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EFFECT OF ZINC AND BORON ON YIELD AND YIELD CONTRIBUTING CHARACTERS OF LENTIL IN LOW GANGES RIVER FLOODPLAIN SOIL AT MADARIPUR, BANGLADESH

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Abstract

A study was conducted in Calcareous Low Ganges River Floodplain Soil (AEZ 12) at Regional Pulses Research (RPRS), Madaripur during the Rabi season of 2010-12.The objectives were to evaluate the effect of Zinc (Zn) and Boron (B) on the yield and yield contributing characters of lentil (*Lens culinaris* Medic) and to estimate the optimum dose of Zn and B for yield maximization. There were 16 treatment combinations comprising four levels each of Zinc (0, 1.0, 2.0 and 3.0 kg/ha) and Boron (0, 0.5, 1.0 and 1.5 kg/ha) along with a blanket dose of N_{20} P_{16} K_{30} S_{10} kg/ha were used. The treatments were arranged viz. T_1= Zn_0B_0; T_2= $Zn_0B_{0.5}$; T_3= $Zn_0B_{1.0}$; T_4= $Zn_0B_{1.5}$; T_5= $Zn_{1.0}B_0$; T_6= $Zn_{1.0}B_{0.5}$; $T_{7=}$ $Zn_{1.0}B_{1.0}$; T_8= $Zn_{1.0}B_{1.5}$; T_9= $Zn_{2.0}B_0$; T_{10}= $Zn_{2.0}B_{0.5}$; T_{11}= $Zn_{2.0}B_{1.0}$; T_{12}= $Zn_{2.0}B_{1.5}$; T_{13}= $Zn_{3.0}B_0$; T_{14}= $Zn_{3.0}B_{0.5}$; T_{15}= $Zn_{3.0}B_{1.0}$ and T_{16}= $Zn_{3.0}B_{1.5.}$ The experiment was laid out in RCBD with three replications. Results showed that the combination of $Zn_{3.0}B_{1.5}$ produced significantly higher seed yield (1156 kg/ha). The lowest seed yield (844 kg/ha) was found in control (Zn_0B_0) combination. The combined application of zinc and boron were superior to their single application. Therefore, the combination of $Zn_{3.0}B_{1.5}$ may be considered as suitable dose for lentil cultivation in Bangladesh. But from regression analysis, the optimum treatment combination was $Zn_{2.85}B_{1.44}$ for Madaripur, Bangladesh.

Keywords: Zinc, boron, lentil yield and yield contributing characters

Introduction

The pulse crop yield status in Bangladesh is generally low. There are so many reasons for low yield. Plant nutrients like Nitrogen (N), Phosphorus (P), Potassium (K), Sulphur (S), Calcium (Ca), Magnesium (Mg), Zinc (Zn) and Boron (B) deficiency, among them, is an important factor, especially micronutrients like Zn and B. The extent and magnitude of nutrient deficiency has aggravated in the recent past due to intensive agriculture and indiscriminate use of plant nutrients (Anonymous 2009).

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Lentil (*Lens culinaris* Medic) is an important grain legume in Asia. It occupies an important position in this region. It is an important source of protein and several essential micronutrients. It synthesizes N in symbiosis with Rhizobia and enriches the soil. It improves the fertility status of soil through atmospheric N fixation.

The soil of different part of southern belt in Bangladesh are more or less deficient in Boron and Zinc as well as Nitrogen fixing Bacteria (*Rhizobium* sp.) which are mail cause of poor yield.

Madaripur district is situated under Low Ganges River Floodplain soil (AEZ 12). The soil type predominantly include calcareous dark grey and calcareous brown floodplain soils. Soils are calcareous in nature having neutral to slightly alkaline reaction. General fertility level is medium with high CEC and K status and the Zn and B status is medium or low (Rashid 2001; FRG 2005).

However, there is a great possibility to increase lentil production by cultivating HYV with balanced fertilization including micronutrient. Micronutrients play an important role in increasing yield of pulses through their effect on the plant itself and on the Nitrogen fixing by symbiotic process. Deficiencies of these nutrients have been very pronounced under multiple cropping system due to excess removal by HYV of crops and hence their exogenous supplies are urgently required. Zinc and B deficiency is widespread in the country; much observed in wetland rice soils, light textured soils and calcareous soils (Jahiruddin *et al.* 1992; Rahman *et al.* 1993; Islam *et al.* 1997).

The functional role of Zn includes auxins metabolism, Nitrogen metabolism, influence on the activities of enzymes (e.g. dehydrogenase and carbonic anhydrase, proteinases, and peptidases), and cytochrome c synthesis, stabilization of ribosomal fractions and protection of cells against oxidative stress (Tisdale *et al.* 1997; Obata *et al.* 1999). Poor growth, interveinal chlorosis and necrosis of lower leaves are the common symptoms of Zn deficiency in field crops. Plants emerged from seeds with low concentrations of Zn could be highly sensitive to biotic and abiotic stresses (Obata *et al.* 1999). Zinc enriched seeds can perform better with respect to seed germination, seedling health, crop growth and finally yield advantage (Cakmak *et al.* 1996).

Boron is very important in cell division and in pod and seed formation (Vitosh *et al.* 1997). Reproductive growth, especially flowering, fruit and seed set is more sensitive to B deficiency than vegetative growth (Noppakoonwong *et al.* 1997). Boron influence the absorption of N, P, K and its deficiency changed the equilibrium of optimum of those three macronutrients. The N and B concentrations of grain for lentil were markedly influenced by B treatment indicating that the B had a positive role on protein synthesis (Iqtidar and Rahman, 1984) found that essential amino acid increased with increasing B supply. Therefore, applications of micronutrients in addition to essential major elements have gained practical significance. The present study was therefore, undertaken (i) to evaluate the response of Zn and B on the yield and yield contributing characters of lentil; and (ii) to find out a suitable dose of Zn and B for the maximization of lentil yield.

Materials and Method

An experiment was conducted in Calcareous Low Ganges river floodplain soil (AEZ 12) at Regional (RARS) Pulses Research, Madaripur during the Rabi season of 2010-11 and 2011-12 to evaluate the response of Zn and B on yield and yield components of lentil and to estimate suitable dose for yield maximization. There were 16 treatment combinations comprising four levels each of Zinc (0, 1.0, 2.0 and 3.0 kgha^{-1}) and Boron (0, 0.5, 1.0 and 1.5 kg/ha) along with a blanket dose of N_{20} P_{16} K_{30} S_{10} kg/ha were used. The treatment were arranged viz. T_1= Zn_0B_0; T_2= $Zn_0B_{0.5}$; T_3= $Zn_0B_{1.0}$; T_4= $Zn_0B_{1.5}$; T_5= $Zn_{1.0}B_0$; T_6= $Zn_{1.0}B_{0.5}$; $T_{7=}$ $Zn_{1.0}B_{1.0}$; T_8= $Zn_{1.0}B_{1.5}$; T_9= $Zn_{2.0}B_0$; T_{10}= $Zn_{2.0}B_{0.5}$; T_{11}= $Zn_{2.0}B_{1.0}$; T_{12}= $Zn_{2.0}B_{1.5}$; T_{13}= $Zn_{3.0}B_0$; T_{14}= $Zn_{3.0}B_{0.5}$; T_{15}= $Zn_{3.0}B_{1.0}$ and T_{16}= $Zn_{3.0}B_{1.5.}$

Initial soil samples (0-15 cm depth) were collected from experimental field and dried in the air through passing a 2-mm sieve and analyzed their physical and chemical properties following standard method. The sample soil of PRSS, Madaripur was loamy in texture having 1.25% organic matter (OM), 0.071% N, 17 µg g^{-1} P , 0.12 meq.100 g^{-1} K, 16 µg g^{-1} S, 10.4 meq.100 g^{-1} Ca, 3.2 meq.100 g^{-1} Mg, 1.2 µg g^{-1} Zn and 0.13 µg g^{-1} B. The soil pH was 7.1 (Table 1).

Table 1. Fertility status of initial soil sample of the experimental field at Regional Pulses Research Station, Madaripur

Item	pH	OM (%)	Total N (%)	Ca	Mg	K	P	S	Mn	Zn	B
				meq. 100 g^{-1}			µg g^{-1}				
Result	7.1	1.25	0.071	10.4	3.2	0.12	17	16	3.6	1. 2	0.13
Critical level	-	-	0.12	2.0	0.8	0.2	14	14	5	2	0.20
Interpretation	Neutral	Low	Very low	High	High	Low	High	High	Low	Low	Low

The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 4 m × 3 m. The variety was BARI Masur-6. Blanket doses of fertilizer were applied at the time of final land preparation. Zinc and B were applied as Zinc Sulphate and Boric acid, respectively in the respective treatments plot during final bed preparation. Seeds were sown @ 30 kg/ha with a spacing of 30 cm x 5 cm on 10 November 2010 and 11 November 2011. Two weeding were done at 20 and 35 days after sowing (DAS). The disease (*Stemphylium*) was control by spraying of Rovral fungicide @ 0.2% with three times interval of 7 days, first start at before flowering to flowering stage and insects were control properly by spraying insecticide of karatee @ 0.2%. Crop was harvested at maturity. Yield contributing characters were recorded from 10 randomly selected plants from each plot. Yield (kg/ha) was recorded from the whole plot technique. The data were then statistically analyzed by using MSTAT package.

Results and Discussion

Effect of Zinc

The mean yield of lentil was significantly increased due to the application of zinc during 20010-12 (Table 1). The mean seed and stover yield ranged from 881-1048 and 1921-2379 kg/ha, respectively. Highest seed yield (1048 kg/ha) was recorded with Zn level 3.0 kg/ha treatment which was statistically identical with Zn level 2.0 kg/ha, but significantly higher than the other levels. The yield increased 15.9% with Zn level 3.0 kg/ha. The stover yield of lentil also showed similar trend like seed yield (Table 2). Lowest yield was recorded with control (881 kg/ha). From the Table 2, it was observed that the yield increased gradually with the increase of Zn level up to 3.0 kg/ha. Similar trend was also reported by several authors (Ryan and El-Moneim 2007; Singh *et al.*2004). Others yield contributing characters showed significant variation due to different levels of Zn application. The highest plant height 27.8 cm was recorded with Zn level 3.0 kg/ha which was statistically identical to Zn level 2.0 and 1.0 kg/ha, respectively but significantly higher over control. The maximum number of pods per plant was found with Zn level 3.0 kg/ha which was statistically identical with Zn level 2.0 and 1.0 kg/ha but significant difference was observed with control. The maximum number of seeds per pod was obtained from Zn level 3.0 and 2.0 kg/ha which were statistically identical with the Zn level 1.0 but significantly higher over control. The highest 1000 seed weight 16.03 g was obtained from the treatment Zn level 3.0 kg/ha which was significantly higher than that of other treatments (Table 2). Hossain *et al.* (2010) reported that different level of Zn application with blanket dose of 20-20-20-5-1 kg NPKSB ha^{-1} significantly influenced the yield contributing characters like plant height, number of pods per plant, number of seeds per pod and 1000 seed weight of lentil.

Table 2. Mean effect of zinc on plant height (cm), pods per plant, seeds per pod, 1000 seed weight (g), seed and stover yields (kg/ha) of lentil at on-station, Madaripur (mean of two years).

Level of Zinc (kg/ha)	Plant height(cm)	Pods/plant	Seeds/pod	1000 seed weight (g)	Yield (kg/ha)	Stover yield (kg/ha)	Yield increased over control %
	2010-12	2010-12	2010-12	2010-12	2010-12	2010-12	2010-12
0	26.9b	35.0b	1.61b	15.4c	881c	1921c	-
1.0	27.1ab	40.6a	1.73a	15.8b	971b	2179b	9.27
2.0	27.7a	40.8a	1.74a	15.9b	1043a	2377a	15.5
3.0	27.8a	41.4a	1.74a	16.0a	1048a	2379a	15.9
CV (%)	3.54	3.51	2.80	2.01	4.30	5.38	-

Values within a column having same letter(s) do not differ significantly (p=0.05)

Effect of Boron

Significant variation was found in mean yield of lentil due to application of boron during 2010-12. Seed and stover yield ranged from 896-1040 kg/ha and 1997-2349 kg/ha, respectively. The highest seed yield 1040 kg/ha was recorded with B level 1.5 kg/ha which was statistically identical with B level 1.0 kg/ha but significantly higher than that of others. The yield increased 13.8% with boron level 1.5 kg/ha over control.The stover yield of lentil showed similar trend as it was stated in seed yield (Table 3). Anonymous (2009) reported that balanced application of N, P, K, S, Zn and B significantly increased the yield of lentil over control. The results obtained in this experiment is in agreement with the findings of Mondal *et al.* (2010); Bhuiyan *et al.* (2008); Singh *et al.* (2004). Yield contributing characters like plant height, pods per plant, seeds per pod and 1000 seed weight showed significant variation due to different levels of boron application. The highest plant height (28.7 cm) was recorded from the treatment B 1.5 kg/ha followed by B 1.0 kg/ha. The lowest value (25.6 cm) was recorded in control treatment. Other characters such as number of pods per plant and number of seeds per pod showed significant variation due to the application of different levels of B. The highest weight of 1000 seed 16.2 g was recorded with B level 1.5 kg/ha which was significantly higher than that of other treatments. The lowest value of 15.2 g was recorded in control (Table 3). Anonymous (2009) reported that the application of N, P, B and *Rhizobium* inoculum was significantly enhanced the positive growth and yield parameters of lentil.

Table 3. Mean effect of boron on plant height (cm), pods per plant, seeds per pod, 1000 seed weight (g), seed and stover yields (kg/ha) of lentil at on-station, Madaripur (2 yrs mean).

Level of boron (kg/ha)	Plant height(cm)	Pods/plant	Seeds/pod	1000 seed wt (g)	Yield (kg/ha)	Stover yield (kg/ha)	Yield increased over control %
	2010-12	2010-12	2010-12	2010-12	2010-12	2010-12	2010-12
0	25.6c	34.6d	1.54d	15.2d	896c	1997c	-
0.5	26.9b	38.3c	1.72c	15.7c	979b	2192b	8.48
1.0	28.2a	41.6b	1.76b	15.9c	1027a	2319a	12.8
1.5	28.7a	43.2a	1.80a	16.2a	1040a	2349a	13.8
CV (%)	3.54	3.51	2.80	2.01	4.30	5.38	-

Values within a column having same letter(s) do not differ significantly (p=0.05).

Interaction Effect of Zinc and Boron

The interaction effect between Zn and B on the yield of lentil was significant during 2010-12. The highest seed yield (1156 kg/ha) was obtained with the treatment $Zn_{3.0}B_{1.5}$ followed by $Zn_{2.0}B_{1.0}$ and $Zn_{3.0}B_{1.0.}$ No significant variations were observed among them. The lowest yield (844 kg/ha) was obtained in the control (Zn_0B_0). The mean yield of lentil varied from 844-1156 kg/ha and the yield increase over control ranged from 3.65 to 26.9% (Table 4).

The combined application of Zn and B showed significant positive impact on lentil yield than the single application of Zn or B. Sakal *et al.* (1986) also reported the similar trend. Other yield contributing characters such as plant height, pods per plant, seeds per pod and 1000 seed weight were significantly influenced due to the combined application of B and Zn. Bhuiyan *et al.* (2008) found that the yield contributing characters of lentil responded significantly due to combined application of nutrient. Abdo (2001) reported the similar trend with foliar spray of Zn and B.

Regression analysis showed positive and quadratic response for mean yield and applied Zn (Fig. 1). The optimum dose of Zn was calculated from the quadratic response function and was 2.85 kg/ha (Table 5). For optimum dose, the maximum seed yield (1051 kg/ha) could be expected in Madaripur area (Table 5). However, the optimum economic dose of Zn was 2.71 kg/ha. The use efficiency showed that each 1 kg Zn could produce 60.5 kg/ha of seed yield. Beyond the optimum dose, 1 kg/ha excess Zn was applied, then a risk of 21.3 kg/ha reduced seed yield was noted (Table 5).

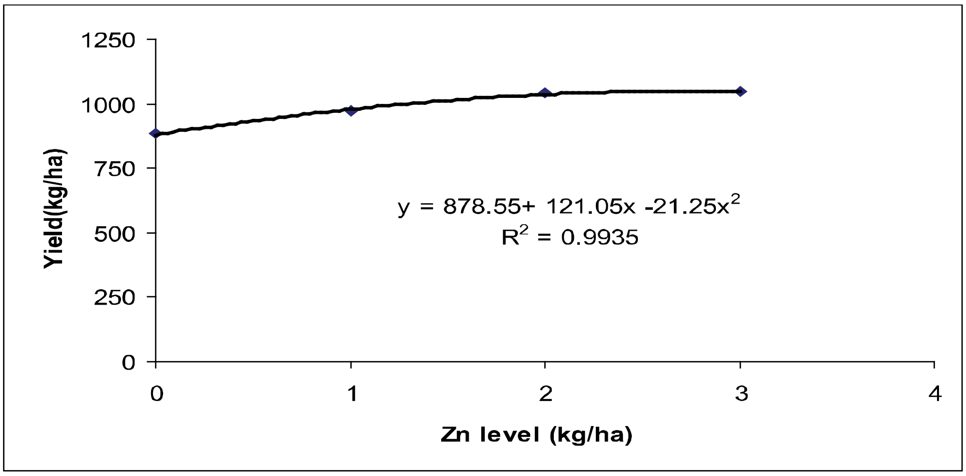

Fig. 1 Response of lentil to Zn fertilization.

A positive and quadratic relationship was also observed between seed yield and level of B (Fig. 2). The optimum dose of B from the quadratic production function was 1.44 kg/ha (Table 5). Using the optimum dose, the maximum seed yield 1040 kg/ha could be expected for Madaripur area (Table 5). However, the

Table 4. Combined effect of zinc and boron on plant height (cm), pods per plant, seeds per pod, 1000 seed weight (g), seed and stover yield (kg/ha) at on-station, Madaripur (mean of two years).

Combined effect of Zn and B fertilization (kg/ha)	Plant height (cm)	Pods/ plant	Seeds /pod	1000-seed weight (g)	Yield (kg/ha)	Stover yield (kg/ha)	% Yield increased over control
	2010-12	2010-12	2010-12	2010-12	2010-12	2010-12	
T_1= Zn_0B_0	25.5f	30.7k	1.47f	14.9g	844i	1814g	-
T_2= $Zn_0B_{0.5}$	26.8cde	33.9j	1.60de	15.2fg	876hi	1894fg	3.65
T_3= $Zn_0B_{1.0}$	27.9abcd	37.3ghi	1.63d	15.6de	894ghi	1967efg	5.59
T_4= $Zn_0B_{1.5}$	28.2abc	38.9fgh	1.73c	15.8cd	909ghi	2021efg	7.15
T_5= $Zn_{1.0}B_0$	26.1ef	37.0hi	1.58de	15.4ef	907ghi	2012efg	6.95
T_6= $Zn_{1.0}B_{0.5}$	26.3de	39.7efj	1.75bc	15.8cd	950efg	2107def	11.2
$T_{7=}$ $Zn_{1.0}B_{1.0}$	27.9abcd	42.3cd	1.78abc	16.0bc	1005de	2261cd	16.0
T_8= $Zn_{1.0}B_{1.5}$	29.1a	43.9bc	1.80ab	16.2ab	1022cd	2324bcd	17.4
T_9= $Zn_{2.0}B_0$	26.3de	36.8hi	1.55e	15.2fg	898ghi	1987efg	6.01
T_{10}= $Zn_{2.0}B_{0.5}$	27.5abcd	39.7efg	1.78abc	15.8cd	1092ab	2510ab	22.7
T_{11}= $Zn_{2.0}B_{1.0}$	28.2abc	41.8cde	1.82ab	16.0bc	1108ab	2553a	23.8
T_{12}= $Zn_{2.0}B_{1.5}$	28.98a	44.0bc	1.80ab	16.4a	1073bc	2467abc	21.3
T_{13}= $Zn_{3.0}B_0$	26.7bcd	34.9ij	1.57e	15.2fg	936fgh	2164de	9.83
T_{14}= $Zn_{3.0}B_{0.5}$	27.1bcd	39.9def	1.77c	16.2ab	998def	2257cd	15.4
T_{15}= $Zn_{3.0}B_{1.0}$	28.8ab	44.9ab	1.83a	16.3a	1100ab	2495ab	23.3
T_{16}= $Zn_{3.0}B_{1.5}$	28.6abc	47.0a	1.83a	16.3a	1156a	2593a	26.9
CV (%)	3.54	3.51	2.80	2.01	4.30	5.38	-

Values within a column having same letter(s) do not differ significantly (p=0.05)

Blanket dose : N_{20} P_{16} K_{30} S_{10} kg/ha optimum economic dose of B was 1.35 kg/ha. The use efficiency showed that each 1 kg B could produce 101 kg/ha of seed yield upto the optimum level. Above this optimum dose, 1 kg/ha excess B if applied then there was a risk of 70 kg/ha reduced seed yield (Table 5).

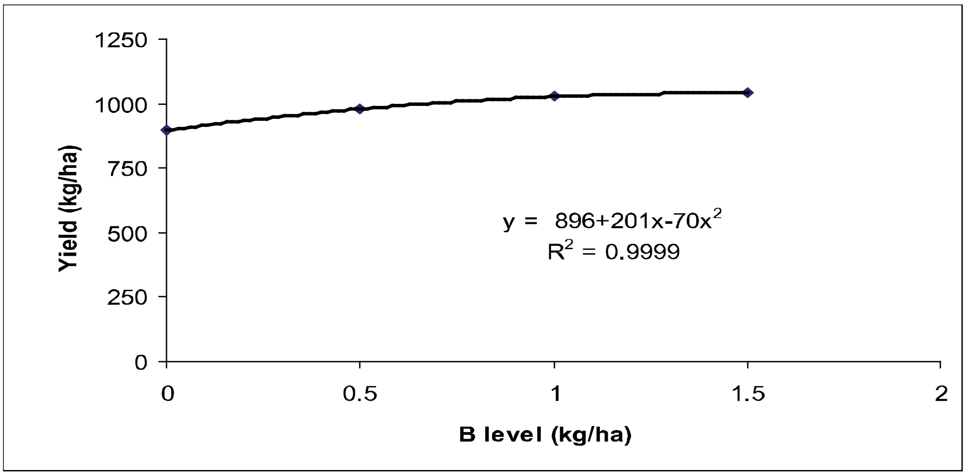

Fig. 2. Response of lentil to B fertilization.

Soil fertility status

Initially the soil pH was 7.1, but after completion of two years trial, the soil pH slightly increased in most of the treatments that was might be due to the cultivation of lentil (Table 6). The nutrients status both for macro and micro was influenced by cultivation of legume crop. The amount of organic matter was highest 1.51% with the treatment $Zn_{3.0}B_{1.5}$ and the lowest was with T_1 (control) treatment. In most of the cases, the content of macro and micro nutrients were found to be higher with $Zn_{3.0}B_{1.5}$ treatment and lowest with T_1 (control) treatment (Table 6). Sing *et al.* (2003) reported that incorporation of pulses crop in intensive agriculture is beneficial as this improve soil fertility.

Summary and Conclusion

From the trial, it was found that the combination of $Zn_{3.0}B_{1.5,}$ $Zn_{2.0}B_{1.0}$ and $Zn_{3.0}B_{1.0}$ with a blanket dose of N_{20} P_{16} K_{30} S_{10} kg/ha gave higher yield. From this study it can be concluded that for maximizing the lentil yield in Calcareous Low Ganges Floodplain Soils (AEZ 12), specially Madaripur's farmer can use $Zn_{2.0}B_{1.0}$ kg/ha.

Table 5 Response function of lentil to Zn and B for seed yield at Madaripur.

Regression equation	Co-efficient of determination (R^2)	Optimum dose (kg/ha)	Economic dose (kg/ha)	Maximum seed yield (kg/ha) for optimum dose	Production of seed (kg/ha) for 1 kg Zn or B (use efficiency)	Beyond optimum dose the reduction of seed yield (kg/ha) for 1 kg Zn or B
Zn						
$y = 878.55 + 121.05x – 21.25x^2$	0.9935	2.85	2.71	1051	60.5	21.3
B						
$y = 896 + 201x - 70x^2$	0.9999	1.44	1.35	1040	101	70

Lentil= 65 Tk./kg; Zn = 377 Tk./kg; B = 800 Tk./kg.

Table 6. Fertility status of initial and post harvest soil.

Treatment	pH	OM (%)	Total N (%)	Ca	Mg	K	P	S	Mn	Zn	B
				Meq. 100 g^{-1}			µg g^{-1}				
$T_1 = Zn_0B_0$	7.2	1.32	0.069	10.5	3.1	0.12	17.0	15.0	5.5	1.10	0.12
$T_2 = Zn_0B_{0.5}$	7.2	1.33	0.071	10.4	3.2	0.13	18.0	16.0	6.0	1.10	0.14
$T_3 = Zn_0B_{1.0}$	7.3	1.33	0.072	10.6	3.2	0.13	18.0	16.0	6.5	1.11	0.15
$T_4 = Zn_0B_{1.5}$	7.3	1.34	0.073	10.7	3.3	0.13	18.0	16.0	7.0	1.11	0.16
$T_5 = Zn_{1.0}B_0$	7.3	1.34	0.073	10.8	3.2	0.12	19.0	15.0	7.0	1.12	0.13
$T_6 = Zn_{1.0}B_{0.5}$	7.3	1.37	0.074	10.8	3.3	0.13	19.0	16.0	7.1	1.13	0.15
$T_{7=}$ $Zn_{1.0}B_{1.0}$	7.3	1.39	0.078	10.9	3.4	0.13	19.0	17.0	7.2	1.14	0.17
$T_8 = Zn_{1.0}B_{1.5}$	7.3	1.40	0.079	11.0	3.4	0.14	20.0	17.0	7.5	1.14	0.20
$T_9 = Zn_{2.0}B_0$	7.2	1.40	0.078	10.9	3.3	0.13	18.0	16.0	7.2	1.13	0.12
$T_{10} = Zn_{2.0}B_{0.5}$	7.3	1.42	0.080	11.0	3.4	0.14	19.0	17.0	7.4	1.15	0.18
$T_{11} = Zn_{2.0}B_{1.0}$	7.3	1.43	0.081	11.0	3.4	0.15	19.0	17.0	7.4	1.15	0.21
$T_{12} = Zn_{2.0}B_{1.5}$	7.4	1.45	0.083	11.1	3.5	0.15	20.0	18.0	7.5	1.16	0.24
$T_{13} = Zn_{3.0}B_0$	7.3	1.45	0.083	11.0	3.3	0.14	18.0	17.0	7.2	1.13	0.14
$T_{14} = Zn_{3.0}B_{0.5}$	7.3	1.46	0.085	11.2	3.4	0.14	19.0	18.0	7.3	1.14	0.19
$T_{15} = Zn_{3.0}B_{1.0}$	7.3	1.48	0.086	11.2	3.4	0.15	19.0	18.0	7.7	1.15	0.23
$T_{16} = Zn_{3.0}B_{1.5}$	7.4	1.51	0.089	11.3	3.5	0.15	20.0	19.0	7.8	1.16	0.26
Initial level	7.1	1.25	0.071	10.4	3.2	0.12	17	16	3.6	1. 2	0.13
Critical level	-	-	0.12	2.0	0.8	0.2	14	14	5	2	0.20

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