

Research Article

Evaluation of Suitable Extractants and Establishment of Critical Limits of Boron for Sunflower (*Helianthus Annus* L.) Grown On Red and Lateritic Soils of Odisha, India

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Abstract

A pot culture experiment was conducted using sunflower as test crop to establish critical limit for boron with suitable extractants for red and laterite zones of Odisha, India. The red and lateritic soils under study were very strongly acidic (pH of 4.5) to slightly acidic (pH of 6.4) and selected for estimation of available boron with three widely used extractants viz. Hot water soluble, 0.01 N hot CaCl₂ and 1 N salicylic acid. Sunflower (Cv Shakti) was raised with 5 graded doses of boron(0,0.5, 1.0,1.5,2.0 kg B/ha) as borax applied as soil application along with RDF with 2 replications. Sunflower responded well to boron application with an increase in biomass and Brays percent yield varied from 43-100 % with mean value of 72.9 %. Critical limit of soil available Boron for sunflower for red – lateritic soils with respect to three different extractants were established as 1.05 mg/kg for hot CaCl₂, 1.1 mg/kg for salicylic acid and 0.48 mg/kg, for hot water extractable boron as per Cate and Nelson graphical model. Out of the three methods tested hot CaCl₂ and Salicylic acid extracted boron correlated positively and significantly with sunflower yield.

Keywords: Boron, Sunflower, Critical limit, redand lateritic soils, Odisha

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Introduction

In eastern region of India, micronutrient deficiency in soils is a common problem. Particularly boron deficiency is found to present in maximum soils due to upland sandyloam red soils low in organic matter coupled with heavy rainfall. Red soils are one of the major soils of Odisha covering an area of 7.14 mha [1]. It is reported that boron deficiency to the extent of 50% in surface soils of Odisha (Report AICRP on Micronutrients). Presently hot water soluble boron is used as soil test method for plant available boron estimation with a critical limit of 0.5 mg/kg [2]. Extraction with hot water poses some difficulty both during extraction and estimation due to presence of organic matter leading to erroneous results. Also acid soils with high amount of Fe, Mn interferes during estimation. However, the range between B deficiency and toxicity is very narrow [3], and its application slightly above the optimum level proves to be toxic to plants. This emphasizes the need for a careful appraisal of available B status in soils particularly for acid soils. Hence it is necessary to compare or test other available methods of extraction of soil boron and to establish its critical limit taking into account the crop response and soil status.

The hot water extraction method [4] has been widely used for establishing the index of plant-available B in soil. However, the amount of B extracted by this method is affected by the extraction time and temperature [5] and the potential resorption of B during the cooling period [6]. The hot water extract of some soils may be coloured which may affect spectrophotometric B determination. Treatment with activated charcoal to remove the colour of the extract was suggested [7]; however, this treatment may lower B concentration in the extract due to B sorption on charcoal [8]. Since the hot-water extraction procedure is difficult, time consuming and tedious for routine use for acid soils hence other available methods were compared. Hence the present study was aimed to evaluate the boron extraction methods for acidic red and laterite soils of Odisha and to establish the critical limit of boron for sunflower crop.

Materials and Method

Pot culture

A Pot culture experiment was conducted using sixteen bulk surface soils collected from red laterite zones of Bhubaneswar, Odisha, India. Soils were grinded and packed in polypots. Four kg of each soil was filled in poly pots of five kg capacity having a hole at the bottom. Boron was applied in graded doses @0, 0.5, 1.0, 1.5 and 2.0 kg/ha as basal application along with RDF(Recommended dose of fertilizer). Recommended dose of 60-80-60 kg N-P₂O₅-

K₂O/ha were also applied at the time of sowing of sunflower. Seeds of Sunflower (var. Shakti) were sown @5 /pot and thinned to three plants after ten days. Plant sampling was done at critical growth stage of 45 DAS for biomass yield and Boron concentration. The crop was harvested at maturity at 90 DAS (days after sowing). Yields were recorded treatment wise. Soils were analysed for physico-chemical properties using standard laboratory procedures [9].

Extraction and determination of boron

Plant available boron in the soil sample was extracted using 3 different extractants, viz., Hot water soluble [4], 0.01 N Hot CaCl₂ method [10] and 0.1 N Salicylic acid method. After extraction of boron, it was estimated spectrophotometrically by using Azomethin- H [11] for development of colour.

Plant analysis

The harvested plants were washed with water, air dried and kept in the hot air oven at 70°C for 72 hr and total boron in plant tissues was determined by dry ashing in muffle furnace at 550 °C and dissolved its content in 0.01 N HCl. The extract was used for determination of Boron colorimetrically using azomethin –H method (Jackson,1973).

Calculations: From the yield, brays percent yield was calculated as given under:

$$\text{Bray's per cent yield} = \frac{\text{Yield without B fertilizer(control)}}{\text{Maximum yield in B treated pots}} \times 100$$

By taking into account the Brays percent yield and initial soil B content, the critical limit of B for were calculated as per [12].

Results and Discussion

The physic-chemical properties of soils used for pot culture experiment are presented in **Table 1**. Soils are very strongly acidic (pH of 4.5) to slightly acidic(pH of 6.4) with mean of pH 5.33 indicating soils were acid, non saline with EC of 0.2-0.36 dSm⁻¹ and organic carbon of the soils varied from 0.17-0.9 per cent with mean of 0.52 per cent indicating medium fertility status.

Table 1 Initial physico-chemical properties of soils

Sl No.	pH (1:2.5)	EC dSm ⁻¹	OC (%)	N Salicylic acid B mgkg ⁻¹	Hot water HWS-B	0.01 M Hot CaCl ₂
1	5.19	0.28	0.46	0.63	0.08	1.04
2	4.74	0.36	0.54	0.88	0.14	0.76
3	4.81	0.26	0.73	0.55	0.31	0.37
4	5.03	0.27	0.31	0.67	0.21	0.82
5	5.18	0.33	0.52	0.96	0.16	0.88
6	5.15	0.27	0.36	1.08	0.23	0.33
7	5.54	0.22	0.63	0.08	0.23	0.25
8	5.56	0.21	0.17	1.65	3.21	4.13
9	5.4	0.22	0.27	1.66	0.62	3.02
10	5.1	0.23	0.86	1.14	0.55	2.27
11	5.82	0.20	0.23	0.37	0.27	0.61
12	4.44	0.29	0.90	1.43	0.04	0.67
13	6.49	0.26	0.78	0.69	0.06	0.1
14	5.09	0.30	0.48	0.16	0.19	0.29
15	6.51	0.30	0.40	1.08	0.1	0.29
16	5.23	0.22	0.84	1.29	0.12	0.39
Mean	5.33	0.26	0.52	0.89	0.41	1.01
Min	4.44	0.2	0.17	0.08	0.04	0.10
Max.	6.51	0.36	0.9	1.66	3.21	4.13

The hot water extractable boron ranged from 0.01-3.21 mgkg⁻¹ with a mean value of 0.41 mgkg⁻¹. Whereas the Hot CaCl₂ extractable boron varied from 0.10-4.13 mgkg⁻¹ with a mean value of 1.01 mgkg⁻¹ and Salicylic acid extracted boron of 0.08-1.66 mgkg⁻¹ with mean value of 0.89 mgkg⁻¹. Correlation studies showed that there is a positive correlation between hot water and hot CaCl₂ extraction methods for boron. Boiling the soil in solution (hot 0.01M CaCl₂) extracted comparatively more B than did other extractants. Similar findings were also reported by Gupta et al. (1985) and he cited the reason as they extract not only inorganic soluble B, but B from other pool like organic and adsorbed pool including higher Ionic strength. Boron extracted by different extractants was weakly correlated with soil pH and OC.

Yield

Biomass yield of sunflower recorded at active growth stage is presented in **Table 2**. Yield is found to be affected with respect to different soil properties and graded doses of boron. It was observed that the increase in sunflower yield was recorded with graded boron dose along with increase of Bray's percent yield from 43-100 %. For two soils i.e. Soil no 8 and 9 no response to boron application was observed with control treatment showing more yield. Taking the Brays percent yield and soil available boron status, the critical limit was calculated and presented in **Figures 1-3** respectively for three extractants tested .

From the correlation coefficient values it indicated that strong positive correlation was established between soil available boron extracted by Hot CaCl₂ and salicylic acid and Brays percent yield where as hot water soluble boron was weakly correlated. Critical limit thus calculated by taking soil test values of respective extraction methods with Brays percent yield were found to be 1.1, 1.15 and 0.48 mgkg⁻¹ for Hot CaCl₂ soluble, salicylic acid and hot water soluble boron respectively.

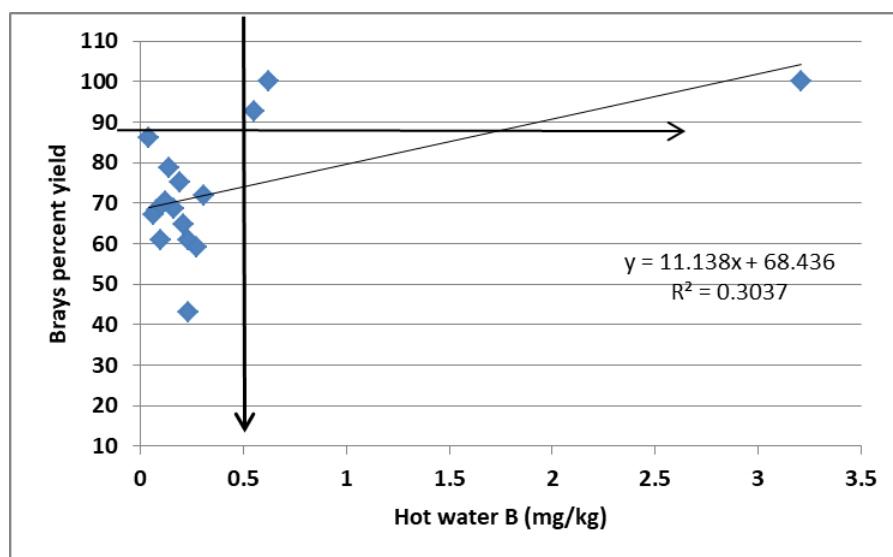


Figure 1 Critical limit of Boron by Hot water soluble method

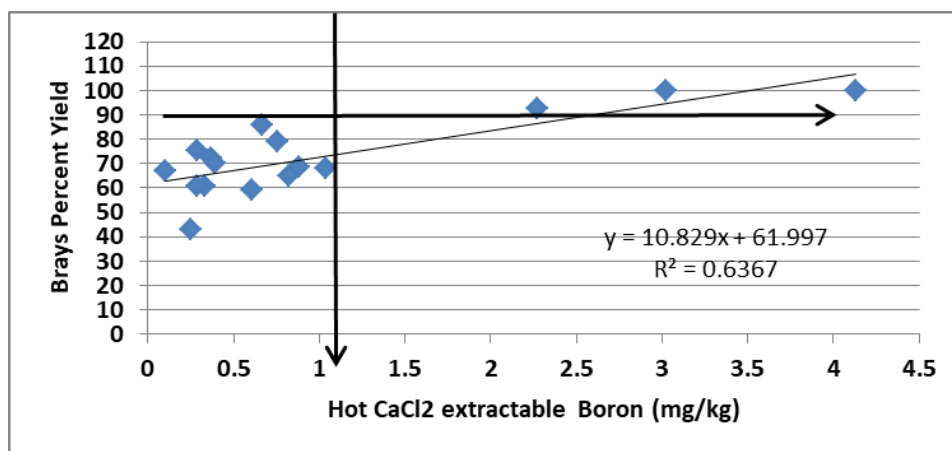


Figure 2 Critical limit of Boron by Hot CaCl₂ method

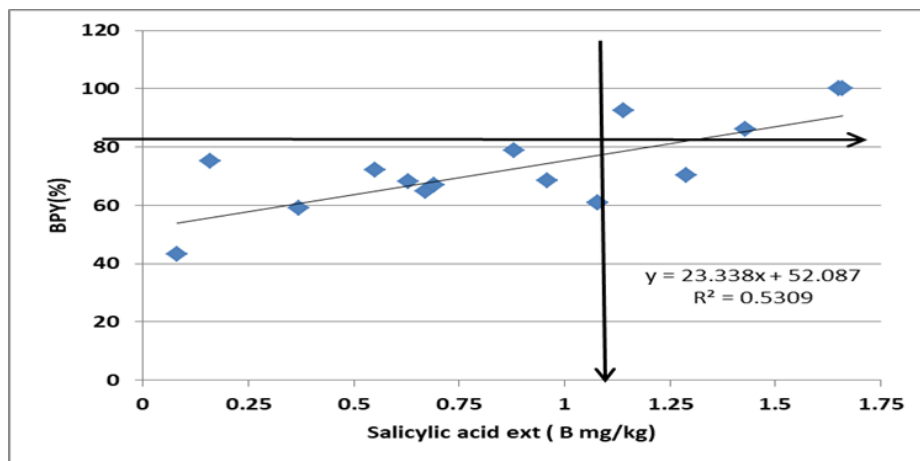


Figure 3 Critical limit of Boron by Salicylic acid

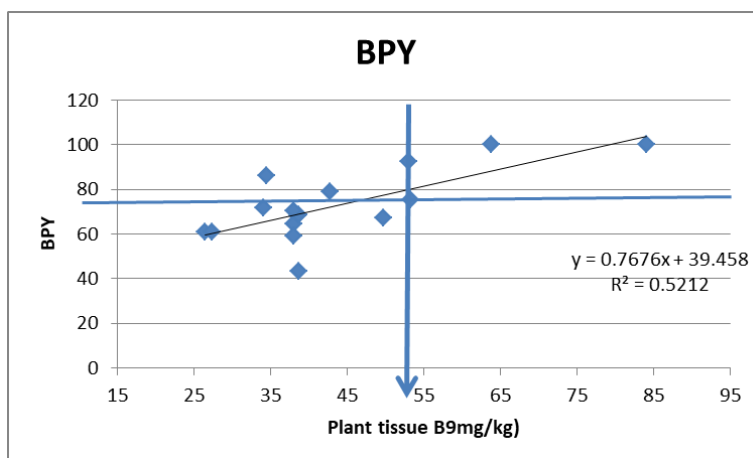


Figure 4 Critical limit of plant tissue Boron for sunflower crop

Table 2 Effect of graded doses of Boron on biomass yield(gm/pot) of Sunflower (45 DAS)

	B0	B0.5	B1.0	B1.5	B2.0	BPY (%)
S1	11.8	12.5	13.3	15.4	17.3	68.2
S2	11.5	12.5	14.4	14.6	13.4	78.8
S3	10.8	12	15	13.4	12.7	72.0
S4	10.1	11.8	13.6	14.2	15.6	64.7
S5	10.9	13.1	14.6	15.7	15.9	68.6
S6	7.6	7.5	10.2	12.5	8.6	60.8
S7	6.7	10.6	15.6	13.9	8.3	43.2
S8	8.5	5.4	4.0	3.0	3.6	100.0
S9	8.0	4.7	4.9	3.5	3.5	100.0
S10	5.3	5.3	5.6	5.7	5.8	92.6
S11	3.5	4.4	4.7	5.9	1.2	59.2
S12	6.7	6.8	7.8	7.6	6.8	86.1
S13	8.2	10.3	11.8	12.2	10.6	67.1
S14	10.6	11.0	13.0	13.8	14.1	75.2
S15	4.6	6.8	6.0	7.6	7.4	60.8
S16	9.8	12.5	14.0	12.6	10.7	70.3
Mean	8.42	9.20	10.53	10.71	9.72	72.97
Min.	3.49	4.45	4.00	2.98	1.25	43.20
Max.	11.8	13.1	15.612	15.7	17.3	100.0

Table 3 Effect of graded doses of Boron on plant boron concentration (mgkg⁻¹) of Sunflower

Soil	B0	B0.5	B1.0	B1.5	B2.0
S1	38.56	58	53.7	67.65	77.55
S2	42.75	54.5	60.45	72.4	85.15
S3	34.02	38.39	85	88	90.1
S4	37.95	47.95	62.5	69.5	73.5
S5	38.6	50.69	62.91	73.63	80.89
S6	26.40	47.93	51.40	60.90	40.29
S7	50.71	37.51	25.01	53.26	72.01
S8	37.04	51.40	82.20	84.05	132.91
S9	63.68	35.20	37.51	42.37	46.31
S10	53.72	128.51	148.66	149.58	291.06
S11	38.44	40.06	113.46	141.01	231.55
S12	34.50	32.42	43.30	42.37	47.00
S13	49.78	84.52	46.08	30.10	46.08
S14	53.26	65.30	73.63	75.02	82.20
S15	27.32	31.03	63.99	53.26	64.83
S16	38.67	35.20	40.29	31.49	24.08
Mean	62.59	51.43	69.26	62.50	77.61
Min.	26.40	31.03	25.01	30.10	24.08
Max.	63.68	128.51	148.66	149.58	291.06

Similar results were also observed by [13] for soils of Arunachal Pradesh.

Plant boron concentration in control treatment due to native soil status ranged from 26.4-84.05 mgkg⁻¹. Plant tissue boron concentration increased with increase in boron dose with maximum of 291 mgkg⁻¹. Critical limit of plant tissue boron concentration with Brays percent yield was computed to be 53 mgkg⁻¹ for sunflower crop.

Table 4 Critical limit of soil available Boron

	CL in soil	R ²	CL in Plant	R ²
1.HWS-B	0.48 mg/kg	0.303	53 mg/kg	0.521
2. Hot CaCl ₂	1.1 mg/kg	0.636		
3.Salicylic acid	1.15	0.530		

Conclusion

From the pot culture study, it was concluded that the critical limit of boron for red-lateritic soils of Odisha found out as 1.1 mg/kg with hot CaCl₂ extractant and 1.15 mg/kg for salicylic acid extractable Boron. It is concluded from the above experiment that Hot CaCl₂ extracted more boron than salicylic acid extractant. As per the suitability of the methods either salicylic acid or Hot CaCl₂ method is suitable for boron extraction from acid soils due to strong

positive correlation of the extracted boron with bray's percent yield. But plant tissue Boron correlated with HWS extraction method over other two methods.

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