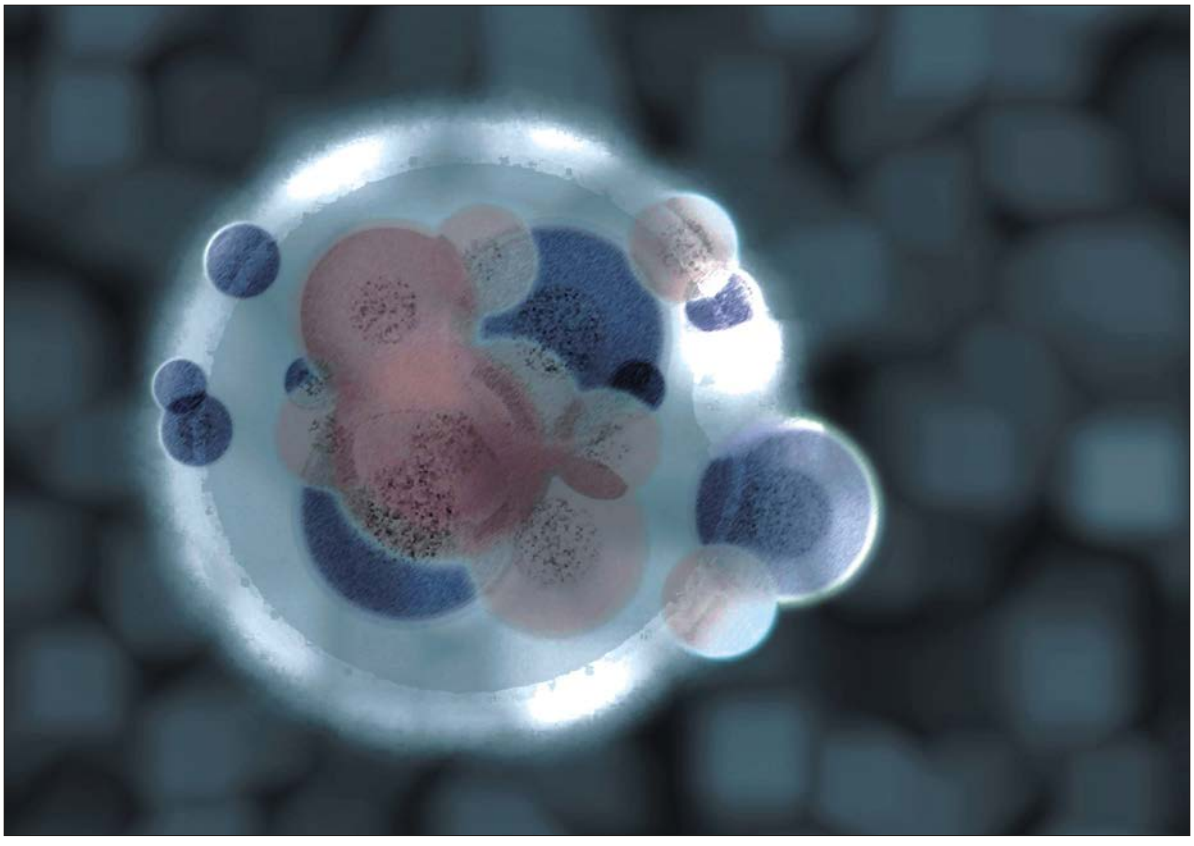

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Response of Turmeric to Zinc and Boron Fertilization

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Abstract: The field study of Zn and B on the yield of turmeric was carried out at Brown Hill Soils (Eutrochrepts) of South Eastra Hilly region of at Hill Tracts Agricultural Research Station, Ramgarh, Khagrachari during the Kharif seasons of 2001-2005 and 2005-2006, respectively. The objective was to evaluate the response of turmeric to Zn and B fertilization. Four levels of B (0, 1, 2 and 3 kg ha^{-1}) and 4 levels of Zn (0, 1.5, 3.0 and 4.5 kg ha^{-1}) oxide were included in the study. A combined blanket dose of $N_{130}P_{35}K_8S_{20}$ kg and CD 5 t ha^{-1} were also mixed in all the treatment plots. It was evident from two years study that both Zn and B either in single or in combination had significant effect on the growth and yield attributes of turmeric in Zn-B deficient soil at experimental site. Boron produced approximately 11.0 and 18.19% higher yield than Zinc in both the years. However, the highest turmeric yield (21.4 and 25.5 t ha^{-1}) was recorded with the maximum B level ($B_{3.0}$ kg ha^{-1}) which was 79.58% higher over B control (B_0). While Zn produced 28.57 and 66.43% higher yield compared to Zn control (Zn_0) treatment. However, the integrated effect of Zn and B was found to be highly responsive and markedly dominated the turmeric yield and their yield attributes. The highest rhizome (turmeric) yield (27.5 and 28.9 t ha^{-1}) was recorded with the combination of Zn and B at the rate of 4.5 and 3.0 kg ha^{-1} and 170% higher yield over Zn-B control treatment (Zn_0B_0) in 2nd year and 145% in first year. It was also revealed from the economic analysis that same Zn-B combination gave the highest gross margin Tk. 422704 and Maximum Rate of Return 1557% (MRR) which was economically profitable for turmeric production in hilly region.

Key words: Turmeric, zinc, boron, fertilization

INTRODUCTION

Turmeric (*Curcuma longer* L.) is a popular spice crop in Bangladesh. It has multiple uses in dying industries, medicines, culinary preparation and in cosmetics for its typical color and flavor. It can no way be denied that turmeric is a potential cash crop of Chittagong Hill Tracts Region. Tribal and hilly farmers usually plant turmeric in hill slopes either in the from of shifting cultivation locally known as Jhum cultivation or in Furrows after conventionally preparing the lands with subsequent ridging. These methods of cultivation are very much hazardous for soil erosion due to excessive rainfall during monsoon months. Since, most of the lands in this area are hilly and undulated topography. Zero tillage or minimum tillage along with across the planting system could be best suited for growing this spicy crop in this area as they are capable to reduce and minimize the soil erosion to a tolerable range (Van Doran *et al*., 1977). Besides, turmeric can be grown in variety of soil but it prefers to grow in light textured soil and well suited to shady places. Though the hilly people cultivate this spice crop abundantly in hill slopes but even they do not have any recommended dose of fertilizers to grow this crop. It is well evidenced that spicy crops like ginger and turmeric are highly responsive to chemical fertilizers. In addition, micro-nutrient fertilizers are mostly liable to reduce disease incidence and enhance durability of post harvest life of ginger and turmeric. Banafer and Tiwan (1995), Gupta and Singar (1997), Roy *et al*. (1992), stated in their reports that ginger and turmeric are highly responsive to chemical fertilizers and increased the growth and rhizome yield with the increment of fertilizer rates. However, many hilly farmers now feel discouraged to grow this spice crop extensively for poor yield and disease incidence. It is also evident that inadequate and imbalanced use of chemical fertilizers along with micro-nutrients drastically reduced the yield of turmeric especially in hilly region. Not only this, very limited and sporadic works have been done in turmeric production in Bangladesh.

Therefore, from above justification and context such type of field study was conducted to evaluate the response of turmeric to different levels of zinc and boron for maximizing yield of turmeric in Brown Hill Soils (Eutrocrepts) of Chittagong hilly region.

MATERIALS AND METHODS

The field studies were carried out at Brown Hill Soils (Eutrocrepts) of hill Tracts Agricultural Research station,

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Table 1: Nutrient status of experimental soil prior to fertilizer application

Chemical properties	pH	OM	Ca	Mg	K	Total N (%)	P	S	B	Cu	Fe	Mn	Zn
	----------	----------	mg/100 g	----------	----------		----------	----------	----------	μg g^{-1}	----------	----------	----------
Initial soil	4.5	0.90	1.2	0.5	0.09	0.056	3.0	11.0	0.23	3.8	200.0	12.0	1.2
Critical level	-	-	2.0	0.8	0.2	-	14.0	14.0	0.2	1.0	10.0	5.0	2.0

Source: Soil Science Laboratory, BARI

Ramgarh, Khagrachari during Kharif seasons of 2004-2005 and 2005-2006 to find out the response of turmeric to Zinc and Boron for maximizing yield of turmeric in hilly region. The fertility status of the soil of experimental field was found to be poor in organic matter, strongly acidic in nature and nutrient elements are almost bellow critical levels. The physical and chemical properties of analyzed soil samples are shown in Table 1.

The experiment was designed in randomized complete block having replications thrice. The plot dimension and seed to seed distance were maintained as 4×5 and 50×25 cm, respectively. There were sixteen treatment combinations having each four levels of zinc (0, 1.5, 3.0 and 4.5 kg ha^{-1}) and each four levels of boron (0, 1, 2 and 3 kg ha^{-1}) along with combined blanket dose of NPKS and CD at the rate of 30: 35: 80: 20 kg and 5 t ha^{-1} taken in the study. Dimla was used as a test crop in the study. All PKSZnB and cowdung 5 t ha^{-1} were applied during final land preparation. Nitrogen was top dressed around, the plants in split at 80 and 110 days after planting rhizome. The rhizome seeds were planted on 18 April 2004, 13 April 2005 and harvested by mid February, 2005 and 2006, respectively. All the necessary field are rations were performed in time. The field data on important parameters were recorded from 10 randomly selected plants for analysis. The collected data were statistically analyzed and adjusted with Least Significance Difference (LSD) at 5% level of significance.

RESULTS AND DISCUSSION

Effect of B: The significant effect of B progressively increased the growth and yield parameters of turmeric with the increasing rates of B up to 3.0 kg ha^{-1}. It was also noticed that increasing trend among the different yield parameters were found to be markedly pronounced by boron application as compared to Zinc. However, plant height, number of leaves, primary, secondary and tertiary fingers, finger weight per plant, finger size and rhizome yield were highly influenced by addition of boron at maximum level (B_3 kg ha^{-1} in both the years of study. The highest plant height (103.8 and 104.2 cm), maximum leaves number (13.6 and 12.6) and finger numbers (43 and 45.2) were recorded from 0 to 3.0 kg B ha^{-1} which was significantly differed over other B levels and B control (B_0) in both the years of 2004 and 2005, respectively (Table 2a and b). Other yield parameters like finger weight, finger size and turmeric yield also significantly responded to B levels up to 3 kg B ha^{-1}. Boron at 3.0 kg ha^{-1} markedly increased the turmeric weight (428 g and 436 g $plant^{-1}$), finger size (7.6×7.5 and 8.2×8.3 cm) and turmeric yield (24.4 and 25.5 t ha^{-1}) which were statistically differed over lower B level (1 kg B ha^{-1}) and 79.58% yield increase in 2nd year was due to B deficiency in experimental soil. Sugtto and Mafutuchah (1995), Pawer and Gavande (1992) and Singh *et al.* (1992) observed similar findings in their report as found in boron application.

Effect of zinc: The yield of turmeric was augmented progressively due to Zn application (Table 2a and b). The significant increase of growth and other yield parameters were noticed with the subsequent addition of Zn up to 4.5 kg ha^{-1}. But these increasing trends among different parameters were not pronouncedly distinct as compared to boron. However, applied 4 levels of Zn (0, 1.5, 3.0 and 4.5 kg ha^{-1}), the highest plant height (93.7 and 94.3 cm), maximum leaves number (10.0 and 10.5/plant) and finger numbers (40.4 and 43.5/plant) were recorded in Zn at the rate of 4.5 kg ha^{-1} followed by $Zn_{3.0}$ kg ha^{-1} in two consecutive years of 2004 and 2005, respectively. This was happened due to poor presence of Zn in native soil. Like B, other parameters such as finger weight, finger size and turmeric yield were also influenced by Zn fertilization positively. However, the highest finger weight (410 g and 412 g/plant), maximum finger size (1.7×6.7 and 7.1×6.9 cm) and the highest turmeric yield (23.9 and 24.3 t ha^{-1}) were recorded in the said Zinc level (4.5 kg ha^{-1}) which was significantly differed from other Zn levels and were 28.57 and 66.43% yield increase over the Zn control (Zn_0) in both the years of study. This result was in partially agreement with the findings of Pranjal and Supriya (1994) and Shoe *et al.* (1995).

Integrated effect of Zn and B: It is evident in the Table 2a and b that both Zn and B had significant influence on the yield and yield attributes of turmeric. It was also noticed that both growth and yield contributing parameters increased progressively with the increased dosage of zinc and boron in combination. The crop

Table 2a: Main effect of boron and zinc on the yield and yield attributes of turmeric at HARS, Ramgarh during 2004-05

Boron level (kg ha^{-1})	Plant height (cm)	No. of leaves/ plant	No. of fingers: Primary fingers	No. of fingers: Secondary fingers	No. of fingers: Tertiary fingers	Wt. of fingers/ plant (g)	Wt. of turmeric/ plant (g)	Wt. of corm (g)	Finger size: Length (cm)	Finger size: Diameter (cm)	Turmeric yield (t ha^{-1})	Yield (%) increase over control
B_0	70.5d	6.4d	4.1d	18.2d	12.8d	313d	346d	6.2d	4.8d	4.9d	13.0d	-
B_1	87.1c	8.4	4.6c	20.2c	13.6c	329c	390c	7.4c	5.8c	5.9c	15.3c	17.69
B_2	94.1b	9.9bc	4.9b	21.0b	14.0b	361b	405b	7.7b	6.7b	6.6b	17.0b	13.54
B_3	103.8a	12.2a	5.5a	22.6a	14.9a	383a	428a	8.1a	7.6a	7.5a	24.4a	56.46
LSD (0.05)	*	*	*	*	*	*	*	*	*	*	*	-
Zinc (kg ha^{-1})												
Zn_o	82.6d	8.5b	4.6d	19.8d	13.4d	337d	378d	7.0d	5.8d	5.7d	14.0d	-
$Zn_{1.5}$	88.5c	8.8c	4.7c	20.3c	13.9c	343c	385c	7.3c	6.1c	6.1c	17.0c	21.43
$Zn_{3.0}$	90.6b	9.5b	4.9b	20.9b	14.0b	351b	395b	7.5b	6.4b	6.4b	19.9b	20.71
$Zn_{4.5}$	93.7a	10.0a	5.1a	21.1a	14.2a	355a	410a	7.6a	6.7a	6.7a	23.9a-	28.57
LSD (0.05)	*	*	*	*	*	*	*	*	*	*	*	-

Figures having common letter(s) in a column are not significantly different by DMRT at 5 (%) level

Table 2b: Main effects of boron and zinc on the yield and yield attributes of turmeric at HARS, Ramgarh during 2005-2006

Boron level (kg ha^{-1})	Plant height (cm)	No. of leaves/ plant	No. of Fingers: Primary fingers	No. of Fingers: Secondary fingers	No. of Fingers: Tertiary fingers	Wt. of fingers/ plant (g)	Wt. of turmeric/ plant (g)	Wt. of Corm (g)	Finger size: Length (cm)	Finger size: Diameter (cm)	Turmeric yield (t ha^{-1})	Yield (%) increase over control
B_0	70.7d	6.6d	4.2d	18.3d	13.2d	317d	350d	6.3	4.7d	5.2d	14.2d	-
B_1	88.2c	7.9c	4.7c	21.0c	14.3c	331c	396c	7.7	5.9c	6.3c	16.3c	14.79
B_2	95.6b	10.2b	5.3b	21.7b	15.2b	363b	406b	7.8	6.8b	7.2b	18.3b	28.88
B_3	104.2a	12.6a	6.1	22.8a	16.3a	386a	436a	8.8	8.2a	8.3a	25.5a	79.58
LSD (0.05)	*	*	*	*	*	*	*	*	*	*	*	-
Zinc (kg ha^{-1})												
Zn_o	83.3d	8.6d	4.7d	20.1d	14.2d	337d	318d	7.3d	6.0d	6.2d	14.6d	-
$Zn_{1.5}$	88.7c	8.9c	4.8c	20.5c	15.1c	350c	386c	7.6c	6.3a	6.3c	18.3c	25.34
$Zn_{3.0}$	91.0b	9.7b	5.2b	21.3b	15.7b	362b	400b	7.9b	6.7b	6.7b	21.0b	43.84
$Zn_{4.5}$	94.3a	10.5a	5.3a	22.2a	16.0a	370a	412a	8.3a	7.1a	6.9a	24.3a	66.48
LSD (0.05)	*	*	*	*	*	*	*	*	*		*	-

Figures having common letter(s) in a column are not significantly different by DMRT at 5 (%) level

Table 3a: Interaction effect of boron and zinc on the yield and yield attributes of turmeric of HARS, Ramgah, Khagrachari, during 2004-2005

Level of B (kg ha^{-1})	Level of Zn (kg ha^{-1})	Plant height (cm)	No. of leaves/ plant	No. of fingers: Primary fingers	No. of fingers: Secondary fingers	No. of fingers: Tertiary fingers	Wt. of fingers/ plant (g)	Wt. of turmeric/ plant (g)	Wt. of corm (g)	Finger size: Length (cm)	Finger size: Diameter (cm)	Turmeric yield (t ha^{-1})
B_o	Zn_0	56.0	5.3	3.7	17.0	12.0	300	313	5.6	4.3	4.3	11.23
B_1		84.3	8.3	4.5	19.4	13.4	322	384	7.3	5.8	5.8	14.67
B_2		92.0	9.3	4.8	20.8	13.9	357	401	7.6	6.1	5.8	16.7
B_3		98.3	11.0	5.2	22.0	14.6	369	414	7.8	7.1	7.1	21.5
B_o	Zn_{15}	71.0	6.0	4.0	17.9	12.6	312	331	6.2	4.6	4.6	13.0
B_1		86.3	8.0	4.6	20.1	13.7	329	389	7.3	5.8	5.9	14.8
B_2		93.6	9.6	4.9	20.9	14.0	360	403	7.6	6.8	6.8	16.7
B_3		103.3	11.6	5.3	22.3	14.9	371	418	8.0	7.2	7.2	23.7
B_o	$Zn_{3.0}$	76.0	7.0	4.2	18.8	13.2	320	359	6.6	5.1	5.1	13.9
B_1		87.6	8.3	4.7	20.5	13.7	331	392	7.5	5.9	5.9	15.5
B_3		94.3	10.3	4.9	21.1	14.1	362	405	7.7	6.9	6.9	17.3
B_2		104.6	12.6	5.8	23.0	15.0	389	425	8.2	7.9	7.7	25.0
B_o	$Zn_{4.5}$	79.0	7.3	4.4	19.0	13.4	321	380	6.6	5.5	5.6	14.1
B_1		90.3	9.0	4.8	20.7	13.8	333	396	7.5	6.0	6.1	16.4
B_2		96.7	10.3	5.2	21.4	14.3	361	412	7.8	7.0	7.0	17.5
B_3		109.0	13.6	5.9	23.2	15.4	403	454	8.3	8.3	8.2	27.5
LSD (0.05)		2.54	1.09	0.19	0.59	0.18	3.22	4.0	0.17	0.14	0.30	0.69
CV (%)		3.7	7.1	3.4	7.1	8.1	6.6	6.6	4.1	3.1	3.9	3.4

responded positively to Zn-B application up to Zn 4.5 kg and $B_{3.0}$ kg ha^{-1} as the available Zn and B levels of the experimental soil was in deficient. The increase in the rhizome yield has resulted due to cumulative effect of finger weights per plant, finger size and number of fingers per plant. However, it is also observed in the table that

both Zn and B individually and their integrated effect statistically influenced the yield and yield contributing characters of turmeric. Besides, the highest plant height (109.0 and 110.0 cm), maximum leaves number (13.6 and 14.2/plant) and fingers number (44.50 and 47.60/plant) were recorded with the combined application of Zn and B at the highest level ($Zn_{4.5}B_{3.0}$ kg ha^{-1}) which was significantly different over Zn-B control (Zn_0B_0) in two successive years of 2004-2005 and 2005-2006. The yield response of turmeric to Zn and B was almost similar in both the years of study might be the possible reasons of appropriate management practices and unique agro-climatic conditions. Other yield contributing parameters like figure weight, finger size and turmeric yield noticeably increased with successive addition of Zn and B, respectively. However, the maximum finger size (83×8.2 and 8.5×8.4 cm) and the highest turmeric yield (27.5 and 28.9 t ha^{-1}) were obtained from same Zn-B ($Zn_{4.5}B_{3.0}$kg ha^{-1}) integration and mean yield 28.20 t ha^{-1} was also recorded in the same from two years investigation.

Economics: The economic analysis for combined effect of Zn and B has been presented in Table 4a, 4b and 5a, 5b, respectively. It is revealed from the tables reflected that both Zn and B in combination gave higher monitory return. Moreover, the Table 4a, b and 5a, b studied showed that the highest gross margin Tk. 401704 and Tk. 422704 and maximum rate of return (MRR) 390 and 1557% were recorded by treatment T_{16} ($Zn_{4.5}B_{3.0}$ kg ha^{-1})which was significantly dominated over all other Zn-B combinations in two years study. This is might be the

Table 3b: Interaction effect of boron and zinc on the yield and yield attributes of turmeric of HARS, Ramgah, Khagrachari, during 2004-2005

level of B (kg ha^{-1})	Level of Zn (kg ha^{-1})	Plant height (cm)	No. of leaves/ plant	No. of fingers			Wt. of fingers/ plant (g)	Wt. of turmeric/ plant (g)	Wt. of Corm (g)	Finger size		Turmeric yield (t ha^{-1})
				Primary fingers	Secondary fingers	Tertiary fingers				Length (cm)	Diameter (cm)	
B_o	Zn_o	57.0	5.2	3.8	17.2	13.2	302	317	5.7	4.4	4.5	12.2
B_1		83.1	8.6	4.5	20.1	14.3	323	386	7.2	6.0	5.9	14.73
B_2		93.2	9.5	4.9	21.0	14.6	361	402	8.3	6.3	6.2	17.02
B_3		97.0	11.7	5.6	22.6	15.3	372	418	8.7	7.5	7.4	22.3
B_o	$Zn_{1.5}$	72.0	7.0	4.2	18.3	13.3	314	332	6.2	4.9	4.7	13.6
B_1		87.1	8.3	4.7	21.0	14.2	321	389	7.6	6.3	5.9	15.2
B_2		94.0	10.0	4.7	22.0	14.6	365	407	7.8	6.8	6.9	17.6
B_3		103.3	12.1	5.6	24.0	15.6	373	419	8.3	7.7	7.6	24.2
B_o	$Zn_{3.0}$	75.6	7.6	4.3	19.3	13.2	321	362	6.8	5.3	5.3	14.2
B_1		88.2	8.7	4.8	21.0	13.9	332	409	7.6	5.8	6.2	16.2
B_2		96.3	10.7	4.9	21.7	14.3	363	427	7.8	8.1	7.8	18.3
B_3		105.1	13.2	5.9	24.0	15.8	393	4.38	8.3	5.6	8.3	26.2
B_o	$Zn_{4.5}$	78.2	7.4	4.3	20.1	14.0	321	382	6.7	6.2	5.6	14.7
B_1		91.3	9.7	4.9	21.0	14.7	334	393	7.6	6.7	6.2	16.5
B_2		97.2	10.5	5.3	21.7	15.3	363	427	7.9	7.3	7.1	19.3
B_3		110.0	14.2	6.1	25.3	16.2	412	481	8.4	8.5	8.4	28.9
LSD (0.05)		2.78	1.12	0.22	0.61	0.19	3.28	4.3	0.18	0.16	0.32	0.73
CV (%)		4.6	6.3	6.1	5.2	6.2	6.1	6.7	4.3	3.3	4.1	5.2

Table 4a: Partial budget and dominance analysis for response of turmeric to zinc and boron at HARS, Ramgarh, Khagrachari during 2004-2005

Treatments combination	Turmeric yield (t ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Gross marin (Tk. ha^{-1})
T_1 = B_0Zn_0	11.2	9,272	1,68,000	1,58,728
T_2 = B_1Zn_0	14.6	9,684	2,19,000	2,09,316
T_3 = B_2Zn_0	16.7	10,096	2,50,500	2,40,404
T_4 = B_3Zn_0	21.5	10,508	3,22,500	3,11,992
T_5 = $B_2Zn_{1.5}$	13.0	9,368	1,95,000	1,85,632
T_6 = $B_1Zn_{1.5}$	14.8	9,780	2,22,000	2,12,220
T_7 = $B_2Zn_{1.5}$	16.7	10,192	2,50,500	2,40,308
T_8 = $B_3Zn_{1.5}$	23.7	10,604	3,55,500	3,44,896
T_9 = $B_0Zn_{3.0}$	13.9	9,464	2,08,500	1,99,036
T_{10} = $B_1Zn_{3.0}$	15.5	9,876	2,32,500	2,22,624
T_{11} = $B_2Zn_{3.0}$	17.3	10,288	2,59,500	2,49,212
T_{12} = $B_3Zn_{3.0}$	25.0	10,770	3,75,000	3,64,300
T_{13} = $B_0Zn_{0.5}$	14.1	9,560	2,11,500	2,01,940
T_{14} = $B_1Zn_{0.5}$	16.4	9,972	2,46,000	2,36,028
T_{15} = $B_2Zn_{0.5}$	17.5	10,384	2,62,500	2,52,116
T_{16} = $B_3Zn_{4.5}$	27.5	10,796	4,12,500	4,01,704

Price : Urea : Tk. 6.00/kg, TSP : Tk. 12.00/kg, MP : Tk. 8.00/kg, GYP : Tk. 4.00/kg, Boric Acid : Tk.70.00/kg, Zinc Oxide : Tk. 50.00/kg, Cowdung: Tk. 0.75/kg, Turmeric Price : Tk = 15.00/kg

Table 4b: Partial budget and dominance analysis for response of turmeric to zinc and boron at HARS, Ramgarh, Khagrachari during 2004-2005

Treatments combination	Turmeric yield (t ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Gross marin (Tk. ha^{-1})
T_1 = B_0Zn_0	12.2	9,272	1,83000	1,73,728
T_2 = B_1Zn_0	14.73	9,684	2,20950	2,11,666
T_3 = B_2Zn_0	17.02	10,096	2,55300	243204
T_4 = B_3Zn_0	22.3	10,508	3,34500	323992
T_5 = $B_2Zn_{1.5}$	13.6	9,368	2,04000	194632
T_6 = $B_1Zn_{1.5}$	15.2	9,780	2,28,000	218220
T_7 = $B_2Zn_{1.5}$	17.6	10,192	264000	253808
T_8 = $B_3Zn_{1.5}$	24.2	10,604	363000	352396
T_9 = $B_0Zn_{3.0}$	14.2	9464	2,13000	203536
T_{10} = $B_1Zn_{3.0}$	16.2	9876	2,40000	230124
T_{11} = $B_2Zn_{3.0}$	18.3	10288	274500	264212
T_{12} = $B_3Zn_{3.0}$	26.2	10,770	393000	382230
T_{13} = $B_0Zn_{4.5}$	14.7	9,560	220500	210528
T_{14} = $B_1Zn_{4.5}$	16.5	9,972	247500	237528
T_{15} = $B_2Zn_{4.5}$	19.3	10,384	289500	279116
T_{16} = $B_3Zn_{4.5}$	28.9	10,796	433500	422704

Price : Urea : Tk. 6.00/kg, TSP : Tk. 12.00/kg, MP : Tk. 8.00/kg, GYP : Tk. 4.00/kg, Boric Acid : Tk.70.00/kg, Zinc Oxide : Tk. 50.00/kg, Cowdung : Tk. 0.75/kg, Turmeric Price : Tk = 15.00/kg

Table 5a: Marginal analysis of cost undominated treatment for response of turmeric to zinc and boron at HARS, Ramgarh, Khagrachari during 2004-2005

Treatments combination	Gross margin (Tk.ha^{-1})	Total variable cost (Tk ha^{-1})	Marginal increase in gross margin (Tk. ha^{-1})	Marginal increase in variable cost (Tk ha^{-1})	Marginal rate of return (%) (MRR)
T_{16} = $B_3Zn_{4.5}$	4,01,704	10,796	37,404	96	390
T_{12} = $B_3Zn_{3.0}$	3,64,300	10,700	19,404	96	202
T_8 = $B_3Zn_{1.8}$	3,44,896	10,604	32,904	96	343
T_4 = B_3Zn_0	3,11,992	10,508	59,876	124	483
T_{15} = $B_2Zn_{4.5}$	2,52,116	10,384	2,904	96	30
T_{10} = $BZn_{3.0}$	2,49,212	10,288	8,808	192	46
T_3 = B_2Zn_0	2,40,404	10,096	4,376	14	35
T_{14} = $B_1Zn_{4.5}$	2,36,028	9,972	13,404	96	140
T_{10} = $B_1Zn_{3.0}$	2,22,624	9,876	10,404	96	108
T_6 = $B_1Zn_{1.5}$	2,12,220	9,780	2,904	96	30
T_2 = B_1Zn_0	2,09,316	9,684	7,376	124	59
T_{13} = $B_0Zn_{4.5}$	2,01,940	9,560	2,904	96	30
T_9 = $B_0Zn_{3.0}$	1,99,036	9,464	13,404	96	140
T_5 = $B_0Zn_{1.5}$	1,85,632	9,368	26,904	96	280
T_1 = B_0Zn_0	1,58728	9,272	-	-	-

Table 5b: Marginal analysis of cost undominated treatment for response of turmeric to zinc and boron at HARS, Ramgarh, Khagrachari during 2004-2005

Treatments combination	Gross margin (Tk.ha^{-1})	Total variable cost (Tk ha^{-1})	Marginal increase in gross margin (Tk. ha^{-1})	Marginal increase in variable cost (Tk ha^{-1})	Marginal rate of return (%) (MRR)
T_{16} = $B_3Zn_{4.5}$	422704	10,796	40474	26	1557
T_{12} = $B_3Zn_{3.0}$	382230	10,770	29834	166	180
T_8 = $B_3Zn_{1.8}$	352396	10,604	28404	96	296
T_4 = B_3Zn_0	323992	10,508	44876	124	362
T_{15} = $B_2Zn_{4.5}$	279116	10,384	14904	96	155
T_{10} = $BZn_{3.0}$	264212	10,288	21008	192	109
T_3 = B_2Zn_0	243204	10,096	5676	124	46
T_{14} = $B_1Zn_{4.5}$	237528	9,972	7404	96	71
T_{10} = $B_1Zn_{3.0}$	230124	9,876	18458	96	192
T_6 = $B_1Zn_{1.5}$	211666	9,780	1138	96	12
T_2 = B_1Zn_0	210528	9,684	6992	96	73
T_{13} = $B_0Zn_{4.5}$	203536	9,560	8904	96	93
T_9 = $B_0Zn_{3.0}$	194632	9,464	20904	96	218
T_5 = $B_0Zn_{1.5}$	173728	9,368	-	-	-
T_1 = B_0Zn_0				9,272	

cause of high yield values. It also meant that if the farmers would invest Tk.100 ha might get maximum profit Tk.1557/-. So, from economic point of view, application of Zn and B at the rate of 4.5 and 3.0 kg ha^{-1} along with blanket dose of $N_{130}P_{35}K_{80}S_{20}$ kg and CD 5 t ha^{-1} would be economically viable and profitable turmeric cultivation in hilly region.

CONCLUSIONS

It is evident from the two years study that both zinc and boron have exerted significant effect on the growth and yield attributes of turmeric either in single and or in combination. However, it is summarized from the result that B at the rate of 3.0 kg ha^{-1} and Zn 4.5 kg ha^{-1} along

with blanket dose of $N_{130}P_{35}K_{80}S_{20}$ kg ha^{-1} and CD 5 t ha^{-1} was found to be optimum for maximizing the yield of turmeric in South-Eastern Brawn Hill Soils of Chittagong Hill Tracts region.

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