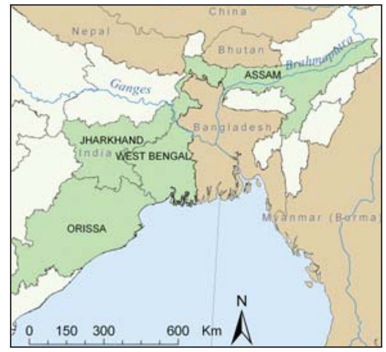
Proper Timing and Placement of Boron and Lime Impacts Legumes on Acid Upland Soils



By Surendra Singh and Ravindra Naryan Singh

Soil acidity creates many serious crop production problems, and on the acid upland soils of Jharkhand State in India low plant-available B is a prominent concern. Use of in-furrow B and lime just prior to planting proved effective at producing better soybean, groundnut, lentil, pigeon pea, and gram crops—all of which are critical food and income sources for this region.

The upland soils of Jharkhand occupy an area of 300,000 ha and represent an important rainfed-production zone suited to grain legume cultivation. However, the region generally has low crop productivity, which is blamed on common regional issues such as soils with coarse texture, low water and nutrient retention capacity, low base saturation, and soil acidity. Low fertilizer use (e.g., 30 kg of total $N+P_2O_5+K_2O$/ha application) is also commonplace and deficiencies of N, P, K, S, and B are widespread.

Boron deficiency extensively affects crops on acidic soils in the states of Assam, Orissa, West Bengal, and Jharkhand (Sarkar et al., 2010). Legumes and pulses are highly sensitive to B deficiency, which partly explains their low productivity in the region. The correction of (a) B deficiency through fertilization and (b) soil acidity through liming have the potential to improve crop productivity and quality, thus, providing better livelihood opportunities for farmers in the region. Mathur et al. (1991) showed the benefits of in-furrow application of small rates of lime in grain legumes as compared to simple surface broadcasting. This article presents an evaluation of the advantages of co-applying B plus lime, along with other recommended nutrients, on major legume and pulse crops grown in the region.

Table 1. Recommended N, P, K and B application rates for the major legume and pulse crops grown in east Singhbhum, Jharkhand, India.

Crops	N	P_2O_5	K_2O	B
	--------- kg/ha ---------			
Legumes				
Soybean	20	60	20	0.5-2.0
Groundnut	25	50	20	1.0-2.0
Pulses				
Lentil	20	40	20	1.0-4.0
Pigeon pea	20	20	16	1.0-2.0
Gram	20	40	20	0.5-2.0

Field experiments were conducted from 1995 to 2005 during *Kharif* (monsoon) and *Rabi* (winter) seasons at an upland location in east Singhbhum district in Jharkhand. Soils were coarse-textured with pH values (soil:water w/v ratio of 1:2.5) between 5.1 to 5.5, organic carbon (OC) of 0.2 to 0.4%, potentially mineralizable N (alkaline permanganate method) between 140 to 231 kg/ha, available P (Bray 1-P method) between 7.9 to 9.8 kg/ha, available K (1 N ammonium acetate) between 160 to 210 kg/ha, and available B (hot water extractable) between 0.26 to 0.47 mg/kg.

To control soil acidity, just prior to each crop seeding, 300 to 400 kg/ha of powdered lime (1/10th of the measured lime requirement) was applied within furrows opened at the recommended row spacing of 15 to 20 cm. The lime was mixed in the soil, and then B was applied and mixed in soil. NPK fertilizers were applied in the same furrows at recommended rates (**Table 1**) and mixed again with soil. Seeds were sown in the opened furrows and finally covered with soil. Boron was applied using borax (10.5% B) at rates varying from 0.5 to 4.0 kg B/ha, while fertilizer N, P and K sources used were urea, TSP and KCl.

Berger and Truog (1939) determined a critical limit of 0.5 mg/kg of hot water-extractable B to delineate B deficiency or sufficiency in soils. **Table 2** shows the extent of B deficiency in different districts of Jharkhand, which varies from 4% in

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; S = sulfur; B = boron; KCl = potassium chloride; TSP = triple superphosphate.

Table 2. Distribution of B-deficient and acid (pH<5.5) soils in different districts of Jharkhand, India.

District name	Approximate area, '000 ha	Area with severe to moderate acidity, %	Area with low available B, %	Range of available B, mg/kg
West Singhbhum	718	74	38	0.02-7.2
East Singhbhum	354	72	77	0.02-0.9
Saraikela	272	67	55	0.03-3.0
Ranchi	770	73	43	0.02-3.5
Simdega	377	73	46	0.01-2.3
Gumla	532	69	49	0.02-3.3
Lohardaga	149	72	71	0.04-1.1
Latehar	14	50	35	0.02-1.6
Palamau	509	4	67	0.02-4.2
Chatra	382	19	23	0.07-4.5
Hazaribagh	502	53	39	0.03-7.9
Koderma	240	26	24	0.02-5.8
Giridih	494	56	47	0.02-5.2
Deoghar	248	38	45	0.03-1.9
Dumka	441	48	27	0.11-7.2
Godda	211	28	25	0.05-9.0
Sahebganj	159	22	38	0.07-3.8
Pakur	180	41	27	0.10-7.2
Jamtara	180	64	23	0.02-6.1
Dhanbad	209	60	04	0.22-5.9
Bokaro	286	70	22	0.09-5.0
Garhwa	404	5	71	0.01-3.0
Overall	7,629	52	41	0.01-9.0

Source: Sarkar et al. (2010).

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Boron deficiency in soybean field (center strip) with unaffected strip seen on the right.

Dhanbad to 77% in east Singhbhum. The wide variation in B deficiency across districts is probably related to variable soil OC contents and the differences in losses of borate ions due to leaching from these coarse-textured soils.

A soil application of 0.5 to 2.0 kg B/ha as borax to soybean, groundnut, lentil, pigeon pea, and gram gave yield responses of 115, 61, 66, 179, and 73 kg grain/kg of applied B, respectively (**Table 3**). Groundnut and pigeon pea yields increased by 34 and 61%, respectively, with B and lime application. Similarly, the application of lime and 2 kg B/ha increased the protein content in groundnut and pigeon pea seeds by 11 and 18%, respectively, while the protein content in gram increased appreciably with the application of 1 kg B/ha and lime (**Table 4**). As observed with yield, B application improved the profitability for each crop in the following order: pigeon pea > groundnut > lentil > soybean > gram (**Table 5**).

Table 3. Effect of lime and B application on yields of major legume and pulse crops grown in the acidic upland soils of east Singhbhum, Jharkhand, India. Data shown is the average of three years for each crop.

		------- Yield, kg/ha -------			
	Optimum B† rate, kg/ha	NPK + Lime	NPKB + Lime	Response, kg grain/kg B	References
Legume crops (1995-2003)					
Soybean	2.0	1,390	1,620	115 (16.5)*	Singh et al. (2006)
Groundnut	2.0	943	1,263	160 (33.9)	Singh et al. (2004a)
Pulse crops (1995-2005)					
Lentil	2.0	865	1,070	103 (23.7)	Kushwaha et al. (2009)
Pigeon pea	2.0	1,041	1,673	316 (60.7)	Singh et al. (2004a)
Gram	1.0	876	966	90 (10.2)	Singh et al. (2004b)

LSD (p=0.05) for soybean = 80; groundnut = 61; lentil=66; pigeon pea =179 and gram =73. †Applied as Borax. *Percent (%) response to B application (i.e., % increase in grain yield with B application compared to no B application).

Table 4. Effect of lime and B application on protein content in grains of major legume (1995-2003) and pulse (1995-2005) crops grown in the acidic upland soils of east Singhbhum, Jharkhand, India.

		---- Protein content, % ----			
	Optimum B† rate, kg/ha	NPK + Lime	NPKB + Lime	B response, %	References
Legume crops					
Soybean	2.0	35.8	36.7	2.5	Singh et al. (2006)
Groundnut	2.0	24.4	27.2	11.4	Singh et al. (2004a)
Pulse crops					
Lentil	2.0	17.5	19.1	9.1	Kushwaha et al. (2009)
Pigeon pea	2.0	18.1	21.3	17.6	Singh et al. (2004a)
Gram	1.0	17.9	19.7	10.0	Singh et al. (2004b)

LSD (p=0.05) for soybean = 0.2; groundnut = 1.2; lentil = 0.6; pigeon pea = 0.7 and gram = 0.5.
†Applied as Borax.
Data shown is the average of three years for each crop.

Summary

Use of B and lime in the acidic upland soils of Jharkhand produced higher legume and pulse crop yields with higher protein content. There is a need to popularize the practice of targeted in-furrow placement of lime and fertilizers with resource poor farmers producing these food and cash crops that are of critical

Table 5. Profits obtained with B application on major legume (1995 -2003) and pulse (1995-2005) crops grown in the acidic upland soils of east Singhbhum, Jharkhand, India.

	Optimum B† rate, kg/ha	B response, kg grain/kg B	Increase in income/kg of applied B, ₹
Legume crops			
Soybean	2.0	115	2,944
Groundnut	2.0	160	6,400
Pulse crops			
Lentil	2.0	103	2,987
Pigeon pea	2.0	316	13,588
Gram	1.0	90	2,700

†Applied as Borax. Prices/costs of crops and fertilizers used per kg were: ₹25.60 for soybean, ₹40 for groundnut, ₹29 for lentil, ₹43 for pigeon pea and ₹30 for gram; ₹78 for borax. ₹59 (Indian Rupee) = US$1. Data shown is the average of three years for each crop.

importance to this region.

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