Effectiveness of borax and colemanite as boron sources for rice grown in flooded acidic soil

M. Saleem[A], Y. M. Khanif[A], Che Fauziah[A], A. W Samsuri[A] and B. Hafeez[A]

[A]Department of Land Management Faculty of Agriculture Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia.

Abstract
A field study was conducted to evaluate the effectiveness of boron fertilizers borax and colemanite (powder and granular) in supplying B to rice under flooded conditions. Boron application improved all the agronomic growth parameters and increased the yield. Both B fertilizers significantly increased the plant height, panicles/plant, number of grains/panicle and weight of 1000 grains. Both B sources were found equally effective in supplying B to rice crop. Borax gave significantly high yield at 2 kg B/ha and powder colemanite at 3 kg B/ha. Yield difference between borax and powder colemanite was not significant at all three levels. Powder colemanite applied plots had significantly high residual B in compare to borax at 0-15 and 15-30 cm and at 30-45 cm depth borax applied plots had high B content. Granular colemanite application did not significantly increase the crop growth and yield due to the large particle size B so that release was very slow.

Key Words
Boron, Rice, Borax, Colemanite.

Introduction
Rice production will need to increase upto 30% by 2025 in order to sustain the growing demand (IRRI 2008). Micronutrient deficiency is one of the major causes of the declining productivity trends (Alloway 2008). Boron is a micronutrient essential for normal healthy plant growth and development of reproductive tissues. Boron deficiency is wide spread in many regions and cropping systems (Shorrocks 1997). The common B sources are sodium tetra borate, ($Na_2B_4O_7{\cdot}5H_2O$), borax ($Na_2B_4O_7{\cdot}10H_2O$), sodium pentaborate ($Na_2B_{10}O_{16}{\cdot}10H_2O$) and calcium borate colemanite ($Ca_2B_6O_{11}{\cdot}5H_2O$). The sodium salts of B are reasonably soluble and therefore are widely used. Colemanite on the other hand is less soluble and therefore is applied to soils which have possibility of leaching. According to Shorrocks (1997) very few field studies on comparative efficiency of different B sources on crop yield have been conducted. Most studies of this nature have been carried out in pots often with B toxicity and leaching in mind rather than crop response. In this study we conducted field experiments to evaluate the effectiveness of borax, colemanite powder and colemanite granular on growth parameters and yield of rice under flooded acidic soil. The concentration of soil residual B after harvesting was also determined.

Materials and methods
A field experiment was conducted during 2008-2009 at traditional rice growing area in the northern part of Malaysia. The soil series was Kangkong (Typic Tropaquepts) deficient in B (0.3 mg/kg). Texture of the soil was silty clay loam with 4.8 pH and 2.2% organic carbon. Three B fertilizers borax, powder colemanite (PC) with particle size 75µm and granular colemanite (GC) particle size 0.3 mm were used. Boron levels were 0 kg B/ha, 1 kg B/ha, 2 kg B/ha and 3 kg B/ha; it was applied at the time of planting by broadcasting. Nitrogen (N), phosphorus (P) and potassium (K) fertilizers were given according to the recommendations of Malaysian Agriculture Development Authority (MADA). The crop parameters determined include number of tillers and panicles/plant, plant height, panicle height, fresh and dry weight of straw with and without grain, weight of panicle, grains/panicle, empty grains/panicle, weight of grain from each plot, weight of 1000 grains, B in plant straw and grain, B in three depths of soil.

Results and discussion
Boron application increased the number of tillers and panicles/plant at all three levels over the control. The number of grains/plant and the weight of the 1000 grains was increased with the increasing rate of B; the maximum number of grains were recorded in 3 kg B/ha (as borax) applied plots. Data regarding the empty grains/plant revealed that a steep reduction in empty grains was observed because of B application, minimum empty grains were at 3 kg B/ha. Boron also significantly increased the straw yield of the rice at 3 kg B/ha applied as borax and CP. Fertilizer application improved the B content of plant straw and grain at 2 and 3 kg B/ha. Yield of the rice crop significantly increased with the increasing level of CP and borax, it was 23% higher over the control at 3 kg B/ha, but in the case of borax yield difference between 2 kg and 3 kg B/ha

was not significant. Borax and CP were equally effective as B sources. Borax and PC similarly affected on number of tillers, panicles, grains, plant height, weight of grains and B content of tissue over the control. At all three rates of B (1, 2, 3 kg B/ha) both fertilizers improved the plant growth parameters, only difference was noted at 1 kg B/ha rate, where borax gave significantly better results from colemanite by increasing number of tillers and panicles/plant, number of grains/panicle, B content in straw and grain. Boron fertilizer application significantly increased the residual B content in soil after harvesting at all three depths. The residual B in PC applied soil was significantly higher (0.88 mg/kg) in compared to borax (0.70 mg/kg) at 0-15 and 15 -30 cm depth while at lower depth (30-45 cm) borax applied soil had more B. Powder colemanite gave much better results in compared to GC because of finer particle size. Finer colemanite proved to be effective B source. Ashraf (2004) and Yu (2002) reported that plant height, number of productive tillers, grain weight and ultimately yield of paddy cultivars increased with B application.

Table 1. Effect of different levels of B sources on rice growth parameters

Fertilizers type	Boron rates Kg/ha	No. tillers/ plant	No. panicles/ plant	No. grains/ panicle	Weight 1000 grains (grams)	Empty Grains/ panicle	B in plant straw (mg/kg)
Borax	0	10.3* c	8.0 c	90.6 b	19.0 b	25.6 a	9.0 c
	1	13.0 c	10.0 c	96.0 c	19.6 b	23.0 a	14.0 b
	2	15.5 b	11.3 bc	129.0 a	22.83 a	20.3 b	16.0 a
	3	17.6 a	14.3 a	135.0 a	23.8 a	19 bc	17.0 a
Colem(P)	0	10.3 c	8.0 c	90.6 c	19.0 b	24.3 a	9.0 b
	1	13.3 b	10.6 b	96.0 c	19.8 b	23.0 a	12.7 b
	2	16.0 a	13.3 a	109.6 b	22.1 a	19.3 b	14.0 a
	3	17.1 a	14.6 a	133.0 a	22.9 a	17.6 b	15.7 a
Colem (G)	0	10.3 a	7.0 a	90.0 a	17.0 a	24.0 a	9.0 a
	1	11.0 a	7.3 a	93.3 a	17.7 a	23.6 a	9.7 a
	2	12.0 a	8.0 a	94.0 a	19.2 a	22.3 a	11.2 a
	3	12.5 a	9.0 a	100 a	20.3 a	21.6 a	11.7 a

*Means with same letter for each fertilizer and parameter are not significantly different at p=0.05

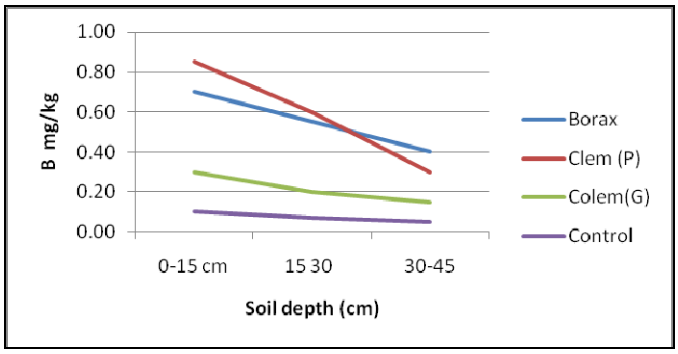
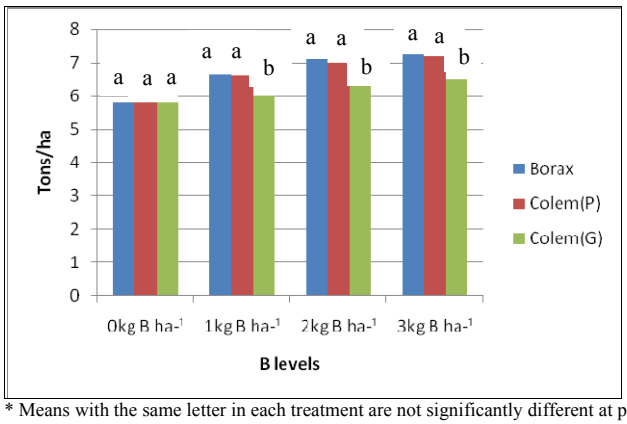


Figure 1. Residual B content remaining at different soil depths after harvest from plots receiving different sources of B fertilizer



* Means with the same letter in each treatment are not significantly different at p=0.05.

Figure 2. Yield of crop from field plots receiving different sources and rates of B

Conclusion

Boron application significantly increased the growth and yield of rice crop by improving number of tillers, panicles, grains and its weight at all three B levels. Fertilizer application also increased the B content in plant tissue. Both B sources borax and powder colemanite were equally effective for supplying B to rice crop. Yield difference between borax and PC applied soils was not significant at all three rates of B. After harvesting residual B from fertilizers was present in the soil. Powder colemanite applied soil had significantly high residual B content in upper layer in compare to borax applied soil. Powder colemanite prove to be much better source of B in compare to GC as GC did not significantly improve the growth parameters of the rice crop because of its particle size.

References

Ashraf M, Rashid A, Yasin M, Mann RA (2004) Boron deficiency in calcareous soil reduces rice yield and impairs grain quality. *International Rice Research Notes* **29** 58-60

Brian J Alloway (2008) 'Micronutrient Deficiencies in Global Crop Production'. (Springer Science).

IRRI (International Rice Research Institute) (2008) Background Paper: *The rice crisis*: What needs to be done? Los Baños (Philippines): IRRI.

Shorrocks VM (1997) The occurrence and correction of boron deficiency *Plant and Soil* **193**, 121-148.

Yu X, Bell PF (2002) Boron and lime effects on yield and deficiency symptoms of rice grown in greenhouse on acid typic Glossaqualf. *Journal of Plant Nutrition* **25**, 2591–2602