Original Research Article

Critical limit of boron in soil and cauliflower

Comment [AB1]: The title of the article is very general and may be improved. It is suggested that the title will be better suited as, A study of critical limit of boron in soil and cauliflower in rice growing region of Imphal, India.

ABSTRACT

Boron, plays an important role in crop nutrition. Cauliflower expresses its sensitivity towards boron application which ultimately decides the potential of crop yield and quality of curds. Thus, an attempt was made to assess the Critical level of soil boron concentration by graphical and statistical procedures using cauliflower as a test crop. Thirty (30) soil samples collected from three rice growing sub-division of Imphal-west district were used for conducting pot experiment. The experiment was laid out in a Completely Randomized Design with six treatments replicated thrice. The treatments were: T_0= Control, T_1= 0.5 mg B kg^{-1} soil, T_2= 1 mg B kg^{-1} soil, T_3= 1.5 mg B kg^{-1} soil, T_4= 2 mg B kg^{-1} soil and T_5= 2.5 mg B kg^{-1} soil. The plants were harvested at curd formation stage and used for estimation of critical limits of boron. The critical level of boron concentration in soil and plant was found to be 0.46 and 24.50 mg kg^{-1} respectively by graphical procedure whereas by statistical procedure it was found to be 0.45 and 24.59 mg kg^{-1} in soil and plant respectively. It was evident that critical limits worked out by both the procedures i.e. graphically and statistically were closely related. These values may be used to predict the response of cauliflower to applied boron. The range between deficiency and toxicity for boron in plants is little therefore utmost care in management should be taken.

Keywords: boron, cauliflower, soil, critical limits, graphically, statistically

Comment [AB2]: The keywords are traditionally written in alphabetical order separated by semicolons. The author(s) may please take a note of it.

1. Introduction

Boron that are available to plant exists in soil mostly as a neutral boric acid molecule and decomposing organic matter serves as the main source of this boron. Boron is usually present as an un-dissociated boric acid in the soil solution which is taken up by the plants.The total concentration of boron in soil ranges from 20-200 mg kg^{-1}. Different species of plant require B differently and the general range for critical deficiency in monocots (wheat, barley etc.) is found to range from 5 to 10 mg kg^{-1} of dry matter and in dicots (legumes) it ranges from 20 to 70 mg kg^{-1} of dry matter (Romheld and Marschner, 1991; Gupta, 1993). These differences in the demand of B in monocots and dicots may be due to the present of pectic substances in their cell wall. Also, monocots plant species have much lower Ca requirements as only a small amount of pectic material is present in their cell walls.

Being a less mobile nutrient in plants, the symptoms of boron deficiency first started to appear on young leaves, stem tips, flowers and buds (Dobermann and Fairhurst, 2000). The symptoms of B deficiency in plants include leathery, dark green, downward cupping of leaves and dieback of shoot tips (Bell, 1997). Abortion in flower buds, squares in cotton, poorly shaped fruits and malformed seeds have the most shocking effect on growers which fetch a much lower price in the market. Few of the peculiar B deficiencies are ‘tip burn’ in lettuce ,‘crown and heart rot’ in sugar beets, ‘cracked stems’ in celery, formation of internal ‘cork like’ material in cauliflower and ‘hollow heart’ in groundnut kernels. All these effects are due to association of B with pectoc material in cell walls (Mengel and Kirkby, 1987). B is crucial for improving the fruits quality. Boron plays an important role in crop nutrition. Cauliflower expresses its sensitivity towards boron application which ultimately decides the potential of crop yield and quality of curds. Critical level approach, though, used in field crops on large scale, it was rarely advocated in vegetable crops. Thus, an attempt was made to assess the soil boron concentration by graphical and statistical procedures using cauliflower as a test crop.

The present investigation is, therefore, initiated to study the Critical limit of boron both in soil and cauliflower crop.

2. Materials and Methods

The pot experiment was conducted to evaluate the critical values of boron in cauliflower soils and in cauliflower plants for predicting response of cauliflower to boron application. Thirty (30) soil samples collected from three rice growing sub-division of Imphal-west district were used for the purpose. The experiment was laid out in a Completely Randomized Design with six treatments replicated thrice. The treatments were: T_0= Control, T_1= 0.5 mg B kg^{-1} soil, T_2= 1 mg B kg^{-1} soil, T_3= 1.5 mg B kg^{-1} soil, T_4= 2 mg B kg^{-1} soil and T_5= 2.5 mg B kg^{-1} soil. Seedlings of cauliflower crops (variety= sweta) raised in nursery beds were carefully picked up using sharp stick and carefully replanted in pots. Normal water management practices for cauliflower were followed. The plants were harvested at curd formation stage from the pots. Then the samples were washed sequentially with tap water, 0.1N HCl and finally rinsed with deionized water. The plant material was dried at 60˚C for 48 hours in a hot air oven and dry matter yield was recorded. The dried plant samples of each pot were dry ashed in a muffle furnace at 550˚C for 5 hours and then ash was extracted in 10mL 0.36N H_2SO_4 for 1 hour at room temperature as described by Gaines and Mitchell (1979). The concentration of boron was determined colorimetrically using azomethine- H method (Wolf, 1971) for estimation of critical limits of boron. The steps for calculation of critical limit of boron in soil and plant were followed by using graphical method as well as by statistical approach suggested by Cate and Nelson (1965). Bray’s per cent yield was plotted against soil available boron to evaluate the critical limit of boron in rice soils. Similarly, critical limit of boron in cauliflower plant was determined by plotting Bray’s percent yield against boron concentration in plant. Bray’s percent yield was calculated using following formula:

$$\text{Bray percent yield} = \frac{\text{Yield without boron}}{\text{Yield at optimum boron}} \times 100$$

3. Results and Discussion

Comment [AB3]: The Longitude and Latitude of the study areas should also be mentioned for better clarity to readers not well versed with the location by name.

The critical levels of B for deficiency, adequacy and toxicity were determined from the relationships between extractable soil B or plant B concentration and Bray's percent yield. Critical level of B was calculated using both the graphical and statistical procedures as proposed by Cate and Nelson (1965, 1971). The available B content in soil ranged from 0.19 to 0.93 mg kg^{-1} with a mean value of 0.49 mg kg^{-1} and the plant boron concentration ranged from 20.46 to 25.79 with a mean value of 23.97 while the Bray's percent yield ranged from 65.31 to 90.61 percent with a mean value of 75.54 percent as presented in Table 2.The critical limit of B in soil and in plant as determined by graphical procedure of Cate and Nelson (1971) were found to be 0.46 $mgkg^{-1}$(Fig.1) and 24.50 $mgkg^{-1}$ (Fig.3). B concentration of soil samples from most of the responsive (i.e., deficient) soils lied in 1^{st} lower left quadrant containing less than 0.46 ppm B which may be considered as critical limit in soil, below which economic response to B application can be expected.

By statistical procedure, the critical limit was found to be 0.45 mg kg^{-1}(Fig.2) and 24.59 mg kg^{-1}(Fig.4) in soil and plant respectively. The data on available soil boron corresponding to corrected sum of squares for the population, postulated critical level and predictability value (R^2) are computed as per statistical model as described by Cate and Nelson (1971).Results revealed that R^2 values ranged between -0.341 and 0.437 (Table 3) and the highest R^2 value recorded was 0.437. On the basis of highest predictability (R^2) value, two populations can be easily partitioned which correspond to the postulated critical level i.e. 0.44 mg kg^{-1} and 24.48 mg kg^{-1} in soil and plant respectively. It was evident from the Table 1 that critical limits worked out by both the procedures i.e. graphically and statistically were closely related.

Table 1. **Comparison of critical limits of B by graphical and statistical methods**

Conc.(ppm)	Critical limits (mg kg^{-1})	
	Graphical procedure	Statistical procedure
soil	0.46	0.45
plant	24.50	24.59

Table 2.Bray's percent yield (%) vs. Boron conc. in soil and cauliflower(mg/kg)

Villages	Total dry matter yield (g pot^{-1})							Bray's percent yield (%)	Boron conc. in soil (mg/kg)	Boron conc. in cauliflower(mg/kg)
	T_0	T_1	T_2	T_3	T_4	T_5	Mean			
Phaobakchou	15.06	15.19	15.83	16.82	20.47	19.27	17.11	73.57	0.64	25.63
Thongam	13.58	14.66	15.79	16.72	18.46	17.15	16.06	73.56	0.21	21.31
YumnamHuidrom	16.07	17.12	17.75	18.03	20.22	18.42	17.94	79.48	0.27	24.48

Wangoi	11.80	12.18	12.60	14.33	17.00	15.41	13.89	69.41	0.20	24.14
Samurou	21.99	22.01	24.62	28.18	32.66	31.89	26.89	67.33	0.42	24.24
NaranKonjim	12.25	12.54	13.23	14.15	15.81	14.39	13.73	77.48	0.55	21.52
Hiyangthang	39.96	40.28	40.70	42.97	44.10	43.62	41.94	90.61	0.71	25.71
LangthabalPhura makhong	46.12	46.76	48.42	51.69	55.53	52.79	50.22	83.05	0.46	25.27
Ningombam	18.32	19.28	20.25	23.27	25.47	24.41	21.83	71.93	0.73	21.44
Kondompokpi	14.22	15.17	15.28	17.47	20.73	19.91	17.13	68.60	0.36	25.79
Howrang	16.85	17.31	19.37	22.08	24.87	23.42	20.65	67.75	0.26	25.73
Heibongpokpi	35.49	37.15	38.74	39.28	42.15	39.21	38.67	84.20	0.25	24.74
Lairankabi	12.93	13.09	14.38	15.09	18.01	17.52	15.17	71.79	0.19	21.40
Phayeng	12.45	13.59	13.64	14.05	16.81	14.33	14.15	74.06	0.44	20.46
Awanglairenkabi	14.29	14.73	14.74	17.58	18.06	17.80	16.20	79.13	0.41	21.29
Lamlongei	21.21	23.36	24.43	26.84	27.66	25.25	24.79	76.68	0.54	26.45
Lairensajik	15.93	16.31	16.36	19.13	24.39	21.99	19.02	65.31	0.40	24.26
Khurkhul	31.58	32.98	34.69	35.02	37.42	36.80	34.75	84.39	0.26	25.49
Phumlou	11.52	12.84	14.15	15.50	16.36	16.01	14.40	70.42	0.89	23.89
Akham	18.30	18.78	19.09	21.87	22.92	22.23	20.53	79.84	0.78	24.70
Patsoi	25.42	27.50	29.89	31.68	33.43	34.68	30.43	76.04	0.28	25.72
Yurembam	22.43	24.07	24.88	24.90	29.57	29.52	25.90	75.85	0.42	26.01
Sagoltongba	26.03	28.07	30.58	33.09	36.93	34.89	31.60	70.48	0.33	21.88
Konthoujam	14.21	16.01	16.80	18.85	20.57	19.66	17.68	69.08	0.34	22.34
Moidangpok	32.37	33.28	34.04	34.59	36.97	35.50	34.46	87.56	0.77	25.70
New Keithelmanbi	14.50	15.79	16.96	18.21	21.62	20.39	17.91	67.07	0.93	23.58
Khumbong	12.50	12.86	14.58	15.37	17.76	16.26	14.89	70.38	0.64	22.56
Heigrujam	35.63	36.92	39.25	40.05	41.07	40.23	38.86	86.75	0.60	23.67
Kamong	42.61	45.22	49.96	53.11	54.86	54.07	49.97	77.67	0.82	24.79
Langing	15.52	16.19	19.29	19.47	20.22	19.83	18.42	76.76	0.49	24.79
Mean	**21.37**	**22.37**	**23.68**	**25.31**	**27.74**	**26.56**	**24.51**	**75.54**	**0.49**	**23.97**
Range	11.52 - 46.12	12.18 - 46.76	12.60 - 49.96	14.05 - 53.11	15.81 - 55.53	14.33 - 54.07	13.73 - 50.22	65.31 - 90.61	0.19 - 0.93	20.46-25.79

Critical limit of boron in soil:

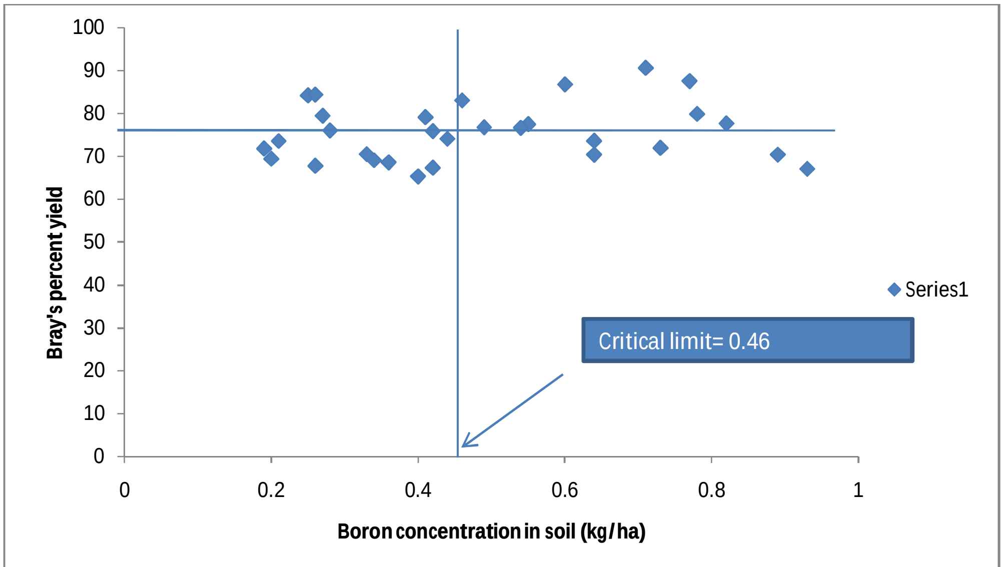

Fig. 1. Scatter diagram of boron concentration in soil (kg/ha) vs. bray's percent yield by graphical method

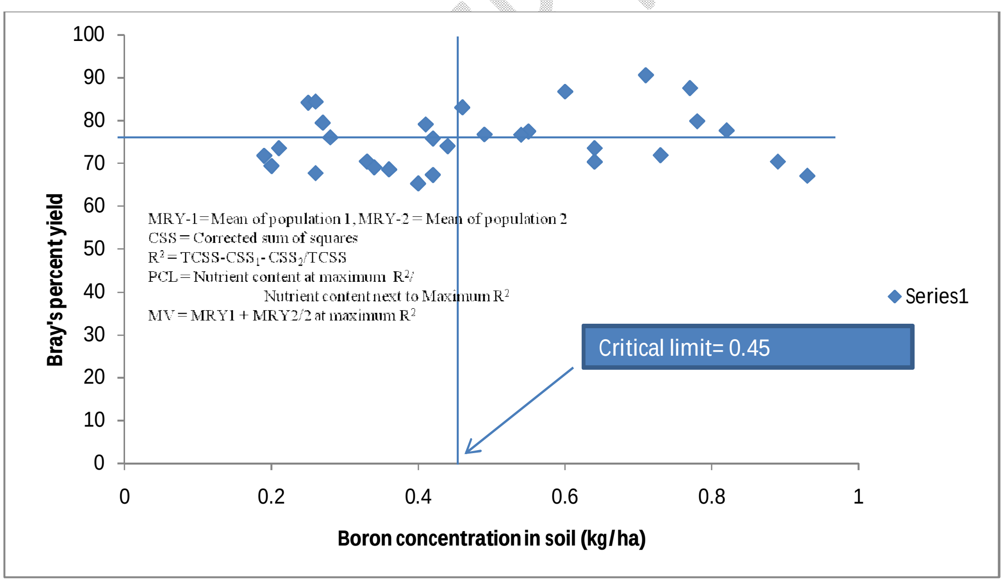

Fig. 2. Scatter diagram of boron concentration in soil (kg/ha) vs. bray's percent yield by statistical method

Critical limit of boron in cauliflower:

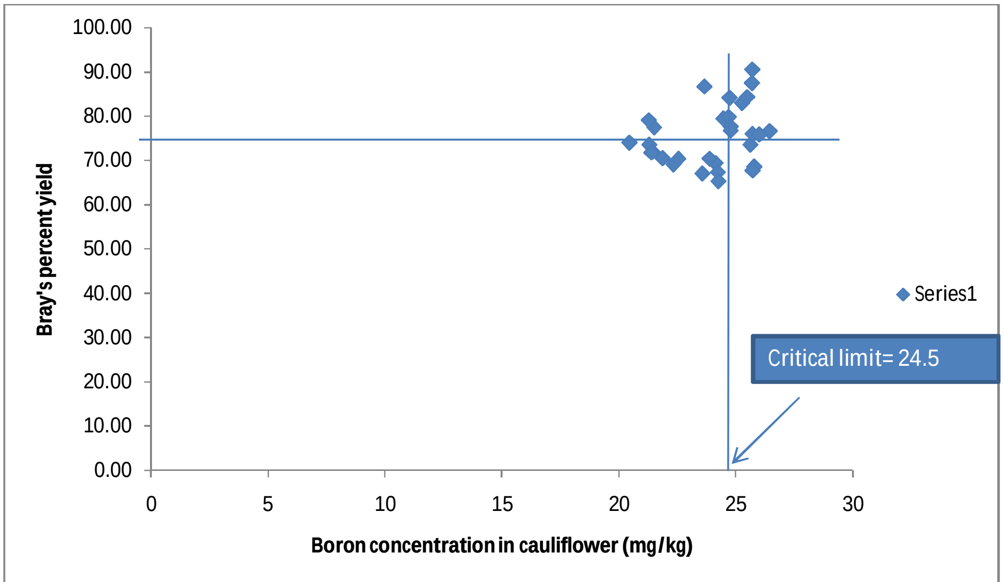

Fig. 3. Scatter diagram of boron concentration in cauliflower (mg/kg) vs. bray's percent yield by graphical method

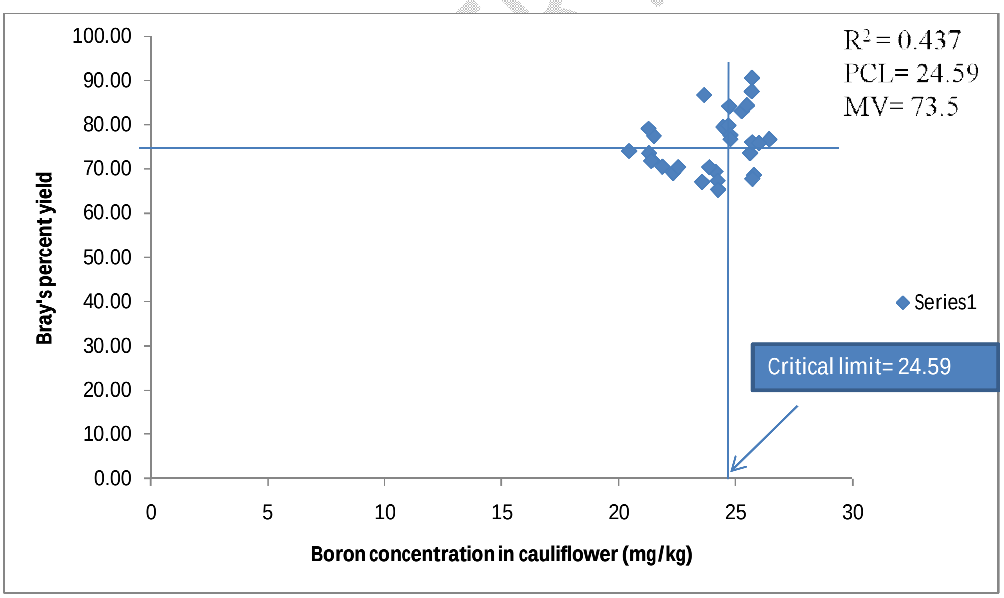

Fig. 4. Scatter diagram of boron concentration in cauliflower (mg/kg) vs. bray's percent yield by statistical method

Table 3. Soil available boron, Plant boron concentration, Bray's per cent yield and predictability values (R^2)

Villages	**Soil B (ppm)**	**Plant B (ppm)**	Bray's % yield	Mean Bray's % yield in population -1	Corrected sum of squares of deviation from mean of population CSS_1	Mean Bray's % yield in population -2	Corrected sum of squares of deviation from mean of population CSS_2	$R^2 = TCSS-CSS_1-CSS_2/TCSS$
Phaobakchou	0.19	20.46	65.31			71.68	1760.59	**-0.34**
Thongam	0.2	21.29	67.07	66.19	1.55	72.01	1641.34	**-0.25**
YumnamHuidrom	0.21	21.31	67.33	66.57	2.42	72.29	1554.50	**-0.19**
Wangoi	0.25	21.4	67.75	66.87	3.46	72.58	1465.29	**-0.12**
Samurou	0.26	21.44	68.6	67.21	5.87	72.88	1376.91	**-0.05**
NaranKonjim	0.26	21.52	69.08	67.52	8.78	73.17	1298.89	**0.00**
Hiyangthang	0.27	21.88	69.41	67.79	11.83	73.46	1222.89	**0.06**
LangthabalPhuramakhong	0.28	22.34	70.38	68.12	17.68	73.77	1145.12	**0.11**
Ningombam	0.33	22.56	70.42	68.37	22.40	74.05	1079.81	**0.16**
Kondompokpi	0.34	23.58	70.48	68.58	26.40	74.38	1005.66	**0.21**
Howrang	0.36	23.67	71.79	68.87	35.75	74.77	921.09	**0.27**
Heibongpokpi	0.4	23.89	71.93	69.13	44.31	75.10	856.01	**0.31**
Lairankabi	0.41	24.14	73.56	69.47	62.43	75.50	781.48	**0.36**
Phayeng	0.42	24.24	73.57	69.76	78.04	75.78	734.89	**0.38**
Awanglairenkabi	0.42	24.26	74.06	70.05	95.27	76.15	675.45	**0.41**
Lamlongei	0.44	24.48	75.85	70.41	126.82	76.56	612.57	**0.44**
Lairensajik	0.46	24.7	76.04	70.74	156.63	76.74	588.38	**0.43**
Khurkhul	0.49	24.74	76.68	71.07	189.92	76.97	557.80	**0.43**
Phumlou	0.54	24.79	76.76	71.37	220.56	77.12	539.42	**0.42**
Akham	0.55	24.79	77.48	71.68	256.00	77.48	496.20	**0.43**
Patsoi	0.6	25.27	77.67	71.96	290.20	77.58	485.29	**0.41**
Yurembam	0.64	25.49	79.13	72.29	339.24	78.09	428.78	**0.41**
Sagoltongba	0.64	25.63	79.48	72.60	388.70	78.44	393.21	**0.40**
Konthoujam	0.71	25.7	79.84	72.90	438.92	78.72	366.18	**0.39**
Moidangpok	0.73	25.71	83.05	73.31	537.76	79.44	304.20	**0.36**
New Keithelmanbi	0.77	25.72	84.2	73.73	651.82	80.12	244.14	**0.32**
Khumbong	0.78	25.73	84.39	74.12	761.29	80.66	197.88	**0.27**
Heigrujam	0.82	25.79	86.75	74.57	915.05	81.33	154.21	**0.19**
Kamong	0.89	26.01	87.56	75.02	1077.88	81.96	106.33	**0.10**
Langing	0.93	26.45	90.61	75.54	1312.79			
							SS	172506.1
							CF	171193.3
							TSS	1312.79

4. Conclusion

The critical level of boron concentration in soil and plant (cauliflower at curd initiation stage) was found to be 0.46 and 24.50 mg kg^{-1} respectively by graphical procedure whereas by statistical procedure it was found to be 0.45 and 24.59 mg kg^{-1} in soil and plant respectively. It was evident that critical limits worked out by both the procedures i.e. graphically and statistically were closely related. These values may be used to predict the response of cauliflower to applied boron. The range between deficiency and toxicity for boron in plants is little therefore utmost care in management should be taken.

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