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Critical Limits of Zinc in Soil and Rice Plant in Valley Soils of Manipur

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ABSTRACT: A pot study was conducted to estimate the critical limit of zinc (Zn) in soil and rice plant in rice growing soils of Manipur. Thirtysix soil samples were collected from different paddy fields of four valley districts namely Imphal-east, Imphal-west, Thoubal and Bishnupur district of Manipur using Stratified Random Sampling. All the soil samples were acidic in reaction ranging frompH 4.9 to 6 with mean value of 5.32, organic carbon content 0.79 to 3.51 %, cation exchange capacity of the soils 8.3 to 24[cmol (p^{+}) kg^{-1}] and the clay content of soil varied from 20 to 73.2 % (mean 50.46%). The DTPA-extractable Zn showed a positive correlation with dry matter yield (r=0.939**), Bray's per cent yield (0.901**), Zn content (0. 977**) and Zn uptake (0.984**). The critical limit of Zn in these soils was established at 0.78 mg kg^{-1} for rice and critical limit of 75 days old rice plants is 24.5 mg kg^{-1}, below which response to Zn fertilization may be expected. Soil containing Zn below this critical limit may be responded economically to Zn fertilization for rice growing.

Key words: Zinc, bray's per cent yield, critical limits, soil, rice.

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I. INTRODUCTION

In India, zinc deficiency has been reported in all agro-ecological regions, irrespective of the nature of soil and cropping system. Its deficiency, in particular, has been noticed almost in all the rice growing regions and it is the major constraints in world for food production. Identification of Zn deficient areas and causes would help in planning the appropriate stratragies to correct these Zn deficiencies. The availability of Zn in the soil varies widely depending on the soil properties. It plays an important role in several plant metabolic processes; it activates enzymes and is involved in protein synthesis and carbohydrate, nucleic acid and lipid metabolism (Marshner, 1986). However, an excess of Zn has been reported to have negative effect on mineral nutrition (Chaoui, *et al*., 1997). Different sources of zinc such as $ZnSO_4$, ZnS, Zn chelates, ZnO, etc. are used for correction of zinc deficiency in rice crops. The amount of zinc required for alleviating zinc deficiency varies with severity of deficiency, soil types, nature of crops and cultivars (Sahoo *et al*., 2010). However, in order to apply zinc fertilizers for better efficiency of yield, it is also important to know the critical limit of Zn in the soil. Critical limit of a nutrient in soils refers to a level below which the crops will readily respond to its application. Although, Zn is widely used as a fertilizer but efficient and economical method to correct its deficiency on a long term basis and in a specific cropping system is desirable. The information on Zn fertilizer use emanating from soil testing laboratories should be based on the critical limits of extractable Zn for different crops and soils. This also save numerous amount of fertilizers being wasted by the farmers while growing the crops. In view of the above, an attempt was made to study the critical limit of zinc in soil and rice plant which is a major crop grown widely in the state of Manipur for optimum yield.

II. MATERIAL AND METHODS

A total of 36 soil samples (0-20 cm depth) were collected from different paddy fields of four valley districts of Manipur namely, Imphal-east, Imphal-west, Thoubal and Bishnupur district covering all the blocks under using Stratified Random Sampling. The soil samples were air dried, ground and passed through the 2mm sieve for laboratory analysis. These samples were analyzed for soil reaction (pH) electrical conductivity (EC) using standard procedures as described by Jackson (1973), organic carbon was determined by wet oxidation method of Walkley and Black (1934), Soil texture by Hydrometer method (Buoyoucous (1962), cation exchange capacity (CEC) by (Borah *et al*., 1987). Available zinc content of soils was measured in atomic absorption spectrophotometer (AAS) after extracting the soils with 0.005M DTPA (Diethylenetriaminepenta acetic acid) in 1:2 ratio (soil: extractant) following the standard procedure (Lindsay and Norvell, 1978).

The pot experiment was conducted to evaluate the critical values of zinc in soils and in rice plants. Four kg of air dried soils were treated with the recommended doses of nitrogen, phosphorus and potassium @ 60, 40 and 30 kg/ha, respectively as reagent grade i.e. urea, single super phosphate and muriate of potash. Five 25 day old rice seedlings var. Tamphafou (CAU-R1) were transplanted in each pot. Zinc was applied @ 0, 5, 10 and 15 mg kg^{-1} soil as reagent grade of Zinc sulphate ($ZnSO_4.7H_2O$) after 7 days of transplanting of rice seedling. Each treatment was replicated thrice in completely randomized design. Watering with deionized water and intercultural operations were adopted uniformly in each pot as and when required. Rice plants of above ground portion were harvested at 75 days of transplanting and washed in acidified solution, rinsed with deionized water, dried at 65^0 C in a hot air oven for 24 hours and dry-matter yield was recorded and ground in the stainless steel blender. The dry powdered plant samples were digested in tri-acid mixture (HNO_3:$HClO_4$:H_2SO_4::10:3:1) and filtered through Whatman No.42 for estimation of Zn with the help of Atomic Absorption Spectrophotometer (AAS). The critical value of DTPA-extracted zinc in soil and in plant were determined by plotting the Bray's percent yield against soil DTPA extracted zinc content and separately against plant tissue zinc content, respectively, following the method of Cate and Nelson (1965).

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

III. RESULT AND DISCUSSION

The soil pH values ranged from 4.9 to 6. All the soil samples were acidic in nature with the mean value of 5.32. The electrical conductivity of the soils varies from 0.05 dSm^{-1} to 0.26 dSm^{-1} at 25^0C with a mean value of 0.11 dSm^{-1}. The organic carbon content in the soils sample was high with a mean value of 2.68% and ranged from 0.79 to 3.51 %. The cation exchange capacity of the soils was ranged from 8.3 to 24 [cmol (p^+) kg^{-1}] and the mean value was 15.94 [cmol (p^+) kg^{-1}]. The clay content of soil varied from 20.0 % to 73.2 % (mean 50.46%). The silt and sand contents of the soils ranged from 5.0 to 54.1 % (mean 25.16%) and 6.8 to 53.4 % (mean 62.99%), respectively. The texture of the soils was mostly clay, though some soils were clay loam, sandy clay, sandy loam, silty clay loam and silty clay.

Effect of zinc application on dry matter yield, Zn content and uptake

The dry matter yield of rice was greatly influenced by different levels of zinc. The dry matter yield in the control varied from 10.8 to 18.5 g/pot as compared with 13.9 to 19.2 g/pot in 5 mg Zn kg^{-1}, 15.5 to 19.4 g/pot in 10 mg Zn $kg^{-1}$and `16.2 to 18.9 g/pot in 15 mg Zn kg^{-1}, respectively.The zinc concentration in control pot ranged from 19.0 to 43.0 mg kg^{-1} as compared with 21.0 to 44.0 mg kg^{-1} in 5 mg Zn kg^{-1}, 23.0 to 44.0 mg kg^{-1} in 10 mg Zn kg^{-1} and 25.0 to 43.0 mg kg^{-1} in 15 mg Zn kg^{-1}. The average zinc contents in the plants were 31.25 mg kg^{-1}, 33.36 mg kg^{-1}, 34.05 mg kg^{-1} and 33.13 mg kg^{-1} for 0, 5, 10 and 15 mg Zn kg^{-1}, respectively. It was recorded that the zinc content in the plants was gradually increased with increase application of zinc, highest at 10 mg Zn kg^{-1} which was significantly higher than the control. Zinc uptake by rice was highest with zinc applied at the rate of 10 mg Zn kg^{-1} (mean 609.35 µg/pot) which was significantly superior over control (mean 489 µg/pot).

Relationship of DTPA-Zn with Bray's percent yield, Zn contentand Zn uptake in rice plant

Correlation studies indicate that DTPA-Zn have positive and significant relationship with dry matter yield (r = 0.939**), Bray's per cent yield (r = 0.901**), Zn content (r = 0. 977**) and Zn uptake

(r = 0.984**).

Critical limits of zinc in soil and rice plant

Using graphical procedure of Cate and Nelson (1965), the plot of Bray's per cent yield against soil DTPA-Zn and plant revealed that the critical limit of zinc was found to be 0.78 mg kg^{-1} in soil (Fig. 2) and 24.5 mg kg^{-1} in rice plant (Fig. 1) below which economic response to zinc application can be expected. this finding is closely conformity with the findings reported by by Mahata *et al*. (2012) and Sakal *et al*. (1982).

CONCLUSION

The results indicate that the critical limit values of DTPA-extracted Zn in soil and rice plant were 0.78 and 24.5 mg kg^{-1}, respectively. The soils will likely respond to Zn application effectively when it contains less than 0.78 mg kg^{-1}DTPA- extracted Zn and 75 days old rice plant contains less than 24.5 mg kg^{-1}.

Table 1: Physico-chemical properties of the soils

Districts & Blocks	Sl. No.	Villages	pH	EC (dS m^{-1})	OC %	CEC [cmol(P+) kg^{-1}]	Sand (%)	Silt (%)	Clay (%)	Textural class	DTPA-Zn (mg kg^{-1})
IMPHAL-WEST											
Lamshang	1	Kangchup	5.0	0.26	2.11	9.4	35.9	10.0	54.1	Clay	1.10
	2	AwangLeirankabi	5.1	0.14	2.73	11.8	38.4	13.2	48.4	Clay	1.14
	3	Lamsang	5.5	0.12	2.78	24.0	45.9	10.0	44.1	Sandy Clay	1.13
	4	Phayeng	5.1	0.19	1.85	10.3	35.9	8.2	55.9	Clay	1.03
	5	Tharoijam	5.2	0.08	3.07	10.6	44.1	14.3	41.6	Clay	0.74
Patsoi	6	Ghari	5.3	0.10	3.00	10.7	30.7	25.2	44.1	Clay	0.75
	7	Langjing	5.4	0.09	2.88	12.6	35.9	11.6	52.5	Clay	1.01
Lamphelpat	8	TakyelMapal	5.2	0.12	2.90	22.2	35.9	5.0	59.1	Clay	0.85
	9	Hiyangthang	5.2	0.22	3.02	24.0	36.6	15.0	48.4	Clay	0.99
	10	Lairengjam	5.0	0.11	3.19	22.0	32.5	10.9	56.6	Clay	0.82
THOUBAL											
Thoubal	11	CharangpatMamang	5.3	0.08	2.85	23.1	53.4	11.4	35.2	Sandy Clay	0.99
	12	Uyal	5.3	0.05	3.12	21.4	45	35.0	20.0	Sandy Loam	0.55
	13	Thokchom	5.0	0.13	3.33	19.9	12.5	34.8	52.7	Clay	0.91
Lilong	14	Haoreibi	5.5	0.16	3.45	17.0	11.6	30.0	58.4	Clay	0.87
Kakching	15	KakchingKhullel	5.4	0.08	3.38	23.1	20	21.6	58.4	Clay	0.97
	16	Keirak	5.1	0.11	3.31	21.0	1401	21.8	64.1	Clay	0.86
	17	Wabgai	5.4	0.08	3.51	18.0	14.1	20.0	65.9	Clay	0.84
IMPHAL-EAST											
Jiribam	18	Hilgat	5.2	0.11	0.79	10.3	27.3	43.6	29.1	Clay Loam	0.59
	19	Sonapur	5.3	0.11	2.29	8.50	21.8	17.5	60.7	Clay	1.17
	20	Dibong	5.2	0.08	0.80	12.2	22.7	35.7	41.6	Clay	0.77
	21	Lalpani	4.9	0.15	1.58	10.5	28.0	42.0	30.0	Clay Loam	**1.16**
Sawongbung	22	Tellou	6	0.06	2.47	14.3	14.3	20.0	65.7	Clay	0.58
	23	Tangkham	5.2	0.17	2.02	13.0	11.8	24.1	64.1	Clay	1.01
	24	Waiton	5.9	0.11	2.8	16.0	16.8	14.1	69.1	Clay	0.67
	25	Nungoi	5.8	0.16	2.81	22.1	16.8	10.0	73.2	Clay	0.61
	26	Pangei	5.4	0.12	2.64	16.4	11.8	22.5	65.7	Clay	0.84
Porompat	27	Top Dasura	5.8	0.06	2.75	10.2	6.8	54.1	39.1	Clay	0.76
	28	Waklha	5.4	0.07	3.14	11	19.3	41.6	39.1	Silty Clay Loam	0.87
	29	Gangapat	5.7	0.08	2.47	11.2	11.0	42.0	47.0	Silty Clay	0.89
	30	Khongman	5.6	0.09	2.37	15.42	9.0	44.0	47.0	Silty Clay	0.86
Keirao-bitra	31	Kalika	5.3	0.05	3.20	8.3	21.8	31.6	46.6	Clay	0.96
	32	Andro	5.2	0.18	2.03	11.6	24.3	34.1	41.6	Clay	1.26
BISNUPUR											
Nambol	33	Keinou	5.5	0.13	2.47	19.3	17.5	40.0	42.5	Silty Clay Loam	0.63
Bisnupur	34	Potsangbam	5.1	0.09	3.06	15.6	14.1	30.9	55.0	Clay	0.89
Moirang	35	NgangkhaLawai	4.9	0.08	3.26	23.5	20	25.0	55.0	Clay	0.93
	36	Kumbi	5.0	0.08	3.04	23.2	23.2	35.0	45.0	Clay	1.01
MEAN			5.32	0.11	2.68	15.94	62.99	25.16	50.46		0.89
MIN.			4.9-6.0	0.05-0.26	0.79-3.51	8.3-24.0	6.8-53.4	5.0 - 54.1	20.0-73.2		0.55-1.26

Table 2. Effect of zinc application on dry matter yield, zinc concentration and zinc uptake by rice plants

Soil samples	Dry matter yield(g/pot) Zn levels ((mg/kg)				Bray's % yield	Zinc content in no Zn pots (mg/kg)	Zn uptake by rice plants in no Zn pots (µg/pot)
	0	5	10	15			
1	16.8	18.5	17.2	17.1	90.81	37	621.6
2	17.2	18.9	17.5	17.3	91.00	40	688.0
3	17.0	18.7	17.4	17.2	90.90	38	646.0
4	16.7	18.0	18.2	17.6	89.78	37	617.9
5	13.1	15.0	15.5	17.0	77.05	29	379.9
6	13.3	15.6	15.9	16.2	82.09	28	372.4
7	17.3	18.8	19.0	17.6	91.05	34	588.2
8	14.5	17.3	18.4	17.7	78.80	29	420.5
9	16.0	18.9	19.0	18.1	83.33	36	576.0
10	15.4	17.5	17.9	17.2	86.03	26	400.4
11	16.5	19.0	19.4	17.3	85.05	35	577.5
12	10.8	13.9	16.0	16.9	63.90	19	205.2
13	16.3	19.2	18.7	18.4	84.89	32	521.6
14	15.9	17.6	17.9	17.2	88.82	29	461.1
15	17.0	18.5	19.0	18.1	89.47	35	595.0
16	15.0	17.4	17.4	16.7	86.20	29	435.0
17	15.0	17.9	18.1	17.4	82.87	28	420.0
18	11.7	15.2	16.8	17.6	66.47	20	234.0
19	17.1	18.0	17.3	17.2	95.00	41	701.1
20	14.3	16.5	18.1	17.8	76.88	28	400.4
21	17.2	18.3	17.5	17.3	93.98	36	615.6
22	11.6	14.7	16.7	17.6	95.16	21	243.6
23	17.1	18.2	18.1	17.6	93.95	36	615.6
24	12.9	17.7	18.1	17.4	71.27	24	309.6
25	11.7	14.7	16.7	17.5	66.85	21	245.7
26	15.1	18.0	18.2	17.5	82.96	30	453.0
27	13.3	16.1	16.8	17.3	76.87	27	359.1
28	16.1	17.4	17.5	16.8	92.52	30	483.0
29	16.2	17.7	18.0	17.3	90.00	32	518.4
30	16.0	17.4	17.4	16.7	91.95	34	544.0
31	16.9	19.2	19.3	18.0	87.56	35	591.5
32	18.5	19.1	18.7	18.6	96.85	43	795.5
33	12.0	15.1	16.3	17.7	67.79	23	276.0
34	16.3	18.8	19.0	18.9	83.16	31	505.3
35	16.4	19.2	19.1	17.7	85.41	33	541.2
36	17.2	18.5	18.9	17.8	91.00	36	619.2
Mean	15.3	17.5	17.8	17.5	83.82	31	489.8
Range	10.8 - 18.5	13.9 – 19.2	15.5 – 19.4	16.2 – 18.9	63.90 – 96.85	19 – 43	205.2 – 795.5

Table 3.Correlation coefficient between DTPA- Zn and plant parameters (dry matter yield, Bray's percent yield, Zn content and Zn uptake by rice plant)

Extractant	Dry matter yield	Bray's per cent Yield	Zn content in rice (control pot)	Zn uptake by rice plant (control)
DTPA-Zn	0.939**	0.901**	0.977**	0.984

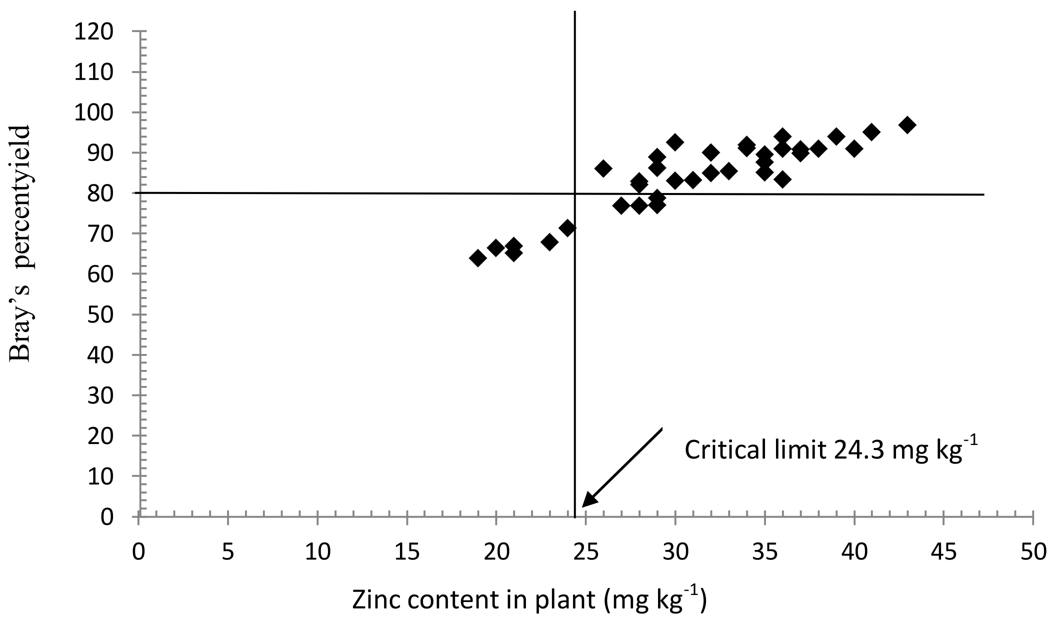

Fig. 1.Critical limit of zinc in rice plant

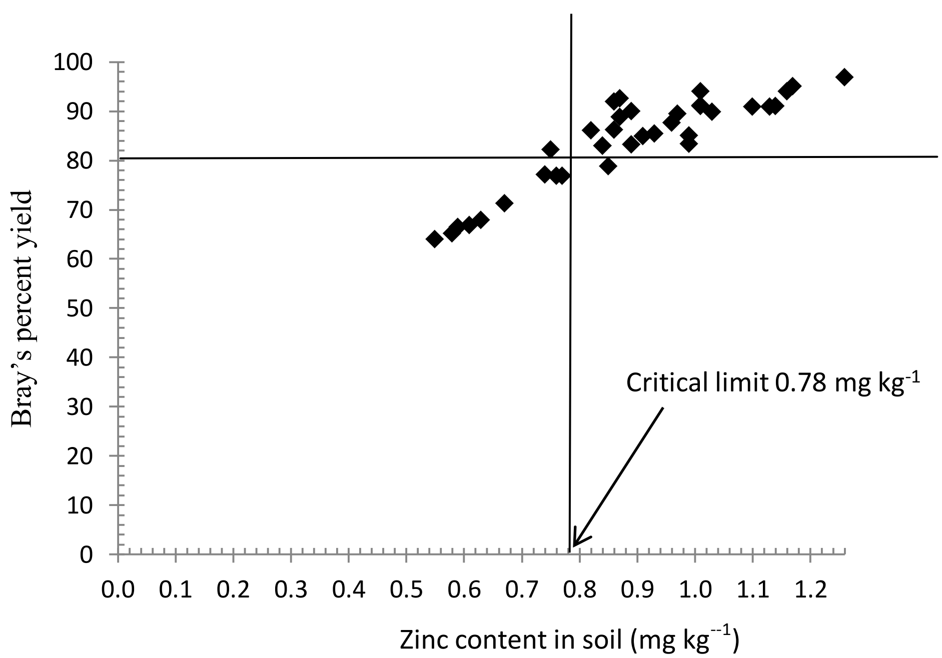

Fig. 2.Critical limit of zinc in soil

REFERENCES

[1] Borah, D.K., Bordolo, P.K., Karmakar, P.M., Barauah, N.G. and Das, M. (1987).Practical manual for fundamental soil scence (Part-II), Jorhat I.

[2] Bouyoucos, G.J. (1962). Hydrometer method improved for making analysis of soils. *Agron. J.***54**: 464-465.

[3] Cate, R.B. and Nelson, L.A. (1965).Graphical procedure for critical limits of nutrients.*Proceedings of the Soil Science Society of America.***89**: 658.

[4] Chaoui, A., Mazhoudi, S., Ghorbal, M.H. and Elferjani, E. (1997). Cadmium and zinc induction of lipid peroxidation and effects on antioxidant enzyme activities in bean(*Phaseolus vulgaris* L.). *Plant Science.***127:** 139 – 147.

[5] Jackson, M.L. (1973). Soil Chemical Analysis, Prentice Hall of India Private Limited, New Delhi.

[6] Lindsay, W.L. and Norvell, W.A. (1978).Development of DTPA soil test for Zn, Fe, Mn and Cu. *American Journal of Soil Science*. **42**: 421-428.

[7] Mahata, M. K., Debnath and Ghosh, S. K. (2012). Critical limits of zinc in soil and rice plant

grown in alluvial soils of west Bengal, India. *SAARC Journal of Agri*culture. **10(2):** 137-146 (2012)

[8] Marschner, H. (1986). Mineral nutrition of higher plants. Academic Press, New York.

[9] Sahoo, A.K., Sarkar. D., Baruah, U. and Butte, P.S. (2010).Characterization, Classification and Evaluation of Soils of Langol Hill, Manipur for Rational Land Use Planning.*Journal of the Indian Society Soil Sci*ence, **58(4):** 355-362.

[10] Sakal, R., Singh, B.P. and Singh, A.P. (1982). Determination of critical limit of zinc in soil and plant for predicting of rice to zinc application in calcareous soils. *Pant and Soil*. **66:** 129 – 132.

[11] Walkley, A.J. and Black, I.A. (1934).Estimation of soil organic carbon by chromic acid titration method.*Soil Sci*. **37**: 29-38.