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Status and distribution of zinc in the soils of Thoubal District, Manipur India

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Abstract
Twenty surface soil samples were collected from different paddy fields of thoubal district, Manipur to determine status and different forms of zinc in the soils. All the soil samples were acidic in nature with mean value of pH 5.49. The mean value of electrical conductivity was 0.07 dSm^{-1}. The mean value of organic carbon was 2.13%. The mean cation exchange capacity, available nitrogen, available phosphorus and available potassium were 17.37 [cmol(p^{+})kg^{-1}], 315.16 kg ha^{-1}, 26.39 kg ha^{-1} and 240.11 kg ha^{-1} respectively. The studied soils were fine-textured that is clay in the textural class. The mean value of available (DTPA extractable) zinc was 0.82 mg kg^{-1}. The DTPA extractable zinc show positive and significant correlation with CEC. A negative and significant correlation was observed with pH. On the basis of average concentration, the distribution of zinc in the soil order was: WSEX-Zn (0.38 mg kg^{-1}) < CRYOX-Zn (1.31 mg kg^{-1}) < MnOX-Zn (1.95 mg kg^{-1}) < AMOX-Zn (3.04 mg kg^{-1}) < OCx-Zn (3.16 mg kg^{-1}) < Res-Zn (82.79 mg kg^{-1}). All the zinc fractions showed positive correlation with EC, OC, CEC, available nitrogen, available potassium, clay; and negative correlation with pH and available phosphorus. WSEX-Zn and Res-Zn showed the lowest and highest concentration among the all zinc fractions, respectively. Different zinc fractions were found to be correlated to eachother, suggesting the dynamic nature of the equilibrium existing between them. The highest correlation among zinc fractions was found between residual and total zinc indicating the dependence of these forms on each other.

Keywords: Zinc, fractions of zinc, correlation, Thoubal

Introduction
Zinc is needed in very small quantities but it is indispensable from a nutritional point of view, like any other essential nutrients. Quick half of the world's soils are zinc deficient. Indian soils typically have a low zinc content. Nene (1966) [17] first recorded the field scale Zn deficiency of rice in tarai soil in India. Zinc is the most deficient micronutrient in Indian soils (49%), and its deficiency affects almost 1/3rd of the acid soils of the country. The deficiency in North-East India's acidic soils (Kumar *et al.*, 2016) [10] is even more extreme (60%), which could be one of the reasons behind the region's lower crop productivity. Therefore, sufficient zinc fertilization is critical to harnessing crop yield capacity. Therefore, correction of the Zn deficiency is required in order to increase productivity, which in effect requires the precise assessment of the available zinc in soil.
Zinc is the 4th most used metal that competes with lead. Zinc is an important element for plants and animals alike. Zinc is one of the important micronutrients for many crop plants like rice, maize, wheat and soybean, all of which are cultivated worldwide. The function of Zn is to help the plant produce chlorophyll. It is a trace element which is necessary in small but critical concentrations. If the amount of Zn in soils is not sufficient, plants can suffer from a physiological stress induced by the malfunction of several enzyme systems and other metabolic functions as it plays an important role in many metabolic processes of plants; it stimulates enzymes and is involved in protein synthesis and carbohydrate, nucleic acid and lipid metabolism (Marschner, 1986; Pahlsson, 1989) [15, 18]. There have been studies of an abundance of Zn having a detrimental effect on mineral intake (Chaoui *et al.*, 1997) [4].
Zinc plays a major role in various processes of plant metabolism, such as cell wall growth, respiration, photosynthesis, chlorophyll formation, enzyme activity and other bio-chemical functions.

The various pools of soil zinc are described as water soluble, exchangeable, adsorbed, chelated or complexed zinc. The distribution of various types of Zn in soil depends upon the soil's chemical and physical properties. The readily available forms of zinc *viz*., water soluble, exchangeable, and chelated forms of Zn are in reversible equilibrium with each other (Viets, 1962) [25]. Water soluble plus exchangeable and organically complexed forms are considered available, and amorphous sesquioxide bound form is theoretically available, although crystalline sesquioxide bound and residual Zn forms are not available to plants (Mandal *et al*., 1992) [12]. Types of Zn in soluble organic complexes and positions of exchange are of great importance in holding the Zn level adequate for wetland rice (Murthy, 1982) [16].

Materials and Methods

Twenty surface soil samples (0-15cm) were collected from different locations of the paddy cultivated fields of Thoubal district, Manipur. The soil samples were thoroughly air dried in shade, ground in wooden mortar and pestle and passed through 2 mm sieve.

The mechanical analysis of various soil samples for its sand, silt and clay fractions was carried out by N.B.S.S. and LUP using hydrometer method (Bouyoucos, 1951) [2]. These samples were analyzed for pH, EC and K_2O using standard procedures as described by Jackson (1973) [8], available N (Subbiah and Asija, 1956) [24], available phosphorus (Bray and Kurtz, 1945) [3] and CEC as described by Borah *et al.*, (1987) [1]. Organic carbon was determined by wet oxidation method of Walkley and Black (1934) [26].

Available zinc was determined by using Atomic Adsorption Spectrophotometer (AAS) as described by Lindsay and Norvell (1978) [11]. Different forms of zinc *viz*., water-soluble + exchangeable (WSEX), organically complexed (OCx), amorphous sesquioxide bound form (AMOX), crystalline sesquioxide bound form (CRYOX), and manganese oxide bound form (MnOX) were determined by sequential fractionation procedure outlined by Murthy (1982) [16] modified by Mandal and Mandal (1986) [14]. The correlation studies was calculated by using SPSS software.

Results and Discussion

Results shows that soil pH values ranged from 5.00 to 6.49 (mean 5.49), EC varied from 0.04 dSm^{-1} to 0.14 dSm^{-1} at 25˚C (mean 0.07 dSm^{-1}), OC varied from 1.44% to 3.31% (mean 2.13%), CEC varied from 12.1[cmol($p^{+)}$ kg^{-1}] to 30.5 [cmol($p^{+)}$ kg^{-1}] mean value was 17.37 [cmol(p^+) kg^{-1}], The available N, P_2O_5 and K_2O varied from 163.07 kg ha^{-1} to 398.27 kg ha^{-1} (mean 315.16 kg ha^{-1}), 21.32 kg ha^{-1} to 34.13 kg ha^{-1} (mean 26.39 kg ha^{-1}), 161.76 kg ha^{-1} to 291.64 kg ha^{-1} (mean 240.11 kg ha^{-1}), respectively. The silt, sand and clay contents of the soils varied from 14.9 per cent to 34.8 per cent and 10.2 per cent to 32.6 per cent, 48.4 per cent to 65.9 per cent, respectively. All soil samples were clay in textural class (Table 1).

Table 1: Soil Physico-chemical properties

Soil No.	pH (mol/lit.)	EC (dSm^{-1})	Org. C (%)	CEC [cmol(p+)/kg]	Av. N (kg/ha)	Av. P (kg/ha)	Av. K (kg/ha)	Sand (%)	Silt (%)	Clay (%)	Textural Class
1	5.19	0.12	1.86	25.6	250.88	22.05	194.59	24.1	17.5	58.4	Clay
2	6.10	0.09	1.63	14.2	366.91	26.38	213.36	10.2	26.3	63.5	Clay
3	5.80	0.08	2.12	15.4	357.50	22.42	246.79	15.5	24.2	60.3	Clay
4	5.31	0.05	2.15	14.3	376.32	30.86	275.82	17.4	23.7	58.9	Clay
5	5.40	0.06	3.12	22.2	313.60	21.32	256.85	28.3	19.3	52.4	Clay
6	5.25	0.06	1.86	14.8	351.23	23.15	260.06	28.8	22.8	48.4	Clay
7	6.11	0.07	2.21	16.9	291.64	23.47	269.86	21.0	19.9	59.1	Clay
8	5.32	0.06	1.83	14.2	366.91	26.12	272.58	13.5	30.7	55.8	Clay
9	5.25	0.07	1.62	24.9	241.47	25.71	291.64	11.2	25.7	63.1	Clay
10	5.00	0.14	2.35	30.5	395.13	23.27	288.67	14.1	20.0	65.9	Clay
11	5.52	0.05	1.53	18.9	275.96	31.26	248.64	11.4	30.2	58.4	Clay
12	5.68	0.06	2.85	13.9	332.41	34.13	239.87	11.7	34.8	53.5	Clay
13	5.20	0.05	3.21	14.3	373.18	27.04	261.56	32.6	14.9	52.5	Clay
14	6.49	0.04	1.44	12.1	163.07	32.26	172.84	21.8	17.5	60.7	Clay
15	5.43	0.08	1.86	15.2	250.88	26.04	226.46	22.8	23.1	54.1	Clay
16	5.48	0.05	2.09	14.8	398.27	23.78	161.76	22.6	25.7	51.7	Clay
17	5.54	0.06	1.49	17.1	241.47	28.54	189.34	22.9	20.6	56.5	Clay
18	5.28	0.08	2.21	18.7	329.28	23.63	265.62	21.9	18.7	59.4	Clay
19	5.45	0.07	3.31	13.9	250.88	32.41	268.34	14.5	27.6	57.9	Clay
20	5.11	0.11	2.04	15.5	376.32	23.97	197.72	15.5	26.2	58.3	Clay
Mean	5.49	0.07	2.13	17.37	315.16	26.39	240.11	19.09	23.47	57.44	

Table 2: Amount of different zinc fractions (mg kg^{-1}) in soils

Soil No.	DTPA Extractant	Zinc fractions						
	Available Zn	WSEX- Zn	OCx-Zn	AMOX-Zn	CRYOX-Zn	MnOX-Zn	Res-Zn	Total-Zn
1.	0.86	0.38	3.89	3.68	1.23	1.67	91.15	102.00
2.	0.52	0.27	2.41	2.71	1.25	1.75	72.94	81.33
3.	0.82	0.42	2.68	2.89	1.84	1.97	93.20	103.00
4.	0.72	0.35	3.10	2.73	1.51	1.55	74.76	84.00
5.	0.75	0.48	2.89	3.61	1.10	2.23	90.69	101.00
6.	1.04	0.15	2.93	3.12	1.12	2.35	72.00	81.67
7.	0.94	0.25	3.72	2.89	1.40	1.26	66.48	76.00
8.	0.86	0.31	3.92	3.21	1.08	0.62	74.86	84.00
9.	0.82	0.41	2.71	2.72	0.51	2.74	82.91	92.00

10.	1.39	1.11	4.42	4.65	2.19	3.15	107.48	123.00
11.	1.05	0.64	2.61	2.36	1.29	2.43	73.34	82.67
12.	0.62	0.41	2.62	1.91	1.51	2.30	94.25	103.00
13.	1.00	0.29	3.12	2.49	1.36	1.68	70.39	79.33
14.	0.61	0.21	2.31	1.85	0.41	0.81	63.74	69.33
15.	0.53	0.31	2.61	4.45	1.51	2.86	80.26	92.00
16.	0.73	0.39	2.78	3.31	0.89	2.34	83.62	93.33
17.	0.83	0.28	3.29	2.43	1.73	0.86	80.41	89.00
18.	0.68	0.25	3.58	3.09	1.78	0.83	81.80	91.33
19.	0.66	0.15	3.57	3.03	0.79	2.59	102.87	113.00
20.	1.02	0.61	4.11	3.82	1.88	3.15	98.76	112.33
Mean	0.82	0.38	3.16	3.04	1.31	1.95	82.79	92.66

Table 3: Simple correlation coefficient of different forms of zinc and physico-chemical properties of soil

	Soil properties	Zinc fractions							
		Available Zn	**WSEX- Zn**	**OCx-Zn**	**AMOX-Zn**	**CRYOX-Zn**	**MnOX-Zn**	**Res-Zn**	**Total-Zn**
1.	PH	-0.499*	-0.404	-0.549*	-0.569**	-0.345	-0.426	-0.491*	-0.534*
2.	EC	0.402	0.582**	0.630**	0.704**	0.546*	0.404	0.637**	0.684**
3.	OC	0.020	0.015	0.195	0.091	0.095	0.233	0.432	0.416
4.	CEC	0.542*	0.679**	0.434	0.511*	0.224	0.330	0.459*	0.492*
5.	AV. N	0.342	0.344	0.279	0.290	0.504*	0.202	0.214	0.252
6.	AV. P	-0.343	-0.208	-0.357	-0.646**	-0.274	-0.115	-0.159	-0.211
7.	AV. K	0.335	0.173	0.255	0.115	0.144	0.133	0.102	0.124
8.	SAND	0.059	-0.331	-0.001	0.117	-0.054	-0.220	-0.287	-0.269
9.	SILT	-0.181	0.070	-0.179	-0.195	-0.070	0.280	0.207	0.181
10.	CLAY	0.121	0.411	0.209	0.051	0.161	0.003	0.187	0.191

* Significant at 5 per cent level
** Significant at 1 per cent level

Available (DTPA-extractable) zinc
The DTPA extractable zinc varied from 0.52 mg kg^{-1} to 1.39 mg kg^{-1} and the mean value was 0.82 mg kg^{-1} (Table 2). The DTPA extractable zinc (Table 3) was positively and significantly correlated with CEC (r=0.542*). A negative and significant correlation was observed with pH (r=-0.499*). The relatively high value of available zinc in surface horizon may also be due to the variable strength of pedogenic processes and more complexity of organic matter, that which, as indicated by Gupta *et al*. (2003) [7], provided chelating agents for complexation and correlated with the organic carbon distribution pattern.

Water soluble + exchangeable zinc (WSEX-Zn)
WSEX-Zn ranged from 0.15 to 1.11 mg kg^{-1} and the mean value was 0.38 mg kg^{-1}. WSEX-Zn was positively and significantly correlated with EC (r=0.582**) and CEC(r=0.679**). Among the all zinc fractions, this fraction was found to be least fraction which might be due to high zinc buffering capacity of the soil which resulted in low amount of WSEX-Zn (Deb, 1997) [5].

Organically complexed zinc (OCx-Zn)
OCx-Zn ranged from 2.31 to 4.42 mg kg^{-1} and the mean value was 3.16 mg kg^{-1}. OCx-Zn was positively and significantly correlated with EC (r=0.630**) and negatively and significantly correlated with pH (r=-0.549*). The high content of OCx-Zn in the soils may be due to high organic carbon content. The organic matter and clay provide exchange sites for the adsorption of Zn in the soils as suggested by Prasad and Sakal (1988) [20] and Pal *et al*. (1997) [19].

Amorphous sesquioxide bound zinc (AMOX-Zn)
AMOX-Zn ranged from 1.85 to 4.65 mg kg^{-1} and the mean value was 3.04 mg kg^{-1}. AMOX-Zn was positively and significantly correlated with EC (r=0.704**) and CEC (r=0.511*). It was negatively and significantly correlated with pH (r=-0.569**) and available phosphorous (r=-0.646**). Due to their high specific surface area, the higher content of amorphous sesquioxide bound zinc than crystalline sesquioxide bound zinc may be due to the greater ability of amorphous sesquioxide to adsorb zinc (Devis and Leckie, 1978) [6].

Crystalline sesquioxide bound zinc (CRYOX-Zn)
CRYOX-Zn ranged from 0.41 to 2.19 mg kg^{-1} and the mean value was 1.31 mg kg^{-1}. CRYOX-Zn was positively and significantly correlated with EC (r=0.546*) and available nitrogen (r=0.504*). Compared to water soluble + exchangeable zinc, this fraction was dominant, this might be due to high proportion of crystalline iron oxide content and also due to chemical affinity or specific adsorption.

Manganese oxide bound zinc (MnOX-Zn)
MnOX-Zn ranged from 0.62 to 3.15 mg kg^{-1} and the mean value was 1.95 mg kg^{-1}. Lower content of this fraction might be due to the antagonistic effect between the manganese and zinc in the soils. Higher the manganese content in the soils as the studied soils are acidic which might have high amount of Mn content as reported by many workers.

Residual zinc (Res-Zn)
Res-Zn ranged from 63.74 to 107.48 mg kg^{-1} and the mean value was 82.79 mg kg^{-1}. Res-Zn was positively and significantly correlated with EC (r=0.637**), CEC (r=0.459*) and negatively and significantly correlated with pH (r=-0.491*). Residual Zn was the dominant fraction among all the fractions in the soils and is in similar findings of Raja and Iyengar (1986) [21].

Total zinc (Total-Zn)
Total-Zn ranged from 69.33 to 123.00 mg kg^{-1} and the mean value was 92.66 mg kg^{-1}. Total-Zn was positively and significantly correlated with EC (r=0.684**), CEC(r=0.492*)

and negatively and significantly correlated with pH (r=-0.534*). The variation in total Zn might be attributed to the fact that soils of these areas have developed over varying parent materials (Krishnakumar and Patty, 1992) [9].

Table 4: Simple correlation coefficient among the different forms of zinc fractions

		DTPA- Zn	WSEX- Zn	OCx-Zn	AMOX-Zn	CRYOX-Zn	MnOX-Zn	Res-Zn	Total-Zn
1	DTPA-Zn	1	0.662**	0.593**	0.331	0.405	0.292	0.224	0.284
2	WSEX-Zn		1	0.380	0.479*	0.508*	0.537*	0.550*	0.596**
3	OCx-Zn			1	0.546*	0.463*	0.024	0.451*	0.498*
4	AMOX-Zn				1	0.398	0.497*	0.510*	0.581**
5	CRYOX-Zn					1	0.140	0.391	0.439
6	MnOX-Zn						1	0.602**	0.634**
7	Res-Zn							1	0.995**
8	Total-Zn								1

* Significant at 5 per cent level
** Significant at 1 per cent level

Correlation between various Zn fractions

There is positive and significant correlation among different zinc fractions with varying degrees (Table 4). The highest significant correlation was found between Res-Zn and Total-Zn (r=0.995**) and the least significant correlation was found between OCx-Zn and Res-Zn (r=0.451*). Such close relationships between different forms suggested that they are more or less the same forms of Zn indicating the existence of dynamic equilibrium among different forms of Zn but relatively of different degree. Similar observations were also reported by Pal *et al.*, (1997) [19], Mandal *et al*., (1986) [13] and Sharma *et al.*, (1996) [22].

Conclusion

The evaluation of zinc fractions in soil order: WSEX-Zn (0.38 mg kg^{-1}) < CRYOX-Zn (1.31 mg kg^{-1}) < MnOX-Zn (1.95 mg kg^{-1}) < AMOX-Zn (3.04 mg kg^{-1}) < OCx-Zn (3.16 mg kg^{-1}) < Res-Zn (82.79 mg kg^{-1}) which is similar findings of Spalbar *et al.* (2017) [23]. The highest correlation among zinc fractions was found between residual and total zinc indicating the dependence of these forms on each other.

References

1. Borah DK, Bordolol PK, Karmakar RM, Baruah NG, Das M. Practical Manual for Fundamental of Soil Science (Part-III). Jorhat (Assam), 1987.
2. Bouyoucos GJ. Soil Sci. 1951; 23:319 & 343.
3. Bray RH, Kurtz LT. Determination of total, organic and available forms of phosphorous in soils. Soil Sci. 1945; 59:39-45.
4. Chaoui A, Mazhoudi S, Ghorbal MH, Elferjani E. Cadmium and zinc induction of lipid peroxidation and effects on antioxidant enzyme activities in beans (*Phaseolus vulgaris* L.). Plant Sci. 1997; 127:139-147.
5. Deb DL. Micronutrient research and crop production in India. J. Indian Soc. Soil Sci. 1997; 45(4):675-692.
6. Devis JA, Leckie JO. Effect of adsorbed complexing ligands on trace metal uptake by hydrous oxides. Environ. Sci. Technol. 1978; 12:1309-1315.
7. Gupta N, Trivedi SK, Bansali KN, Kaul RK. Vertical distribution of micronutrient cations in some soil series of north M.P. J Indian Soc. Soil Sci. 2003; 51(4):517-522.
8. Jackson ML. Soil Chemical Analysis, Prentice Hall of India Pvt. Ltd. New Delhi, 1973.
9. Krishnakumar AK, Patty SN. Nutrition of Hevea. In Natural Rubber: Biology, Cultivation and Technology. Amsterdam, 1992.
10. Kumar M, Jha AK, Hazarika S, Verma BC, Choudhury BU, Ramesh T *et al*. Micronutrients (B, Zn, Mo) for improving crop production on acidic soils of Northeast India. National Academy Sci. Letters. 2016; 39(2):85-89.
11. Lindsay WL, Norvell WA. Development of DTPA soil test for zinc, manganese and copper. Soil Sci. Soc. Am. J. 1978; 42:421-428.
12. Mandal B, Chatterjee J, Hazra GC, Mandal LN. Effect of pre-flooding on transformation of applied zinc and its uptake by rice in lateritic soils. Soil Sci. 1992; 153:250-257.
13. Mandal B, Halder BR, Mandal LN. Distribution of different forms of zinc in some rice growing soils. J Indian Soc. Soil Sci. 1986; 35:672-676.
14. Mandal LN, Mandal B. Zinc fractions in soils in relation to zinc nutrition of lowland rice. Soil Sci. 1986; 142(3):141-148.
15. Marschner H. Mineral nutrition of higher plants. Academic Press, New York, 1986.
16. Murthy ASP. Zinc fractions in wetland rice soils and their availability to rice. Soil Sci. 1982; 133(3):150-154.
17. Nene YL. Symptoms, cause and control of Khaira disease of paddy. Bull Indian Phytopathol. Soc. 1966; 3:97-191.
18. Pahlsson AMB. Toxicity of heavy metals (Zn, Cu, Cd, Pb) to vascular plants. Water Air Soil Pollut. 1989; 47:287-319.
19. Pal AK, Das PR, Patnaik SK, Mandal B. Zinc fractions in some rice growing soils of Orissa. J Indian Soc. Soil Sci. 1997; 45:734-738.
20. Prasad R, Sakal R. Effect of soil properties on different chemical pools of zinc in calcareous soils. J Indian Soc. Soil Sci. 1988; 36(2):246-251.
21. Raja ME, Iyengar BRV. Chemical pools of zinc in some soils as influenced by sources of applied zinc. J Indian Soc. Soil Sci. 1986; 34:97-105.
22. Sharma BL, Bhadoria AKS, Rathore GS, Bapat PN. Evaluation of extractants for available Zinc and its forms in vertisols of Madhya Pradesh. J Indian Soc. Soil Sci. 1996; 44:701-704.
23. Spalbar E, Mondal AK, Rai AP. Distribution of Zinc Fractions and Its Association with Soil Properties in Some Rice-Wheat Growing Soils of Jammu Region, India. Int. J Curr. Microbiol, App. Sci. 2017; 6(4):711-721.
24. Subbiah BV, Asija GL. A rapid procedure for estimation of available N in soils. Curr. Sci. 1956; 25:259-260.
25. Viets FGJR. The chemistry and availability of micronutrients in soils. J. Agric. And Food Chem. 1962; 10:174-178.
26. Walkley A, Black IA. An examination of the Degtjareff method determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci. 1934; 34:29-38.