports indicated that elements like S, Ca, Mg and micro-nutrients particularly Cu, Mn, B, Mo and Zn are becoming depleted and deficient on major crops in different areas of the country (Islam, 2008). Occurrence of Cu, Mo and Mn deficiencies in crops are reported sporadically (Khan *et al.*, 2019). Some reasons of micronutrient deficiency in Bangladesh are organic matter depletion, unbalanced use of fertilizers, minimum or no use of manure, high cropping intensity, high pH (e.g. calcareous soils), nutrient leaching and light textured soils (Begum *et al*., 2015). Farmers of Bangladesh are not habituated with the use of micronutrient in crop cultivation that challenge balanced fertilization and creates negative impact in crop production.

Micronutrients help increase the efficiency of the use of macronutrients. Again, continual use of micronutrients may lead to an accumulation of toxic levels of those that may threaten crop quality. Hence, judicious application of micronutrients is essential. Different institutions have carried out a number of field trials with micronutrients at different regions of the country. These researches were concentrated mainly on cereal crops, but those were scanty with vegetables (Sarker *et al.*, 2018). Among the vegetables, some field trials on micronutrients in vegetables cultivation have been made (Nasreen *et al.*, 2009).

Impact of a micronutrient deficiency is commonly measured as loss of crop yield; nevertheless quality of harvested products is also important. For the sake of improved human and animal health, micronutrient levels in foods need to be enhanced and more than three billion people in the world are suffering from micronutrient malnutrition (Bell and Dell 2008). Studies have revealed that micronutrient deficiency led disorders occur in over half of the total human population globally. As per available literature, an adult human body has about 2-3 g of zinc, about 0.1% of which is replenished daily. The recent studies in molecular physiology strongly suggest that in some cases the iron deficiencies in humans may be associated with zinc deficiency (Raigond *et al.*, 2017). Very limited research has been done on micronutrients and their application method on potato. The present study has therefore been undertaken to evaluate the effects of micronutrients and their methods of application on growth and yield of potato.

Materials and Methods

Experimental site, soil and climate

The research work was conducted at the Horticulture Farm of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh in order to study the effects of micronutrients and their methods of application on the growth and yield of potato during the period from November 2019 to March 2020. The experimental area was located at 26^0 46/ N latitudes and 90^0 44/ E longitudes. The experiment was carried out in a high land belonging to Old Brahmaputra Floodplain Alluvial Tract (UNDP, 1988) and under the Agro-ecological Zone 9. The soil texture was silty loam with pH 6.85 having low organic matter. It was well drained with good irrigation facilities. The climate of the experimental site is subtropical in nature, which is characterized by three distinct seasons, the monsoon extending from May to October, the winter or dry season from November to February and pre-monsoon period, hot season from March to April. The experimental area is under the sub-tropical climate, which is characterized by heavy rainfall during the month of May to September and sparse rainfall during the month from October to April. Plenty of sunshine and moderately low temperature prevails during rabi season from October to March which are suitable for growing potato in Bangladesh.

Planting material and treatments of the experiment

Diamond variety of potato was used as a planting material. This potato variety is well recognized and mostly cultivated in different district of Bangladesh. The experiment consisted of two factors, Factor A: Two methods of micronutrient application *viz.*, M_1= Basal and M_2= Foliar, and Factor B: Four levels of micronutrients viz., T_0= control treatment, T_1= Boron (B) @ 2 kg/ha, T_2= Zinc (Zn) @ 3 kg/ha, T_3= B @ 2 kg/ha + Zn @ 3 kg/ha.

Experimental design and layout

The two-factor experiment was laid out in split plot design with three replications. An area of 225 m^2 was divided into three equal blocks, representing the replications, each containing 8 plots. Thus, the total numbers of unit plots were 24, each plots measuring 3 m × 1 m. The treatment combination of the experiment was assigned at random into 8 plots of each at three replications the distance between two plots was 50 cm and between blocks was 75 cm.

Land preparation

The experimental plot was thoroughly prepared by ploughing for several times with a power tiller followed by laddering. All the weeds and stubbles were collected and removed from the land. The clodes were broken into friable soil and the surface was leveled until the desired tilth was obtained. Finally, the experimental plot was partitioned into unit plots in accordance with the experimental design. Irrigation and drainage channels were prepared around the plots.

Application of manures and fertilizers

In this experiment, manure and fertilizer (except B and Zn fertilizers) were applied according to the recommendation of fertilizer recommendation guide such as cowdung @ 5 t/ha, Urea @ 200 kg/ha, TSP @ 175 kg/ha and MoP @ 150 kg/ha (FRG, 2012). The whole amount of cow dung, TSP, MoP and $^1/_4$th of the urea was applied during the final land preparation as basal dose. The rest of the urea was applied in the equal installments as top dressing at 15 days, 25 days and

35 days after sowing. The foliar application of treatments was done 2 times at 15 days interval starting from 45 day after sowing.

Planting of tuber

Furrows were made with a plough and sprouted seed tubers were planted in the furrows maintaining a spacing 60 cm x 20 cm. All the tubers in the furrows were covered with soil. The first earthing-up was done after the second dose of urea application at 30 DAP. The 2nd earthing-up was done at 45 DAP. Irrigation was provided once at 35 DAP. To control late blight disease, ridomyl was sprayed at 10-day intervals starting from 20 DAP until maturity. To control rodent, phostoxin tablet (fumigant) was inserted into the hole of the rodents and then opening of the hole was blocked with soil.

Intercultural operations

Gap filling was done by healthy seedling from the border within 15 days after tuber sowing. Weeds were found in the plots and weeding was done three times in these plots considering the optimum time for removal. Earthing up around the plants was done at by time of weeding of the experimental plots. Light over-head irrigation was provided with a watering can to the plots immediately after transplanting. Irrigation was also applied by observing the soil moisture condition. However, each top dressing of urea fertilizer was also followed by irrigation. The crop was protected from the attack of insect-pest by spraying Melathion 57 EC @ 2 ml/liter and Ridomil Gold @ 2 g/liter water were sprayed to control the insect and disease, respectively. The crop was harvested on 5 March 2020 when plants attained maturity by showing drying out most of the leaves. Care was taken to avoid injury to potato tuber.

Parameters measured

Data on various parameters such as plant height (cm), number of leaves per plant, number of tiller per plant, leaf length and diameter (cm), total weight of tuber per plant (g), tuber yield per plot (kg) and per hectare (t) were recorded from the sample plants during experimentation. Plant height was measured from 4 randomly selected plants of each plot. After 30 days of sowing data recording was started at 15 days interval up to 60 days of sowing. The height was measured in centimeter (cm) from ground level to the tip of the longest leaf and the average height of the plants was calculated. Number of leaves from 4 selected plants was counted separately after 30 days of sowing and average number of leaves was calculated at an interval of 15 days up to 60 days of sowing. Number of tiller from 4 selected plants was counted separately after 30 days of sowing and average number of tiller was calculated at an interval of 15 days up to 60 days of sowing. The leaf length was measured in centimeter (cm) from 4 selected plants started after 30 days of sowing at an interval of 15 days up to 60 days of sowing. The leaf diameter was measured in centimeter (cm) from 4 selected plants started after 30 days of sowing at an interval of 15 days up to 60 days of sowing. The weight of potato was taken from tuber produced in each unit plot (3m × 1m) and expressed in kilogram (kg). The weight of tuber in kilogram was converted into yield per hectare in tons and was expressed in ton (t) and calculated by the following formula:

$$\text{Tuber yield (t/ha)} = \frac{\text{Crop yield per plot (kg)} \times 1000}{\text{Area of plot in square meter} \times 1000}$$

Statistical analysis

The recorded data on various parameters were statistically analyzed using MSTAT-C computer package programme to find out the significance of variation resulting from the experimental treatments. The mean for the treatments was calculated and analysis of variance for each of the characters was performed by F (variance ratio) test. The significance of the difference among the pairs of treatment means was evaluated by the least significance difference (LSD) test at 5 and 1% levels of probability (Gomez and Gomez, 1984).

Results and Discussion

Plant height

Data on plant were recorded at 30, 45 and 60 days after sowing. Main effects of methods of micronutrient application on plant height were found to be significant at 30 and 60 days after sowing and not significant at 45 days after sowing (Figure 1). Foliar application gave the maximum plant height (48.48 cm) at M_2 and the minimum (47.44 cm) was in basal application M_1 at 60 days after sowing (Figure 1). Main effects of micronutrients were found significant on plant height at different days after sowing (Figure 2). At 60 days after sowing combination of boron and zinc (T_3) treatment gave the tallest plant (56.92 cm) while control treatment (T_0) gave the shortest plant (39.38 cm). The combined effects of methods of application and different levels of micronutrient were also significant in respect of plant height (Table 1). However the maximum plant height was obtained with treatment combination M_2T_3 at 45 and 60 days after sowing and at 30 days after sowing combination M_1T_3 gave tallest plant. The maximum plant height (58.80 cm) was obtained with treatment combination M_2T_3 and the minimum (36.92 cm) with M_1T_0 at 60 days after sowing. Result of present study indicates that foliar application of micronutrients and combine application of boron and zinc increased the plant height. Jafari *et al.* (2013) stated that effects of spraying of boron and manganese on height, leaves number of two potato cultivars was statistically significant. The highest result was recorded in the treatment combination of boron + manganese.

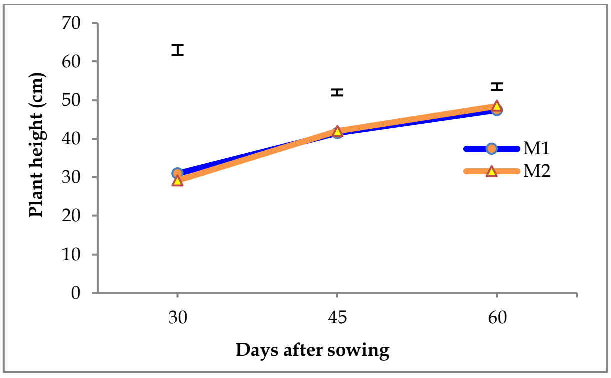

Figure 1. Effect of methods of application of micronutrients on plant height of potato at different days after sowing. Vertical bars represent LSD at 1% level of significance. M_1= Basal application, M_2 = Foliar application.

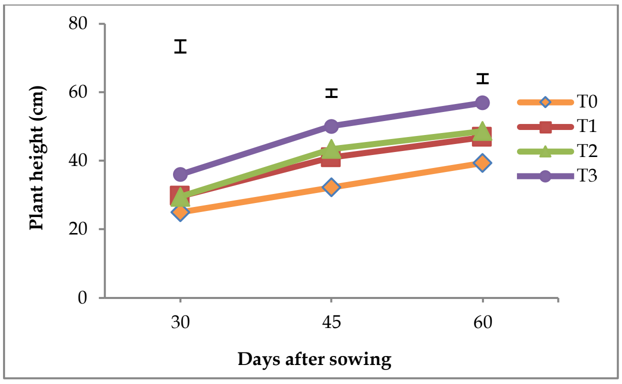

Figure 2. Effects of different levels of micronutrients on plant height of potato plant at different days after sowing. Vertical bars represent LSD at 1% level of significance. T_0= Control treatment, T_1= Boron (B) @ 2 kg/ha, T_2= Zinc (Zn) @ 3 kg/ha, T_3= B @ 2 kg/ha + Zn @ 3 kg/ha.

Table 1. Combined effects of micronutrients and methods of application on plant height and number of leaves per plant of potato at different days after sowing (DAS).

Treatment combination	Plant height (cm) at different DAS			No. of leaves per plant at different DAS		
	30	45	60	30	45	60
M_1T_0	24.00	31.00	36.92	11.00	16.00	18.50
M_1T_1	32.00	41.58	48.58	12.08	17.58	19.58
M_1T_2	29.75	43.50	48.50	11.92	17.50	20.17
M_1T_3	38.08	49.83	55.75	15.75	22.00	24.08
M_2T_0	26.00	33.58	41.83	11.83	16.17	19.00
M_2T_1	27.25	40.25	45.17	13.17	18.00	20.00
M_2T_2	29.42	43.42	48.83	14.50	20.25	24.25
M_2T_3	34.00	50.33	58.08	12.99	23.92	27.25
$LSD_{0.05}$	1.08	0.66	0.79	0.26	0.80	1.16
$LSD_{0.01}$	1.51	0.92	1.10	0.36	1.12	1.63
Level of significance	**	**	**	**	**	**

** = Significant at 1% level of probability. M_1= Basal application, M_2 = Foliar application. T_0= Control treatment, T_1= Boron (B) @ 2 kg/ha, T_2= Zinc (Zn) @ 3 kg/ha, T_3= B @ 2 kg/ha + Zn @ 3 kg/ha.

Number of leaves per plants

Main effect of number of leaves per plant was recorded at different days after sowing and it was observed that the effect of application method and micronutrient on number of leaves were significant (Figure 3-4, Table 1). Foliar application gave the highest number of leaves (22.63) at M_2 and the lowest number of leaves (20.58) at basal application M_1 at 60 days after sowing (Figure 3). At 60 days after sowing the highest number of leaves (25.67) was obtained from T_3, while the minimum number of leaves (18.75) was produced with control treatment (T_0). The treatment combination M_2T_3 produced the highest number of leaves while M_1T_0 produced the lowest at 30 days after sowing. At 60 days after sowing treatment combination M_2T_3 produced the highest number of leaves (27.25) while control treatment M_1T_0 produced the lowest number of leaves (18.50) (Table 1). The above result clearly indicates that the number of leaves per plant was higher with treatment combination containing foliar application and combined application of boron and zinc. Foliar application of full concentration during flowering increased number of tuber per plant, mean weight of tuber, tuber yield and dry matter percentage (Al-Jobori *et al.*, 2014).

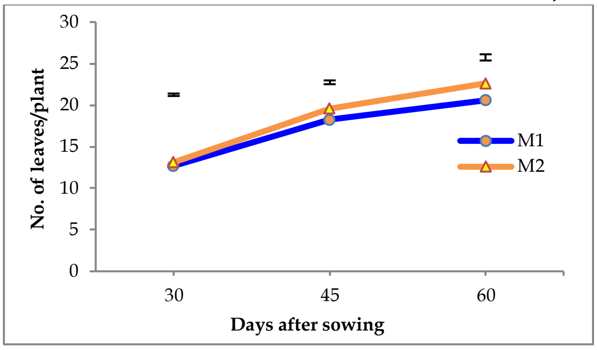

Figure 3. Effect of methods of application of micronutrients on number of leaves of potato plant at different days after sowing. Vertical bars represent LSD at 1% level of significance. M_1= Basal application, M_2 = Foliar application.

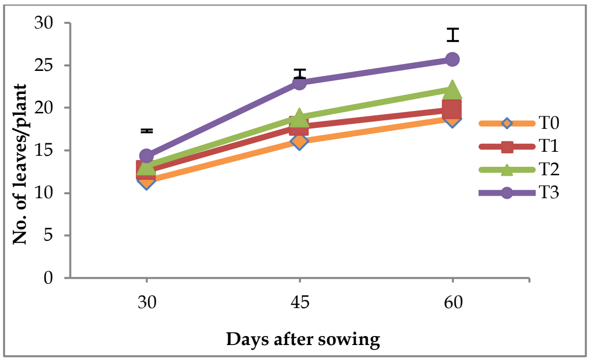

Figure 4. Effects of different levels of micronutrients on number of leaf per plant of potato plant at different days after sowing. Vertical bars represent LSD at 1% level of significance. T_0= Control treatment, T_1= Boron (B) @ 2 kg/ha, T_2= Zinc (Zn) @ 3 kg/ha, T_3= B @ 2 kg/ha + Zn @ 3 kg/ha.

Number of tillers per plant

Data on tiller number of per plant were recorded at 30, 45, and 60 days after sowing. Main effects of micronutrient application methods on tiller number per plant were found to be significant at different days after sowing (Figure 5). Foliar application gave the maximum number of tiller per plant (5.42) at M_2 and the minimum (4.33) was in basal application M_1 at 60 days after sowing (Figure 5). Main effects of different levels of micronutrients were also found significant on number of tillers per plant at different days after sowing (Figure 6). At 60 days after sowing T_3 gave the highest number of tillers while control treatment (T_0) gave the lowest number of tillers (4.04). The combined effects of application method and micronutrient were also significant in respect of number of tillers per plant (Table 2). However the maximum number of tillers per plant was obtained with treatment combination M_2T_3 at 45 and 60 days after sowing. The maximum number of tillers per plant (7.17) was obtained with treatment combination M_2T_3 and the minimum (3.92) with M_2T_0 at days after sowing.

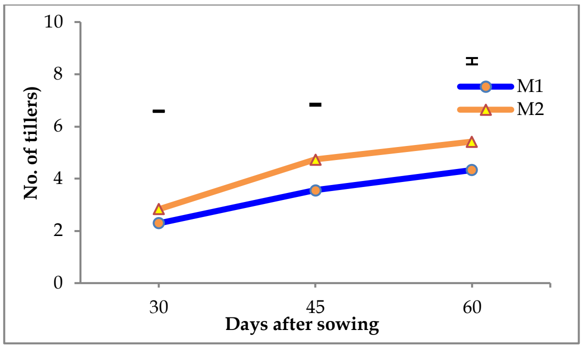

Figure 5. Effect of methods of application of micronutrients on number of tillers per plant of potato plant at different days after sowing. Vertical bars represent LSD at 1% level of significance. M_1= Basal application, M_2 = Foliar application.

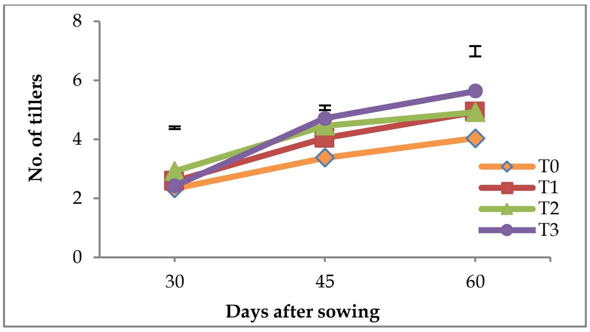

Figure 6. Effects of different levels of micronutrients on number of tillers per plant of potato plant at different days after sowing. Vertical bars represent LSD at 1% level of significance. T_0=Control treatment, T_1= Boron (B) @ 2 kg/ha, T_2= Zinc (Zn) @ 3 kg/ha, T_3= B @ 2 kg/ha + Zn @ 3 kg/ha.

Table 2. Combined effects of micronutrients and methods of application on number of tillers per plant of potato at different days after sowing (DAS).

Treatment combination	No. of tillers per plant at different DAS			Leaf length (cm) at different DAS		
	30	45	60	30	45	60
M_1T_0	2.17	3.25	4.17	13.17	18.33	21.00
M_1T_1	2.50	3.67	4.83	15.67	19.67	22.58
M_1T_2	2.42	3.75	4.25	15.75	22.33	25.08
M_1T_3	2.08	3.58	4.08	19.08	25.92	29.08
M_2T_0	2.50	3.50	3.92	12.17	17.75	20.17
M_2T_1	2.67	4.42	5.00	15.33	19.42	23.08
M_2T_2	3.42	5.17	5.58	20.58	23.08	26.92
M_2T_3	2.75	5.83	7.17	17.58	24.08	29.75
$LSD_{0.05}$	0.11	0.20	0.44	0.97	0.34	0.50
$LSD_{0.01}$	0.16	0.28	0.62	1.35	0.48	0.70
Level of significance	**	**	**	**	**	**

** = Significant at 1% level of probability. M_1= Basal application, M_2 = Foliar application. T_0= Control treatment, T_1= Boron (B) @ 2 kg/ha, T_2= Zinc (Zn) @ 3 kg/ha, T_3= B @ 2 kg/ha + Zn @ 3 kg/ha.

4.1.4 Length of leaf

Analysis of variance revealed that the effects of micronutrients their methods of application on length of leaf were significant (Figure 7-8, Table 2). Main effect of application method on leaf length has been shown in (Figure 7). Foliar Treatment (M_2) produced the highest length of leaf (24.98 cm) and Basal treatment (M_1) produced the lowest (24.44) at 60 days after sowing. On the contrary, single mean effect of different level of micronutrient on leaf length was highly significant. Treatment T_3 gave the height length of leaf (29.42 cm) while control treatment (T_0) gave the lowest (20.58 cm) leaf length (Figure 8). Combined effects of application methods and micronutrient on leaf length were statistically significant (Table 2). However, the maximum leaf length (29.75 cm) was obtained with treatment combination M_2T_3. The minimum leaf length (20.17 cm) was found under the treatment combination M_2T_0. This might be due to the effects of combined doses of micronutrients, which increased the vegetative growth of potato plants.

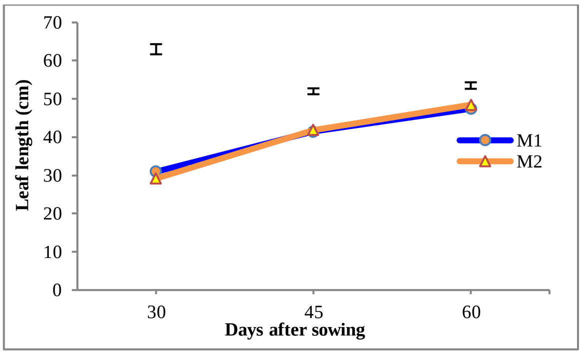

Figure 7. Effect of methods of application of micronutrients on length of leaf of potato plant at different days after sowing. Vertical bars represent LSD at 1% level of significance. M_1= Basal application, M_2 = Foliar application.

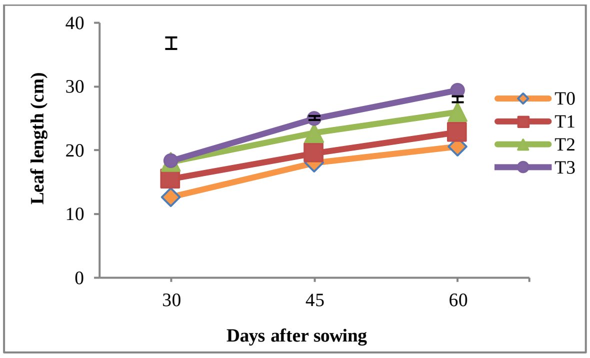

Figure 8. Effects of different levels of micronutrients on length of potato plant at different days after sowing. Vertical bars represent LSD at 1% level of significance. T_0=Control treatment, T_1= Boron (B) @ 2 kg/ha, T_2= Zinc (Zn) @ 3 kg/ha, T_3= B @ 2 kg/ha + Zn @ 3 kg/ha.

Diameter of leaf

Analysis of variance revealed that the effects of micronutrient and their application method significantly influenced the diameter of leaves (Figure 9-10, Table 3). Maximum diameter of leaf (20.15 cm) was obtained from foliar treatment and that of the minimum (17.92 cm) was from basal treatment (Figure 9) at 60 days after sowing. The highest diameter of leaves (22.58 cm) was obtained from combination of boron and zinc treatment (T_3) and the lowest diameter of leaf (16.75 cm) was obtained from control treatment (T_0) (Figure 10) at 60 days after sowing. Maximum diameter of leaf (24.00 cm) was produced in M_2T_3 treatment and that of the lowest (14.92 cm) in M_1T_0 treatment (Table 3) at 60 days after sowing.

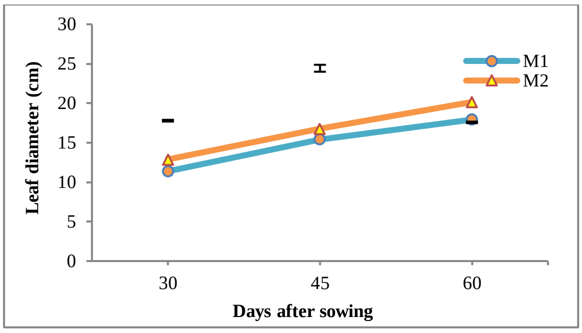

Figure 9. Effect of methods of application of micronutrients on diameter of leaf of potato plant at different days after sowing. Vertical bars represent LSD at 1% level of significance. M_1= Basal application, M_2 = Foliar application.

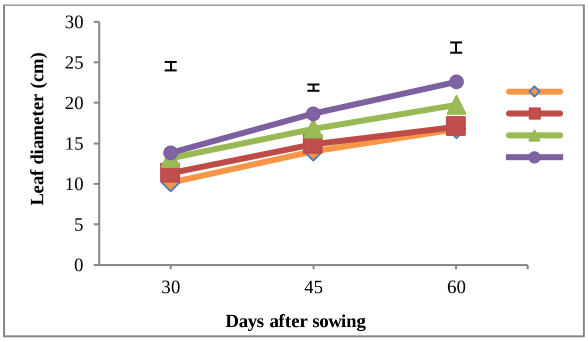

Figure 10. Effects of different levels of micronutrients on diameter of leaf of potato plant at different days after sowing. Vertical bars represent LSD at 1% level of significance. T_0= Control treatment, T_1= Boron (B) @ 2 kg/ha, T_2= Zinc (Zn) @ 3 kg/ha, T_3= B @ 2 kg/ha + Zn @ 3 kg/ha.

Table 3. Combined effects of micronutrients and their methods of application on leaf diameter and tuber yield of potato at different days after sowing (DAS).

Treatment combination	Leaf diameter (cm) at different DAS			Tuber yield (t/ha)
	30	45	60	
M_1T_0	9.50	12.33	14.92	1.78
M_1T_1	11.50	14.67	16.67	3.33
M_1T_2	10.92	16.58	18.92	2.89
M_1T_3	13.58	18.08	21.17	4.22
M_2T_0	10.83	15.67	18.58	2.00
M_2T_1	11.17	15.08	17.42	3.56
M_2T_2	15.42	17.08	20.58	3.67
M_2T_3	14.08	19.25	24.00	4.89
$LSD_{0.05}$	0.84	0.63	1.01	0.14
$LSD_{0.01}$	1.18	0.88	1.42	0.19
Level of significance	**	**	**	**

** = Significant at 1% level of probability, respectively. M_1= Basal application, M_2 = Foliar application. T_0= Control treatment, T_1= Boron (B) @ 2 kg/ha, T_2= Zinc (Zn) @ 3 kg/ha, T_3= B @ 2 kg/ha + Zn @ 3 kg/ha.

Yield of tuber (t/ha)

Yield of potato tuber per hectare was influenced by application method and various levels of micronutrients (Figure 11-12, Table 3). The yield per hector was calculated from per plot yield and was expressed in ton per hector. The yield per hector of tuber increased significantly by application methods (Figure 11). The highest yield of tuber (3.53 t/ha) was recorded with the foliar treatment and the lowest yield of tuber (3.06 t/ha) was obtained in basal treatment. Al-Fadhly (2016) narrated that, foliar application of Zn+Mn at vegetative growth stage increased mean weight of potato tuber, tuber yield per plant and total tubers yield. The yield of tuber also increased significantly by the application of different level of micronutrient (Figure 12). The highest yield (4.56 t/ha) was obtained in T_3 treatment, while the minimum yield (1.89 t/ha) was obtained in T_0 treatment (Figure 12). Parmar *et al.* (2016) revealed that, the main effect of Zn 15 ppm and Mn 6 ppm was significantly superior with respect to various yield and quality attributes. The combined effects of different application methods and different level of micronutrient on yield of tuber of potato were significant (Table 3). Maximum yield (4.89 t/ha) was produced at M_2T_3 treatment combination while the lowest yield (1.78 t/ha) was obtained from treatment combination M_1T_0 (Table 3). Ewais *et al.* (2010) stated that, most vegetative growth parameters were significantly increased by foliar spraying of potato plants with micronutrients and led to improve the tuber quality parameters i.e. all carbohydrate fractions, the protein of tuber, the tuber weight and total tuber yield as compared with the control.

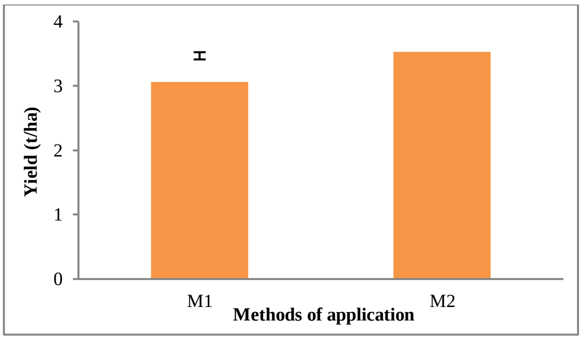

Figure 11. Effect of methods of application of micronutrients on yield of potato. Vertical bar represents LSD at 1% level of significance. M_1= Basal application, M_2 = Foliar application.

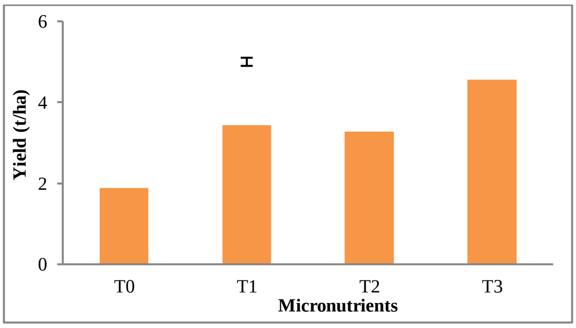

Figure 12. Effects of different levels of micronutrients on diameter of leaf of potato plant at different days after sowing. Vertical bars represent LSD at 1% level of significance. T_0= Control treatment, T_1= Boron (B) @ 2 kg/ha, T_2= Zinc (Zn) @ 3 kg/ha, T_3= B @ 2 kg/ha + Zn @ 3 kg/ha.

Conclusion

Results showed that the micronutrients and their application methods showed significant effects on growth and yield of potato. Growth parameter such as plant height, number of leaves, number of tiller per plant, length and diameter of leaves were responsive to foliar application of micronutrients. Yield was highly responded to boron as well as zinc, hence judicial application of boron and zinc may provide higher yield. The highest yield (4.89 t/ha) was obtained by the foliar application of micronutrient @ 2 kg B/ha + 3 kg Zn/ha. Therefore, combined application of boron and zinc in foliar application method was found to be better in respect of optimum growth and yield of potato.

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