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Effect of Micronutrients in Presence of Different Levels of Organic Manure on Growth and Yield of Tomato (*Solanum lycopersicum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors KK and TM planned the experiment and lead the research. Authors KK and JA designed and carried out the research. Authors MEH performed the statistical analysis. Authors JA, BRB, MNI and MRI collected the data. Authors JA, MEH and MA wrote the manuscript. Authors JA, BRB, MNI and MRI managed the literature searches. All authors provided critical feedback and helped in shape the research, analysis and manuscript. All authors read and approved the final manuscript

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ABSTRACT

A field experiment was conducted at the Horticultural Farm of Sher-e–Bangla Agricultural University, Dhaka from October, 2017 to March, 2018 to study the effect of micronutrients in presence of different level of organic manure on growth and yield of tomato. There were four combinations of micronutrients viz. N_0=0 kg Zn 0 kg B/ha, N_1= Zn_2 kg $B_{1.5}$ kg/ha, N_2=Zn_4 kg B_2 kg/ha, N_3=Zn_6kg $B_{2.5}$ kg/ha and four organic manure viz M_0=0 ton/ha, M_1=Cowdung (15 ton/ha), M_2=Poultry manure (10 ton/ha), M_3=(Cowdung 7.5 ton/ha+ Poultry manure 5 ton/ha). The

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experiment was laid out in a Randomized Complete Block Design with 3 replications and there were altogether 48 plots. Application of micronutrients and organic manure significantly influenced the growth, yield and size of the tomato. The highest yield (66.96 t/ha) was found from treatments N_2 and the lowest yield (25.69 t/ha) was obtained from treatment N_0. Due to the application of organic manure, the highest yield (50.78 t/ha) was obtained from M_3 and the lowest yield (39.86 t/ha) was recorded from M_0. In the case of combined effect, the highest yield (76.33 t/ha) was found from treatment N_2M_3 and the lowest yield (24.60 t/ha) was found from treatment N_0M_0. So, the application of Zn_4 kg B_2 kg/ha along with Cowdung 7.5 ton+Poultry manure 5 ton/ha was the best for growth and yield of tomato. Economic analysis raveled that N_2M_3 gave the maximum benefit-cost ratio (3.2). So, the application of Zn_4 kg B_2 kg/ha along with Cowdung 7.5 ton+Poultry manure 5 ton/ha was the best for growth and yield of tomato.

Keywords: Benefit cost ratio (BCR); boron; growth; organic manure; yield.

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L) is one of the most important vegetable crops grown throughout the world including Bangladesh and belongs to the Solanaceae family. Tomato is cultivated in almost all over the country for its adaptability to a wide range of soil and climate in Bangladesh [1]. Tomato ranks next to potato and sweet potato in respect of vegetable production in the world [2]. It ranks fourth in respect to production and third in respect of area in Bangladesh [3]. The largest tomato producing countries of the world are China, The United States of America, India, Egypt, Turkey, Iran, Italy, Mexico, Brazil and Indonesia [4]. The popularity and different products of tomato are increasing day by day. Tomato is a very valuable crop because of higher contents of vitamins A, B and C with Ca and carotene [5]. It is also popular for its medicinal value. Tomato is a major component in the daily diet and can be used in making soups, pickles, ketchup, sauces, juices etc. The well ripped tomato (edible portion/100g) contains water (94.1%); energy (23 calories); Ca (1.0 gm); Mg (7.0 mg); vitamin A (1000 IU); ascorbic acid (22 mg); thiamin (0.09 mg); riboflavin (0.03 mg); niacin (0.8 mg) [6]. In Bangladesh, the yield of tomato is not enough satisfactory in compare to other tomato growing countries of the World [7]. The cultivated area under tomato in Bangladesh was 75602 acre and total production was 413610 metric tons during the year 2014-2015 [3].The low yield of tomato in Bangladesh is due to the use of poor yielding varieties and improper cultural practices and now it is considered as one of the major problems to successful upland crop production in Bangladesh [8]. For better yield, the cultivation of tomato requires the proper supply of plant nutrient. Sufficient supply of nutrient can improve the yield, fruit quality, fruit size, keeping quality, colour and taste of tomato [9]. Since the land is limited in Bangladesh, it is important to increase the yield of any crop. Though the effects of different on the yield of tomato were studied earlier, the effect of micronutrients and organic manure on growth and yield of tomato were not studied in detail so for in Bangladesh. Among the micronutrients, zinc and boron play an important role in improving the yield and quality of tomato in addition to checking various diseases and physiological disorders [10]. Zinc (Zn) is another important essential micronutrient that helps in the formation of tryptophan, a precursor of IAA responsible for growth stimulation [11] and plays a vital role in the synthesis of carbonic anhydrase enzyme which helps in the transport of CO_2 in photosynthesis [12]. Zinc deficiency causes shorter and thinner internodes, stunted growth, the appearance of chlorotic flecks on the older leaves and twisting of leaf borders in upward direction and plant with abnormal features [13]. The zinc deficiency may be due to soil deficient in Zn, competition with Ca, Mn, Fe, P, to some degree K, and soil properties that influence Zn availability [14]. Boron has a pronounced effect on the production and quality of tomato. Boron is needed by the crop plants for cell division, nucleic acid synthesis, uptake of calcium and transport of carbohydrates [15] Boron also plays an important role in flowering and fruit formation [16]. Adequate levels of Boron help to maintain leaf K levels in tomato during fruit development [17]. Boron has a major influence on the plasma membrane of plant cells and ion transport and those B amendments increased Calcium, and Mg levels [18]. Boron deficiency affects the growing points of roots and youngest leaves. The leaves become wrinkled and curled with a light green color. Its deficiency affects the translocation of sugar, starches, nitrogen and phosp horus, synthesis of amino acids and proteins [19]. In boron deficient plants the youngest leaves become pale green, losing more color at the base than at the tip. Boron deficiency symptoms will often appear in the form of thickened wilted or curled leaves, a thickened, cracked, or water-soaked condition of petioles and stems, and discoloration, cracking or rotting of fruit, tubers or roots [20]. The improvement in quality parameters of tomato fruit due to boron application could be the result of the overall growth and development of the crop [21]. To improve texture, structure, hummus, color, aeration, water holding capacity and microbial activity of soil used by the proper amount of organic manure such as cow dung, poultry manure. In our country, the soils of most regions have less than 1.5%, some soils even have less than one percent organic matter [22]. Organic manure has the largest effect on yield and quality of tomato. It also improves the vegetative growth, flowering and fruit set of tomato. The increase in vegetative growth of tomato could be attributed to physiological role of organic manure and its involvement in the metabolism of protein, synthesis of pectin, maintaining the water relation within the plant, resynthesis of ATP and translocation of sugar at the development of the flowering and fruiting stages [15]. For better growth of tomato, a large amount of organic manure is required [23]. Cow dung also contains beneficial bacteria, which convert nutrients into easily accessible forms so they can be slowly released without burning tender plant roots. Poultry manure contains a high % of N and P for the healthy growth of plants [24]. The physical properties of the soil improved by the application of poultry manure. poultry manure improves the fertility of the cultivated soil by increasing the organic matter content, water holding capacity, oxygen diffusion rate and the aggregate stability of the soils [25,26]. Large quantities of poultry manure are available especially in urban centers and it is an effective source of nutrients for vegetables such as tomato [27].

2. MATERIALS AND METHODS

2.1 Experimental Site

The field experiment was conducted in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka-1207 from October, 2017 to March, 2018. The location of the experimental site was at 23.75^0N latitude and 90.34^0E longitudes with an elevation of 8.45 meter from the sea level in Agro-ecological zone of "Madhupur Tract" (AEZ-28). The soil was sandy loam in texture having pH 5.46- 5.62 and EC 0.60 dS/m.

2.2 Experimental Treatment

The two-factor experiment consisted of four levels of micronutrients (Factor A) N_0=0 kg Zn 0 kg B/ha, N_1= Zn_2 kg $B_{1.5}$ kg/ha, N_2=Zn_4 kg B_2 kg/ha, N_3=Zn_6kg $B_{2.5}$ kg/ha and four levels of organic manure (Factor B). M_0 = 0 ton/ha, M_1 = Cowdung (15 ton/ha), M_2 =Poultry Manure (10 ton/ha), M_3 = Cowndung 7.5 ton + Poultry Manure 5 ton/ha. The experiment was laid out in Randomized Complete Block Design (RCBD) having two factors with three replications. An area of 30.8 m x 7.6 m was divided into three equal blocks. Each block consists of 16 plots where 16 treatments were allotted randomly. There were 48 unit plots in the experiment. The size of each plot was 1.5 m x 2 m. The distance between two blocks and two plots were kept 0.4 m and 0.4 m respectively.

2.3 Application of Micronutrients and Organic Manure

The entire amounts of N_1.N_2.N_3 were applied during the final land preparation. The entire amounts of M_1, M_2 and M_3 were applied during the final land preparation (Table 1).

2.4 Statistical Analysis

The recorded data on different growth and yield parameters were calculated for statistical analysis. Analyses of variances (ANOVA) for most of the characters under consideration were performed with the help of MSTAT program. Treatment means were separated by Duncan's Multiple Range Test (DMRT) at 5% level of significance for interpretation of the results.

2.5 Economic Analysis

The cost of production was analyzed in order to find out the most economic treatment of micronutrients and organic manure. All input cost included the cost for lease of land and interest on running capital in computing the cost of production. The interest was calculated @ 13% in simple interest rate [28]. The market price of tomato was considered for estimating the cost and return. Analyses were done according to the procedure determining by [29]. The benefit cost ratio (BCR) was calculated as follows:

BCR = Gross return per hectare (Tk.) ÷ Cost of production per hectare (Tk.)

Table 1. Doses of nutrients application in the main field as per treatment were applied during the final land preparation

Treatments	Zinc	Boron	Treatments	Cowdung	Poultry manure
N_0	0 kg/ha	0 kg/ha	M_0	0 ton/ha	0 ton/ha
N_1	2 kg/ha	1.5 kg/ha	M_1	15 ton/ha	0 ton/ha
N_2	4 kg/ha	2 kg/ha	M_2	0 ton/ha	10 ton/ha
N_3	6 kg/ha	2.5 kg/ha	M_3	7 .5 ton/ha	5 ton/ha

3. RESULTS AND DISCUSSION

3.1 Plant Height

Plant height was measured starting from 25 days after transplanting. It was measured 20 days interval and continued up to 65 DAT. At 25 DAT, the maximum plant height (51.82 cm) was observed from N_2 (Zn_4 B_2 kg/ha) treatment and minimum plant height (44.13 cm) was observed from N_0 (0 kg/ha) treatment. At 45 DAT, the maximum plant height (83.42 cm) was observed from N_2 treatment and minimum plant height (73.42 cm) was observed from N_0 (0 kg/ha) treatment. At 65 DAT, the maximum plant height (95.60 cm) was observed from N_2 treatment and minimum plant height from N_0 (82.86 cm) treatment in Fig. 1. Dube *et al.* [30] founded the soil application of zinc sulphate and borax @ 10 and 20 kg/ha, respectively in combination with their foliar spray @ 0.5% and 0.3%, respectively where most effective in improving plant height. Marked variation was observed among treatments as to the plant height of tomato due to the application of different levels of organic manure at 25, 45 and 65 DAT (Fig. 2). At 25 DAT, the maximum plant height (52.31cm) was observed from M_3 (Cowdung 7.5 ton+Poultry manure 5 ton/ha) treatment and control treatment (M_0) gave the minimum plant height (44.20 cm) treatment. At 45 DAT, the maximum plant height (82.82 cm) was observed from M_3 treatment M_2 (80.77 cm) and minimum plant height M_0 (75.31cm) treatments. At 65 DAT, the maximum plant height (93.22 cm) was observed from M_3 and minimum plant height (85.77 cm) was observed from M_0 treatment. The reason for higher plant height might be explained in the way that the favorable soil condition influence of balanced uptake of nutrients, which were applied, [24] observed the similar result. The combined Effect of micronutrients and organic manure showed statistically significant variation on plant height at 25, 45 and 65 DAT (Table 3). At 25 DAT, the maximum plant height (57.50 cm) was obtained from N_2M_3 (Zn_4B_2 kg/ha with Cowdung 7.5 ton+Poultry manure 5 ton/ha) and control treatment (N_0M_0) treatment gave the minimum plant height (40.50 cm) which. At 45 DAT, the maximum plant height (89.20 cm) was obtained from N_2M_3.The control treatment (N_0M_0) gave the maximum plant height (70.00 cm).At 65 DAT, the maximum plant height (100.00cm) was obtained from N_2M_3 and control treatment (N_0M_0) gave the minimum plant height (81.25 cm) which similar to N_0M_1(82.00 cm) treatment.

3.2 Number of Leaves Per Plant

No of leaves per plant of tomato varied significantly due to the application of different levels of micronutrients at 25, 45, and 65 DAT (Fig. 3). At 25 DAT, the maximum number of leaves (12.10) was observed in N_2 (Zn_4 B_2 kg/ha) and minimum number of leaves per plant (7.83) was observed in N_0 (0 kg/ha) treatments. At 45 DAT, the maximum number of leaves per plant (25.31) was observed from N_2. The minimum number of leaves per plant (19.15) was observed from N_0 treatment. At 65 DAT, the maximum number of leaves per plant (33.17) was observed from N_2 and minimum number leaves N_0 (27.58) treatment. Oyinlola [31] reported that application of boron significantly increased the number of leaves on tomato plant compared to control. Ejaz et al. [32] found similar result. Number of leaves per plant of tomato varied significantly due to the application of different levels of organic manure at 25, 45, and 65 DAT of (Fig. 4). At 25 DAT, the maximum number of leaves (11.61) was observed from M_3 (Cowdung 7.5 ton +Poultry manure 5 ton/ha) and minimum number of leaves per plant (8.53) was observed from M_0 (0 ton/ha) treatment. At 45 DAT, the maximum number of leaves per plant (24.21) was observed in M_3. The minimum number of leaves per plant (20.43) was observed from M_0. At 65 DAT, the maximum poultry manure 5 ton/ha) and minimum number of leaves per plant (33.51) was observed from M_2 and minimum number leaves M_0 (27.91) .Combined effect micronutrients and organic manure showed statistically significant variation on number of leaves per plant at 25, 45 and 65

DAT (Table 3). At 25 DAT, the maximum number of leaves per plant (15.10) was obtained from N_2M_3 (Zn_4B_2 kg/ha with Cowdung7.5 ton+Poultry manure 5 ton/ha) and control treatment (N_0M_0) gave the minimum number of leaves per plant (7.25). At 45 DAT, the maximum no of leaves per plant (27.95) was obtained from N_2M_3. .The control treatment (N_0M_0) gave the minimum no of leaves per plant (17.40 cm). At 65 DAT, the maximum number of leaves per plant (36.80 was obtained from N_2M_3 .The control treatment (N_0M_0) gave the minimum number of leaves per plant (25.50). From the result present study it can be conducted that the treatment N_2M_3 provided better growing condition perhaps to supply of adequate plant nutrients, resulting in the number of leaves per plant.

3.3 Number of Branches per Plant

Number of branches per plant of tomato varied significantly due to the application of different levels of micronutrients at 45 and 65 DAT (Table 2). At 45 DAT, the maximum number of branches per plant (5.06) was observed from N_2 (Zn_4 B_2 kg/ha) and minimum number of branches per plant (3.55) was observed in from N_0 (0 kg/ha) treatment. At 65 DAT, the maximum number of branches per plant (5.72) was observed from N_2 treatment. The minimum number of branches per plant (4.46) was observed from N_0, Amrachandra and Verma [33] stated similar findings. Number of branches per plant of tomato was found significantly influences due to the application of different levels of organic manure at 45 and 65 DAT (Table 2). At 45 DAT, the maximum number of branches (4.77) was observed from M_3 (Cowdung 7.5 ton/ha+Poultry manure 5 ton/ha) and minimum number of branches per plant (3.70) was observed in M_0 (0 ton/ha) treatment. At 65 DAT, the maximum no of branches per plant (5.89) was observed in M_3. The minimum number of branches per plant (4.78) was observed from M_0 treatment. The combined effect of micronutrients and organic manure showed statistically significant variation on the number of branches per plant at 45 and 65 DAT (Table 4). At 45 DAT, the maximum number of leaves per plant (6.05) was obtained from N_2M_3(Zn_4B_2 kg/ha with Cowdung 7.5 ton/ha+Poultry manure 5 ton/ha) and control treatment (N_0M_0) gave the minimum number of branches per plant (3.15) At 65 DAT, the maximum number of branches per plant (7.25) was obtained from N_2M_3 which. The control treatment (N_0M_0) gave the minimum number of branches per plant (4.10), this might be due to the fact that balanced uptake and influences of nutrients which improve of vegetative growth. Organic manure improved physical conditions of the soil, which increase the water holding capacity and better nutrients availability and uptake by the crop.

3.4 Number of Flowers per Plant

Remarkable differences were observed among the micronutrients application of different levels of micronutrients at 45 and 65 DAT (Table 2). AT 45 DAT, the maximum number of flower per plant (20.73) was observed from N_2 (Zn_4 B_2 kg/ha) and minimum number of flowers per plant (10.56) was observed from N_0 (0 kg/ha).At 65 DAT, the maximum number of flowers per plant (84.60) was observed from treatment N_2 .The minimum number of flowers per plant (27.53) was observed in treatment N_0, Ejaz et al. [32] reported similar result. Number of flowers per plant of tomato varied significantly due to the application of different concentrations of organic manure at 45 and 65 DAT (Table 2). At 45 DAT, the maximum number of flowers per plant (18.68) was observed from M_3 (Cowdung 7.5 ton/ha+Poultry manure 5 ton/ha) and minimum number flowers per plant (12.03) was observed from M_0 (0 ton/ha) treatment. At 65 DAT, the maximum number of flowers per plant (65.15) was observed in treatment M_3. The minimum number of flowers per plant (39.81) was observed from treatment $M_{0.}$

The combined effect of micronutrients and organic manure showed statistically significant variation on number of flower per plant at 45 and 65 DAT (Table 4). At 45 DAT, the maximum number of flowers per plant (24.00) was obtained from N_2M_3 (Zn_4B_2 kg/ha with Cowdung7.5 ton/ha+Poultry manure 5 ton/ha) and control treatment (N_0M_0) gave the minimum no of flowers per plant (9.25). At 65 DAT, the maximum number of flowers per plant (98.80) was obtained from treatment $N_2M_{3.}$The control treatment (N_0M_0) gave the minimum no of flowers per plant (20.50).

3.5 Number of Fruits Per Plant

Significant variation was noted regarding the number of fruits per plant of tomato due to the application of different levels of micronutrients at 45 and 65 DAT (Table 5). AT 45 DAT, the maximum number of fruit per plant (5.61) was observed from N_2 (Zn_4 B_2 kg/ha) and minimum number of fruits per plant (1.18) was observed from N_0 (0 kg/ha) treatment .At 65 DAT, the maximum number of fruits per plant (34.80) was observed from treatment N_2.The minimum number of fruits per plant (17.68) was observed from treatment N_0, Ejaz et al. [32] reported the similar result. The number of fruits per plant of tomato varied significantly due to the application of different concentrations of organic manure at 45 and 65 DAT (Table 5). At 45 DAT, the maximum number of fruits per plant (3.79) was observed from M_3 (Cowdung7.5 ton+Poultry manure 5 ton/ha) which was statistically similar to M_2 (3.47) and minimum number fruits per plant (2.65) treatment was observed in M_0 (0 ton/ha). At 65 DAT, the maximum number of fruit per plant (26.57) was observed from treatment M_0 (control). Solaiman and Rabbani [34] reported similar result. The combined effect of micronutrients and organic manure showed statistically significant variation on number of fruit per plant at 45 and 65 DAT (Table 6). At 45 DAT, the maximum number of fruit per plant (6.75) was obtained from N_2M_3 (Zn_4B_2 kg/ha with Cowdung7.5 ton+Poultry manure 5 ton/ha) and control treatment (N_0M_0) gave the minimum number of fruits per plant (0.95). At 65 DAT, the maximum number of fruit per plant (36.80) was obtained from N_2M_3 treatment. The control treatment (N_0M_0) gave the minimum number of fruits per plant (15.70).

3.6 Brix%

Brix% of tomato varied significantly due to the application of different levels of micronutrients (Table 4). The highest Brix% of fruit (5.86) was observed from N2 (Zn4 B_2 kg/ha) and lowest brix% of fruit (3.61) was observed from N0 (0 kg/ha) treatment. Brix% of tomato varied significantly due to the application of different levels of organic manure (Table 5). The highest brix% of fruit (6.55) was observed in M3 (Cowdung7.5 ton+Poultry manure 5 ton/ha) and lowest brix% fruit (2.88) was observed from M_0 (0 ton/ha). The combined effect of micronutrients and organic manure showed statistically significant variation on brix% of fruit (Table 6). The highest brix% of fruit (8.60) was obtained from N_2M_3 (Zn4B2) kg/ha With Cowdung7.5 ton+Poultry manure 5 ton/ha) and control treatment (N_0M_0) gave the lowest brix% of fruit (2.55).

3.7 Dry Matter Contents in Fruit (%)

Diverse variation was seen as to the dry matter content of tomato due to the application of different levels of micronutrients (Table 5). The highest dry matter of fruit (5.95) was observed from N_2 (Zn_4 B_2 kg/ha) treatment and lowest dry matter of fruit (2.31) was observed from N_0 (0 kg/ha) treatment. Salam et al. [35] reported similar result. Dry matter content of tomato varied significantly due to the application of different concentrations of organic manure Table 4. The highest dry matter of fruit (4.77) was observed in M_3 (Cowdung 7.5 ton+Poultry manure 5 ton/ha) and lowest dry matter of fruit (3.42) was observed from M_0 (0 ton/ha)

Table 2. The effect of different levels of micronutrients and organic manure on number of branches per plant of tomato of at different days after transplanting

Treatments	Number of branch per plant		No of flowers per plant	
	45 DAT	65 DAT	45 DAT	65 DAT
Micronutrients				
N_0	3.55	4.46	10.56	27.53
N_1	3.92	4.79	13.63	39.51
N_2	5.06	6.51	20.73	84.60
N_3	4.53	5.72	17.42	57.82
CV%	10.68	11.58	9.27	9.56
LSD (0.05)	0.25	0.25	2.14	2.21
Organic manure				
M_0	3.70	4.78	12.03	39.81
M_1	4.12	5.17	14.59	47.97
M_2	4.47	5.63	17.04	56.53
M_3	4.77	5.89	18.68	65.15
CV%	10.68	11.58	9.27	9.56
LSD (0.05)	0.21	0.30	1.08	2.57

Means, in a column followed by same letter do not differ significantly at 5% level
N_0=0 kg/ha , N_1=$Zn_2B_{1.5}$ kg/ha, N_2=Zn_4B_2 kg/ha, N_3=$Zn_6B_{2.5}$ kg/ha, M_0=0 ton/ha, M_1=Cowdung (15 ton/ha), M_2=Poultry manure (10 ton/ha), M_3=CD+PM (7.5+5 ton/ha)

Table 3. The combined effect of different levels of micronutrients and organic manure on the plant height (cm), number of leaves per plant of tomato at different days after transplanting

Treatments	Plants height cm			No of leaves/ plant		
	25 DAT	**45 DAT**	**65 DAT**	**25 DAT**	**45 DAT**	**65 DAT**
N_0M_0	40.50	70.00	81.25	7.25	17.40	25.50
N_0M_1	43.30	72.70	82.00	7.60	18.20	26.90
N_0M_2	45.25	74.50	82.80	8.05	20.15	27.45
N_0M_3	47.50	76.50	85.40	8.45	20.85	30.50
N_1M_0	44.00	74.00	85.30	8.35	18.90	27.50
N_1M_1	45.90	76.80	86.00	9.45	21.60	29.30
N_1M_2	47.95	79.90	87.75	10.05	22.50	32.00
N_1M_3	50.05	80.80	90.75	10.50	22.95	32.45
N_2M_0	46.55	78.00	90.25	9.50	23.20	29.60
N_2M_1	50.00	81.20	94.30	11.30	24.30	32.10
N_2M_2	53.25	85.30	97.35	12.50	25.80	34.20
N_2M_3	57.50	89.20	100.50	15.10	27.95	36.80
N_3M_0	45.75	79.25	86.30	9.05	22.15	29.05
N_3M_1	47.50	80.10	88.75	10.40	23.10	30.30
N_3M_2	51.80	83.40	91.45	12.10	24.00	33.20
N_3M_3	54.20	84.80	96.50	12.40	25.10	34.30
CV%	7.41	8.67	8.25	9.98	8.16	10.97
LSD (0.05)	3.82	3.56	1.31	0.76	4.69	4.04

Means, in a column followed by same letter do not differ significantly at 5% level
N_0=0 kg/ha , $N_1=Zn_2B_{1.5}$ kg/ha, $N_2=Zn_4B_2$ kg/ha, $N_3=Zn_6B_{2.5}$ kg/ha, M_0=0 ton/ha, M_1=Cowdung (15 ton/ha), M_2=Poultry manure (10 ton/ha), M_3=CD+PM (7.5+5 ton/ha)

treatment. The combined effect of micronutrients and organic manure showed statistically significant variation on dry matter of fruit Table 6. The highest dry matter of fruit (7.00) was obtained from N_2M_3 (Zn_4B_2 kg/ha with Cowdung7.5 ton+Poultry manure 5 ton/ha) and control treatment (N_0M_0) gave the lowest dry matter of fruit (2.05).

Table 4. The combined effect of different levels of micronutrients and organic manure on number of branches, no of flowers per plant of tomato at different days after transplanting

Treatments	No of branches		No of flowers per plant	
	45 DAT	**65 DAT**	**45 DAT**	**65 DAT**
N0M0	3.15	4.1	9.25	20.5
N0M1	3.45	4.3	9.55	24.75
N0M2	3.7	4.6	10.5	31
N0M3	3.9	4.85	12.95	33.9
N1M0	3.7	4.25	9.74	31.75
N1M1	3.9	4.75	12.34	36.63
N1M2	4	5.05	15.17	40
N1M3	4.1	5.14	17.27	49.68
N2M0	4.05	5.7	16.05	64.5
N2M1	4.7	6.25	19.3	80.6
N2M2	5.45	6.85	23.6	94.5
N2M3	6.05	7.25	24	98.8
N3M0	3.9	5.1	13.1	42.5
N3M1	4.45	5.4	17.2	49.9
N3M2	4.75	6.05	18.9	60.65
N3M3	5.05	6.35	20.5	78.25
CV%	10.68	11.58	9.27	9.56
LSD (0.05)	0.51	0.59	4.28	4.42

Means, in a column followed by same letter do not differ significantly at 5% level
N_0=0 kg/ha , $N_1=Zn_2B_{1.5}$ kg/ha, $N_2=Zn_4B_2$ kg/ha, $N_3=Zn_6B_{2.5}$ kg/ha, M_0=0 ton/ha, M_1=Cowdung (15 ton/ha), M_2=Poultry manure (10 ton/ha), M_3=CD+PM (7.5+5 ton/ha)

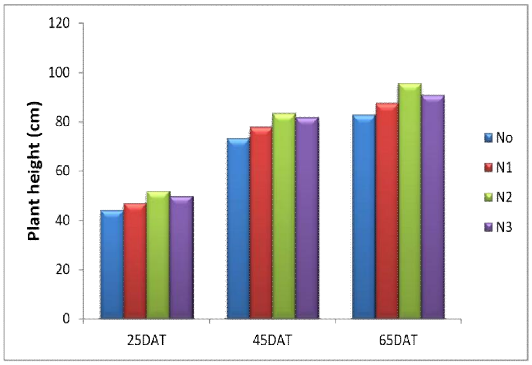

Fig. 1. Graphical representation of treatment (N_0 to N_3) and plant height in 25, 45 and 65 DAT

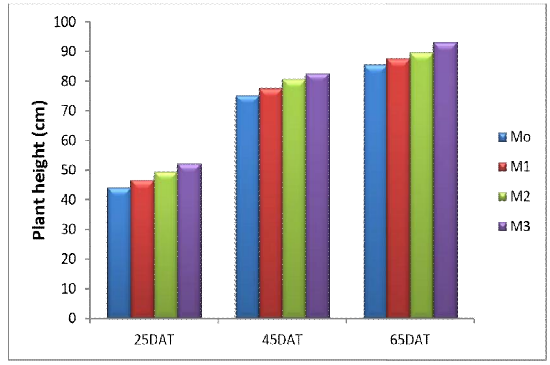

Fig. 2. Graphical representation of treatment (M_0-M_3) and plant height in 25, 45 and 65 DAT

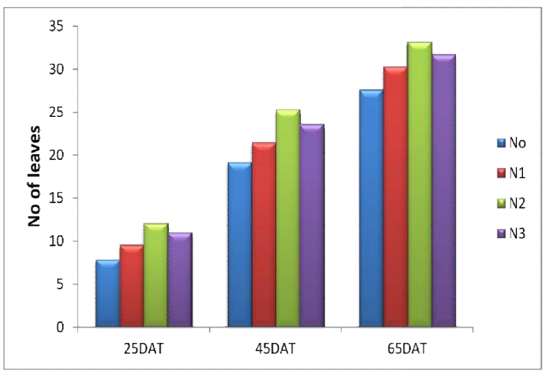

Fig. 3. Graphical representation of treatment (N_0 to N_3) and no. of leaves in 25, 45 and 65 DAT

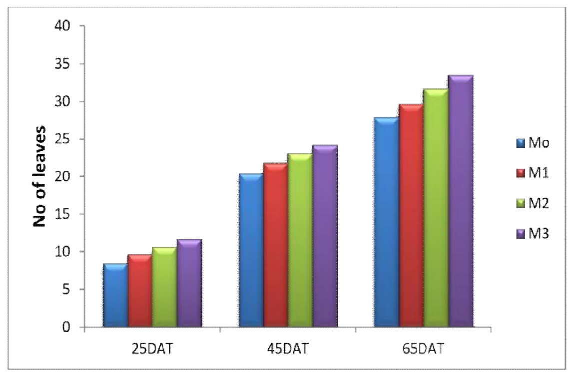

Fig. 4. Graphical representation of treatment (M_0-M_3) and no. of leaves in 25, 45 and 65 DAT

Table 5. The effect of different levels of micronutrients and organic manure on the number of fruits per plant, individual fruit weights, brix%, Dry matter contents in fruit % of tomato at different days after transplanting

Treatments	Number of fruits per plant		Individual fruit weight(g)	Brix%	Dry matter contents in fruit(%)
	45 DAT	65 DAT			
Micronutrients					
N_0	1.18	17.68	85.76	3.61	2.31
N_1	2.47	21.75	92.04	4.42	3.24
N_2	5.61	34.80	104.71	5.86	5.95
N_3	3.71	27.01	100.66	5.45	4.85
CV%	9.37	10.42	9.31	7.17	11.74
LSD(0.05)	0.48	2.02	2.01	0.46	0.15
Organic manure					
M_0	2.65	23.90	86.74	2.88	3.42
M_1	3.07	25.04	92.48	3.68	3.80
M_2	3.47	25.72	98.96	6.22	4.36
M_3	3.79	26.57	105.00	6.55	4.77
CV%	9.37	10.42	9.31	7.17	11.74
LSD(0.05)	0.43	0.64	2.67	0.43	0.22

Table 6. The combined effect of different levels of micronutrients and organic manure on the number of fruits per plant, individual fruit weights, brix%, Dry matter contents in fruit % of tomato at different days after transplanting

Treatments	Number of fruits per plant		Individual fruit weight(g)	Brix%	Dry matter contents in fruit (%)
	45 DAT	65 DAT			
N_0M_0	0.95	15.70	78.95	2.55	2.05
N_0M_1	1.01	17.82	83.00	3.50	2.18
N_0M_2	1.39	18.10	87.45	4.05	2.37
N_0M_3	1.40	19.10	93.65	4.35	2.64
N_1M_0	1.99	20.40	84.20	2.70	2.79
N_1M_1	2.47	21.75	90.15	3.75	2.95
N_1M_2	2.50	22.25	94.85	4.75	3.40
N_1M_3	2.95	22.60	98.95	6.50	3.85
N_2M_0	4.65	33.18	93.70	3.05	5.00
N_2M_1	5.10	33.94	99.95	3.75	5.60
N_2M_2	5.95	35.30	107.80	8.05	6.20
N_2M_3	6.75	36.80	117.40	8.60	7.00
N_3M_0	3.04	26.35	90.10	3.25	3.85
N_3M_1	3.70	26.65	96.80	3.75	4.50
N_3M_2	4.05	27.25	105.75	8.00	5.47
N_3M_3	4.08	27.80	110.00	6.75	5.60
CV%	9.37	10.42	9.31	7.17	11.74
LSD (0.05)	0.97	2.04	2.03	0.93	0.31

3.8 Fruit Yield Per Plot (kg)

The yield of fruits per plot differs noticeably as to different levels of micronutrients (Fig. 5). The highest yield/plot (20.09 kg) was observed from N_2 (Zn_4 B_2 kg/ha) and lowest yield/plot (7.70kg) was observed from N_0 (0 kg/ha) treatment. Fruit yield per plot of tomato varied significantly due to the application of different levels of organic manure (Fig. 6). The highest yield/plot (15.23 kg) was observed from M_3 (Cowdung 7.5 ton+Poultry manure 5 ton/ha) and lowest yield/plot (11.95kg) was observed from M_0 (0 ton/ha) treatment. The combined effect micronutrients and organic manure showed statistically significant variation on yield/plot (Table 7). The highest yield /plot (22.90 kg) was obtained from N_2M_3 (Zn_4B_2 kg/ha with Cowdung7.5 ton+Poultry manure ton/ha), on the other hand, control treatment (N_0M_0) gave the lowest yield/plot (7.38kg). Fruit yield per plant significantly affected as to combindly application of micronutrients and organic manure. It has observed that the minimum fruit yield per plant was found from without micronutrients and organic manure (Table 7). The possible reason for higher fruit yield per plant might be due to higher number of fruits per plant, bigger fruit size and fruit weight. Dube et al. [30] found the highest tomato yield with the soil application of micronutrients.

3.9 Fruit Yield per Hectare

Yield of tomato per hectare varied significantly due to the application of different levels of micronutrients (Fig 7) .The highest yield/hectare (66.96 ton/ha) was observed from N_2 (Zn_4 B_2 kg/ha) and lowest yield/ha (25.69 ton/ha) was observed from N_0 (0 kg/ha) treatment. Gurmani et al. [36] and Hossein [37] reported similar result Fruit yield of tomato per hectare varied significantly due to the application of different levels of organic manure (Fig 8). The highest yield/hectare (50.78 ton/ha) was observed from M_3 (Cowdung7.5+Poultry manure 5 ton/ha) and lowest yield/hectare (39.86 ton/ha) was observed from M_0 (0 ton/ha). The Combined effect of micronutrients and organic manure showed statistically significant variation on yield/ha (Table 7). The highest yield /hectare (76.33 ton/ha) was obtained from N_2M_3 (Zn_4B_2 kg/ha with Cowdung7.5+Poultry manure5 ton/ha) and control treatment (N_0M_0) gave the lowest yield/hectare (24.60 ton/ha).

3.10 Gross Return

In the combination of micronutrients and organic manure showed different gross return under the trial. The highest gross return (Tk. 725136/ha) was obtained from N_2M_3 (Zn_4B_2 kg/ha with Cowdung7.5 ton+Poultry manure 5 ton/ha) On the other hand, the lowest gross return (Tk. 233700/ha) was calculated from control treatment (N_0M_0) (Table 7).

3.11 Net Return

In case of net return, different treatment combinations showed different results. The highest (Tk. 499128/ha) net return were obtained from N_2M_3 (Zn_4B_2 kg/ha with Cowdung7.5+Poultry manure 5 ton/ha). The lowest net return (Tk. 8989/ha) was obtained from control treatment (N_0M_0) (Table 7).

3.12 Benefit Cost Ratio (BCR)

The combination of micronutrients and organic manure for benefit cost ratio was different in all treatment combination (Table 7). The highest benefit cost ratio (3.2) was obtained from N_2M_3 (Zn_4B_2 kg/ha with Cowdung 7.5 ton+Poultry manure 5 ton/ha) and whereas the lowest benefit cost ratio (1.04) was obtained from control treatment (N_0M_0). From the economic point of view, it is apparent that N_2M_3 treatment combination (Zn_4B_2 kg/ha with Cowdung 7.5+ Poultry manure 5 ton/ha) was the most profitable than rest of the treatment combinations under the study.

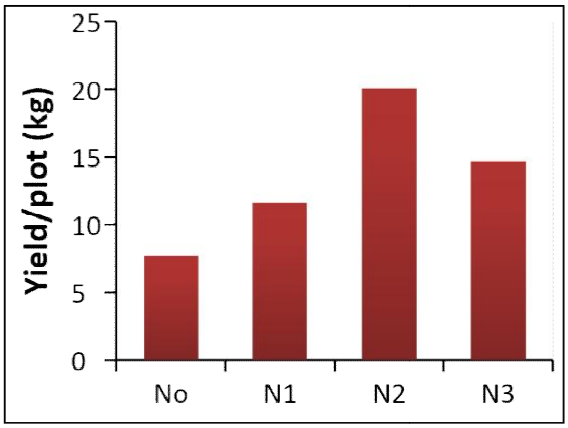

Fig. 5. Graphical representation of yield/plot for treatment (N_0 to N_3)

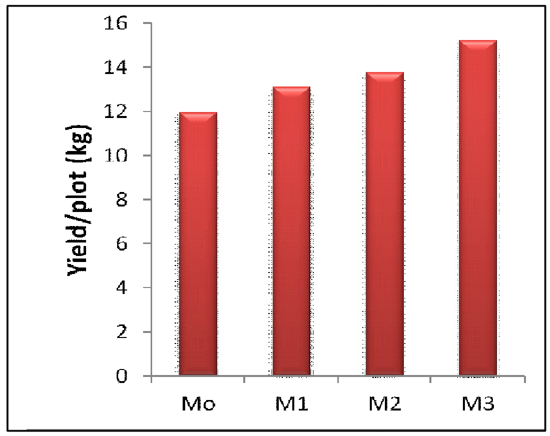

Fig. 6. Graphical representation of yield/plot for treatment (M_0 to M_3)

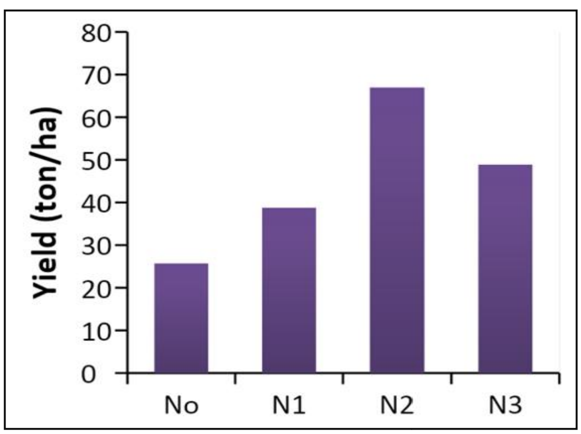

Fig. 7. Graphical representation of yield (Ton/ha) for treatment (N_0 to N_3)

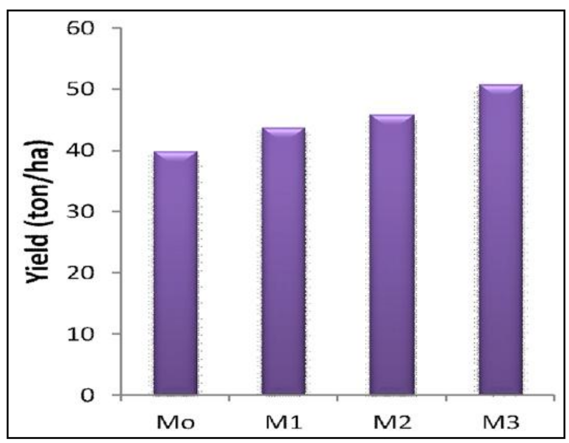

Fig. 8. Graphical representation of yield (Ton/ha) for treatment (M_0 to M_3)

Table 7. The combined effect of different levels of micronutrients and organic manure on yield per plot and yield ton per hectare of tomato at different days after transplanting and return of tomato cultivation as influenced by micronutrients and organic manure

Treatments	Yield per plot (kg)	Yield ton per ha	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
N_0M_0	7.38	24.60	233700	8989	1.04
N_0M_1	7.55	25.16	239020	12521	1.05
N_0M_2	7.75	25.83	245385	37961	1.18
N_0M_3	8.15	27.16	258020	41059	1.25
N_1M_0	9.25	30.85	293075	100363	1.52
N_1M_1	11.65	38.81	368695	137373	1.59
N_1M_2	12.45	41.50	394250	182003	1.85
N_1M_3	13.15	43.83	416385	218856	2.11
N_2M_0	18.15	60.49	574655	344793	2.50
N_2M_1	19.13	63.76	605720	370174	2.57
N_2M_2	20.18	67.28	639160	422689	2.95
N_2M_3	22.90	76.33	725136	499128	3.20
N_3M_0	13.05	43.49	413155	183625	1.80
N_3M_1	14.15	47.16	448020	208251	1.86
N_3M_2	14.70	49.00	465500	244806	2.10
N_3M_3	16.75	55.83	530385	324678	2.57
CV%	12.87	12.43	--	--	--
LSD (0.05)	1.01	2.39	--	--	--

Means, in a column followed by same letter do not differ significantly at 5% level
Here, N_0=0 kg/ha, N_1=$Zn_2B_{1.5}$ kg/ha, N_2=Zn_4B_2 kg/ha, N_3=$Zn_6B_{2.5}$ kg/ha, M_0=0 ton/ha, M_1= Cowdung (15 ton/ha), M_2=Poultry manure (10 ton/ha), M_3=CD+PM (7.5+5 ton/ha), Sale of marketable tomato @ Tk. 9,500/ton

4. CONCLUSION

Both crop yield and economic benefit of the crop are important for crop production. According to the results of the present experiment, it may be concluded the efficient production of tomato is increased by the application of micronutrients and organic manure. Thus, the combined application of micronutrients and organic manure may be helpful for higher and better qualitative tomato production in considering crop productivity and economic return of tomato. Based on the benefit-cost ratio, it may be suggested that a combination of 4 kg zinc and 2 kg boron per hectare with cow dung 7.5 ton/ha+ poultry manure 5ton/ha gave the maximum and profitable yield of the tomato.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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