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Response of cabbage (*Brassica oleracea* var. *capitata* L.) to micronutrients under problematic soil conditions

B.M. Mahmudul Hasan*[1], Md. Hanjala Pipil[1], Tasrin Jahan[2], Md. Nurul Alam[3], Sidratul Montaha[4], Israt Jahan Annee[5], Md. Masudur Rahman[1]

[1]*Department of Biochemistry and Molecular Biology, Trust University, Barishal, Bangladesh*

[2]*Department of Public Health Nutrition, Primeasia University, Dhaka, Bangladesh*

[3]*Department of Crop Science and Technology, University of Rajshahi, Bangladesh*

[4]*Department of Food Processing and Preservation, Hajee Mohammad Danesh Science & Technology University, Bangladesh*

[5]*Department of Food and Nutrition, Barishal Home Economics College affiliated by University of Dhaka, Bangladesh*

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Abstract

A field experiment was conducted in Shampur, Rajshahi, Bangladesh, to assess the effects of different micronutrient treatments on cabbage (cv. Atlas 70) under calcareous soil conditions (AEZ 11: High Ganges River Floodplain). The medium-fertile silty loam soil had a pH of 7.6. The experiment followed a Randomized Complete Block Design (RCBD) with three replications, using eleven micronutrient treatments: T1 (control), T2 (Zn), T3 (B), T4 (Zn+B), T5 (Zn+B+Mo), T6 (Zn+B+Mn), T7 (Zn+B+Cu), T8 (Zn+B+Cl), T9 (Zn+B+Mo+Mn), T10 (Zn+B+Mo+Mn+Cu), and T11 (Zn+B+Mo+Mn+Cu+Cl). Micronutrient doses (kg/ha) were Zn-B-Mo-Mn-Cu-Cl = 3-3-0.5-4-1-20, with N-P-K-S at 150-100-50-20 kg/ha as the basal dose. Data collected at 30, 45, and 60 days post-transplant showed significant effects of micronutrients on growth and yield. The highest plant height (34.89 cm), leaves per plant (21.56), and largest leaf length (36.12 cm) were in T9 (Zn+B+Mo+Mn), while T7 (Zn+B+Cu) had the highest plant spread (66.07 cm) and leaf breadth (24.52 cm). The longest stem (7.04 cm) was in T6 (Zn+B+Mn). Except for days to head formation (54.75 in T2), T4 (Zn+B) showed the highest fresh plant weight (1880 g), head diameter (19.50 cm), marketable head weight (1305 g), and yield (48.33 t/ha), which was 61.89% higher than the control (29.81 t/ha).

* **Corresponding Author:** B. M. Mahmudul Hasan ✉ jewelgono @gmail.com

Introduction

Fertile soil is the fundamental resource for higher crop production and supplies all mineral nutrients to the crops. Intensive cropping accompanied with low use of organic manure and improper soil management practices cause a marked depletion of nutrients in soils. As a result, crops suffer from inadequate supply of nutrients which is manifested through poor crop performances. For better plant growth and higher yield, there is a need for the addition of concerned nutrients from external sources (manures and fertilizers).

The crop production system with high yield targets cannot be sustainable unless nutrient inputs to soil are at least balanced against nutrient removal by crops (Jahiruddin and Rijpma, 2004). Soil fertility of this country has deteriorated over the years (Karim *et al.,* 1994; BRRI, 1999; Ali *et al.,* 1997). Proper identification and management of nutrient deficiency problems in soils are pre-requisites for sustenance of higher crop yield. Field experiment can be a complimentary to soil and plant tissue tests in evaluating fertility status of a soil. The farmers of Bangladesh mainly use four fertilizers such as N, P, K and S, but they never use micronutrient fertilizers. As a result, the benefit of NPKS fertilizers cannot be achieved fully if there remains deficiency of micronutrients. High Ganges River Flood plain is one of the most important AEZs of Bangladesh bearing calcareous soil. This type of soil contains large amount of $CaCO_3$. The pH generally ranges from 7.0 to 8.5 but in most of the upland soils it laid between 8.0-8.5 (Alam, 2006).

Like other cole crops cabbage respond significantly to major essential elements like NPK in respect of their growth and yield (Thompson and Kelly, 1957; Mital *et al.*, 1999). In the objective of our study, response of cabbage (*brassica oleracea* var. *capitata* l.) to micronutrients under problematic soil conditions. Furthermore, while the individual effects of various micronutrients have been studied by different researchers, research on their combined effects remains unexplored.

Materials and methods

To evaluate the effect of micronutrients on the growth and yield of cabbage the investigations were carried out at a field plot of Shampur, Rajshahi, during the period from November, 2008 to February, 2009. The soil of the experimental plots was silty loam in texture belonging to High Gangaje River flood plain. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. N (urea), P (TSP), K (potassium sulfate) and S (gypsum) were applied to the plots as basal dose at the rate of 150, 100, 50 and 20 kg/ha respectively. Different combinations of 6 micronutrient (Zn, B, Mn, Mo, Cu and Cl) treatments were applied as follows.

Healthy and 4 weeks old seedlings were transplanted with a spacing of 45 cm × 50 cm. Soil was irrigated, weeding and ear thing up were also done regularly wherever necessary. Harvesting was done when the plants formed compact head during the period. Data on plant height, plant spread, number of leaves per plant, length of largest leaf, breadth of largest leaf, length of stem were collected at 30, 45, 60 days after transplanting (DAT). Other parameters were recorded at harvest. The collected data were statistically analyzed with MSTAT-C.

Results and discussion

Plant height

Application of different micronutrients and their combinations showed significant effects on plant height at different days after transplanting of cabbage. The height of cabbage plant under present study varied from 17.93 to 23.19 cm, 25.99 to 31.80 cm and 27.60 to 34.89 cm at 30, 45 and 60 DAT respectively. At 30 DAT, the maximum height (23.19 cm) was recorded in treatment T_3. Treatments T_{10}, T_7 and T_5 were statistically similar to T_3. The lowest plant height was found when treatment T_1 (Control) was applied to the soil. However, there was no significant difference among T_1, T_8, T_2 and T_6. At both 45 and 60 DAT, the tallest plant (31.80 and 34.89 cm respectively) was found in the plot treated with T_9, which is statistically similar to the treatments T_3, T_6, T_4, T_7 and T_5 (at 45 DAT) and T_3, T_4, T_6, T_7, T_5 (at 60

DAT). The lowest plant height was observed in T_1 which was statistically similar to T_2 at 45 DAT. Kanujia *et al.* (2006) reported that micronutrients depicted a significant positive response on plant height and maximum plant height was recorded with zinc. Sharma (2002) reported that maximum plant height was obtained when 10 kg Borax/ha was applied.

Table 1. Treatment combinations of 6 micronutrients (Zn, B, Mn, Mo, Cu and Cl).

Treatments	Rates (kg/ha)					
	Zn	B	Mo	Mn	Cu	Cl
T_1 = Control	-	-	-	-	-	-
T_2 = Zn	3	-	-	-	-	-
T_3 = B	-	3	-	-	-	-
T_4 = Zn+B	3	3	-	-	-	-
T_5 = Zn+B+Mo	3	3	0.5	-	-	-
T_6 = Zn+B+Mn	3	3	-	4	-	-
T_7 = Zn+B+Cu	3	3	-	-	1	-
T_8 = Zn+B+Cl	3	3	-	-	-	20
T_9 = Zn+B+Mo+Mn	3	3	0.5	4	-	-
T_{10} = Zn+B+Mo+Mn+Cu	3	3	0.5	4	1	-
T_{11} = Zn+B+Mo+Mn+Cu+Cl	3	3	0.5	4	1	20

Plant spread

Statistically significant difference was observed in plant spread affected by different treatments of micronutrient in cabbage. The plant spread at different stages of growth (at 30, 45, and 60 DAT) was ranged from 29.07 to 40.33 cm, 39.47 to 63.83 cm and 47.63 to 66.07 cm respectively (Table 2). At all the growth stages (30, 45 and 60 DAT) the widest canopy spreads were recorded in the plot treated with T_7. This effect was statistically similar to T_6 at 60 DAT. On the other hand, the lowest spread was observed in T_1 at all DAT. Kanujia *et al.* (2006) reported that plant spread responded significantly to micronutrients application and maximum plant spread (44.4 and 42.5 cm) was recorded with mixture of all micronutrients Alam (2007) reported that plant spread was significantly influenced by applied boron levels and maximum value was found for 4.0 kg B/ha.

Table 2. Effects of micronutrients on growth parameters of cabbage.

Treatments	Plant height			Plant spread		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
T_1 = Control	17.93 d	25.99 f	27.60 c	29.07 f	39.47 g	47.63 f
T_2 = Zn	18.77 cd	27.33 ef	30.84 b	30.67 e	51.54 f	57.52 e
T_3 = B	23.19 a	31.19 ab	33.56 ab	36.07 b	58.22 bc	61.74 b
T_4 = Zn + B	20.32 bc	30.68 abc	33.07 ab	31.63 de	53.67 ef	61.17 bc
T_5 = Zn + B + Mo	21.54 ab	30.06 abcd	32.53 ab	36.00 b	53.78 ef	60.50 bcd
T_6 = Zn + B + Mn	18.82 cd	31.06 ab	32.80 ab	35.03 b	59.61 b	64.45 a
T_7 = Zn + B + Cu	22.00 ab	30.46 abc	32.55 ab	40.33 a	63.83 a	66.07 a
T_8 = Zn + B + Cl	18.13 d	28.44 de	30.52 bc	32.50 cd	53.45 ef	59.02 de
T_9 = Zn + B + Mo + Mn	20.57 bc	31.80 a	34.89 a	34.99 b	56.75 cd	59.44 cde
T_{10} = Zn + B + Mo + Mn + Cu	22.37 ab	29.34 bcd	30.93 b	32.00 cde	53.14 ef	58.92 de
T_{11} = Zn + B + Mo + Mn + Cu + Cl	20.89 b	28.77 cde	30.94 b	33.27 c	55.60 de	58.55 de
Level of significance	**	**	**	**	**	**
CV (%)	5.49	3.52	5.44	2.29	2.64	1.75

In a column, figure(s) having common letter(s) do not differ significantly by DMRT at 5% level.

* = Significant at 5% ** = Significant at 1% NS = Non-significant DAT: Days after transplant

Number of leaves per plant

Application of micronutrient combinations exerted a significant influence on the number of leaves per plant in cabbage. In cabbage variable influence of treatment combination were observed at different DAT (Table 3). At 30 DAT the highest number of leaves (13.93/ plant) was observed in treatment T_5, which was statistically similar to treatments T_3, T_9, T_7, T_2 and T_{10}. But at 45 and 60 DAT the highest number of leaves was found in the plot treated with T_9, which is statistically similar to T_5 and T_2 at 45 DAT. The lowest number of leaves was found in the plot treated with T_1 (Control). Kanujia *et al.* (2006) also reported that the micronutrient had a significant response on the number of non-wrapper leaves. Alam (2007) reported that leaf number was significantly influenced by applied boron levels and maximum leaf number was found for 4.0 kg B/ha.

Table 3. Effects of micronutrients on growth parameters of cabbage.

Treatments	Number of leaves per plant			Length of largest leaf		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
T_1 = Control	10.86 e	13.92 e	15.11 d	17.38 e	24.33 d	29.38 f
T_2 = Zn	12.83 abcd	18.11 abc	19.19 b	18.45 de	27.42 c	32.51 d
T_3 = B	13.75 ab	17.38 bcd	18.33 bc	20.12 cd	30.90 ab	34.48 b
T_4 = Zn + B	11.83 cde	16.28 cd	16.81 cd	22.16 abc	27.27 c	31.41 e
T_5 = Zn + B + Mo	13.93 a	18.22 ab	19.34 b	20.42 bcd	30.78 ab	34.72 b
T_6 = Zn + B + Mn	12.17 bcde	17.50 bcd	19.03 b	22.80 ab	31.44 ab	34.56 b
T_7 = Zn + B + Cu	13.50 abc	17.33 bcd	18.14 bc	21.90 abc	30.61 ab	33.83 bc
T_8 = Zn + B + Cl	11.67 de	16.22 d	16.83 cd	22.27 abc	29.44 b	32.96 cd
T_9 = Zn + B + Mo + Mn	13.65 ab	19.50 a	21.56 a	23.42 a	31.94 a	36.12 a
T_{10} = Zn + B + Mo + Mn + Cu	12.83 abcd	17.61 bcd	18.58 bc	21.27 abc	30.72 ab	34.31 b
T_{11} = Zn + B + Mo + Mn + Cu + Cl	11.92 cde	17.03 bcd	17.72 bc	21.04 abc	30.27 ab	34.37 b
Level of significance	**	**	**	**	**	**
CV (%)	6.99	5.61	6.01	6.00	3.57	1.87

In a column, figure(s) having common letter(s) do not differ significantly by DMRT at 5% level.

* = Significant at 5% ** = Significant at 1% NS = Non-significant DAT = Days after transplant.

Length of largest leaf

The length of leaf influenced by different combinations of micronutrients was found to be significant in cabbage. In cabbage the largest leaf (Table 3) was recorded in the plot treated with T_9. This is statistically similar to T_7, T_8, T_5, T_3, T_{110}, T_6 (at 30 DAT) and T_6, T_3, T_5, T_{10}, T_9, T_{11} (at 45 DAT). However, the lowest length of largest leaf was observed in T_1 at all DAT.

Breadth of largest leaf

Application of different combinations of micronutrients caused significant effects on the breadth of leaves at different DAT. The effects of different micronutrient combinations varied at different DAT (Table 4). At 30 and 45 DAT the highest breadth of leaf was found in T_9 treatment, which is statistically similar to T_7, T_3 and T_4 (at 30 DAT). But at 60 DAT the highest breadth of leaf was found in plot treated with T_7, But T_9 is statistically similar to that effect. At all DAT the lowest breadth of leaf was found in treatment T_1 (Control).

Length of stem

Significant effects of micronutrient combination are observed on the length of cabbage. The result on length of stem influenced by micronutrient combinations have been presented in Table 3. At 30 DAT the highest length of stem (5.46 cm) is recorded in plot treated with T_{10}. The effects of T_3 and T_1 were also statistically similar to that of T_{10}. But at 45 and 60 DAT the highest length of stem was observed at T_6, which was statistically similar to T_1 and T_5 (at 45 DAT) and T_1, T_{11}, T_{10}, T_9, T_3, T_8 (at 60 DAT). At all

DAT the lowest value of stem length was found in T_4. Kanujia *et al.* (2006) reported that the micronutrient has no significant response on the stem length either individually or in combination.

Days to head formation

The number of days required for head formation was significantly influenced by different treatment combinations. In cabbage the number of days required for head formation ranged from 48.65 to 54.75 (Table 5). The maximum number of days required for head formation (54.75 days) was observed for the treatment T_2. The effects of treatments T_1 and T_8 were statistically similar to T_2. However, the minimum number of days required for head formation was observed in T_7. But statistically there were no significant differences among T_{11}, T_9, T_{10}, T_6, T_4, T_3, T_5 and T_7.

Table 4. Effects of micronutrients on growth parameters of cabbage.

Treatments	Breadth of largest leaf			Length of stem		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
T_1 = Control	10.03 e	15.50 h	17.64 g	5.283 ab	6.750 ab	6.943 a
T_2 = Zn	10.83 cde	17.74 g	19.65 f	4.667 c	6.167 de	6.373 bc
T_3 = B	12.47 ab	21.61 b	23.17 b	5.450 a	6.287 cde	6.657 abc
T_4 = Zn + B	12.37 ab	19.28 ef	22.76 bc	4.497 c	5.983 e	6.210 c
T_5 = Zn + B + Mo	12.27 ab	19.34 ef	21.36 de	4.550 c	6.573 abc	6.823 ab
T_6 = Zn + B + Mn	11.52 bcd	20.35 cd	21.30 de	4.950 bc	6.910 a	7.040 a
T_7 = Zn + B + Cu	11.37 bcd	21.05 bc	24.52 a	4.583 c	6.110 de	6.233 c
T_8 = Zn + B + Cl	10.57 de	18.45 fg	20.52 ef	4.827 c	6.307 cde	6.633 abc
T_9 = Zn + B + Mo + Mn	13.32 a	23.02 a	23.75 ab	4.783 c	6.370 bcde	6.717 abc
T_{10} = Zn + B + Mo + Mn + Cu	10.77 cde	19.55 de	22.03 cd	5.460 a	6.447 bcd	6.760 abc
T_{11} = Zn + B + Mo + Mn + Cu + Cl	11.76 bc	19.15 ef	21.59 de	4.927 bc	6.360 bcde	6.900 ab
Level of significance	**	**	**	**	**	*
CV (%)	5.24	2.59	2.87	4.90	3.28	4.39

In a column, figure(s) having common letter(s) do not differ significantly by DMRT at 5% level.

* = Significant at 5% ** = Significant at 1% NS = Non-significant DAT = Days after transplant.

Fresh weight of plant

Fresh weight of plant along with root was found to be affected by the combinations of micronutrients. The fresh weight of plant was recorded from 1162g to 1880 g (Table 5). The maximum fresh weight (1880 g) was observed in the plot treated with T_4. However, the minimum fresh weight of plant was found for T_1.

Diameter of head

Application of different micronutrient combinations caused significant effects on the diameter of head in cabbage. The diameter of head ranged from 16.37 to 19.00 cm (Table 5). The maximum diameter head was found for the treatment T_4 which is statistically similar with T_5 and T_{10}. However, the minimum diameter of head was observed for the treatment T_2 which was statistically similar to T_{11}, T_9, T_3, T_1 and T_8. Kanujia *et al.* (2006) reported that micronutrients significantly enhance the diameter of head in cabbage and maximum response is observed with combined application of micronutrients. Prakash and Bhardwaj (1965) noticed that appreciable increase in weight and volume of head by spraying molybdenum in savoy cabbage.

Marketable head weight

Different combinations of micronutrient showed significant effect on the marketable head weight. The value of MHW ranged between 805 g to 1305 g. The maximum MHW (1305 g) was found when the plant was treated with treatment T_4. However, the lowest MHW (805 g) was observed when the cabbage plant was treated with T_1. Kanujia *et al.* (2006) reported that micronutrients significantly affect the head weight and got the maximum weight with application of micronutrient in combination.

Table 5. Effects of micronutrients on yield parameters of cabbage.

Treatments	Days to head formation	Fresh weight of plant	Diameter of head	Marketable head weight	Marketable head yield	Percent yield change
T_1 = Control	53.30 a	1162 k	16.83 cd	805 k	29.81 k	0.0
T_2 = Zn	54.75 a	1617 e	16.37 d	1123 e	41.61 e	+ 39.58
T_3 = B	49.22 c	1720 c	16.90 cd	1195 c	44.26 c	+ 48.47
T_4 = Zn + B	49.50 c	1880 a	19.50 a	1305 a	48.33 a	+ 62.13
T_5 = Zn + B + Mo	49.08 c	1768 b	18.43 ab	1230 b	45.55 b	+ 52.80
T_6 = Zn + B + Mn	49.56 c	1673 d	17.80 bc	1163 d	43.09 d	+ 44.55
T_7 = Zn + B + Cu	48.65 c	1590 f	18.03 bc	1103 f	40.87 f	+ 37.10
T_8 = Zn + B + Cl	52.50 ab	1467 i	16.72 cd	1018 i	37.72 i	+ 26.53
T_9 = Zn + B + Mo + Mn	50.28 bc	1543 h	16.93 cd	1068 h	39.57 h	+ 32.74
T_{10} = Zn + B + Mo + Mn + Cu	49.72 c	1565 g	18.30 ab	1087 g	40.25 g	+ 35.02
T_{11} = Zn + B + Mo + Mn + Cu + Cl	50.38 bc	1435 j	17.10 bcd	996.7 j	36.91 j	+ 23.82
Level of significance	**	**	**	**	**	
CV (%)	2.68	0.59	4.14	0.7	0.69	

In a column, figure(s) having common letter(s) do not differ significantly by DMRT at 5% level.

* = Significant at 5% ** = Significant at 1% NS = Non-significant DAT = Days after transplant.

Marketable head yield per hectare

Yields per hectare were frond to be significantly influenced by the application of micronutrients. The yield per hectare ranged from 29.81 to 48.33 tons. The maximum yield (48.33 tons) was found for the treatment T_4 while the minimum yield (29.81 tons) was observed in T_1 (control).

Percent yield change

Percent yield change was calculated compared with the yield of control treatment. It was observed that the change in yield was positive (increase) in all the treatments. The maximum (62.13%) when treatment T_4 (Zn+B) was applied.

Conclusion

Plant height (34.89 cm), number of leaves per plant (21.56) and length of largest leaf (13.32 cm) attained their highest values with treatment T_9, while that of plant spread (66.07 cm) and breadth of largest leaf (24.52 cm) were found in T_7. The maximum stem length (7.04 cm) was observed for T_6. All the yield parameters except days to head formation (highest 54.75 days in T_2) attained their maximum values with the treatment T_4 and minimum value for T_1. The maximum marketable head yield (48.33 t/ha) was recorded for the treatment T_4, which was 61.89 % more than that of control treatment T_1 (29.81 t/ha). Result suggested that Zn along with B is suitable for better growth and yield of cabbage in calcareous soils of Bangladesh.

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