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Incubation of Selected Tanzanian Chromic Acrisol with Minjingu Mazao Fertilizer, Cattle and Poultry Manures and Their Effects on Phosphorus Availability

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ABSTRACT

This study investigated effects of incubation period on Phosphorus (P) release from selected P-sources. The latter are reported to improve levels of P in highly weathered Chromic Acrisol, which has been under continuous cultivation. The study was based on screen-house which utilized Minjingu Mazao (MM) fertilizer, Cattle (CM) and Poultry (PM) manures. The MM fertilizer was applied at 0.258 g per 4 kg soil, equivalent to 40 kg P ha^{-1}. Cattle manure and PM were incorporated in soils with and without MM at 10 g per 4 kg soil. The incubation went through 14, 28 and 42 days and P was analyzed after every incubation period. Results showed that incubating the soil with deionized water for 14 days adjusted P from 7.9 to 8.4 mg kg^{-1} soil. The MM, PM and CM increased P to 12.2, 15.9 and 17.9 mg kg^{-1}, respectively. In addition, MM+CM, MM+PM increased P to 16.1 and 14.2 mg kg^{-1}, respectively. Initially, P increased significantly ($p < 0.001$) but later decreased substantially beyond 14 days. However, PM and CM gave relatively promising P values between 14 and 28 days as opposed to 42 days of incubation. It was concluded that incubating cattle manure and incorporating it with Minjingu Mazao fertilizer provides promising P quantities indicating high rates of P depletion in soils. Incubating soil with poultry manure and incorporating Minjingu Mazao fertilizer had slow release of P hence, might benefit a slow growing crop.

Key words: Chromic acrisol, phosphorus, incubation, minjingu mazao, manures

INTRODUCTION

Soil fertility depletion is a fundamental biophysical factor that accounts for the declining agricultural production in Sub-Saharan Africa (SSA), Tanzania inclusive (Kisetu and Teveli, 2013). Unstable agricultural production and low per capita income in developing countries reinforce decline in soil fertility as land degradation and water resources also reduce the capacity of smallholder farmers to invest in sustainable soil fertility management (Shiferaw *et al.*, 2009). There has since long been a contradiction that fertilizer use and adoption of this practice in SSA is low besides high return to fertilizer use and high levels of land degradation and nutrient mining related to continuous agricultural activities (Vondolia, 2011).

Phosphorus (P) deficiency problems are common in highly weathered Chromic Acrisols (Ferralsols) and young soils (Andisols) because of their strong acidic and/or alkaline reactions, respectively and abundance of Al and Fe ions (Saleque *et al.*, 2004), which are the acid forming cations (Kisetu and Teveli, 2013). Phosphorus retention by these agricultural potential soils (Msanya *et al.*, 2003), is also influenced by Fe and Al oxides (Hakim, 2002), exchangeable calcium (Ca) and Magnesium (Mg), soil texture, porosity, ionic strength and hydraulic conductivity (Del Bubba *et al.*, 2003) and land utilization types (Amapu *et al.*, 2000). Man's land use activities affect global P-cycle and if P is applied to soils in excess of crop requirement, P will generally build up in the soil (Zhang *et al.*, 2005) and this would increase the chances of P losses in soil system through leaching, percolation and/or formation of complex compounds in soil suspensions (Sharpley *et al.*, 1999).

Ferralsols are among the major red soils dominating the humid and sub-humid tropics of Africa (Deckers, 1993) and are characterized by low total and available P contents attributed to high P retention capacities (Friesen *et al.*, 1997). Most of these soils have subsurface horizons (fragipans) with hardened accumulations of Fe oxides-haematite (Fe_2O_3) or hydroxides-goethite ($FeO(OH)$) and limonite ($FeO(OH).n(H_2O)$) mixed with other minerals such as plinthite and ironstone (Shaw, 2006), constituents which hamper availability of P for plant uptake. Low quantities of soluble P in soil limit crop production (Moazed *et al.*, 2010). Crop response to P applications to P deficient soils have been highly erratic and below expectations, using various plant growth models, a phenomenon which has been attributed to the P-adsorption capacities and other transformations in soils (Kisetu and Teveli, 2013). According to Heerink *et al.* (2001), a need to restore and preserve sustainability of agriculture and safeguard the livelihood of large segments of rural population should be urgent to rebuild soil fertility using locally available nutrient sources, improve and sustain current levels of productivity and farm income.

There have been low rates of fertilizer consumption in developing countries, hence retarding economic adjustment through agricultural sector. According to Morris *et al.* (2007), fertilizers use intensity in Africa was 8 kg ha^{-1} in the year 2000 as compared to 96 kg ha^{-1} for East and Southeast Asia and 101 kg ha^{-1} for South Asia and Netherlands' usage was 400 kg ha^{-1}. The explanation for this normally ranges from fertilizer marketing system imperfections to systematic biases in dynamic decisions, a situation which has contributed to low food reserves in community thereby increasing hunger in the area concerned (Kisetu and Teveli, 2013). A study by Banful (2009) holds that past efforts to promote use of fertilizer as soil amendments in agricultural potential parts of Africa were too narrow and only concentrated on stimulating increase in fertilizer use without crowding in other complementary inputs such as investment in feasible organic materials on soil and water conservation. Phosphorus is an essential plant nutrient and its deficiency in soils severely affects crop yields (Brady and Weil, 2008).

Depending on its geologic origin, Phosphate Rock (PR) has widely varying mineralogy, texture and chemical properties. Some PR exists as hard-rock deposits, while other exists as soft colloidal (soil-like) PR material (Msolla *et al.*, 2005). The existing high variation in the nutrients' status or elemental compositions and the overall potentials of Phosphate Rocks greatly influences their market and crop values.

The general reaction of PR dissolution added to soils to a plant available form is:

$$Ca_5(PO_4)_3F + 6H+ \leftrightarrow 5Ca^2+ + \underbrace{3H_2PO_5^- +}_{\text{Plant available P}} F^- \qquad (1)$$

Low soil Ca concentrations and high Cation Exchange Capacity (CEC) favour PR dissolution since Ca is one of the reaction products resulting from PR dissolution. A study conducted by Tengerdy and Szakacs (2003) showed that soil conditions that limit Ca availability (soil acidity, high leaching, or presence of organic compounds that complex exchangeable Ca) also favour PR dissolution and release of P. In addition, Akande *et al.* (2004) emphasized that among the cultural practices that may improve P availability from PR include broadcast applications to maximize soil dissolution reactions and using managements that promote root colonization by mycorrhizal fungi. However, Zapata (2002) insisted that an application of PR should be made several weeks or months prior to anticipated need for plant nutrients. Akande *et al.* (2005) also reported that although lime applications are important for reducing harmful effects associated with soil acidity, lime additions tend to reduce the value of PR as a source of nutrient.

Soil moisture and pH are among the important attributes in the dissolution of Phosphate Rock (PR) (Zapata, 2002). The PR is much more soluble in acidic soils ($pH<5.5$) but several local and technical approaches have been used to promote and increase P availability in PR including: (1) Incorporation of additives into PR, (2) Partial acidulation of PR, (3) Compaction of PR with water-soluble P fertilizers and (4) Microbial dissolution methods (Straaten, 2002). Composting manure and/or biological wastes with PR has since long been shown to enhance dissolution of the PR and is practiced widely as a low-input technology to improve the fertilizer P value of manure (Mahimairaja *et al.*, 1995). However, there is little information available on feasibility of this technology with Minjingu-Mazao fertilizer which is of PR origin in enhancing P availability under Tanzanian soils (Ikerra *et al.*, 2006). In addition, there are no studies that have critically been conducted to investigate influence of cattle and poultry manures on release of nutrient P under different soil amendments. These knowledge gaps necessitated the need for this study which determines quantities of P released from Minjingu Mazao (31% P_2O_5 carrying 13% P) fertilizer applied at a rate equivalent to 40 kg P ha^{-1} checked with cattle and poultry manures. Therefore, this study determined effects of incubating soil with M-Mazao fertilizer, cattle and poultry manures to P released.

In addition, it determined the relationship between P-sources incubated and P released.

MATERIALS AND METHODS

Experimental site and acquisition of the experimental materials: The study involved laboratory pot-incubation experiment which was conducted at the Sokoine University of Agriculture (SUA). Fresh organic manures (cattle and poultry) were collected from Magadu Livestock Farm hosted by the Department of Animal Science and Production at SUA, whereas the Minjingu Mazao fertilizer was obtained from fertilizers stock in the Department of Soil Science at SUA. The bulky soil Chromic Acrisol for composting Minjingu Mazao fertilizer and organic manures was collected from SUA Farm, section of the Department of Soil Science located between latitude 07°25' South and longitude 38°04' East and at an elevation of 540 m above mean sea level (amsl). The soil is characteristically kaolinitic receiving annual rainfall between 800 and 950 mm lasting from November to January and the second season (long rains) lasting from February to May (Hatibu *et al.*, 2003).

Decomposing organic manures and setting of incubation experiment: Fresh organic manures (cattle and poultry) were decomposed exclusively in limited supply of oxygen for 14 days into humus by regular moistening with tap-water to 30% moisture content along with monitoring temperature changes in the decomposing containers. Thereafter, organic manure compost was left to cool under shade for 12 h and a small amount of each type of manure was packed in small bags for lab moisture content determination. Thereafter, the composts were incorporated into 4 kg 8 mm sieved soil in 5 L capacity plastic containers. Three pots were kept as absolute control in which its soils were not incorporated with M-Mazao fertilizer or organic composts. In the pots while considering the amount of moisture content, 10 g of manure compost was incorporated with 0.258 g of 31% P_2O_5 Minjingu Mazao fertilizer into 4 kg soil in a pot (equivalent to 5 t ha^{-1} manure and 40 kg P ha^{-1} of MM fertilizer). The treatments were such that: S = Soil alone, MM = Minjingu Mazao alone, C = Cattle manure compost, PM = Poultry manure compost, MM+CM = Minjingu Mazao and cattle manure compost, MM+PM = Minjingu Mazao and poultry manure compost. Each treatment was managed in nine different pots in Complete Randomized Design (CRD) that is three orthogonal replications making total of 54 pots. All pots were incubated at 60% moisture level for 7 days and then maintained at 30% moisture level throughout the period of experiment. The minimum incubation period was 14 days for the first 3 pots of each treatment and the maximum was 42 days for the last 3 pots of each treatment. Between the minimum and maximum incubation periods, there were other 3 pots of each treatment analyzed for P at 28 days from the onset of experiment.

Data collection: Soil analysis was done before and during experimentation periods. The soil was analyzed for pH, available P, total N, organic carbon and corrected to organic matter content before incorporating with treatments (Okalebo *et al.*, 2002) and particle size distribution was determined by Bouyoucos hydrometer method (Gee and Bauder, 1986). In addition, at the end of each incubation period, soil samples were taken from experimental pots using a trenched 15 cm long knife. These soil samples were air-dried on magazines, sieved in 2 mm sieve wire mesh and stored using paper bags. Thereafter, available P for each sample was analyzed accordingly.

Statistical data handling: The data from incubated soil samples were truncated and organized using MS-Excel computer programme including drawing of columns and graphs. The data were analyzed based in one-way ANOVA design in randomized blocks and the means compared based on Duncan's Multiple Range Test at 5% level. Furthermore, the Chi-square statistical test of Maximum Likelihood was used to determine association effects of P-sources and days of incubation to the quantities of P released. All statistics were performed using GenStat Computer Software (Wim *et al.*, 2007).

RESULTS

Properties of the study soil: The results of some physical and chemical characteristics of the experimental soil are presented in Table 1.

Quantities of P released from treatments at different periods of incubation: The results of the quantities of P released from M-Mazao fertilizer, cattle and poultry manures at different periods of incubation are presented in Table 2.

Relationship between P-sources incubated and P released: The results of the quantities of P released as affected by the association of P-sources incubated are presented in Table 3 and 4 and Fig. 1.

Table 1: Some physical and chemical properties of the study soil

Parameter	Unit	Value	Category
pH (H_2O)		5.4	Low (strongly acid)
Available phosphorus	mg kg^{-1}	7.9	Low
Exchangeable potassium	$cmol_{(+)}$ kg^{-1}	8.3	Very high
Total nitrogen	%	0.11	Low
Organic carbon	%	0.58	Very low
Organic matter	%	1.0	Low
C:N ratio		5:1	Very low quality (<8)
Clay	%	47	
Silt	%	8	
Sand	%	45	
Textural class		Sandy clay	

Ratings column were based on the Landon (1991)

Table 2: Quantities of P released at different periods of incubation

	Days of incubation and amounts of P released (mg kg^{-1})		
Sources of P (Treatments)	Day 14	Day 28	Day 42
Soil alone (control)	08.4±0.00^{a}	01.9±0.00^{a}	01.3±0.00^{b}
M-Mazao (MM)	12.2±0.98^{b}	04.0±0.71^{ab}	00.8±0.63^{ab}
Poultry manure (PM)	15.9±3.14^{b}	14.9±4.92^{d}	01.5±0.29^{c}
Cattle manure (CM)	17.5±11.8^{b}	05.1±0.89^{b}	00.6±0.21^{a}
MM+CM	16.1±2.89^{b}	07.1±3.66^{c}	00.6±0.30^{a}
MM+PM	14.2±3.18^{b}	04.5±3.45^{b}	02.8±0.56^{d}
Mean	14.1±3.70	06.3±2.30	01.3±0.33
$LSD_{(0.05)}$	08.90000	05.20000	00.70000
SE	04.90000	02.90000	00.40000
CV (%)	34.90000	46.50000	28.60000
F stat	***	**	***

F stat: p>0.05 = NS, **p <0.01, ***p <0.001, the means in the same column with different letter (s) differ statistically at 5%

DISCUSSION

Effects of M-Mazao fertilizer, cattle and poultry manures to quantities of P released at different periods of incubation quantities of P released 14 days after incubation.

Soil alone: The results of the soil's P obtained from soils incubated for 14 days with different treatments and their combinations differed significantly ($p<0.001$) with the absolute control and among the treatments (Table 2). Based on the in-situ soil's available P (7.9 mg kg^{-1}) (Table 1), the P from soils which were incubated with deionized water but without any treatment for 14 days increased to 8.4 mg kg^{-1} (Table 2), which is 0.5 mg kg^{-1} (8.4-7.9 mg kg^{-1}) increase in P due to incubation. This was attributed to the time of incubation which probably allowed P dissociation from soil's P retaining sites and/or Ca-chelating agents and from Mn, Fe and Al ox-hydroxides.

M-Mazao fertilizer: The P from soils which were treated with M-Mazao fertilizer for 14 days (12.2 mg kg^{-1}), which is 4.3 mg kg^{-1} (12.2-7.9 mg kg^{-1}) increase in P (Table 2). This was attributed to P contained in soil and in M-Mazao fertilizer. However, this P was relatively higher by 3.8 mg kg^{-1} (4.3-0.5 mg kg^{-1}) than that obtained from soils incubated with deionized water alone.

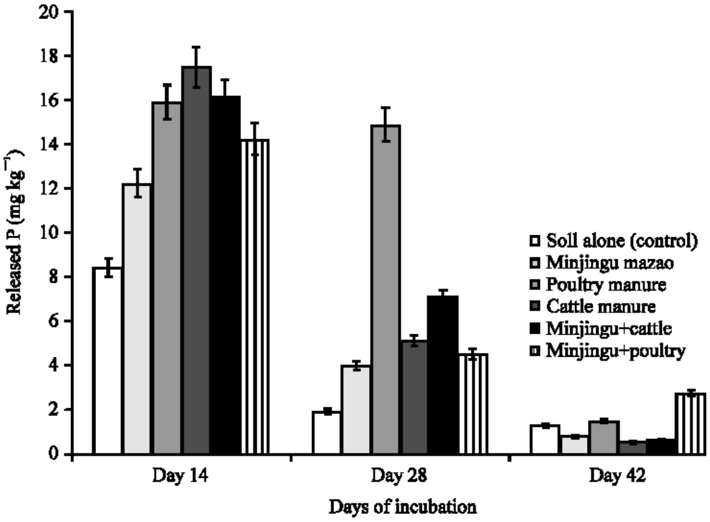

Fig. 1: Comparison of P from treatments at varying days of incubation

This shows that there was an adjustment of P released when M-Mazao fertilizer is applied as a source of P in a Chromic Acrisol whose in-situ available P was low (7.9 mg kg^{-1}) (Table 1). These findings are similar to the findings of Iqbal *et al.* (2010) who report that the efficacy of inorganic fertilizers containing rock phosphate improves soil's physico-chemical parameters during composting.

Poultry manure: The P from soils which were incubated with poultry manure for 14 days (15.9 mg kg^{-1}) indicated 7.5 mg kg^{-1} (15.9-8.4 mg kg^{-1}) soil P recovered, attributed to poultry manure over the absolute control (Table 2). Similar findings are also reported by Mujeeb *et al.* (2010) that poultry manure proves better with 5.37% recovery of P in soil over the absolute control.

Cattle manure: Results showed that 17.9 mg of P per kg soil was obtained from soils which were incubated for 14 days with cattle manure, which is 9.5 mg kg^{-1} more than the absolute control (8.4 mg kg^{-1}) contributed by cattle manure (Table 2). These findings suggest that even though not all P is recovered from the soil but, other P was added to the soil by cattle manure. The P recovered from soil because of incorporating cattle manure could be attributed to the age of cattle and the type of feeds taken by cattle. Similar findings are also reported by Scalenghe *et al.* (2002) who indicate that long-term repeated applications of fertilizers and livestock wastes have resulted in an increase in the soil P status.

M-Mazao fertilizer and cattle manure: The P (16.1 mg kg^{-1}) obtained from soils which were incubated for 14 days with cattle manure and M-Mazao fertilizer in combination was 7.7 mg kg^{-1} (16.1-8.4 mg kg^{-1}) more than the absolute control (8.4 mg kg^{-1}) (Table 2). These findings suggest that the P obtained was relatively lower than that obtained in soils which were incubated with cattle manure alone (17.5 mg kg^{-1}) but larger than that obtained from soils which were incubated with M-Mazao alone (12.2 mg kg^{-1}). The findings indicate that cattle manure posed differences in the quantities of P released from the soil. This could be attributed to the organic materials from cattle manure which differ in their contents of organic acids and in turn might have helped in dissolution of P in soil apart from P from these organic materials. Similar findings are reported by Mujeeb *et al.* (2010). In soils with high P-fixing capacities, such as ferralsols, the organic acids released during decomposition process may increase P availability by coating P adsorption sites or via anion exchange reactions (Brady and Weil, 2008), which could be the case for the P obtained in this soil.

M-Mazao fertilizer and poultry manure: The quantity of P obtained from soils which were incubated with M-Mazao fertilizer and poultry manure in combination (14.2 mg kg^{-1}) was 5.8 and 2.0 mg kg^{-1} more than in the absolute control (8.4 mg kg^{-1}) and M-Mazao alone (12.2 mg kg^{-1}), respectively (Table 2). However, these P quantities were 1.7 mg kg^{-1} less than P obtained from soils which were incubated with poultry manure alone (15.9 mg kg^{-1}). These findings suggest that poultry manure significantly adjusted the quantity of P released from soil and from M-Mazao fertilizer.

Quantities of P released 28 days after incubation: The results of P released from soils which were incubated with different treatments for 28 days showed significant ($p<0.01$) decrease in the quantities of P among treatments and with the absolute control (Table 2). In addition, the P obtained from soils after 28 days of incubation were smaller than the quantities obtained in soils after 14 days of incubation. The general observation showed that decrease in quantities of P released could be attributed to increased P fixation by soil's exchange sites as time of contact increased. Kisetu and Mrema (2010) report that P retained or fixed by soils increased with time of contact and varied with moisture content of the equilibrating medium. The data taken 28 days after incubation showed that the quantities of P (mg kg^{-1}) were in the order: Poultry manure (14)>M-Mazao+cattle manure (7.1)>cattle manure (5.1)>M-Mazao+poultry manure (4.5)>M-Mazao (4.0)>soil alone (1.9) (Table 2).

These results indicate that P decreased rapidly for absolute control and other treatments except P from soils which were incubated with poultry manure, which decreased only very slightly (1 mg kg^{-1}) (Fig. 1). These findings suggest that poultry manure is capable of releasing substantial quantities of P through its decomposition and by dissociating P contained in soil's fixing sites. In addition, the findings suggest that P fixation in soil was decreased due to protective action of poultry manures. Mujeeb *et al.* (2010) report that the concentration of solution P in soil increased with increased organic matter contents. Several mechanisms have been proposed to explain decrease in P adsorption capacity (Iyamuremye and Dick, 1996) including: (1) Competition with phosphate anions for adsorption sites by organic anions produced from decomposition of plant materials and (2) Saturation of adsorption sites by P added to the soil.

Quantities of P released 42 days after incubation: The quantities of P released from soils which were incubated with different treatments for 42 days decreased significantly ($p<0.001$) among treatments and with the absolute control. In addition, P obtained from soils after 42 days of incubation were smaller than P obtained after 14 days of incubation but far smaller than those obtained after 28 days of incubation (Table 2), indicating increase in P fixed with increase in time of contact with the soil.

Table 3: Chi-square test for association between P-sources incubated and P released

P-sources	Days of incubation	Observed deviance	Fitted	Residual
Soil alone (S)	14	8.40	7.56	0.53
	28	1.90	3.36	-1.08
	42	1.30	0.68	0.72
	Mean	3.87	3.87	0.17
M-Mazao (MM)	14	12.20	11.07	0.60
	28	4.00	4.93	-0.55
	42	0.80	1.00*	-0.23
	Mean	5.67	5.67	-0.18
Poultry manure (PM)	14	15.90	21.04	-2.29
	28	14.90	9.36	2.28
	42	1.50	1.90	-0.36
	Mean	10.77	10.77	-0.37
Cattle manure (CM)	14	17.50	15.11	1.12
	28	5.10	6.72	-0.86
	42	0.60	1.36	-0.84
	Mean	7.73	7.73	-0.58
MM+CM	14	16.10	15.50*	0.28
	28	7.10	6.90**	0.10
	42	0.60	1.40	-0.87
	Mean	7.93	7.93	-0.49
MM+PM	14	14.20	14.01**	0.10
	28	4.50	6.23	-0.95
	42	2.80	1.26	1.33
	Mean	7.17	7.17	-0.48

Probability level (under null hypothesis) $p = 0.465$, Likelihood Chi-square value is 9.72 with 10 df, F stat: *$p \leq 0.05$; **$p<0.01$ (picked from Table 4)

The results of the data taken 42 days after incubation showed that the quantity of P in soils treated with poultry manure was relatively larger (5.1 mg kg^{-1}) than P from other soils (Table 2). On the other hand, the quantities of P (mg kg^{-1}) obtained from other soils were in the order: M-Mazao+poultry manure (2.8)>soil alone (1.3)>M-Mazao (0.8)>cattle manure = M-Mazao+cattle manure (0.6) (Table 2). These findings suggest that soils incubated with M-Mazao fertilizer and incorporation of organic manures for a long period (42 days) proves no agronomic importance in enhancing P availability to P depleted soils. The inference to be drawn from this is that there is a need to incorporate composted organic manures well in advance in the season before the onset of rains and in soils which are not flooded.

Relationship between P-sources incubated and P released: The chi-square test (Table 3 and 4) assessed independence of two classifications, P-sources (treatments) and incubation period. Essentially, it tested whether the distribution of P released between the two categories of one factor appears to change according to the categories of the other factor. The test statistic ($p = 0.465$) obtained from this study indicates that the two classifying factors, P-sources and P released, are independent; that is, there is no evidence that they are associated in effecting release of P from soils. The goodness of fit for the chosen distribution is indicated by the residual deviances (Table 3), which have an asymptotic chi-square distribution. The deviance is also the preferred statistic for comparison of nested models.

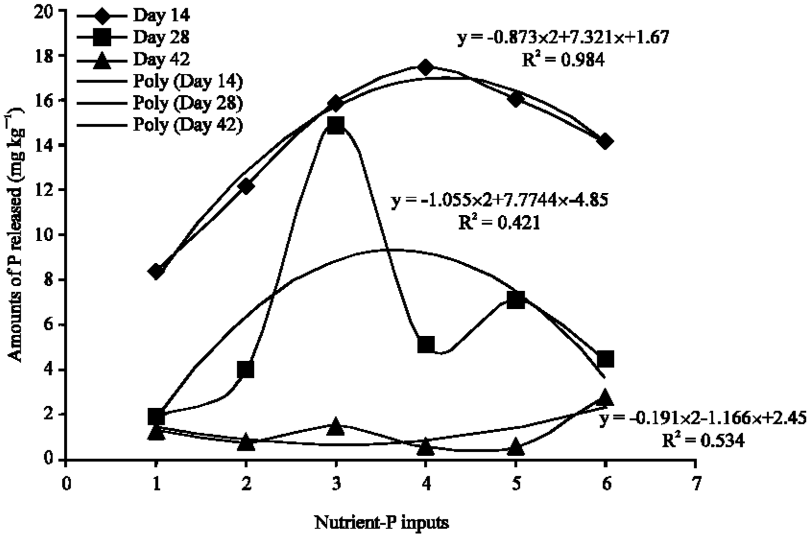

Fig. 2: Comparison of P released in different days of incubating the soil

Table 4: Statistical contributions to the Chi-square of association existing between the studied P-sources and quantities of P released

Days of incubation	14	28	42	Margin
P-sources				
Soil alone (S)	0.091	0.755	0.443	1.288
M-Mazao (MM)	0.111	0.186	0.042	0.339
Poultry manure (PM)	1.374	2.774	0.090	4.237
Cattle manure (CM)	0.358	0.428	0.541	1.327
MM+CM	0.023	0.006	0.581	0.609
MM+PM	0.003	0.533	1.385	1.920
Margin	1.959	4.682	3.081	9.722

Key: The numerals 1, 2, 3, 4, 5 and 6 correspond to soil alone (S), M-Mazao (MM), Poultry Manure (PM), Cattle Manure (CM), MM+CM and MM+PM, respectively

The quantities of P released from the study soils varied significantly with P-sources and decreased with increased period of incubation (Table 3). It was observed from the data that P release decreased slowly with increasing period of incubation from 14 to 42 days. The highest P released from all treatments was noted for data taken 14 days after incubation and the lowest was noted for data taken 42 days after incubation (Table 3; Fig. 1). However, soil alone and soils treated with M-Mazao being it alone or in combination with organic manures showed a resistant decrease in P, which attained almost its threshold of not below 0.5 mg kg^{-1} (Fig. 2). This low decrease in P released by soils could be attributed to increase in P fixed by soil particles as time of contact with soil increased. These results corroborate the findings of Jalali and Zinli (2011) who report that kinetics of P release from soils can be described as an initial rapid rate followed by a slower rate. The same pattern of P release is also observed by Do Carmo Horta and Torrent (2007) and Nafiu (2009).

The greater quantity of P released by soil incubated with poultry manure for 14 and 28 days than P from other soils might be due to distortion of clay particles and more native P in the poultry manure or the adsorbed P might be loosely held by soil particles that were easily released. However, the discrepancy observed for P released between 28 and 42 days of incubation could be attributed to high levels of uric acid produced by poultry manure which suspended P in solution hence low quantity desorbed/released from soil particles. These findings are in agreement with those of Kaloi *et al.* (2011) who report that less release of P with increased time of incubation is due to more positively P Carried over (PCO) soil solution which cannot easily be captured by normal extraction.

On the other hand, in case of soil alone and soils treated with M-Mazao being it alone or in combinations, P in some of them was probably tightly held by soil particles and tends to release slowly due to more sorbing energy. These results are in agreement with those of Do Carmo Horta and Trorrent (2007) who report that the ratio of fast desorbable P or total desorbable P to sorbed P increased with increasing degree of P saturation in the soil.

CONCLUSION

Incubating the soils low in P with different P-containing soil amendments such as cattle and poultry manures and M-Mazao fertilizer substantially increased P levels in soils as the period of incubation exceeded 14 days through 28 and 42 days. However, poultry and cattle manures gave relatively promising quantities of P compared with M-Mazao fertilizer between 14 and 28 days of incubation.

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REFERENCES

Akande, M.O., F.I. Oluwatoyinbo, J.A. Adediran, K.W. Buari and I.O. Yusuf, 2004. Soil amendments affect the release of P from rock phosphate and the development and yield of Okra. J. Vegetable Crop Prod., 9: 3-9.

Akande, M.O., J.A. Adedira and F.I. Oluwatoyinbo, 2005. Effects of rock phosphate amended with poultry manure and soil available P and yield of maize and cowpea. Afr. J. Biotechnol., 4: 444-448.

Amapu, I.Y., V.O. Chude, U. Singl, J.M. Jubrin and S. Adam, 2000. Testing a dynamic phosphorus model in the sub-humid Nigeria savannah agro-ecology. Proceedings of the 26th Annual Conference of Soil Science Society of Nigeria, October 30-November 3, 2000, Ibadan, Oyo State Nigeria, pp: 270-278.

Banful, A.B., 2009. Operational details of the 2008 fertilizer subsidy in Ghana: Preliminary report. Ghana Strategy Support Programme (GSSP), Background Paper 18, International Food Policy Research Institute, Accra, Ghana.

Brady, N.C. and R.R. Weil, 2008. The Nature and Properties of Soils. 14th Edn., Pearson Education Inc., New Jersey, ISBN-13:9780132279383, Pages: 965.

Deckers, J., 1993. Soil Fertility and Environmental Problems in Different Ecological Zones of the Developing Countries in Sub-Saharan Africa. In: The Role of Plant Nutrients and Sustainable Food Production in Sub-Saharan Africa, Van Reuler, H. and W.H. Prins (Eds.). Vereniging van Kunstmest Producenten, Laidschendam, The Netherlands, pp: 37-52.

Del Bubba, M., C.A. Arias and H. Brix, 2003. Phosphorus adsorption maximum of sands for use as media in subsurface flow cultivated reed beds as measured by the *Langmuir adsorption* isotherms. Water Res., 37: 3390-3400.

Do Carmo Horta, M. and J. Torrent, 2007. Phosphorus desorption kinetics in relation to phosphorus forms and sorption properties of Portuguese acid soils. Soil Sci., 172: 631-638.

Friesen, D.K., I.M. Rao, R.J. Thomas, A. Oberson and J.I. Sanz, 1997. Phosphorus acquisition and cycling in crop and pasture systems in low fertility tropical soils. Plant Soil, 196: 289-294.

Gee, G.W. and J.W. Bauder, 1986. Particle Size Analysis. In: Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods, Klute, A. (Ed.). 2nd Edn., American Society of Agronomy, Madison, WI., pp: 383-411.

Hakim, N., 2002. Organic matter for increasing P fertilizer use efficiency of maize ultisol by using 32P technique. Proceedings of the 17th World Congress of Soil Science, August 14-21, 2002, Bangkok, Thailand, pp: 1-8.

Hatibu, N., M.D.B. Young, J.W. Gowing, H.F. Mahoo and O.B. Mzirai, 2003. Developing improved dryland cropping systems for maize in semi-arid Tanzania. Part 1: Experimental evidence for the benefits of rainwater harvesting. Exp. Agric., 39: 297-302.

Heerink, N., H. Van Keulen and M. Kuiper, 2001. Economic Policy and Sustainable Land Use: Recent Advances in Quantitative Analysis for Developing Countries. Springer, New York, USA., ISBN-13: 9783790813517, Pages: 376.

Ikerra, S.T., E. Semu and J.P. Mrema, 2006. Combining *Tithonia diversifolia* and minjingu phosphate rock for improvement of P availability and maize grain yeilds on a chromic acrisol in Morogoro, Tanzania. Nutr. Cycling Agroecosyst., 76: 249-260.

Iqbal, M.K., T. Shafiq, A. Hussain and K. Ahmed, 2010. Effect of enrichment on chemical properties of MSW compost. Bioresour. Technol., 101: 5969-5977.

Iyamuremye, F. and R.P. Dick, 1996. Organic amendments and phosphorus sorption by soils. Adv. Agro., 56: 139-185.

Jalali, M. and N.A.M. Zinli, 2011. Kinetics of phosphorus release from calcareous soils under different land use in Iran. J. Plant Nutr. Soil Sci., 174: 38-46.

Kaloi, G.M., N. Bhughio, R.N. Panhwar, S. Junejo, A.H. Mari and M.A. Bhutto, 2011. Influence of incubation period on phosphate release in two soils of district Hyderabad. J. Anim. Plant Sci., 21: 665-670.

Kisetu, E. and J.P. Mrema, 2010. Phosphate sorption by Andisols and Ultisols and its implication on phosphorus bioavailability in the wet tropics of Tanzania. Proceedings of the 2nd RUFORUM Biennial Meeting, September 20-24, 2010, Entebbe, Uganda, pp: 719-723.

Kisetu, E. and C.N.M. Teveli, 2013. Response of green gram (*Vigna radiata* L.) to an application of Minjingu Mazao fertilizer grown on Olasiti soils from Minjingu-Manyara, Tanzania. Pak. J. Biol. Sci., 16: 1601-1604.

Landon, J.R., 1991. Booker Tropical Soil Manual: A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. John Wiley and Sons, New York, ISBN-13: 978-0582005570, Pages: 474.

Mahimairaja, S., N.S. Bolen and M.J. Hedley, 1995. Dissolution of phosphate rock during the composting of poultry manure: An incubation experiment. Nutr. Cycling Agroecosyst., 40: 93-104.

Moazed, H., Y. Hoseini, A.A. Naseri and F. Abbasi, 2010. Determining phosphorus adsorption isotherm in soil and its relation to soil characteristics. Int. J. Soil Sci., 5: 131-139.

Morris, M., V.A. Kelly, R.J. Kopicki and D. Byerlee, 2007. Fertilizer Use in African Agriculture: Lessons Learned and Good Practice Guidelines. World Bank Publications, Washington, DC., USA., ISBN-13: 9780821368817, Pages: 144.

Msanya, B.M., A.K. Kaaya, S. Araki, H. Otsuka and G.I. Nyadzi, 2003. Pedological characteristics, general fertility and classification of some benchmark soils of Morogoro District, Tanzania. Afr. J. Sci. Technol., 4: 101-112.

Msolla, M.M., J.M.R. Semoka and O.K. Borggaard, 2005. Hard Minjingu phosphate rock: An alternative P source for Maize production on acid soils in Tanzania. Nutrient Cycling Agroecosyst., 72: 299-308.

Mujeeb, F., Rahmatullah, J. Akhtar and R. Ahmad, 2010. Integration of organic and inorganic P sources for improving P use efficiency in different soils. Soil Environ., 29: 122-127.

Nafiu, A., 2009. Effects of soil properties on the kinetics of desorption of phosphate from Alfisols by anion-exchange resins. J. Plant Nutr. Soil Sci., 172: 101-107.

Okalebo, J.R., K.W. Gathua and P. Woomer, 2002. Laboratory Methods of Soil and Plant Analysis: A Working Manual. 2nd Edn., TSBF-CIAT, Nairobi, Kenya, Pagers: 126.

Saleque, M.A., U.A. Naher, A. Islam, A.B.M.B.U. Pathan, A.T.M.S. Hossain and C.A. Meisner, 2004. Inorganic and organic phosphorus fertilizer effects on the phosphorus fractionation in wetland rice soils. Soil Sci. Soc. Am. J., 68: 1635-1644.

Scalenghe, R., A.C. Edwards, F.A. Marsan and E. Barberis, 2002. The effect of reducing conditions on the solubility of phosphorus in a diverse range of European agricultural soils. Eur. J. Soil Sci., 53: 439-447.

Sharpley, A.N., T. Daniel, T. Sims, J. Lemunyon, R. Stevens and R. Parry, 1999. Agricultural phosphorus and eutrophication. U.S. Department of Agriculture, Agricultural Research Service, ARS 149, Washington, DC., USA.

Shaw, J.N., 2006. Ultisols. In: Encyclopaedia of Soil Science, Lal, R. (Ed.). Marcel Dekker Inc., Auburn, Alabama, USA., ISBN-13: 9780849350535.

Shiferaw, B., G. Obare, G. Muricho and S. Silim, 2009. Leveraging institutions for collective action to improve markets for smallholder producers in less-favored areas. Afr. J. Agric. Resour. Econ., 3: 1-18.

Straaten, H.P.V., 2002. Rocks for Crops: Agrominerals of Sub-Saharan Africa. World Agroforestry Centre, ICRAF, Nairobi, Kenya, ISBN-13: 9780889555129, Pages: 338.

Tengerdy, R.P. and G. Szakacs, 2003. Bioconversion of lignocellulose in solid substrate fermentation. Biochem. Eng. J., 13: 169-179.

Vondolia, G.K., 2011. Nudging Boserup? The impact of fertilizer subsidies on investment in soil and water conservation. Working Papers in Economics No. 509, pp: 1-24.

Wim, B., R. Stern, R. Coe and C. Matere, 2007. GenStat Discovery. 4th Edn., ICRAF, Nairobi, Kenya, Pages: 117.

Zapata, F., 2002. Assessment of soil phosphorus status and management of phosphatic fertilizers to optimize crop production. IAEA-TECDOC-1272, International Atomic Energy Agency (IAEA), Vienna, Austria.

Zhang, H., J.L. Schroder, J.K. Fuhrman, N.T. Basta, D.E. Storm and M.E. Payton, 2005. Path and multiple regression analyses of phosphorus sorption capacity. Soil Sci. Soc. Am. J., 69: 96-106.