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Transformation of zinc in soil under different phosphorus levels on long term fertiliser experiment

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Abstract
A field experiment was conducted at Regional Agricultural Research Station, Pattambi to study fractions of Zn under different P levels in Long Term Fertilizer Experiment (LTFE). The field was laid out in RBD having 12 treatments with four replications which was commenced in 1997 and of which 6 treatments having different P levels was taken for the study. The soil samples were taken after the paddy harvest of kharif 2020 and sequential extraction of Zn (water soluble + extractable, organically bound Zn, amorphous sesquioxide Zn and crystalline sesquioxide Zn) and P (sol-P, Al-P, Fe-P, sesquioxide occluded P and Ca-P) were carried out. The results of fractionation study revealed that continuous use of inorganic fertilisers with organic manures (INM) in T5 (100% NPK + FYM) increased various Zn fractions except amorphous sesquioxide Zn fraction which was highest in the control. In case of P fractions even though the increase in P dose increased different P fractions significantly higher content was observed in 100% NPK+ FYM but Ca-P fraction was more in the lime treated plot.

Keywords: LTFE, Zn fractions, P fractions, INM

Introduction

Phosphorus is an essential nutrient required by the plants for metabolic activities, component of several major plant structural compounds and acts as a catalyst of many key biological reactions. Phosphorus application is beneficial for stimulated root development increased stalk and stem strength, improved flower formation and seed production. Similar to phosphorus zinc is also an essential element required for various metabolic activities in plants, including cytochrome and nucleotide synthesis, auxin metabolism, chlorophyll formation, enzyme activation and membrane integrity.

Rice (*Oryza sativa* L.) is a major staple crop that sustains more than half of the world's population, and expanding rice production is very important because traditional rice-producing countries will demand 70% more rice by 2025 (Swaminathan, 2007) [21]. Rice accounts for 35–60% of the nutritional calories consumed by three billion people, making it the most significant crop on the earth (Confalonieri and Bocchi, 2005) [6].

Phosphorus content in Kerala soils reported to be very high for variety of reasons (Srinivasan *et al*., 2014) [19], including intensification of agriculture and the introduction of high-yielding varieties as well as concurrent use of high doses of chemical fertilisers and utilisation of low amounts of organic manures over time. Several micronutrients, particularly zinc, are also depleted. Zinc deficiency has emerged as one of the greatest limitation to increased crop production, apparently affecting 49 percent of India's farmland.

High P levels can alter soil attributes such as pH shift due to fertiliser dissolution in soil solution or reactivity of both the phosphate and the associated cation with soil components, and changes in surface charge due to phosphate adsorption on soil colloids (Shuman, 1988) [17]. Saeed and Fox (1979) [15] found that P fertilisation increased Zn sorption in Hawaiian soil. They proposed that P sorption on the surfaces of Fe and AI oxides enhanced negative charges on them, resulting in greater zinc sorption. Previously, Stanton and Burger (1970) [20] noticed that hydrous oxides of Fe and A1 improved the sorption of Zn from solution. Such changes in soil characteristics may have an effect on transformation of both native and applied Zn in soil into various forms, and hence its availability to plants.

Hence the present study was conducted with the objective of assessment of the effects of different levels of P application on Zn differences in soil under long term fertiliser experiments.

Materials and methods

In this experiment fractions of Zn under different P levels were studied. For achieving the objective field experiment was carried out under All India coordinated Research Project on Long Term Fertiliser Experiment was commenced in 1997 at Regional Agricultural Research Station, Pattambi. Following are the treatment selected for the study.

T1 No fertiliser control T2 50% NPK.
T3 100% NPK.
T4 150% NPK.
T5 100% NPK + FYM @ 5t/ha.
T6 100% NPK + lime @ 600 kg/ha.

Following the harvest of the paddy crop of kharif, soil samples from 0-15 cm depth were taken from each plot from the experimental fields. The samples were dried in the shade, ground with wooden pestle and mortar, sieved through 2 mm sieve and kept in polythene bags for analysis. The inorganic phosphorus fractions were extracted using the procedure described by Peterson and Corey (1966) [14], which involved sequential extraction of soluble and loosely bound phosphorus, aluminium phosphate, iron phosphate, sesquioxide occluded phosphate and calcium phosphate by various extractants. These are then filtered through whatman No. 42 filter paper and ICP-OES was used to quantify P in all of the extracts (Model: Perkin Elmer-Optima 8000). To find out the distribution of Zn between the various binding forms, Iwasaki and Yoshikawa (1990) [11] employed the sequential fraction approach, which is a modified method of Miller, Martens and Zeolazincy (1986) [12] fractionation methodology. These data were then statistically tested using analysis of variance (ANOVA) and multiple comparison procedures. The significant difference between treatments were compared by critical difference (C.D) and correlations using various parameters were computed.

Results Saloid-P

The effect of continuous cropping and fertilizer applications on content of Saloid bound phosphorus form revealed that saloid P increased from control to 150 percent NPK. This could be due to transformation of P into Saloid-P in the soil system from both inherent and applied sources (Badrinath *et al*., 2005) [2]. Significantly higher content of Saloid P was noted in 100 percent NPK+FYM (8.88 mg kg-1), showing that organic manure had a synergistic effect on speeding the rate of transformation into Saloid-P content in the soil pool for future consumption by crop plants (Bahl and Singh, 1997) [3] while the lowest in control that could be due to absence of phosphorus application.

Al-P form

The content of aluminium phosphate form in the soil increased as fertiliser doses were increased. Decrease in Al-P in the control plot (61.48 mg kg-1) is due to the lack of P (Dwivedi *et al*., 2007) [8]. On the other hand, significant P accumulation was observed when fertiliser levels were increased from optimal to super optimal, and even more when NPK was applied in conjunction with FYM (112.35 mg kg-1) as this have enhanced the transformation process that resulted in the accumulation of Al-P form in the soil (Brar and Vig, 1989) [5].

Table 1: Effect of long term fertilizer application on different fractions of phosphorus b

Treatment	Soluble P	Al-P	Fe-P	Sesquioxide occluded P	Ca-P
T1: Control	6.26f	61.48f	133.29f	44.35f	31.3f
T2: 50% NPK	6.73e	81.65d	165.23e	48.23ef	34.69e
T3: 100% NPK	6.98de	87.36bc	175.55cd	52.24de	36.25de
T4: 150% NPK	7.99b	100.45b	183.35b	58.11bc	38.74c
T5: 100% NPK+ 5t/ha FYM	8.88a	112.35a	190.43a	62.94ab	38.8bc
T6: 100% NPK+ Lime @ 600 kg/ha	7.48c	71.69e	171.49d	52.77cde	39.41abc
C.D.	0.362	9.061	5.562	5.623	1.662
SE(m)	0.119	2.979	1.828	1.849	0.546

Fe-P form

Iron phosphate occurred in greatest percentage among total inorganic P, accounting for 48.16 percent. The findings were comparable to the study of Bhattacharyya *et al*. (2015) [4] who reported that higher Fe content present in the acid soil may have fixed the P applied from an inorganic P source. Among different treatments, using 100% NPK + FYM (T5) recorded significantly highest value of 190.43 mg kg-1 that might be due to release of organic acids during the decomposition of organic matter, resulting in the resolution of both applied and native P into Fe-P compounds, resulting in enriched Fe-P pools in soil solution.

Sesquioxide occluded-P form

The sesquioxide occluded P fraction constitute about 10 percent of total inorganic P. Among different treatment combination the addition of graded fertiliser, increased occluded-P fraction. But a significant increase was not observed in T5 (62.94 mg kg-1) implying that Fe and Al played a major role in fixing the applied inorganic P by fertiliser (Sihag *et al*., 2005) [18].

Ca-P form

Except Soluble and readily available P, Ca-P fraction occupied the lowest position among the inorganic P fractions It is expected lower Ca-P fraction due to acidic pH of the experimental soil. The data in the table demonstrated that Ca-P content increased by adding graded dose of fertilisers, however the highest content of this fraction was registered in treatment T6 where 100 percent NPK+ lime (38.8 mg kg^{-1}) was applied and significant lower content was noted in control. Higher Ca-P fraction is due to direct supply of calcium by lime.

Water soluble plus extractable Zn

The water soluble plus extractable zinc fraction was significantly higher in treatment T5 and remaining treatments were on par to each other even though a slight increase was noted by increasing the dose of fertiliser (Table 12). Agbenin (2003) [1] found that FYM-fertilized fields maintained total and extractable Zn levels significantly higher than the natural site. Because this is the fraction that is most bioavailable and mobile in soil, its low concentration as compared to other fractions could be attributable in part to losses through leaching and plant absorption (Filgueiras *et al*., 2002) [10].

Organically bound Zn

The addition of FYM in treatment T5 resulted in the highest amount of organically bound fraction, indicating that organic manure played significant role in Zn availability in the soil systems (El- Fouly *et al*., 2015) [9].

Table 9: Effect of long term fertilizer application on different fractions of zinc (mg kg-1)

Treatment	Water soluble + Extractable	Organically bound Zn	Amorphous sesquioxide Zn	Crystalline sesquioxide Zn
T1: Control	1.02f	1.78f	4.45a	0.98f
T2: 50% NPK	1.08ef	1.8ef	4.08bc	1.01ef
T3: 100% NPK	1.13de	1.84def	3.98cd	1.08cdef
T4: 150% NPK	1.25bc	1.98bc	3.87de	1.12bcd
T5: 100% NPK+ 5t/ha FYM	1.55a	2.21a	3.71f	1.34a
T6: 100% NPK+ Lime @600 kg/ha	1.19cd	1.89cde	3.77ef	1.06def
C.D.	0.071	0.103	0.113	0.107
SE(m)	0.023	0.034	0.037	0.035

Table 3: Correlation coefficient values between P fractions and Zn fractions

	Sol-P	Al-P	Fe-P	Occl-P	Ca-P	WS+E Zn	Org-Zn	Amo-FeOZn	Cry-FeOZn
Sol-P	1								
Al-P	0.473NS	1							
Fe-P	-0.075NS	0.544NS	1						
Occl-P	-0.097NS	-0.066NS	0.319NS	1					
Ca-P	0.028NS	0.243NS	-0.132NS	0.600NS	1				
WS+E Zn	0.070NS	0.099NS	-0.050NS	0.819*	0.937**	1			
Org-Zn	-0.270NS	0.711NS	0.689NS	0.152NS	0.338NS	0.180NS	1		
Amo-FeOZn	-0.338NS	0.387NS	0.961**	0.394NS	-0.063NS	0.011NS	0.732NS	1	
Cry-FeOZn	-0.124NS	-0.120NS	0.430NS	0.973**	0.402NS	0.668NS	0.108NS	0.495NS	1

Amorphous sesquioxide Zn

Amorphous sesquioxide zinc fraction was significantly higher in control plot. In acid soils, the FYM played a critical role in Fe and Al activity and these iron and aluminium forms strong compounds with biological materials (Dhiman, 2007) [7] because fertilisers improved root biomass in soil by raising crop yield.

Thus resulting in higher organic matter content, most of the Fe and Al in the soil may have formed strong complexes with the increased organic matter, leaving little oxides for zinc adsorption.

Crystalline sesquioxide Zn

Crystalline sesquioxide zinc registered significant higher value in Treatment T5 whereas control had the lowest content. According to Nolovic (1978) [13], the low amount of this fraction is attributable to the crystallinity of Fe oxides, which may have interfered with trace elements like Zn.

Relationship between different zinc fractions and phosphorus fractions

Correlation coefficients between different phosphorus and zinc fractions is furnished in table 11. It is clear from the table that by increasing phosphorus doses in different treatment, different P fraction is non- significantly negatively correlated with different Zn fractions (Shambhavi, 2011) [16]. Fe-P fraction is significantly correlated with amorphous sesquioxide zinc (r = 0.961**), Occluded-P fraction is significantly correlated with water soluble plus extractable (r = 0.819*) and crystalline sesquioxide zinc (r = 0.973**) fraction. Similarly calcium bound P fraction is significantly correlated with water soluble plus extractable zinc fraction (r = 0.937**).

Conclusion

Effect of long term P applications on P fractions found that liming and organic matter addition showed beneficial effect by decreasing P fixation and increasing soluble bound P fraction. Effect of long term P applications on dynamics of Zn fractions found that organic matter addition increased plant available water soluble plus extractable zinc fraction. Correlation study concluded that most of P fractions had non-significant negative correlation with various zinc fractions. Calcium phosphate and sesquioxide occluded phosphate found positively and significantly correlated with water soluble plus extractable zinc fraction.

References

1. Agbenin JO. Zinc fractions and solubility in a tropical semi-arid soil under long-term cultivation. Biol. Fertil. Soil 2003;37(2):83-89.
2. Badrinath MS, Niranjana KS, Nandkishore TG. Distribution and fractionation of phosphorus in soils of different agro-climatic zones of Karnataka (India). Soil Sci. Soc. Am. J 2005;43:523-528.
3. Bahl GS, Singh A. The inorganic soil phosphorus fractions and available P as influenced by green manuring, cropping and P fertilisation. J Indian Soc. Soil Sci. 1997;45(1):19-53.
4. Bhattacharyya P, Nayak AK, Shahid M, Tripathi R, Mohanty S, Kumar A *et al*. Effects of 42-year long-term fertilizer management on soil phosphorus availability, fractionation, adsorption-desorption isotherm and plant uptake in flooded tropical rice. Crop J 2015;3(5):387-395.
5. Brar BS, Vig AC. Forms of inorganic phosphorus in some benchmark soil of Punjab. J Agric. Biol 1989;19(1):17-21.
6. Confalonieri R, Bocchi S. Evaluation of cropsyst for simulating the yield of flooded rice in northern Italy. Eur J Agron 2005;23(5):315-332.
7. Dhiman S. Long term effect of integrated nutrient supply on zinc dynamics in rice-wheat cropping system in an acid Alfisol of Himachal Pradesh. M.Sc. (Ag) thesis, CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur 2007, 147.
8. Dwivedi AK, Singh M, Kauraw DL, Wanjari RH, Chauhan SS. Research bulletin on impact of fertiliser and manure use for three decades on crop productivity and sustainability and soil quality under Soybean-Wheat system on vertisol in central India. IISS (ICAR), Bhopal 2007, 224-235.

9. El-Fouly MM, Fawzi AFA, Abou El-Nour EAA, Zeidan MS, Firgany AH. Impact of long-term intensive cropping under continuous tillage and unbalanced use of fertilizers on soil nutrient contents in a small holding village. African. J Agric. Res 2015;10(53):4850-4857.
10. Filgueiras AV, Lavilla I, Bendicho C. Chemical sequential extraction in environmental solid samples. Journal of Environmental Monitoring 2002;4:823-857.
11. Iwasaki K, Yoshikawa G. Fractionation of copper and zinc in greenhouse soils. In Proceedings of the Transactions of the 14th International Congress of Soil Science 1990;2:363-364.
12. Miller WP, Martens DC Zeolazincy LW. Effect of sequence in extraction of trace metals from soils. J Soil Sci. Soc. Am 1986;50(3):598-601.
13. Nolovic L. Geochemical studies on transition events in soils. Experimental study on the influence of trace elements on the behavior of iron and the evolution of fervic compounds in pedogenesis. Soil Fertil 1978;4:580.
14. Peterson GW, Corey RB. A modified Chang and Jackson procedure for routine fractionation of inorganic soil phosphates. Soil Sci. Soc. Am. J 1966;32(5):73-76.
15. Saeed M, Fox RL. Influence of phosphate fertilization on zinc adsorption by tropical soils. Soil Sci. Soc. Am. J 1979;43(4):683-6.
16. Shambhavi S. Dynamics of micronutrient cations in soil-plant system as influenced by long-term application of chemical fertilizers and amendments in an acid Alfisol. Ph.D. (Ag) thesis, CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur 2011, 222.
17. Shuman LM. Effect of phosphorus level on extractable micronutrients and their distribution among soil fractions. Soil Sci. Soc. Am. J 1988;52(1):136-141.
18. Sihag O, Singh JP, Mehta OS, Bhardwaj KK. Effect of integrated use of inorganic fertilizer and organic material on the distribution of different forms of phosphorus in soil. J India. Soc. Soil Sci 2005;53(1):80-84.
19. Srinivasan Dinesh R, Varshini Srambikkal, Hamza Anandaraj Manonmani. Massive phosphorus accumulation in soils: Kerala's continuing conundrum. Current Sci 2014;106:343-344.
20. Stanton DA, Burger RD. Studies on zinc in selected Orange Free State soils: V: mechanisms for the reaction of zinc with iron and aluminium oxides. Agrochemophysica 1970;2(3):65-79.
21. Swaminathan MS. Can science and technology feed the world in 2025? Field Crop Res 2007;104(1):3-9.