GROWTH RESPONSE AND ANTIOXIDANT CONTENT OF ALOE VERA L. PLANT UNDER DIFFERENT TYPES AND DOSAGE OF GREEN MULCH IN SANDY SOIL

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Abstract: The research aims to determine the effect of mulch types and dosage on the growth and nutritional content of *Aloe vera* L. The research was conducted from December 2015 to October 2016, in Kretek Depok subdistrict, Bantul, Yogyakarta. There were two factors arranged in factorial Randomized Completely Block Design with three replications. The first factor was the types of green mulch consisting of five levels, i.e. control (without mulch), gliricidia leaves, cashew tree leaves, and casuarina leaves. The second factor was the dosage of green mulch consisting of three levels i.e.: 5.0; 7.5 and 10.0 ton. ha^{-1}. Observation was made on the growth component and nutritional content. Growth component includes fresh and dry weight of leaf, growth index, and relative growth rate, while antioxidant component includes concentration of provitamin A, vitamin C, provitamin E, and antioxidant value. Data were analysed with analysis of variance and subjected to Duncan's Multiple Range Test at 5% significance level. The result showed interaction between types and dosage of green mulch on all variables. The highest growth and antioxidant component were obtained on the addition of 7,5 ton. ha^{-1} gliricidia and 10 ton ha^{-1} of other green mulch.

Keywords: *Aloe vera*, green mulch, growth component, nutritional content.

I. INTRODUCTION

Among the four members of aloe namely *Aloe vera* L., *Aloe barbadensis* Mill., *Aloe ferrox* , *Aloe perryi* Baker, the highest population found in the Special Region of Yogyakarta is *Aloe vera* L. (Darini et al. 2014). *Aloe vera* plant has been used as ornamental plant, healthy food ingredient, materials for cosmetic industry, and medicinal plant. This plant is therefore a multifunctional plant and it has been called *Miracle Plant*. The leaves of this plant contain fat compounds, carbohydrates, proteins, and 18 essential amino acids, four kinds of vitamins, minerals and six kinds of enzymes. They also contain secondary metabolites: alkaloids, aloins, lectins, lignin, saponins, tannins, phenolic and glukomannan (Boundreau and Beland 2006; Darini et al. 2013). The sinergistic activity of all these active substances contributes to the efficacy of aloe leaves. *Aloe vera* leaves can be used to improve hair growth, cell regeneration, and immunity as well as to heal wound and skin irritations. In addition, they also work as anti-inflammatory, antiseptic, antibiotic, antioxidant, anticancer, anti-cholesterol, and antidiabetes, thus *Aloe vera* leaf is currently used as one of ingredients in phytotherapeutics (Bunyapraphatsara et al. 2007: Nandal et al. 2012: Rajeswari et al. 2012).

Society's tendency to go back to nature has brought a change in the pattern of food consumption, industrial and cosmetics materials as well as drugs from natural materials. Acording to the WHO data, about 80% of the world population utilize traditional medicines derived from plant extracts for health care. Approximately 25% of the world pharmaceutical products use raw materials derived from plants. This proves that medicinal plants have become important source of material for modern medicine. Aloe plant has been developed in countries like America, Australia and countries in Europe as raw material in the pharmaceutical, cosmetic, and healthy food industries (Widharto 2011).

Land is needed for the development of this plant. However, the available land has decreased due to land conversion. One of the types of land which is still available for agriculture is marginal land in the form of sandy soil. Up till now the handling of sandy soil is still relatively inadequate. Java Island has an 81.000 km^2 area of seaside potential to be developed as agricultural land. The Special Region of Yogyakarta has an expanse of coastland covering approximately 3.300 hectares or 4% of the total area, extending 110 km on the south coast of Indonesia . The ocean stretch of sand is between 1-3 km from the coastline. The coastland is marginal land with the following characteristics: sandy textures, loose structure, low nutrient content, low cation exchange capacity (CEC), low water storage capacity, extremely high soil temperature during the day, wind speed and evaporation rate (Yuwono 2009).

To improve the properties of sandy soil, an innovative technique is required such as the use of ameliorative materials. If the soil ameliorants will be one of the alternatives for the recovery degraded lands, it is necessary to select appropriate soil ameliorants available at the location, for example: compost, animal manure, green manure and green mulch. One of available soil ameliorants based on local wisdom is green mulches. Green mulch can reduce the intensity of light, decrease soil temperature, reduce evaporation, increase soil moisture, control weeds and pests and soil pathogens (Chalker-Scott, 2007; Pakdel et al. 2011). Therefore, it is necessary to

study the growth response, and nutritional content of the *Aloe vera* plant under different types and dosage of green mulch in sandy soil.

II. MATERIALS AND METHODS

II.1. Description of the study

The field experiment was conducted in Depok, Kretek, subdistrict of Bantul Regency in the Special Region of Yogyakarta, at temperature of 31-40 °C, 100% light intensity, 64-75% humidity, and 1672.5 mm.year^{-1} of rainfall. Meanwhile, the growth, nutritional content, and antioxidant properties analysis were carried out in the Crop Production Laboratory of the Faculty of Agriculture Universitas Sarjanawiyata Tamansiswa, Biotechnology Laboratory of Technology Agriculture Faculty and Integrated Research and Testing Laboratory of Universitas Gadjah Mada.

II.2. Experimental design

The experiment was arranged in factorial complete randomized block design with 3 replications. The first factor was types of green mulch consisting of five levels, i.e without mulch: casuarina leaves, cashew leaves, acasia leaves and gliricidia leaves. The second factor was urea fertilizer consisting of three levels i.e : 5, 7.5, and 10 ton. ha^{-1} . Therefore, there were 15 combined treatments with 3 replications.

II.3. Experimental procedure

Experimental procedure consisted of: (1) preparations of aloe plant seedlings in polybags, (2) soil tillage using hoe, land plotting, and planting holes making, (3) application of manure as basic fertilizer, (4) planting of the plant, by previously measuring fresh and dry weight of the seedlings, (5) application of types and dosage of green mulch referring to the treatment, (6) daily irrigation in the afternoon using sprayer, (7) manual weeding, (8) final observation of soil, growth component, and nutritional contents 10 months after planting.

II.4. Data collection and analysis

The variables for observation of growth component included: leaves fresh and dry weight of seedling and plant, total fresh and dry weight of seedling and plant, growth index, crop growth rate; while those of nutritional content included: water, protein, lipid, carbohydrate and ash concentration. Data analysis used analysis of variance at the significance level of 5%, continued by Duncan's Multiple Range Test at the significance level 5%.

III. RESULTS AND DISCUSSION

III.1. Growth component

There was interaction effect between types and dosage of green mulch on the fresh weight of aloe seedlings (Table 1). The lowest fresh weight of the seedlings was obtained in the plant without mulch. There was an increase in the weight of seedling treated with 5 ton of green mulch. Along with the increasing of the green mulch dosage, there was an increase in seedling fresh weight. However, the highest fresh weight was obtained at 10 ton.ha^{-1} of gliricidia. The highest seedling fresh weight was obtained on green mulch gliricidae with dosage of 7.5 to 10 ton. ha^{-1}, while the other mulch at 10 ton. ha^{-1} resulted in lower seedling fresh weight. This is in the accordance with Sunghening et al. (2012) who stated that giving straw mulch could increase the growth of green beans. Likewise, Caliskan et al. (2014) mentioned that green manures increased the growth of organic lettuce.

The result also showed that there was interaction effect between types and dosage of green mulch on the dry weight of aloe seedlings (Table 1). The highest seedling dry weight was obtained at 7.5 to 10 ton.ha^{-1} of gliricidia and 10 ton.ha^{-1} of cashew. While, lower dosage resulted in low dry seedling weight. The lowest seedling fresh weight was found in plants without mulch. This is similar to the opinion of Karkanis et al. (2007) who stated that giving mulch straw could increase the growth of tobacco seedling.

Plant fresh weight was influenced by interaction effects between types and dosage of green mulch (Table 1). The lowest fresh weight of the seedlings was obtained on treatment without mulch. There was an increase in the weight at 5 ton.ha^{-1} of green mulch. Along with the increasing of the green mulch dosage, there was an increase in the seedling fresh weight. However, the highest weight was obtained at 10 ton. ha^{-1} of gliricidia. The highest seedling fresh weight was obtained on gliricidia with dosage of 7.5 to 10 ton. ha^{-1}, while the other mulch at 10 ton. ha^{-1} gave lower seedling fresh weight. This is similar to the opinion of Sunghening et al. (2012) stating that giving straw mulch could increase the growth of green beans. Likewise, Komla (2013) proposed that rice husk mulches increased the growth of sweet pepper as well as Kwambe et al. (2015) suggesting that grass mulch increase the growth of green bean (*Phaseolus vulgaris* L.)

The result showed that there was interaction effect between types and dosage of green mulch on the dry weight of aloe plant (Table 1). High dry weight of plant was obtained on gliricidia dosage of 7.5 to 10 ton, and acacia at 10 ton. ha^{-1}. While lower dosage resulted in low plant dry weight. The lowest plant dry weight was obtained on treatment without mulch. This is similar to the report of Karkanis *et al*. (2007) stating that application of straw mulch could increase the growth of tobacco plant. Egbe et al. (2012) also reported that high biomassa of maize was affected by calliandra mulch. Likewise, Jabran *et al*. (2015) reported that green mulch straw application increased the dry weight of rice.

Table 1 shows that plant growth index was influenced by the interaction effect between types and dosage of

green mulch. High growth index of plant was obtained at 7.5 to 10 ton.ha^{-1} of gliricidia application. While lower dosage led to low plant growth index. The lowest one was obtained on treatment without mulch. This is similar to the report of Sujana (2011) stating that application of crotalaria mulch could increase the growth of lettuce seedling. Talgre *et al*. (2012) also reported that application of green manure increased growth index of cereal.

Table 1 shows that plant growth rate was influenced by the interaction effect between types and dosage of green mulch. High growth index of plant was obtained at 7.5 to 10 ton.ha^{-1} of gliricidia application. While, lower dosage resulted in low plant growth index. The lowest growth index was obtained on treatment without mulch and casuarina application at 5 ton.ha^{-1}. This is similar to the report of Harsono et al. (2011) stating that application of green mulches could increase the absolute growth rate of red chili. Likewise, Chosin et al. (2014) reported that green mulch *Arachis pinoi* could increase the growth of tomato plant. According to Adeniya et al. (2017), status moringa mulch also increased the growth of okra (*Abelmoschus esculentus*)

Table 1. Fresh and dry weight of seedling, fresh and dry of plant, index of growth, andcrop growth rate (C.G.R.)

No	Types/dosage of mulch treatment	Seedling fresh weight (g)	Seedling dry weight (g)	Plant fresh weight (g)	Plant dry weight (g)	Growth index (%)	C.G.R. (g/m^2/ week)
1.	Without mulch	29.39 d	5.35 d	1020 d	204.24 d	3030.31 d	4.47 d
2.	Without mulch	32.85 d	5.36 d	1150 d	270.76 d	3000.76 d	5.61 d
3.	Without mulch	31.15 d	4.32 d	1280 d	268.89 d	3048.16 d	5.56 d
4.	Casuarina 5.0 t	36.51 c	6.40 c	1320 c	317.24 c	3424.97 c	6.77 d
5.	Casuarina 7.5 t	39.07 b	6.38 c	1310 c	354.10 c	3420.65 c	7.22 c
6.	Casuarina 10 t	53.02 b	7.34 b	1360 c	363.60 b	3522.73 c	7.93 c
7.	Cashew 5.0 t	39.14 c	6.86 c	1370 c	327.74 c	3400.25 c	7.02 c
8.	Cashew7.5 t	52.19 b	7.23 b	1770 b	301.72 c	3657.70 b	9.09 b
9.	Cashew 10 t	54.59 b	7.81 a	1840 b	368.78 b	3676.76 b	9.02 b
10.	Acacia 5.0 t	51.44 c	6.28 c	1590 c	318.68 b	3677.85 b	7.81 c
11.	Acacia 7.5 t	52.95 b	7.54 b	1520 c	304.24 b	3137.48 c	7.44 c
12.	Acacia 10 t	51.49 b	7.78 b	1630 b	416.66 a	3665.66 b	9.97 b
13.	Gliricidia 5.0 t	52.11 b	7.18 b	1610 b	362.42 b	3698.61 b	9.37 b
14.	Gliricidia 7.5 t	57.77 a	8.28 a	2330 a	466.44 a	3933.23 a	11.46 a
15.	Gliricidia 10 t	56.66 a	7.88 a	2310 a	464.72 a	3932.67 a	10.80 a

Note: Means associated with the same letter within a column are not significantly different according to Duncan's Multiple Range Test at 5% of significance level.

III.2. Antioxidant component

III.2.1. Pro-vitamin A concentration

Pro-vitamin A concentration in leaves was influenced by the interaction between types and dosage of green mulch (Table 2). Plants without mulching showed no significant difference. There was an increase in the concentration of pro-vitamin A under application of green mulch with the increasing dosage. High pro-vitamin A was obtained at 7.5 to 10 ton.ha^{-1} of gliricidia, while lower pro-vitamin A concentration was obtained on gliricidia application at 7.5 to 10 ton.ha^{-1}. This is similar to the report of Minya et al. (2008) stating that giving crotalaria green mulch could increase vitamin A concentration of amaranthus leaves. Likewise, Gomes de Moura et al. (2015) reported that the application of leucaena and acasia green mulch could increase total carotenoid of maize in the humic tropics. Tswanya et al. (2016) mentioned that type of green mulch did not affect, but the dosage of green mulch could increase caroten concentration in tomato fruit. Gomes de Moura et al. (2017) also said that the application of gliricidia, crotalaria and acasia green mulch could increase caroten and provitamin A of cassava.

Table 2. Pro-vitamin A, vitamin C, pro-vitamin E, and antioxidant value

No	Type/dosage of mulch treatment	Pro-vitamin A (ppm)	vitamin C (ppm)	Pro-vitamin E (ppm)	Antioxidant (%)
1.	Without mulch	4.85 d	15.17 d	32.12 d	30. 23 e
2.	Without mulch	4.10 d	15.06 d	34.41 d	29. 55 e
3.	Without mulch	4.69 d	14.66 d	30.31 d	29.77 e
4.	Casuarina 5 t	5.15 c	17.11 c	46.22 c	31.89 d
5.	Casuarina 7.5 t	6.01 c	18.10 b	53.33 b	35. 44 c
6.	Casuarina 10 t	7.02 b	18.87 b	52.20 b	35. 75 c
7.	Cashew 5 t	5.11 c	17.22 c	42,62 c	32. 20 d

8.	Cashew 7.5 t	6.39 c	18.89 b	56.34 b	37. 62 b
9.	Cashew 10 t	7.11 b	20.19 b	55.11 b	43.95 a
10.	Acasia 5 t	5.46 c	16.89 c	53.11 b	31.88 d
11.	Acasia 7.5 t	6.78 b	19.23 b	54.41 b	37.08 b
12.	Acasia 10 t	7.19 b	20.01 b	55.74 b	38. 37 b
13.	Gliricidae 5 t	6.44 c	19. 98 b	55.37 b	37.31 b
14.	Gliricidae 7.5 t	7.93 a	21. 24 a	58.87 a	38.37 b
15.	Gliricidae 10 t	7.64 a	21.01 a	59.78 a	41.92 a

Note: Means associated with the same letter within a column are not significantly different according to Duncan's Multiple Range Test at 5% of significance level.

III.2.2. Vitamin C concentration

Tabel 2 showed that protein concentration was influenced by the interaction between types and dosage of green mulch. The lowest vitamin C concentaration was obtained on treatment without mulch. The higher dosage of mulch can increase vitamin C concentaration. The highest vitamin C concentration was obtained on gliricidia at 10 ton. ha^{-1}. Lower vitamin C concentration was obtained at 10 ton. ha^{-1} of cashew and acacia green mulch. This is similar to the opinion of Lundegard et al. (2008) mentioning that red clover green manure could increase vitamin C concentration in leek (*Allium porrum*). Likewise, Minya et al. (2008) stated that crotalaria green mulch increased vitamin C concentaration of tomato fruit. While Ali and Ridwan (2008) said that straw mulch could increase vitamin C concentration in strawberry. Tringouska et al. (2016) also reported that giving different types of cover crop could increase vitamin C concentration in tomato fruit.

III.2.3. Pro-vitamin E concentration

Pro-vitamin E concentration in leaves was influenced by the interaction between types and dosage of green mulch (Tabel 2). The highest pro-vitamin E concentration was obtained on green mulch gliricide at 7.5 - 10 ton ha^{-1}. Lower pro-vitamin E concentration was obtained on acacia and cashew mulch at 10 ton. ha^{-1}. Among other treatments including without mulch, pro-vitamin E concentration was not significantly different. This is similar to the opinion of Leblanc et al. (2006) stating that giving *Inga edulis* green mulch could increase polyphenol content in maize. Protein has exellent potential as antioxidant additive because they can inhibit lipid oxidation through multiple pathway (Elias et al., 2008). Based on the statement on the results, high protein concentrations might also increase vitamin E concentration.

III.2.4. Antioxidant value

Antioxidant values in leaves was influenced by the interaction between types and dosage of green mulch (Tabel 2). The highest antioxidant values were obtained on gliricide application at 7.5 - 10 $ton.ha^{-1}$ and cashew at 10 $ton.ha^{-1.}$. Lower antioxidant values were obtained on other green mulches application at 5 – 7.5 $ton.ha^{-1}$. The lowest antioxidant values were observed on the treatment without mulch. This is in the accordance with Okon et al. (2010) revealing that application of gliricidia mulch increased nutrient content on cassava. Likewise, Marcadenti et al. (2015) said that antioxidant obtained from the diet mainly vitamin C, E, Zinc, Se and carotenoid have an important role in reducing oxidative stress and also DNA damage. Based on the statement on the results, high vitamin A, C, and E concentrations will also increase antioxidant value.

CONCLUSION

Based on the results, there were interaction effects between types and dosage of green mulch on all growth variables and nutritional content of the leaves of aloe. Gliricidae mulch application at dosage of 7.5 $ton.ha^{-1}$ gave the best growth response of aloe plants and high antioxidant value. Other types of leaves can be utilized as alternative green mulch, although higher dosage is required.

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