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Influence of Manganese and Boron on Sustainable Sugarcane Yield in Old Himalayan Piedmont Plain Soils

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ABSTRACT

A field study was conducted to investigate the effects of manganese and boron with recommended NPKSZn fertilizers for sustaining sugarcane yield in Old Himalayan Piedmont Plain soils of Bangladesh. It included eight treatments in the study. Results indicated that the applications of boron and manganese @ 2-3 kg B and 2 kg Mn ha^{-1} along with recommended NPKSZn fertilizers improved Mn, B, Zn, N, P and Ca concentrations in sugar cane leaf and produced higher sugarcane yields of 51.73-70.89 t ha^{-1}. Higher gross margin of Tk. 44,305 to Tk. 67, 877 ha^{-1} was also obtained by the application of manganese and boron.

Keywords*:* Boron, manganese, sugarcane, yield, soil

INTRODUCTION

Sugarcane is one of the most important cash crops in Bangladesh. It provides income to growers and employment for many farm workers throughout the year. In recent years, the importance of micronutrients in increasing agricultural production and correcting deficiencies in crops has been realized all over the world. Micro-nutrients play a vital role in the growth and development of sugarcane plant. Juang *et al.* (1974) found beneficial effects of micro-nutrient like zinc application in sugarcane. Boron and Manganese though required in lesser amounts for plant growth but are as essential as N, P and K. They play an important role in absorption and translocation of some macronutrients like N, P, Ca and Mg. Deficiencies of B and Mn in soil and plants develop undesired symptoms of crop (Bowen, 1981; Jones, 1972). Micro-nutrients are also essential for production and growth regulating hormones (Kanwar and Randhawa, 1967). In sandy acidic soils of Old Himalayan Piedmont Plain, scarce in manganese and leaching of boron, crop might suffer in its normal growth. It is expected that proper use of Mn and B can increase plant growth and yield of sugarcane in this cane-growing zone of Bangladesh. It further needs to generate the database on the requirement of manganese and boron for sugarcane in Bangladesh. Therefore, the experiment was undertaken to ascertain and quantify the requirement of manganese and boron for sustainable production of sugarcane in the study area.

MATERIALS AND METHODS

The study was conducted during 2004-05 and 2005-06 crop seasons at Regional Sugarcane Research Station farm, Thakurgaon under Old Himalayan Piedmont Plain soils of Bangladesh to evaluate the effects of manganese and boron on sustainable crop yield of sugarcane. It was laid out in RCBD with three replications. Eight treatments were included in the study (Table 1). The unit plot size was 48 sq. meters. Three extra guard rows surrounding the experimental plots were planted. It was transplanted with two eyed soil bed settlings of Isd 32 and was harvested after full maturity of the crop. The initial and post harvest status of soil is presented in Table 2. The full amounts of P from triple super phosphate, S from gypsum, Mg from magnesium oxide, Zn from zinc sulphate, B from boric acid and Mn from manganese sulphate were applied at the time of transplanting. One third of K from muriate of potash and one third of N from urea was also applied as basal after 3 weeks of transplantation. The rest two splits of N and K were applied at 120 and 180 days after transplanting as top dressing. Recorded data on the number of tiller at 150 days after transplantation (DAT), cane stalk at harvest, yield of cane, stalk height and girth, and percent brix in cane is presented in Table 4a. The economic benefit of boron and manganese fertilization in sugarcane production is shown in Table 5. LSD and DNMR test was performed to statistically analyze all the recorded data presented in Table 4a using 'Analysis of Variance' technique where differences among treatment means were compared (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

The soil of the experimental field had pH 5.20, total N 0.075%, available P 18.00 ppm, exchangeable K 0.16 meq%, available Ca 0.02 meq%, available Mg 0.01 meq%, available S 18.00 ppm, available B 0.16 ppm and available Mn 4.00 ppm (Table 2). A slight increasing trend was observed in available P, B and Mn contents in soil after harvest of the crop because of the application of boron and manganese fertilizers. The other soil parameters were nearly unchanged.

Table 3 shows the effects of manganese and boron on some nutrient concentration in leaf of sugarcane at maturity phase. It was revealed that the application of Mn @ 3 kg ha^{-1} with recommended NPKSZn fertilizers slightly improved Mn, Zn, N, P, Ca concentration in leaves of sugarcane at maturity phase. It also showed that application of B @ 2 kg ha^{-1} with recommended NPKSZn fertilizers considerably increased B, Zn, N, P, S, and Ca concentration in sugarcane leaves at mature stage. Similarly Jamro *et al.* (2000) demonstrated better effect of boron application in sugarcane growth through increased N and P concentration in leaves. Kalyani *et al.* (1994) also found that boron increased crop growth and yield in pigeon pea.

From the results presented in Table 4a, it was found that the treatments T_4 and T_7 produced significantly higher numbers of tillers in 2004-2005 cropping year, viz.231.88 x 10^3 and 230.90 x 10^3 respectively over T_1, T_2 and T_8, but it was identical for T_3, T_5 and T_6. Whereas in the cropping year 2005-06 it was found that all the treatments produced statistically higher number of tiller over T_1.Though the treatments T_5 and T_6 produced the highest number of tiller (142.31 x 10^3 and 137.91 x 10^3 respectively) but they were statistically identical with T_2, T_3, T_4, T_7 and T_8. In both the cropping years (2004-05 and 2005-06) the highest and second highest number of millable cane per hectare were found in T_7 (105.80 x 10^3 and 79.42 x 10^3) and T_4 (105.60 x 10^3 and 79.17 x 10^3) among all other treatments. The treatments T_7 and T_4 also produced significantly higher cane yields of 70.89 and 70.13 tha^{-1} in 2004-05 respectively over T_1 and T_2 but it was identical with all other treatments. Whereas in 2005-06 T_8 produced the highest number of cane yield over T_1 and T_2 than that of other treatments. Treatment T_3, T_4, T_6 and T_7 showed statistically identical cane yield with T_8 but higher cane yield over T_1. Even though T_4 and T_7 in 2004-05 showed a little better stalk heights (3.33 m and 3.26 m) and cane girth (2.16 cm and 2.17 cm), respectively whereas in 2005-06 the highest stalk height was obtained from T_3 and T_4 (both 2.64 m) but the effects were found as non-significant for all in both the cropping years. While the treatment T_1 (control) produced significantly lower number of tillers (147.57 x 10^3) and millable cane (67.08 x 10^3) per hectare. It also produced significantly lower cane yield (36.82 t ha^{-1}). Again, T_1 produced lower stalk height (2.95 m) and girth (2.08 cm) in both the cropping years. Even though the applications of Mn and B slightly increased brix (%) in cane but the effects were found as non-significant for all. Anderson and Bowen (1990) also reported that boron is involved in sugar translocation, protein synthesis and cell wall formation in sugarcane. Similarly Sinha and Chatterjee (1994) confirmed that application of boron increased sugar accumulation in pearl millet crop in India. They further confirmed the boron deficiency in well-drained sandy-textured soils by their experiment. Better effect from manganese application in sugarcane was highly supported by Anderson and Bowen (1990) where they mentioned its significant role as enzyme activator, particularly involved in Kreb's Cycle reactions and in protein synthesis resulting with higher cane tonnage.

It is further evident from Table 4b that the treatment T_7 (which is addition to the recommended fertilizer included 2 Kg B ha^{-1}) gave the highest average cane yield of two seasons (59.23 tha^{-1}) and also showed the highest percent increase in cane yield (18.25) over recommended fertilizer. Table 4b again shows that the treatments T_3 and T_4, which received 1 and 2 Kg Mn ha^{-1} in addition to the recommended fertilizer, gave higher average cane yields of 57.75 and 57.70 t ha^{-1} with percent increase in cane yields of 15.29 and 15.19, respectively over the present recommended fertilizers.

From the economic analysis, it was found that the treatment T_4 gave the highest gross margin of Taka 67, 877 ha^{-1} with MBCR 1.40 followed by Taka 67, 177 ha^{-1} with MBCR 1.16 from T_7 in the cropping year 2004-05, while in 2005-06 the highest gross margin of Taka 44,305 ha^{-1} with MBCR 0.86 followed by Taka 42608 ha^{-1} with MBCR 1.08 was obtained from T_6 (Table 5).

In conclusion, results of the study revealed that the application of boron and manganese @ 2-3 kg B and 2 kg Mn ha^{-1} along with recommended NPKSZn fertilizers improved Mn, B, Zn, N, P and Ca concentrations in sugar cane leaf and produced higher sugarcane yields. They further showed higher gross margins per hectare of sugarcane cultivation. Thus, the treatments T_4, T_7 and T_8 were found superior to all other treatments for sustaining sugarcane yield and income in Old Himalayan Piedmont Plain soils of Bangladesh. However, it needs further investigation of the results of the experiment for confirmation.

Table 1. Treatments code.

Code	Treatment detail
T_1	Control (No fertilizer)
T_2	Recommended Fertilizer Doses (RFD) at N_{120} P_{35} K_{100} S_{25} and Zn_2 kg ha^{-1}
T_3	T_2 + 1kg Mn ha^{-1}
T_4	T_2 + 2 kg Mn ha^{-1}
T_5	T_2 + 3 kg Mn ha^{-1}
T_6	T_2 + 1 kg B ha^{-1}
T_7	T_2 + 2 kg B ha^{-1}
T_8	T_2 + 3 kg B ha^{-1}

Table 2. Status of initial and post harvest soil of the experiment as affected by different fertilizer treatments (Average).

Treatment	Analytical value								
	pH	N (%)	P (ppm)	K (meq 100^{-1} g soil)	S (ppm)	Ca (meq 100^{-1}g soil)	Mg (meq 100^{-1} g soil)	B (ppm)	Mn (ppm)
Initial Soil	5.20	0.075	18.00	0.16	18.00	0.02	0.01	0.16	4.00
Post harvest soil									
T_1	5.20	0.060	19.00	0.15	0.17	0.02	0.01	0.14	4.00
T_2	5.20	0.060	22.00	0.16	0.19	0.02	0.01	0.14	4.00
T_3	5.30	0.070	25.00	0.16	0.20	0.02	0.01	0.14	4.00
T_4	5.30	0.065	24.00	0.15	0.19	0.02	0.01	0.16	4.50
T_5	5.40	0.060	22.00	0.16	0.19	0.02	0.01	0.18	4.50
T_6	5.20	0.065	22.00	0.16	0.18	0.02	0.01	0.25	4.00
T_7	5.20	0.070	23.00	0.17	0.19	0.02	0.01	0.30	4.00
T_8	5.30	0.070	22.00	0.16	0.18	0.02	0.01	0.32	4.00

Table 3. Effect of manganese and boron on some nutrient concentrations in leaf of sugarcane at maturity phase (Average).

Cropping year 2004-2005									
Treatment	Mn (ppm)	B (ppm)	Zn (ppm)	N (%)	P (%)	K (%)	S (%)	Ca (%)	Mg (%)
T_1	73.000	6.197	13.333	0.777	0.113	1.550	0.103	0.240	0.023
T_2	76.667	6.207	12.667	0.853	0.113	1.667	0.107	0.290	0.027
T_3	77.000	6.180	14.667	0.947	0.110	1.667	0.107	0.303	0.027
T_4	77.333	6.073	16.000	0.887	0.113	1.683	0.107	0.293	0.030
T_5	78.000	6.380	16.000	1.010	0.120	1.633	0.117	0.320	0.037
T_6	75.000	6.647	14.000	0.977	0.143	1.683	0.113	0.320	0.027
T_7	74.667	7.153	16.667	1.053	0.140	1.617	0.113	0.350	0.027
T_8	74.667	6.580	12.000	1.020	0.150	1.617	0.103	0.383	0.023
SE mean (0.05)	3.393	0.214	1.417	0.052	0.012	0.033	0.004	0.025	0.005
CV (%)	7.8	5.8	17.0	9.5	16.7	3.5	5.8	14.0	30.6

Table 4a. Yield and yield parameters of sugarcane as affected by different fertilizer management treatments with or without manganese and boron.

Crop Year	Treatments	Maximum tiller (10^{-3} ha^{-1})	Mill able cane at harvest (10^{-3} ha^{-1})	Cane yield (t ha^{-1})	Stalk height (m)	Cane girth (cm)	Brix (%)
2004 -2005	T_1	147.57 c	67.08 c	36.82 c	2.95	2.08	18.11
	T_2	201.94 b	98.33 ab	56.98 b	3.12	2.12	17.73
	T_3	222.78 a	104.40 a	69.26 a	3.16	2.15	18.17
	T_4	231.88 a	105.60 a	70.13 a	3.33	2.16	18.31
	T_5	227.57 a	102.20 ab	66.43 a	3.09	2.15	18.08
	T_6	215.69 ab	96.11 b	69.37 a	3.08	2.09	18.46
	T_7	230.90 a	105.80 a	70.89 a	3.26	2.17	18.40
	T_8	198.61 b	98.89 ab	66.61 a	3.07	2.16	18.24
	LSD (0.05)	19.57	7.76	7.19	ns	ns	ns
	CV (%)	5.33	4.55	6.48	4.48	2.81	2.04
2005-2006	T_1	75.57b	42.50b	16.43c	2.19	2.03	18.56
	T_2	137.29a	73.75a	43.19b	2.54	2.15	17.82
	T_3	137.43a	75.33a	46.24ab	2.64	2.08	17.94
	T_4	134.17a	79.17a	45.27ab	2.64	2.18	17.58
	T_5	137.91a	77.92a	44.93ab	2.62	2.32	18.11
	T_6	142.31a	76.25a	48.19ab	2.49	2.27	18.16
	T_7	137.67a	79.42a	47.56ab	2.53	2.48	17.76
	T_8	137.50a	72.67a	51.73a	2.59	2.08	18.04
	LSD (0.05)	17.11	10.72	7.94	NS	NS	NS
	CV (%)	7.52	8.48	10.56	6.66	10.38	3.35

*Figures in column with same letter (s) do not differ significantly at 5% level as per LSD test

Table 4b. Influences of Manganese and Boron fertilizers on sugarcane yield in a sandy loam soil under Old Himalayan Piedmont Plain.

Added Manganese and Boron with recommended NPKSZn (Kg ha^{-1})	Average cane yield of two seasons (t ha^{-1})	Increase in cane yield by Manganese and Boron over recommended NPKSZn (%)
0	50.09	-
Mn 1	57.75	15.29
Mn 2	57.70	15.19
Mn 3	55.68	11.16
B 1	58.78	17.35
B 2	59.23	18.25
B 3	59.17	18.13

Note: Manganese sulphate (36% Mn) and boric acid (17% Boron) were used for manganese and boron respectively.

Table 5. Cost and return analysis of different fertilizer management treatments for sugarcane production.

Crop Year	Treatment	Gross Return (Tk ha^{-1})	Fertilizer cost (Tk ha^{-1})	Total variable cost (Tk ha^{-1})	Gross Margin (Tk ha^{-1})	Marginal Benefit Cost Ratio (MBCR)
2004-2005	T_1	41, 423	-	33, 898	41, 423	-
	T_2	64, 103	10, 463	44, 361	53, 640	0.17
	T_3	77, 918	10, 916	44, 639	67, 002	1.10
	T_4	78, 896	11, 019	44, 917	67, 877	1.40
	T_5	74, 734	11, 296	45, 194	63, 438	0.95
	T_6	78, 041	11, 606	45, 504	66, 435	1.16
	T_7	79, 751	12, 574	46, 647	67, 177	1.40
	T_8	74, 936	13, 891	47, 789	61, 045	0.41
2005-2006	T_1	18,484	-	33, 898	18484	-
	T_2	48,592	10, 463	44, 361	38129	0.88
	T_3	52,020	10, 916	44, 639	41104	1.07
	T_4	50,929	11, 019	44, 917	33910	0.40
	T_5	50,546	11, 296	45, 194	39250	0.84
	T_6	54,214	11, 606	45, 504	42608	1.08
	T_7	53,505	12, 574	46, 647	40931	0.79
	T_8	58,196	13, 891	47, 789	44305	0.86

Price (Tk. / kg):

Input: Urea = 6.50, TSP =14.00, MP =11.00, Gypsum =4.00,

Zinc sulphate = 60.00, MgO = 40.00, Manganese sulphate= 100.00,

Boric acid= 200.00, Labour = Tk 70 $person^{-1}day^{-1}$

Output: Sugarcane =1.125

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