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The potency of biomass and carbon stocks in smallholder rubber trees (*Hevea Brasiliensis* Muell. Arg), Serdang bedagai, Indonesia

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Abstract

Agroforestry system based on rubber crops is one of agroforestry system that potencial to carbon stocks. The purpose of the researches were: (1) to determine the potency of biomass in smallholder rubber crops; and (2) to find the allometric equations of biomass and carbon stocks in smallholder rubber crops. This research was conducted in smallholder rubber plantations, Serdang Bedagai, North Sumatra, Indonesia. The research was conducted in three areas stand by stand age, rubber plant 5, 10 and 12 years of age. The results showed allometrice quations to estimate biomass in plants smallholder rubber was $W = 3.425\ DBH^{1.153}$. This research showed that the potenty of biomassage of 5, 10 and 12 years of age was43.69 Mg ha^{-1}, 64.87 Mg ha^{-1} and 67.45 Mg ha^{-1}, respectively and the potenty of carbon stocks age of 5, 10 and 12 years of age was19.13 Mg C ha^{-1}, 32.93 Mg C ha^{-1} and 34.70 Mg C ha^{-1}, respectively.

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Introduction

The cause of climate change is increasing concentrations of greenhouse gases (GHGs), particularly carbon dioxide (CO_2) cause of land use and change of forests. It has been a lot of conversion of forests into agricultural land, plantations and residential. .

Forest is a natural resource tha is very important for life and living. While the indirect benefit is in the form of environmental services, a regulator of the water sys-tem, the aesthetic function, as well as a provider of oxygen and carbon sinks (Linder *et al.* 2008; Preece *et al*., 2012). Replanted rainforests have considerable ecological and conservation value (Dennis and Westcott, 2006). Agroforestry system based on rubber crops is one of agroforestry system that potencial to carbon stocks. Several studies showed that carbon stocks of forests have been found but the biomass and carbon stocks on another land utilization e.g. rubber plantation crops in particular has not been found. Rubber plant has a very big role in the absorption of CO_2 because it has a wider canopy and leaves. If the land is used and managed properly, carbon absorption capacity can be increased (Parreso, 1999). This condition causes acquired enough information for decision makers to choose the pattern of land use that is economically viable but also environmentally friendly.

This research can be beneficial for the Indonesian government, especially local government and surrounding communities in decisions about land use that demonstrate aspects of the environment, especially carbon sequestration. The purpose of this study was to determine the potential of carbon stocks in smallholder rubber plantations *(Hevea brasiliensis* Muell. Arg.) in North Sumatra.

Materials and methods

Research Area

This research was conducted in the small holder rubber plantation Serdang Bedagai, North Sumatra on September- November 2014. Sample test analysis was performed at the Laboratory of forest products. Technology, Faculty of Forestry, University of Sumatera Utara and at the Forest Products Laboratory of Chemistry, Faculty of Forestry, Bogor Agricultural University.

Methods

We used a modified transect method for recording tree locations within a 0.4 ha (40mx 100 m) plot. Number of plots was 9 plots. Placement of the plot carried out by random sampling.

Allometric equations of biomass and carbon stocks in the stands, by felling trees selected. Determination of the number of trees felled by stratified random method that is based on the class of tree diameter and stand age.

Number of tree sampling was 9 (nine) trees. The selected sampling tree is felled, then separated by stems, branches and leaves. All parts of the tree are weighed, in order to know the wet weight of each of its parts. Wet weight of the tree is the sum of all the wet weight of the part of the tree.

Test sampling of water content of stems was made with a size of 2 cm x 2 cm x 2 cm. Procedures determination of volatile matter content using the American Society for Testing Materials (ASTM) D 5832-98. The procedure of determining the ash content using the American Society for Testing Materials (ASTM) D 2866-94.

Determination of the carbon content of the test sample of each part of the tree using the Indonesian National Standard (SNI) 06-3730-1995, wherein the carbon content of the sample is the result of 100% reduction of the levels of volatile matter and ash content.

Results

Water content

Results of laboratory analysis showed that there are variations in water content atvarious ages stands and rubber plant (Table 1).

Table 1. Water content of rubber tree (Hevea brasiliensis Muell. Arg).

No.	Age (Year)	Water content (%)		
		Stem	Branch	Leave
1	5	75.25	78.94	153.74
2	10	73.82	77.59	155.57
3	12	85.80	86.48	155.32

Table 1. showed that highest water content that is on the leaf age of 10 years was 155.57%. The lowest water levels are on the shaft of the age of 10 years was 73.82%.

Carbon Content

Levels of carbon rubber plant parts can as a follow (Table 2).

Table 2. Carbon content of parts of rubber plant (*Hevea brasiliensis* Muell. Arg.).

No.	Age (Year)	Carbon content (%)		
		Stem	Branch	Leave
1	5	50.37	40.58	21.68
2	10	61.77	47.95	21.84
3	12	63.03	49.20	19.73

Table 2 showed that the largest carbon content contained on the shaft of the age of 12 years was 63.03%. The smallest carbon content present in the leaves age of 12 years was 19.73%.

Biomass and Carbon Stocks

The model equations are successfully constructed for estimating biomass and carbon in smallholder rubber plantations can be seen in Table 3 and Table 4.

Table 3. Allometric equations of rubber plant biomass (*Hevea brasiliensis* Muell.).

Part of plant	Allometric equations	R-Sq (%)
Stems	$W=0.151\ H^{2.179}$	84.79
Branches	$W=0.398\ H^{1.485}$	95.68
Leaves	$W= 0.165\ H_{bc}^{0.879} + H^{1.871}$	21.46
Total	$W=3.425\ DBH^{1.153}$	99.93*

Note : W = Biomass (kg); H= Total tree height (m); H_{bc} = Clear bole height; DBH = Diameter at breast height (cm); *= Selected model.

Allometric equationswas selected to estimate rubber plant biomass was W= 3.425 $DBH^{1.153}$. Allometric eqution was selected to estimates of carbon was C = 0.582 $DBH^{1.586}$ with independent variable diameter at breast height.

Table 4. Allometric equations of rubber plant carbon (*Hevea brasiliensis* Muell.).

Part of plant	Allometric equations	R-Sq (%)
Stems	$W=0.017\ H^{2.816}$	85.92
Branches	$W=0.040\ H^{2.085}$	94.54
Leaves	$W=0.078\ H^{1.236}$	27.26
Total	$C = 0.582\ DBH^{1.586}$	99.81*

Keterangan: C = Carbon (kg); H= Total tree height (m); H_{bc} = Clear bole height; DBH= Diameter at breast height (cm); * = Selected model.

Based on the selected modelof allometricequations indicated that potential biomass rubber plantations age of 5 years, 10 years and 12 years was 43.69 Mg ha^{-1}; 64.87 Mg ha^{-1} and 67.45 Mg ha^{-1}, respectively. Carbon stocks at a rubber plantation age of 5 years, 10 years and 12 years was 19.13 Mg C ha^{-1}; 32.93 Mg C ha^{-1}and 34.70 Mg C ha^{-1}, respectively.

Discussions

This study resulted that average of carbon content at the stem was50.37%-63.03%. Part stems have the greatest carbon content because during the growth and productive period, rubber plants absorb carbon through photosynthesis in the leaves and spread to all parts of the plant. The average level of the smallest carbon contained in the leaves was 19.73% - 21.84 %. Leaves have a volatile matter content and high ash content. Stems are part of plant that composed of rubber plants that cell wall components consist of the element carbon in stem cells. The walls are stem cells typically composed of cellulose, lignin and extractive substances are mostly composed of the elements carbon.

Partitioning of aboveground biomass into various tree components changed considerably with stand age. While stem biomass became the major pool with increasing stand age, the relative portion of foliage and branch biomass decreased. These changes need to be considered in total forest biomass estimates, especially in young stands (Peichl and Arain, 2007).

This study shows that the selected model k that have the best ability to explain the estimation of carbon stocks was C = 0.582 1.586 DBH with independent variable diameter at breast height has R-sq amounted to 99.81%. Determination of allometric equations that will be used in the estimation of biomass is an important stage of the process of estimating the mass of carbon. All the allometric models expressing dry weights of tree components as a function of DBH had high R^2 values and low standard errors of estimates. All the models show an exponential relationship between dry weights of tree components and DBH. Each allometric equations developed based stand condition and certain types of variations are different from one another (Brown and Lugo, 1984; Navar, 2009). Forest biomass contains approximately 80% of all aboveground terrestrial carbon (C) and 40% of below ground (Goodale *et al.*, 2002).

Changes in tree biomass allocation and allometry throughout different stages of forest stand development need to be considered in order to improve forest biomass and carbon sequestration accounting on regional and national scale.

Conclusions

Allometric eqution was selected to estimates of carbon was C = 0.582 1.586 DBH with independent variable diameter at breast height. Carbon stocks of rubber plantation age of 5 years, 10 years and 12 years was 19.13 Mg C ha^{-1}; 32.93 Mg C ha^{-1}and 34.70 Mg C ha^{-1}, respectively.

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