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Effect of Zinc, Boron, Sulphur and Magnesium on the Growth and Yield of Potato

M. S. Bari, [1]M. G. Rabbani, M. Sq. Rahman, M. J. Islam and A. T. M. R. Hoque
Hajee Mohammad Danesh University of Science and Technology, Dinajpur, Bangladesh
[1]Horticulture Department, Bangladesh Agricultural University, Mymensingh, Bangladesh

Abstract: A fertilizer trial was carried out in old Brahmaputra floodplain soil with a view to examine the effect of Zn, B, S and Mg on the growth and yield of potato (cv. diamant). The elements were added in 15 (fifteen) possible combinations along with a control. The rate of Zn, B, S and Mg were 9.0, 1.1, 12.6 and 6.5 kg/ha, respectively. The treatment receiving Zn, B, S and Mg together gave the highest tuber yield (30.90 t/ha) and the lowest yield (25.40 t/ha) was obtained in control treatment. Assessing the contribution of individual elements, S alone had a marked influence on crop yield and resulted in 6.30% yield increase over control as against the yield increment of 21.65% by the combined treatment of Zn, B, S and Mg. The yield contributing characters showed a similar trend. Thus for efficient potato production in this soil, application of S is essential and further, the addition of B and Mg to this soil may substantiate the yield to some extent. The soil does not require Zn supplement for potato.

Key words: Zinc, boron, sulphur, magnesium, potato, growth and yield

Introduction

Potato (*Solanum tuberosum*) is one of the leading food crops and it occupies first position in both acreage and production among the vegetable crops in Bangladesh. It contributes 55% of the total annual vegetable production (BBS, 1996). However, the scope of horizontal increase in production of potato is limited in this country mainly due to shortage of land. Therefore, emphasis should be given to increase the yield per unit area. A judicious application of fertilizers might be the best way to increase the production. Potatoes are heavy nutrient requiring crop because of their bulk yields within a short time having shallow root systems. In potato cultivation , some elements like Zn, B, S and Mg can help in increasing the foliage coverage at initial growth stages and in the later stages, the translocation of assimilates is responsible for higher yield (Trehan and Grewal, 1981). Many workers are in opinion that application of minor nutrients in addition to essential major elements can play a good role in increasing the yield of potato (Islam *et al.*, 1986; Mondal *et al.*, 1993; Mahmood *et al.*, 1995; Tiwari, 1995; Rykbost *et al.*, 1993; Taya *et al.*, 1994; Sharma and Grewal, 1988). But increasing land use intensity, introduction of modern varieties of crops, minimal and imbalanced use of fertilizers and no practice of return of crop residues to soil have led to a marked depletion in nutrient reserves of Bangladesh soils. Consequently along with NPK, some nutrient elements deficiencies (eg. Zn, B, S and Mg) have been observed (Mondal *et al.* , 1991; Jahiruddin *et al.*, 1992). Further, our soils having low organic matter content, nutrient leaching during rainfall are likely to favour new nutrient deficiency along with a wide range of soil heterogeneity. So, independent technology needs to be adopted to each soil situation. But information regarding the use of Zn , B, S and Mg either alone or in combination with NPK for potato production under Bangladesh condition is scant. Hence, the present experiment was undertaken to investigate the effects of Zn, B, S and Mg on the growth and yield of potato in Old Brahmaputra Flood Plain, a major agro-ecological region of Bangladesh.

Materials and Methods

The experiment was carried out in the active flood plain of Old Brahmaputra floodplain soils of Horticulture farm of Bangladesh Agricultural University, Mymensingh during the rabi season (1997-1998). Composite sample of the top soil (0 - 20 cm depth) was analyzed in the laboratory of Soil Science Division, Bangladesh Institute of Nuclear Agriculture (BINA). A description of the physical and chemical properties of soils of experimental plots is presented in Table 1.

Table 1: Characteristics of soil samples of the experimental plots

Soil properties	Values	*Critical level
Physical properties:		
Sand(%)	35.4	
Silt(%)	60.0	
Clay(%)	4.6	
Textural class	Silty loam	
Chemical properties:		
pH	6.8	
Organic carbon (%)	1.02	
Total N (%)	0.085	
Available P (ppm)	16.0	14.0
Exchangeable K (me%)	0.22	0.2
Available Mg (me%)	0.80	0.8
Available S (ppm)	8.5	14.0
Available B (ppm)	0.19	0.2
Available Zn (ppm)	1.80	2.0

*Source : Hussain (1993)

The experiment was laid out in a randomized complete block design with sixteen treatments each replicated three times. The treatment combinations were as follows :

T_1 =control (NPK), T_2 = Zn, T_3 = B,
T_4 =S, T_5 = Mg, T_6 = Zn+B, T_7 = Zn+S,
T_8 =Zn+Mg, T_9 = B+S, T_{10} = B+Mg,
T_{11} =S+Mg, T_{12} = Zn+B+Mg,
T_{13} =B+S+Mg, T_{14} = Zn+S+Mg,
T_{15} =Zn+B+Mg, T_{16} = Zn+B+S+Mg.

Where,
N =124 Kg N/ha from urea
P =89 Kg P_2O_5 /ha from TSP
K =193 Kg K_2O /ha from MP
S =12.6 Kg S /ha from gypsum
Mg =6.5 Kg Mg/ha from magnesium oxide
B =1.1 Kg B /ha from borax
Zn =9.0 Kg Zn/ha from zinc oxide

Whole amount of P, K, S, Mg, B, Zn and half of total N were applied as basal dose and remaining N was given after 45 days of planting as top dressing . The tubers of diamond potato after collection from cold storage were spread over the

floor for sprouting and the well sprouted seed potatoes were cut into two equal halves, 48 hours before planting. Planting was done in each plot of size 3.0 x 2.4 m^2. Tuber to tuber and row to row distance was 20 and 60 cm , respectively. Intercultural operations like, weeding, earthing-up and irrigation were done as needed. Normal spray schedules were followed to protect the crop from pests and diseases. Data on ten randomly selected plants/plot were recorded during the crop growth period and also at harvest. The crops were harvested at 95 days after planting. Tubers were collected and graded as A, B, C, D and E according to their diameter. and tuber yield was recorded in Kg/plot. The collected data were then analyzed statistically followed by Least Significant Difference (LSD) test.

Results and Discussion

Growth parameters: It is quite evident from Table 2 that there was no significant effect of applied nutrient elements on time required for 80% emergence of the crop. The plant height of potato at 90 DAP (Days after planting) under present study varied from 57.1 to 65.9 cm as affected by different treatments. The tallest plant was recorded for treatment Zn+B+S+Mg and the lowest (57.1 cm) was the case where Zn was used alone. However, statistically there was no significant difference between the treatments in respect of plant growth. Islam *et al.* (1982) did not notice significant effect of S and Zn on plant height of potato. Pregno and Arour (1992) stated that application of B did not increase plant height. Khurana *et al.* (1990) also found that in presence of NPK fertilizer, Mg application did not show any significant effect on plant height of potato. The foliage coverage of the plants was markedly influenced by the application of various nutrient elements. Similar to plant height, the highest foliage coverage (94.4%) was recorded in the plot where Zn, B, S and Mg were applied together and the lowest record was obtained in plots where Zn was applied alone (Table 2). The number of main stem/hill and fresh haulm weight/hill also varied significantly with the nutrient treatments. The highest number of main stem/hill and fresh haulm weight/hill were recorded in the combined treatment of Zn, B, S and Mg which were comparable with those obtained using Zn+B, Zn+S, B+S, B+Mg, B+S+Mg, Zn+S+Mg and Zn+B+Mg treatments. The lowest result was achieved for control. The other plant characteristics viz. number of tubers/hill and dry matter of tubers (%) varied significantly with the application of above four nutrients. It was observed that the full combination of four nutrients (Zn, B, S and Mg) produced the maximum number of tubers/hill as well as dry matter of tubers. The application of NPK with no use of Zn, B, S and Mg exhibited the lowest result. In general, performance of S was better than the other three nutrient elements(Zn, B and Mg).

Tuber yield: Tuber yield responses on the fertilizer treatments have been shown in Table 2. The highest yield (30.90 t/ha) was recorded in the treatment of four nutrients together. However, this yield was not significantly different from that observed in case of B+S, B+Mg, Zn+B+S, B+S+Mg, Zn+S+Mg and Zn+B+Mg treatments. The lowest yield (25.40 t/ha) was obtained in the control. The control yield was statistically similar with that of the treatments Zn, B, S, Mg, Zn+B and Zn+Mg. In present study, it was seen that all the combination treatments except Zn+B and Zn+Mg significantly increased the tuber yield over control. The effect of different nutrient elements on tuber yield were in the order of Zn+B+S+Mg > B+S+Mg > Zn+B+S > B+S > B+Mg > Zn+S+Mg > S+Mg > Zn+B+Mg > Zn+S > Zn+B > Zn+Mg > S > B > Mg > Zn. Such results indicated that the combined application of nutrients (Zn, B, S and Mg) gave the best yield of all other applications. The yield increases were in agreement with the findings of Karmakar *et al.* (1988), who reported that application of the mixture of Zn, B and Mg increase the average tuber yield to a considerable extent. Although the individual application of Zn, B, S and Mg could not produce any significant effect on the tuber yield but their application appreciably increased tuber yields. Further, it was observed that out of the four nutrients, contribution of S was dominant. The treatment comprising Zn, B, S and Mg (T_{16}) resulted in 21.65% yield increase over control while S alone (T_4) gave 6.30%yield benefit over control (Fig. 1). The pronounced effect of S on tuber yield of potato was also reported by Mondal *et al.* (1993) and Islam *et al.* (1986) . They noticed that S deficiencies in Bangladesh soils were wide and responses to its application have demonstrated significantly positive yield increases for potato production. The present results showed a positive yield response to soil test value, since available S content (8.5 ppm) of this soil was inadequate to support normal plant growth (Hussain, 1993). Again, the available status of B and Mg of the soil under study

Table 2: Growth and yield components of potato as influenced by different nutrient elements

Treatment	Days required to 80% emergence	Plant height (cm) at 90 DAP	Foliage coverage (%)/hill at 90 DAP	No. of main stem/ hill (g)	Fresh haulm weight/ hill (g)	No. of tubers/ hill	Dry matter of tubers (%)	yield of tuber/ Hill (g)	Yield of tuber/ plot (kg)	Yield of tuber/ha (t)
Control	14.00	59.30	78.70	3.40	100.30	6.23	18.50	308.70	18.27	25.4`
Zn	14.70	57.10	76.50	3.56	102.30	6.33	19.10	320.10	18.63	25.70
B	15.70	57.30	81.70	3.46	105.00	6.36	19.70	340.20	19.29	26.80
S	15.30	59.50	83.20	3.66	108.30	7.10	19.90	337.60	19.44	27.00
Mg	15.30	61.20	83.80	3.50	105.30	6.53	19.90	330.00	18.85	26.90
Zn+B	14.30	60.70	85.30	3.80	114.00	7.40	20.70	345.20	19.96	27.70
Zn+S	14.30	62.40	86.20	3.90	119.00	7.40	20.60	350.50	20.12	27.90
Zn+Mg	14.30	57.40	83.90	3.70	110.00	7.20	20.10	341.30	19.51	27.10
B+S	16.70	63.40	91.80	4.10	126.00	8.20	20.70	365.00	20.86	29.00
B+Mg	14.00	62.20	85.70	4.10	130.00	8.00	20.70	358.50	20.52	28.50
S+Mg	14.70	62.90	89.30	3.73	112.00	7.36	20.60	343.00	20.29	28.20
Zn +B+S	13.70	63.80	92.90	4.20	135.70	8.63	20.90	367.60	21.23	29.50
B+S+Mg	14.30	64.60	93.40	4.30	140.30	8.73	21.00	370.70	21.50	29.90
Zn+S+Mg	14.70	62.50	90.70	4.00	122.00	7.93	21.20	356.40	20.36	28.30
Zn+B+Mg	14.00	62.80	88.60	3.94	121.30	7.80	21.10	352.50	20.13	28.00
Zn+B+S+Mg	13.70	65.90	94.40	4.36	146.70	9.29	21.60	383.00	22.28	30.90
LSD(0.05)	NS	NS	10.60	0.42	20.40	1.17	1.57	26.84	1.67	2.40
CV(%)	6.20	7.90	27.89	8.50	12.14	11.34	5.62	6.32	7.74	7.16

NS = Non-Significant

Table 3: Percentage of different grade tubers as received by application of different nutrient elements

Treatment	Grade-A (>55 mm diameter)	Grade-B (46-55mm diameter)	Grade-C (36-45mm diameter)	Grade-D (28-35 mm diameter)	Grade-E (<28 mm diameter)
Control	9.00	26.50	27.80	19.50	16.80
Zn	15.40	32.80	28.10	12.90	10.40
B	19.00	33.20	26.30	11.00	10.00
S	16.30	32.40	28.60	9.60	12.70
Mg	16.60	31.60	25.30	14.00	11.90
Zn+B	16.70	30.00	25.40	13.60	14.10
Zn+S	18.10	28.80	24.80	15.00	13.30
Zn+Mg	18.80	33.10	28.40	10.90	7.60
B+S	18.40	30.80	23.90	17.00	9.60
B+Mg	19.50	28.90	29.30	12.40	9.90
S+Mg	18.80	28.60	26.50	15.20	10.80
Zn +B+S	20.40	31.30	30.30	9.90	7.10
B+S+Mg	22.30	30.40	29.60	10.20	7.50
Zn+S+Mg	19.40	33.90	21.30	14.50	9.50
Zn+B+Mg	23.90	30.70	25.20	12.80	7.20
Zn+B+S+Mg	20.10	32.80	29.90	9.30	7.50
LSD(0.05)	2.94	3.29	2.97	3.50	2.63
CV(%)	11.54	9.25	8.63	15.37	14.53

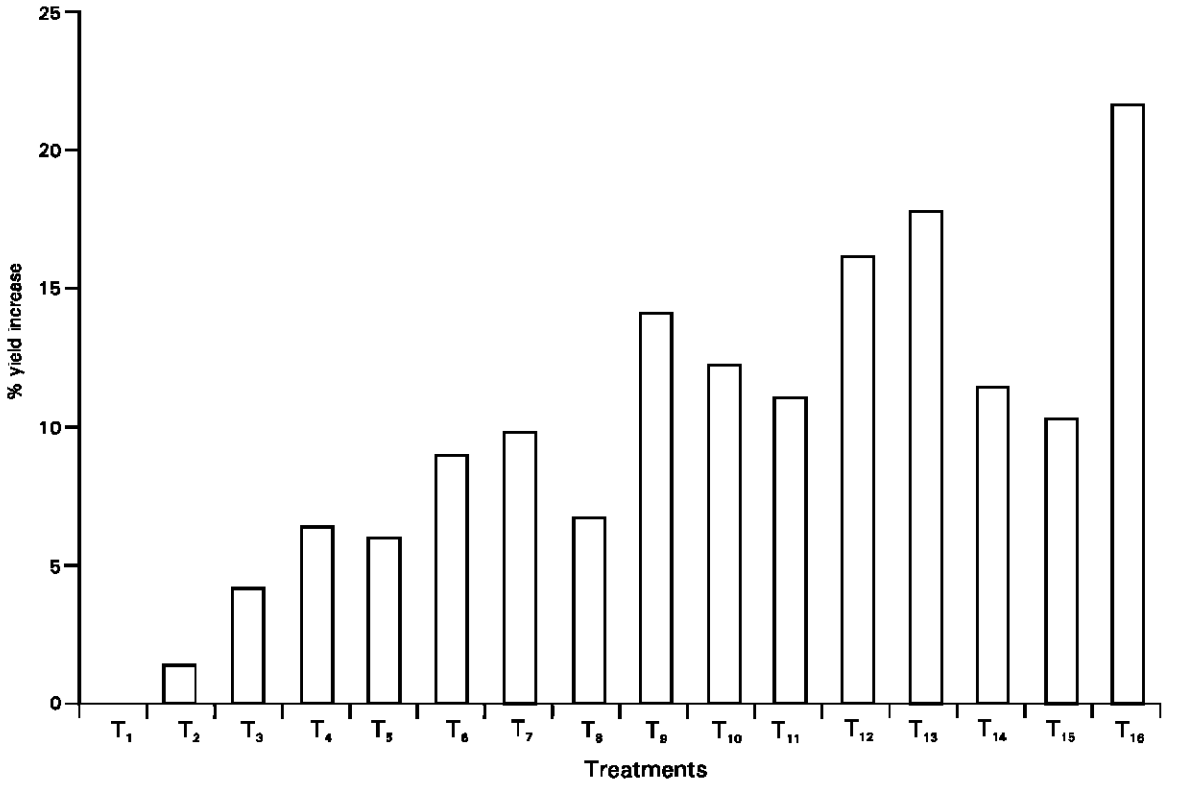

Fig. 1: Per cent yield increase over control by different treatments.

were low showing 0.19 ppm and 0.80 me%, respectively. Thus, response to added B and Mg in the soil was very likely.

Gradation of tubers: The nutrient application either alone or in the form of mixture showed a pronounced positive effect on the number and size of tubers (Table 3). Percentage size-grade distribution of tubers in the range greater than 55 mm in diameter (A-grade) was significantly influenced . The highest percentage (23.9) of this grade was obtained in the treatment Zn+B+Mg followed by B+S+Mg (22.3). The control treatment ranked the lowest (9.0) in this grade. Among the four nutrients, B produced the highest percentage of A-grade tubers which was also statistically significant over control. Dwivedi and Dwivedi (1992) reported that B application markedly increased the yield of tubers exceeding 55 mm in diameter, which agrees with the present results. B-grade tubers (46-55 mm in diameter) also varied significantly due to application of different nutrient elements. The treatment Zn+S+Mg produced the highest percentage (33.9) of this grade tubers which was identical with treatments Zn, Mg,

Zn + Mg, B + S, Zn + B + S, Zn + B + Mg and Zn + B + S + Mg. The lowest percentage (26.5) was found in control. Again maximum percentage (30.3) of C-grade tubers (36-45 mm diameter) was recorded in the treatment Zn + B + S . But it was statistically identical with the treatments Zn, S, Zn + Mg, B + Mg, S + Mg, B + S + Mg, Zn + B + S + Mg and control. The minimum percentage of this grade tubers were produced by the treatment Zn + S + Mg. In case of D-grade tubers (28-35 mm in dia), the highest percentage (19.5) was found in the control treatment and the lowest (9.3) was in the treatment Zn + B + S + Mg. Similar to D - grade tubers, the highest percentage (16.8) of E-grade tubers (< 28 mm in dia) was also obtained in control treatment, while the lowest (7.1) was recorded in the treatment Zn + B + S. Such decrease in the percentage of small sized tubers due to application of Zn, B, S and Mg was reported by many workers (Taya *et al.*,1994; Karmakar *et al.* (1988) and Islam *et al.* (1982). The above result reveals that the increase in yield was the cumulative effect of increased number of large sized tubers.

It can be inferred that N, P and K application were more effective with the combination of Zn, B, S and Mg which played a significant role in increasing the tuber yield of potato. Application of 9.0 kg Zn, 1.1 kg B, 12.6 kg S and 6.5 kg Mg per hectare with a blanket dose of fertilizers (N_{124}, P_{89}, K_{193} kg/ha) might be the sufficient for maximum yield of potato in Old Brahmaputra Flood Plain agro-ecological region of Bangladesh.

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