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Soil Available Zinc and Its Relationship with Soil Properties in Rice Soils of West Bengal, India

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A B S T R A C T

The aim of this study was to evaluate the relationship between soil zinc and soil properties for which soil samples were collected from different agro-climatic zones of West Bengal covering five districts and eleven blocks. Soils were collected from rice growing fields across these districts. pH of the soil ranged from 5.14-7.81 while the organic carbon content ranged from 0.65-2.12 per cent with a mean value of 1.30 per cent. The CEC of the soil ranged from 6.51-21.23 meq 100g^{-1} of soil while clay content ranged between 17.68-42.29 per cent. DTPA extracted soil Zn value ranged from 0.55-1.92 mg kg^{-1} with a mean value of 1.08 mg kg^{-1}. The availability of Zn in the rice soils were positively correlated with the organic carbon, EC, clay content and CEC and negatively correlated with pH, amorphous Al and Mn oxides of the soils.

Introduction

Zinc (Zn) deficiency is the most widespread micronutrient deficiency problem resulting in reduced crop production and nutritional quality of edible plant parts (Cakmak, 2002). It has also been reported in almost all countries (Alloway, 2008) including India in different soil types (Shukla *et al.,* 2014). It is commonly prevalent in highly leached, heavily weathered and sandy acid soils with low organic matter content (Rautaray *et al.,* 2003). Rice (*Oryza sativa* L.) is one of highly sensitive crops to zinc (Zn) deficiency; Zn is the most important micronutrient limiting rice growth and yield (Alloway, 2004; Dong *et al.,* 2006). The availability of Zn in the soil varies widely depending on the soil properties and is associated with many soils and environmental factors which affect its availability to crop. The major factors which are responsible for zinc deficiency includes alkaline calcareous soil, sandy texture, low organic matter, high pH, use of high analysis NPK fertilizer, high yielding genotypes etc (Cakmak, 1998; Anonymous, 1998; Tandon, 1995; Mortvedt *et al.*, 1991). Availability of micronutrients including Zn not only depend on the total amount of nutrients present in the soil at a particular time but is also controlled by physico-chemical properties like: soil texture, organic carbon and calcium carbonate, cation exchange capacity, pH and electrical conductivity of soil (Bell and Dell, 2008). Keeping these facts in view, the present investigation was undertaken to study of relationship between soil Zn with soil properties which influences its availability to crop plants.

Materials and Methods

Description of the study area

For studying the different physico-chemical properties including soil Zn, surface soil samples (0-15 cm) from eleven (11) rice growing fields situated in three different agro-climatic zones of West Bengal were collected for a greenhouse experiment. The soils were collected from five different districts of West Bengal covering 11 blocks. Description of the soil collection sites are given in Table 1. Representative soil samples were collected from each of the above eleven blocks for measuring the different soil properties using standard protocols.

Soil analysis

Soil pH was measured in 1:2.5 soil water suspension using glass electrode pH meter (Jackson (1973). Electrical conductivity was measured in 1:2.5 soil water supernatant solution with the help of conductivity bridge (Jackson, 1973). The organic carbon was determined by rapid titration method (Walkley and Black, 1934) and clay content of the soils was determined through mechanical analysis by hydrometer method (Black, 1965). Determination of cation exchange capacity (CEC) of the soils was done by using the procedure given by Schollenberger and Simons (1945) Amorphous manganese and aluminium oxides was determined by the procedure given by McKeague and Day (1966). The available Zn in soil samples were extracted with DTPA (0.005 M DTPA + 0.01 M $CaCl_2$ + 0.1 M TEA, pH 7.3) as per the method described by Lindsay and Norvell (1978) and the concentration of Zn in the DTPA-extract was determined using atomic absorption spectrophotometer.

Results and Discussion

The range and mean values of analyzed soil properties viz pH, organic carbon, E.C, amorphous Al and Mn oxides, CEC and clay and soil available Zn is given in Table 2. The results in Table 2 shows that the pH of the soil ranges from 5.14-7.81, the organic carbon content ranged from 0.65-2.12 per cent with a mean value of 1.30 per cent, E.C values ranges from 0.08-0.24 dSm^{-1}, the amorphous Al and Mn oxides ranges from 3.55-6.84 and 0.47- 0.75 g kg^{-1} respectively. The mean value of amorphous Al and Mn oxides was 5.44 and 0.63 g kg^{-1} respectively. The CEC of the soil ranged from 6.51-21.23 meq $100g^{-1}$ of soil with a mean value of 13.50 meq $100g^{-1}$ of soil while clay content ranged between 17.68-42.29 per cent with a mean value of 29.55 per cent. The soil available Zn value ranged from 0.55-1.92 mg kg^{-1} with mean value of 1.08 mg kg^{-1}.

Correlation between extractable Zn cations and soil characteristics showed dependence of available soil Zn on soil organic carbon, clay, CEC etc. From the results in Table 3 we observe that available Zn showed significant negative correlations with pH but positive correlations with organic carbon (r= 0.722*), EC (r= 0.542), cation exchange capacity

(0.524*) and clay content (r= 0.249*) of the soils. The availability of zinc increased significantly with increase in organic carbon because zinc forms soluble complexes with soil organic matter component. Sharma *et al.*, in 2003 also noted positive correlations of soil Zn and organic carbon. Sidhu and Sharma (2010) also reported that the available micronutrients including Zn increased with increase in organic carbon. Yadav and Meena (2009) reported that the availability of Zn increased significantly with increase in clay (r= +0.597**), organic carbon (r = +0.896**), EC (r = +0.305*) and CEC (r = +0.527**). On the other hand, Mathur *et al.*, (2006) also reported that the DTPA-extractable zinc was significantly and positively correlated with organic C (r= +0.738**), CEC (r= +0.875**) and clay content (r = +0.385**). The amorphous Al-oxides and Mn oxides content were negatively correlated with extractable soil Zn indicating a decreased availability of Zn with increased concentration of Al (r = -0.317) and Mn (r= -0.084).

On the other hand, the availability of zinc reducing significantly with an increase in pH (r = - 0.714*) of soil is further concluded by many other studies. Widespread zinc deficiency problems in Indo-Gangetic plain are mostly due to the high soil pH both in Pakistan and India (Qadir, 2002). Havlin and Soltanpour (1981) also reported decrease in extractable zinc with increase in pH of soil and further explained that activity of zinc reduced 100 times with increase in one unit of pH from 6.2 to 7.2. In addition higher pH and $CaCO_3$ content results in insoluble Zn compounds such as Zn $(OH)_2$ and $ZnCO_3$ which can reduce the availability of zinc. The findings of the present investigation was also confirmed by the results of Singh, 2006 and Mehra, 2007.

Table.1 Description of the sampling sites

Agro-climatic zones	Districts	Blocks	Sites	GPS location	
				Latitude	Longitude
Coastal saline Zone	S-24 Parganas	Sonarpur	Kalikapur	22˚29´611"	88˚27´182"
		Canning- I	Amrabaria	22˚18´937"	88˚38´725"
Gangetic Alluvial Zone	Nadia	Haringhata	Mitrapur	22˚57´096"	88˚35´38"
		Ranaghat- I	Radhanagar	23˚13´449"	88˚33´525"
	Burdwan	Burdwan-I	Nerodighi	23˚20´996"	87˚02´367"
		Memari- II	Dhunui	23˚15´746"	88˚07´934"
	Hoogly	Bolagarh	Sherpur	23˚02´10"	88˚25´544"
		Pandua	Berui	23˚06´717"	88˚21´025"
Undulating Red and Laterite zone	Bankura	Kotulpur	Muidara	22˚59´938"	87˚35´799"
		Jaipur	Demodarbati	23˚2´563"	87˚31´821"
		Onda	Rajagram	23˚7´633"	87˚13´369"

Table.2 Some important properties of the experimental soils

Site	Soil Zn	pH	Oxidisable carbon	EC	Al-oxides	Mn oxides	CEC	Clay
	mg kg^{-1}		%	dS m^{-1}	g kg^{-1}	g kg^{-1}	meq $100g^{-1}$	(%)
Kalikapur	1.25	5.43	1.23	0.18	4.02	0.59	14.34	29.09
Ambrabaria	1.16	6.88	1.04	0.12	5.96	0.61	7.88	18.51
Mitrapur	1.92	5.76	2.12	0.16	4.92	0.69	21.23	32.67
Radhanagar	1.87	5.14	1.91	0.24	4.41	0.67	18.72	29.86
Dhunui	0.67	6.25	1.76	0.13	3.55	0.55	12.22	40.95
Nerodighi	0.58	7.81	1.19	0.15	6.84	0.75	19.44	28.92
Sherpur	1.58	5.87	1.53	0.19	6.13	0.47	15.56	42.29
Berui	0.55	6.11	0.93	0.17	5.38	0.55	6.51	27.71
Muidara	0.81	7.24	0.65	0.10	6.37	0.61	9.21	17.68
Rajagram	0.63	7.16	0.81	0.08	6.31	0.70	15.79	20.59
Demodarbati	0.88	6.76	1.13	0.21	5.95	0.73	7.59	36.78
Range	0.55-1.92	5.14-7.81	0.65-2.12	0.08-0.24	3.55-6.84	0.47-0.75	6.51-21.23	17.68-42.29
Mean	1.08	6.40	1.30	0.16	5.44	0.63	13.50	29.55

Table.3 Relationship between zinc concentration (mg kg^{-1}) and physico-chemical properties of the initial soils

	Soil Zn	pH	OC	EC	Al	Mn	CEC	Clay
Soil Zn	1.000	-0.714*	0.722*	0.542	-0.317	-0.084	0.524*	0.249*
pH		1.000	-0.653*	-0.655*	-0.759**	0.417	0.221	-0.433
OC			1.000	0.524	-0.603*	-0.034	0.632*	0.645*
EC				1.000	-0.329	-0.015	0.165	0.569
Al					1.000	0.302	-0.107	-0.397
Mn						1.000	0.323	-0.290
CEC							1.000	0.221
Clay								1.000
*** Correlation is significant at the 0.05 level (2-tailed).**								

The result of this study is backed by many more similar findings as shown by Sharma *et al.*, 2004 who reported that the content of Zn increased with an increase in clay, CEC and organic C content but decreased with increasing pH. Similar results were also confirmed in which the DTPA-extractable Zn showed significant positive correlation with organic carbon (Jassal *et al.*, 2014). In another study by Tundup and Akbar 2014, DTPA extractable Zn gave negative significant correlation with soil pH but was positively and significantly correlated with organic carbon and showed positive correlations with clay. Katyal and Sharma 1991, Sharma *et al.*, 1992, Ghosh *et al.*, 1993 further concluded similar findings. The soil samples were collected from different agro climatic zones of the state showing variable soil properties and concentration of soil Zn however showed similar relationships with the soil properties controlling the availability of Zn in such soils irrespective of the site of soil sample collection for the above study.

The results of the studied soils indicated that the soil properties pH, EC organic carbon, CEC, clay content etc are the main characteristics playing major role in controlling the availability of Zn. Available Zn showed significant negative correlations with pH (r=-0.714*) but positive correlations with organic carbon (r = 0.722*), EC (r = 0.542), cation exchange capacity (r= 0.524*) and clay content (r = 0.249*) of the soils.

References

Alloway, B.J. 2004. Zinc in soils and crop nutrition. Brussels, Belgium: International Zinc Association. http://www.zinc-crops.org/Crops/Alloway-PDF

Alloway, B.J. 2008. Zinc in soils and crop nutrition. International Zinc Association, Brussels, 330 Belgium. pp. 1-135.

Anonymous, 1998. Micronutrients in Agriculture: Pakistan Perspective; National Fertilizer Development Center: Islamabad, Pakistan. *antidotale* Retz., under salt stress. *Pak. J. Bot*., 38: 1661-1669.

Bell, R.W. and Dell, B. 2008. Micronutrients for Sustainable Food, Feed, Fibre and Bioenergy Production. First edition, IFA, Paris, France (www.fertilizer.org).

Black C.A. Methods of Soil Analysis. Part-II. Agronomy Series. No. 9, American Society Agronomy, Inc., Madison, Wisconsin.1965

Cakmak, I. 1998. Selection and characterization of cereal genotypes with high zinc efficiency and evaluation of bioavailability of zinc in wheat for the Central Anatolia Region; Science for Stability Programme, Cukurova University: Adana Turkey, pp.171.

Cakmak, I. 2002. Plant nutrition research priorities to meet human needs for food in 352 sustainable ways. *Plant and Soil*, 247: 3 -24.

Dong, Y., Ogawa, T., Lin, D., Koh, H.J., Kamiunten, H., Matsuo, M. And Cheng, S. 2006. Molecular mapping of quantitative trait loci for zinc toxicity tolerance in rice seedling (*Oryza sativa* L). *Field Crop Research*; 95:420–425.

Havlin, I. L. and P. N. Soltanpur. 1981. Evaluation of NH_4HCO_3-DTPA soil test for iron and zinc. *Soil Sci. Soc. Am*. 45: 70-75.

Jackson, M.L. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi. 1973

Jackson, T.L., Hay, J. and Moore, D.P. 1967. The effect of Zn on yield and chemical composition of sweet corn in the Willamette Valley. American Society of Horticultural Science; 91: 462-471.

Katyal, J.E. and Sharma, B.D. 1991. DTPA extractable and total Zn, Cu, Mn and Fe in Indian soils and their association with some soil properties. *Geoderma*, 49: 165-179.

Lindsay, W.L. and Norvell, W.A. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal*; 42: 421–428.

Mathur, G. M., Deo, R. and Yadav, B. S. 2006. Status of zinc in irrigated north-west plain soils of Rajasthan. *Journal of the Indian Society of Soil Science*, 54 (3): 359-361.

McKeague, J.A. and Day, J.H. 1966. Dithinite and oxalate extractable Fe and Al as aids in differenting various classes of soils. *Canadian Journal of Soil Science*; 46: 13-22.

Mehra, R.K. and Jat, J.R. 2007. To delineate the area of sufficiency and deficiency of micronutrients and their relationship with soil properties of Mokala soil series. M.Sc. (Ag.) Thesis, RAU, Bikaner.

Mortvedt, J. J., Cox, F. R., Shuman L. M. and Welch, R. M. 1991. In: J. J. Mortvedt, F. R. Cox, L. M. Shuman and R. M. Welch (eds.), *Micronutrients in Agriculture, 2nd edition.* Soil Sci. Soc. Am.: Madison, WI.

Pati, R. and Mukhopadhyay, D. 2011. Distribution of cationic micronutrients in some acid soils of West Bengal. *Journal*

of Indian Society Soil Science 59, 125-133.
Qadir, M., I. Ahmad and A. M. Ranjha. 1988. Response of wet land rice to copper and zinc in the presence of NPK. *Pak. J. Agri. Sci*. 55: 485-486.
Rautaray, S.K., Ghosh, B.C. and Mittra B.N. 2003. Effect of fly ash, organic wastes and chemical fertilizers on yield, nutrient uptake, heavy metal content and residual fertility in a rice–mustard cropping sequence under acid lateritic soils. *Bioresource Technology*; 90: 275–283.
Schollenberger, C.J. and Simon, R.H. 1945 Determination of exchange capacity and exchangeable bases in soil ammonium acetate method. *Soil Science*; 59: 13-24.
Sharma, B. D., and H. S. Jassal. 2013. Study of a toposequence for variability in micronutrients from the moist subhumid Siwalik agro-ecological subregion of Punjab. *Archives of Agronomy and Soil* Science; 59: 573–91.
Sharma, B. D., Arora, H., Kumar, R. and Nayyar, V. K. 2004. Relationships between soil characteristics and total and DTPA-extractable micronutrients in Inceptisols of Punjab. *Communications in Soil Science and Plant* Analysis; 35 *(5 & 6), 799 – 818.*
Sharma, R. P., Singh, M. and Sharma, J. P. 2003. Correlation studies on micronutrients *vis-à-vis* soil properties in some soils of Nagaur district in semi-arid region of Rajasthan. *J. Indian Soc. Soil Sci.*, 51 (4): 522-527.
Sharma, S.S. 1994. Characterization and classification of soils across a toposequence over basaltic terrain in humid southern Rajasthan M.Sc. (Ag.) Thesis, R.A.U., Bikaner, Campus, Udaipur.
Sidhu, G. S. and Sharma, B. D. 2010. Diethylenetriaminepenta acetic Acid-Extractable Micronutrients Status in Soil under a Rice-Wheat System and Their Relationship with Soil Properties in Different Agro-climatic Zones of Indo-Gangetic Plains of India. *Communications in Soil Science and Plant Analysis*; 41 (1): 29 – 51.
Singh, B.K. 2006. Available micronutrient status and their relationship with soil properties of Sangaria Tehsil of Hanumangarh District (Rajasthan). M.Sc. (Ag.) Thesis, RAU, Bikaner.
Tandon, H. L. S. 1995. Micronutrients in Soils, Crops, and Fertilizers. Fertilizer Development and Consultation Organization: New Delhi, India.
Tundup P and Akbar A. 2014 Distribution of micronutrient cations (Zn, Cu, Mn, Fe) and their relationship with soil properties of saffron growing soils of district Kishtwar in J&K. *An Asian Journal of Soil Science*; 9(1): 59-62.
Walkley, A. and Black, I.A. 1934. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*; 37: 29-37.
Yadav, R.L. and Meena, M.C. 2009. Available micronutrient status and their relationship with soil properties of Degana soil series of Rajasthan. *Journal of Indian Society Soil Science* 57, *90-92.*

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