Available online at:
http://journal.unila.ac.id/index.php/tropicalsoil
DOI: 10.5400/jts.2022.v27i2.49-58

Soil Chemistry Character, N, P, and K Uptake, and the Growth and Yield of Corn (*Zea mays* L.) Due to Application of Ela Sago Palm Waste Compost and Liquid Organic Fertilizer in Ultisols

Elizabeth Kaya[1*], Adelina Siregar[1], Diane Matulessy[2], Masita Hasan[2] and Arsando Akollo[2]

[1]*Study Program Land Management, Graduate Program, Pattimura University, Indonesia*
[2]*Study Program Agroecotechnology, Agriculture Faculty, Pattimura University, Indonesia*
e-mail: elizabethkaya712@gmail.com

Received 16 December 2021; Revised 29 December 2021; Accepted 18 February 2022

ABSTRACT

Application of organic matter (compost Sago Ela palm waste and Liquid Organic fertilizers (LOF)) to the soil could have major benefits, such as to improve the soil physical condition (soil structure, water retention), and soil chemical properties (binding and providing nutrients, increasing CEC). The purpose of this study are (1) to improve the soil chemical properties of Ultisols, and (2) to increase plant uptake of N, P, and K, and the growth and yield of corn (*Zea mays* L.). The research was conducted in the field, namely in Telaga Kodok Village, Leihitu Sub District, and Central Maluku District. The experiment was designed in a factorial, and arranged in a randomized completed block design (RCBD). The first factor was the provision of compost Sago Ela palm waste (K) and the second factor was the provision of liquid fertilizer (C). The results showed that the compost combined with LOF could improve pH, Al-exchangeable, Total-N, P-available soil, Uptake-P, Uptake-K, and the dry weight of seed corn. While the treatment of sago Ela palm waste compost and LOF can independently raise the K-available soil, N-uptake, and affect corn's plant growth (height and trunk diameter). The treatment doses of sago Ela palm waste compost of 60 Mg ha^{-1} and LOF of 20 mL L^{-1} solution can increase the exchangeable Al, Total-N, and P-available soil, respectively 0.56 cmol(+)kg^{-1}, 0.21%, and 31.00 mg kg^{-1}; also able to increase the uptake of P, K, and weight dry seed corn respectively 0.21% and 1.26%, and 121.33 g $plant^{-1}$. The treatment doses of Sago Ela palm waste compost of 60 ton ha^{-1} and liquid organic fertilizer of 10 mL L^{-1} solution can increase the soil pH by 5.70.

Keywords: Compost sago ela, corn, LOF, soil chemistry, ultisols

INTRODUCTION

Ultisols is one type of soil in Indonesia which has a wide distribution of 45,794,000 ha or about 25% of the total land area of Indonesia. The largest distribution is in Kalimantan (21,938,000 ha), followed by Sumatra (9,469,000 ha), Maluku and Papua (8,859,000), Sulawesi (4,303,000 ha), Java (1,172,000 ha) and Nusa Tenggara (53,000 ha) Subagyo *et al.* (2004).

Ultisols soils have a considerable degree of development, characterized by a deep soil cross-section, an increase in clay fraction with soil depth, acid soil reaction (pH < 4.5), low base saturation (< 35%), and low Cation Exchange Capacity. In general, this area has the potential for Al poisoning due to its high Al content/Al saturation and low organic matter (OM) content. This soil is also poor in macronutrients, primarily N and P, low in micronutrients such as Mo and Zn, low exchangeable cations such as Ca, Mg, Na, and K, and is also sensitive to erosion (Adiningsih and Mulyadi 1993; Prasetyo and Suriadikarta 2006). This yellow podzolic soil is widely available in Indonesia (Hardjowigeno 2007).

Ultisols soil analysis data from various regions in Indonesia indicates that the soil has a very acid soil reaction characteristic (pH 4.1 - 4.8). The content of topical organic material is thin (8-12 cm), generally low to medium. The content of N, P, and K varies from very low to low, both top and bottom layers. With the number of low exchange bases, the K-exchangeable content ranges from 0 - 0.1 cmol(+)kg^{-1} in all layers, including low. It can be concluded that the natural fertility potential of Ultisols is very low to low (Subagyo *et al.* 2004). This is also consistent with the results of laboratory analysis (Kaya 2016) showing that the chemical properties of Ultisols soil before the study were as follows: soil reaction (pH) 4.68 (acid); organic matter 1.23 % (low); N-Total 0.08% (very low); C/N 15.4 (moderate); P_2O_5 available 14.0 mg kg^{-1} (low); K_2O available 23.0 mg kg^{-1} (very low); Ca-exchangeable 3.09 cmol(+)kg^{-1} (low); K-exchangeable 0.05 cmol(+)kg^{-1} (very low); Na-exchangeable 0.06 cmol(+)kg^{-1} (very low); Mg-dd 0.71 cmol(+)kg^{-1} (low); Base Saturation 37.22% (medium); Al-exchangeable 2.84 cmol(+)kg^{-1} (high); H-exchangeable 0.78 cmol(+)kg^{-1}; CEC 10.56 cmol(+)kg^{-1} (low).

Ultisols soil has potential as agricultural land, including for the development of corn plants, but the obstacle is the very low level of physical, chemical, and biological fertility. The condition can be overcome with proper and balanced fertilization. According to Marvelia *et al*. (2006), fertilization aims to maintain or increase soil fertility so that plants can grow faster, more fertile, and healthy. The addition of organic matter into the soil is an alternative that is needed. Besides being intended as a source of macro, micro, and organic acids, it also acts as a soil enhancer to improve physical, chemical, and biological soil fertility in the long term to increase soil and plant productivity (Dibia and Atmaja 2017).

The provision of OM into the soil will experience the process of decomposition. During decomposition, organic acids such as malic acid, citric acid, succinic acid, formic acid, and acetic acid are available (Iyamuremye 1995). Matulessy (2006) shows that sago after decomposition with a dose of 100 g polybag^{-1} can increase plant growth and P uptake and increase soil pH and P available on acid soils such as Podsolic soil. In addition, Kaya *et al.* (2010) showed that the provision of compost sago palm waste 15 Mg ha^{-1} with organic fertilizer ABG BB 3 mL L^{-1} water could increase soil pH 7.72, P available (53.8 Mg kg^{-1}), P-uptake (0.775%), and weight dry seed corn (86.0 g plant^{-1} or 5.38 Mg ha^{-1}).

In Indonesia, corn is the second most crucial food commodity after rice. Corn has an essential role in meeting the needs of food, fodder, and domestic industries, whose demand continues to increase throughout the year along with population growth and the development of the food and feed industry.

Support the food production, a basic need for the community is still experiencing many obstacles. Corn production in Maluku Province is targeted to reach 14,930 Mg by the end of 2015 (Directorate General of Food Crops of the Ministry of Agriculture 2015), but in 2014 corn production in Maluku Province reached only 10,560 Mg, and in 2015 increased to 13,947 Mg (BPS 2016). This fact shows that although corn production has been increasing every year until now, the production of corn in Maluku is still below national production targets, so efforts need to be made to increase the production and self-sufficiency of corn. The primary constraint of low productivity of plants is the soil factor, where without the enrichment of organic materials with complete nutrient content, fertility and soil productivity are difficult to be improved.

The growth and production of corn plants require at least 13 nutrients, both macro, and micro, absorbed through the soil. Macro-nutrients such as N, P, and K are needed in more significant amounts, so they are called primary nutrients, while Ca, Mg and S are needed in moderate amounts and are called secondary nutrients. Plants continuously absorb the elements N and P until they are near maturity, while K is mainly needed when silking. Most N and P are carried to the growing points, stems, leaves, and male flowers, where they are transferred to seeds, while the element K is left in the stems (Olson and Sander 1988). Therefore, soil as a medium for plant growth needs to consider its fertility level, physical, chemical, and biological soil.

The study aimed to examine the effect of providing a sago Ela compost and liquid organic fertilizer on soil chemical characteristics, the uptake of N, P, and K, and the growth and yield of corn (*Zea mays L.*) in Ultisols.

MATERIAL AND METHODS

The research was conducted in the field at Telaga Kodok Village, Leihitu Sub-district, Central Maluku District, using Ultisols Soil. Soil and plant analysis was conducted in the Laboratories of Land Installation of BPTP Maros, Bogor Land Research Institute, Plant Disease, Soil and Water Analysis of Faculty of Agriculture Unpatti.

The tools and materials used in this study, namely hoes, machetes, shovels, digital scales, laboratory equipment used for soil and plant analysis, Ultisols soil, compost material and Liquid Organic Fertilizer (LOF), PGPR culture solution, seaweed solution, EM-4, sweet corn seed, and soil and plant analysis chemicals in the laboratory.

The study was designed using a randomized complete block design (RCBD) with 4 × 3 factorial patterns with three replications. The first factor was compost sago ela palm waste (K), consisting of three levels, namely K_0 without compost sago palm waste; K_1 30 Mg ha^{-1}, K_2 45 Mg ha^{-1}, and K_3 60 Mg ha^{-1}. The second factor was liquid organic fertilizer

(LOF) (C), consisting of three levels, namely C_0 without fertilizer, C_1 10 mL L^{-1} of plant solution, and C_2 20 mL L^{-1} of plant solution.

Ultisols soil was cleaned of weeds, then processed and made beds of 3 m × 2 m of as many as 48 treatment combinations. The prepared treatment beds were then mixed evenly with sago palm waste compost and half the dose of LOF according to the treatment combination. Planting 3 corn seeds per planting hole with a spacing of 70 cm x 30 cm and two weeks later selected to be one plant per planting hole. A half dose of LOF was given when the plant was three weeks after planting.

Observations included soil chemical properties (pH, Al-exchangeable), N-total, P and K available soil, plant height, stem diameter, and crop yield (length, diameter, and dry kiln weight) of corn. Parameter of soil chemical properties and plant growth (plant height and stem diameter) was done after the plant reached the final vegetative phase (49 days) after planting, while the production of dry corn pipe was done after harvest.

The data were analyzed by univariate variety analysis (ANOVA); if there were significant and significant effects, then continued with the least significant difference (LSD) test α 0,05.

RESULTS AND DISCUSSION

Nature of Soil Chemistry

The results showed that compost and LOF independently had a significant effect on increasing K-available soil. In contrast, the interaction of sago palm waste compost with LOF significantly affected pH, Al-exchangeable, N-total, and P-available of Ultisols soil. Table 1 shows the treatment of sago palm waste compost 60 Mg ha^{-1} and LOC 10 mL L^{-1} solution was significantly different from all treatments and can increase up to the highest pH of 5.70.

The increase of soil pH by adding sago palm waste compost and LOF is caused by the release of the bases contained by the organic matter (OM). The basic cations of the decomposition of OM in the fertilizer released into the soil cause the soil to be saturated with the basic cation and may affect the soil pH.

Table 2 shows that for each treatment of sago palm waste compost when applied together with the LOC, the higher the dosage given, the lower the Al can be exchanged (Al-exchangeable) of Ultisols soil. Composting of sago palm waste doses of 60 Mg ha^{-1} and (LOF) doses of 20 mL L^{-1} of solution can decrease up to the lowest Al-exchangeable of 0.56 cmol(+)kg^{-1}.

Application of sago palm waste compost and LOF with increasing doses decreased Al-exchangeable levels in the soil. The result is in line with Yunus (2006), indicating an interaction between the residue of manure and lime on the decrease of Al-exchangeable soil, which was initially 1.86 cmol(+)kg^{-1}, after the application of manure decreased to 0.02 cmol(+)kg^{-1}. The contribution of manure produces compounds that make up the Al complex, which causes the OH ions to increase so that the soil pH increases, and Al-exchange decreases and increases the cation's absorbency (Soepardi 1983). According to Wahjudin (2006), the composting leftover rice, corn, soybeans, or peanuts into Vertic Hapludult soil reduced the Al-exchangeable content in different soils. Similar to Puspita (2010), the application of 3 L of LOF per plant decreases the concentration of Al-exchangeable to 0.80 cmol(+)kg^{-1} from the initial

Table 1. Soil pH after the application of Compost Sago Palm Waste and Liquid Organic Fertilizer (LOF) on Ultisols Soil.

Sago Palm Waste Compost (Mg ha^{-1}) (K)	LOF (mL L^{-1} planting solution) (C)		
	C_0 (0.0)	C_1 (10.0)	C_2 (20.0)
	.... Soil pH		
K_0 (0.0)	4.64 a	5.05 a	5.16 a
	A	AB	B
K_1 (30.0)	5.32 b	5.17 a	5.25 a
	A	A	A
K_2 (45.0)	5.11 a	5.25 a	5.56 a
	A	AB	B
K_3 (60.0)	4.92 ab	5.70 b	5.14 a
	A	B	A

Note: The numbers followed by the same letter in each column (small letters) and in each line (capital letters) are not significantly different on the LSD level 5% = 0.447

Table 2. Al-exchangeable Soil after the application of Sago Palm Waste Compost and Liquid Organic Fertilizer (LOF) on Ultisols Soil.

Sago Palm Waste Compost (Mg ha^{-1}) (K)	LOF (mL L^{-1} planting solution) (C)		
	C_0 (0.0)	C_1 (10.0)	C_2 (20.0)
	……............ Al-exchangeable Soil (%) ………………		
K_0 (0.0)	1.93 a	1.54 a	1.45 a
	A	B	B
K_1 (30.0)	1.39 b	1.39 b	1.30 b
	A	A	A
K_2 (45.0)	1.17 c	1.09 c	0.89 c
	A	A	B
K_3 (60.0)	0.82 d	0.70 d	0.56 d
	A	B	C

Note: The numbers followed by the same letter in each column (small letters) and in each line (capital letters) are not significantly different on the LSD level 5% = 0.11.

soil Al-exchangeable 6.80 cmol(+)kg^{-1}. Low soil acidity causes the level of Al-exchangeable in soil tends to be higher, resulting in lower nutrient availability for plants, so the soil should be treated for Al-exchangeable levels since Al-exchange is toxic to plants.

Table 3 shows the composting of sago palm waste 60 Mg ha^{-1} when given together with LOF 20 mL L^{-1} solution was significantly different from other treatment doses in increasing the highest N-total soils by 0.21%. The result is consistent with the research (Jedidi *et al*. 2004, Bouajila and Sanaa 2011), indicating that the availability of N in the soil increases with the compost/ Bokashi sago palm waste and LOF ABG flower fruits from 0.19% to 0.24% and 0.18% to 0.23% in Inceptisol soil, respectively.

In Adijaya and Rasa's study (2014), N-total levels increased due to the interaction of manure with bio urine of cattle from 0.11% to 0.163%. The higher levels of nitrogen in the soil cause the available nitrogen for the plant will increase so that the growth of plants will be increasingly encouraged.

In Table 4, it is seen that the application of sago palm waste compost of 60 Mg ha^{-1} together with LOF 20 mL L^{-1} solution was significantly different from other treatment doses in increasing to the highest P-available soil at 31.00 mg kg^{-1}.

The availability of P in the soil, resulting from the decomposition of OM produces organic acids which will react with oxides and hydroxides to form organic compounds to decrease the adsorption capacity of P and increase the availability of P (Kaya 2003). Increased P-available is due to sago palm waste compost and liquid organic fertilizer, converting organic phosphorus from OM to inorganic phosphorus. According to Kaya (2012), the higher dosage of sago palm waste compost and (LOF)

Table 3. N-total Soil after the application of Sago Palm Waste Compost and Liquid Organic Fertilizer (LOF) on Ultisols Soil.

Sago Palm Waste Compost (Mg ha^{-1}) (K)	LOF (mL L^{-1} planting solution) (C)		
	C_0 (0.0)	C_1 (10.0)	C_2 (20.0)
	…………………… N-total Soil (%) ………………………		
K_0 (0.0)	0.13 a	0.15 a	0.14 a
	A	A	A
K_1 (30.0)	0.14 a	0.14 a	0.13 a
	A	B	B
K_2 (45.0)	0.13 a	0.13 a	0.14 a
	A	A	A
K_3 (60.0)	0.14 a	0.15 a	0.21 b
	A	A	B

Note: The numbers followed by the same letter in each column (small letters) and in each line (capital letters) are not significantly different on the LSD level 5% = 0.03

Table 4. Phosphorous (P)-Available Soil after the application of Sago Palm Waste Compost and Liquid Organic Fertilizer (LOF) on Ultisols Soil.

Sago Palm Waste Compost (Mg ha^{-1}) (K)	LOF mL L^{-1} planting solution) (C)		
	C_0 (0.0)	C_1 (10.0)	C_2 (20.0)
	……………………. Soil P-available (mg kg^{-1})		……………………….
K_0 (0.0)	10.00 a A	13.33 a A	12.67 a A
K_1 (30.0)	15.33 ab A	17.33 ab A	24.67 b B
K_2 (45.0)	15.00 b A	14.67 a A	26.00 b B
K_3 (60.0)	14.00 ab A	21.33 b B	31.00 c C

Note: The numbers followed by the same letter in each column (small letters) and in each line (capital letters) are not significantly different on the LSD level 5% = 4.21.

ABG fruit-flower given together can increase the availability of P in soil Inceptisol. Likewise, according to Kaya (2009), the application of bokashi sago at a dose of 80 Mg ha^{-1} and phosphate fertilizer at a dose of 240 kg P ha^{-1} increased the available P of Ultisols soil 16.233 mg kg^{-1}.

Table 5 shows that the inter-dose treatment of sago palm waste compost is significantly different in increasing K-available soil. The dosing of 60 Mg ha^{-1} gave a marked difference with either 30 or 40 Mg ha^{-1} of compost and no in increasing the K-available soil from 205.22 mg kg^{-1} to 258.78 mg kg^{-1}. Likewise, for the treatment of LOF10 and 20 mL L^{-1}, different solutions with no LOF increased K-available soil, whereas the treatments (10 and 20 mL L^{-1}) had no significant effect. Application of LOF doses of 20 mL L^{-1} solution may increase K-available soil by 241.5 mg kg^{-1}.

Increased K-available is due to the interaction of sago palm waste compost and LOF, which converts organic K from OM into inorganic K. This is consistent with the research by Kaya (2014) on how the higher doses of manure and NPK fertilizers that are given together can increase the availability of K in paddy soil. As a result of the decomposition of OM, the availability of K in the soil can increase the soil K-exchangeable of 1.02 cmol(+)kg^{-1} so that K will be available in the soil because K is not easily leached.

Plant Uptake

The variance results indicate that applying compost and LOF independently significantly influence the uptake of N of maize plants, whereas the interaction of sago compost with LOF significantly influences the uptake of P and K of maize.

Table 5 shows that all doses of sago palm waste compost were significantly different from that without sago palm waste compost, which was 0.33 - 0.45% in increasing the N uptake of maize plants.

Increased N-uptake of plants can be caused by the increased availability of N in soils sourced from compost. This is because compost has been given since the beginning of the crop. Composting on soil can improve the physical and chemical properties of the soil. In contrast to the application of LOF that started at the age of 28 DAT plants. This causes the plants first to absorb more of the N elements and fulfill the N element's needs more

Table 5. Plant N-uptake and K-available Soil after the application of Sago palm waste Compost on Ultisol soil.

Sago Palm Waste (K) (Mg ha^{-1})	Plant N-Uptake (%)	K-available Soil
K_0 (0.0)	1.49 a	205.22 a
K_1 (30.0)	1.82 b	225.11 b
K_2 (45.0)	1.84 b	238.56 c
K_3 (60.0)	1.94 b	258.78 d

Note: The numbers followed by the same letter in each column are not significantly different on the LSD level 5% (N-uptake = 0.20; K-availabe soil = 13.45).

from the already composted soil. Planting media is the main line of plants in obtaining nutrients that become their needs. Therefore, the fulfilled N requirement of compost can lead to the application of LOF not affecting the N-uptake of the plant. This is also due to fresh LOF applied when the plant is aged 28 DAT. Wahyudi (2009) stated that the increase in crop development has to do with improving soil conditions. This will lead to an increase in the ability of plant roots to absorb water and nutrients of N in the soil, which will support an increase in above-ground development.

In Table 7, it can be seen that plants respond adequately to the treatment of compost and LOF to P-uptake. This may be due to a lack of P elements in the soil (14 mg kg^{-1}). High levels of Al-exchangeable 2.84 cmol(+)kg^{-1}) on soil may also suppress P elements due to fixation by Al. The fixation of P by Al results in the soluble variance (Hardjowigeno 2007). The addition of OM (compost) with 60 Mg ha^{-1} treatment and LOF dose of 20 mL L^{-1} solution into the soil with low P content due to P fixation by Al element will increase P availability. Stevenson (1982) describes the availability of P in the soil can be increased by the addition of OM through the following actions: (1) Through the mineralization process, the OM occurs through the release of mineral P (PO_4^{3-}); (2) By the action of an organic acid or other chelating compounds of the decomposition, there is the release of phosphate bound to insoluble Al and Fe to soluble form:

$Al(Fe)(H_2O)_3(OH)2H_2PO_4$ + Chelate $\rightleftarrows$ PO_4^{2-} (soluble) + Complex Al-Fe-Chelate; (3) Organic matter will reduce phosphate drag because humic acid and fulvic acid protect sesquioxide by blocking exchange sites; (4) The addition of OM is capable of activating the process of decomposition of native OM of soil; (5) Forming phospho-humor complexes and exchangeable and more available phosphates for plants, because phosphates are absorbed in OM weakly.

Fathan *et al*. (1988) stated that the necessary extent of nutrients in the soil for corn crops is 0.5% C-organic, K-exchangeable is 0.3 cmol(+) kg^{-1}, and P-available (Bray-2) is 20 mg kg^{-1}. Lower levels of P-available soil cause the plant's response by providing OM to fulfill the P element for plant growth and development.

According to Sanchez (1976), the level of nutrient sufficiency of P for maize is 0.25%, and based on Table 7, the value of P uptake for all treatments other than K_3C_2 treatment is still

Table 6. K-available soil after the application of Liquid Organic Fertilizer (LOF) on Ultisols soil.

LOF (mL L^{-1} planting solution)	K-available soil (%)
C_0 (0.0)	218.00 a
C_1 (10.0)	236.25 b
C_2 (20.0)	241.50 b

Note: The numbers followed by the same letter are not significantly different on the LSD level 5% = 11.65.

Table 7. Plant P-uptake after the application of Sago Palm Waste Compost and Liquid Organic Fertilizer (LOF) on Ultisols Soil.

Sago Palm Waste Compost (Mg ha^{-1}) (K)	Liquid Organic Fertilizer (POC) (mL L^{-1} planting solution) (C)		
	C_0 (0.0)	C_1 (10.0)	C_2 (20.0)
	……………………. Plant P-uptake (%) ……………………….		
K_0 (0.0)	0.14 a	0.16 a	0.18 a
	A	A	A
K_1 (30.0)	0.16 a	0.20 a	0.22 a
	A	B	B
K_2 (45.0)	0.20 a	0.20 a	0.20 a
	A	A	A
K_3 (60.0)	0.19 a	0.20 a	0.21 b
	A	A	B

Note: The numbers followed by the same letter in each column (small letters) and in each line (capital letters) are not significantly different on the LSD level 5% = 0.04

deficient. It is suspected that P-available for plants is still low, although P-available in soil solution from the addition of compost is already in the soil. Rainfall starts at the generative phase would affect the availability of nutrients in the soil due to leaching by rainwater. As a result, more nutrients are needed, especially P, to support the growth and development of plants.

Table 8 shows that the effect of 45 Mg ha^{-1} composting and 20 mL L^{-1} organic fertilizer on K-plant uptake is higher than the other treatments by 1.39 %. Poerwowidodo (1992) stated that LOF contains K elements that play an essential role in every process of plant metabolism, namely in amino acid synthesis and protein from ammonium ions. The K element also plays a role in maintaining the pressure of the turgor well to enable the smoothness of metabolic processes and ensure the continuity of cell lengthening.

Nevertheless, the value of K-plant uptake for all treatments is still low. According to Sanchez (1976), the critical limit of K nutrient deficiency in corn plants is 1.9%. The addition of the K element in the soil solution through compost treatment with a dose of 45 Mg ha^{-1} (K_2) of compost has increased the number of K that can be exchanged and gives a higher tendency for K-uptake (Table 5). This also corresponds to the condition of P-available in moderate soil, so there is no need to add compost with higher doses. Hardjowigeno (2007) states that K elements are found in large quantities in the soil, but only a small portion is used by water-soluble or interchangeable plants (in soil colloids).

Plant Growth

The result of variance showed that compost treatment gave a natural effect, while Liquid Organic Fertilizer (LOF) and interaction between compost and LOF did not significantly affect the height and diameter of corn stalk.

Table 9 shows that the higher the dosage of sago palm waste compost, given the increased growth of the plant, both plant height and diameter of corn stalk. The compost dose of 45 and 60 Mg ha^{-1} was significantly different without or given 30 Mg ha^{-1} dose of sago palm waste compost, but the two did not differ in maize's plant growth (plant height and stem diameter). The best dose in increasing plant growth, i.e., K_2 (45 Mg ha^{-1}) increased plant height from 33.31 cm to 114.22 cm, and K_3 (60 Mg ha^{-1}) increased the diameter of corn stalk from 1.5 cm to 6.42 cm.

Hadisuwito (2007) stated that the function of N nutrients is to form proteins and chlorophyll, the function of element P as a source of energy that helps the plant in the vegetative phase development, and Ca function to activate the formation of roots and strengthen rods, K elements function in protein formation, and carbohydrates and functional elements of S also helps in the formation of amino acids. If these elements are less available to plants, other growth processes will affect the process of growth and development of plants so that plants cannot grow to the maximum.

This fact illustrates that the application of compost sago palm waste can increase the vegetative growth of maize plants (height and stem

Table 8. Plant K-uptake Due to Sago Palm Waste Compost Treatment With Liquid Organic Fertilizer (LOF) In Ultisol Soil.

Sago Palm Waste (Mg ha^{-1}) (K)	Liquid Organic Fertilizer (LOF) (mL L^{-1} planting solution) (C)		
	c_0 (0.0)	c_1 (10.0)	c_2 (20.0)
	……………………. % ………………………		
k_0 (0.0)	0.49 a	0.90 a	0.77 a
	A	B	B
k_1 (30.0)	0.89 b	1.24 b	1.25 b
	A	B	B
k_2 (45.0)	1.23 c	1.23 b	1.39 c
	A	A	B
k_3 (60.0)	1.24 c	1.23 b	1.28 bc
	A	A	A

Note : The numbers marked with different letters in the direction of each column (regular letters) and towards the line capital letters) are evident by LSD test 5% = 0.13

Table 9. Plant Growth of Maize after the application of Sago Palm Waste Compost on Ultisols Soil.

Sagu Palm Waste Compost Mg ha^{-1} (K)	Plant Height (PH) (cm)	Diameter of Stem (DS) (cm)
K_0 (0.0)	33.31 a	1.50 a
K_1 (30.0)	89.25 b	5.17 b
K_2 (45.0)	114.22 c	6.32 c
K_3 (60.0)	111.42 c	6.42 c

Note : The numbers followed by the same letter in each column are not significantly different on the LSD test 5% (PH = 11.11; DS = 0.68)

diameter). This happens because compost sago palm waste can provide macro and micronutrients in sufficient quantities balanced for the growth and development of plants.

Yield of Corn

Dry Shell Weight

The results of variance showed that treatment of sago palm waste compost and LOF independently and interaction had a significant effect on the weight of dry seed corn.

Instead of giving LOF without sago composting into the soil, corn does not produce because the growth of the corn crop is also hampered. Whereas if LOF is given together with compost sago palm waste, then the higher doses given either sago palm waste compost or LOF will increase the yield of dry seed corn. In Table 10, the higher dosage of sago palm waste compost and LOF increase dry corn kiln weight from 0.0 g to 121.33 g. The highest dry corn kiln weight was found in treating 60-Mg ha^{-1} sago palm waste compost with 20 mL L^{-1} LOF solution.

They are organic materials (Sago palm Waste) and LOF as suppliers of various macronutrients (C, N, P, K, S, Ca, Mg, and other compounds) in a wide range as a result of the decomposition process in the form of simple compounds that are rapidly exploited by soil microorganisms and also available as nutrients for plants (Syakir *et al*. 2009). Each nutrient element has its respective functions. For example, the N element has the function of forming protein and chlorophyll, and the P element is an energy source that helps plants in generative phase development. While the Ca element activates the hairs of the roots and strengthens the stem, the K elements in the formation of proteins and carbohydrates, and the S element also helps in the formation of amino acids and helps other growth processes (Hadisuwito 2007).

CONCLUSIONS

The compost combined with liquid organic fertilizer could improve pH, Al-exchanged, total-N and P-available soil, P-uptake, K-uptake, and dry weight of seed corn. In contrast, the treatment of

Table 10. Dried Shell Weight after the application Sago Palm Waste Compost and Liquid Organic Fertilizer (LOF) on Ultisols Soil.

Sago Palm Waste Compost (Mg ha^{-1}) (K)	LOF (mL L^{-1} planting solution) (C)		
	C_0 (0.0)	C_1 (10.0)	C_2 (20.0)
	……………………. Dried Shell Weight (g) ………………………		
K_0 (0.0)	0.00 a	0.00 a	0.00 a
	A	A	A
K_1 (30.0)	40.11 b	69.33 b	77.50 b
	A	B	B
K_2 (45.0)	64.11 c	83.67 bc	90.00 b
	A	A	A
K_3 (60.0)	64.56 c	83.67 c	121.33 c
	A	B	C

Note: The numbers followed by the same letter in each column (small letters) and in each line (capital letters) are not significantly different on the LSD level 5% = 13.17

sago palm waste compost and liquid fertilizer are independently able to raise the K-available soil, N-uptake, and affect plant growth (height and trunk diameter) of corn. Sago palm waste compost dose of 60 Mg ha^{-1} and liquid organic fertilizer dose of 20 mL L^{-1} solution can increase the Al-exchanged, total-N and P-available soil respectively 0.56 cmol(+) kg^{-1}, 0.21%, and 31.00 mg kg^{-1}; also able to increase the uptake of P, K, and the dry weight of seed corn respectively 0.21%, 1.26%, and 121.33 g $plant^{-1}$. Sago palm waste compost dose of 60 Mg ha^{-1} and liquid organic fertilizer dose of 10 mL L^{-1} solution can increase soil pH by 5.70.

REFFERENCES

Adijaya IN and IM Rasa. 2014. Pengaruh pupuk organik terhadap sifat tanah dan hasil jagung. Balai Pengkajian Teknologi Pertanian (BPTP). Bali. Prosiding Seminar Nasional "Inovasi Teknologi Pertanian Spesifik Lokasi". Banjarbaru, pp. 299-310. (in Indonesian).

Adiningsih S and Mulyadi. 1993. Alternatif teknik rehabilitasi dan pemanfaatan lahan alang – alang untuk usaha tani berkelanjutan. Prosiding Seminar Lahan Alang–alang. Pusat Penelitian Tanah dan Agroklimat, Bogor. Badan Litbang Pertanian, pp.29-50. (in Indonesian).

Bouajila K and M Sanaa. 2011. Effect of organik amendments on soil physico-chemical and biological properties. *J Mater Environ Sci* 2:485-490.

BPS [Badan Pusat Statistik]. 2016. Maluku dalam angka 2016. Badan Pusat Statistik Maluku. Ambon. (in Indonesian).

Dibia IN and IWD Atmaja. 2017. Peranan bahan organik dalam peningkatan efisiensi pupuk anorganik dan produksi kedelai edamame (*Glycine max* L. Merill) pada tanah subgroup vertic epiaquepts Pegok Denpasar. *Agrotop* 7: 167-179. (in Indonesian)

Fathan R, M Raharjo and AK Makarim. 1988. Hara tanaman jagung. In: I Subandi, G Ismail and Hermanto (eds). *Jagung*. Puslitbangtan. Bogor, pp. 49-66. (in Indonesian).

Hadisuwito S. 2007. *Membuat pupuk kompos cair*. Agromedia Pustaka. Jakarta. 50 p. (in Indonesian).

Hardjowigeno S. 2007. *Ilmu tanah*. Penerbit Pusaka Utama. Jakarta. 288 p. (in Indonesian).

Iyamuremye F, RP Dick and J Baham. 1996. Organic amandements and phosphorus dynamis: ii. distribution of soil phosphorus fractions. *Soil Sci* 161:436-443.

Jedidi N, A Hassen, F Ayari, S Benzarti, H Cherif, O Bouzaiane, S Mokni and A Gharbi. 2004. Rapport d'avancement des travaux de recherche : Etude du compostage des déchets urbains dans la station de Béja/Tunisie. Valorisation agronomique du compost. 114 p.

Kaya E. 2003. Perilaku P dalam tanah, serapan P dan hasil jagung (*Zea mays L.*) akibat pemberian pupuk fosfat dengan amelioran pada inceptisols Sukabumi. [Disertasi] Universitas Padjajaran, Bandung. (in Indonesian).

Kaya E. 2009. Ketersediaan fosfat, serapan fosfat, dan hasil tanaman jagung (*Zea mays L*) akibat pemberian bokashi ela sagu dengan pupuk fosfat pada Ultisols. *J Ilmu Tanah dan Lingkungan* 9: 30-36. (in Indonesian).

Kaya E, JA Putinella and F Puturuhu. 2010. Pengaruh pemberian kompos ela sagu dan pupuk bunga buah terhadap sifat kimia dan fisik tanah, serapan NPK serta pertumbuhan dan hasil jagung (*Zea mays* L) pada tanah kambisol. Laporan Akhir Pelaksanaan Penelitian Hibah Penelitian Strategi Nasional DIPA Universitas Pattimura Ambon. (in Indonesian).

Kaya E. 2012. Pengaruh pemberian bokashi ela sagu dan pupuk ABG bunga buah terhadap N-tersedia, serapan N serta hasil tanaman jagung pada inceptisols. *J Budidaya Pertanian* 8: 89-94. (in Indonesian).

Kaya E. 2012. Pengaruh pemberian kompos ela sagu dan pupuk ABG bunga buah terhadap P-tersedia, Serapan P serta hasil tanaman jagung pada inceptisols. *J Buana Sains* 12: 21-26.

Kaya E. 2014. Pengaruh pupuk kandang dan pupuk NPK terhadap pH dan K-tersedia tanah, serta serapan K, pertumbuhan dan hasil padi sawah (*Oryza sativa L.*). *J Agrinimal* 4: 45-52.

Kaya. 2016. Pengaruh pupuk organik terhadap sifat kimia dan fisik tanah, serta serapan, pertumbuhan dan produksi tanaman jagung (*Zea mays* L) pada ultisols. Laporan Penelitian Hibah Pascasarjana. Fakultas Pertanian Universitas Pattimura, Ambon. 72 p.

Marvelia A, D Sri and P Sarjana. 2006. Produksi tanaman jagung manis (*Zea mays L.* Saccharata) yang diperlakukan dengan kompos kascing dengan dosis yang berbeda. *Buletin Anatomi dan Fisiologi* 2:7-18. (in Indonesian).

Matulessy F. 2006. Pengaruh lumpur laut dan ela sagu terhadap P-tersedia, Serapan P dan Pertumbuhan Jagung Pada Podsolik. [Skripsi]. Universitas Pattimura. (in Indonesian).

Olson RA and DH Sander. 1988. Corn production. In Monograph Agronomy Corn and Corn Improvement. Wisconsin. p.639-686.

Poerwowidodo. 1992. Telaah kesuburan tanah. angkasa. Bandung. (in Indonesian).

Prasetyo BH and DA Suriadikarta. 2006. Karakteristik, potensi, dan teknologi pengolahan tanah ultisols untuk pengembangan pertanian lahan kering di Indonesia. *J Litbang Pertanian* 25: 39-46. (in Indonesian).

Puspita BD. 2010. Uji efektivitas pupuk organik cair terhadap pertumbuhan dan produktivitas tanaman jagung (*Zea mays* L) dan sifat kimia tanah pada ultisols Cijayanti, Bogor. (Skripsi) Fakultas Pertanian IPB. Bogor. (in Indonesian).

Sanchez PA. 1976. Properties and management of soils in the tropics. John Wiley and Sons. New York.

Soepardi. G. 1983. Sifat dan ciri tanah. Departemen Ilmu Tanah. Fakultas Pertanian IPB. Bogor. (in Indonesian).

Stevenson FJ. 1982. Humus chemistry: Genesis, Composition, Reaction. John Wiley and Sons, New York.

Subagyo H, N Suharta and AB Siswanto. 2004. Tanah-tanah pertanian di Indonesia. In: A Adimihardja, LI Amien, F Agus and D Djaenudin (eds). Sumberdaya lahan Indonesia dan pengelolaannya. Pusat Penelitian dan Pengembangan Tanah dan Agroklimat, pp. 21-26. Bogor. (in Indonesian).

Syakir M, MH Bintoro and H Agusta. 2009. Pengaruh ampas sagu dan kompos terhadap produktivitas lada perdu. *J Littri* 15: 168-173. (in Indonesian).

Wahjudin UM. 2006. Pengaruh pemberian kapur dan kompos terhadap aluminium dapat ditukar dan produksi tanaman kedelei pada tanah vertic hapludult dari Gajrug, Banten. Bul Agron 34: 141-147. (in Indonesian).

Wahyudi I. 2009. Perubahan konsentrasi aluminium dan serapan fosfor oleh tanaman pada ultisols akibat pemberian kompos. *J Buana Sains* 9: 1-10. (in Indonesian).

Yunus. 2006. Efek residu pengapuran dan pupuk kandang terhadap basa-basa dapat ditukarkan pada tanah Ultisols dan hasil kedelai. *J Solum* III: 27-33.