Effect of sago palm waste compost and SP-36 fertilizer against fractionation of P on ultisols

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Abstract. Ultisols is a marginal type of soil that is acidic, which is mostly cultivated for agricultural areas. Nevertheless this type of soil has many obstacles, especially from the chemical and physical properties of the soil. Some of the chemical constraints faced in the use of Ultisols soil include: low soil pH (acidic soil reaction), nutrient content especially low P nutrients and high interchangeable Al concentrations. High interchangeable Al can bind P to form Al-P (Strengit) compounds so that the P concentration in the soil solution is reduced and consequently plants lack P, besides that high metal content can poison / cause toxicity to plants so that plant growth becomes unfavorable. One effort to increase P soil solution and reduce P stability is the application of P fertilizer, but it must be accompanied by organic matter. Giving organic material to acid soils can produce organic acids that are capable of chelating Al metal so that P will be released from soil solubility and available in soil solution. The research was conducted in the laboratory analysis of soil, water and plants, as well as greenhouse Faperta Unpatti Ambon, which lasted from March - November, 2011. This study used a complete randomized design with 2 factors factorial pattern consisting of the first factor is the maturity of Sago pith Waste compost and the second factor is the phosphate fertilizer (SP-36). Other research results indicate that administration of sago pith waste Compost can independently reduce Fe-P compounds. Granting SP-36 can independently reduce Fe-P compounds. Provision of compost ell sago together with SP-36 can increase the Ca-P compounds from 17.87 to 38.53 ppm, and Al-P compounds decrease from 35.00 to 16.67 ppm.

1. Introduction

Ultisols is one type of marginal soils that are acidic, which are widely cultivated for agricultural land. Nevertheless this soil type has a lot of obstacles particularly from the chemical and physical properties of soil. Some of the obstacles encountered in the use of chemical podzolic soil are: low soil pH (acidic soil reaction), nutrient content, especially low-nutrient P and Al concentrations are high interchangeable. While the physical constraints of the real ground state of the soil texture is smooth or high lead content liatnya poor soil porosity. Such is not beneficial for plants because it will inhibit root development.

Sources of acidity of mineral soil in general is aluminium. [1] and [2] showed that Al in the soil can undergo hydrolysis and produces H⁺ ion. Furthermore, Al can also bind to P so that the concentration of P in soil solution and consequently reduced plant P deficiency, but it's a high metal content which can poison / toxic plants that cause plant growth to be less good.

One attempt to improve the soil solution P and are reduced kekahatan. However, the provision of fertilizer P in acid soils such as Ultisols experienced dissolution by ground water that turned into fertilizer solution and will react with clay minerals and oxides and hydroxides of aluminium and iron phosphate causes changes back from the solution phase to form poorly soluble as variscite and strengite.
The event is known as P fixation or retention of P [3]. Therefore the use of P fertilizer efficiency can be improved by lowering the content of Exchangeable Aluminium soil, soil acidity (pH), the maximum P adsorption capacity of the soil, and the bond energy P, and increase the availability of P in soil-available P and P soil solution. If the provision of fertilizer P without regard to such matters would cause a given amount of fertilizer and inefficient crop will remain low. Therefore, in the provision of fertilizer P in acid soils to improve soil conditions that can increase the efficiency of P, among others, by giving lime and organic matter.

Giving organic material into the soil will undergo a process of decomposition. During the decomposition process takes place organic acids such as: malic acid, citric acid, succinic acid, formic acid, and acetic acid [4].

Organic acids react with oxides and hydroxides of aluminum and iron hydroxide. The second condition that causes the adsorption capacity of the land and max P-P bond energy decreases so that the availability of P increased [4]. Giving cow manure also increases the efficiency of fertilizer P in the corn, from 33.5 kg grain per kg fertilizer P to 56.0 kg grain per kg fertilizer P and increase the effectiveness of residual P fertilizer [5]. The use of 5 ton ha\(^{-1}\) manure combined with NPK fertilizer gave higher yield (2.9 ton ha\(^{-1}\)) compared with only inorganic fertilizer N, P, and K is 1.5 ton ha\(^{-1}\) [6].

One of the remaining crop that can be used in conjunction with composted cow manure to the ell sago. Sago Palm Waste (Ela sago) as sago-processed waste is the insulating material inside the sago tree which is thrown a way after being taken by the sago. Ela sago has not utilized so that if allowed to pollute the environment. The results [7] that the application of Bokashi sago palm waste (Ela sago) together with SP-36 fertilizer can increase soil pH and P availability in Ultisol soil

The objectives of this study were: Assessing the sago waste palm processed sago as an organicfertilizer, improve soil fertility Ultisol, and explain fractionation in soil P Ultisol.

2. Materials And Methods
The experiment was conducted in the laboratory analysis of Soil, Water, Plants and the Faculty of Agriculture, University of green house Pattimura Ambon lasted from March - November, 2011. While the analysis of soil and plant samples were analyzed at the Laboratory of Soil Chemistry Soil Research Institute Bogor.

2.1. Materials
Materials used in this study is the first year of cow manure, sago palm waste, EM-4, Sugar Sand, lamtoro, seed corn, fertilizer SP-36, Urea, KCl, ember, soil Ultisols, H\(_2\)O, HCl, distilled water, and pH indicator, solution of pesticides, plastic sample bags, chemical in the laboratory for analysis.

The tools used are: Munsell soil color chart, description cards, plastic bags, compasses, abneylevel, altimeter,field knife, Loupe, meter roller, GPS, hoe, shovel, drill (auger), bucket, hiter, machete, machine counter compost, scales, and laboratory analysis equipment.

2.2. Methods
Pot experiments carried on in a green house with a 3x4 factorial pattern is laid out according to Complete Randomized Design (CRD) with three replications. The first factor is the compost fermentation time, the same dose of 20 t ha\(^{-1}\) as a factor A, which are: K\(_1\) = 2 weeks, K\(_2\) = 3 weeks, and K\(_3\) = 4 weeks. The second factor is the provision of SP-36 (P) consisting of 4 standard dose, namely: no fertilizer P=P\(_0\), P\(_1\) = 60 kg ha\(^{-1}\) P, P\(_2\) = 120 kg ha\(^{-1}\) P, and P\(_3\) = 180 kg ha\(^{-1}\) P.

The data collected consists of a data set and there spone variables were statistically analyzed as well as supporting other data that were not analyzed statistically. Response variables are defined as follows: P fractions (Al-P, Fe-P, Ca-P). Data were analyzed by various univariate analysis, whereas the differences were tested by LSD [8].

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3. Results And Discussion
3.1. Soil Characteristics of the Experiment.
Based on the results of laboratory analysis of soil chemical Ultisol on soil pH appears that ultisol have lower value is 4.7 (acidic), soil organic C were, total soil N of low-, and P content available on the ground. Very low base saturation, while the soil CEC is moderate, with the content of exchangeable cations (Ca, Mg, Na, and K) to the soil is very low - low. While the value of P fractionation (Al-P, Fe-P, Ca-P), respectively: 47.2 ppm; 68.9 ppm, and 15.3 ppm. Texture with a ratio of each particle sand, clay, and dust was 4.28%, 58.36% and 37.36% clay so it belongs to a class.

Based on these characteristics, type of soil Ultisols for the trial has a fertility rate is very low. Thus, efforts are needed before fertility improvement in the cultivation of maize cultivation.

3.2. Sago Palm Waste Compost
The results of compost sago palm waste analysis based on the level of maturity (2 months, 3 weeks and 4 weeks) is as follows: pH value, respectively: 6.1; 6.1, and 7.6; C-10 organic, 35%, 10.27% and 10.27%, N-total 0.71%, 0.95% and 1.19%, while the ratio C/N is: 14.58, 10.81, and 8.63, and the CEC value of 18.95; 27.46, and 39.27 me 100 g⁻¹. Total content of elements in compost sago palm waste based on maturity (2 weeks, 3 weeks and 4 weeks as follows: P-total 0.83, 0.97, and 1.04%, K-total 0.19; 0.31; 0.56%, Ca-total 0.38; 0.44, and 0.52%, and total-Mg 0.14; 0.16, and 0.21%. sago palm waste compost moisture content is 49.30; 57.12, and 62.35%.

The high pH due to organic acids is reduced after decomposition sago palm waste and the formation of compost. The end goal should be a simple decomposition of simple compounds and cations available to plants. Base cations (Ca, Mg, K, and Na) and P-total increased due to the addition of manure, while N-total increased due to the addition of other materials such as manure than leaf lamtoro. C-organic content decreases due to decomposition. Ratio C/N <20 means that the mineralization process went well.

3.3. Aluminium Phosphate compounds (Al-P)
Diversity analysis results showed that administration of compost sago palm waste based on maturity and phosphate fertilizer and interaction both independently significant effect in reducing the compound of Al-P soil.

Table 1 shows that the provision of compost sago palm waste based on maturity 2 and 3 weeks of treatment with phosphate fertilizer 180 kg P ha⁻¹ were significantly different with no fertilizer and fertilizer were 60 kg P ha⁻¹, but not different from the given fertilizer 120 kg P ha⁻¹ in reducing the compound of Al-P soil. While the provision of compost sago palm waste maturity by 4 weeks, together with 180 kg phosphate fertilizer P ha⁻¹ were significantly different without fertilizer, were given 60 and 120 kg P ha⁻¹ in reducing the compound of Al-P soil.

In contrast treatment without phosphate fertilizer and phosphate fertilizer when given a dose of 180 kg P ha⁻¹ together with sago palm waste compost based on maturity of the 4-week differ significantly with maturity 2 and 3 weeks in lowers the compound of Al-P soil, while the combined treatment of phosphate fertilizers 60 and 120 kg P ha⁻¹ with a time of maturity of compost sago palm waste 4 weeks significantly different with the maturity of two weeks, but did not differ with time of maturity of 3 weeks in lowers the compound of Al-P soil. Value of Al-P compounds, namely the lowest ground on composting treatment based on the maturity of the sago ell 4 weeks with a dose of phosphate fertilizers 180 kg P ha⁻¹ at 16.67 ppm.

Sago Palm Waste Compost can reduce the compound of Al-P soil as organic acids decomposition of organic materials, in addition to chelating Al-free, these acids can also dissolve P from its binding with aluminium phosphate (Al-P), so as to reduce the compound Al–P soil. It also affects the reduction of fertilizer phosphate content of Al-P compounds in soil due to the presence of Ca in the fertilizer elements. Ca²⁺ ion replaces the ion H⁺ and Al³⁺ ion in the complex as a result of adsorption of H⁺ ion concentration in solution decreases and OH⁻ ion concentration increased. Al³⁺ ions in the soil solution
will react with the OH\textsuperscript{-} form compound Al(OH)\textsubscript{3} is poorly soluble and no chance for Al can bind to the phosphate, so that the aluminium phosphate content is reduced.

Table 1. Al-P Fraction When Given Sago Palm Waste Compost based on Maturity with Phosphate Fertilizer on Ultisols Soil.

| Sago Palm Waste Compost (K) | Phosphate Fertilizer (P) | \( \text{P}_0 (0 \text{ kg ha}^{-1}) \) | \( \text{P}_1 (60 \text{ kg ha}^{-1}) \) | \( \text{P}_2 (120 \text{ kg ha}^{-1}) \) | \( \text{P}_3 (180 \text{ kg ha}^{-1}) \) |
|-----------------------------|--------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
|                             |                          | ppm                           | ppm                           | ppm                           | ppm                           |
| \( \text{K}_0 \) (2 weeks)  |                          | 35.00 a                       | 29.30 a                       | 28.33 a                       | 27.63 a                       |
|                             | A                        | B                             | BC                            | C                              |
| \( \text{K}_1 \) (3 weeks)  |                          | 29.67 b                       | 25.70 b                       | 24.83 b                       | 23.80 b                       |
|                             | A                        | B                             | BC                            | C                              |
| \( \text{K}_2 \) (4 weeks)  |                          | 27.60 c                       | 25.90 b                       | 23.53 b                       | 16.67 c                       |
|                             | A                        | B                             | C                             | D                              |

Note: The figures marked with different letters in the direction of each column (lowercase) and the direction of the line (upper case) is the real test by LSD 5% = 1.65

3.4. Iron Phosphate compounds (Fe-P)

Diversity analysis results showed that administration of compost sago palm waste based on maturity and phosphates independently significant effect, while the interaction of the two compounds had no effect in lowering the Fe-P soil.

Table 2 shows that the provision of compost sago palm waste based on maturity 3 and 4 weeks were significantly different with the maturity of 2 weeks, 4 weeks maturity time also significantly different from 3 weeks in the lower maturity of the compound Fe-P soil. While the phosphate fertilizer either 60, 120 and 180 kg ha\textsuperscript{-1} were significantly different without fertilizer, but they were not different between treatments in reducing the compound Fe-P soil.

Table 2. Fe-P compounds when Given Sago Palm Waste Compost Based on Maturity and Phosphate Fertilizer In Ultisols Soil.

| Sago Palm Waste Compost (K) | Phosphate Fertilizer (P) | On average sago palm waste compost (K) |
|-----------------------------|--------------------------|---------------------------------------|
|                             | \( \text{P}_0 (0 \text{ kg ha}^{-1}) \) | \( \text{P}_1 (60 \text{ kg ha}^{-1}) \) | \( \text{P}_2 (120 \text{ kg ha}^{-1}) \) | \( \text{P}_3 (180 \text{ kg ha}^{-1}) \) |
|                             | ppm                      | ppm                                   | ppm                                   | ppm                                   |
| \( \text{K}_1 \) (2 weeks)  |                          | 56.20 a                               | 49.80 a                               | 48.10 a                               | 53.27 a                               |
| \( \text{K}_2 \) (3 weeks)  |                          | 47.33                                 | 47.60                                 | 45.67                                 | 42.57                                 |
| \( \text{K}_3 \) (4 weeks)  |                          | 44.03                                 | 41.83                                 | 31.87                                 | 25.03                                 |
| Average of phosphates      |                          | 49.19                                 | 46.41 ab                              | 41.88 b                               | 40.29 b                               |

Note: The figures marked with different letters are real according to LSD test 5%:5.92 (K) and LSD 5%:6.84(P)

Giving Sago palm waste compost will reduce the content of Fe-P because decomposition organic acids will react with free Fe to form chelate compounds. Organic acids besides being able to react to form complex compounds with free Fe in soil solution, also with Fe on the surface of clay particles. The process of forming complex compounds or chelating of cations of Fe by organic acids causes the activity of Fe in the soil to decrease, so that the Phosphate (P) will be released from its bond with the iron phosphate compound (Fe-P) which causes the availability of Phosphate (P) in the soil solution to increase, whereas the content of Fe-P compounds will decrease in the soil.
Phosphate Fertilizer (SP-36) affected the decrease in content of Fe-P compounds in the soil because there are elements of Ca in the fertilizer. Ca$^{2+}$ ions will replace the H$^+$ ions and Fe$^{3+}$ in the complex as a result of adsorption of H$^+$ ion concentration in solution decreases and OH$^-$ ion concentration increased. Fe$^{3+}$ ions in the soil solution will react with the OH$^-$ form compound Fe(OH)$_3$ is poorly soluble and no chance for Fe can bind to phosphate, iron phosphate so that the content will be reduced.

3.5. Calcium Phosphate Compounds (Ca-P)
The results of the diversity analysis showed that the administration of sago palm waste compost based on maturity and phosphate fertilizer independently as well as the interaction of both had significant effects in increasing soil Ca-P compounds.

In Table 3 it can be seen that the administration of sago palm waste compost based on 2 weeks maturity together with the treatment of 180 kg ha$^{-1}$ phosphate fertilizer is significantly different from without fertilizer, but it is not different from being given 60 and 120 kg ha$^{-1}$ in increasing Ca-P soil compounds. In addition, the addition of sago palm waste compost based on maturity of 3 weeks, where the treatment of phosphate fertilizer did not differ in increasing Ca-P soil compounds, while the administration of sago palm waste compost based on 4 weeks maturity together with given phosphate fertilizer 180 kg ha$^{-1}$ was significantly different from without fertilizer, or if given fertilizer 60 and 120 kg ha$^{-1}$ in increasing Ca-P soil compounds.

Instead the treatment of 180 kg P ha$^{-1}$ phosphate together with sago palm waste compost maturity time of 4 weeks was significantly different from the maturity of 2 weeks and 3 weeks in increasing Ca-P soil compounds. In addition treatment without phosphate fertilizer or 60 kg P ha$^{-1}$ and 120 kg P ha$^{-1}$ phosphate fertilizer together with sago palm waste compost maturity 4 weeks is significantly different from 2 weeks maturity, but not different from 3 weeks maturity in increasing compounds Ca-P soil. The highest value of Ca-P soil compound content is 38.53 ppm found in the sago palm waste compost treatment based on 4 weeks maturity which was given together with a phosphate fertilizer dose of 180 kg ha$^{-1}$.

**Table 3.** Ca-P compounds when Given Sago Palm Waste Compost Based on Maturity with Phosphate Fertilizer in Ultisols Soil.

| Sago Palm Waste Compost (K) | Phosphate Fertilizer (P) | P$_0$ (0 kg ha$^{-1}$) | P$_1$ (60 kg ha$^{-1}$) | P$_2$ (120 kg ha$^{-1}$) | P$_3$ (180 kg ha$^{-1}$) |
|-----------------------------|--------------------------|------------------------|------------------------|------------------------|------------------------|
| K$_1$ (2 weeks)             |                          | 17.87 a                | 19.50 a                | 21.67 a                | 23.00 a                |
|                             | A                        | AB                     | AB                     | B                      |
| K$_2$ (3 weeks)             |                          | 23.27 b                | 23.90 ab               | 24.70 ab               | 26.97 a                |
|                             | A                        | A                      | A                      | A                      |
| K$_3$ (4 weeks)             |                          | 22.37 b                | 26.40 b                | 29.17 b                | 38.53 b                |
|                             | A                        | AB                     | B                      | C                      |

Note: The figures marked with different letters in the direction of each column (Lowercase) and the direction of the line (upper case) are real by LSD 5% = 4.92

Sago palm waste compost given into the soil will increase the content of Ca-P, due to ligand exchange between organic acids with the hydroxyl group of Fe and Al in the soil and will free OH-ions into soil solution. Beside electrons originating from the decomposition of organic materials can neutralize a positive charge present in the colloidal system, thereby increasing soil pH, and Ca$^{2+}$ will be free in the soil solution and will react with the elements of P form a compound of calcium phosphate (Ca-P).

Fertilizer phosphate (SP-36) effect on the increase in Ca-P in the soil, because this fertilizer contains CaO (calcium oxide) which is the main ingredient in addition liming calcite and dolomite [9].
4. Conclusion
The results of the study can be summarized as follows: Results of a complete initial soil analysis that Ultisols soil types have low soil fertility. The best maturity time for sago compost when fermented for 4 weeks. Supplement with sago ela compost and SP-36 fertilizer can reduce Fe-P compound. While the administration of sago ela compost together with SP-36 fertilizer can increase Ca-P compounds from 17.87 to 38.53 ppm, and decrease Al-P compounds from 35.00 to 16.67 ppm in Ultisols soil.

References
[1] Lindsay W L 1979 Chemical Equilibria in Soils (New York: John Wiley & Sons)
[2] Wolt J D 1994 Soil Solution Chemistry: Applications to Environmental Science and Agriculture (New York: John Wiley and Sons, Inc)
[3] Sample E C, Soper R J, and Raoz G J 1980 Reaction of Phosphate fertilizers in Soils p263-310. In Khasawneh F E, Sample E C, and Kamprath E J 9 eds. The Role of Phosphorus in Agriculture in: A.S.A., C.S.S.A., and S.S.S.A. (Madison Wiscons)
[4] Iyamuremye F, Dick R P, and Baham J 1995 Organic Amendment and Phosphorus Dyanmis: II. Distribution of Soil Phosphorus Fractions Soil Sci 161 436-443.
[5] Sri-Adiningsih J 1987 Penelitian Pemupukan P pada Tanaman Pangan di Lahan Kering Masam p285-307 in Prosiding Lokakarya Nasional Penggunaan Pupuk Fosfat (Cipanas: Pusat Penelitian Tanah. Balai Penelitian dan Pengembangan Tanaman. Departemen Pertanian)
[6] Rochayati S, Subiksa I G M, Subagyono K, Siswanto A B, dan Adiningsih J S 1997 Pengelolaan Hara Untuk Menghadapi Tantangan Peningkatan Produksi Tanaman Pangan di Masa Datang in Prosiding Pertemuan dan Komunikasi Hasil Penelitian Tanah dan Agroklimat. (Cisarua: Pusat Penelitian Tanah dan Agroklimat)
[7] Kaya E 2009 Ketersediaan Fosfat, Serapan Fosfat, dan Hasil Tanaman Jagung (Zea mays L) Akibat Pemberian Bokashi Ela Sagu Dengan Pupuk Fosfat Pada Ultisols. Jurnal Ilmu Tanah dan Lingkungan Fakultas Pertanian Universitas Gadjah Mada 9(1) 30-36.
[8] Steel R G D, and Torrie J H 1995 Prinsip dan Prosedur Statistika. 2nd Eds (Jakarta: PT Gramedia Pustaka Utama)
[9] Radjagukguk B 1983 Masalah Pengapuran Tanah Mineral Masam di Indonesia (Yogyakarta: Fakultas Pertanian UGM)