Eco. Env. & Cons. 26 (2) : 2020; pp. (847-854)
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ISSN 0971–765X

Sunan Candlenut (Reutalis Trisperma (Blanco) Airy Shaw) land fertility improvement using biopore in Alfisols

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(Received 23 December, 2019; accepted 28 January, 2020)

ABSTRACT

Sunan candlenut is an annual plant that can grow on marginal land, with the characteristics of marginal land is having a limited ability in the supply of nutrients, air, and plants. Based on this, it is necessary to improve the level of soil fertility through Bio-pore. Bio-pore technology has long been discovered, but the use of this technology for plants is still very few. Sunan hazelnut leaf waste is quite large during the dry season, where plants enter the flowering period, which is around July to August. Sunan candlenut leaves that physiologically dry fall to the ground, then replaced by new shoots, and flower buds appear to become ovaries. In such conditions, plants need a large number of nutrients, especially macronutrients. The study was conducted in 2017, using soil types that belong to the Alfisols category, the altitude of 323 m above sea level, and rainfall of 1500 mm per year. The coordinates are at 8°12'0.4.66 "South Latitude and 112°27'0.037" East Longitude. The treatments used were arranged using a Randomized Block Design (RBD) and repeated 5 times, with treatment arrangements are, a). Without using pipe (0), without filled with Sunan candlenut dried leaves; b). 20 cm pipe length, filled with 410 grams of dried Sunan candlenut leaves; c). 30 cm pipe length, filled with 615 grams of dried Sunan candlenut leaves; d). 40 cm pipe length, filled with 820 grams of dried Sunan candlenut leaves and e). 50 cm pipe length, filled with 1025 grams of dried Sunan candlenut leaves. All treatments were planted under the canopy of the Sunan candlenut tree. The moisture content of Sunan candlenut dried leaves 9.4%. The parameters observed included plant height, stem circumference, number of branches, canopy width, Carbon, Nitrogen, and C/N ratio analysis, and also Organic Matter. The research aims to determine how far the contribution of organic material sourced from Sunan candlenut dried leaves through the Bio-pore process to improve Alfisols soil fertility. The results showed that the Bio-pore treatment did not affect the vegetative parameters of Sunan candlenut plants such as height, stem circumference, canopy width and the number of branches, but had a significant effect on organic-C, total-N, and organic matter in Alfisols as for the C/N ratio, it has not been affected. Based on this, the use of the Bio-pore system by utilizing Sunan Candlenut dried leaves can improve soil fertility.

Key words *: Sunan candlenut, Reutealis trisperma, Carbon, Nitrogen, C/N ratio, Bio-pore, Alfisols.*

Introduction

Sunan candlenut (Reutealis trisperma (Blanco) Airy Shaw) is a plant that produces vegetable oil in the form of biodeisel. Nowadays, the need for fuel oil used to start diesel engines is quite a lot. Indonesia still has to import diesel fuel to meet it fuel needs. Whereas the availability of fuel oil for producing countries, comes from petroleum or fossil-based oil fields, which eventually run out. Therefore it is necessary to find alternative fuels that can be renewed and sustainable. The approach through the candlenut plant as an alternative source for fuel oil is a very wise and environmentally friendly step. The area of dry land which is still not utilized for agriculture and plantations in Indonesia is quite extensive. According to Mulyani and Hidayat (2010), the marginal land area in the form of dry land which is spread in Sulawesi, Kalimantan, Sumatra, and Papua are around 14.6 million hectares. If part of the dry land is used for Sunan candlenut plants, it can contribute to the supply of biodiesel fuel, while at the same time saving the country's foreign exchange. Sunan candlenut production potential is 8 tons per hectare and biodiesel potential is around 4.16 tons per hectare.

The fertility level in marginal land is generally low, so, land improvement using organic material could be made to overcome such conditions. Sunan candlenut has quite a lot of dried leaves waste. Sunan candlenut dried leaves can be used as soil enhancers through the Bio-pore system, where organic material is inserted into a hole to a certain depth in the soil (Maillard and Angers, 2014; Guo *et al.,* 2018, 2019). Soil organic matter in dry land in the wet tropics cannot last long in the soil because it undergoes a fast decomposition process, temperature factor and soil moisture of soil organic matter (Kirschbaum, 1995; Leiros *et al.,* 1999; Reichstein al., 2005; Dariah *et al.,* 2013; Sierra *et al.,* 2015).

The source of carbon and nutrients for soil microorganisms is soil organic matter. According to Craswell and Lefroy (2001), the weathering results of bedrock is generally poor in nutrients if there is no organic material. Soil organic matter is a central element in soil fertility, land productivity and land quality (Katyal and Reddy, 2001). Therefore, in a sustainable land management system, it is very important that organic material put into holes in the soil is considered very important to improve soil characteristics and quality (Christensen, 1986; Zhang, 1994; Zhang Hartge and Ringe 1997; Oye dele *et al.,* 1999; Eriksen, Thorup-Kristenseri and Askegaard, 2004; Pulleman *et al.,* 2005; Kaiser and Kalbitz 2012).

The organic matter decomposition process in the soil is overhauled by organisms that remodel organic matter, which consists of microorganisms and fauna that play a role in various functions in the ecosystem (Hartley and Ineson, 2008; Handayanto *et al.,* 2016). The stage of mineralization occurs when organic material is overhauled by soil microorganisms resulting in the release of mineral elements. If the addition of organic material is unable to provide N, or C/N is still high, then the organism will take (bind) N from the soil, this process is often called the nutrient immobilization (Kanamori and Yasuda, 1979; Treamblay and Benner, 2006 Hermann and Witter, 2008;. (Hastrosupadi *et al.,* 2019). Further stated that if the C/N ratio has reached a value of 30-20 then the organic material can already provide N for plants. This research was conducted to find out how far the effect of application of organic matter in the form of Sunan candlenut dried leaves using the Bio-pore system on Alfisols soil fertility characteristics.

Research Materials

Planting material used in the planting of Sunan Candlenut, KS1 clone which is 4 years old. The plastic pipe used is 5 dim, which is given a hole every 1 cm (Bio-pore). The study was conducted in early January 2017. The research location was in the Kalipare Experimental Garden, precisely in the village of Sukowilangun, Kalipare sub-district, Malang Regency. The coordinates are at 8°12'0.4.66 "South Latitude and 112°27'0.037" East Longitude. Altitude 323 m above sea level (asl) with Alfisols soil type.

A brief description of Bio-pore is a cylindrical hole made vertically into the soil and in it, small holes are formed by organism's activity. A brief description of the Sunan candlenut garden condition at the age of 4 years, plant height reaches 2-4 meters, stem circumference, 35-40 cm, number of branches 200-250, canopy width 250-300 cm, leaf area reaches 185 $cm^{2,}$ and plant spacing of 7m x 7 m with a population of around 200 trees per hectare. The agro-climate description of the test site is the type of land that is rainfed dry land. Based on climate classification, rainfall data is less than 60 mm in one month and the amount of rainfall in 1 year is around 2100

mm, so areas that have low rainfall are usually called dry areas, with temperatures around 23 °C to 30 °C. The trash or litter used for organic matter are dried Sunan candlenut leaves with a dried leaves water content of around 9.40%. The design used is randomized block design. The composition of the treatment consists of:

a) Without using pipe (0), without filled with Sunan candlenut dried leaves;
b) 20 cm pipe length, filled with 410 grams of dried Sunan candlenut leaves;
c) 30 cm pipe length, filled with 615 grams of dried Sunan candlenut leaves;
d) 40 cm pipe length, filled with 820 grams of dried Sunan candlenut leaves and
e) 50 cm pipe length, filled with 1025 grams of dried Sunan candlenut leaves.

All treatments were planted under the canopy of the Sunan candlenut tree. The moisture content of Sunan candlenut dried leaves 9.4%. The parameters observed included plant height, stem circumference, number of branches, canopy width, carbon, nitrogen, and C/N ratio analysis. Data is processed using M-stat and the results of these tests carried out by analysis of variance (ANOVA). If there is a difference between the treatments tried, then proceed using HSD (Honest Significantly Difference) test at 5% level. The results of the carbon, nitrogen and C / N ratio analysis of Alfisols before the experiment are presented in Table 1. Besides that, the propyl of the study area is also made in Appendix 1.

Soils Morphological Properties – Cross-section of ground propyl made at coordinates 112° 22 "41" – 112°29 '17 "East Longitude and 8° 10 '54" - 8°15 '50 "South Latitude. Propil as deep as 200 cm is in the plain with a height of 293 m above sea level, slope level <3%, vegetation of Sunan candlenut, teak, sugarcane and jatropha.
Land is dominated by clayey soil.

Table 1. Soil pH, content of organic-C, Total-N and C/N-ratio before field experiment in the research location

Soil Characteristics	Value	Category
pH H_2O 1:1	7.60	Alkaline
pH HCl 1:1	6.60	Neutral
Organic-C	0.45	Very ;low
Total-N	0.07	Very low
C/N ratio	6.00	Low

Alfisols Propyl Description

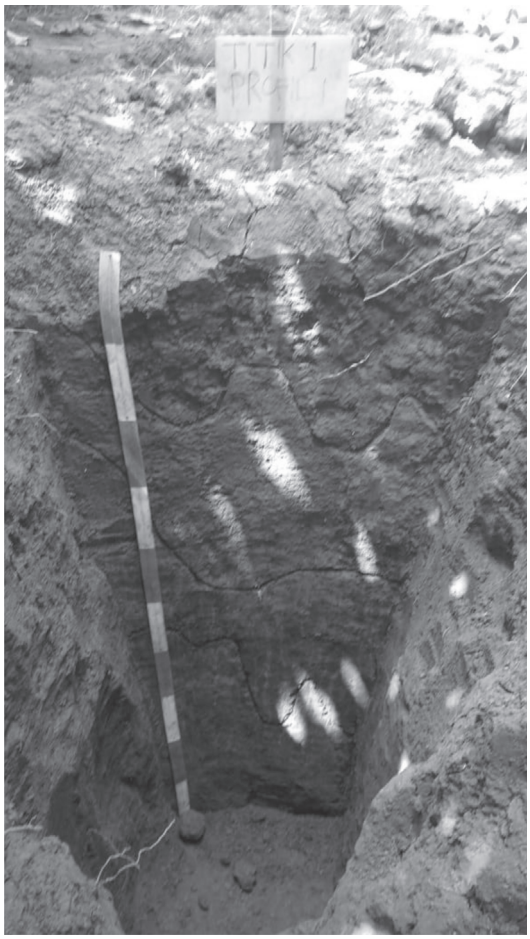

Fig. 1. Alfisols section

Soil Physical Properties – The texture consists of 70% clay; 10% sand and 20% dust. Generally located in semi arid to humid areas.

Land Classification – AbtC profiles, Alfisol soil type, soil type characterization with base-saturation > 50% in B horizon, having an A horizon or an organic-C rate> 12 kg/m^3. The color of B horizon is red to dark red (more than 5 years). Alfisol is a fertile soil, widely used for agriculture, livestock, or forests. The soil has high base saturation, high cation exchange capacity, high elemental reserve (Hardjowigeno, 1993).

Soil chemical properties: The results of chemical analysis of pH, organic-C, total-N, C/N, total-P, total-K and CEC in the Alfisols section are presented in Table 2.

Results and Discussion

ANOVA results showed that the growth of plant height, stem diameter, canopy width, and the num-

ber of branches of the treatments were not significant (Table 3).

Table 3 shows that Bio-pore treatment has not significantly effect the parameters of plant height, number of branches, stem circumference and canopy width. It is suspected that the decomposition reaction of Sunan candlenut dried leaves in the Bio-pore is slow, so that the effect is not seen on the vegetative growth of Sunan candlenut plants. Organic fertilizers have an important role in improving soil physical, chemical and biological properties (Edmeades, 2003; Eghball *et al.*, 2004; Hartatik *et al.*, 2013). Although the nutrient contained in organic fertilizer is relatively low, but its soil properties role is far beyond artificial fertilizers. Furthermore, the return of dried sugar cane leaf litter into the field has a positive impact on soil fertility, although the process is slow (slow release) but sure (Graham *et al.*, 2002; Robertson and Thorburn, 2007; Surendran *et al.*, 2016) .

The results of the analysis of variance showed that the treatments tried, affected the content of organic-C, total-N, and soil organic matter, but did not have a significant effect on the C/N-ratio of the soil (Table 4).

Table 4 shows that for each addition of dried sunan candlenut leaf litter, there is a tendency for an increase in the content of organic-C, total-N, and organic matter, while the C / N-ratio values are not significantly different. The increase in organic-C content was due to the administration of Sunan Candlenut dried leaves. This is consistent with the results of previous studies, that an increase in the content of soil organic-C can be done through the application of organic matter, compost, manure, green manure, and organic waste to the soil (Rudrappa *et al.*, 2006; Manna *et al.*, 2007; Banger *et al.*, 2010; Asmarhansyah and Subardja, 2012). In the treatment which was not given Sunan candlenut dried leaves (0), the soil organic-C content was 0.79%, while the 50 cm Bio-pore treatment that was given 1025 g of litter produced a soil organic-C content of 1.22%. The organic-C content (0.79%) is relatively low, and the cation exchange capacity (CEC) in Alfisols at the research location is also low. As a result, the ability of the soil in holding water and nutrients is categorized as very low or classified as infertile. Therefore, for soil quality improvement, application of organic matter to the soil is required. The results of Benfeldt *et al.*, 2001 showed that application of organic matter to the soil could increase CEC in the available water holding capacity (Hudson, 1994; Paterson and Sim, 2013; Chowdhury *et al.*, 2014).

Table 2. Chemical analysis results on Alfisol soil profile in Kalipare subdistrict Malang

Horizon	Depth (cm)	pH 1:1		Organic-C	Total -N	C/N	Available P	K	Na	Ca	Mg	CEC	Total	Water Content
		pH H_2O	pH KCl	……%.....			mg kg^{-1}			.....me/100g.....				….%....
B	0-10	5.6	6.1	0.07	0.04	1.75	0.01	12.6	60.4	1.66	1.78	12.40	-	1.83
B	20	5.9	6.9	0.08	0.02	4	0.01	2.40	62.5	1.50	1.50	11.60	-	1.75
Nh	30	6.1	6.0	0.07	0.03	2.33	0.01	1.60	62.1	1.22	1.74	11.90	-	1.79
Nr	40	5.8	6.6	0.06	0.03	2.00	0.01	1.60	71.2	1.26	1.74	12.10	-	1.29
Nd	50-80	5.9	6.0	0.07	0.02	3.50	1.60	1.60	37.9	1.36	1.40	12.30	-	1.62
Ne	100-150	6.0	6.8	0.07	0.05	1.40	0.80	0.80	45	1.44	1.96	12.10	-	1.74
	160-200	6.0	6.9	0.5	0.04	12.50	0.80	0.80	55.4	1.18	1.64	11.40	-	1.72

Table 3. Plant height, branches number, stem circle and canopy wide in the different treatmens of Bio-pore in Kalipare experiment station Malang

Bio-pore treatment (Bio-pore are filled with plant residues)	Plant height .....cm.....	Stem circle .....cm....	Branches number	Canopy wide. .... cm....
O (twithout residues)	335.0 a	36.00 a	225 a	286.0 a
20 cm (410 g of residues)	378.0 a	36.50 a	211 a	284.4 a
30 cm (615 g of residues)	333.0 a	37.00 a	225 a	275.4 a
40 cm (820 g of residues)	330.0 a	36.00 a	227 a	288.6 a
50 cm (1025 g of residues)	321.0 a	37.50 a	221 a	263.0 a

Note: The number followed by the same letter in the column is not significantly different in the 5% HSD test.

In general, the nitrogen content in the soil is very small, this happens due to the nature of nitrogen which is easily lost, dissolved, and evaporates. The total-N analysis results in Table 4 shows that in all treatments tried, the value ranged from 0.10% to 0.12%. Based on the criteria for evaluating the soil chemical status, the value is categorized as low (Madjid, 2015). Though nitrogen is a very important element for plants. According to Soemarno, (2014) nitrogen is a constituent of amino acids, proteins, enzymes, chlorophyll, auxsin, phytohormones and alkoloid which are in DNA, RNA and nucleic acids, so their existence is very important for plants. It was further stated that dry land usually absorbs N in the form of NO_3^- ions greater than NH_4^+ ions. But if the soil pH value is neutral then the absorption of nitrogen is relatively the same. On that basis, it is necessary to add nitrogen derived from organics such as Sunan candlenut dried leaves litter and compost. The results of Hartatik and Sarmah (2013) research showed that nitrogen is one of the macro nutrients needed by plants. Nitrogen is often called a primary macro nutrient, because it is needed in large quantities and becomes an important element in the plants life cycle. Nitrogen absorption occurs during the life cycle of plant growth. In addition to plant nutrition, nitrogen is also needed to stimulate the activity of microorganisms that play a role in the decomposition process.

The indication of the organic matter contribution to fertility is the C/N-ratio (Janssen, 1996; Megawati *et al.,* 2015). Carbon and nitrogen are the two main components of organic matter. The soil C / N content is not affected by the treatment tried, but there is a trend of increasing C/N-ratio values (Table 4). Organic matter as the formation of humic substances and nutrients main source is available in the soil, so the presence of organic-C in the soil can stimulate reactions involving microorganisms (Carcia-Gil *et al.,* 2000; Utami and Hadayani, 2003; Tu. Ristaino and Hu, 2006; Mandal *et al.,* 2010).

The data in Table 4 shows that the addition of 1026 grams of dried Sunan candlenut leaf litter at 50 cm treatment results in soil organic matter content of 12.60%. The contribution of organic matter as much as 12.60% is the most crucial indicator in the level of soil fertility. The role of organic matter in soils is multifunction, which can change the physical properties, chemical properties and biological properties of the soil.

Application of organic matter to the soil can affect soil physical characteristics *et al.,* 2008, such as soil aggregation and soil properties (Pccolo and Mbagwu, 1999; Malkawi *et al.,* 1999; Dexter *et al.,* 2008; Mulumba and Lal, 2008), so that the physical condition of soil that dense and compact can turn into porous and loose soil because the organic matter presence (Ferreras *et al.,* 2006; Celik *et al.,* 2004). The presence of organic matter in the soil can also improve soil aggregate stability, porosity and soil permeability, so that drainage and soil aeration are better (Chenu *et al.,* 2000; Goebel *et al.,* 2005). This organic material decomposition is a humic substance that has an active group that functions as a land sorption (Plaza *et al.,* 2002; Adani *et al.,* 2006; Illes and Tombacz, 2006), thus affecting soil sorption capacity or Cation Exchange Capacity (CEC) (Quedraogo *et al.,* 2001; Leifeld *et al.,* 2002).

Application of organic matter to the soil can also affect the soil biological and biochemical characteristics by increasing soil microbial populations (Mandal *et al.,* 2007). The dynamics of microbial population usually associated with the increasing microbial individuals types and numbers, microbial biomass and soil enzyme activity (Elfstrand *et al.,* 2007; Iyyemperumal and Shi, 2008; Chakraborty *et al.,* 2011). As a result, soil quality is better for plant growth and production (Wong *et al.,* 199; Monaco *et al.,* 2008; Zhao *et al.,* 2009).

Conclusion

From the study it can be concluded that the administration of organic material from Sunan candlenut dried leaves using Bio-pore system in Alfisols soil can increase C-Organic, N-Total, C/N Total, and soil organic matter, so as to improme soil fertility. The treatments tried have not affected Sunan Candlenut vegetative growth such as, plant height, stem circumference, canopy width, and number of branches.

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