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RESPONSE OF CHILLI (*Capsium annuum* L.) TO ZINC AND BORON APPLICATION

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Abstract

Field trial on chilli (cv. *Bogra* local) was conducted in Grey Terrace Soil under AEZ-25 (Level Barind Tract) at Spice Research Centre, Bogra during rabi seasons of 2005-2006, 2006-2007 and 2007-2008. The objectives were to evaluate the response of chilli to zinc and boron and to find out the optimum dose of zinc and boron for maximizing the yield. Treatments for this study comprised of four levels each of zinc (0, 1.5, 3.0, and 4.5 kg/ha) and boron (0, 1.0, 2.0, and 3.0 kg/ha) along with a blanket dose of N_{130} P_{60} K_{80} S_{20} Mg_{10} kg/ha. The experiment was set up in a randomized block design (factorial) with 3 replications. The integrated use of zinc and boron was found superior to their single applications. The interaction effect between zinc and boron was significant in case of yield of dry chilli and weight of ripe chilli/plant. The highest yield (1138 kg/ha) was recorded from Zn_3B_1 kg/ha, which was closely followed by Zn_3B_2, $Zn_{4.5}B_2$ and the lowest (703 kg/ha) in control (Zn_0B_0). The yield benefit over control varied from 4.4 to 61.9 % due to interaction effect. Consecutive three years studies showed almost similar trend of results. However, from regression analysis, the optimum-economic dose of zinc was found to be 3.91 kg/ha whereas it was 1.70 for boron. Hence, a package of ($Zn_{3.91}$ $B_{1.70}$ kg/ha) along with the said blanket dose may be recommended for maximizing the yield of chilli in the study area.

Keywords: Chilli, zinc, boron, optimum yield.

Introduction

Chilli (*Capsium annuum* L.), the most important spice crop is grown all over Bangladesh. It is an indispensable spice, which is liked for pungency and spicy taste and the appealing colour adds to the curry. Chilli occupies about 1,80,000 hectares with a production of 1,50,000 tons (BBS, 2001). However, the average yield of dry chilli is low (700-800 kg/ha) in Bangladesh compared to the neighbouring countries (1000-1200 kg/ha). One of the reasons of lower yield might be imbalanced use of fertilizers and manure and low levels of available Zn and B in the soils of major chilli growing areas. It is realized that productivity of crop is being adversely affected in different areas due to deficiencies of

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micronutrients (Bose and Tripathi, 1996). The deficiency of micronutrients increased markedly due to intensive cropping, loss of top soil by erosion, loss of micronutrients by leaching, liming of soil and lower availability and use of farm yard manure (Fageria *et al*., 2002). Micronutrients are usually required in minute quantities, nevertheless are vital to the growth of plant (Benepal, 1967). Improvement in growth characters as a result of application of micronutrients might be due to the enhanced photosynthetic and other metabolic activity which leads to an increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al.* (2003). The photosynthesis enhanced in presence of zinc and boron was also reported by Rawat and Mathpal (1984). Mallick and Muthukrishnan (1979) explained that presence of zinc activates the synthesis of tryptophan, the precursor of IAA and it is responsible for stimulated plant growth. The deficiency of B retards apical growth and development because of its impacts on cell development and on sugar formation and translocation. Boron also plays an important part in flowering and fruiting processes, N metabolism, hormonal action and cell division.

The nutrient removal and uptake capacity by capsicum cultivar is higher, which indicates the greater nutrient requirements by chilli. Integrated use of both chemical fertilizers and organic manure was found significant in increasing the growth and yield of chilli (Sharma *et al*., 1996; and Hegde, 1997). Nitrogen @ 120 kg/ha and P @ 60 kg/ha produced significantly higher yield of chilli (Sharma *et al*., 1996). Singh and Srivastava (1998) recommended 120 kg N and 60 kg P/ha for high yield. Karnataka (2009) recorded highest yield of chilli with N P K @ 100:50:50 kg/ha and secondary and micronutrients. Ahmed and Tanki (1991) worked out the optimum dose of nitrogen and phosphorus to be 120 kg/ha and 82.8 kg/ha, respectively. Potassium had no influence on yield, duration of flowering, plant height, and fruit ripening. Sporadic research works on nutrient management on chilli were done where N, P, K, and S fertilizers were considered for recommendation. However, no systematic research work has been done so for to find out the response of chilli to zinc and boron fertilization.

The potential chilli growing soils in north-western regions of Bangladesh was reported to be zinc and boron deficient. Like many other crops, chilli might be responsive to zinc and boron fertilization especially for rabi season when the availability of Zn is likely to reduce further due to low temperature. The present study was therefore, undertaken (i) to evaluate the response of zinc and boron on chilli and (ii) to find out the optimum dose of zinc and boron for maximizing the yield of chilli.

Materials and Method

The experiment was conducted in Grey Terrace Soil under AEZ-25 (Level Barind Tract) at Spices Research Centre (SRC), Bogra during rabi seasons of

2005-2006, 2006-2007 and 2007-2008. The initial soil samples of the experiment field were collected and analyzed following standard laboratory procedures and are presented in Table 1. The soil was slightly acidic (pH 6.2) having low organic matter content (1.12 %). The content of total-N was very low. The exchangeable K and Mg contents were low. Available P and S contents were also low. In particular, the contents of available Zn and B were low too. There were 16 treatment combinations comprising 4 levels each of boron (0, 1, 2 and 3 kg/ha) and zinc (0, 1.5, 3.0 and 4.5 kg/ha). Besides, a blanket dose of N_{130} P_{60} K_{80} S_{20} Mg_{10} kg/ha was used in the study. The treatments were arranged in a randomized block design (factorial) with 3 replications. The size of the unit plot was 3 m x 2.4 m. All fertilizers except N were applied at the time of final land preparation. Nitrogen was top dressed in 4 equal splits at 5, 30, 55 and 75 days after planting followed by light irrigation. Zinc and boron were applied as zinc sulphate and boric acid, respectively. About one month old seedlings of chilli (cv. *Bogra* local) were transplanted on the last week of December maintaining a spacing of row to row 40 cm and plant to plant 30 cm. Intercultural operations and plant protection measures were done to keep the plant healthy. Ripe fruits of chilli were harvested and sun dried during May. Crop performance data on plant height, fruit length, fruit breadth and yield were recorded and statistically analyzed using MSTATC Package.

Table 1. Fertility status of initial soil sample of the experimental field at SRC, Bogra.

Item	pH	OM (%)	Total N (%)	Ca	Mg	K	P	S	Mn	Zn	B
				meq 100 g^{-1}			μg g^{-1}				
Result	6.2	1.12	0.06	3.6	0.7	0.18	12	13	5	1.1	0.16
Critical level	-	-	0.12	2.0	0.8	0.2	14	14	5	2	0.20
Interpre-tation	Slightly Acidic	Low	Very low	Opti-mum	Low	Low	Low	Low	At par	Low	Low

Results and Discussion
Interaction effect

Yield component: The yield components like plant height, length and breadth of fruit did not alter significantly due to interaction (Zn x B) effect although combined application of both the elements augmented higher results than their single application, which collectively might have contributed to the yield (Table 2).

Table 2. Interaction effect of boron and zinc on the yield component of chilli at SRC Bogra.

Treatments			Plant height (cm)				Fruit length (cm)				Fruit breadth (cm)			
Code	Zn (kg/ha)	B (kg/ha)	2005-06	2006-07	2007-08	Mean	2005-06	2006-07	2007-08	Mean	2005-06	2006-07	2007-08	Mean
T_1	0.0	0.0	74.3	69.4	67.7	70.5	6.60	6.74	6.54	6.63	0.62	0.58	0.57	0.59
T_2	1.5	0.0	74.6	71.6	69.1	71.8	6.69	6.81	6.60	6.70	0.62	0.58	0.58	0.59
T_3	3.0	0.0	74.8	73.2	70.2	72.7	6.80	6.92	6.71	6.81	0.64	0.61	0.58	0.61
T_4	4.5	0.0	74.6	73.3	70.6	72.8	6.70	6.88	6.60	6.73	0.63	0.61	0.59	0.61
T_5	0.0	1.0	75.1	71.8	68.3	71.7	6.51	6.71	6.58	6.60	0.61	0.58	0.59	0.59
T_6	1.5	1.0	75.4	72.9	69.1	72.5	6.87	7.01	6.71	6.86	0.66	0.60	0.60	0.62
T_7	3.0	1.0	76.9	74.0	71.0	74.0	7.06	7.84	6.73	7.21	0.76	0.75	0.61	0.71
T_8	4.5	1.0	77.3	74.2	71.4	74.3	6.75	7.72	6.60	7.02	0.70	0.66	0.60	0.65
T_9	0.0	2.0	75.2	72.2	68.7	72.0	6.74	6.78	6.58	6.70	0.63	0.63	0.59	0.62
T_{10}	1.5	2.0	75.6	71.8	68.5	72.0	6.45	7.18	6.35	6.66	0.68	0.70	0.61	0.66
T_{11}	3.0	2.0	77.6	74.2	71.9	74.6	6.72	7.76	6.67	7.05	0.73	0.69	0.61	0.68
T_{12}	4.5	2.0	77.4	73.1	70.9	73.8	6.65	7.65	6.62	6.97	0.74	0.71	0.62	0.69
T_{13}	0.0	3.0	75.2	72.6	69.4	72.4	6.81	6.78	6.71	6.77	0.64	0.61	0.60	0.62
T_{14}	1.5	3.0	75.2	71.5	68.9	71.9	6.60	7.22	6.56	6.79	0.67	0.64	0.62	0.64
T_{15}	3.0	3.0	77.1	74.2	71.9	74.4	6.54	7.69	6.53	6.92	0.72	0.68	0.62	0.67
T_{16}	4.5	3.0	77.0	74.3	71.4	74.2	6.77	7.54	6.73	7.01	0.69	0.65	0.62	0.65
Probability (<0.05)			NS	NS	NS		NS	NS	NS	-	NS	NS	NS	-
CV (%)			2.70	3.25	3.23		6.50	3.68	4.17	-	7.00	8.53	4.13	-

NS = Non-significant

Table 3. Interaction effect of boron and zinc on yield of chilli at SRC, Bogra.

Treatments			Fresh fruit wt/plant (g)				Fruit dry weight (kg/ha)				Yield increased over control (%)
Code	Zn (kg/ha)	B (kg/ha)	2005-06	2006-07	2007-08	Mean	2005-06	2006-07	2007-08	Mean	
T_1	0.0	0.0	25.6c	24.1e	24.8f	24.8	735d	685d	688f	703	-
T_2	1.5	0.0	25.9c	25.7de	25.4ef	25.7	758cd	725cd	720ef	734	4.4
T_3	3.0	0.0	27.4c	28.5cde	28.2def	28.0	795cd	809cd	805def	803	14.2
T_4	4.5	0.0	26.4c	27.3cde	27.1ef	26.9	783cd	805cd	797def	795	13.1
T_5	0.0	1.0	28.1c	28.8cde	27.8def	28.2	772cd	766cd	761def	766	9.0
T_6	1.5	1.0	28.6c	30.1cd	28.8def	29.2	779cd	774cd	768def	774	10.1
T_7	3.0	1.0	40.8a	43.7a	41.5a	42.0	1102a	1169a	1143a	1138	61.9
T_8	4.5	1.0	37.2ab	36.4b	32.9cd	35.5	1003ab	996b	977bc	992	41.1
T_9	0.0	2.0	27.3c	27.6cde	27.8ef	27.6	763cd	754cd	759def	759	8.0
T_{10}	1.5	2.0	29.4c	30.1cd	30.5de	30.0	847cd	863c	872cd	861	22.5
T_{11}	3.0	2.0	38.3ab	40.5ab	36.7abc	38.5	1027a	1051ab	1035ab	1038	47.7
T_{12}	4.5	2.0	39.2a	41.3a	38.1ab	39.5	1029a	1066ab	1041ab	1045	48.6
T_{13}	0.0	3.0	26.8c	27.2cde	27.4ef	27.1	748cd	723cd	735ef	735	4.6
T_{14}	1.5	3.0	28.2c	29.6cd	28.4def	28.7	816cd	838c	836de	830	18.1
T_{15}	3.0	3.0	34.8b	36.7b	35.4bc	35.6	985ab	1012b	991bc	996	41.7
T_{16}	4.5	3.0	31.5c	29.9c	30.3de	30.6	876bc	855c	848de	860	22.3
Probability (<0.05)			*	*	*	-	*	*	*	-	-
CV (%)			9.20	9.13	8.70	-	8.60	9.98	8.19	-	-

Figures in a column having same letter(s) do not differ significantly at 5 percent level by DMRT

The mean plant height varied from 70.5 cm to 74.6 cm where the highest result was observed in (Zn_3B_2) followed by $Zn_{4.5}B_1$ and the lowest in control (Zn_0B_0). The highest fruit length (7.21 cm) was found in Zn_3B_1 followed by Zn_3B_2 and the lowest in control. Again, the fruit breath due to interaction ranged from 0.59 cm to 0.71 cm where the highest result was observed in Zn_3B_1 followed by $Zn_{4.5}B_2$ and the lowest in control (Table 2).

Yield

The interaction effect between zinc and boron was found statistically significant for the yield of dry chilli (Table 3). The yield of ripe fruits/plant was found highest (40.8, 43.7 and 41.5g for the first, second and third year, respectively) in T_7 (Zn_3B_1), which was statistically identical with T_{11} (Zn_3B_2) and T_{12} ($Zn_{4.5}B_2$) but significantly higher over other combinations and single application of either zinc or boron. The mean yield of ripe fruits/plant varied from 24.8 to 42.0 g where the highest result was observed in T_7 followed by T_{12} and T_{11} and the lowest in T_1 (Zn_0B_0). However, combined application of both zinc and boron contributed higher fruit weight than their single application. The yield of dry chilli also increased significantly due to integrated use of both zinc and boron. The highest yield (1102, 1169 and 1143 kg/ha for the first, second and third year, respectively) was recorded form T_7 (Zn_3B_1), which was identically followed by T_{12} ($Zn_{4.5}B_2$) and T_{11} (Zn_3B_2), but significantly higher over remaining combinations and single application of either zinc or boron. The mean yield of dry chilli ranged from 703 to 1138 kg/ha where the highest result was observed in T_7, which was followed by T_{12} and T_{11} and the lowest in control. However, the interaction effect became narrower when either lowest or highest dose of zinc applied with either lowest or highest dose of boron. These explanations can be well understood when yield increase (%) over control by different treatments are compared (Table 3). Integrated use of Zn and B contributed 10.1 - 61.9 % increased yield over control while single application contributed only 4.4 to 14.2% and 4.6 to 9.0 % for zinc and boron, respectively, which signifies their requirement for optimizing the yield of chilli (Table 3). Hatwar *et al.* (2003) reported application of micronutrients viz., zinc, iron and boron in combination, which resulted in improvement of growth, yield parameters and yield of chilli. Consecutive three years studies provided almost similar trend of results. Thus, integrated use of boron and zinc are remunerative in augmenting the yield of chilli in the study area.

Main effect of zinc

Zinc played significant role in augmenting the yield components and yield of chilli (Table 4). The yield of dry chilli increased significantly due to added zinc. The highest yield (977, 1010 and 994 kg/ha for the first, second and third year, respectively) was found with 3.0 kg Zn/ha, which was significantly higher over rest of the doses. The mean yield was 993.7 kg/ha, which was 33.9% higher over zinc control. Lower dose of zinc (1.5 kg/ha) increased the yield only by 8.1% while the highest dose (4.5 kg Zn/ha) contributed 24.4 % yield benefit over control (Table 4). These results are in conformity with the findings of Pillai (1967) and Pillai and Vadivelu (1966). Fresh fruit weight/plant was also varied significantly due to zinc as reveled by the three years' results. The highest fresh ripe fruit weight (35.5, 37.4 and 35.3 g/plant for the first, second and third year, respectively) was recorded from 3.0 kg Zn/ha, which was significantly higher over rest of the doses for the second and third year. Incase of first year, it was identical with 4.5 kg Zn/ha but significantly higher over rest of the doses. Yield components like plant height, fruit length and breath were influenced markedly due to added zinc (Table 4).

Main effect of Boron

The main effect of boron on the yield and yield component of chilli are presented in Table 4. The highest dry yield (917, 933 and 933 kg/ha for the first, second and third year, respectively) was obtained with 2.0 kg B/ha, which was significantly higher over control and the highest dose (3.0 kg B/ha) but at par with immediate lower dose (1.0 kg B/ha). Three years' mean yield varied from 759.0 to 927.7 kg/ha where the highest result was estimated with 2.0 kg B/ha and the lowest in boron control. As a result, boron contributed yield benefit over control by 20.9, 22.2 and 13.0 % for 1.0, 2.0 and 3.0 kg B/ha, respectively. These findings revealed that 1.0-2.0 kg B/ha are sufficient enough for maximizing the yield of chilli. The yield of chilli was increased with boron application as reported by Govindan (1952)

The yield contributing characters like fruit breadth and weight of fresh ripe fruits/plant increased significantly due to boron but different boron doses produced identical results although slight variations were noticed (Table 4). Three years mean result showed that the fresh fruit weight varied from 26.4 g to 33.9 g/plant where the highest value was found with 1.0 kg B/ha followed by 2.0 kg B/ha and the lowest in B control. The plant height and fruit length did not alter significantly due to boron variation.

Response function

A quadratic relationship was observed between dry chilli yield and added zinc (Fig. 1). The optimum dose (3.96 kg/ha) of zinc was calculated from the quadratic equation (Table 5). Using the same optimum dose, the maximum yield (949 kg/ha) could be expected for chilli at Bogra. However, the economic dose (3.91 kg/ha) of zinc was calculated from the quadratic response function. Besides, regression equation showed that, each 1 kg Zn could produce 100 kg/ha yield of dry chilli. Beyond the said optimum dose, if 1 kg excess Zn is applied then there is a risk of losing 14.5 kg/ha of dry yield.

Table 4. Main effect of zinc and boron on the yield attributes and yield of chilli at Bogra.

Treatment	Plant height (cm)			Fruit length (cm)			Fruit breadth (cm)			Fresh ripe fruit weight/ plant (g)				Yield (kg/ha)				Yield increase over control (%)
	2005-06	2006-07	2007-08	2005-06	2006-07	2007-08	2005-06	2006-07	2007-08	2005-06	2006-07	2007-08	Mean	2005-06	2006-07	2007-08	Mean	
Level of Zn (kg/ha)	**Main effect of Zn**																	
0	74.7	71.4b	68.5b	6.75b	6.67	6.60	0.63c	0.60c	0.59	26.8b	26.9c	27.0c	26.9	754b	732d	741c	742.3	-
1.5	77.0	71.9b	68.9b	7.06b	6.65	6.58	0.66bc	0.63bc	0.60	28.0b	28.9c	28.3c	28.4	801b	800c	806c	802.3	8.1
3.0	77.4	73.9a	71.2a	7.55a	6.78	6.66	0.71a	0.68a	0.61	35.5a	37.4a	35.3a	36.1	977a	1010a	994a	993.7	33.9
4.5	77.3	73.7a	71.0a	7.45a	6.72	6.64	0.69ab	0.66ab	0.61	33.4a	34.1b	31.9b	33.5	923a	930b	917b	923.3	24.4
Probability < 0.05	NS	*	*	*	NS	NS	*	*	NS	*	*	*	-	*	*	*	-	-
CV (%)	2.70	3.25	3.23	6.50	3.68	4.17	7.00	8.53	4.13	9.1	9.13	8.70	-	8.6	9.98	9.19	-	-
Levels of B (kg/ha)	**Main effect of B**																	
0.0	75.1	71.9	69.4	6.84b	6.70	6.61	0.63b	0.60b	0.58b	26.5c	26.4c	26.2b	26.4	769c	755c	753b	759.0	-
1.0	76.5	73.2	69.9	7.34a	6.80	6.65	0.70a	0.65a	0.60ab	34.3a	34.8a	32.7a	33.9	914ab	926a	912a	917.3	20.9
2.0	76.5	72.7	70.0	7.32a	6.64	6.58	0.68a	0.68a	0.61ab	33.1a	34.9a	33.3a	33.8	917a	933a	933a	927.7	22.2
3.0	75.4	73.1	70.4	7.31a	6.68	6.63	0.68a	0.64a	0.62a	29.9b	31.2b	30.4a	30.5	856b	857b	860b	857.7	13.0
Probability <0.05	NS	NS	NS	*	NS	NS	*	*	*	*	*	*	-	*	*	*	-	-
CV (%)	2.70	3.25	3.23	6.5	3.68	4.17	7.00	8.53	4.13	9.1	9.13	8.70		8.6	9.98	9.19	-	-

Figures in column having same letter(s) do not differ significantly at 5 percent level by DMRT

Table 5. Response function of chilli to zinc and boron at SRC, Shivgonj, Bogra.

Regression equation	Coefficient of determination (R^2)	Optimum dose	Economic dose	Maximum yield from optimum dose	Production of dry chilli for 1 kg Zn or B	Beyond optimum dose the reduction of yield for 1 kg Zn or B
		(kg/ha)				
For Zinc						
$Y = 723 + 114x - 14.49x^2$	0.801	3.96	3.91	949	100	14.5
For Boron						
$Y = 762 + 202x - 57.08x^2$	0.988	1.77	1.70	941	145	57.1

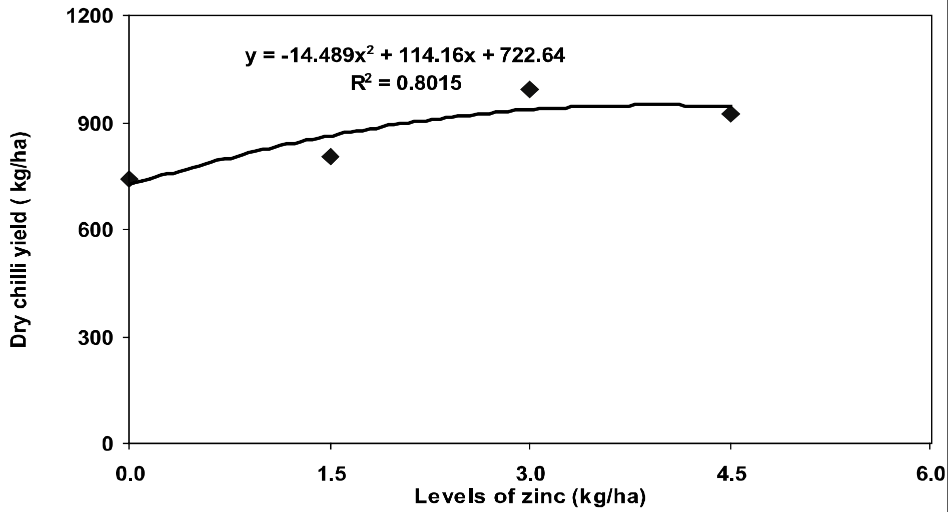

Fig.1. Response of chill to Zn fertilization at SRC, Shivgonj, Bogra.

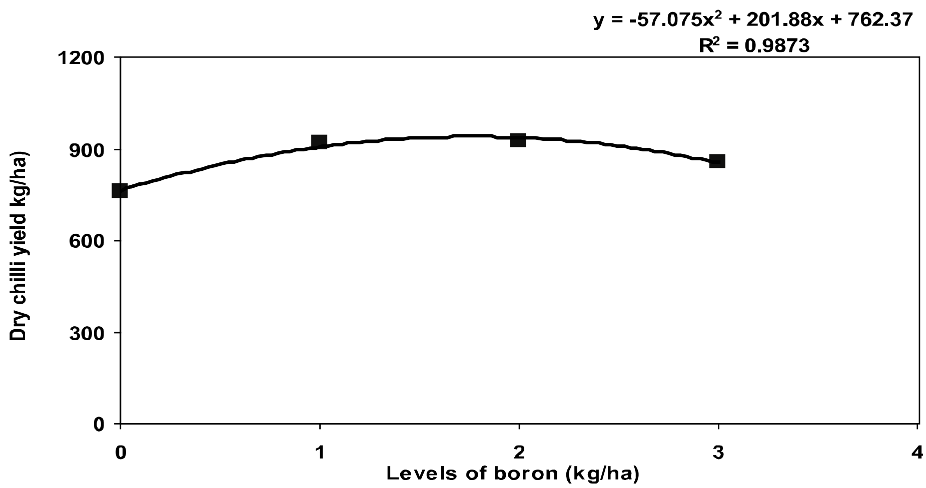

Fig. 2. Response of chilli to B fertilization at SRC Shivgonj, Bogra.

Similarly, different levels of boron showed quadratic relationship with yield (Fig. 2). The optimum dose of boron (1.77 kg/ha) was calculated from the quadratic equation (Table 5). Using the said optimum dose, the maximum yield (941 kg/ha) could be expected for chilli at Bogra. The economic dose (1.70 kg/ha) of boron was worked out from the regression equation. The use efficiency showed that each 1 kg B could produce 145 kg/ha of dry yield up to the optimum level. Beyond the said optimum dose, if 1 kg/ha excess B is applied, then there is a risk of loosing 57.1 kg/ha of yield.

Conclusion

Chilli was found responsive to both zinc and boron as revealed by consecutive three years' study. Zinc @ 3.0 kg/ha and boron @ 1.0 kg/ha along with a blanket dose of $N_{130}P_{60}K_{80}S_{20}Mg_{10}$ kg/ha appeared as the best-suited combination. From the quadratic response function, the optimum-economic dose of boron and zinc were calculated to be 1.70 and 3.91 kg/ha, respectively. Thus a package of ($B_{1.70}$ $Zn_{3.91}$ kg/ha) along with the said blanket dose may be recommended for the cultivation of chilli in Grey Terrace Soil under AEZ-25.

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