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Effects of Different Types and Dosage of Green Mulch on Yield and Quality of *Aloe vera* L. on Coastal Sandy Soil

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ABSTRACT

A complete content of chemical substance in *Aloe vera* leaf makes this plant has many functions such as the ingredient of functional food for health, cosmetics, and herbal medicines. This research aimed to determine the yield and quality of *Aloe vera* L. as affected by various types and rates of green mulch in coastal sandy soil. The research was conducted in coastal sandy soil of Poncosari Srandakan, Bantul, Yogyakarta and arranged in a Randomized Complete Block Design (RCBD) of two factors with three replications. The first factor was four types of green mulch (cashew tree leaves, acasia leaves and gliricidia leaves). The second factor was various dosage of green mulch, consisting of three dosages of green mulch (5.0, 10.0, and 15.0 ton.ha^{-1}). Soil without mulching was used as a control treatment. The variables observed were yield at the first harvest time and leaf content quality including water, protein, fat, carbohydrate, ash, fiber, and mineral (Ca, Fe and Zn). The results showed that there was interaction effect of types and dosage of green mulch on all variables observed. Gliricidia leaves mulch gave the best effect with optimum dosage about of 10 ton.ha^{-1}. The effectiveness of green mulch abilities to improve the observed variables from higher order, respectively, was gliricidia, acasia, cashew tree, and casuarina leaves with the rate dosage between 10 up to 15 ton.ha^{-1}.

Keywords: functional food crop, organic mulch, nutrient, biomass

INTRODUCTION

Aloe vera is a multifunctional plant as it has been used for various needs, namely as an ornamental plant and as ingredients for functional food, cosmetic, and medicinal plant, thus the plant is referred as an amazing miracle plant. The leaf of *Aloe vera* contains fat, carbohydrate, protein and 18 essential amino acids, four kinds of vitamins, ten kinds of minerals, 6 kinds of enzymes, as well as alkaloids, aloin, lectin, lignin, saponin, tannin, phenolic, and glucomannan. The synergistic activity of all the active substances is considered as the potential of *Aloe vera* leaf. The results of secondary metabolites of *Aloe vera* can be used to improve hair fertility, to heal wound and skin irritation, to enhance cell regeneration, and to boost immune. Other functions are as anti-inflammatory, antiseptic, antibiotic, antioxidant, anti-cancer, anti-diabetes and anti-cholesterol. Accordingly, *Aloe vera* leaves are currently used as the main fitoterapeutic (Nandal *et al*., 2012). *Aloe vera* is the species frequently grown in Specially Region of Yogyakarta, out of four species that can be found (Darini *et al*., 2014).

In the development of *Aloe vera* production, an available fertile land becomes the main problem as it has been decreased because of other uses. The coastal sandy area is one of the marginal lands that has the potential to be utilized as its utilization is still relatively low. Indonesia has coastal area of around 81,000 km^2, which is potentially to be developed as an agricultural area with the characteristics of sandy texture, loose structure, high daytime soil temperature, low water retention, high wind speed, high evaporation rate, low nutrient content, and low cation exchange capability (Yuwono, 2009). The characteristic of sandy soils is the presence of spodic, acidic horizons, and poor cation retention capacity due to low clay content. Often, it is believed that sandy textured soils are suitable for agriculture because of their sandy texture, lack of moisture, and concomitant infertility. Elsewhere in South Africa, long and fertile cultivation under sandy textured Alfisols causes loss of carbon,

nitrogen, and microbial biomass. Sandy soils in Indian semi-arid regions are low in organic carbon, nitrogen, phosphorus, and sulfur under peanut cultivation for more than 5 years. While in Peninsular Malaysia, underground sandy textured agricultural activities, known as sandy beach backs interspersed with swales, are common through improved fertilizer management. In addition, soil organic matter is very important in BRIS soils to increase soil fertility during the planting period (Ho *et al*., 2019).

The laboratory analysis showed the nutrients contained in sandy soil of the research area, including 0.57% C-organic; 0.03% N-total; 12.95 me 100 g^{-1} P-available; 1.20 me 100 g^{-1} K-available; and 2.81 me 100 g^{-1} CEC (Darini, 2014). The result of previous study showed that the application of 30 ton.ha^{-1} cow manure resulted in higher air temperature, which reached 38°C during the day. This environmental condition will promote the evapotranspiration that will affect the physical and chemical properties of the soil, as well as affecting the growth, yield and quality of *Aloe vera* (Darini, 2017).

Weed mattresses and compost are generally the most beneficial practices in terms of plant and soil nutrition. However, given the respective impact on soil pH and or plant and soil K, further investigation is needed to determine whether this practice is sustainable in the long run for the production of conventional and organic highbush blueberries. (Larco and Strik, 2013). Wodajo (2015) stated that the main effects of compost and mulch and their interactions were observed to significantly affect thousands of seed weight, seed yield ha^{-1}, number of seeds per fruit and percentage of seed germination. In general, 6 ton.ha^{-1} compost and mulch thickness of 10 cm are recommended to make farmers benefit from the system.

Aprodisia and Maina (2018) reported that mulch enhanced better plant performance within the variables studied. However, grass mulch is proven to be more suitable for improving crop performance than other mulch so that mulch should be used for better strawberry yields. The report of Qu *et al*. (2019) showed that treatment of permeable bricks, green waste compost, and grasses also increased total porosity, macroporosity, and soil microporosity at lower depths. Furthermore, bricks that can absorb water exacerbate soil density and porosity, increasing pH at lower depths. Organic matter, total N, N minerals, P available, and K available soil content at lower depths increases when mulching with organic matter is carried out.

Handling the condition of coastal sandy soil that has low nutrient content and high temperature, is necessary to innovate in order to improve the growth, yield, and quality of the plant. One of the efforts that can be done is by providing the organic mulch (leaves mulch) that are available in surrounding area, such as casuarina, cashew tree, acacia, and gliricidia leaves. Therefore, it is necessary to determine whether the application of various types and rates of leave mulch could improve yield and nutrient content of *Aloe vera* grown in coastal sandy area. This research aimed to determine the yield and quality of *Aloe vera* L. on various types and rates of leave mulch in coastal sandy soil of Poncosari Srandakan, Bantul, Yogyakarta.

MATERIALS AND METHODS

The research was conducted from March to December 2017 in the coastal sandy soil area, Cangkring, Poncosari, Srandakan, Bantul, Yogyakarta with 31 – 36°C air temperature, 100% light intensity, 64–75% air humidity, and 1672.5 mm annual rainfall. Observations were carried out in the Laboratory of Plant Production, Faculty of Agriculture, Universitas Sarjanawiyata Tamansiswa, the Laboratory of Plant Sciences, Universitas Gadjah Mada, and Institute for Integrated Research and Development of Universitas Gadjah Mada.

The experiment was arranged in a Randomized Complete Block Design with 3 replications. It was (4×3) factorial, plus one control, where no mulch was applied. The treatments consisted of four types of green mulch (casuarina, cashew tree, acacia, and gliricidia leaves) and three rates of green mulch (5, 10 and 15.0 ton.ha^{-1}), plus one control without mulch, so there were 13 treatments.

Soil tillage was done using hoe, and then 39 plots of 3 × 3 m were prepared. Cow manure was used as the basal fertilizer, at the rate of 30 ton.ha^{-1}, and spread over each plot. Urea fertilizer at rates of 300 kg.ha^{-1} was top dressed in three stages. 40% was applied one week after planting, 30% was given one month later, and the rest 30% was applied the following month. Green mulches were obtained from pruning twigs and branches of plants, then leaves were separated from the twigs. The green mulch was spread on the soil surface of each plot according to the types and rates of treatment.

The variables observed were leaves fresh weight per hectare at the first harvest time and the leaf content

Table 1. Organic-C, total-N, total-P, and total-K in various types of green mulch

Types of green mulch	C-Organic (%)	N-Total (%)	P-Total (%)	K-Total (%)
Shrimp-type Evergreen	53.09 a	1.76 b	0.24 b	0.70 b
Cashew	54.84 a	1.79 b	0.28 b	0.58 b
Acacia	54.47 a	2.69 b	0.34 b	0.94 b
Gliricidia	57.70 a	3.61 a	0.42 a	1.97 a

(water content, protein, fat, carbohydrate, crude fiber, ash, Ca, Fe and Zn minerals). Plants of one year old after transplanting were measured for fresh weight at the first harvest. Leaves were sampled from each plot for determination of leaf content. Data were analyzed using analysis of variance at 5% significance level, followed by Duncan's Multiple Range Test at α= 5% significant level. The plant tissue analysis (Table 1) showed that gliricidia leaves mulch has the highest content of N-total, P-total and K-total, which are significantly different from those of other mulch types, while the C-organic content in gliricidia leaves was not significantly different from that of others (Darini and Amalia, 2017). The results of the tissue analysis of C-organic, N-total, P and K content in various types of leaf mulch are presented in Table 1.

RESULTS AND DISCUSSION

Fresh weight of leaves and water content

Average values of leaf fresh weight and water content are presented in Table 2. The application of green mulch mostly increased the yield of *Aloe vera*, except the application of casuarina leaves at the dosage of 5 ton.ha^{-1}. The dosage of 10 to 15 ton.ha^{-1} of casuarina leaves was needed to increase the yield, while cashew tree and acacia leaves gave better effect on yield of *Aloe vera*, compared to casuarina leaves.

The highest yield of *Aloe vera* was obtained when casuarina leaves was applied at the dosage of 10 to 15 ton.ha^{-1}, although the application dosage of 10 ton.ha^{-1} or 15 ton.ha^{-1} did not give significant result on the variable measured. Gliricidia leaves contain adequate nutrients promoting plant growth and root absorption. Harsono *et al*. (2011) stated that various types of green mulch (straw, husk, sawdust, bark and corn waste) gave positive effect on the growth and yield of chili. Sunghening *et al*. (2012) also reported that the straw mulch was able to increase the growth and yield of green beans up to 31.25%. Kwanbe *et al*. (2014) stated that the grass mulch could keep the soil temperature low, increase moisture and weed population, thus increasing the growth and yield of beans (*Phaseolus vulgaris* L.). Supporting result was given by Murdaningsih and Mbu'u (2014), who stated that green kirinyu (*Chromolaena odorata* L.) mulch could increase the yield of carrot, and Awopegba *et al*. (2017) reported that mulch application of *Cajanus cayan* and *Chromolaena odorata* improved the yield of corn.

Water content of *Aloe vera* leaves was not significantly different, neither with nor without application of green mulch. Since the *Aloe vera* leaf is succulent, giving various types and dosages of leave mulch did not reveal any increase in water content, but study by Chakrabarty *et al*. (2008) resulted that the application of rice husk could increase the relative and potential water content of wheat seeds.

Table 2. Fresh weight of leaves and water content

Types of green mulch	Fresh weight of leaves (ton.ha^{-1})				Water content (%)			
	Rates of green mulch (ton.ha^{-1})				Rates of green mulch (ton.ha^{-1})			
	0	5	10	15	0	5	10	15
Evergreen	-	6.56 de	7.18 d	7.65 d	-	95.64 a	95.67 a	95.45 a
Cashew	-	7.65 d	8.43 c	8.90 c	-	95.62 a	95.71 a	95.66 a
Acacia	-	7.81 c	8.74 c	9.53 b	-	95.63 a	95.66 a	95.68 a
Gliricidia	-	9.37 b	11.56 a	12.49 a	-	95.69 a	95.67 a	95.63 a
Control	5.78	-	-	-	95.32	-	-	-

Remark: Means by followed by the same letter in the same column are not significantly different based on the Duncan Multiple Range Test at a significant level of 5%.

Table 3. Protein and fat content in leaves

Types of green mulch	Protein content (%)				Fat content (%)			
	Rates of green mulch (ton.ha^{-1})				Rates of green mulch (ton.ha^{-1})			
	0	5	10	15	0	5	10	15
Evergreen	-	0.24 c	0.26 c	0.24 c	-	0.05 c	0.05 c	0.06 b
Cashew	-	0.29 b	0.28 b	0.32 a	-	0.06 b	0.06 b	0.07 b
Acacia	-	0.26 c	0.30 b	0.30 b	-	0.07 b	0.08 a	0.08 a
Gliricidia	-	0.33 a	0.39 a	0.37 a	-	0.08 a	0.09 a	0.09 a
Control	0.16	-	-	-	0.03	-	-	-

Remark: Means followed by the same letter in the same column are not significantly different based on the Duncan Multiple Range Test at a significant level of α= 5%.

Table 4. Carbohydrate and raw fiber content

Types of green mulch	Carbohydrate content (%)				Raw fiber content (%)			
	Rates of green mulch (ton.ha^{-1})				Rates of green mulch (ton.ha^{-1})			
	0	5	10	15	0	5	10	15
Evergreen	-	2.24 a	2.44 a	2.47 a	-	0.47 b	0.47 b	0.47 b
Cashew	-	2.42 a	2.45 a	2.32 b	-	0.52 b	0.57 a	0.57 a
Acacia	-	2.08 c	2.30 b	2.08 c	-	0.57 a	0.58 a	0.59 a
Gliricidia	-	1.75 c	1.90 c	1.94 c	-	0.59 a	0.60 a	0.69 a
Control	2.83	-	-	-	0.23	-	-	-

Remark: Means followed by the same letter in the same column are not significantly different based on the Duncan Multiple Range Test at a significant level of α= 5%.

Protein and fat content

Protein and fat content in the leaves are shown in Table 3. The application of various types of green mulch can increase the protein level in *Aloe vera* leaves. The application of 15 ton.ha^{-1} casuarina and cashew tree leaves gave a positive effect on increasing the protein content in the leaves. The same effect was also given by the application of acacia leaves except for the application at a dose a rate of 5 ton.ha^{-1}. Gliricidia leaves gave the best result among other treatments as the nitrogen content in gliricidia leaves is higher compared to the nitrogen content in other types of green mulch. These results are supported by the study of Vidya and Girish (2014) who stated that the application of water hyacinth mulch could increase the chlorophyll and protein level in the wheat seeds. Awopegba *et al*. (2017) also reported that *Cajanus cayan* and *Chromolaena odorata* mulch could improve nutrient composition of corn.

The application of green mulch also increased fat content of *Aloe vera* leaves. The result showed that gliricidia leaves gave the highest increase in fat content of aloe leaves. The same effect was also observed in the application of acacia leaves at the dosage of 10 ton.ha^{-1} to 15.0 ton.ha^{-1}. Result of tissue analysis showed higher level of C-organic and nutrient content in gliricidia leaves compared to the other mulch. Study from Montemurro *et al*. (2013) showed that the application of vetch mulch (*Vicia sativa* L.) can increase the yield and quality of zuchini. Awopegba *et al*. (2017) also stated that *Cajanus cayan* and *Chromolaena odorata* were able to increase the nutrient content of corn.

Carbohydrate and raw fiber content

Table 4 shows carbohydrate and raw fiber content in the leaves. The application of casuarina and cashew tree leaves did not decrease the carbohydrate content in the leaves except at the application of 15 ton.ha^{-1}. There was a significant decline of carbohydrate content by the treatments of acacia and gliricidia leaves except for the application of 10 ton.ha^{-1} acacia leaves. However, study by Kosterna (2014) showed that the application of rye, corn, rape, and buckwheat straw increased the total sugar content in tomatoes and broccoli. These results were supported by Vidya and Girish (2014) who stated that the application of water hyacinth mulch can increase the carbohydrate content in wheat seeds. Jabran *et al*. (2015) stated that 5 ton.ha^{-1} of straw mulch could improve the quality of rice seeds. Similarly, Awopegba *et al*. (2017)

Table 5. Ash and Ca content

Types of green mulch	Ash content (%)				Ca content (ppm)			
	Rates of green mulch (ton.ha^{-1})				Rates of green mulch (ton.ha^{-1})			
	0	5	10	15	0	5	10	15
Evergreen	-	0.46 c	0.46 c	0.48 c	-	139.66 b	139.66 b	142.74 b
Cashew	-	0.53 c	0.53 c	0.59 b	-	145.73 b	149.07 b	220.03 a
Acacia	-	0.66 b	0.56 c	0.69 b	-	217.93 a	218.09 a	239.73 a
Gliricidia	-	0.62 b	0.65 b	0.85 a	-	249.16 a	233.70 a	222.17 a
Control	0.36	-	-	-	82.72	-	-	-

Remark: Numbers followed by the same letters in one colomn indicate no significant difference based on DMRT test of α= 5%.

Table 6. Fe and Zn content

Types of green mulch	Fe content (ppm)				Zn content (ppm)			
	Rates of green mulch (ton.ha^{-1})				Rates of green mulch (ton.ha^{-1})			
	0	5	10	15	0	5	10	15
Evergreen	-	6.68 a	6.68 a	6.96 a	-	0.77 a	0.77 a	0.78 a
Cashew	-	6.95 a	6.90 a	6.41 a	-	0.80 a	0.77 a	0.75 a
Acacia	-	6.56 a	6.61 a	6.98 a	-	0.79 a	0.80 a	0.75 a
Gliricidia	-	6.86 a	7.24 a	7,19 a	-	0.73 a	0.77 a	0.73 a
Control	6.65	-	-	-	0.75	-	-	-

Remark: Numbers followed by the same letters in one colomn indicate no significant difference based on DMRT test of α= 5%.

also reported that the application of *Cajanus cayan* and *Chromolaena odorata* mulch could increase the carbohydrate content of corn.

Fiber content in *Aloe vera* leaves increased with the application of green mulch. Gliricidae and acacia mulch gave the best result on increasing the fiber content in the leaves, but there was no significant differences in fiber content obtained by increasing dosage of both mulch. The cashew mulch and casuarina leaves has less effect than gliricidia and acacia leaves on increasing the fiber content in *Aloe vera* leaf. This result is supported by the previous study done by Samela *et al*. (2016) who stated that the application of mulch did not give any significant effect on raw fiber content in tomato plants. Whilst Ossom *et al*. (2016) reported that the application of straw mulch could increase the nutrient content of sweet potato (*Ipomoea batatas* L.), and Awopegba *et al*. (2017) stated that the application of *Cajanus cayan* and *Chromolaena odorata* mulch was able to increase the nutrient content of corn plants.

Ash and Ca content

The application of various types and dosages of green mulch was able to increase the ash content in the *Aloe vera* leaves (Table 5). There was no significant effect resulted by the addition of both casuarina and cashew tree leaves on the ash content, except the application pf cashew tree leaves at a dosage of 15 ton.ha^{-1}. The application of acacia leaves at a dosage lower than 10 ton.ha^{-1} could increase the ash content in the *Aloe vera* leaf. Gliricidia leaves gave the best result on increasing the ash content in the leaves. These results are supported by Ossom *et al*. (2016) who reported that straw mulch was able to increase the nutritional content in sweet potato (*Ipomoea batatas* L.). Awopegba *et al*. (2017) also reported that the application of *Cajanus cayan* and *Chromolaena odorata* mulch was able to increase ash content in corn. On the other hand, study done by Kosterna (2014) stated that the application of green mulch did not increase ash content in tomato and broccoli.

The application of both acacia and gliricidia leaves resulted in the highest Ca content in the leaves as these mulches already contain Ca in the cell wall. Acacia and gliricidia probably also increase Ca content in the soil, as Mugwe *et al*. (2017) stated that legume could increase Ca content in the soil. According to Mollah *et al*. (2015), the organic fertilizer is a source of C-organic and Ca, and this is in line with the study done by Ossom *et al*. (2016) who stated that the application of straw mulch was able

to increase the Ca content in sweet potato (*Ipomoea batatas* L.).

Micro-mineral Fe and Zn content in the leaves

There was an interaction effect of various types and dosages of green mulch on the observed Fe and Zn content. Fe and Zn content in the leaves are presented in Table 6. The result showed that application of various types and dosages of green mulch did not give any significant differences on the content of Fe and Zn, even compared to the control.

This probably due to very low content of micro-minerals in sandy soil, which is less than 0.01% (Sutardi, 2009), and low content of micro-mineral in the green mulch as well. On the other hand, Mollah *et al*. (2015) stated that organic fertilizer is a source of minerals (Ca, Mg, Fe and Zn), and Ossom *et al*. (2016) also reported that the application of straw mulch was able to increase the mineral content (Ca, Mg, Fe and Zn) in sweet potato (*Ipomoea batatas* L.). Fe and Zn levels in *Aloe vera* are lower compared to Fe and Zn content in Aloe barbadenses Miller (Sharma *et al*., 2011).

CONCLUSIONS

There was an interaction effect of the various types and dosages of green mulch on all variables observed. The application of green mulch can improve the yield and quality of *Aloe vera* leaves grown in coastal sandy soil. Gliricidia leaves gave the best effect with optimum dosage about 10 ton.ha^{-1} among other treatments. The effectiveness of various types of green mulch abilities on improving the observed variables, from high to low, was shown by gliricidia, acacia, cashew tree and casaurina leaves with the dosage range between 10 up to 15 ton.ha^{-1}.

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