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Assessment of correlation coefficient between zinc fractions & some soil properties under rice-rapeseed cropping sequence in Manipur

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Abstract

An experiment was initiated with rice crops in the month of July 2018 & rapeseed crops in late December 2018. This experiment comprises thirteen (13) treatments viz.
1) Zn = 0 kg Zn ha^{-1}, 2) Zn = 2.5 kg Zn ha^{-1}, 3) Zn= 5 kg Zn ha^{-1}, and 4) Zn= 7.5 and 5) 10.0 kg Zn ha^{-1}) with different frequencies of Zn application i.e. once in 1st year, alternate years, and continuous, were applied in the soil. The treatments were imposed on triplicate unit plots (4 × 5 m) before rice planting. This research aims to ascertain the relationship between soil physicochemical properties and zinc fractions under the Rice-Rapeseed cropping system in Manipur. Among the zinc fractions, WSEXZn is negatively correlated with EC and pH and correlated positively with soil organic carbon, CEC, and clay. OC-Zn significantly correlates with organic carbon, DTPA-Zn, and clay, except CEC and pH and EC of soils are negatively correlated with OC-Zn. MN-Zn significantly correlates with organic carbon and CEC but only positively correlates with DTPA-Zn and clay. pH correlates significantly negatively with Mn-Zn. AMOX-Zn is significantly negatively correlated with pH and positively correlated with EC, OC, CEC, clay, and DTPA-Zn. CEC, OC, DTPA-Zn, and clay have a positive and negative association with pH and EC of soils with CRYOXZn, respectively. OC, CEC, DTPA-Zn, and clay are positively and negatively correlated to the pH and EC of soils with RES-Zn. pH and EC are negatively correlated with total Zn and significantly positively with OC, except CEC and clay of the soils.

Keywords: Zinc, fractions, rice-rapeseed, correlation

Introduction

Zn shortage is known to be exacerbated in lowland rice farming under flooded conditions as a result of alterations in soil pH and the development of insoluble Zn compounds, such as ZnS (Mikkelsen and Shiou 1977) [1] and other insoluble Zn compounds that are produced when Fe and Mn oxides break down and bind to carbonates, particularly magnesium carbonate. Zn undergoes transformation into franklinite, $ZnFe_2O_4$, or amorphous sesquioxide precipitates when rice is grown in flooded conditions (Sajwan and Lindsay 1988) [2]. Among the micronutrients, wetland rice has a common nutritional issue caused by zinc deficiency, which is the most limiting nutrient. The most restrictive nutrient for wetland rice is zinc, whose absence results in a widespread nutritional disease (Sarkar and Deb, 1982) [3]. There are five different pools of zinc in soil: water soluble, exchangeable, adsorbed, chelated, or complex. These pools have varying strengths, affecting how easily plants can extract, leach, and absorb. The concentration of zinc and other cations, especially iron and manganese, as well as pH, Eh, and other factors affect the equilibrium between the various pools. Water-soluble, exchangeable, and chelated zinc forms, which are the readily accessible zinc forms, were in reversible equilibrium (Viets, 1962) [4]. The distribution of microelements throughout the soil fractions affects several variables, including pH, organic matter, CEC, and soil texture. Given the information above, an effort was made to investigate the relationship between soil physicochemical parameters and zinc fractions in Manipur's rice-rapeseed cropping system.

Material and Methods

An experiment was initiated with rice crops in the month of July 2018 & rapeseed crops in late December 2018. This experiment comprises thirteen (13) treatments viz.
1) Zn = 0 kg Zn ha^{-1}, 2) Zn = 2.5 kg Zn ha^{-1}, 3) Zn= 5 kg Zn ha^{-1}, and 4) Zn= 7.5 and 5) 10.0 kg Zn ha^{-1}) with different frequencies of Zn application i.e. once in 1st year, alternate years, and continuous, were applied in the soil. The treatments were imposed on triplicate unit plots (4 × 5 m) before rice planting. Before transplanting rice seedlings, zinc was applied as zinc

sulphate heptahydrate (22% Zn) and blended into the soil in accordance with the treatment instructions. Using urea, SSP, and muriate of potash, a base dose of 60 kg N, 40 kg P_2O_5, and 30 kg K_2Oha^{-1} was evenly applied to each plot. The soil samples were pulverised, air-dried, and put through a 2 mm sieve for laboratory analysis. The samples were analyzed for pH (soil reaction) and electrical conductivity (EC) using methods given by Jackson (1973) [5], organic carbon was estimated by the wet oxidation method of Walkley and Black (1934) [6], Soil texture was estimated by Hydrometer method given by Buoyoucous (1962) [7], cation exchange capacity (CEC) was estimated using methods given by Borah *et al.*, 1987 [8]. The available zinc was estimated by following the procedure of 0.005M DTPA given by Lindsay and Norvell, 1978 [9]. Six chemical fractions of Zn were separated using a sequential procedure fractionation method (Chatterjee and Khan, 1992) [10] (Table 1). The following formula will be used to calculate correlation coefficient (r) studies between various types of soil zinc and soil properties:

$$r = \frac{\Sigma xy - \frac{\Sigma x - \Sigma y}{N}}{\sqrt{\left[\Sigma x^2 - \frac{(\Sigma x)^2}{N}\right]\left[\Sigma y^2 - \frac{(\Sigma y)^2}{N}\right]}}$$

Where,
N=number of samples, r = ratio of covariance of the variables x and y to the product of the standard deviations of x and y (Gomez and Gomez, 1986) [11].

Table 1: Sequential procedure for Zinc fractionation (Chatterjee and Khan, 1992) [10]

Fraction	Soil (g): solution (ml)	Solution	Conditions
1. Water soluble + Exchangeable (WSEX)	5:50	IM(Mg)NO_3 (pH 7.0)	2 hours shaking
2. Organically complexed (OC)	5:50	0.05M Cu(OAc)2	30 minutes shaking
3. Manganese oxide bound (MNOX)	5:50	0.1 M $NH_2OH.HCl$ (pH 2.0)	30 minutes shaking
4. Amorphous sesquioxide bound form (AMOX)	5:50	0.2 $M(NH_4)_2C_2O_4.H_2O$ (pH 3.0)	4 hours shaking
5. Crystalline sesquioxide bound form (CRYOX)	1:10	0.1 M Ascorbic acid with acidified ammonium oxalate	30 minutes in the water bath
6. Residual zinc	**Total zinc – the summation of all the Zn fractions**		
7. Total Zinc	2:25	Aqua regia	6-8 hours or overnight for pre-digestion Heated the content on the hot plate

Result and Discussion

The pH of the soil ranged from 4.9 to 5.4, with an average value of 5.16, making all of the soil samples acidic. The organic carbon content of soils ranges from 1.2 to 1.8% with an average value of 1.38%. The electrical conductivity of soils ranges from 0.08 to 0.14 dSm-1 with an average value of 0.106 dSm-1. The cation exchange capacity of soils ranges from 14.84 to 18.26 [cmol (p+) kg-1] with an average value of 16.91 [cmol (p+) kg-1. and the soil's average clay concentration was 56.48%, ranging from 52.5 to 60.0%. The soils' respective silt and sand values ranged from 14.45 to 32.5% (mean 24.40%) and 7.50 to 30.0% (mean 18.92%).The texture of the soil was clayey in nature. Total zinc varied between 71.94 and 112.62 mg kg-1 (average 91.90 mg kg-1), while the DTPA zinc varied from 0.30-1.36 mg kg^{-1} (mean 0.88 mg kg^{-1}). (Table 2).

Water soluble and exchangeable zinc fractions (WSEXZn)

It ranged from 0.52-0.66 mg kg^{-1}, with a mean of 0.59 mg kg^{-1} (Table 3). WSEXZn is significantly negatively correlated with EC($r = -.719^{**}$) and pH ($r = -.697^{**}$). This is because zinc becomes more soluble at low pH levels, where it then binds to the clay complex. The results are line with Hazra *et al.*, (1987) [18] and correlated positively with soil organic carbon (r=0.291), CEC (r=0. 279), and clay (r = 0.161), indicating that organic materials and clay provide greater exchange sites for zinc adsorption (Table 4). Such results are in accordance with Iyengar and Deb 1977 [12]; Pal *et al.*, 1997) [13]. Water soluble plus exchangeable zinc significantly correlates with DTPA-Zn ($r= 0.841^{**}$).

Organically bound zinc fractions (OC-Zn)

It ranged from 3.12-4.51 mg kg^{-1} (mean 3.80 mg kg^{-1}) (Table 3). OC-Zn significantly correlates with organic carbon ($r = .809^{**}$), DTPA-Zn ($r= .572^{*}$), and clay ($r= .553^{*}$), except CEC (r = 0.523) and pH ($r = -0.671^{*}$) and EC (r = -.483) of soils are negatively correlated with OC-Zn, indicating that organic materials and clay provide greater exchange sites for zinc adsorption. Mandal and Mandal (1986) [17] and Pal *et al.*, (1997) [13].

Manganese oxide bound zinc (Mn-Zn)

It ranged from 0.98-4.01 mg kg^{-1} (mean 2.47 mg kg^{-1}) (Table 3). MN-Zn significantly correlates with organic carbon (r = 0.463*) and CEC ($r = .606^{*}$) but only positively correlates with DTPA-Zn (r=0.544), EC (r = .301) and clay (r = 0.385). pH ($r = -.645^{*}$) correlates significantly negatively with Mn-Zn. Similar results were observed by Singh *et al.*, (1988) [15] (Table 4).

Amorphous sesquioxide bound zinc (AMOX-Zn)

It ranged from 2.34-3.84 mg kg^{-1} (mean 3.09 mg kg^{-1}) (Table 3). AMOX-Zn is significantly negatively correlated with pH ($r = -0.573^{*}$), EC (r = -0.483) of the soils and positively correlated with OC (r = 0.288), CEC(r = 0.163), clay (r = 0.045), and DTPA-Zn (r = 0.483) (Table 4) (Shuman, 1985) [19]. Because amorphous sesquioxide has a higher specific surface area than crystalline sesquioxide, it can adsorb zinc more effectively, which may explain why soils contain more amorphous sesquioxide-bound zinc than crystalline sesquioxide-bound zinc (Wijebandara *et al.*, 2011) [16].

Crystalline sesquioxide bound zinc (CRYOX-Zn)

It ranged from 0.98-2.24 mg kg^{-1} (mean 1.84 mg kg^{-1}) (Table 3). Clay (r = 0.045), OC (r = 0.175), CEC (r=0.213), and DTPA-Zn (r=0.284) have a positive association, while pH (r=-0.225) and EC (r = -0.386) of soils are negatively associated with CRYOXZn respectively. Such findings are in conformity with Shuman (1985) [19] (Table 4).

Residual form of zinc (RES-Zn)

It ranged from 63.58-96.47 mg kg^{-1} (mean 78.85 mg kg^{-1}) (Table 3). These data, along with those of Raja and Iyengar (1986) [20] and Iyengar and Deb (1977) [12], show that this fraction was the dominating one among all the zinc fractions examined. OC (r = 0.727**), CEC (r = 0.377), DTPA-Zn (r=0.295), and clay (r = 0.355) are positively correlated, and the relationship of pH (r = -0.484) and EC (r = -0.236) are negative with RES-Zn (Table 4). Such findings are in conformity with Pal *et al*., (1997) [14].

Total zinc

It ranged from 74.19-110.28 mg kg^{-1} with an average of 90.73 mg kg^{-1} (Table 3). pH (r = -0.549) and EC (r = -0.289) are negatively correlated with total Zn and have a significant positive correlation with OC (r = 0.784**), except CEC (r = 0.427), and clay (r = 0.386) of the soils. Such findings are in line with Katyal and Sharma, (1991) [21].

Table 2: Status of physicochemical properties

Treatments	Frequency	pH	EC	OC	CEC	Clay	Silt	Sand
T1(Zn0.0)		5.3	0.11	1.2	16.71	55	25	20
T2(Zn2.5)	Once	5.2	0.12	1.3	16.58	55	22.5	22.5
T3(Zn5.0)		5.1	0.08	1.2	17.29	54	32.5	13.5
T4(Zn7.5)		5.1	0.1	1.2	15.42	57.5	30	12.5
T5(Zn10.0)		5.1	0.12	1.6	17.45	59.9	18.5	21.6
T6(Zn2.5)	Alternate	5.4	0.14	1.2	16.87	58.4	17.5	24.1
T7(Zn5.0)		5.3	0.11	1.2	14.84	56.5	14.5	29
T8(Zn7.5)		5	0.09	1.5	17.63	60	32.5	7.5
T9(Zn10.0)		5.1	0.1	1.8	17.81	55.9	30	14.1
T10(Zn2.5)	Continuous	5.3	0.12	1.2	17.16	52.5	17.5	30
T11(Zn5.0)		5.2	0.11	1.2	16.48	56.5	25	18.5
T12(Zn7.5)		5.1	0.08	1.5	18.16	54.9	26	19.1
T13(Zn10.0)		4.9	0.09	1.6	18.26	58.6	27.5	13.9
Range		4.9-5.4	0.08-0.14	1.2- 1.8	14.84-18.26	52.5- 60.0	14.45-32.5	7.50-30.0
Mean		5.16	0.106	1.38	16.91	56.48	24.40	18.92
sem		0.07223	0.00163	0.019409	0.246852	0.768437	0.420234	0.23216
cd		0.210836	0.004773	0.05665	0.720511	2.24291	1.226575	0.677627

Table 3: Different fractions of zinc (mg kg^{-1}) in soils

Treatments		WSEX	OC-Zn	Mn-Zn	Amox-Zn	Cryox-Zn	Res-Zn	Total Zn
T1(Zn0.0)		0.56	3.45	1.98	2.82	1.8	63.58	74.19
T2(Zn2.5)	Once	0.61	3.12	2.62	2.91	0.98	68	78.24
T3(Zn5.0)		0.62	3.45	2.54	3.05	2.06	64.86	76.58
T4(Zn7.5)		0.64	3.85	1.98	2.96	2.24	80.96	92.63
T5(Zn10.0)		0.52	4.36	3.16	3.07	1.72	89.43	102.26
T6(Zn2.5)	Alternate	0.56	3.54	2.08	2.64	2.01	71.71	82.54
T7(Zn5.0)		0.55	3.62	1.84	3.47	1.92	72.86	84.26
T8(Zn7.5)		0.66	4.16	3.42	3.14	1.97	78.22	91.57
T9(Zn10.0)		0.62	4.28	4.01	2.86	2.04	96.47	110.28
T10(Zn2.5)	Continuous	0.53	3.21	1.86	3.08	2.14	72.12	82.94
T11(Zn5.0)		0.6	3.59	0.98	2.89	1.26	89.14	98.46
T12(Zn7.5)		0.63	4.51	2.21	3.21	2.15	91.15	103.86
T13(Zn10.0)		0.64	4.26	3.52	3.84	2.18	84.28	98.72
Range		0.52-0.66	3.12-4.51	0.98-4.01	2.34-3.84	0.98-2.24	63.58-96.47	74.19-110.28
Mean		0.60	3.80	2.48	3.07	1.88	78.68	90.50
SeM		0.01	0.05	0.03	0.04	0.02	1.24	1.41
CD		0.03	0.14	0.09	0.12	0.05	3.62	4.13

Table 4: Relationship between soil physicochemical properties and zinc fractions under the Rice-Rapeseed cropping system

	DTPA Zn	WS-Zn	OC-Zn	MN-Zn	AMOX-Zn	CRYS-Zn	RES-Zn	TOTAL-Zn
pH	-.860**	-.697**	-.671*	-.645*	-.573*	-.225	-.484	-.549
EC	-.638*	-.719**	-.483	.301	-.483	-.386	-.236	-.289
OC	.454	.291	.809**	.857**	.288	.175	.727**	.784**
CEC	.395	.279	.523	.606*	.163	.213	.377	.427
Clay	.544	.161	.553*	.385	.173	.045	.355	.386
DTPA Zn	1	.841**	.572*	.544	.483	.284	.295	.361

Conclusion

Among the zinc fractions, WSEXZn is negatively correlated with EC and pH and correlated positively with soil organic carbon, CEC, and clay. OC-Zn significantly correlates with organic carbon, DTPA-Zn, and clay, except CEC and pH and EC of soils are negatively correlated with OC-Zn. MN-Zn significantly correlates with organic carbon and CEC but only positively correlates with DTPA-Zn and clay. pH correlates significantly negatively with Mn-Zn. AMOX-Zn is significantly negatively correlated with pH and positively correlated with EC, OC, CEC, clay, and DTPA-Zn. CEC, OC, DTPA-Zn, and clay have a positive and negative association with pH and EC of soils with CRYOXZn, respectively. OC, CEC, DTPA-Zn, and clay are positively and negatively correlated to the pH and EC of soils with RES-Zn. pH and EC are negatively correlated with total Zn and significantly positively with OC, except CEC and clay of the soils.

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