As. J. Food Ag-Ind. **2009**, *Special Issue*, S205-S210

Asian Journal of Food and Agro-Industry
ISSN 1906-3040
Available online at www.ajofai.info

Effect of manure and chemical fertilizer on solubility of phosphate of phosphorus in soils

Ratchaneeporn Suthiphasilp*

Faculty of Agricultural Technology, ChiangMai Rajabhat University, 202 Changpuak Rd., Chiang Mai 50300, Thailand

*Author to whom corresponding author's e-mail address: rsuthiphasilp@hotmail.com

Abstract

Effects of manure and chemical fertilizer on solubility of phosphate of phosphorus in soils were studied. The experiment was conducted with Yasothon soil series (Yt). Soil was amended with animal manure, chemical fertilizer, or a mixture of the two. Animal manure (poultry, cow, and swine) and chemical fertilizer (KH_2PO_4) were mixed with soil at the rate of 100 mg P·kg^{-1} and extracted phosphorus by; Mehlich 3, Bray II, $CaCI_2$ and H_2O. Treatments were completely randomized design and three replications. Changes in phosphorous in the soil were observed over time. The study found that the chemical fertilizer had the highest phosphorous concentration in the soil. Lesser concentrations of phosphorous were found in the animal manure-chemical fertilizer mix, animal manure, and the control, respectively. However, when the incubation time was increased, the amount of phosphorous in the soil with the chemical fertilizer was high initially but fell progressively with time; Conversely, with the animal manure-chemical fertilizer mix and the animal manure, the concentration of phosphorous in the soil increased concomitantly with the incubation period. The extracted phosphorous was obtained using different agents; Mehlich 3 extracted the highest concentration of phosphorous, followed by Bray II, H_2O and $CaCI_2$.

Keywords : manure, KH_2PO_4, phosphorus.

Introduction

In general, most soils that are used in agriculture often have limited amounts of phosphorus which could be beneficial to plants. Sustainable agricultural systems depend on maintaining adequate amounts of plant nutrients, including P, without unduly increasing either environmental nutrient load or loss. The availability of both applied and indigenous soil P is in influenced by a number of soil characteristics. Soil was formed over a long period of time, so the soil itself contains a low amount of organic matter. Moreover, Pattama (2546) also found that the forest soil in the Northeast region had organic matter at 5.5 g./kg, which reduced to 1.2 g./kg. when the soil was changed into agricultural use. This also caused the soil to be low in pH, and a higher fix of phosphorus. A strong inverse relationship between soluble P concentration and extractable Al and Fe oxides, was demonstrated Sharpley(1983) and Agbenin and Teissen (1995) by Soil P may also from phosphorus precipitates with soil Ca, Al, or Fe (Sharpley et al., 1984) Plus, the report by Udo and Uzu (1972) explained that acid soil in tropical areas would be fixed of the phosphorus as high as the amount of phosphorus in soil. Also, the fixing could increase if the pH value of the soil decreases. The availability of soil P is further influenced by soil texture, primarily because of differences in clay content and soil organic C (Sharply,1983;Sharpley and Sisak,1997). By fixing the phosphorus in soil it then could decrease the useful phosphorus in the plant. The objection of this research was to compare the effect of KH_2PO_4 and animal manure P application on soil P concentrations over time

Materials and Methods

Soils used in the study, was divided in to Yasothon soil series (Yt). The characteristics of the soil was sandy loam, was collected from the Ap horizon (0–20 cm) of a field, sieved (2 mm), air-dried, Also, they were analyzed for pH, OM, CEC, N, P, K, Ca, Mg, S, Fe, Al, and Soil texture : soil pH = 5.7 (1:1, soil/water);Organic matter (OM) 0.72 %; cation-exchange capacity (CEC) = 2.44 cmol kg^{-1}; N= 0.04 %; P = 11.24 ppm.; K = 0.49 cmol kg^{-1}; Ca = 0.66 cmol kg^{-1} Mg = 0.22 cmol kg^{-1}; and extractable S, Fe and Al were 0.004%, 43.37 ppm and 0.69%, respectively.

Poultry, cow, and swine manure were collected directly from commercial farms. They were dried and ground (1mm) for the experiments. Moreover, some characteristics of chemicals in the animal manure being used in the experiment were also analyzed. (table 1).

The experiment was divided into different step experiments in completely randomized design, which consisted of eight treatments and three replications. 80 grams of air-dry soil was weighed into 20-mL scintillation vials. Three replications of the following treatments were prepared: poultry, cow, and swine manures, and KH_2PO_4, all applied at 100 mg total P kg^{-1} dry soil, and an unamended control. Sufficient samples were prepared for each treatment to allow for destructive sampling at 3, 7, 14, and 28 d after amendment. Eight P sources, four sample dates, four extract and three replications. Dry soil and manure were thoroughly mixed, while KH_2PO_4 was dissolved in water and added to soil at the same rate as the manures. Soil water was adjusted to 80% (approximately field capacity), and capped vials were incubated at 30°C; soil water was not adjusted during the incubation period. 3,7,14 and 28d, these samples were dried at temperature's room for 48 h. At each sampling time, subsamples were extracted in water (1 g soil in 10 mL, shaken for 1 h), 0.01 *M* $CaCl_2$ (1 g soil in 10 mL, shaken for 1 h) Bray II (2 g. soil in 20 ml of Bray II, and shaken 1 minute), and Mehlich-III (Mehlich, 1984; 1 g soil in 10 mL of 0.2 *M* CH_3COOH + 0.25 *M* NH_4NO_3 + 0.015 *M* NH_4F + 0.013 *M* HNO_3 + 0.001 *M* EDTA, shaken for 5 min.) Each sample was filtered using #5 filter Paper. The concentration of phosphorus in the sample solution was isolated by Blue's Method (Murphy and Riley, 1962). Furthermore, MSTAT was used for analysis of variance to classify the statistical differences in resource's types of phosphorus, and the amount of phosphorus in the soil. Lastly, the differences in averages between treatments were compared using Duncan's Multiple Range Test.

Table 1: Chemical properties of manures

Manure	pH (1:1)(H_2O)	N	P	K	Ca	Mg	S	C	EC (1:5)dS/m	C:N
		%								
Poultry	8.7	1.92	5.23	1.46	6.16	0.90	2.29	38.78	11.00	20.20
Cow	7.9	2.43	0.87	1.66	0.08	0.06	0.36	45.68	8.30	18.79
Swine	6.6	1.07	1.07	0.29	1.43	0.27	0.27	29.44	0.84	27.51

Results and Discussion

The effects of treatment factors for all extractants are summarized in Table 2-5. Analysis of variance indicated that four extractable soil P pools changed over time, and most exhibited significant differences because of P source. All P fractions declined rapidly after KH_2PO_4 was added to the soil. Water-soluble P, $CaCl_2$, P fractions that were essential immediately available to plants but Bray II and Mehlich 3 extractant were capable of cleaving Al, Fe-bound P, while the WSP and $CaCl_2$ extractant is not. The P concentration of P source (KH_2PO_4 and manure-chemical fertilizer mix, not manure) was rapilly decline in soluble P, with P concentration decline within 28 d of amendment, the fact that are indicative of rapid sorption by soil Al and Fe. The primary difference between KH_2PO_4 and manure P being that KH_2PO_4 had a higher initial solubility in four extractants. This was expected because this mineral P fertilizer source is completely soluble in water, while the average WSP concentration in the manures was between 7.55 (cow) and 18.23% (swine; Table 1) of total P on 28 days. The same as Griffin et al., (2003), he found that the concentration of phosphorus in soil which used chemical fertilizer would be high in the first stage, and would reduce as time goes on. The dissolved phosphorus also is absorbed by Fe & Al in the soil (Sharpley, 1983); while the concentration of phosphorus from animal manures increased because there was little decomposition and there were organic acids to prevent phosphorus fixation to the soil.

An additional trend, best illustrated using manure; as soil P level increases, presumably because the capacity of the soil increases with soil P level over time. In soil mix poultry, cow, and swine manure found that phosphorus concentration in swine manure soil had extractive phosphorus more than soil mixing with poultry and cow manure respectively; swine manure has least C:P ratio, which is 6.30 while poultry manure has 7.41 of C:P ratio and 52.50 in cow manure (table 1). Pattama *et al*., (2003) reports that the progress of changing phosphorus's form in organic decomposition process is similar to nitrogen, which during the early period of decomposition, it will occur net immobilization of phosphorus so C:P ratio of organic will decrease and finally will occur net mineralization of phosphorus. When C:P ratio drops down, there will be P release. The results of the Bray II and Mehlich-III P extractions indicates that, although of these soil tests are useful for predicting crop response to P. Our results suggest, however, that different sources of P contribute to different pools of soil P. McDowell and Sharpley (2001) successfully used M3-P concentration to identify what they termed change points in the relationship between soil P level and $CaCl_2$–P. The rate of increase in $CaCl_2$–P per unit of M3-P was greater above the change point than below the change point.

Our results indicate that these differences in solubility are evident even after a 28-d incubation in soil, with significantly more of the P from KH_2PO_4 remaining in this soluble P fraction. The phosphorus concentration from various extractives such as H_2O, $CaCl_2$, Bray II and Mehlich 3 found that Mehlich 3 gave higher phosphorus concentration than Bray II, H_2O or $CaCl_2$ respectively.

Table 2: H_2O extraction over time after amendment with manure (poultry, cow, swine) or KH_2PO_4

treatment	P concentrations (mg kg^{-1})			
	3d*	7d	14d	28d
Control	0.492 e	0.500 f	0.232 f	0.480 e
KH_2PO_4	34.731 a	32.350 a	32.702 a	22.535 a
Poultry (PM)	8.195 d	8.208 de	12.723 d	12.843 bc
Cow (CM)	4.720 de	4.597 ef	4.927 e	7.550 d
Swine(SM)	15.233 c	13.695 cd	20.117 bc	18.230 ab
Poultry+ KH_2PO_4	15.375 c	19.683 bc	23.162 b	11.772 cd
Cow + KH_2PO_4	19.178 bc	14.541 bc	17.252 c	13.877 bc
Swine + KH_2PO_4	23.200 b	20.253 b	22.337 b	13.157 bc
Avg.	15.140	14.228	16.681	12.555
CV(%)	16.64	18.20	11.60	17.79

Significant at the 0.01 probability level.
*d = Day after application

Table3: $CaCl_2$ extraction over time after amendment with manure (poultry, cow, swine) and KH_2PO_4

treatment	P concentrations (mg kg^{-1})			
	3d*	7d	14d	28d
Control	0.002 d	0.005 c	0.005 c	0.006 c
KH_2PO_4	21.378 a	16.185 a	14.317 a	10.427 ab
Poultry (PM)	2.672 d	2.458 c	3.738 c	5.330 c
Cow (CM)	2.762 d	1.038 c	1.108 d	0.635 d
Swine(SM)	9.378 c	13.182 ab	9.968 b	11.023 a
Poultry+ KH_2PO_4	11.867 bc	10.550 b	9.700 b	6.973 bc
Cow + KH_2PO_4	13.112 b	9.473 b	4.850 c	4.422 c
Swine + KH_2PO_4	14.407 b	11.817 b	8.957 b	5.078 c
Avg.	9.447	8.088	6.580	5.487
CV(%)	18.53	16.23	17.15	16.28

Significant at the 0.01 probability level.
*d = Day after application

Table 4. Bray II extraction over time after amendment with manure (poultry, cow, swine) and KH_2PO_4

treatment	P concentrations (mg kg^{-1})			
	3d*	7d	14d	28d
Control	5.984 c	6.555 d	6.641 c	6.955 c
KH_2PO_4	104.533 a	97.983 a	89.875 a	83.421 b
Poultry (PM)	78.133 b	90.625 a	66.742 b	77.646 b
Cow (CM)	23.942 c	45.350 bc	22.309 c	33.167 c
Swine(SM)	72.467 b	42.792 c	75.050 ab	113.159 ab
Poultry+ KH_2PO_4	82.567 b	74.292 ab	81.108 ab	132.650 a
Cow + KH_2PO_4	72.358 b	70.100 abc	62.667 b	85.655 ab
Swine + KH_2PO_4	109.067 a	96.916 a	81.900 ab	103.971 ab
Avg.	68.631	65.577	60.786	97.578
CV(%)	12.92	18.98	13.81	24.79

Significant at the 0.01 probability level.
*d = Day after application

Table 5: Mehlich-III extraction over time after amendment with manure (poultry, cow, swine) and KH_2PO_4

treatment	P concentrations (mg kg^{-1})			
	3d*	7d	14d	28d
Control	4.548 c	4.627 e	4.650 d	7.028 f
KH_2PO_4	106.817 a	105.492 a	87.500 a	88.746 ab
Poultry (PM)	69.542 b	51.633 d	56.817 c	67.304 cd
Cow (CM)	21.475 c	19.583 e	17.967 d	18.375 f
Swine(SM)	64.842 b	62.700 cd	62.092 bc	76.617 bc
Poultry+ KH_2PO_4	78.825 b	72.942 bc	74.117 ab	91.425 a
Cow + KH_2PO_4	59.383 b	76.883 bc	53.633 c	45.592 e
Swine + KH_2PO_4	70.975 b	91.842 ab	75.925 ab	62.175 d
Avg.	59.551	60.713	54.088	57.158
CV(%)	14.15	14.82	14.43	10.47

Significant at the 0.01 probability level.
*d = Day after application

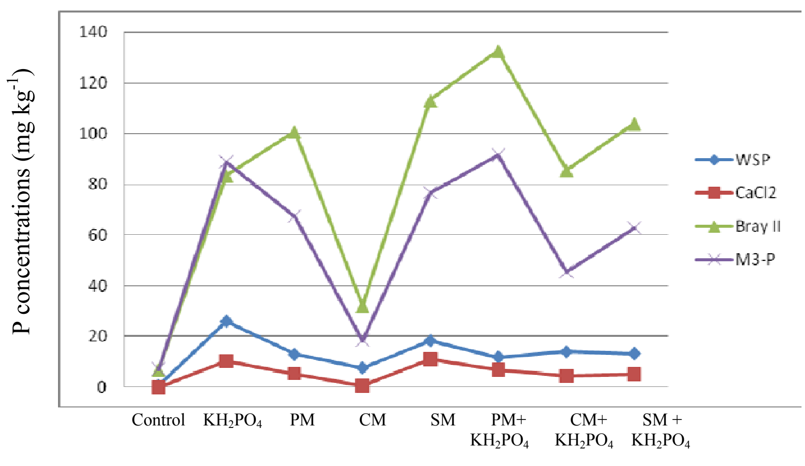

Figure 1: Water soluble P (WSP), $CaCl_2$, Bray II and Mehlich 3 P extractions on 28 d after amendment with manure and KH_2PO_4

Conclusions

The contributions of phosphorus in soil, the phosphorus changes over time. The use of phosphorus chemical fertilizers help increase the amount of available phosphorus in the soil in the first stage, and it then decreases as time goes on. Also, the dissolved phosphorus would be absorbed by iron and aluminum in the soil. Too the amount of phosphorus in the soil would be increased by adding animal manure or an animal manure-chemical fertilizer mix as the time goes on because the animal manures would then decompose, and release the nutrients. The influence of each extractives to extracted phosphorus concentration found that gave different concentration of phosphorus, it revealed that using Mehlich3 > Bray II > H_2O > $CaCl_2$ respectively.

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