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Evaluation of suitable extractant of boron in soil of Manipur

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Abstract
A pot experiment was conducted during 2018-2019 with thirty number of soil samples having different soil characteristics for evaluating the suitability of extractants in soils of Bishnupur distric taking cauliflower as a test crop. Five different extractants such as hot 0.01 calcium chloride, hot water, Mehlich-3, 0.1M salicylic acid and 1.0M of ammonium acetate were used for extracting the soil boron. In terms of efficiency of boron extraction, the extractants followed the order in decreasing trend as Mehlich-3 (M3) > hot 0.01M Calcium Chloride (HCC) > hot water (HW) >0.1M salicylic acid (SA) > 1.0M ammonium acetate (AA). Among the extractants, hot 0.01M Calcium Chloride recorded the highest correlation with Bray's percent yield, dry matter yield, B concentration at control and B uptake at control.

Keywords: Boron, hot 0.01 calcium chloride, hot water, mehlich-3, 0.1m salicylic acid and 1.0m of ammonium acetate, Manipur

Introduction
According to Indian agriculture, micronutrient deficiency in soils is becoming a big issue. Although required in petty quantities, the impacts they have on the plant health and yield production were significant. It is considered as one of the second most significant micronutrients confines crop production next to zinc (Alloway 2008) [1]. It is reported that on an average, 18.3 % of total cultivated soils in India are deficient in Boron (Shukla *et al.* 2014) [6]. A report of widespread B deficiencies has found in different parts of the world (Gupta *et al.*, 1985; Mandal *et al*., 2004; Niaz *et al*., 2013) [2, 3, 4]. Several extractants have been engaged globally for extracting the available boron. For accurate evaluation, a sole extractant cannot be used for all soil-crop combination with the diverse difference in soil physio-chemical properties. In a given agro-climatic condition, suitability of different soil extractant needs to be checked in predicting the response of a particular nutrient application (Watham *et al*., 2014) [8].

Materials and Methods
Collection of soil samples
Surface soils (0–15 cm) were collected from 30 different locations of Bishnupur district covering all the three blocks. The soils were air-dried, ground and passed through a 2-mm sieve.

Soils were air dried, grind and passed through a 2 mm sieve. The processed soil samples were analyzed for important physio-chemical properties before start of the experiment and presented in Table 3. The experiment was conducted in a plastic pots filled with 5 kg air-dried soil. Three level of B (B) viz., T_0(no B), T_1(0.5 $mgkg^{-1}$of B), T_2(1.0 $mgkg^{-1}$ of B), T_3 (1.5 $mgkg^{-1}$ of B) and T_4 (2.0 $mgkg^{-1}$ of B) were applied through AR grade Borax ($Na_2B_4O_7.7H_2O$).Treatments were replicated thrice for each soil. A basal dose of 50:50:60 NPK Kg/acre was applied in the form of urea, single super phosphate and murate of potash, respectively ineach pot. The soils in the pots were then moistened to field capacity with deionized water and planted with one healthy seedling of cauliflower (var.Sweta) plant in each pot and irrigation was given with deionized water as and when required. The cauliflower plants were harvested after 60 days of growth, washed with distilled water and dried in an oven at65 ºC. Dry matter yield of oven dried samples was recorded.

Pot experiment
Thirty soil samples of varying soil characteristics were collected from three different blocks of Bishnupur district for conducting a pot experiment during 2018-2019 to evaluate the suitability

of five different extractants in soils of Bishnupur district. Use of a single extractant may not give reliable prediction for the availability of B to plants from thesoil. Hence, it is desirable to select a suitable extractant for a certain group of soils, which may give better prediction of B availability to growing plants. Five extractants employed for the estimation of plant available B in soil is given in Table 1. Suitable extractant for B was selected based on the amount of B extracted from the soil and its subsequent correlation with Bray's per cent yield, dry matter yield, B concentration in plant and uptake of B by cauliflower plant.

Table 1: Extractants used for extraction of available soil boron

Sl. No	Extractant	Chemical composition	Soil extractant	Reference
1	Hot 0.01M $CaCl_2$	0.01 M $CaCl_2$	1:2	Aitken *et al*.,1987
2	Hot water	Soil water	1:2	Berger and Troug,1993
3	Mehlich-3	0.2 M CH_3COOH + 0.015 M NH_4F + 0.013 M HNO_3 + 0.25 M NH_4NO_3 + 0.001 M EDTA	1:10	Mehlich,1984
4	Salicylic acid	0.01 M $C_7H_6O_3$	1:2	Datta *et al*.,1998
5	Ammonium acetate	0.1 M NH_4OAc	1:2	Gupta and Steward,1975

Statistical analysis

The raw data observed from pot experiments were put for statistical analysis using Complete Randomized Design (CRD), respectively to draw the valid differences among the treatments. Simple correlation coefficients between B content in soils with Bray's per cent yield, dry matter, B concentration and uptake in cauliflower plant were determined using SPSS 17.0.

Results and discussion

Initial physico-chemical properties of soil samples: The data pertaining to the physico-chemical properties ofinitial bulk soil samples are presented in Table 2. The soil pH (1:2.5, soil: water) values of the collected and studied soil samples were acidic in nature and varied in the range of 5.24-6.14 with a mean value of 5.52 which were considered as strongly acidic soil. The electrical conductivity varied from 0.08 to 0.41 $dSm^{-1}$with an average of 0.23dSm^{-1}. The value of organic carbon content in experimental soil varies from 1.12 to 2.96% with a mean of 1.73%.The cation exchange capacity (CEC) of the soil ranged from 9.07 to16.20 [C mol (P^+) kg^{-1}] with an average of 11.92[C mol (P^+) kg^{-1}].

Table 2: Some chemical parameters of soil in Bishnupur district

Sl. no	Name of village	Latitude/ Longitude	pH	EC (dS/m)	OC%	CEC [cmol(p+) /kg]	Sand%	Silt%	Clay%	Textural class
1	Leimapokpam	24˚41'55.9"N, 93˚51'28.1"E	5.67	0.18	1.75	13.9	23.6	25.0	51.4	Clay
2	Thiyam	24˚42'28.8"N, 93˚52'2.17"E	5.40	0.24	1.27	14.8	14.5	41.6	43.9	Silty clay
3	Irengbam	24˚41'40.2"N, 93˚47'30.8"E	5.50	0.19	1.65	13.4	25.5	20.1	54.3	Clay
4	Leimaram	24˚42'23.9"N, 93˚47'58.7"E	5.78	0.30	1.42	13.6	24.5	29.1	46.4	Clay
5	Kabowakching	24˚42'31.8"N, 93˚47'39.4"E	5.32	0.22	1.50	11.2	26.5	20.7	52.6	Clay
6	Oinam	24˚41'31.2"N, 93˚47'46.8"E	5.24	0.25	1.50	12.5	39.9	19.2	40.9	Sandy clay
7	Nambol	24˚42'47.1"N, 93˚50'18.3"E	5.27	0.23	1.65	13.3	42.2	19.8	38.0	Clay loam
8	Utlou	24˚43'53.6"N, 93˚51'33.0"E	5.31	0.30	1.42	12.0	28.1	16.4	55.5	Clay
9	Lourembam	24˚41'44.3"N, 93˚52'27.9"E	5.46	0.41	2.32	11.4	21.3	24.8	53.9	Clay
10	Yumnam Khunou	24˚40'56.8"N, 93˚47'32.0"E	5.12	0.26	2.96	12.1	34.7	19.8	45.5	Clay
11	Ngaikhong Khullen	24˚37'35.3"N, 93˚46'38.6"E	5.32	0.25	1.50	11.2	24.2	21.2	54.6	Clay
12	Khoijuman	24˚37'1.48"N, 93˚46'38.2"E	6.14	0.18	2.02	11.6	37.1	27.5	35.4	Clay loam
13	Nachou	24˚36'10.2"N, 93˚46'26.4"E	5.84	0.24	1.65	12.5	28.8	27.3	43.9	Clay
14	Potshangbam	24˚36'4.46"N, 93˚45'48.9"E	5.35	0.17	1.95	10.4	17.7	30.0	52.3	Clay
15	Kwakshiphai	24˚36'8.10"N, 93˚45'4.64"E	5.85	0.08	1.12	9.60	24.4	28.4	47.2	Clay
16	Bishnupur	24˚37'49.2"N, 93˚45'35.3"E	5.60	0.16	1.80	12.2	24.3	22.5	53.1	Clay
17	Thinungei	24˚35'11.1"N, 93˚45'55.5"E	5.41	0.20	1.50	11.6	35.2	30.0	34.8	Clay loam
18	Sunushiphai	24˚32'0.74"N, 93˚45'24.0"E	5.25	0.13	1.95	11.3	33.6	26.6	39.8	Clay loam
19	Phubala	24˚31'14.8"N, 93˚45'48.0"E	5.22	0.18	1.87	9.07	24.4	27.5	48.1	Clay
20	Toubul	24˚30'43.1"N, 93˚45'32.0"E	5.64	0.15	1.72	12.8	31.9	25.0	43.1	Clay
21	Kumbi	24˚26'25.5"N, 93˚47'52.9"E	5.59	0.24	1.95	15.4	34.0	20.7	45.3	Clay
22	Ithai	24˚24'50.9"N, 93˚50'45.9"E	5.69	0.20	2.55	16.2	14.4	22.5	63.1	Clay
23	Ahallup	24˚24'18.0"N, 93˚49'22.3"E	5.75	0.19	1.20	12.2	24.1	21.2	54.7	Clay
24	Sagang	24˚23'40.4"N, 93˚49'43.6"E	5.30	0.16	1.65	9.60	31.5	10.5	58.0	Clay
25	KumbiTerakhong	24˚25'20.1"N, 93˚48'44.9"E	5.55	0.26	1.87	10.4	21.5	25.7	52.8	Clay
26	Kwakta	24˚26'33.6"N, 93˚43'36.3"E	5.71	0.27	1.57	9.67	35.3	25.7	39.0	Clay loam
27	Torbung	24˚25'17.3"N, 93˚43'1.12"E	5.63	0.22	1.72	11.8	29.5	19.7	50.8	Clay
28	Tronglaobi	24˚28'39.6"N, 93˚45'10.9"E	5.48	0.31	1.12	9.45	21.9	22.5	55.6	Clay
29	Moirang	24˚30'7.74"N, 93˚45'42.6"E	5.73	0.21	1.80	13.1	25.7	21.8	52.5	Clay
30	Ngangkhalawai	24˚30'2.91"N, 93˚45'47.3"E	5.71	0.19	1.35	9.23	26.3	20.6	53.1	Clay
	Mean		5.52	0.21	1.71	11.9	27.5	23.7	48.6	
	Range		5.12-6.14	0.08-0.41	1.12-2.96	9.07-16.2	14.4 - 42.2	10.5-41.6	34.8-63.1	

Available boron content extracted by different extractants

The data pertaining to the available B extracted by different extractants has been presented in Table 3. Different extractants extracted varying amount of B from the soils. The results also revealed that all the extractants showed some variation in terms of B concentration and they extracted

variable amount of B from these soils under study. The extractants in decreasing order of the mean values of extractable B were Melich-3> HCC (Hot 0.01M calcium chloride) > HW (Hot water) > SA (0.1M Salicylic acid) > AA (1.0M ammonium acetate).

Table 3: Available B content (ppm) extracted by using different Extractants

Sl. No	HCC	HW	M3	SA	AA
1	0.613	0.546	0.821	0.452	0.292
2	0.213	0.321	0.666	0.228	0.130
3	1.229	1.100	4.460	0.636	0.403
4	0.365	0.168	0.821	0.074	0.130
5	0.767	0.726	1.512	1.007	0.467
6	0.733	0.639	0.928	0.546	0.259
7	0.193	0.661	0.554	0.092	0.129
8	0.749	0.894	0.771	0.567	0.328
9	0.741	0.578	1.162	0.506	0.136
10	0.717	0.665	1.092	0.572	0.286
11	1.163	0.684	2.010	0.947	0.487
12	0.849	0.263	1.162	0.801	0.198
13	0.613	1.041	0.760	0.591	0.135
14	0.815	0.758	1.350	0.664	0.332
15	0.677	0.600	0.827	0.485	0.128
16	0.429	0.350	0.709	0.357	0.314
17	0.673	0.545	1.052	0.170	0.254
18	0.299	0.186	0.990	0.602	0.138
19	0.695	0.450	0.794	0.546	0.121
20	0.456	0.380	0.772	0.256	0.296
21	0.623	0.639	1.011	0.452	0.093
22	0.717	0.668	1.617	0.363	0.319
23	0.507	0.695	0.777	0.287	0.096
24	0.235	0.166	0.793	0.373	0.245
25	0.649	0.893	1.153	0.510	0.360
26	0.999	0.603	2.161	1.245	0.465
27	0.645	0.575	1.173	0.112	0.357
28	0.191	0.326	0.692	0.481	0.110
29	0.369	0.512	0.836	0.233	0.142
30	0.575	0.206	0.923	0.418	0.331
Mean	0.617	0.561	1.145	0.485	0.249
Range	0.191-0.617	0.166-0.561	0.554-1.145	0.074-0.485	0.092-0.249

Evaluation of suitable extractant for available Boron in soil

The suitability of different B extractants was evaluated by correlating these extractants with the plant parameters such as bray's percent yield, dry matter yield and concentration of B in plant of control pots (T_0) and total plant uptake in control pots (T_0). The different B extractants and plant parameters are found to be positively and significantly correlated with each other (Table 4) indicated that all the five extractants were suitable for estimation of available B for cauliflower plant with varying degree. However the highest correlation was found between hot 0.01 M $CaCl_2$ and the plant response. While in terms of capability of B extraction from the soil, the extractants followed the order of decreasing trends as Mehlich-3(M3) > hot 0.01M $CaCl_2$ (HCC) > hot water (HW) > 0.1M salicylic acid (SA) > 1.0M ammonium acetate (AA).Based on the correlation studies and ease of estimation in colourless extract, high extraction value, fast and economic, hot 0.01 M $CaCl_2$ was recommended to be an agreeable for evaluating available B in different soils over other extractants.

Table 4: Correlation coefficients (r) between different B extractants with Dry matter (control), Bray's percent yield and concentration in plant

	Dry matter(control) gpot^{-1}	B content in plant (control)[mg/kg]	Total B uptake by plant (µg pot^{-1})	Bray's percent yield
HCC	0.698**	0.510**	0.755**	0.782**
HW	0.587**	0.412*	0.689**	0.402*
M3	0.420*	0.303	0.520**	0.411*
SA	0.365*	0.223	0.378**	0.400*
AA	0.405*	0.402*	0.511**	0.447*

** Significant at 1% level, * Significant at 5% level

Conclusion

Status of available boron (HWS-B) content in the soil of Bishnupur district of Manipur was found low to high category. Amongst the extractants, hot 0.01M Calcium Chloride was found to be the best extractant for assessing the available boron in soils of Manipur for cauliflower.

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