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Some extractable iron contents as influenced by some organic manures application in the soils of Lake Geriyo, Adamawa state, Nigeria

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ABSTRACT

Organic manures are safer sources of plant nutrients and a good source of micronutrients therefore; pot experiments were carried out to estimate some extractable iron contents as influenced by organic manure application in the soils of Lake Geriyo, Adamawa state, Nigeria. Two types of organic manures; poultry droppings, cow dung and control were used for the experiment. Three levels of organic manures; 5, 10 and 15 tons per hectare (ton ha^{-1}) and three sampling time (30, 60 and 90 DAS were laid down in a completely randomized (CRD) design replicated three times. Results obtained revealed that rate, type of organic manures and time of submergence significantly ($P \leq 0.05$) changed Fe content in the soil. Mean extractable iron concentrations of 42.01, 56.13 and 24.63 $mgkg^{-1}$ were recorded for ammonium oxalate extractable iron, Citrate Bicarbonate Dithionite extractable iron and sodium pyrophosphate extractable iron in the first experiment while 45.81, 59.29 and 28.89 $mgkg^{-1}$ were recorded for the second experiment respectively. However, CBD which extracts both amorphous and crystalline Fe recorded the highest Fe contents throughout the treatments with poultry droppings applied pots recording superior values than that of cowdung manure. similarly, higher values of oxa-Fe and Pyro-Fe were recorded in both manures compared to the control. In conclusion poultry droppings may result in iron accumulation and toxicity hence should be used with caution in the soil of Lake Geriyo and similar soils to avoid serious soil reduction leading to iron toxicity and soil phosphorus antagonism.

INTRODUCTION

Iron (Fe) is ranked fourth in abundance after oxygen, silicon and aluminium in the earth's crust (Schulte 2004). It is the most abundant of all the elements plants derived from the soil. Total iron concentrations in soils ranged from 1-5 % (Schulte 2004). Nutritionally, in plants system, Fe is classified as a micronutrient or trace element, as it is required only in small amounts (Brady and Weil 2008). Any problem with iron supply to plants is therefore one of availability in the soil because, most of the iron in soil is found in ferromagnetic minerals or as iron oxides and hydroxides, forms that are readily available for plant use (Ghodsie and Ahmad 2013).

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Iron availability is very sensitive to soil pH, oxygen and organic matter content of the soil (Claudio et al. 2014). Iron solubility increases 1,000-fold for every one unit change in pH. Soil oxygen reacts with iron to create Fe_2O_3, which is basically soil rust, if there is more oxygen in the soil, more soluble iron will be converted to soil rust (Schulte 2004). Factors that reduce soil oxygen include excess soil moisture and microbial activity. The addition of organic residue through microbial activity reduces soil oxygen because soil microbes consume soil oxygen as they decompose the residue (Brady and Weil 2008).

Organic matter has the strongest attraction for iron than any other nutrient, therefore, it is a great storehouse for iron and helps maintain soil iron in a highly available chelated form that is readily taken up by the plant (Turner and Leytem 2004). However, the organic manure source is a determining factor in the quantity of iron complexes and released for plant uptake (Chen and Avnimelech 1986). Many arid soils contain 5 to 50 percent free limestone ($CaCO_3$) and iron is readily adsorbed to the surfaces of the limestone mineral.

Soils with clay or silt size have much more mineral surface area to adsorb iron than soil that contains predominantly sand or gravel-size limestone (Parsa et al. 1979). Clay and silt texture are therefore, more susceptible to iron toxicity. Iron toxic soils have high amounts of reducible Fe, low pH, and low CEC and exchangeable K content (Ottow et al. 1982*)*. These may be associated with P and Zn deficiency and H_2S toxicity (Kirk 2004). Schulte (2004) also linked Fe toxicity to water logging and anoxic soil conditions.

The amount of extractable Fe^{2+} increases with the source and quantity of organic matter and reduced soil conditions (Ghodsie and Ahmad 2013). It is enhanced by low initial soil pH, a sustained supply of organic matter and the absence of compounds with a higher oxidation state than Fe(III) – oxide (Ponnamperuma 1972). It also, increases with the duration of sub-mergence, potentially reaching peak values at about 2–8 weeks after soil flooding and remains constant thereafter (Sadana et al. 1995). When field are drained, which results in a re-oxidation, Sahrawat (1979) reported that extractable iron content of the soil decreased significantly leading to detoxification of Fe^{2+} to Fe^{3+} (This re-oxidation has been shown to be either an enzymatic process involving aerobic microbes or an anaerobic microbial iron oxidation, involving both phototrophic and nitrate-reducing bacteria.

MATERIALS AND METHODS

The experiment was laid out in a completely randomized design (CRD) (as the soil samples were collected from the field and made into a composite sample before weighing it into the experimental pots i.e soil samples were homogenize as such, variation was eliminated hence the absence of blocking but replications to increase precision) replicated three (3) times with the following treatments; Organic manure source (three treatments): control, cow dung and poultry droppings; Organic manure level (three treatments): 5 ton ha^{-1}, 10 ton ha^{-1} and 15 ton ha^{-1} and Incubation time (three treatments): 30, 60 and 90 days after submergence (DAS).

The study was conducted at the Modibbo Adama University of Technology (MAUTECH), Yola, Soil Science Laboratory and Landscape unit, Girei Local Government Area of Adamawa State. The soil samples were collected from Geriyo which is located 2km North of Jimeta metropolis, Yola North Local Government Area, Adamawa State, within the savannah ecological zone of Nigeria (Tya Tahye 2011).

Two organic manures; Cow dung and poultry (Broilers) droppings sourced from the university farm and other farms around were used. Nine kg (9 kg) of soil samples (at field moisture condition) was collected from Geriyo and weighed into perforated plastic pots of height = 23.5cm, diameter = 22.5cm. This was kept under submergence at MAUTECH land scape unit.

The organic manures; Cow dung and Poultry droppings were air dried and ground using porcelain mortar and pestle, sieved through a 2-mm sieve for laboratory analysis. Manure for incorporation into the experimental pots was ground to increase the surface area, before incorporating it into the soil for ease of decomposition.

Soil samples were taken randomly across the experimental field (Geriyo) to a depth of 20 cm and bulked for laboratory analysis before the commencement of the research. In the laboratory, the soil samples were air-dried, crushed using a porcelain mortar and pestle and then sieved through a 2-mm mesh sieve. The sieved samples were stored in labeled polythene bags for laboratory analysis at the Modibbo Adama University of Technology (MAUTECH), Yola, Soil Science laboratory.

Soil samples were collected from the experimental pots after every 30 days and were analyzed for pH, Available P and three extractable Fe (Ammonium oxalate, Citrate Bicarbonate Dithionite and Sodium pyrophosphate extractable iron) the soil pH was determined as described by Jaiswal (2003), Available P was determined as described by Bray and Kurtz (1945). Oxalate extractable iron, CBD extractable and pyrophosphate extractable iron were determined as described by Haluschak (2006). The data collected were analyzed using Statistical analysis software (SAS) (Arthur, 2013) and the means were separated using least significant difference (LSD) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Result on the effects of organic manures on ammonium oxalate extractable iron (oxa-Fe) showed that, there were highly significant differences ($P \leq 0.01$) among the level of organic manures on Oxa-Fe concentration in the first experiment (Table 1). The increase in oxa-Fe concentration with time of submergence and applied organic manures may not be unconnected to increased available P with Time and added organic manures. Studies have shown that greater availability of soil P under flooded condition is related to increased ammonium oxalate extractable iron (Khalid et al. 1977; Willet 1986). Similarly, Shahandeh et al. (1994) reported increased oxalate extractable iron in soils of southern U.S.A and attributed it to phosphorus availability.

Table 1. Effect of Rate, Time and Type of Organic Manures on soil pH, AVP and Some Soil Extractable Fe for First Experiment

Trts	pH	AV.P (mg Kg^{-1})	Oxa-Fe (mg kg^{-1})	CBD-Fe (mg kg^{-1})	Pyro Fe (mg kg^{-1})
Level					
5 ton ha^{-1}	7.09	5.47	42.08	55.67	23.16
10 ton ha^{-1}	7.01	6.28	41.94	56.19	24.30
15 ton ha^{-1}	6.92	7.45	42.00	56.52	26.40
Mean	7.01	6.40	42.01	56.13	24.63
LSD	0.227	0.941	0.03	0.063	0.031
Time					
30 DAS	7.20	5.29	41.70	54.73	22.34
60 DAS	7.01	5.79	41.93	56.60	24.47
90 DAS	6.81	8.11	42.39	57.06	27.06
Mean	7.01	6.40	42.01	56.13	24.63
LSD	0.227	0.941	0.03	0.063	0.031
Type					
Control	6.77	5.59	41.56	56.34	23.55
Cow dung	6.91	6.12	42.07	55.84	25.62
Poultry D.	7.34	7.48	42.39	56.21	24.71
Mean	7.01	6.40	42.01	56.13	24.63
LSD	0.227	0.941	0.03	0.063	0.031

DAS = Days after submergence, Poultry D. = Poultry droppings, Oxa-Fe = Ammonium oxalate extractable iron, CBD-Fe = sodium citrate bicarbonate dithionite extractable iron, pyro Fe = sodium pyrophosphate extractable iron

Table 2. Effect of Rate, Time and Type Organic Manures on soil pH, AVP and Some Soil Extractable Fe for Second Experiment

Trts	pH	AV.P (mg Kg^{-1})	Oxa-Fe (mg Kg^{-1})	CBD-Fe (mg Kg^{-1})	Pyro-Fe (mg Kg^{-1})
Rate					
5 ton ha^{-1}	6.81	15.88	45.85	58.88	25.93
10 ton ha^{-1}	6.93	17.51	45.77	59.97	26.40
15 ton ha^{-1}	6.97	20.72	45.81	59.33	28.34
Mean	6.91	18.03	45.81	59.29	26.89
LSD	0.142	1.43	0.143	0.179	0.259
Time					
30 DAS	7.09	21.82	45.44	58.40	25.22
60 DAS	6.80	11.83	45.76	59.49	26.48
90 DAS	6.83	20.45	46.24	59.97	28.98
Mean	6.91	18.03	45.81	59.29	26.89
LSD	0.142	1.43	0.143	0.179	0.259
Type					
Control	6.56	15.92	45.39	59.14	25.60
cow dung	6.86	17.87	45.90	59.62	27.75
Poultry D.	7.30	20.31	46.15	59.11	27.33
Mean	6.91	18.03	45.81	59.29	26.89
LSD	0.142	1.43	0.143	0.179	0.259

DAS = Days after submergence, Poultry D. = Poultry droppings, Oxa-Fe = Ammonium oxalate extractable iron, CBD-Fe = sodium citrate bicarbonate dithionite extractable iron, pyro Fe = sodium pyrophosphate extractable iron

Table 3. Characterization of Organic Manures

	Moist (%)	N (g kg^{-1})	P (mg kg^{-1})	%K	OC (g kg^{-1})	pH	Fe (g kg^{-1})
Poultry droppings	28.45	21.6	4250	3.01	220.1	8.2	0.2
Cow dung	34.63	19.2	800	2.75	318.2	7.8	0.05

Adopted from Solomon et al. (2014 a and b) only Fe (g kg^{-1}) was determined during this experiment.

Similar to Oxa- Fe, highly significant differences (P≤0.01) were observed among the type and rate of organic manures on citrate bicarbonate dithionite extractable iron (CBD-Fe) in the first experiment (Table 1). Increased concentration of Citrate bicarbonate dithionite extractable iron by applied organic manures was not consistent to support their influence on the concentration of CBD-Fe. However, CBD-Fe concentration increased with increasing time of submergence. Similar result was reported by Sadana et al. (1995). They reported that the extractable iron content increased with duration of sub-mergence, potentially reaching peak values at about 2–8 weeks after soil flooding and remain constant thereafter. They linked the increase to the quantity of decomposable organic matter, temperature, and amount of available redox buffers. Similar result was also reported by Ghodsie and Ahmad (2013). The rise in CBD-Fe concentration with time of submergence may be attributed to the increase in Oxa-extractable iron (amorphous iron) as well as increased clay content with time on the application of organic manures. Wongchandaeng and Keerati- kasikorn (2002) obtained similar result and attributed increased CBD-Fe content to the percentage clay content of the soil. Higher CBD-Fe was recorded throughout and treatments compared to either ammonium oxalate or sodium pyrophosphate. This concurred with the report of Wongchandaeng and Keerati- kasikorn (2002). They reported that CBD extracts both crystalline and amorphous iron whereas, ammonium oxalate and sodium pyrophosphate extract amorphous and organically bound iron respectively.

The effects of organic manures on sodium pyrophosphate extractable iron (pyro-Fe) showed highly significant differences ($P \leq 0.01$) in the first and second experiments (Table 1 and 2). Results obtained (Table 1 and 2) indicate synergy between pyro-Fe and time of submergence. Although the application of organic manures increased pyro-Fe concentration, type of the organic manures had greater impact on its concentration. The higher pyro-Fe concentration recorded by the cow dung application may not be unconnected with the organic carbon content of 31.82 % (Table 3) of the applied organic manure. Wongchandaeng and Keerati- kasikorn (2002) obtained similar result and reported that pyrophosphate extractable iron as well as crystalline and amorphous iron oxides was related to total organic matter and carbon. Turner and Leytem (2004) also reported that organic matter has the strongest attraction for iron than any other nutrient and is a great storehouse for iron and helps maintain soil iron in a highly available chelated form that is readily taken up by the plant.

CONCLUSION

Concentrations of ammonium oxalate, CBD and sodium pyrophosphate extractable iron increased with time and application of organic manures. However, poultry droppings applied pots recorded higher extractable iron values which may result in iron accumulation and toxicity. Poultry droppings should therefore be used with caution in the soils of Lake Geriyo and similar soils to avoid serious soil reduction leading to iron toxicity and soil phosphorus antagonism.

REFERENCES

Arthur L. (2013) Handbook of SAS DATA Step Programming. CRC Press. pp. 149. ISBN 978-1-4665-5238-8.

Brady N. C. and Weil R. R. (2008) The Nature and Properties of Soils (14^{TH} ed.). Prentice hall Inc. New Delhi. 980pp.

Bray R.A and Kurtz L.T. (1945) Determination of Total and Available Forms of Phosphorus In: Soil Science, 38. 617 – 628.

ChenY. and Avnimelech (1986) Developments in Plant and Soil Science: The Role of Organic Matter in Modern Agriculture. Martinus Nijholf Publishers, Bosto. Pp. 128-130.

Claudio C. Giuseppe P. Ji- Zheng H. Roberto P. and Stefano C. (2014)Review on iron availability in soils: Interaction of Iron with plant and Microbes. Journal of Soil and Sediment, 14:538-548.

Ghodsie H. R. and Ahmad G. A. (2013) Effects of cow manure application on the distribution fraction of Fe, Mn, and Zn in Agricultural soils. IOSR Journal of Agriculture and Veternary science e-ISSN:2319-2386, p-ISSN:2319-2372 6 (2):60-66.

Haluschak P. (2006) Laboratory methods of soil analysis. Canada- Manitoba soil survrey. Pp. 116-122.

Jaiswal P. C. (2003) Soil, Plant and Water Analyses. Kalyani Publishers Ludhiana, New Delhi – Norda Hyderabab, India. Pp. 1 – 399.

Khalid R. A. Patrick Jr.W. H. and Delaune E. D. (1977) Phosphorus Sorption Characteristics of Flooded Soils. Soil Science Society of America Proceeding, 41, 303 – 310.

Kirk G. J. D. (2004) The Biogeochemistry of Submerged Soils. John Wiley & Sons, Chichester, UK., p. 291.

Ottow J. C. G. Benckiser G. and Watanabe I. (1982) Iron Toxicity of Rice as a Multiple Nutritional soil Stress. In: Proc.Int.Symposium on Distribution, Characteristics and Utilization of Problem Soils. Tropical Agriculture Research Center, Ibaraki, Pp. 167–179.

Ponnamperuma,F. N. (1972) The Chemistry of Submerged Soils. Advances in Agronomy, 24. 29–96.

Prade, K. Ottow J. C. G. Jacq, V. A. Malouf, G. and Loyer, J. Y. (1990): Relationships between the Properties of Flooded Rice Soils and Iron Toxicity in Lower Casamance (Senegal). Studies, Review and Summary of Previous Work. Cahiers ORSTOM, Serie Pedologie,IRD, Montpelliers, Fra nce, Pp. 453–474.

Sadana U. S. Chahal D. S. and Abadia J. (1995) Iron Availability, Elec-Trochemical Changes and Nutrient Content of Rice as Influenced by Green Manuring in Aa Submerged Soil. Iron Nutrition in Soils and Plants. Develop. Plant and Soil Science,59. 105–109.

Sahrawat K. L. (1979) Iron Toxicity to Rice in an Acid Sulfate Soil as Influenced By Water Regimes. Plant and Soil, 51: 143–144.

Schulte E. E. (2004) Soil and Applied Iron. Cooperative Extension Publication,University of Wisconsin Extension. Pp. 1-2.

Shahandeh H. Hosssner L. R. and Turner F. T. (1994a) Phosphorus Relationship in Flooded

Soils with Low Extractable Phosphorus. Soil Science Society of America Journal, 58, 1184-1189.

Solomon R. I. Saddiq A. M. and Usman B. H. (2014a) Effects of Different Types of Organic Materials on Different Forms of P Under Submerged Condition in the Soils of Lake Geriyo Irrigation Project, Adamawa State, Nigeria. IOSR Journal of Agric. And Veterinary Sciences (IOSR- JAVS). 7 (6): 11-18.

Solomon R. I. Saddiq A. M. and Usman B. H. (2014b) Effects of Some Organic Manures on N, P, K, Zn And Fe Uptake in Straw and Grains Of Rice in the Soils of Lake Geriyo, Adamawa State, Nigeria. American Eurasian Journal of Agric. and Environmental science, 14 (7):674-680.

Turner B.L. and Leytem, A.B. (2004) Phosphorus Compounds in Sequential Extracts of Animal Manures: Chemical Speciation and a Novel Fractionation Procedure. Environ Science Technology, 38. 6101–6108.

Tya Tahye S. K. (2011) Assessment of Water Allocation Strategies on Adequacy and Equity of Water Distribution at Tertiary Level of Geriyo Irrigation Project. American-Eurasian Journal of Agriculture & Environmental Science, 10 (3): 419-424, ISSN 1818-6769© IDOSI Publications.

Willet I.R. (1986) Phosphorus Dynamics in Relation to Redox Processes in flooded soils. Trans. 13th International Congo Soil Science. (Hamburg) 6. 748-755.

Wongchandaeng A. and Keerati-kasikorn P. (2002) Relationship between Phosphate Adsorption and Forms of Iron and Aluminium Oxides in Thai Soils. Symposium No. 28, 17th World Congress of Soil Science. Pp. 2324-2331.

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