JOURNAL OF DEGRADED AND MINING LANDS MANAGEMENT
ISSN: 2339-076X (p); 2502-2458 (e), Volume 6, Number 1 (October 2018): 1457-1465
DOI:10.15243/jdmlm.2018.061.1457

Research Article

The use of pineapple liquid waste and cow dung compost to improve the availability of soil N, P, and K and growth of pineapple plant in an Ultisol of Central Lampung

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Received 15 August 2018, Accepted 3 September 2018

Abstract: A study that was aimed to elucidate the effect of adding pineapple liquid waste and cow dung compost in increasing the availability of soil N, P, K, contents of N, P, K in pineapple leaves and growth of pineapple plant in an Ultisol was conducted in Central Lampung. The study consisted of two steps, i.e. incubation of pineapple liquid waste with cow dung compost in the soil, and planting pineapple by adding pineapple liquid waste and cow dung compost. Treatments tested in experiment 1 (laboratory incubation experiment) were combinations of pineapple liquid waste (L) and cow dung compost (K). Changes of soil chemical characteristics were observed at 15, 30, 45, and 60 days. Three best treatments of experiment 1 were selected for the experiment 2 (plant growth experiment in a glasshouse). Two control treatments were included in experiment 2. N, P, and K contents in pineapple leaves as well as and pineapple root length were observed at 30 and 60 days. Results of the first experiment showed that addition of pineapple liquid waste and cow dung compost significantly increased soil pH, availability of soil N, P, and K compared to controls at 15, 30, 45, and 60 days. Addition of 20 t cow dung compost/ha and 20,000 L pineapple liquid waste/ha (K3L3 treatment) resulted in higher values of soil pH, total N, available P, and available K than the control. Results of the second experiment showed that the addition of pineapple liquid waste and cow dung compost gave no significant effect on the growth of pineapple plant, but the addition of 20 t cow dung compost/ha and 10,000 L pineapple liquid waste/ha (K3L2 treatment) gave optimum growth compared to other treatments at 60 days. The K3L2 treatment also had higher pineapple leaf nutrient content, compared to control.

Keywords: *cow dung compost, pineapple liquid waste, Ultisol*

To cite this article: Ramadhani, W.S. and Nuraini, Y. 2018. The use of pineapple liquid waste and cow dung compost to improve the availability of soil N, P, and K and growth of pineapple plant in an Ultisol of Central Lampung. J. Degrade. Min. Land Manage. 6(1): 1457-1465, DOI: 10.15243/jdmlm. 2018.061.1457.

Introduction

One of the largest pineapple production companies in Lampung is PT. Great Giant Foods. Pineapple production in Lampung has decreased in 2013 (722,621 t), 2014 (560,036 t) and 2015 (534,774 t) (Nuryati et al., 2016). Decreased soil fertility is suspected because of intensive use of chemical fertilizers, monoculture planting of pineapple plant every year. Dey et al. (2012) explained that the planting of pineapple plant in monoculture had lower nutrient availability (pH (4.62) and organic C (2.38%) if compared to planting polyculture fruit trees (pH (5.80) and C - organic (4.03). Besides decreasing soil fertility, it is suspected that Lampung Province has Ultisol soil type. Ultisol is soil with the advanced washing that has a soil pH of 3.10 - 5 and poor contents of P, Ca, Mg, Na, K and high saturation of aluminium (>60%) (Prasetyo and Suriadikarta, 2006) caused by leaching (Ermadani and Muzar, 2011). Chaudhuri et al. (2016) reported that increasing the vegetative growth of pineapple plant, fruit weight and the percentage of pineapple fruit were related to pH, P, K, clay content, and the number of worms in the soil. Soil suitable for pineapple plant should have a pH of 4.5 to 6.5 (Hadiyati and Indriyani, 2008), phosphorus of 20 ppm and potassium of 0.4 me/100 g (Safuan, 2007). Efforts to increase nutrient availability at PT. Great Giant Food is the use of chemical fertilizers, the addition of cow dung compost and the return of pineapple leaves to the soil. However, excessive use of inorganic fertilizers can cause soil degradation and reduce crop productivity (Rahman and Zhang, 2018), create environmental pollution and hinder soil biological activity (Bakri et al., 2010).

An organic matter that has been used in PT. Great Giant Food is cow dung compost. Sanni (2016) explained that animal waste is effective in increasing organic matter into the soil by improving soil physical and chemical conditions and increasing plant growth. However, the problem is the low availability of cow manure that cannot meet the company's land supply. Therefore, it is necessary to add other organic materials that can increase nutrient availability at PT. Great Giant Food. One of the materials available in the pineapple company is pineapple liquid waste. Abdullah and Mat (2008) explained that pineapple liquid waste has a nutrient content of K (526 mg/L), Na (294 mg/L), Ca (194 mg/L), Mg (47.7 mg/L), P (27.4 mg/L) needed for plant growth. Besides that, pineapple liquid waste has a total sugar of 75.76 g/L and contains organic acids is citric (2.18 g/L). Microorganisms use citric acid as the primary means in dissolving P (Khan et al., 2014) and producing phosphatase enzymes (Fitriatin et al., 2014). However, the problem of pineapple liquid waste is that it has a low total N content of 0.064% and a low pH of 4.3 (Abdullah and Mat, 2008). Therefore, it is necessary to add organic matter to increase nutrients and increase the number of microorganisms in the soil.

The study was aimed to determine the effects of the application of pineapple liquid waste and cow dung compost on the availability of N, P, K, in an Ultisol and growth of pineapple plant.

Materials and Methods

The study was conducted from November 2017 until May 2018 at PT. Great Giant Food, Terbanggi Besar of Central Lampung. Research materials (Ultisol, pineapple liquid waste, and cow dung compost) were collected from PT. Great Giant Food. The soil used for the study had the following characteristics: pH (H_2O) 4.17, 1.76% organic C, 0.17% total N, 12.06 ppm available P, 0.95 me/100g available K, and 2.15 me/100g exchangeable Al. The pineapple liquid waste used for the study had the following characteristics: pH 3.04, 0.08% total N, 1.15% organic C, 0.02% total P, 0.37% total K, 0.02% total Ca, 0.02% total Mg, 58.03 ppm total Fe, 2.43 ppm total Zn, 0.75 ppm total Cu, 9.33 ppm total Mn, 4.19 ppm B, BOD 20,533 mg/L, COD 25,666 mg/L, glucose 43 mg/L, sucrose 29.5 mg/L, fructose 26 mg/L, and total solids 27,441 mg/L. The cow dung compost used for the study had the following characteristics: pH 6.67, 16.58% organic C, 1.50% total N, 0.32% total P, 0.02% available P, 0.84% total K, 0.66% available K, 1.21% available Ca, 0.27% available Mg, 0.10% available Na, 186.4 ppm available Zn, and 0.1 me/100 g exchangeable Al.

The study consisted of two steps, i.e. incubation of pineapple liquid waste with cow dung compost in the soil, and planting pineapple by adding pineapple liquid waste and cow dung compost. Treatments tested in experiment 1 (laboratory incubation experiment) were combinations of pineapple liquid waste and cow dung compost. Each treatment of a mixture of pineapple liquid waste and cow manure compost (Table 1) was mixed with 10 kg of soil (passed through 2 mm sieve and air-dried) and placed into a polybag. Water was then added to 50% of soil water holding capacity. The polybags were randomly placed in a screen house. During the experiment, water was periodically added to maintain moisture in the soil. Sixteen treatments (Table 1) were arranged in a completely randomized design with three replications. At 0, 15, 30, 45, and 60 days, pH and contents of exchangeable Al, total N, organic C, available P, and available K in the soil were determined in the laboratory using standard methods developed by Soil Laboratory of Brawijaya University.

Three best treatments of experiment 1 [P1 = A (best treatment 1), P2 = B (best treatment 2), and P3 = C (best treatment 3)] were selected for experiment 2 (plant growth experiment in a glasshouse). Two control treatments (K0 = control, and K1 = control 1 (chemical fertilization) were included in the second experiment. Five treatments of the second experiment were arranged in a completely randomized design with three replications. At 0, 30, and 60 days, soil pH, total N, organic C, available P, and available K were observed. N, P and K contents in the pineapple plant were observed at 60 days. Pineapple leaf length and width of D-Leaf were observed at 0, 7, 14, 21, 28, 35, 42, 49, and 56 days. N, P, and K contents in pineapple leaves, as well as pineapple root length, were observed at 30 and 60 days. Data obtained from the two experiments were subjected to analysis of variance at 95% significant level, followed by Duncan test at 5% level.

Table 1. Treatments of experiment 1 (laboratory incubation experiment); application of pineapple liquid waste with cow dung compost in an Ultisol

No	Code	Description
1	K0L0	Control
2	K1L0	Cow dung compost 10 t/ha
3	K2L0	Cow dung compost 15 t/ha
4	K3L0	Cow dung compost 20 t/ha
5	K0L1	Pineapple liquid waste 10,000 L/ha
6	K0L2	Pineapple liquid waste 15,000 L/ha
7	K0L3	Pineapple liquid waste 20,000 L/ha
8	K1L1	Cow dung compost 10 t/ha+ Pineapple liquid waste 10,000 L/ha
9	K1L2	Cow dung compost 10 t/ha+ Pineapple liquid waste 15,000 L/ha
10	K1L3	Cow dung compost 10 t/ha+ Pineapple liquid waste 20,000 L/ha
11	K2L1	Cow dung compost 15 t/ha+ Pineapple liquid waste 10,000 L/ha
12	K2L2	Cow dung compost 15 t/ha+ Pineapple liquid waste 15,000 L/ha
13	K2L3	Cow dung compost 15 t/ha+ Pineapple liquid waste 20,000 L/ha
14	K3L1	Cow dung compost 20 t/ha+ Pineapple liquid waste 10,000 L/ha
15	K3L2	Cow dung compost 20 t/ha+ Pineapple liquid waste 10,000 L/ha
16	K3L3	Cow dung compost 20 t/ha+ Pineapple liquid waste 10,000 L/ha

Results and Discussion

Effect of addition of pineapple liquid waste and cow dung compost on soil chemical properties (experiment 1)

pH

Application of pineapple liquid waste and cow dung compost increased soil pH compared to control. The K3L3 treatment had a higher soil pH compared to other treatments on observations of 15, 30, 45 and 60 days. Results of analysis of variance showed that the addition of pineapple liquid waste and cow dung compost significantly increased soil pH compared with controls at 15, 30, 45 and 60 days (Table 2). The results showed that application of 20,000 L pineapple liquid waste/ha and 20 t cow dung compost/ha increased soil pH by 8% compared to that of the K3L0 treatment (20 t cow dung compost/ha). Abegunrin et al. (2016) reported that the application of 20 t cow dung compost/ha could increase the soil pH of 6.75 compared to the control (without cow manure compost) that was 6.05. Pineapple liquid waste contains sugar that can be used as a microorganism substrate which can increase microorganism activities. The activity of microbes that produce citric acid having $COOH^-$ can indirectly increase soil pH. According to Dacera et al. (2009), microbes produce citric acid having carboxy $COOH^-$ which can be used as chelating and absorbing metal ions.

Organic C

Application of cow dung compost and pineapple liquid waste increased soil organic C at 15, 30, 45 and 60 days compared to control. The K3L3 treatment has a higher organic C content if compared to other treatments at 15 and 30 days. The results of analysis of variance showed that the combination of pineapple liquid waste and cow dung compost significantly increased organic C content in the soil at 15, 30, 45 and 60 days (Table 2). This is because of the higher organic matter content in K3L3 treatment than other treatments. Organic matter is a natural substrate for microorganisms and indirectly provides nutrients in the soil for plant growth (Rao, 1994). Abegunrin et al. (2016) reported that addition of 20 t cow dung compost/ha resulted in higher organic carbon of 0.7% compared to the addition of 10 t cow dung compost/ha, or chemical fertilizer.

Total N

Application of pineapple liquid waste and cow dung compost increased total nitrogen in the soil compared to controls. The K3L3 treatment had higher total N than the control. The results of analysis of variance showed that the combination of pineapple liquid waste and cow dung compost significantly increased total nitrogen in the soil at 15, 30, 45 and 60 days (Table 2). This increase is because of the decomposition of organic matter by soil microbes as indicated by the lower C: N ratio in the K3L3 treatment than other treatments. This resulted in a higher total N in the soil. Application of 20,000 L pineapple liquid waste/ha and 20 t cow dung compost /ha increased total N by 29%. Nutrient availability due to an addition of organic materials is influenced by soil pH that affects the presence of microorganisms and the rate of mineralization (Simanungkalit et al., 2012).

Table 2. Effect of application of pineapple liquid waste and cow dung compost on soil chemical properties

Treatments	Soil pH (days)					Organic Carbon (%) (days)					Total N (%) (days)				
	0	15	30	45	60	0	15	30	45	60	0	15	30	45	60
K0L0	4.15 b	3.96 a	3.93 a	3.77 a	3.68 a	2.07 a	1.97 a	1.80 a	1.63 a	1.60 a	0.10 a	0.20 a	0.20 a	0.17 a	0.10 a
K0L1	4.15 b	4.06 ab	4.00 a	3.92 ab	3.82 b	2.60 cdef	2.37 bc	2.17 bc	2.07 b	1.90 abcd	0.20 b	0.20 a	0.20 a	0.20 ab	0.20 bc
K0L2	4.15 b	4.22 bc	4.00 a	4.03 b	3.90 b	2.50 cd	2.07 a	2.00 ab	1.73 a	1.72 abc	0.20 b	0.20 a	0.20 a	0.20 ab	0.20 bcd
K0L3	4.15 b	4.37 cd	4.16 a	4.02 b	3.82 b	2.37 bc	2.20 ab	2.00 ab	1.73 a	1.67 ab	0.20 b	0.20 a	0.20 a	0.17 a	0.17 b
K1L0	4.15 b	4.49 de	4.44 b	4.38 c	4.28 c	2.10 a	2.40 bc	2.33 bcde	2.13 b	2.04 cde	0.20 b	0.20 a	0.30 c	0.20 ab	0.17 b
K1L1	4.14 a	4.51 de	4.48 b	4.45 c	4.26 c	2.37 bc	2.70 def	2.50 cdefg	2.17 b	2.01 cde	0.20 b	0.23 ab	0.20 a	0.20 ab	0.20 bc
K1L2	4.15 b	4.65 ef	4.57 b	4.50 c	4.30 cd	2.6 cde	2.43 bcd	2.40 cdef	2.23 bc	2.15 def	0.23 b	0.20 a	0.20 a	0.20 ab	0.20 bc
K1L3	4.15 b	4.70 ef	4.54 b	4.48 c	4.37 cd	2.63 defg	2.60 cde	2.20 bcd	2.03 b	1.96 bcd	0.23 b	0.20 a	0.20 a	0.20 ab	0.20 bc
K2L0	4.15 b	4.66 ef	4.56 b	4.47 c	4.41 d	2.20 ab	2.63 cde	2.62 efg	2.57 d	2.48 g	0.20 b	0.20 a	0.30 c	0.20 ab	0.20 bc
K2L1	4.15 b	5.01 gh	5.05 cd	4.97 d	4.84 f	2.43 bcd	3.00 gh	2.30 bcde	2.10 b	1.98 bcd	0.20 b	0.27 bc	0.20 a	0.20 ab	0.20 bc
K2L2	4.15 b	5.08 gh	5.05 cd	4.89 d	4.65 e	2.53 cd	2.80 efg	2.53 defg	2.20 bc	2.14 def	0.20 b	0.20 a	0.27 bc	0.27 b	0.27 ce
K2L3	4.16 c	5.00 gh	5.06 cd	4.87 d	4.67 e	2.87 hi	2.77 efg	2.60 efg	2.17 b	2.09 def	0.23 b	0.20 a	0.23 ab	0.27 b	0.23 bcde
K3L0	4.15 b	4.84 fg	4.82 c	4.82 d	4.74 ef	2.067 a	3.04 gh	3.03 h	2.47 cd	2.40 fg	0.20 b	0.23 ab	0.30 c	0.20 ab	0.20 bcd
K3L1	4.15 b	4.97 gh	4.95 cd	4.96 d	4.73 ef	2.83 egh	3.27 h	2.77gh	2.47 cd	2.14 def	0.27 b	0.20 a	0.27 bc	0.27 b	0.27 ce
K3L2	4.16 c	4.96 gh	4.95 cd	4.91 d	4.77 ef	2.93 hi	2.97 fgh	2.73 fgh	2.67 d	2.63 g	0.23 b	0.23 ab	0.30 c	0.27 b	0.30 e
K3L3	4.15 b	5.20 h	5.12 d	5.03 d	4.87 f	3.10 i	3.20 h	2.83 gh	2.47 cd	2.32efg	0.27 b	0.30 c	0.27 bc	0.27 b	0.27 ce

Table 2 (continuation).

Treatments	Available P (ppm) (days)					Available K (me/100g) (days)					Exchangeable Al (me/100g) (days)				
	0	15	30	45	60	0	15	30	45	60	0	15	30	45	60
K0L0	34.33	32.37 a	30.20 a	26.70 a	25.87 a	0.21	0.21 a	0.20 a	0.16 a	0.18 a	1.83	1.87 h	1.87 fg	1.87 f	1.90 f
K0L1	32.00	76.57 d	47.27 b	31.53 ab	31.07 a	0.21	0.27 a	0.26 ab	0.26 b	0.24 ab	1.73	1.60 g	2.00 g	2.00 f	2.00 f
K0L2	32.93	74.72 d	73.77 def	65.30 cde	28.70 a	0.22	0.30 a	0.28 bc	0.29 b	0.22 a	1.80	1.63 g	1.73 ef	1.73 e	1.77 e
K0L3	33.13	75.86 d	45.67 b	39.87 b	29.73 a	0.23	0.35 a	0.33 c	0.33 c	0.30 b	1.87	1.20 f	1.60 e	1.67 e	1.63 d
K1L0	32.43	62.62 b	71.57 de	68.30 cde	49.27 b	0.22	0.70 b	0.69 d	0.64 d	0.52 c	1.83	0.63 e	0.70 cd	0.70 cd	0.73 c
K1L1	32.80	67.20 c	63.33 c	58.40 c	49.43 b	0.21	0.69 b	0.68 d	0.64 d	0.57 c	1.80	0.60 e	0.60 bc	0.80 d	0.73 c
K1L2	33.93	62,20 b	70.47 de	64.90 cde	51.37 bc	0.21	0,75 bc	0.74 d	0.70 e	0.56 c	1.77	0.60 e	0.53 b	0.60 c	0.70 c
K1L3	33.60	67.67 c	64.23 c	60.93 cd	53.77 bc	0.23	0.79 bc	0.68 d	0.65 d	0.56 c	1.80	0.43 cd	0.53 b	0.60 c	0.63 c
K2L0	31.23	65.57 bc	72.00 de	67.40 cde	59.67 cd	0.23	0.88 cd	0.83 e	0.80 f	0.72 d	1.80	0.50 de	0.80 d	0.80 d	0.70 c
K2L1	30.57	68.30 c	68.60 cd	66.97 cde	61.03 cde	0.23	1.03 e	0.88 ef	0.73 e	0.65 d	1.80	0.20 ab	0.20 a	0.27 ab	0.30 b
K2L2	33.13	75.17 d	71.83 de	69.13 cdef	54.40 bc	0.21	0.98 de	0.91 f	0.91 g	0.65 d	1.77	0.17 ab	0.17 a	0.30 b	0.30 b
K2L3	31.33	76.67 d	76.20 ef	69.43 cdef	64.10 def	0.24	1.07 e	0.93 f	0.90 g	0.71 d	1.83	0.17 ab	0.17 a	0.27 ab	0.27 ab
K3L0	34.03	82.23 e	84.10 g	73.13 def	69.67 efg	0.20	1.21 f	1.20 g	1.12 h	0.91 e	1.83	0.30 bc	0.17 a	0.13 a	0.13 a
K3L1	30.37	94.43 f	83.33 g	76.60 ef	70.80 fg	0.22	1.32 fg	1.20 g	1.13 h	0.86 e	1.83	0.20 ab	0.23 a	0.20 ab	0.27 ab
K3L2	32.30	94.20 f	78.77 fg	77.97 ef	79.83 g	0.21	1.27 fg	1.23 g	1.17 i	1.09 f	1.77	0.17 ab	0.13 a	0.17 ab	0.20 ab
K3L3	31.93	94.67 f	91.87 h	83.17 f	73.30 fg	0.23	1.37 g	1.22 g	1.09 h	0.87 e	1.83	0.10 a	0.13 a	0.17 ab	0.20 ab

Description: K0 (no compost), K1 (cow dung compost 10 t/ha), K2 (cow dung compost 15 t/ha), K3 (cow dung compost 20 t/ha), L0 (without pineapple liquid waste), L1 (pineapple liquid waste 10,000 L/ha), L2 (pineapple liquid waste 15,000 L/ha), L3 (pineapple liquid waste 20,000 L/ha)

The increase of nitrogen in the decomposition process is because of the conversion of organic matter into CO_2 + H_2O + nutrient + humus + energy so that during the decomposition process CO_2 evaporates causing carbon to decrease and increase nitrogen (Widiarti et al., 2015). According to Boulter et al. (2000), microbial community converts decomposing organic matter into more stable, humified form and chemical products (CO_2, H_2O, ammonia, nitrate and methane).

Available P

Application of pineapple liquid waste and cow dung compost increased the availability of phosphorus in the Ultisol soil compared to controls. The K3L3 treatment had higher available phosphorus compared to other treatments (Table 2). The increase of phosphorus availability because microorganisms decomposed organic matter as indicated by the decrease of its C:N ratio. The K3L3 treatment had lower C:N ratio than other treatments this resulted in a higher available P content in the treatment. Application of 20,000 L pineapple liquid waste/ha and 20 t cow dung compost/ha increased available P by 15% compared to the K3L0 treatment (20 t cow dung compost/ha). Simanungkalit et al. (2012) explained that the activity of phosphate solubilizing microbes is influenced by soil pH which in turn affecting the rate of mineralization. The increase in available P is because of mineralization by soil microbial activity that can be indicated by the decrease in C:N ratio (Hanafiah, 2014). Pineapple liquid waste is used as an energy source for microorganisms as it contains glucose, fructose and sucrose to produce citric acid (Zakaria et al., 2007; Dacera and Babel, 2007). Microbes produce citric acid which has a carboxy $COOH^-$ (Dacera et al., 2009). Furthermore, organic acids react with phosphate chelates of Al^{3+} and Fe^{2+} which forms organic chelates so that they can dissolve phosphate ions (Sharma et al., 2013).

Available K

Application of pineapple liquid waste and cow dung compost increased the availability of potassium in the Ultisol soil compared to control. The K3L3 treatment had a higher content of available K compared to other treatments (Table 2). Application of 20,000 L pineapple liquid waste/ha and 20 t cow dung compost/ha increased available K by 14% compared to the K3L0 treatment. Ogbomo and Osaigbovo (2017) reported that the addition of cow dung compost increased the exchangeable cations of Ca^{2+}, Mg^{2+} and K^+. Addition of 20 t cow dung compost/ha increased available K higher than the addition of cow dung compost of 15 t/ha and 10 t/ha.

Exchangeable Al

Application of pineapple liquid waste and cow dung compost reduced aluminium in the soil. The K3L3 treatment had a lower content of exchangeable Al compared to other treatments. The results of analysis of variance showed that the addition of pineapple liquid waste and cow dung compost at 15, 30, 45 and 60 days significantly reduced aluminium in the soil studied (Table 2). The decrease in exchangeable Al was followed by the increase of soil pH. The K3L3 treatment had higher soil pH than the control. This was followed by the lower exchangeable Al in the K3L3 treatment compared to control. Organic matters enhance microbial activities that release organic acids, especially citric acid which has a carboxy $COOH^-$(Dacera et al., 2009). The citric acid can form organic chelate that can dissolve phosphate and Al, and precipitate Fe (Sharma et al., 2013).

Effect of addition of pineapple liquid waste and cow dung compost on pineapple growth and N, P, and K contents in pineapple plant (experiment 2)

Length and width of D-Leaf of the pineapple plant

The effect of addition pineapple liquid waste and cow dung compost to length and width D-leaf is shown in Tables 3 and 4. The K3L2 treatment had longer D-Leaf at 49 and 56 days. The K3L2 treatment had wider D-leaf of pineapple plant at 56 days compared to other treatments. The K3L2 treatment gave an optimal effect on the growth of the pineapple plant. The results of analysis of variance showed that addition of cow dung compost and pineapple liquid waste gave no significant impact to the width and length of D-Leaf of pineapple at all observation times although the K3L2 treatment had broader and longer D-Leaf compared to other treatments. This is related to the nitrogen content at 30 days that was not significantly different in each treatment. At 60 days, nitrogen in pineapple leaves of the K3L2 treatment was higher than other treatments. Nitrogen plays essential roles in the development of meristem tissue in vegetative plants, especially leaves (Hanafiah, 2014). Nitrogen is required for the production of proteins and primary materials that are used for the formation of cells and chlorophyll (Sitorus et al., 2014). Phosphorus has a function for the development of meristem tissues so that the leaves will be broader and more prolonged. While potassium as an activator of enzymes essential in the photosynthesis reaction. These three factors affect cell division in plants.

Table 3. Length of D-Leaf of the pineapple plant

Treatments	Length of D-Leaf (cm) at days after planting								
	0	7	14	21	28	35	42	49	56
K0	19.9	20.4	21.3	22.6	23.7	25.3	27.8	31.2	34.5
K1	19.8	20.5	21.4	22.6	23.9	27.2	29.4	31.8	34.3
K3L1	18.9	19.3	20.1	21.6	23.3	24.9	27.1	30.8	33.6
K3L2	22.2	23.1	23.1	22.5	25.1	27.0	29.0	33.4	37.2
K3L3	21.7	22.3	22.7	23.6	25.0	25.6	27.8	30.7	33.1

Description: K0 (no compost), K1 (chemical fertilizer), K3 (cow dung compost 20 t/ha), L1 (pineapple liquid waste 10,000 L/ha), L2 (pineapple liquid waste 15,000 L/ha), L3 (pineapple liquid waste 20,000 L/ha).

Table 4. The width of D-Leaf of the pineapple plant

Treatments	Width of D-Leaf (cm) at days after planting								
	0	7	14	21	28	35	42	49	56
K0	2.3	2.5	2.7	2.9	3.1	3.3	3.4	3.6	3.7
K1	2.5	2.7	2.8	3.0	3.1	3.3	3.4	3.6	3.6
K3L1	2.6	2.8	2.9	3.0	3.1	3.4	3.5	3.6	3.6
K3L2	2.6	2.7	3.0	3.0	3.2	3.2	3.3	3.5	3.8
K3L3	2.6	2.9	3.1	3.2	3.3	3.4	3.5	3.6	3.7

Description: K0 (no compost), K1 (chemical fertilizer), K3 (cow dung compost 20 t/ha), L1 (pineapple liquid waste 10,000 L/ha), L2 (pineapple liquid waste 15,000 L/ha), L3 (pineapple liquid waste 20,000 L/ha).

Plant fresh weight

The K3L2 treatment had higher plant weight at 60 days compared to other treatments. The addition of pineapple liquid waste and cow dung compost gave no significant effect to fresh weight of pineapple plant (Table 5). The increase in plant weight is influenced by the length and width of the leaves of the pineapple plant. The K3L2 treatment also had broader and longer D-leaf than other treatments at 60 days. Davis and Mack (1991) observed that there was a positive correlation between leaf area index with leaf dry weight (R^2 = 0.93 to 0.97), number of leaves (R^2 = 0.74 to 0.95) and height of plant (R^2 = 0.85 to 0.96) on peanuts.

Root length

The K3L2 treatment had a longer root of pineapple plant at 60 days compared to other treatments. The results of the analysis of variance showed that the addition of pineapple liquid waste and cow dung compost significantly affected the root length of the pineapple plant at 30 days. At 60 days, however, the root length of the pineapple plant was not significantly affected by the treatment (Table 5). The K3L3 treatment, however, yields lower root length of pineapple plant compared to the K0 treatment at 60 days.

Nitrogen content of pineapple leaves

The K3L2 treatment had higher nitrogen content in pineapple plant compared to other treatments at 30 and 60 days. The addition of pineapple liquid waste and cow dung compost significantly affected the nitrogen content of pineapple plant at 60 days (Table 6). The K3L2 treatment increased the nitrogen content of pineapple leaves by 4% compared with the use of chemical fertilizers.

Table 5. Fresh weight and root length of the pineapple plant

Treatments	Plant Fresh Weight (g/plant) at days after planting			Root Length (cm) at days after planting	
	0	30	60	30	60
K0	367.78	510.00	600.00	18.53 b	30.97
K1	363.33	490.00	596.67	17.47 b	23.90
K3L1	361.11	466.67	616.67	13.10 a	30.97
K3L2	368.89	476.67	660.00	17.63 b	33.07
K3L3	357.78	466.67	620.00	18.47 b	26.03

Description: K0 (no compost), K1 (chemical fertilizer), K3 (cow dung compost 20 t/ha), L1 (pineapple liquid waste 10,000 L/ha), L2 (pineapple liquid waste 15,000 L/ha), L3 (pineapple liquid waste 20,000 L/ha).

Nutrients in the leaves are affected by the availability of nutrients in the soil and the soil pH. The high nitrogen content in the leaves is reflected by the availability of nitrogen in the soil. This is consistent with the soil pH in the treatment of the application of cow dung compost and pineapple liquid waste that had higher soil pH than the control and chemical fertilizer treatments. Soil pH affects the presence of organisms in the decomposition of organic matter and affects the availability of nutrients (Hardjowigeno, 2015). Plant growth will be optimal if supporting factors such as availability of N, P, and K nutrients (Bustami et al., 2012). The availability of N, P and K for plants is affected by soil pH (Safuan, 2007).

Phosphorus content of pineapple leaves

The K3L2 treatment had higher phosphorus content in pineapple plant compared to other treatments at 60 and 30 days. The results of the analysis of variance showed that the addition of pineapple liquid waste and cow dung compost significantly affected the phosphorus content in pineapple plant (Table 6). The K3L2 treatment increased the phosphorus content of pineapple leaves by 7% compared with the use of chemical fertilizers. Nutrients in leaves are affected by the availability of nutrients in the soil and the soil pH. The soil pH in the treatments of the addition of pineapple liquid waste and cow dung compost had higher pH compared to the control and chemical fertilizer treatments. According to Estianty et al. (2006), nutrient absorption in plants is affected by the availability of nutrients in the soil, and if the soil has high nutrient availability, then the plants absorb high nutrients. Alkaline pH has more OH^- ions than H^+ ions, then OH^- ions bind to Al^{3+} to $Al(OH)_3$ which are precipitated and difficult to dissolve in the soil and phosphorus can be available in the soil (Rosmarkam and Yuwono, 2002).

Potassium content of pineapple leaves

The K3L2 treatment had a higher content of potassium in pineapple leaves compared to other treatments at 30 days. At 60 days, however, the K1 treatment had the highest potassium content. The addition of pineapple liquid waste and cow dung compost significantly affected potassium content in pineapple plant in each treatment (Table 6). The K3L2 treatment increased the potassium content of pineapple leaves by 12% compared with the use of chemical fertilizers. Dhalimi (2003) reported that addition of chemical fertilizer (KCl + Urea) between the base of the stem until canopy stem of the cashew yielded higher plant height compared to the application of chemical fertilizer at 50 cm outside of the canopy at one year. This is because the root of the plant reached the stem so that the root absorbed the nutrients.

Table 6. Nutrient content in pineapple plant

Treatments	**Nitrogen (%)**		**Phosphorus (%)**		**Potassium (%)**	
	Days After Planting					
	30	**60**	**30**	**60**	**30**	**60**
K0	1.40	1.47 a	0.27 a	0.24 a	1.67 a	2.50 a
K1	1.47	1.60 b	0.34 b	0.26 ab	2.53 b	2.93 b
K3L1	1.53	1.60 b	0.33 b	0.25 a	2.63 b	2.80 b
K3L2	1.53	1.67 b	0.36 c	0.27 b	2.83 b	2.43 a
K3L3	1.43	1.63 b	0.33 b	0.25 a	2.70 b	2.43 a

Description: K0 (no compost), K1 (chemical fertilizer), K3 (cow dung compost 20 t/ha), L1 (pineapple liquid waste 10,000 L/ha), L2 (pineapple liquid waste 15,000 L/ha), L3 (pineapple liquid waste 20,000 L/ha).

Conclusion

Application of pineapple liquid waste and cow dung compost increased the availability of N, P, and K in an Ultisol of Central Lampung compared to controls. The treatment of addition of 20 t cow dung compost/ha and 20,000 L pineapple liquid waste/ha resulted in the highest availability of N, P and K. A combination application of 20 t cow dung compost /ha and 15,000 L pineapple liquid waste/ha was the best treatment enhancing vegetative growth of pineapple plant (length of D-Leaf, width of D-Leaf, plant fresh weight, and root length). The K3L2 treatment yielded higher N, P, and K contents in pineapple leaves compared to the chemical fertilizer treatment.

Acknowledgements

The authors thank the Management and Staff of PT. Great Giant Foods, Central Lampung for providing technical assistance and facilities to carry out this study.

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