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# Effect of sago palm waste compost and SP-36 fertilizer against the availability of P, P uptake and growth of corn (*Zea mays* L.) in ultisols

**Elizabeth Kaya***, **J. A. Putinella**

*Department of Agriculture, Faculty of Agriculture, University of Pattimura, Indonesia*

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## Abstract

The objectives of this research are: assessing the sago palm waste which processed as an organic fertilizer, improving Ultisol soil fertility, explaining the increase in soil acidity and nutrient availability of P of Ultisol soil, and increasing the uptake of P and growth of Corn (Zea mays L ). The research was conducted in laboratory of soil, water and plants analysis, and in Faperta Unpatti greenhouse, Ambon, from March - November 2010. This study used a complete factorial randomized design pattern with 2 factors: the maturity of sago palm waste compost and the phosphate fertilizer (SP-36). The result of this research showed that application of Sago Palm Waste Compost independently increase the soil pH and plant stem diameter growth of corn. Likewise SP-36 fertilizer independently can increase stem diameter growth of corn. Provision of sago palm waste compost together with SP-36 can increase the P-available in soil from 15,40 to 30,80 ppm. Provision of sago palm waste compost together with SP-36 can increase P-uptake of plant from 0,07% to 0,15%, corn plant height grow is from 96,23 cm to 140,60 cm. Provision of sago palm mature waste compost in 4 weeks with a dose of 180 kg phosphate fertilizer ha-1 can increase P-uptake of plant of 0,15% and plant height of 140,60 cm.

* **Corresponding Author:** Elizabeth Kaya ✉ lis_kaya@yahoo.com

**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 podsolic soil are: low soil pH (acidic soil reaction), unstable nutrient content; especially low P nutrient and high interchangeable of Al concentrations. While the physical constraint of soil texture is smooth or has high clay content and poor soil porosity. It is not beneficial for plant because it will inhibit root development (Putinella, 1994). A general source of mineral soil acidity is aluminum. Lindsay (1979) and Wolt (1994) showed that Al in the soil can undergo hydrolysis and produces $H^+$ ion. Furthermore, Al can also bind P to consequently reduced plant P deficiency, but it caused high metal content which can poison plants; cause less plant growth.

An attempt to improve the soil solution P and reduced P deficiency are giving P fertilizer. However, the provision of P fertilizer in acid soils such as Ultisols experienced dissolution by ground water that turned fertilizer into solution and react with clay minerals, oxides and hydroxides of aluminum and iron phosphate causes changes back from the solution phase to form poorly soluble varisit and strengit, called P fixation or retention of P (Sample *et al.,* 1980). Therefore efficiency of P fertilizer use can be improved by lowering the content of Al-dd soil, soil acidity (pH), the soil maximum P adsorption capacity, energy P bond, and increase the availability of P in soil solution. Provision of P fertilizer would cause a sufficient amount of fertilizer and efficient crop. Therefore, provision of P fertilizer in acid soils aimed to improve soil conditions which increase the efficiency of P, by giving lime and organic matter.

Addition of organic matter into the soil through decomposition, resulting organic acids such as malic acid, citric acid, succinic acid, formic acid and acetic acid (Iyamuremye, 1995). Organic acids react with oxides and hydroxides of aluminum and iron hydroxide. The second condition that causes the adsorption capacity and maximum P-P energy bond decreased lead to the increased availability of P (Iyamuremye, 1995). Considering that cow manure also increases P efficiency in corn, from 33,5 kg grain per kg P fertilizer to 56,0 kg grain per kg P fertilizer and increase residual P fertilizer effectiveness (Sri-Adiningsih, 1987). 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$^{-1}$ (Rochayati *et al.*, 1997).

A remaining crop can conjunct with composted cow manure to *ela sago* or Sago Palm Waste. *Ela sago* or sago palm waste is processed as waste material inside sago starch fiber which was discarded after. Unutilized sago palm waste pollutes the environment. The research of Matulessy (2006) explain that administration of sago palm waste after decomposition with dose of 100 g.polybag$^{-1}$ can enhance plant growth and P uptake, can also increase soil pH and available P in acid soils such as Ultisol soil. Therefore, this study attempt to: 1) Assess the waste processed sago (*ela* sago) as an organic fertilizer; 2) Improve Ultisol soil fertility, 3) explainthe behavior of P in soil Ultisol; 4) Increase soil acidity and nutrient availability in P Ultisol soil; and 5) improve P nutrient uptake and growth of Corn (*Zea mays* L).

**Materials and methods**

The experiment was conducted in Laboratory of Soil, Water and Plant Analysis, and greenhouse of Faculty of Agriculture, University of Pattimura, Ambon from March to November 2010. Soil and plants sample were analyzed in Laboratory of Soil Chemistry, Bogor Soil Research Institute. Material and tools used in this study is the first year cow manure, sago palm waste, EM-4, sugar sand, *lamtoro* (*Leucaena leucocephala* Lamk.), corn's seed, SP-36 fertilizer, Urea, KCl, polybags, pots, Ultisol soil, $H_2O_2$, HCl, distilled water. We also used pH indicator, pesticides, plastic sample bags, munsell soil color chart, a description card, plastic bags, compasses, abney level, altimeter, field knife, loupe, meter roller, GPS, hoes, shovels, drills (auger), bucket, hammer, compost counter machine, scales, and laboratory analysis equipment.

Experiments plot carried on in a greenhouse with a 3 x 4 factorial pattern lay out according to Complete Randomized Design (CRD) with three replications. The first factor is the compost fermentation time, the same doses of 20 ton ha-1 as a factor A, which are: K1 = 2 weeks, K2 = 3 weeks, and K3 = 4 weeks. The second factor is the provision of SP-36 (P) consisted of 4 standard dose, i.e. $P_0$ = no P fertilizer; $P_1$ = 60 kg $ha^{-1}$ P; $P_2$ = 120 kg $ha^{-1}$ P; and $P_3$ = 180 kg $ha^{-1}$ P.

Data collections consist of a data set and response variables which were statistically analyzed. Response variables are defined as follows: P-available, soil pH, plant P-uptake, and growth of corn plants (plant height and stem diameter). Data were analyzed by various univariate analyses, where the differences were tested by LSD (Steel and Torrie, 1995).

## Results and discussion

*Reaction (pH) Soil*

Analysis of variance showed that administration of sago palm waste compost based on independent maturity significantly affect soil pH, while the phosphate fertilizer on their own or together with sago palm compost insignificantly affect soil pH.

**Table 1.** pH soil of Compost Sago Palm Waste based on the level of maturity in Ultisol Soil.

| sago Palm Waste compost Dose (K) | Soil pH |
|---|---|
| $K_1$ (1 weeks) | 5.35 a |
| $K_2$ (2 weeks) | 5.54 ba |
| $K_3$ (3 weeks) | 5.71 b |

Note: different letters are according to the LSD Test 5% =0.19

Table 1. shows provision of sago palm waste compost based in maturity was significantly different for 4 weeks and 2 weeks period, but insignificantly different from 3 weeks to increase pH soil. 4 weeks maturation treatment is the highest soil pH (5.71). It assumed that because initially high organo-complexes – which compound to Al, Fe and Mn ions – is reduced (Soepartini and Adiningsih, 1993).

*Availability of phosphate*

Analysis of variance showed that administration of sago palm compost based on maturity and phosphate fertilizer, and interaction both significantly affect the increasing of soil P-availability.

**Table 2.** P-availability based on Sago Palm Waste Compost Maturity and SP-36 Fertilizers in Ultisol Soil

| Sago Palm Waste Compost (K) | SP-36 Fertilizer (kg $ha^{-1}$ P) P-availability (ppm) | | | |
|---|---|---|---|---|
| | $P_0$ (0) | $P_1$ (60.0) | $P_2$ (120.0) | $P_3$ (180.0) |
| $K_1$ (2 weeks) | 15.40 a A | 17.27 a AB | 18.90 a BC | 20.70 a C |
| $K_2$ (3 weeks) | 16.70 a A | 18.03 a AB | 19.30 a AB | 20.80 a B |
| $K_3$ (4 weeks) | 17.10 a A | 19.83 a AB | 21.20 a B | 30.80 b C |

Note: Lowercases are ANOVA within P treatment and uppercases are ANOVA between P treatment, LSD 5% = 3.38.

Table 2. shows that provision of sago palm compost based on 2 weeks maturity treatment with phosphate fertilizer 180 kg $ha^{1}$ were significantly different with no fertilizer and 60 kg $ha^{-1}$ fertilizer, but not different from 120 kg $ha^{-1}$ fertilizer in enhancing the soil P-availability. In addition, provision of 3 weeks sago

palm compost together with a dose of 180 kg $ha^{-1}$ phosphate fertilizer being significantly different compared to the one without phosphate fertilizers, but not different from the given fertilizer 60 and 120 kg $ha^{-1}$ in increasing P-availability. While provision of 4 weeks sago palm compost with 180 kg $ha^{-1}$ was significantly different from untreated fertilizer phosphate with 60 and 120 kg $ha^{-1}$ phosphate fertilizer in enhancing soil P-availability.

*Conversely, giving 80 kg.$ha^{-1}$ phosphate* fertilizers with 4 weeks sago palm waste was significantly different 2 and 3 weeks in increasing P-availability. While the combined treatment of phosphate fertilizers with others maturation time of sago palm waste compost significantly indifferent in increasing the soil P-availability.

The highest soil P-availability is treatment of 4 weeks sago palm waste compost and 180kg.$ha^{-1}$ in 30, 80 ppm phosphate fertilizer. Related to availability of P, Kaya (2003) explains that decomposition of organic matter produced organic acids that naturally bind ions of Al, Fe and Ca from the soil solution. Organic acids will react with oxides and hydroxides form of organic complex compounds that cause P adsorption capacity decreased as a result the availability of P increased.

Besides the addition of organic matter, phosphate fertilizer in higher doses is also capable of providing available phosphate in soil. Presence of $Ca^{2+}$ in the fertilizer replace ion $H^+$, $Al^{3+}$ and $Fe^{3+}$ in the complex as result of decreases $H^+$ ions adsorption in solution and increased OH-ion concentration. Ion $Al^{3+}$ and $Fe^{3+}$ in soil solution will react with $OH^-$ to form Al $(OH)_3$ or $Fe(OH)_3$ which is poorly soluble, then it will be free and available in soil solution (Kaya, 2003).

*P uptake*

Analysis of variance showed that administration of sago palm waste compost based on its maturity and phosphates affect in improving crop P-uptake.

**Table 3**. P-uptake based on Sago Palm Waste Compost Maturity and SP-36 Fertilizer in Ultisol Soil

| **Sago Palm Waste Compost (K)** | **SP-36 Fertilizer (kg ha⁻¹ P) P-uptake (%)** | | | |
|---|---|---|---|---|
| | **$P_0$ (0)** | **$P_1$ (60.0)** | **$P_2$ (120.0)** | **$P_3$ (180.0)** |
| $K_1$ (2 weeks) | 0.07 a A | 0.07 a BC | 0.09 a BC | 0.10 a C |
| $K_2$ (3 weeks) | 0.08 b A | 0.08 a A | 0.11 b B | 0.12 a B |
| $K_3$ (4 weeks) | 0.08 b A | 0.08 b B | 0.12 b B | 0.15 b C |

Note: Lowercases are ANOVA within P treatment and uppercases are ANOVA between P treatment, LSD 5% = 0.01.

In Table 3., 2 weeks and 3 weeks treatment of sago palm waste compost provision with 180 kg $ha^{-1}$ phosphate fertilizer was significantly different with no fertilizer and 60 kg $ha^{-1}$ fertilizer, but indifferent from the 120 kg $ha^{-1}$ P, in increasing plant uptake. While the 4 weeks sago palm wastes compost provision and 180 kg $ha^{-1}$ phosphate fertilizer was significantly different with no fertilizer or manure whether given 60 or 120 kg $ha^{-1}$ in enhancing the P-uptake.

In contrast, treatment without fertilizer and 120 kgha$^{-1}$ phosphate fertilizer with 4 weeks and 2 weeks sago palm waste compost are significantly different, but not different from the 3 week in increasing plant P-uptake, where 60 and 180 kg ha$^{-1}$ phosphate fertilizer with 4 weeks sago palm compost which significantly different with 2 and 3 weeks in increasing crop P-uptake.

The highest P-uptake is 4 weeks sago palm waste compost with dose of 180 kg ha$^{-1}$ phosphate fertilizers of 0,15%. It is because the organic matter may release P which is fixed by Al and Fe through the formation of complex organic compounds that led to increased soil P-availability; it is also raise P-uptake. Furthermore, elements of the organic material as a source of N, P and S bound in both organic form or microorganisms in the body and can form complexes with the elements of micro-elements. It was protected from leaching and will be available again after the microorganisms dead (Hardjowigeno, 2003). Increase in P-uptake was related to the availability of P, where the presence of increasing doses of P fertilizer will increase the P-availability and P-uptake (Kaya, 2003; Sufardi, 1999).

**Corn plant growth**

*Plant height*

Analysis of variance showed that administration of sago palm compost based on the time of maturity and phosphate fertilizer itself and interactions form were significantly affect plant height.

**Table 4.** Corn Plant Height based on Sago Palm Waste Compost Maturity and SP-36 Fertilizer in Ultisol Soil.

| **Sago Palm Waste Compost (K)** | **SP-36 Fertilizer (kg ha$^{-1}$ P) H (cm)** | | | |
|---|---|---|---|---|
| | **$P_0$ (0)** | **$P_1$ (60.0)** | **$P_2$ (120.0)** | **$P_3$ (180.0)** |
| $K_1$ (2 weeks) | 96.23 a A | 102.70 a B | 107.33 a B | 114.40 a B |
| $K_2$ (3 weeks) | 105.27 b A | 106.70 ab A | 112.53 a AB | 119.67 a B |
| $K_3$ (4 weeks) | 106.33 b A | 114.90 b AB | 122.97 b B | 140.60 b C |

Note: Lowercases are ANOVA within P treatment and uppercases are ANOVA between P treatment, LSD 5% = 8.70.

Table 4. shows that the provision of sago palm waste compost based on maturity 2 weeks treatment with phosphate fertilizer 60, 120, and 180 kg ha$^{-1}$ were significantly different from without fertilizer, but the three are indifferent in increasing corn plant height. In addition, the provision of 3 weeks sago palm waste compost and 180 kg ha$^{-1}$ fertilizer was significantly different to no fertilizer and 60 kg ha$^{-1}$ fertilizer, but not different from 120 kg ha$^{-1}$ fertilizer, while provision of 4 weeks sago palm waste compost and 180 kg ha$^{-1}$ phosphate fertilizer were significantly different with no fertilizer or manure when 60 and 120 kg ha$^{-1}$ is given to increase corn plant height.

In contrast, treatment without phosphate fertilizer and 60 kg P ha$^{-1}$ phosphate fertilizer with 4 weeks sago palm waste compost is significantly different from 2 weeks maturity, but did not differ with the increasing 3 weeks maturity of corn's height. Phosphate fertilizer of 120 and 180 kg P ha$^{-1}$ along with the 4 weeks sago palm waste compost are different from the maturity of 2 weeks and 3 weeks in increasing corn plant height. The highest plant height found in the 4 weeks treatment sago palm waste compost with phosphate fertilizer 180 kg ha$^{-1}$, i.e. 140,60 cm. Increase in plant height is assumed due to provision of sago palm waste compost associated with increased P-availability in soil which then increases P-uptake. It is closely correlated to the development of meristem tissues, which determines the plants growth.

Phosphate fertilizers can provide nutrients source such as P and micro elements (Fe, Zn, Mo). P element is a constituent in plant cell's nucleus, cell division, and development of meristem tissues. Formation of carbohydrates and fidelity mechanism of chloroplast metabolic activities also require P element. It affects much in crop's quality. Micro elements such as Fe, Zn, and Mo as electron carrier in enzymes system cause oxidation-reduction reactions in plants that useful for the development and propagation of plants.

*Stem Diameter*

Analysis of variance showed that administration of sago palm compost and fertilizer phosphate was independently had significant effect on stem diameter, while the interaction between the two does not significantly affect corn stem diameter.

**Table 5.** Corn Stem Diameter based on Sago Palm Waste Compost Maturity and Phosphate Fertilizer in Ultisol Soil

| **Sago Palm Waste Compost (weeks) (K)** | **Stem Diameter (cm)** | **SP-36 Fertilizer (kg ha$^{-1}$ P)** | **Stem Diameter (cm)** |
|---|---|---|---|
| $K_1$ (2) | 1.01 a | P0 (0.0) | 0.81 a |
| $K_2$ (3) | 1.11 a | P1 (60.0) | 1.14 a |
| $K_3$ (4) | 1.60 b | P2 (120.0) | 1.46 b |
| | | P3 (180.0) | 1.64 c |

Note: Lowercases are ANOVA within P treatment and uppercases are ANOVA between P treatment, LSD 5% = 0.22 (K) and LSD 5% = 0.25 (P).

Table 5. Shows that the provision of sago palm waste compost maturity significantly different from 4 weeks maturity to 2 and 3 weeks in increasing stem diameter. The highest corn stem diameter found in the sago palm waste compost is in treatment 4 weeks maturity, i.e. 1,60 cm. Provision of sago palm waste compost and SP-36 fertilizer can affect stem diameter because in addition to macro nutrients N, P, and K, there are also micro nutrients Fe, Zn and absorbed by the plant for vegetative growth of plants.

**Conclusion**

Ultisol soils have low soil fertility. 4 weeks Maturity Time of sago palm waste compost gave the best results for all improving purpose in this study. Provision of sago palm waste compost can independently increase soil pH and stem diameter growth of the plant, besides granting SP-36 fertilizer can independently increase the growth of the plant stem diameter. Provision of sago palm waste compost together with SP-36 can increase soil P-availability from 15, 40 to 30,80 ppm. Provision of sago palm waste compost together with SP-36 fertilizer can increase plant P-uptake of 0,07% to 0,15%, the growth of the corn plant height 96,23 cm to 140,60cm. Provision of sago palm waste compost maturity 4 weeks with a dose of 180 kg ha$^{-1}$ P phosphate fertilizer can increase plant P uptake of 0.15 % and plant height of 140,60 cm.

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