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Critical Limits of Zinc in Soil and Rice Plant in Hill District Soils of Manipur

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ABSTRACT

Pot experiment for estimation of critical limit of zinc (Zn) in soil and rice plant in rice growing hill soils of Kangpokpi district of Manipur was conducted. Twenty four soil samples were collected from different paddy fields of Gamdeiphai, Sadukoireng, Utonglok, Saijang villages of Saikul block of Kangpokpi district of Manipur with Stratified Random Sampling. All the soil samples were acidic in reaction ranging from pH 4.5 to 6.06 with mean value of 5.20, electrical conductivity is ranging from 0.06 to 0.20 dSm^{-1} with mean value of 0.10 dSm^{-1}, organic carbon content 0.30 to 1.59 % with mean value of 0.91%, cation exchange capacity of the soils 9.2 to 23.6 [cmol (p+) kg^{-1}] with mean value of 15.60[cmol (p+) kg^{-1}] and the clay content of soil varied from 33.50 to 54.40 % (mean 45.39%). The critical limit of Zn in these soils was established at 0.74 mg kg^{-1} and critical limit of rice plants at maximum panicle initiation stage was 20 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.*

Introduction

Rice is a staple food for about 50 per cent of the world's population that lives in Asia, where 90 per cent of the world's rice is grown and consumed. It is an important staple food that provides 66 -70 per cent body calorie intake of the consumers (Barah and Pandey, 2005). In India, to meet the demand of growing population, it is needed to produce 143 million tonnes of rice by 2030 (Subbaiah *et al*. 2001). The production could be increased by intensification of paddy cultivation rather than increasing the area. Due to intensified crop cultivation, the soils have been depleted of several plant nutrients including micronutrients. Micronutrient deficiencies are becoming serious problem because of intensive agriculture along with use of high analysis fertilizer and low amount of organic inputs.

Zinc is the most limiting nutrient among the micronutrients and whose deficiency is a wide spread nutritional disorder of wetland rice. Widespread occurrence of zinc deficiency has been reported from many parts of world where high yielding, fertilizer responsive varieties of rice (*Oryza sativa* L.) are being grown intensively under wetland conditions (Ponnamperuma 1977; Randhawa *et al*. 1978). The introduction of high yielding varieties of crops and the concomitant usage of high doses of chemical fertilizers over a period of time not only boosted crop yields but also caused depletion of the native available zinc status of soils. Many farmers have failed to exploit the full yield potential of the high yielding varieties of paddy in spite of judicious application of NPK fertilizers.

In order to supply zinc fertilizers for better efficiency of yield, very important to know the critical limit of Zn in the soil. Critical limit of a nutrient in soils represents a level below which the crops will readily respond to its application. The information on Zn fertilizer use emanating from soil testing laboratories should be based on the critical limits of available Zn for different crops and soils to save numerous amount of fertilizers being wasted. In view of the above, an experiment was conducted to study the critical limit of zinc in rice plant and soil, rice is a major crop grown in the state of Manipur for optimum yield.

Materials and Methods

Twenty four soil samples (0-20 cm depth) were collected from different paddy fields of Gamdeiphai, Sadukorireng, Utonglok, Saijang villages of Saikul block of Kangpokpi district of Manipur using Stratified Random Sampling with proportionate allocation. The soil samples were air dried, grinded and passed through the 2mm sieve for 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 of Buoyoucous (1962), cation exchange capacity (CEC) by Borah *et al*. (1987). Available zinc content of soils was measured by using Atomic Absorption Spectrophotometer (AAS) by Lindsay and Norvell (1978).

The pot experiment was conducted to study 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. Twenty five day old rice seedlings var. Tamphaphou (CAUR-1) were transplanted in each pot. Zinc (Zinc sulphate, $ZnSO_4.7H_2O$) was applied

Table 1. Physico-chemical properties of the initial soils before study

District & Block	Villages	Sl. No.	pH	EC (dS m^{-1})	OC %	CEC [cmol(P^+) kg^{-1}]	DTPA-Zn (mg kg^{-1})	Sand (%)	Silt (%)	Clay (%)	Textural class
Kangpokpi district, Saikul block	Gamdeiphai	1	4.45	0.11	1.20	23.60	0.94	15.40	37.70	46.90	Clay
		2	4.47	0.08	1.05	19.40	0.85	4.50	42.70	52.80	Silt Clay
		3	4.58	0.12	1.20	11.00	0.94	24.50	25.20	50.30	Clay
		4	5.32	0.09	1.59	17.00	1.24	17.00	35.20	47.80	Clay
		5	4.55	0.14	0.57	13.00	1.20	10.40	35.20	54.40	Clay
		6	4.45	0.13	0.99	20.80	1.24	15.40	32.70	51.90	Clay
	Sadukoireng	7	5.16	0.10	1.26	14.00	1.36	16.30	37.70	46.00	Clay
		8	5.69	0.07	1.20	12.00	0.86	26.30	35.20	38.50	Clay Loam
		9	4.94	0.11	0.30	16.60	0.90	19.50	37.70	42.80	Clay
		10	4.96	0.06	0.93	20.80	1.17	17.00	40.20	42.80	Clay
		11	4.75	0.07	1.17	18.40	0.95	13.80	37.70	48.50	Clay
		12	5.20	0.10	1.05	16.00	0.80	7.00	40.20	52.80	Clay
	Utonglok	13	6.06	0.12	0.30	11.00	0.80	46.30	14.30	39.40	Sandy Clay
		14	5.66	0.09	0.60	13.00	0.74	37.00	22.00	41.00	Clay
		15	5.53	0.08	0.45	20.00	0.80	41.30	24.30	34.40	Clay Loam
		16	5.24	0.13	0.30	16.40	0.85	32.00	34.50	33.50	Clay Loam
		17	5.67	0.11	1.35	20.40	0.90	40.40	21.80	37.80	Clay Loam
		18	5.30	0.06	0.90	18.40	0.85	31.40	26.80	42.80	Clay
	Saijang	19	5.56	0.08	0.63	13.00	0.74	17.90	35.20	46.90	Clay
		20	5.79	0.11	0.87	10.80	0.30	8.60	41.10	50.30	Silt Clay
		21	5.49	0.12	0.57	15.00	0.48	13.80	40.20	46.00	Clay
		22	5.23	0.20	1.41	9.20	0.59	3.60	43.60	52.80	Silt Clay
		23	5.18	0.11	1.14	11.00	1.00	7.90	47.70	44.40	Silt Clay
		24	5.50	0.09	0.90	13.60	0.52	12.90	37.70	49.40	Clay
	Mean		5.20	0.10	0.91	15.60	0.88	0.88	34.44	45.59	
	Range		4.45 6.06	0.06- 0.20	0.30 1.59	9.20- 23.60	0.30- 1.36	0.30- 1.36	14.30 47.70	33.50 54.40	

@ 0, 2.5, 5 and 7.5 mg kg^{-1} soil and all the treatments were replicated thrice in completely randomized design. Watering and intercultural operations were adopted uniformly in all the pots when required. Rice plants were harvested at maximum panicle initiation stage and washed in acidified solution, rinsed with deionized water, dried at 65^0 C in a hot air oven for 24 hours and then the dry-matter yield was recorded. 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 measured by plotting the Bray's percent yield against soil available zinc content and separately against plant tissue zinc content, respectively, by Cate and Nelson (1965).

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

Results and Discussion

All the soil samples were acidic in nature, the soil pH values ranged from 4.45 to 6.06 with the mean value of 5.20. Electrical conductivity of soils ranging from 0.06 to 0.20 dSm^{-1} with mean value of 0.10 dSm^{-1}, organic carbon content is varies from 0.30 to 1.59 % with mean value of 0.91%, cation exchange capacity of the soils is 9.2 to 23.6[cmol (p+) kg^{-1}] with mean value of 15.60[cmol (p+) kg^{-1}] and the clay content of soil varied from 33.50 to 54.40 % with mean value of 45.39%. The silt and sand contents of the soils ranged from 14.30 to 47.70 % (mean 34.44%) and 3.60 to 46.30 % (mean 19.97%), respectively. The texture of the soils was mostly clay, though some soils were clay loam, sandy clay, silt clay and silt clay. The data was presented in Table 1.

Bray's yield

The bray's yield was obtained by the ratio of control yield and optimum yield of treatment and which is expressed in percentage. The bray's yield of rice crop at maximum panicle initiation stage is ranged from 72.58 to 86.89 per cent and the mean value is 82.17 per cent. The data was presented in the Table 2.

Table 2. Effect of zinc application on dry matter yield of paddy at maximum P I stage (Bray's yield)

Soil samples	Dry matter yield(g/pot) Zn levels mg/Kg				Bray's yield%	Zinc in soil mg/kg	Zinc in plant mg/kg
	0	2.5	5.0	7.5			
1	33.46	38.11	38.64	40.12	83.40	0.94	23.20
2	35.46	43.12	42.08	39.81	82.24	0.85	21.37
3	33.13	35.41	37.41	39.66	83.54	0.94	23.42
4	35.46	37.46	39.48	41.56	85.32	1.24	27.12
5	38.31	40.80	45.26	42.80	84.64	1.20	26.77
6	35.62	37.56	39.23	41.43	85.98	1.24	27.13
7	35.73	41.12	39.85	37.84	86.89	1.36	27.29
8	34.52	37.56	39.45	41.75	82.68	0.86	22.10
9	33.41	37.78	39.42	40.26	82.99	0.90	23.11
10	32.89	35.64	37.61	39.21	83.88	1.17	26.31
11	32.45	34.61	36.41	38.74	83.76	0.95	23.79
12	36.40	39.52	44.65	41.80	81.52	0.80	20.58
13	30.64	32.78	34.42	37.41	81.90	0.80	20.58
14	33.50	41.46	39.12	35.12	80.80	0.74	19.79
15	31.64	32.98	36.83	38.51	82.16	0.80	20.68
16	32.56	35.84	37.54	38.90	83.70	0.94	23.42
17	38.40	42.70	44.90	46.43	82.71	0.90	22.69
18	32.89	34.23	37.56	39.94	82.35	0.85	22.06
19	38.55	47.63	45.79	42.17	80.94	0.74	19.85
20	32.75	39.45	42.76	45.12	72.58	0.30	15.27
21	27.89	35.89	33.46	30.49	77.71	0.48	16.54
22	32.40	36.56	41.15	38.90	78.74	0.59	19.51
23	33.84	35.81	38.64	40.37	83.82	1.00	24.14
24	30.42	34.50	37.68	39.10	77.80	0.52	18.64

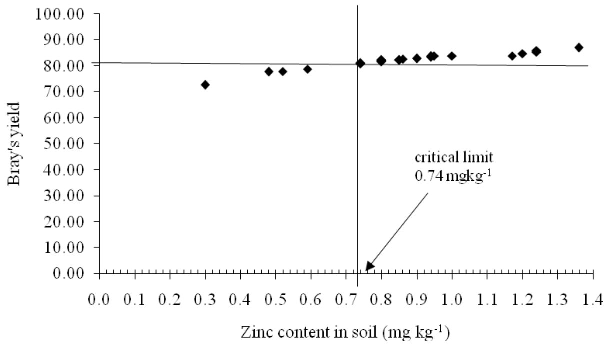

Fig. 1. Critical limit of zinc in soil

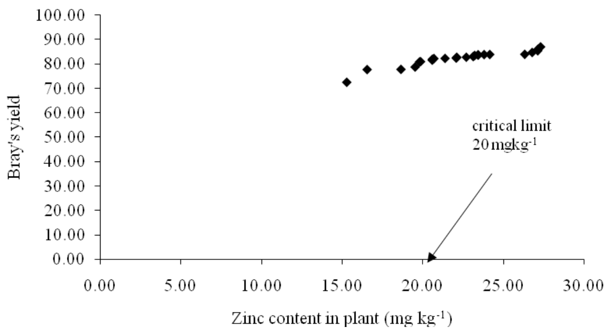

Fig. 2. Critical limit of zinc in rice plant

Critical limits of zinc in soil and rice plant

Using graphical procedure of Cate and Nelson (1965), the critical limit of zinc was found to be 0.74 mg kg^{-1} in soil (Fig. 1) and 20 mg kg^{-1} in rice plant (Fig. 2) below which economic response to zinc application is expected. Similar findings were reported by Rahman *et al.*, (2007), Muthukumararaja and Sriramachandrasekharan (2012) and Oinam *et al.* (2017).

Conclusion

The results indicate that the critical limit values of DTPA-extracted Zn in soil and rice plant were 0.74 and 20 mg kg^{-1}, respectively. The soils will likely respond to Zn application effectively when it contains less than 0.74 mg kg^{-1} DTPA- extracted Zn and maximum panicle initiation stage of rice plant contains less than 20 mg kg^{-1}.

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