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The Role of Plant Tillers toward Carbon Dioxide Sequestration

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ABSTRACT

Carbon dioxide (CO_2) is one of greenhouse gas which level in the atmosphere escalates rapidly and highly contributes to global warming. One of the efforts to decrease the number of CO_2 gas concentrate in the atmosphere is by using the nature of plants which work CO_2 through photosynthesis. The research objectives are; (a) to measure the CO_2 sequestration level to the tillers of Jackfruit plants (*Artocarpus heterophyllus* Lam.) and Papaya (*Carica papaya* L.), (b) to measure organic carbon stocks stored in the tillers of Jackfruit and Papaya, (c) to estimate the number of CO_2 sequestrated by the tillers of Jackfruit and Papaya based on age variation of plants, and (d) to recognize the role and the contribution of Papaya and Jackfruit tillers to decrease global warming effect. CO_2 sequestration measurement applied containment method (*chamber*) sized 50 cm x 50 cm x 30 cm and CO_2 concentrate analysis used *Chromatography Gas*. The time period of CO_2 sequestration measurement conducted at 06:00, 09:00 and 12:00 AM and 03:00 PM with time interval of CO_2 sampling on the 5th, 10th, 15th, 20th, 25th dan 30th minute. Gravimetric method was used to determine dry weight, percentage and organic carbon of Jackfruit and Papaya tillers. The result of the research shows that the CO_2 absorption of the Papaya tillers are higher (0.64 mg/m^2/minute) compared to the Jackfruit (0.15 mg/m^2/minute) in 1 month tiller age. The high absorption of Papaya tillers affects to the increase of the stored organic carbon stocks as much as 36.72 g/m^2. On the other hand, the organic carbon stock in the Jackfruit tiller is about 3.75 g/m^2. The older the Papaya and the Jackfruit tiller, the higher CO_2 absorption. Papaya at one year age is predicted to be able to absorb CO_2 for about 460.80 mg/m^2/hour/tree and the Jackfruit is about 108 mg/m^2/hour/tree. The Papaya and the Jackfruit tillers related to the ability to well absorb CO_2, has the potential to improve and to cultivate by Indonesian societies in their mitigation attempt toward climate change. Moreover, Papaya and Jackfruit are the fruit plants which have quite high economical value.

KEYWORDS: *tillers, jackfruit, papaya, CO2 sequestration*

INTRODUCTION

Carbon dioxide (CO_2) is one of *greenhouse gas* (GHG) which has rapidly increased in the atmosphere and contributed to global warming. IPPC (2001) stated that in 1800 the CO_2 gas concentrate in the atmosphere was close to 280 ppm which at the beginning increased slowly and furthermore raised rapidly to 367 ppm in 1999. The accumulation of CO_2 gas concentrate in the atmosphere is caused by human activities (*anthropogenic*) that has been increased, such as fossil fuel combustion, industrial activities, land clearing activity for infrastructure development, plant cultivating intensification, also waste production (State Ministry of Environment, 2012).

Based on the 13th Climate Change Convention in Bali (*The 13th Conference of the Parties-COP13*) in 2007, Indonesia is committed to lower down the GHG emission for about 26 % by the year 2020 funded by domestic budget fund and international funding support (State Ministry of Environment, 2012). One of the efforts committed by Indonesian Republic government in decreasing GHG emission (particularly CO_2 gas) by implementing mitigation activity which is related to the increase of carbon stocks by tree planting activities. To support the activity program, a review is needed through research activity about the variety of tree plants related to the ability to absorb CO_2 because every plant or tree species has different abilities to absorb CO_2. Several factors which effects plants in absorbing CO_2 are; including chlorophyll quality, stomata numbers, leaf area index, leaf age, growth phase, temperature, sun light, and water availability (Dwidjoseputro, 1980).

Studies related to the measurement toward CO_2 absorbing ability by such plants are commonly conducted. Nonetheless several past studies were still limited to the phase of tree level growth. While the phase of tillers growth is rarely studied. In fact, the data is very important to observe and it can become the basic data to predict how much CO_2 absorbed in time of the plants grow. Therefore, this research aimed focused to comprehend the sequestration ability CO_2 on tiller growing phase. Jackfruit and papaya are commonly cultivated fruit plants by Indonesian people, because beside the fruits can

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be consumed, they have high economical value.

The research objective are; (a) to measure the CO_2 sequestration level to the tillers of Jackfruit and Papaya plants, (b) to measure organic carbon stocks stored in the tillers of Jackfruit and Papaya, (c) to estimate the number of CO_2 sequestrated by the tillers of Jackfruit and Papaya based on age variation of plants, and (d) to recognize the role and the contribution of Papaya and Jackfruit tillers to decrease global warming effect.

MATERIALS AND RESEARCH METHODOLOGY

Location and Time of Research

The research of CO_2 sequestration was conducted in Palangka Raya, Central Kalimantan Province, and CO_2 gas analysis was studied in Indonesian Agriculture and Environment Research Institute in Jakenan, Pati, Central Java. Dry weight, percentage and organic carbon analyses were conducted at Laboratory of Foresty Product Technology, Agriculture Faculty, Palangka Raya University. Research was conducted during 3 months from September until November 2014.

RESEARCH TOOLS AND MATERIAL

Tools used for the research are containments (*chamber*) sized 50 cm x 50 cm x 30 cm, *Chromatography Gas*, *syringe*, label stickers, oven, desiccator, ashing furnace, ashing dish, pail, small plastic basket, paper bag, stopwatch, scissor, analytical scale, blender also stationeries. Materials used are tillers of jackfruit (*Artocarpus heterophyllus* Lam.) and papaya (*Carica papaya* L.) aged 2-3 months, sand, planting medium in the form of soil, and sawdust mix with some cow manure fertilizer.

RESEARCH PROCEDURE

Preparation

There were 3 containment units used for the research; 2 units used for the jackfruit and the papaya tillers and 1 unit for controlling purpose (without plant tiller). The jackfruit and the papaya tillers were being stored in seedling bed for approximately 2 weeks in order to adapt the environment aroung the research location. While the total *syringe* needed to take CO_2 gas sampling were as much as 288 tubes.

The Measurement of Carbon Dioxide Sequestration on Plant Tillers

The Jackfruit and the Papaya tillers were put on cement floor and covered by each containment which equipped with thermometer, dry battery, and small fan also the containment without tiller (*control*). Then cover the each side of the containmentwith sand to avoid incoming air into the containment. Turn on the small fan inside the containment and open the covering lid/septum on the top of the containment for 2 until 3 minutes and then put the cover down again. Take the gas sample from inside of the containment through *the septum* by using *syringe*, and note the temperature data on the thermometer from inside the containment also the temperature around the research location with the thermometer out of the containment at every gas sampling period. Gas samplings were taken on 6:00, 09:00, 12:00 and 15:00 Western Indonesian Time period with the interval every 5, 10, 15, 20, 25 and 30 minutes. After finishing the gas sampling at every time period, the containment would be opened again. Gas sampling inside the containment was carried out for 4 times during 4 weeks.

Gas sampling in the syringe then was brought to the laboratory at Indonesian Agricultural Environment Research Institute in Jakenan Pati, Central Java to analyse the CO_2 gas using *Chromatography Gas*. The result of CO_2 gas sampling and the CO_2 gas absorption rate inside the containment were calculated by using Khalil formula, *et.al*., (1991) :

$$F = \frac{dc}{dt} \times \frac{Vch}{Ach} \times \frac{mW}{mV} \times \frac{273,2}{273,2 + T}$$

Where :

F = CO_2 gas absorption rate inside the containment (mg/m^2/minute)
dc/dt = CO_2 concentrate difference per time unit (ppm/minute)
Vch = Box olume (m^3)
Ach = Box Width (m^2)
mW = CO_2 Molecule Mass (gr)
mV = Molecule Volume CO_2 (22.41 L)
T = Average temperature during gas sampling (^{o} C)

CO_2 Absorbency by the tillers (Fb) is the difference between CO_2 absorption rate inside the

containment which contained the tillers, with the CO_2 absorption rate inside the containment without any plant/for control use (K), with the formulation as follows :

$$\mathbf{Fb = F - K}$$

Where :

Fb = CO_2 Absorption Rate by tillers (mg/m^2/minute)

F = CO_2 Absorption Rate inside the containment (mg/m^2/minute)

K = CO_2 Absorption Rate inside the containment for control use/without plant (mg/m^2/minute)

Analysis on Dry Weight, Organic Carbon Percentage and Organic Carbon Rate

Analysis on dry weight, organic carbon percentage and organic carbon rate on each tiller were conducted after CO_2 gas sampling done by gravimetric method.

RESULTS AND DISCUSSION

CO_2 Absorbency on the Papaya and the Jackfruit Tillers

The research result shows that the average CO_2 absorbency of Papaya tillers (*Carica papaya* L.) is higher (0.64 mg/m^2/minute) compared to the J ackfruit tiller (*Artocarpus heterophyllus* Lam.) (0.15 mg/m^2/minute) of one month age. The difference of CO_2 absorbing ability is affected by the CO_2 concentrate quantity and surrounding temperature. Dwidjoseputro (1980), stated that the ability of a plant in absorbing CO_2 was influenced by some factors, such as temperature, sun rays intensity, water availability, leaf area, leaf age and growth phase. The enviromental CO_2 temperature and concentrate are the determining variables in CO_2 fixation by plants related to the growing process of plants. The change on CO_2 temperature and concentrate brings the real effect on the vegetation and the ecosystem productivity because 90% plant dry weight comes from CO_2 fixation through photosyntesis process (Gardner, *et. al*., 1991).

The temperature effect on the CO_2 absorbency by tillers is shown by the temperature quantity inside the containment of papaya tiller which is higher (36.64 ºC) compared to jackfruit tiller (36.27 ºC). That condition can effects the fixation process of CO_2 by plants in photosythesis process. Ginting (2009) stated that the temperature on photosythesis process affects the enzyme work process on *chloroplast* which influences the CO_2 fixation to produce carbohydrates. The higher the temperature in normal limit can increase the enzyme work process in *chloroplast* so that CO_2 fixation process gets higher.

CO_2 gas concentrate can influence the CO_2 absorbing process by plants. CO_2 concentrate increase that goes with the high sun rays intensity can enhance the CO_2 fixation rate for some plants (Ginting, 2009). CO_2 concentrate inside the containment which contains the papaya tiller is higher (545.40 ppm) compared to the jackfruit (540.25 ppm). CO_2 fixation by plants will increase along with the higher CO_2 concentrate around. Furthermore, Mooney and Ehrelinger (1977) also stated, CO_2 is the main material in photosynthesis process and the photosythesis speed will advance as the intracellular CO_2 concentrate gets higher. Some reactions of the increasing CO_2 concentrate toward plants are such as to stimulate the growth in the form of biomass, to boost the plant to experience acclimatization, to store greater carbohydrates, and to increase the organ size but not to influence its growth (Ginting, 2009).

CO_2 absorbency fluctuation is based on observance time period indicates varied trends, as depicted in Image 1.

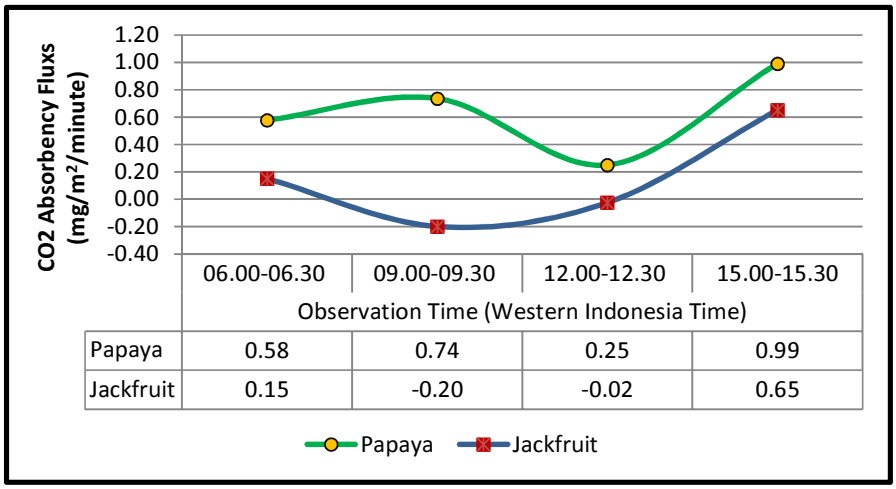

Figure 1. CO_2 absorbency fluctuation based on observance time period on Papaya and Jackfruit Tillers.

Based on the observance time period, it indicates the CO_2 absorbency rates of Papaya and Jackfruit tiller reach the highest rate on 03:00-03:30 PM. This happened because on those period of time the sun rays in the research location was quite intense which impacted on the temperature increase, both in the containment or surround. The temperature increase impacts on the CO_2 fixation quantity by plants and the maximum CO_2 fixation happened when the sun rises at the highest peak (Gratimah, 2009).

Organic Carbon Stock on Jackfruit and Papaya Tillers

The *gravimetric analysis* shows that the Papaya tillers contains higher organic carbon stock than Jackfruit. The number of organic carbon stock stored inside the plant structure can describe how much CO_2 which can be absorbed. The condition can be seen from this research result, where papaya tillers dimana anakan tumbuhan Pepaya have higher CO_2 absorbency compared to the Jackfruit tiller. Hairiah, *et. al*. (2011), the calculation on carbon number that stored in living plant (biomass) on one field can depict how much CO_2 in the atmosphere which is absorbed by plants.

Organic carbon number in plants is effected by biomass (dry weight) inside the plants. The higher the biomass can influence the organic carbon materials in the plant gets higher. Papaya tiller has higher biomass number by 70.80 gr/m^2 compared to the Jackfruit tiller which is 7 g/m^2. The high number of Papaya tiller's biomass is suspected as the effect of more optimum photosynthesis process compared to the Jackfruit tiller so the carbohydrates forming process also gets higher. The opmization of photosynthesis process that happened was influenced by the absorbed CO_2, where the papaya tiller has higher CO_2 absorbency quality compared to the jackfruit so the primary productivity of the photosythesis result gets higher. The CO_2 absorption process from the air through photosynthesis process will be processed into carbohydrates and distributed to the whole organs of plant and eventually stored inside the plant. Carbon Storage Process inside plant is termed *as sequestration process* (Hairiah, *et. al.*, 2011). Whitten, *et. al*., (1984), forest vegetation biomass is the difference between the photosynthesis result with the consumption to respiration process and harvesting. Photosynthesis result is used by the plants to grow vertically and horizontally (Adinugroho and Sidiyasa, 2009).

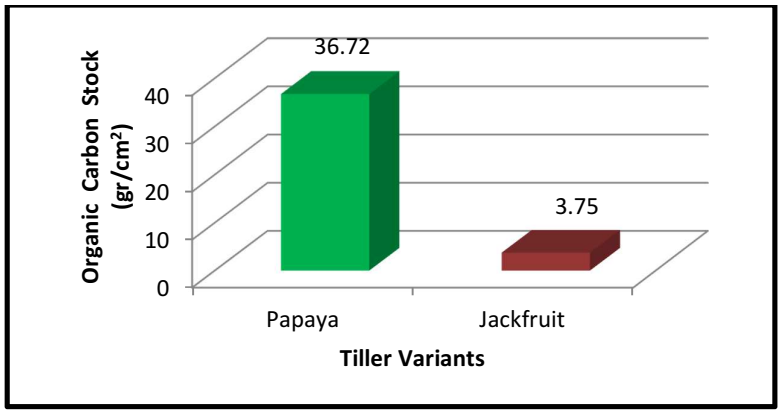

Figure 2. Organic Carbon Stock of Papaya and Jackfruit Tiller

The Estimation of CO_2 Absorbency on the Papaya and the Jackfruit Tiller Based on Age Extension

The plant tiller will keep on growing alongside with the age of the plant and the CO_2 absorbency process will always happen during the growing process occurs. The more the plant age extends, the higher CO_2 absorbency process is. It will apply similarly to the papaya and the jackfruit tillers. Assumed that the 1 month old papaya tiller can absorb CO_2 as much 0.64 mg/m^2/minute or 38.40 mg/m^2/hour, then in one year it can be predicted that CO_2 that can be absorbed is as much 460.80 mg/m^2/hour. CO_2 absorption of the one month old Jackfruit tiller is as 0.15 mg/m^2/minute or 9 mg/m^2/hour, therefore the one year old tiller can absorb CO_2 as much as 108 mg/m^2/hour. The prediction on CO_2 absorption of the P apaya and the Jackfruit tiller is in gross total because how much CO_2 that can be released has not been indicated yet at the time of respiration process. Furthermore the CO_2 absorbency prediction is the minimum margin of CO_2 that can be absorbed by the papaya and the jackfruit tillers because the older the plants, the more CO_2 to absorb. The estimation of CO_2 absorbency on the Papaya and the Jackfruit tillers based on age extension can be viewed on Image 3.

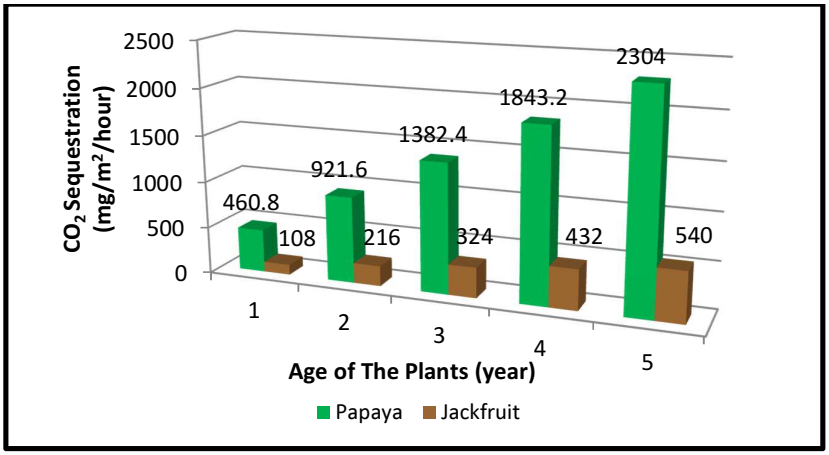

Figure 3. The Estimation of CO_2 Absorbency on the Papaya and the Jackfruit Tillers Based on Age Extension

The Roll and the Contribution of Papaya and Jackfruit to Decrease the Global Warming Effect

Global warming is a phenomenon of increasing average temperature on the surface of the earth as the impact of the rise of greenhouse gas (GHG) in the atmosphere which canthreat living being on earth. To overcome the global warming impact, Indonesian government committed to lower the GHG emission in 2020 for about 26% by domestic attempt and 41% by international fund support with the mitigation program and climate change adaptation (State Ministry of Environment, 2012) Climate change mitigatio is a controlling effort to prevent climate change to happen by committing the activities that can decrease emission or increase the sequestration of greenhouse gas from any emission sources (Presidential Regulation of Indonesia Republic No. 46/2008). Generally, the activities that can support mitigation are those which related with the supplementary of carbon stocks by engaging the planting activities to press down the increase of GHG concentrate in the atmosphere, particulary untuk menekan peningkatan konsentrasi GRK di atmosfir, khususnya CO_2.

Wahyuni (2014), various planting activities in Indonesia which have been accomplished and still been going until present time, such as through rehabilitation and reforestation, like National Afforestation Movement (National Forest and Land Rehabilitation Movement), One Man One Tree Movement (OMOT), *One Billion Indonesian Trees* or OBIT movement, Communal Forest establishment, Community Forest, and Industrial Plantation Forest.

The knowledge about the plant preferances which are going to use as the varieties in climate change mitigation program is absolutely needed in order to achieve the goal required. Based on this research result, it can be recommended that papaya and jackfruit have potential CO_2 absorbency to decrease GHG in the atmosphere. One year old papaya predicted to be able to absorb CO_2 at least as much as 460.80 mg/m^2/hour/tree or 5.53 kg/m^2/day/tree (assuming that the photosynthesis process in one day occurs in 12 hours). On the other hand, the one year old Jackfruit plant can absorb CO_2 at least as much as 180 mg/m^2/hour or 1.3 kg/m^2/day/tree. Moreover, Papaya and Jackfruit have quite high economical value which can be benefited as salable commodity and those are the varieties that mostly cultivated by Indonesia people.

CONCLUSION AND RECOMMENDATION

Conclusion

a. The CO_2 absorbency of Papaya tiller (*Carica papaya* L.) and Jackfruit (*Artocarpus heterophyllus* Lam.) of one month old as much as 0.64 mg/m^2/minute and 0.15 mg/m^2/minute
b. Papaya tiller has higher organic carbon stock (36.72 g/m^2) compared to the Jackfruit (3.75 g/m^2)
c. The older the tillers of the Papaya and the Jackfruit caused the higher absorbency ability of CO_2
d. The Papaya and the Jackfruit tillers have the potential roles and contribution in the effort to hold down global warming related to their ability in absorbing CO_2.

Recommendation

a. Future research is needed related to the CO_2 release by Papaya and Jackfruit tillers during respiration process at night

b. To implement the development and the cultivation of Papaya and Jackfruit, some policies are considered important to be made by the central or regional government to support the efforts to lower the impact of global warming.

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