

PAPER • OPEN ACCESS

Application of pulp and paper sludge compost on Anthocephalus cadamba seedlings in ultisol and peat media

To cite this article: S Wahyuningsih 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **415** 012021

View the [article online](#) for updates and enhancements.

You may also like

- [Performance of vegetative and reproductive characters of some maize inbred line \(*Zea Mays L.*\) in ultisol soil applied with the coffee skin compost](#)
K Lubis, D R Panjaitan and H Setiada
- [Effect of Coal Ash Enriched Compost on Soil Chemical Properties of Ultisols](#)
A Putri, I Iskandar, P Oktariani et al.
- [Total N in Soil, N Absorption, and Growth of Corn \(*Zea mays L.*\) Due to the Amendment of Sago Palm Waste Compost and NPK Compound Fertilizer to Ultisols](#)
Elizabeth Kaya, Adelina Siregar and Nurlaila Maruapey

Application of pulp and paper sludge compost on *Anthocephalus cadamba* seedlings in ultisol and peat media

S Wahyuningsih

Research and Development Institute of Fiber Technology of Forest Plant, Ministry of Environment and Forestry, Riau 28401 Indonesia

E-mail: sitiwahyuningsih02@gmail.com

Abstract. Pulp and paper sludge contains cellulose which has a positive potential as compost material. This study aims to examine responses of jabon (*Anthocephalus cadamba*) seedlings planted in Ultisol and peat media with addition of pulp and paper sludge compost. Before composting, the sludge was air drained to reduce water content from 80.92% to around 60-70%. Bio decomposers consist of a combination of *P. citrinum* and *P. oxalicum* with a density of 10^7 ml/spores were inoculated to the sludge and incubated for six months. Compost of sludge was added to grow media (ultisol and peat) with doses equal with 2, 4, 6, 8, 10, 12, 14 and 16 (ton/ha). Control treatment consists of fertile soil as a negative control, and Ultisol and peat soil with chicken manure compost addition as a positive control. Seedlings height and diameter measurement were held for six months. Both in ultisol and peat media, the addition of chicken manure compost was better in raising seedlings height and diameter. However, the sludge compost addition in peat media was better in raising the seedlings biomass than those added with the chicken manure compost.

I. Introduction

In 2013, Indonesia's pulp production capacity was about eight million tons, among top ten world's pulp producers [1, 2]. Meanwhile in 2015, Indonesia's paper production were about 12 million tons, rank at six of the world's paper producers [2]. However, Indonesia pulp and paper are mainly composed of virgin woods [3]. On the other hand, pulp and paper sludge from virgin wood will generate more organic materials than from recycled and deinking paper [4]. According to [5], 1 tonne paper produced from paper mill will generate 40 to 50 kg sludge (dry). However, pulp and paper sludge is potential for soil amendment, especially of its fibres and calcium carbonate content [6, 7].

Some fungi species are able to degrade organic matter. *Penicillium citrinum* and *Penicillium oxalicum* are among of *Penicillium sp* that produce cellulases [8, 9]. *P. citrinum* can generate xylanase in alkali condition which can benefit for pulp and paper industry or food and feed industry [10]. The fungi is also reported as phosphate solubilizing fungi that can raise phosphor availability for plants [11]. *P. oxalicum*, on the other hand, has a gene to encode swollenin-like protein which can weakening cellulose [12]. *P. oxalicum* is also produce MnP to degrade polymeric lignin, lignin model compounds and aromatic pollutants [13]. Those *Penicillium sp* are potential as pulp and paper sludge decomposer to increase the decaying rate.

Application of compost to marginal soil can raise both soil's physical and biological properties. Peatlands and ultisols are marginal soil spread across Sumatra Island, Indonesia. In Riau Province,



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](#). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Indonesia, peatland and Ultisol cover 3.8 and 2.6 million hectares, respectively [14]. Peatland is rich of organic materials, however, the acidity causes some nutrients such as phosphor become unavailable for plants. A high rainfall can also leach nutrients from the peatland [15]. A rehabilitation of damaged peatland are commonly failure because of poor nutrients. However, according to [16], a mix of pulp and paper sludge compost (80 %) and peat raised plants growth. Moreover, calcium carbonate contained in the sludge can lime acidic soil such as peat [6]. On the other hand, application of non-composted pulp and paper sludge immobilize N, P and S that can cause soil nutrients deficiency [17].

In Riau Province, ultisol is characterized as acid, saturated with Al, low fertility and cation change capacity (CEC) [18]. Liming is often applied to an acid soil to raise pH and increase phosphor availability. However, liming can leach some micronutrients such as Zn. In Sumatra and Sulawesi Island, Indonesia, the soil are known deficient for Zn with a total concentration of Zn range from 33-174 (mg Zn kg⁻¹) [19]. Therefore, farmers in Sumatera are often combine liming with fertilizer or compost application. However, the practice is costly. Compost of pulp and paper sludge can offer both lime and Zn for the marginal soil. Our study showed a six months composted pulp and paper sludge has nutrients quality similar to compost from chicken manure. However, the CN ratio of the compost was still above 20. This study aims to compare a response of *Antocephalus cadamba* seedlings to addition of commercial chicken manure compost and pulp and paper sludge compost. *Antocephalus cadamba* is a native species of South and South East Asia and the fibres is suitable for pulp and paper production [20].

2. Materials and Methods

2.1. Materials

The pulp and paper sludge was generated from a pulp and paper company in Riau Province, Indonesia. The sludge was then sun dried to obtain water content of 60-70%. The treated sludge was placed in a bucket, inoculated with decomposers and incubated for six months. The decomposers was a combination of *P. citrinum* and *P. oxalicum* with a density of 10⁷ (spores/ml). Both fungi were obtained from collection of the Research and Development Institute of Forest Fiber Technology, Riau Province. Chemicals and laboratory equipment's for soil chemicals analysis, compost and peat chemicals analysis, and biomass and plant tissues analysis were based on [21].

2.2. Methods

2.2.1. Preparation for the composting

A counting of the decomposers density was held by diluting spores of a combination of *P. citrinum* and *P. oxalicum* into 150 ml sterile water and the spores were accounted using haemocytometer. A determination of the decomposers spores density was based on our previous study that found a density of 10⁷ (spore/ml) was having the highest cation exchange capacity (CEC) (Table 1). Composting was undertaken by adding the 150 ml sterile water contained decomposers into 15 kg's treated pulp and paper sludge. The sludge was placed in a bucket and the top of the bucket was covered with a clear plastic sheet to avoid flies. The sludge then incubated for six months and the sample was analysed for macro nutrients (N, P, K, Ca and Mg), micro nutrient (Zn), heavy metals (Pb, Cd) and chemicals content (pH, CEC).

Table 1. A comparison of macro nutrients, micro nutrients and chemicals content of composted pulp and paper sludge inoculated with a combination of *P. citrinum* and *P. oxalicum* at a density of 10^7 , 10^8 and 10^9 (spores/ml).

Decomposers spores density (spores/ml)	pH H ₂ O	Org C (%)	CN ratio	N	P ₂ O ₅	K ₂ O (%)	Ca	Mg	CEC (me/ 100 mg)	Zn	Pb	Cd
10^7	7.33	36.5	25.1	1.48	1.83	2.86	0.4	0.5	48.2	158.9	3.6	0.2
10^8	7.43	35.2	24.5	1.46	1.83	2.89	0.4	0.5	46.6	164.8	3.2	0.2
10^9	7.43	34.8	23.9	1.48	1.97	2.85	0.4	0.5	45.8	166.7	2.9	0.2

2.2.2. Compost application.

The compost was then applied to *Anthocephalus cadamba* seedlings planted in ultisol and peat media. Seedlings with height of 10-30 cm were selected for the study. The growing media consisted of ultisol and peat were each weighed for 10 kg's and was put into a polybag. Both the ultisol and peat were collected at a depth 10-15 cm from the soil surface. Compost of the pulp and sludge was weighed and added to the growing media with doses equal to 2, 4, 6, 8, 10, 12, 14 and 16 (ton/ha) (Table 2) [22]. Each treatment was replicated three times. Control treatment consisted of positive and negative control. The negative control was fertile soil (top soil rich of decomposed leaves) for growing media. The fertile soil was a growing media that commonly used in our nursery. Meanwhile positive control was an application of commercial chicken manure compost (the commercial brand was "Mabar") to the growing media with doses equal to 2, 4, 6, 8, 10, 12, 14 and 16 (ton/ha) (Table 2). For both negative and positive control, each treatment was replicated three times. The study was held in a nursery and the seedlings were watered by using sprinkled irrigation system. The seedlings height and diameter were measured every month until six months after planting.

Table 2. Weight of chicken manure compost or sludge compost (g) added to 10 kg ultisol or peat and the dose equivalent (ton/ha).

Chicken manure or compost sludge (g) added to 10 kg ultisol or peat	Dose equivalent (ton/ha)
8.9	2
17.8	4
26.7	6
35.6	8
44.6	10
53.5	12
62.4	14
71.3	16

2.2.3. Ultisol chemicals analysis.

The soil was cleared from contaminants and stored in an oven with a temperature of 40⁰ C. The soil then was destructed manually using a mortar and sifted to get particles size <0.5 mm and <2 mm. The soil pH determination was held by using a pH meter. The P₂O₅ determination was based on the Bray I method. The exchangeable cations (Ca²⁺, Mg²⁺, K⁺ and Na⁺) was determined using atomic absorption

spectrophotometry and the CEC was determined by colorimetry. The organic C was determined using spectrophotometry. The soil nitrogen content was determined using the Kjeldahl method [21].

2.2.4. Compost and peat chemicals analysis.

The analysis was undertaken to determine the pH, CEC (me/100 g), organic C (%), macronutrients (N, P, K, Ca, Mg) (%), micronutrients (S, Zn) (ppm) and heavy metals (Pb, Cd) (ppm) content of composts and peat. Sample preparation was held by grinding and sieving the sample using 2 mm sieve before analysis. pH measurement was held by diluting 10 g prepared sample in 50 ml sterile water in a tube test and centrifuging for 30 minutes. The sample suspension was then measured to determine pH and CEC (me/100 g). The organic C (%) was determined using the Walkley & Black method. The total N (%) was determined using the Kjeldahl method. P_2O_5 (%) and S (%) were determined using a spectrophotometer. Determination of K_2O (%), Ca (%), Mg (%), Zn (ppm), Pb (ppm) and Cd (ppm) were determined using atomic absorption spectrophotometer [21].

2.2.5. Biomass and plant tissues analysis.

The biomass and plant tissue analysis was held for seedlings planted in peat and added with chicken manure compost and sludge compost at various doses. The seedlings planted in ultisol were not analysed because a low life percentage made the samples were not sufficient. The analysis was held by washing the samples with sterile water before analysis to be free from contaminants. Then, the seedlings were dried using a fan oven. For biomass analysis, the seedlings were cut based on root, stem and leaves and dried in the oven at 70°C for 48 hours before weighed. For plants tissues analysis, the dried seedlings were milled using a grinder machine and sifted to get fineness 0.5 mm. The nitrogen content was determined using the Kjeldahl method. The macro and micronutrients were determined using atomic absorption spectrophotometry and visible spectrophotometry [21].

2.2.6. Statistical analysis.

The seedlings height and diameter were analysed using Analysis of Variance (ANOVA) procedure followed by Duncan Multiple Range Test (DMRT) at 95% level of significance.

3. Result and Discussion

3.1. Chemicals analysis of composts and growing media used in the study

The composted pulp and paper sludge had similar chemicals content to that of commercial chicken manure compost (Table 3). However, a CN ratio of the composted pulp and paper sludge was still higher than that of the chicken manure compost. Indonesian National Standard (SNI) 19-7030-2004 mentioned that CN ratio for compost of organic waste should be ranged from 10-20. Therefore, the sludge compost should be incubated for longer than six months to meet the CN ratio criteria of the SNI. On the other hand, cation exchange capacity (CEC) of the sludge's compost was higher than that of the chicken manure compost. A higher CEC showed a rising ability of compost to provide nutrients for plants [23]. The sludge compost was also contained a higher micronutrient Zn. Zn is a critical micronutrient in marginal and leached soils, such as ultisol. Application of compost with a high Zn content to the ultisol can raise plants growth. Soil with a Zn concentration of 28 ppm is categorized as the lowest [24]. Ultisol used as growing media in this study contained Zn concentration of 27.33 ppm (Table 4).

Table 3. Chemical analysis of chicken manure compost and pulp and paper sludge compost used in the study

Chemicals parameter	Commercial compost of chicken manure	Compost of pulp and paper sludge
pH H ₂ O	7.1	6.67
Org C (%)	29.65	29.43
Total nitrogen (%)	1.43	1.32
C/N ratio	20.7	22.3
P ₂ O ₅ (%)	4.95	3.87
K ₂ O (%)	2.51	2.24
Ca (%)	0.38	0.52
Mg (%)	0.24	0.26
CEC (me/100 g)	46.26	49.82
Fe (ppm)	187.4	193.5
Zn (ppm)	493.2	565.6
Mn (ppm)	241.6	207.9
Pb (ppm)	5.8	4.17
Cd (ppm)	1.1	1.4
Cr (ppm)	0.6	0.27

Table 4. Chemical analysis of the grow media used in the study consist of fertile soil as negative control, peat and ultisol.

Chemicals parameter	Fertile soil	Peat	Ultisol
pH H ₂ O	3.5	3.6	4.53
Org C (%)	46.22	40.6	1.43
Total nitrogen (%)	0.68	0.81	0.17
C/N ratio	53.7	50.17	8.27
P ₂ O ₅ (ppm)	12.4	2.97	2.2
K ₂ O (%)	0.83	0.73	0.033
Ca (%)	0.13	0.077	0.057
Mg (%)	0.41	0.35	0.013
CEC (me/100 g)	39.41	35.39	13.01
Fe (ppm)	302.6	398	64.57
Zn (ppm)	74.9	89.53	27.3
Mn (ppm)	107.7	128.8	150.07
Pb (ppm)	2.3	2.7	0.33
Cd (ppm)	0.6	0.5	0.17
Cr (ppm)	0.7	0.7	0.1

Grow media consisted of peat and ultisol was selected because that soil type dominates soil cover in Riau Province, Indonesia where the study took place. According to chemical analysis for those soil (Table 4), ultisol was more marginal than peat. However, fertile soil used in this study, as well as peat and ultisol, has low soil pH. The low pH of the peat and fertile soil could be because of the high CN ratio. Microbes' activities in decomposing organic matter in those soil type generate organic acids which can lower the soil pH. [25]. The aim of using fertile soil as growing media was to compare with the growth of seedlings planted in peat and ultisol after compost application. According to Table 3 and 4, application of chicken manure compost or sludge compost in peat and ultisol can rise the N and K level than in the fertile soil. However, during the study, the high clay content of ultisol caused the soil to be compacted. The ultisol in Riau Province contains a high percentage of clay, such as ultisol in Rokan Hulu District which the clay content was 57% [26].

3.2. The growth of *Anthocephalus cadamba* in fertile soil and in ultisol added with chicken manure compost and sludge compost at various doses

White jabon (*Anthocephalus cadamba*) is a local forest plant and become popular for forest plantation [27]. The plant is also a pioneer species that is commonly found in seconder forest along riverbanks [20]. The species is more adaptive to waterlogged stress than to drought [28]. In this study, white jabon seedlings planted in ultisol looked infertile than in peat. Some seedlings planted in ultisol experienced dry because the large leaves area prevented the water from the sprinkler irrigation system to reach the soil. Moreover, ultisol contains clay for about 50% which harden the soil when dry. When the soil becomes very dry, the water hardly penetrates to the soil pores. As a result, some of the seedlings buds or stems were dry. However, some of those dried seedlings can rise new branches from the broken or dried stems. In addition, mealybugs (*Pseudococcidae*) had also attacked some seedlings in the nursery. Therefore, the height of the seedlings in this study was fluctuating during the study.

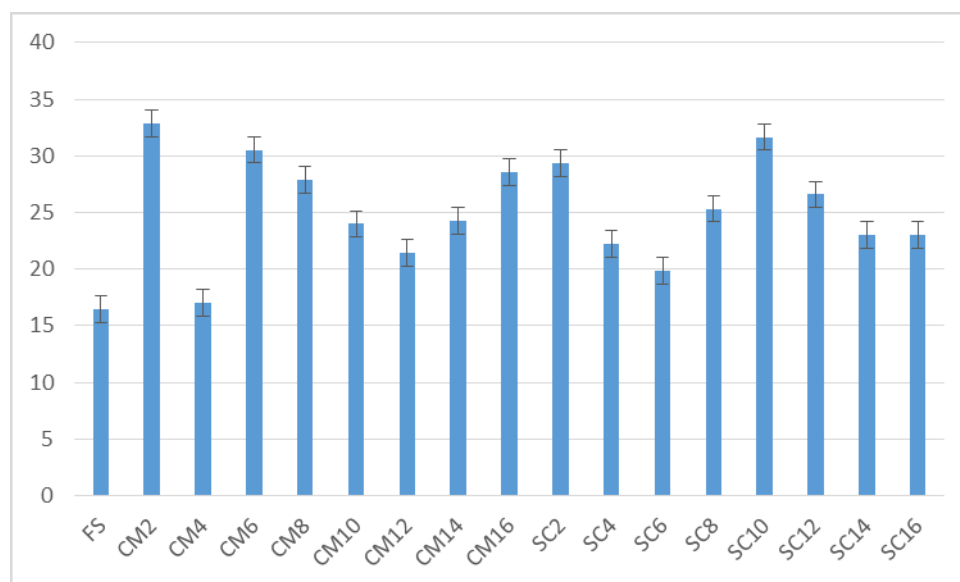


Figure 1. The average of seedlings height planted in fertile soil (FS) and ultisol added with chicken manure (CM2-CM16) and sludge compost (SC2-SC16) at various doses after six months planting. A number following an initial represents the compost doses.

Seedlings planted in ultisol and added with sludge compost were less fertile than those with the chicken manure addition. Chicken manure addition with a dose equal to 2 ton/ha generated seedlings with the best height after six months planting (Figure 1). While chicken manure compost addition equal to 8 ton/ha produced the biggest seedlings diameter (Table 6). On the other hand, compost sludge addition at various doses (2-16 ton/ha) did not significantly different in raising seedlings height and diameter with the chicken manure compost addition at doses equal to 10-16 ton/ha (Table 5).

In ultisol media, the addition of compost at a large quantity was not significantly raised seedlings growth because when the soil dry, compost will be leached. In a field with a soil type of ultisol, the planting activities are commonly combined with organic mulching such as mulches from twigs, stems or leaves. The aims are to reduce soil erosion or compost washing, to increase soil water retention and to maintain soil temperature. In this study, the sludge compost addition can raise the height of the seedlings in ultisol but the chicken manure compost addition gave a better effect. However, chicken manure compost addition at dose 4 ton/ha gave a similar effect to seedlings planted in fertile soil. The

seedlings were shorter probably because of no fertilizer addition. Although the fertile soil is a common grow media in our nursery, some chemicals fertilizers are usually added to support seedlings growth.

Table 5. Seedlings height in fertile soil and ultisol added with chicken manure compost or compost sludge at various doses at one until sixth months after planting

Treatment	M1	M2	M3	M4	M5	M6	M7
Fertile soil	20.5 ^a	20 ^{ab}	15.2 ^a	13.67 ^{ab}	11.4 ^a	11.53 ^a	16.47 ^a
Chicken manure (ton/ha)							
2	21.67 ^a	22.33 ^{ab}	28.83 ^b	27.13 ^{abc}	30.13 ^{bc}	31.8 ^c	32.87 ^b
4	14.46 ^a	16.33 ^{ab}	16.27 ^a	16.2 ^{ab}	14.67 ^{ab}	14.8 ^{ab}	17 ^a
6	24.93 ^a	23.33 ^b	28 ^b	31.67 ^c	32 ^c	32.2 ^c	30.53 ^{ab}
8	13.3 ^a	16.67 ^{ab}	20.20 ^{ab}	26.47 ^{abc}	27 ^{abc}	27.47 ^{abc}	27.87 ^{ab}
10	17.5 ^a	19.17 ^{ab}	18.67 ^{ab}	13.4 ^a	17.13 ^{abc}	18.4 ^{abc}	24 ^{ab}
12	16.33 ^a	11.5 ^a	17.33 ^a	17 ^{ab}	24.07 ^{abc}	24.53 ^{abc}	21.4 ^{ab}
14	21.83 ^a	22.67 ^{ab}	23.27 ^{ab}	20.53 ^{abc}	22.93 ^{abc}	23.53 ^{abc}	24.37 ^{ab}
16	20.17 ^a	21 ^{ab}	23.67 ^{ab}	24.4 ^{abc}	26.071 ^{bc}	26.73 ^{abc}	28.6 ^{ab}
Compost sludge (ton/ha)							
2	20.83 ^a	24.67 ^b	24.33 ^{ab}	20.6 ^{abc}	22.67 ^{abc}	23.07 ^{abc}	29.33 ^{ab}
4	18.17 ^a	18.33 ^{ab}	17.33 ^a	21.33 ^{abc}	19.6 ^{abc}	19.4 ^{abc}	22.2 ^{ab}
6	19 ^a	18.5 ^{ab}	16 ^a	13.67 ^{ab}	14.8 ^{ab}	16.0 ^{abc}	19.87 ^{ab}
8	16.83 ^a	16.5 ^{ab}	18.33 ^a	21.67 ^{abc}	23 ^{abc}	23.33 ^{abc}	25.33 ^{ab}
10	25.33 ^a	26.17 ^b	28 ^b	27.47 ^{bc}	29.67 ^{bc}	29.87 ^{bc}	31.67 ^{ab}
12	25 ^a	27.67 ^b	22.67 ^{ab}	22 ^{abc}	24.07 ^{abc}	21.07 ^{abc}	16.6 ^{ab}
14	25.33 ^a	16.33 ^{ab}	18.67 ^{ab}	20 ^{abc}	22.47 ^{abc}	22.13 ^{abc}	23 ^{ab}
16	20.17 ^a	21 ^{ab}	23.67 ^{ab}	13.67 ^{ab}	20.33 ^{abc}	21.33 ^{abc}	23 ^{ab}

Means represented by same letter along column are not significantly different.

Table 6. Seedlings diameter in fertile soil and ultisol added with chicken manure or compost sludge at various doses at one until sixth months after planting

Treatment	M1	M2	M3	M4	M5	M6
Fertile soil	1.67 ^a	1.10 ^a	1.27 ^a	1.00 ^a	1.00 ^a	1.00 ^a
Chicken manure (Ton/ha)						
2	2.10 ^a	1.43 ^{ab}	1.41 ^a	1.10 ^a	1.20 ^{ab}	1.16 ^{ab}
4	2.03 ^a	1.5 ^b	1.28 ^a	1.13 ^{ab}	1.19 ^{ab}	1.20 ^{ab}
6	1.68 ^a	1.27 ^{ab}	1.57 ^a	1.63 ^b	1.53 ^{ab}	1.56 ^{ab}
8	1.92 ^a	1.43 ^{ab}	1.46 ^a	1.67 ^b	1.67 ^b	1.74 ^b
10	1.68 ^a	1.53 ^b	1.57 ^a	1.17 ^{ab}	1.17 ^{ab}	1.31 ^{ab}
12	1.63 ^a	1.43 ^{ab}	1.23 ^a	1.17 ^{ab}	1.33 ^{ab}	1.52 ^{ab}
14	1.93 ^a	1.37 ^{ab}	1.06 ^a	1.41 ^{ab}	1.37 ^{ab}	1.49 ^{ab}
16	1.92 ^a	1.5 ^b	0.93 ^a	1.43 ^{ab}	1.52 ^{ab}	1.62 ^{ab}
Sludge compost (Ton/ha)						
2	1.75 ^a	1.57 ^b	1.40 ^a	0.96 ^a	1.13 ^{ab}	1.26 ^{ab}
4	1.87 ^a	1.43 ^{ab}	1.30 ^a	1.37 ^{ab}	1.32 ^{ab}	1.41 ^{ab}
6	1.97 ^a	1.33 ^{ab}	1.48 ^a	1.07 ^{ab}	1.07 ^{ab}	1.10 ^{ab}
8	1.73 ^a	1.27 ^{ab}	1.30 ^a	1.23 ^{ab}	1.20 ^{ab}	1.30 ^{ab}
10	1.82 ^a	1.33 ^{ab}	1.27 ^a	1.37 ^{ab}	1.29 ^{ab}	1.43 ^{ab}
12	1.78 ^a	1.47 ^b	1.33 ^a	1.27 ^{ab}	1.25 ^{ab}	1.30 ^{ab}
14	2.17 ^a	1.53 ^b	1.50 ^a	1.47 ^{ab}	1.51 ^{ab}	1.61 ^{ab}
16	1.85 ^a	1.57 ^b	1.33 ^a	1.10 ^{ab}	1.23 ^{ab}	1.33 ^{ab}

Means represented by same letter along column are not significantly different.

3.3. The growth of *Anthocephalus cadamba* in fertile soil and peat media added with chicken manure compost and sludge compost at various doses

Anthocephalus cadamba planted in peat media showed better growth than in ultisol. According to Table 4, the peat media contained higher macro and micronutrients than ultisol. Moreover, a structure of peat is fibrous which can preserve water. An addition of sludge compost or chicken manure compost to the peat can raise the nutrients and water availability for the seedlings. The chicken manure compost addition equal to 8 ton/ha resulted in the tallest seedlings after six months planting. In contrary, the sludge compost addition at the same dose resulted fluctuate seedlings height during the study and ended as the shortest seedlings. While the biggest seedlings diameter found after chicken manure addition at doses 10 and 16 ton/ha. Seedlings diameter planted in peat and added with compost sludge at doses 6-16 ton/ha were not significantly different with the chicken manure compost addition at doses 2-8 ton/ha. A fluctuate seedlings height planted in peat media was caused by an insect infestation of mealybugs. The insect stick to the leaves or stems. The attacked seedlings experienced dwarf leaves and dry stems tip. To prevent the attacked seedlings died, both the dwarf leaves and the dries stem were cut using a scissor. However, some have died but the other attacked seedlings could rise new branches at green stem segments.

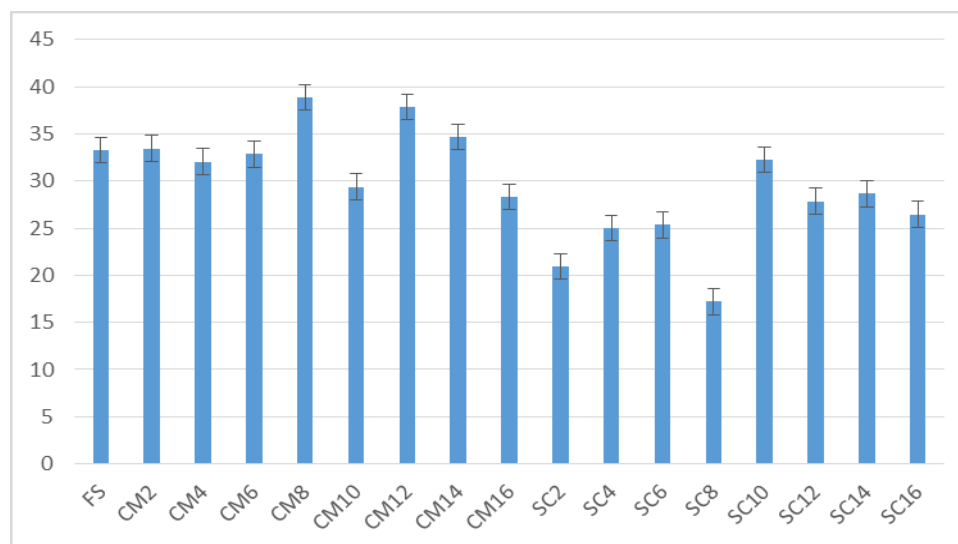


Figure 2. The average of seedlings height planted in fertile soil (FS) and the peat added with chicken manure (CM4-CM16) and the sludge compost (SC2-SC16) at various doses after six months planting. A number following an initial represents the compost doses.

According to Figure 2, the average height of seedlings planted in peat and added with sludge compost was lower than that with chicken manure compost addition. Probably a low concentration of P_2O_5 and a high concentration of Fe of the sludge compost could not support the phosphorus needs for the seedlings in peat media. Plants require phosphorus and nitrogen to develop height, root collar diameter, chlorophyll content and root morphology [29]. Moreover, the chicken manure compost has a higher pH than of compost sludge which can raise the pH of the peat (Table 4). As the peat pH increased, the phosphorus was more available for the seedlings. Probably a lower pH of the sludge compost is related to the CN ratio above 20. According to the compost standard of SNI, the sludge compost is immature then the microbes still produce organic acids in regards to a decomposition process. Although the sludge compost can provide macro and micronutrients for the seedlings, the

concentration of the nutrients is low. Therefore, the seedlings require a large quantity of the compost sludge to support the growth.

Table 7. Seedlings height in fertile soil and peat added with chicken manure and the sludge compost at various doses from one until sixth months after planting.

Treatment	M1	M2	M3	M4	M5	M6	M7
Fertile soil	26.33 ^{cd}	29.17 ^c	29.6 ^b	30 ^{abc}	33.67 ^{bc}	31.47 ^{ab}	33.27 ^{ab}
Chicken manure (ton/ha)							
2	20.17 ^{abcd}	20.83 ^{abc}	24 ^{ab}	28.2 ^{abc}	27.67 ^{abc}	36.33 ^b	33.47 ^{ab}
4	24 ^{bcd}	24.67 ^{bc}	28.67 ^{ab}	34.07 ^c	34 ^{bc}	34.33 ^b	32.07 ^{ab}
6	14.5 ^{ab}	13.5 ^a	17.67 ^a	19 ^a	22.47 ^{ab}	23.4 ^{ab}	32.87 ^{ab}
8	27.33 ^d	27.97 ^c	31.27 ^b	34.4 ^c	36 ^c	35.73 ^b	38.87 ^b
10	19 ^{abcd}	21.5 ^{abc}	24.33 ^{ab}	26.33 ^{abc}	28 ^{abc}	27.73 ^{ab}	29.4 ^{ab}
12	22.33 ^{abcd}	14.17 ^{abc}	20.67 ^b	32 ^{bc}	34 ^{bc}	34.27 ^b	37.87 ^{ab}
14	18.83 ^{abcd}	21.5 ^{abc}	26.33 ^{ab}	30.8 ^{abc}	34.2 ^{bc}	34.93 ^b	34.67 ^{ab}
16	19.67 ^{abcd}	19.63 ^{abc}	23.6 ^{ab}	29.27 ^{abc}	30.27 ^{abc}	30.27 ^{ab}	28.33 ^{ab}
Compost sludge (ton/ha)							
2	15.83 ^{abc}	18.67 ^{abc}	20 ^{ab}	20.67 ^{ab}	21 ^a	19.33 ^a	20.93 ^{ab}
4	15.5 ^{abc}	19.17 ^{abc}	21.33 ^{ab}	34.07 ^c	24 ^{abc}	24.67 ^{ab}	25 ^{ab}
6	12.67 ^a	15.33 ^{ab}	20.33 ^{ab}	22 ^{abc}	24 ^{abc}	23.67 ^{ab}	25.33 ^{ab}
8	19.17 ^{abcd}	21.67 ^{abc}	23.67 ^{ab}	32.33 ^{bc}	27.67 ^{abc}	28.67 ^{ab}	17.8 ^a
10	18 ^{abcd}	21.5 ^{abc}	21.33 ^{ab}	26.67 ^{abc}	28 ^{abc}	27.73 ^{ab}	32.27 ^{ab}
12	22.17 ^{abcd}	24.83 ^{bc}	27 ^{ab}	30.93 ^{abc}	34 ^{bc}	32.73 ^{ab}	27.87 ^{ab}
14	22.17 ^{abcd}	22.67 ^{abc}	26.67 ^{ab}	32.33 ^{bc}	34.2 ^{bc}	32.2 ^{ab}	28.67 ^{ab}
16	22 ^{abcd}	23.17 ^{abc}	23.67 ^{ab}	26.33 ^{abc}	30.27 ^{abc}	27.07 ^{ab}	26.47 ^{ab}

Means represented by same letter along column are not significantly different.

Table 8. Diameter of seedlings planted in fertile soil and peat added with chicken manure and sludge compost at various doses from one until sixth months after planting

Treatment	M1	M2	M3	M4	M5	M6	M7
Fertile soil	1.33 ^a	1.37 ^{ab}	1.86 ^a	1.66 ^{ab}	1.61 ^{abc}	1.63 ^a	1.78 ^{ab}
Chicken Manure (Ton/ha)							
2	1.30 ^a	1.43 ^{ab}	1.30 ^a	1.69 ^{ab}	1.58 ^{abc}	1.93 ^a	1.98 ^{ab}
4	1.18 ^a	1.20 ^a	1.89 ^a	1.77 ^{ab}	1.60 ^{abc}	1.78 ^a	1.81 ^{ab}
6	1.23 ^a	1.47 ^{ab}	1.77 ^a	1.90 ^{ab}	1.43 ^{ab}	1.86 ^a	1.71 ^{ab}
8	1.53 ^a	1.63 ^b	1.13 ^a	1.90 ^{ab}	1.85 ^{bc}	1.92 ^a	2.00 ^{ab}
10	1.37 ^a	1.63 ^b	1.90 ^a	1.67 ^{ab}	1.97 ^{bc}	1.96 ^a	2.10 ^b
12	1.43 ^a	1.60 ^{ab}	1.63 ^a	1.90 ^{ab}	1.77 ^{abc}	1.83 ^a	1.73 ^{ab}
14	1.30 ^a	1.57 ^{ab}	1.63 ^a	1.77 ^{ab}	1.75 ^{abc}	1.67 ^a	1.97 ^{ab}
16	1.50 ^a	1.27 ^{ab}	3.11 ^a	2.11 ^b	1.27 ^a	1.98 ^a	2.10 ^b
Sludge Compost (Ton/ha)							
2	1.23 ^a	1.30 ^{ab}	1.40 ^a	1.43 ^a	1.27 ^a	1.29 ^a	1.35 ^a
4	1.27 ^a	1.33 ^{ab}	1.37 ^a	1.30 ^a	1.27 ^{abc}	1.27 ^a	1.33 ^a
6	1.23 ^a	1.27 ^{ab}	1.43 ^a	1.60 ^{ab}	1.57 ^{abc}	1.63 ^a	1.60 ^{ab}
8	1.27 ^a	1.27 ^{ab}	1.43 ^a	1.77 ^{ab}	1.43 ^{ab}	1.57 ^a	1.58 ^{ab}
10	1.33 ^a	1.37 ^{ab}	1.47 ^a	1.53 ^{ab}	1.53 ^{abc}	1.70 ^a	1.75 ^{ab}
12	1.47 ^a	1.63 ^b	1.63 ^a	1.72 ^{ab}	1.75 ^{abc}	1.72 ^a	1.85 ^{ab}
14	1.17 ^a	1.47 ^{ab}	1.53 ^a	1.53 ^{ab}	1.73 ^{abc}	1.90 ^a	1.90 ^{ab}
16	1.30 ^a	1.37 ^{ab}	1.50 ^a	1.70 ^{ab}	1.47 ^{bc}	1.66 ^a	1.63 ^{ab}

3.4. Biomass and plant tissue analysis of seedlings planted in peat media and added with chicken manure compost and sludge compost at various doses after six months planting

Seedlings planted in peat and added with sludge compost had average biomass higher than those with the chicken manure addition (Table 9). However, the average height of seedlings was lower than that with the chicken manure addition (Figure 2). The seedlings planted in peat and added with sludge compost invested the absorbed nutrients to develop biomass. The average of leaves, stem and root biomass with sludge compost addition was higher than that with the chicken manure addition in peat media. Plants biomass production is influenced by some factors such as soil humidity, soil and air temperature, air humidity, photoperiod, light intensity, soil fertility and genotype ([30]. High biomass of seedlings which is planted in peat and added with compost sludge is probably because of the high soil humidity. Moreover, *Anthocephalus cadamba* is a fast-growing species and prefer a moist environment to grow [31]. The inoculation of fungi to the sludge compost can also raise the nutrient's availability to the seedlings. In addition, *P. citrinum*, a fungus inoculated to the sludge compost can chelate Al and Fe in acid soil such as peat [32].

Table 9. Dry weight of biomass (leaves, stem and root) of *Anthocephalus cadamba* seedlings planted in peat media and added with chicken manure compost and sludge compost at various doses (ton/ha) after six months planting

Treatment	Biomass (dry weight) (g)			Total Biomass (g)
	Leaves	Stem	Root	
Fertile soil	0.81	0.62	0.3	1.73
Average weight (g)	0.81	0.62	0.3	1.73
Chicken manure (Ton/ha)				
2	0.86	1.94	0.86	3.66
4	1.2	2.33	2.35	5.88
8	1.27	3.54	0.88	5.69
10	1.6	2.1	3.37	7.07
12	0.76	3.61	1.98	6.35
14	1.52	4.77	1.4	7.69
16	2.72	2.72	0.96	6.4
Average weight (g)	1.42	3.0	1.69	6.11
Sludge compost (Ton/ha)				
2	0.07	2.51	1.01	3.59
4	1.89	5.22	2.44	9.55
6	0.68	3.96	0.98	5.62
8	2.56	7.6	1.42	11.58
10	2.83	6.19	2.41	11.43
12	2.76	2.89	1.76	7.41
14	3.38	5.27	2.8	11.45
16	3.01	10.3	3.76	17.07
Average weight (g)	2.145	5.49	2.07	9.71

Seedlings planted in peat and added with sludge compost accumulated a higher percentage of nitrogen than that with the chicken manure addition (Table 10). While according to Table 3, the sludge compost's total nitrogen content was lower than that of the chicken manure. Probably, the fungi inoculated in the sludge compost can generate nitrogen for the seedlings. Moreover, the CN ratio of peat is high (Table 4). The fungi decomposes organic matter of the peat media and provides available nutrients for the seedling. However, decomposition of organic matter can raise soil temperature which will cause the plant to suffer. Probably, in this study, high moisture content of the peat media can reduce the soil temperature because of the decomposition process. From Table 10, the seedling with

sludge compost addition was also accumulated a higher lead, chrome and cadmium than that of the chicken manure. Nutrients availability may influence absorption of heavy metals by the seedlings [30].

Table 10. Plant tissue analysis of *Anthocephalus cadamba* seedling planted in fertile soil and peat added with chicken manure compost and sludge compost at various doses (ton/ha) after six months planting

Sample	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	Pb	Cr	Cd
	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Fertile soil	0.48	0.07	1.02	0.17	0.17	12.8	52.6	83.3	42.6	0.2	0.2	0.1
Chicken manure (ton/ha)												
2	0.53	0.11	1.14	0.53	0.24	13.1	66.4	103.2	55.1	0.3	0.2	0.2
4	0.69	0.14	1.17	0.58	0.28	18.2	59.5	96.4	58.6	0.3	0.4	0.2
8	0.73	0.12	1.20	0.72	0.26	13.7	60.1	113.4	62.4	0.3	0.3	0.1
10	0.86	0.14	1.18	0.78	0.29	19.4	53.7	104.6	68.5	0.4	0.4	0.3
12	0.51	0.16	1.22	0.86	0.28	15.3	50.8	108.3	71.3	0.8	0.8	0.2
14	0.93	0.16	1.31	0.87	0.30	22.1	48.6	118.3	84.1	0.4	0.4	0.3
16	1.28	0.13	1.28	0.71	0.27	28.3	55.3	116.5	61.7	0.4	0.4	0.3
Compost sludge (Ton/ha)												
2	0.16	0.09	1.16	0.42	0.21	15.8	41.8	87.3	45.1	0.1	0.3	0.2
4	1.08	0.12	1.21	0.61	0.28	22.1	54.5	95.3	53.6	0.3	0.4	0.4
6	0.63	0.13	1.28	0.46	0.31	16.9	56.3	117.2	58.2	0.4	0.4	0.3
8	1.39	0.14	1.63	0.84	0.35	24.7	61.1	121.4	56.1	0.4	0.6	0.6
10	1.42	0.19	1.59	0.86	0.35	28.3	57.3	108.6	63.6	0.9	0.7	0.4
12	1.38	0.14	1.24	0.76	0.28	27.2	62.4	121.8	75.8	0.6	0.6	0.4
14	1.68	0.16	1.31	0.82	0.34	35.1	66.5	119.8	77.3	0.5	0.6	0.4
16	1.44	0.2	1.67	0.91	0.36	29.5	62.8	131.4	84.3	0.6	0.8	0.3

4. Conclusion

Results of this study indicate that peat was better media for the seedlings than ultisol. The sludge compost was not as better as the chicken manure compost in increasing seedlings height and diameter. The sludge compost can provide nutrients for the seedlings. The addition of sludge compost into ultisol with doses 2 ton/ha was not significantly different with other doses in increasing the height and diameter of the seedlings. Addition of sludge compost into peat media with doses 8 ton/ha gave the shortest seedlings. However, sludge compost added to peat resulted in a better biomass than that with the chicken manure compost addition.

References

- [1] Simao L, Hotza D, Raupp-Pereira F, Labrincha JA and Montedo ORK 2018 Wastes from pulp and paper mills: a review of generation and recycling alternatives *Cerâmica* **64**(371)443–53
- [2] APKI 2016 *Opportunities and challenges of Indonesian pulp and paper industry*
- [3] The Forest Trust 2015 Pulp & Paper Sourcing Country Profile: Indonesia
- [4] Mabee WE 2001 *Study of woody fibre in papermill sludge* Doctoral dissertation (National Library of Canada= Bibliothèque nationale du Canada)
- [5] Bajpai P 2015 Generation of waste in pulp and paper mills *Management of Pulp and Paper Mill Waste* (Springer, Cham.) pp 9–17
- [6] Torkashv AM, Haghighat N and Shadparvar V 2010 Effect of paper mill lime sludge as an acid soil amendment *Sci. Res. Essays* **5**(11) 130–6
- [7] Mohammad N 2018 Chemical composition and nutritional values of pulp and paper mill sludge compost

- [8] Dutta T, Sahoo R, Sengupta R and Ghosh 2008 Novel cellulases from an extremophilic filamentous fungi *Penicillium citrinum*: Production and characterization *J. Industrial Microbiol. Biotechnol.* **35** 275–82
- [9] Kim D, Cho EJ, Kim JW, Lee Y and Chung H 2014 Production of cellulases by *Penicillium sp.* in a solid- state fermentation of oil palm empty fruit bunch *African Journal of Biotechnology* **13**(1) 145–55
- [10] Dutta T, Sengupta R, Sahoo R, Ray SS, Bhattacharjee A and Ghosh S 2007 A novel cellulase free alkaliphilic xylanase from alkali tolerant *Penicillium citrinum*: production , purification and characterization *Letters in Applied Microbiology* **44**(2) 206–11
- [11] Yadav J, Verma PJ and Tiwari NK 2011 Plant growth promoting activities of fungi and their effects on chickpea plant growth *Asian J. Biol. Sci.* **4** 291–99
- [12] Kang K, Wang S, Lai G, Liu G and Xing M 2013 Characterization of a novel swollenin from *Penicillium oxalicum* in facilitating enzymatic saccharification of cellulose *BMC biotechnology* **13**(1) 42
- [13] Jha H and Patil M 2011 Biopulping of sugarcane bagasse using manganese peroxidase from *Penicillium oxalicum* isolate-1 *Rom. Biotechnol. Lett.* **16**(6) 6809–19
- [14] Representative Office of National Land Board of Riau Province 2015 *Luas dan Jenis Satuan Tanah* (Accessed: 21-May-2019) <https://riau.bps.go.id/statictable/2015/03/17/44/luas-dan-jenis-satuan-tanah-2015.html>.
- [15] Posa MRC, Wijedasa LS and Corlett RT 2011 biodiversity and conservation of tropical peat swamp forests *BioScience* **61**(1) 49–57
- [16] Ou-yang W and Wu W 2002 Investigations of papermill sludge as a component of container medium *Plant Pathol. Bull.* **11** 19–24
- [17] Camberato JJ, Gagnon B, Angers DA, Chantigny MH and Pan WL 2006 Pulp and paper mill by-products as soil amendments and plant nutrient sources *Canadian journal of soil science* **86**(4) 641–53
- [18] Prasetyo BH, Suharta N, Subagyo H and Hikmatullah H 2016 Chemical and mineralogical properties of Ultisols of Sasamba area, East Kalimantan *Indonesian Journal of Agricultural Science* **2**(2) 37–47
- [19] Alloway BJ 2008 *Zinc in Soils and Crop Nutrition 2nd Edition* (Belgium: International Zinc Association)
- [20] Krisnawati H, Kalio M and Kanninen M 2011 *Anthocephalus cadamba* Miq.: *ekology, silviculture and productivity* (Bogor: CIFOR)
- [21] Evianti and Sulaeman 2009 *Analisa kimia tanah, tanaman, pupuk dan air* (Bogor: Balai Penelitian Tanah)
- [22] Naik SP 2007 *Studies on Microbial Consortia for Production And Enrichment of Bio-Compost from Grapevine Residues* (Dharwad: Univeristy of Agriculture Sciences)
- [23] Angelova VR, Akova VI, Artinova NS and Ivanov KI 2013 The effect of organic amendments on soil chemical characteristics *Bulg. J. Agric. Sci.* **19**(5) 958–71
- [24] Hafeez B, Khanif YM and Saleem M 2013 Role of Zinc in Plant Nutrition- a Review *American journal of experimental Agriculture* **3**(2). 374–91
- [25] Adeleke R, Nwangburuka C and Oboirien B 2017 Origins, roles and fate of organic acids in soils: A review *South African J. Bot.* **108** 393–406
- [26] Yunizar 2011 Planting System and Mulch Related to Growth and Results Corn in the of Land Slope of Riau Province pp. 287–290.
- [27] Sarjono A, Lahjie AM, Simarangkir BDAS, Kristiningrum R and Ruslim Y 2017 Carbon sequestration and growth of *Anthocephalus cadamba* plantation in North Kalimantan, Indonesia *Journal of Biological Diversity* **18**(4) 1385–93
- [28] Sudrajat DJ, Siregar IZ, Khumaida N, Siregar UJ and Mansur I 2015 Adaptability of white jabon (*Anthocephalus cadamba* miq.) seedling from 12 populations to drought and waterlogging *Journal of Agricultural Science* **37**(2) 130–43

- [29] Razaq M, Zhang P and Shen H 2017 Influence of nitrogen and phosphorous on the growth and root morphology of *Acer mono* *PloS one* 12(2) e0171321
- [30] Chatzistathis T and Therios I 2013 How soil nutrient Availability influences plant biomass and how biomass stimulation alleviates heavy metals toxicity in soils: The cases of nutrient use efficient genotypes and phytoremediators, respectively *Biomass Now-Cultivation and Utilization*, IntechOpen, pp. 427–448.
- [31] Bijalwan A, Dobriyal MJR and Bhartiya JK 2014 A potential fast growing tree for agroforestry and carbon sequestration in India: *Anthocephalus cadamba* (Roxb.) *Am. J. Agric. For.* **2**(6) 296–301
- [32] Rea SM, McSweeney NJ, Dwyer RB and Bruckard WJ. 2015 Application of biotechnology in iron ore beneficiation (Woodhead Publishing) pp. 373–91