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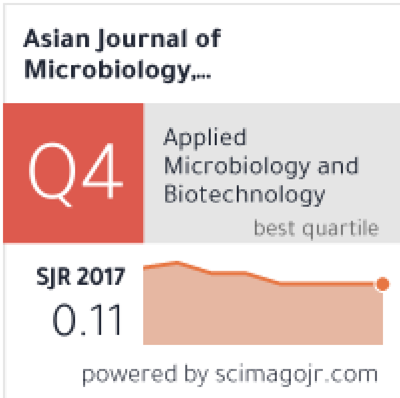

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ALLOMETRIC EQUATIONS FOR PREDICTING ABOVE AND BELOW-GROUND BIOMASS OF YOUNG RAIN TREE [*ALBIZIA SAMAN* (JACQ.) MERR.] TO HANDLE CLIMATE CHANGE

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Key words : *Allometric equation, Rain tree, R/S ratio, BEFs, Climate change*

Abstract - Climate change challenge is real and urgent in the world including Southeast Asia. The rain tree (*Albizia saman* Jacq. Merr.) is becoming more important and recognized as having a major role in carbon storage to address climate change. This paper is to describe and discuss a method to estimate the above and below-ground biomass and to determine root-to-shoot ratio and biomass expansion factors of young rain tree in Ambon Island, Indonesia. The carbon mass equation model was constructed based on a significant relationship between carbon mass of young rain tree and its diameter at 3 cm height and tree height. In order to analyze the biomass content, a destructive sampling technique was used. After felling, dimensional measurement was performed for each tree. The results of the study showed that the equation model for estimating above and below-ground biomass of rain tree was allometric equation: $Y = -10{,}310.50 + 1{,}820.89X_1 + 10.89X_2$ where X_1 = Diameter and X_2 = Height, R Square (adj) was 0.847 and SE was 1,540; root-to-shoot varied from 0.09 to 1.09 with a mean of 0.548 and biomass expansion factors varied from 1.17 to 3.41 with a mean of 1.896.

INTRODUCTION

Albizia saman (Jacq.) Merr, formerly *Samanea saman* (Jacq.) Merr. or rain tree is a medium-sized or large tree of potentially great size, often reaching 25-30 m tall, occasionally 45 m, with a short stout bole to 2-3 m dbh and a wide, low, spreading crown, often twice as wide as the tree is high. It is a stately tree, with heavy, nearly horizontal branches and an umbrella-shaped crown. One notable old *A. saman* tree near Government House in Trinidad was recorded to shade approximately a hectare, and reach 50 m in height, a stem 2.6 m in diameter, with a crown diameter of 60 m (Allen and Allen, 1981; Raintree, 1987). According to Merrill (1912) this tree was one of the first roadside exotic trees to be widely planted in many tropical countries and it is now so widely cultivated, particularly in Southeast and south Asia, that it is often mistaken as native to that area. It was planted principally as a shade or ornamental tree in streets, parks and in coffee plantations. In general, *A. saman* has large crown and heavy branches. Its canopy, with crowns of great diameter is unsurpassed for shade in silvopastoral systems, parks or roadsides and the pink flowers add to its value as an ornamental. The wood of this tree is strong, durable or very durable, with a light yellow sapwood and rich dark chocolate-brown heartwood. The wood is also used for fencing, construction timber, plywood, making crates, boats, and cart wheels made from single cross-sections of the thickest trunks which are said to be very durable and were a common sight on two-wheeled oxcarts in parts of Central America. The tree also contains gum and resin. (Standley and Steyermark, 1946, Jensen, 2001). Invasiveness of this plant i.e: has high reproductive potential; has propagules that can remain viable for more than one year; highly adaptable to different environments; highly mobile locally; proved

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invasive outside its native range, tolerates, or benefits from, cultivation, browsing pressure, mutilation, fire etc. (CABI, 2015). Moreover, rain tree is a multi-purpose tree, adaptable to tropical conditions, and with great potentiality as alternative feed for ruminants and monogastrics. Its nutritional value is given by its production of abundant edible biomass, with crude protein levels higher than 20 %, and the presence of lipidic compounds, soluble carbohydrates and minerals in its foliage and fruits (Delgado *et al.*, 2014).

Climate change challenge is real and urgent in the world including Southeast Asia. According to Yuen and Kong (2009), Southeast Asia is one of the world's fastest growing regions in terms of population and urban growth. Scientific assessment indicates that the coastlines of Southeast Asia are highly vulnerable to the effects of climate change. In this regard, the research on climate change needs to be encouraged by the researchers through colaboration at national and international level. The rain tree is becoming more important and recognized as having a major role in carbon storage to address climate change. Based on everyday experience if we take shelter under rain tree feels cooler than other trees such as pine, agathis or flamboyant (flame tree) etc. This indirectly indicates that these plants play a major role in the carbon sequestration and oxygen production. In other words, these plants play a role in tackling climate change. Therefore, at this time rain tree planting began in earnest in various areas such in the area of Southeast Asia including Singapore, Malaysia (Tan and Yeo, 2009; Ng, 2015), Philippine and Indonesia. Two leading banks in Indonesia (Panin Bank and BNI Bank) have been using funds of corporate social responsibility (CSR) to warrant planting in some provinces in Indonesia. Reforest Indonesia supported by Panin Bank is a national tree planting program aiming at creating a better living environment and reducing emission of glasshouse gas in Indonesia. To support the OBIT (One Billion IndonesianTrees) program launched by the Indonesian President, Panin Bank invites every citizen in Indonesia to plant rain tree or Indonesian original trees such as *A. saman* and Sengon (*Paraserianthes falcataria*) trees. In this case, Panin Bank provides up to 500 million rain tree and Sengon seeds to be donated to partners and training for green officers who will help people to plant trees (Panin, 2013). Beside that, BNI Bank redistributes tree seedlings that were planted together with Budiasi Society at Perennials Breeding Center BNI-Budiasi, Bogor, West Java, to support the Government's program OBIT. There were 5,000 trees planted to shade the newest airport in the province of North Sumatra, namely Kualanamu Airport (Paguyuban Budiasi, 2014).

The role of plants in tackling climate change can not be separated from the distribution of biomass in an area. In general, measurement of biomass distribution relates to the application of allometric equations for predicting above and below-ground biomass, ratio of root-to-shoot and biomass expansion factors (BEFs). According to IPCC (2006), National and regional above-ground biomass (AGB) estimates are generally calculated based on estimates of standing stem volume from forest inventories and from default biomass expansion factors (BEFs). The AGB estimates are converted into below-ground biomass (BGB) using default root-to-shoot ratio (R/S) values. This method is commonly used to estimate carbon stocks for national greenhouse gas (GHG) inventories. Currently, carbon storage capacity of forest is generally computed as per BEFs specifically, carbon storage capacity of forest can be concluded by biomass muliplying by carbon content per unit area with regression equation of biomass and storage capacity, resulting from comprehensive effect of semi-environment (temperature and rainfall), tree species, age, and growth, reflecting environmental factors, tree ages, tree density, and forest stand. Hence, storage capacity of forest stand can be taken as a factor for BEFs (Xie and Zhao, 2014). Based on Mokany *et al.* (2006), reliable root-to-shoot ratios are needed for a wide range of vegetation types in order to improve the accuracy of root biomass estimates, including those required for estimating the effects of land management and land use change in National Greenhouse Gas Inventories. In general, forest biomass estimation can be done by destructive and non-destructive sampling. According to Soares and Tome (2012), non-destructive biomass estimation does not require harvesting trees; it uses biomass equation to estimate biomass at tree-level and sampling weights to estimate biomass at the forest level. So far allometric equations to predict biomass of young rain tree are poorly documented. In this regard research on measurements AGB and BGB of young rain tree (*A. saman*) needs to be done.

MATERIALS AND METHODS

The research was based in Nursery Area near the Greenhouse of Faculty of Agriculture, Pattimura University, Ambon City. The research was conducted in May 2012- August 2014. There were 27 pcs of young rain tree at level seedling and sapling with age between 8-22 months old, tree diameter at 3cm height between 3.4 – 9.8 cm and tree height between 280 – 690 cm in Nursery Area. The plants were irrigated weekly and fertilized with bokashi of 500 g/plant/4 months. Location of nursery is open area (full sun) and soil type is renzina. The type of climate in Ambon Municipality was type A of Schmidt and Fergusson that is a tropical marine climate and climate season, because the location of Ambon Island itself is surrounded by the sea. The rain is 2,962 mm yr^{-1} and 217 days of rain per year; wet months (> 100 mm $month^{-1}$) occurs year around. Therefore, the climate in the study site is strongly influenced by the ocean and coincides with the summer climate, i.e. the West or North season and the East or Southeast season. Total of 27 trees were cut (destructive sampling). The stem of the sampled cut trees was devided into bole, branch, twig, leaf and root. A fresh weight of each morphological tree compartment (bole, branch, twig, leaf and root) were separately weight. After the weighing is done, sample of each morphological tree compartment was taken and dried in an oven at 80^0-85^0 C for 24 hours to obtain the constant dry weight in the laboratory.

Data analysis

From the field and laboratory data for each morphological tree component was calculated. For the selection of biomass equations, the following dependent variables were studied: the total root biomass, total-stem wood biomass inside bark, total branches biomass, total leafs biomass and total trees biomass. From the obtained data, multiple linear regression model was used to develop tree biomass equations. $Y = b_0 + b_1X_1 + b_2X_2 + e_i$. The use of this regression model was followed by analysis of multiple linear regression as follows: check normality assumption by the One-sample Kolmogorov-Smirnov, model fit, collinearity diagnostics, check homogeneity of variance. Statistical analysis of data and regression analysis for developing allometric equations were performed using the SPSS software package (ver.21). It is a comprehensive system for analyzing data. SPSS Statistics can take data from almost any type of file and use them to generate tabulated reports, charts, and plots of distributions and trends, descriptive statistics and complex statistical analyses (IBM 2012). Calculation of BEFs and R/S as below:

$$\text{BEFs} = \frac{W_{aboveground}}{W_{bole}}$$

$$\text{R/S} = \frac{W_{root}}{W_{aboveground}}$$

where BEFs = biomass expansion factors, R/S = root-to-shoot ratio, $W_{aboveground}$ = total dry weight of bole, branch, twig and leaf, W_{bole} = dry weight of bole, and W_{root} = dry weight of root. The average, standard error, confidence interval, coefficient of variation and precision of R/S and BEFs were calculated by formula as below:

Average $\bar{X} = \frac{\sum Xi}{n}$

Variance: $S^2 = \frac{\sum (Xi - \bar{X})^2}{n-1}$ or

$$S^2 = \frac{\sum Xi^2 - \frac{(\sum Xi)^2}{n}}{n-1}$$

Standard deviation: $S = \sqrt{\frac{\sum (Xi - \bar{X})^2}{n-1}}$ or

$$S = \sqrt{\frac{\sum (Xi^2) - \frac{(\sum Xi)^2}{n}}{n-1}}$$

Standard error of the mean: $S\bar{x} = \frac{S}{\sqrt{n}}$

Confidence interval: $CI = \bar{X} \pm t.S\bar{X}$

Coefficient of variation: $CV = \frac{S}{\bar{X}}.100\%$

Table 1. Dry weight of morphological tree compartment, R/S and BEFs calculation

No.	Tree diameter (cm)	Tree height (cm)	Dry Weight (g) with Oven 80°-85° C				W_{above} ground (g)	W_{root} (g)	W_{above} ground & root (g)	R/S	BEFs
			Bole	Branch	Twig	Leaf					
1	3,4	300	344.82	188.56	25.90	72.61	631.89	625.50	1,257.39	0.99	1.83
2	3,5	290	164.81	287.88	20.06	44.34	517.09	460.44	977.53	0.89	3.14
3	3,7	300	456.60	401.51	56.15	83.38	997.64	484.98	1,482.62	0.49	2.18
4	3,9	280	596.22	222.33	37.75	72.31	928.61	896.82	1,825.43	0.97	1.56
5	4,0	330	789.83	28.07	31.84	75.96	925.70	432.60	1,358.30	0.47	1.17
6	4,1	340	476.54	369.63	37.62	55.17	938.96	542.76	1,481.72	0.58	1.97
7	4,3	370	649.89	498.36	66.58	124.32	1,339.15	668.28	2,007.43	0.50	2.06
8	4,5	400	786.96	189.61	42.42	66.52	1,085.51	611.49	1,697.00	0.56	1.38
9	4,6	430	860.55	296.18	106.19	125.53	1,388.45	671.24	2,059.69	0.48	1.61
10	4,7	390	929.44	418.65	72.35	161.07	1,581.51	873.11	2,454.62	0.55	1.70
11	4,8	300	333.83	575.58	25.63	36.19	971.23	1,054.62	2,025.85	1.09	2.91
12	4,9	330	858.90	250.51	33.24	67.08	1,209.73	693.20	1,902.93	0.57	1.41
13	5,0	440	920.59	412.49	68.50	133.18	1,534.76	523.22	2,057.98	0.34	1.67
14	5,1	430	1,114.69	372.42	85.87	114.16	1,687.14	1,103.31	2,790.45	0.65	1.51
15	5,2	430	1,124.22	429.12	115.84	130.67	1,799.85	891.12	2,690.97	0.50	1.60
16	5,3	400	1,513.89	1957.86	136.18	190.21	3,798.14	1,102.27	4,900.41	0.29	2.51
17	5,4	350	1,944.21	347.62	73.29	120.76	2,485.88	1,058.83	3,544.71	0.43	1.28
18	5,5	470	1,630.62	479.61	51.98	127.08	2,289.29	942.61	3,231.90	0.41	1.40
19	5,6	360	1,341.90	494.34	51.58	106.19	1,994.01	1,416.05	3,410.06	0.71	1.49
20	5,8	410	1,171.75	379.27	44.62	97.32	1,692.96	983.54	2,676.50	0.58	1.44
21	5,9	530	2,201.06	1,850.47	344.17	525.16	4,920.86	1,434.64	6,355.50	0.29	2.24
22	6,0	390	1,100.26	744.04	204.54	243.04	2,291.88	980.53	3,272.41	0.43	2.08
23	6,1	320	573.72	971.32	164.32	244.42	1,953.78	1,024.33	2,978.11	0.52	3.41
24	6,3	470	1,211.72	792.31	131.95	200.80	2,336.78	1,144.35	3,481.13	0.49	1.93
25	6,4	340	1,038.86	490.01	197.42	138.53	1,864.82	1,481.69	3,346.51	0.79	1.80
26	9,5	590	6,801.77	5,358.26	788.20	1,346.15	14,294.38	1,968.90	16,263.28	0.14	2.10
27	9,8	690	8,679.16	4,733.47	834.24	1,439.79	15,686.66	1,436.13	17,122.79	0.09	1.81

Correlation among diameter, height and above-ground biomas (AGB)

Check normality assumption, multicollinearity, t-test and allometric equation result

The NPar tests result was presented in Table 2 and multicolleanirity test result was presented in Table 3.

Table 2. The One-Sample Kolmogorov-Smirnov test

		Diameter	Height	Above ground biomass	Unstandardized residual
N		27	27	27	27
Normal parameters[a]	Mean	5.31	394.85	2,709.14	0.00
	Standard deviation	1.51	94.67	3,667.21	1.48734474E3
Most extreme differences	Absolute	0.16	0.13	0.38	0.11
	Positive	0.16	0.13	0.38	0.10
	Negative	-0.10	-0.11	-0.27	-0.11
Kolmogorov-Smirnov Z	0.84	0.70	1.95	0.56	
Asymp. sig. (2-tailed)	0.49	0.73	0.00	0.91	

a. Test distribution is normal.

Based on Table 2, Asym.sig 2 tailed value was 0,91 > 0,05. Its means test distribution was normal

Table 3. Unstandardized and standardized coefficients

Model		Unstandardized coefficients	Standardized coefficients				Collinearity statistics	
		B	Std. error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	-10,306.99	1,301.88		-7.92	0.00		
	Diameter	1,557.53	348.13	0.64	4.47	0.00	0.33	3.01
	Height	12.03	5.56	0.31	2.16	0.04	0.33	3.01

a. Dependent variable: Above-ground biomass

Based on Table 3, VIF value was <10 and tolerance value was > 0.1 and its means there was no multicollinearity. The t-tests for each of the individual slopes are non-significant (*P*> 0.05). In this case, Diameter variable was significant with *P* value was 0.00 (<0.05) and also Height variable was sigificant with *P* value was 0.04 (<0.05). Beside that, the result of allometric equation was Y = -10306,993 + 1557,526X_1 + 12,029X_2 where X_1 = Diameter and X_2 = Height.

The Glejser test for heteroscedasticity, F-test and Adjusted R square calculation result

The result of Glejser test for heteroscedasticity was presented in Table 4.

Table 4. Unstandardized and standardized coefficients

Model		Unstandardized coefficients		Standardized coefficients		
		B	Std. error	Beta	t	Sig.
1	(Constant)	98.34	639.45		0.15	0.88
	Diameter	256.45	170.99	0.48	1.50	0.15
	Height	-0.59	2.73	-0.07	-0.22	0.83

a. Dependent variable: ABS_RES

Based on Table 4 the two independent variables (Diameter and Height) have significant value > 0.05 and it can be concluded that there was no heteroscedasticity at regression model.

The F-test result was presented in Table 5.

Precision: $p = \frac{S\bar{x}}{\bar{x}}.100\%$ where: n = number of sample, t = table of distribution- t

RESULTS

Measurement results of dry weight of morphological tree compartment, R/S and BEFs calculation

Measurement results of dry weight of

Table 5. ANOVA

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	2.921E8	2	1.461E8	60.951	0.00[a]
	Residual	5.752E7	24	2,396,543.90		
	Total	3.497E8	26			

a. Prdictors: (Constant), Height, Diameter
b. Dependent variable: Above-ground biomass

The overall F-test for testing all of the slopes are simultaneously 0 is significant ($P < 0.05$). In this case, based on Table 5 Diameter variable together with Height variable were significant with P value was 0.000 (<0.05). The Adjusted R square calculation results of allometric equation was presented in Table 6

Table 6. Adjusted R square

Model	R	R square	Adjusted R square	Standard error of the estimate
1	0.914[a]	0.836	0.822	1,548.077

a. Predictors: (Constant), Height, Diameter
b. Dependent variable: Above-ground biomass

Based on Table 6 it can be stated that there were highly correlation among biomass and tree diameter and tree height. It can be shown that R Square (adj) was 0.822 and standard error of the estimate (SE) was 1,548.077

Correlation among diameter, height and total biomass (TB)

Check normality assumption, multicollinearity, t-test and allometric equation result

The NPar tests result was presented in Table 7 and multicolleanirity test result was presented in Table 8.

Table 7. The One-Sample Kolmogorov-Smirnov test

		Diameter	Height	Biomass total	Unstandardized residual
Normal parameters[a]	Mean	27	27	27	27
	Standard	5.31	394.85	3,653.82	0.00
	deviation	1.51	94.67	3,935.05	1.47958681E3
Most extreme differences	Absolute	0.16	0.13	0.36	0.11
	Positive	0.16	0.13	0.36	0.08
	Negative	-0.10	-0.11	-0.25	-0.11
Kolmogorov-Smirnov Z	0.84	0.70	1.89	0.54	
Asymp. sig. (2-tailed)	0.49	0.73	0.00	0.93	

a. Test distribution is normal.

Based on Table 7, Asym. sig 2 tailed value was 0,93 > 0,05. Its means test distribution was normal.

Table 8. Unstandardized and standarized coefficients

Model	Unstandardized coefficients		Standardized coefficients			Collinearity statistics	
	B	Std. error	Beta	t	Sig.	Tolerance	VIF
1 (Constant)	-10,310.50	1,295.09		-7.96	.00		
Diameter	1,820.89	346.32	0.70	5.26	.00	0.33	3.01
Height	10.89	5.54	0.26	1.97	.06	0.33	3.01

a. Dependent Variable: Total biomass

Contd.......

Based on Table 8, VIF value was <10 and tolerance value was > 0.1 and its means there was no multicollinearity. The t-tests for each of the individual slopes are non-significant (*P*> 0.05). In this case, Diameter variable was significant with *P* value was 0.00 (<0.05) but Height variable was non sigificant with *P* value was 0.06 (>0.05). Beside that, the result of allometric equation was $Y = -10,310.50 + 1,820.89X_1 + 10.89X_2$ where X_1 = Diameter and X_2 = Height.
The Glejser test for heteroscedasticity, F-test and Adjusted R square calculation result
The result of Glejser test for heteroscedasticity was presented in Table 9.

Table 9. Unstandardized and standardized coefficients

Model		Unstandardized coefficients		Standardized coefficients		
		B	Std. error	Beta	t	Sig.
1	(Constant)	251.71	649.68		0.39	0.70
	Diameter	279.65	173.73	0.52	1.61	0.12
	Height	-1.32	2.78	-0.15	-0.48	0.64

a. Dependent Variable: ABS_RES

Based on Table 9 the two independent variables (Diameter and Height) have significant value > 0.05 and it can be concluded that there was no heteroscedasticity at regression model.
The F-test result was presented in Table 10.

Table 10. ANOVA

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	3.457E8	2	1.728E8	72.88	.000[a]
	Residual	5.692E7	24	2,371,608.55		
	Total	4.026E8	26			

a. Predictors: (Constant), Height, Diameter
b. Dependent variable: Total biomass

The overall F-test for testing all of the slopes are simultaneously 0 is significant (*P* < 0.05). In this case, based on Table 10 Diameter variable together with Height variable were significant with *P* value was 0.000 (<0.05). The Adjusted R square calculation results of allometric equation was presented in Table 11.

Table 11. Adjusted R square

Model	R	R square	Adjusted R square	Stdandard error of the estimate
1	0.927	0.859	0.847	1,540.003

a. Predictors: (Constant), Height, Diameter
b. Dependent variable: Total biomass

Based on Table 11 it can be stated that there were highly correlation among biomass and tree diameter and tree height. It can be shown that R Square (adj) was 0.847 and standard error of the estimate (SE) was 1,540.003.

morphological tree compartment, R/S and BEFs calculation were presented in Table 1.

DISCUSSION

Based on Table 3, correlation among diameter, height and above-ground biomas (AGB) can be shown by the result of allometric equation $Y = -10306,993 + 1557,526X_1 + 12,029X_2$ where X_1 = Diameter and X_2 = Height. R Square (adj) was 0.822 and it can be stated that there were highly correlation among AGB and tree diameter and tree height with SE was 1,548.077 (Table 6). Beside that, based on Table 8 correlation among diameter, height and total biomass (TB) can be shown by the result of allometric equation was $Y = -10,310.50 + 1,820.89X_1 + 10.89X_2$ where X_1 = Diameter and X_2 = Height. R Square (adj) was 0.847 and it can be stated that that there were highly correlation among TB and tree diameter and tree height with SE was 1,540.003 (Table 11).

In general, there was no big differences analysis of multiple linear regression (check normality assumption by the One-sample Kolmogorov-Smirnov, model fit, collinearity diagnostics, check homogeneity of variance) between correlation among diameter, height and above-ground biomas (AGB) and correlation among diameter, height and total biomass (TB). Both of them were normal distribution, there were no multicollinearity and also no heteroscedasticity at regression model, based on F-test result stated that diameter variable together with height variable were significant with *P* value was 0.000 (<0.05). This indicate that the two allometric equations can be used to estimate AGB and TB through diameter and height measurement for young rain tree. A small difference occurs only in value of R square (adj) and SE between two of the allometric equation. According to Widhanarto (2009), the models were chosen among those used highest R square (adj), lowest standard error (SE) and the simplicity of models. If we consider the matter, we can choose allometric equation as the most suitable to predict TB than AGB. We apply R square (adj) and not apply R square in this analysis of regression equation. Acording to Andale (2015), both R square and the adjusted R square give us an idea of how many data points fall within the line of the regression equation. However, there is one main difference between R square and the adjusted R square: R square assumes that every single

Table 12. Summary of R/S and BEFs of young rain tree

No.	Elucidation	R/S	BEFs
1.	Total	14.80	51.19
2.	Average	0.548	1.896
3.	Standard error of the mean	0.046	0.107
4.	Confidence interval	0.548 ± 0.095	1.896 ± 0.221
5.	Coefficient of variation (%)	43.883	29.481
6.	Precision (%)	8.44	5.67

variable explains the variation in the dependent variable. The adjusted R square tells us the percentage of variation explained by only the independent variables that actually affect the dependent variable. From the standpoint of statistical methods, the standard error of the estimate is a measure of the dispersion (or variability) in the predicted scores in a regression. In a scatterplot in which the SE is small, one would therefore expect to see that most of the observed values cluster fairly closely to the regression line. When the SE is large, one would expect to see many of the observed values far away from the regression line (McHugh, 2008). On the Normal P-P Plot Regression Standardized Residual with dependent variable TB was clear that most of the observed values cluster fairly closely to the regression line compared with dependent variable AGB (Figure 1).

Roots and shoots are functionally inter-dependent and these two systems maintain a dynamic balance in biomass which reflects relative abundance of above-ground resources (light and

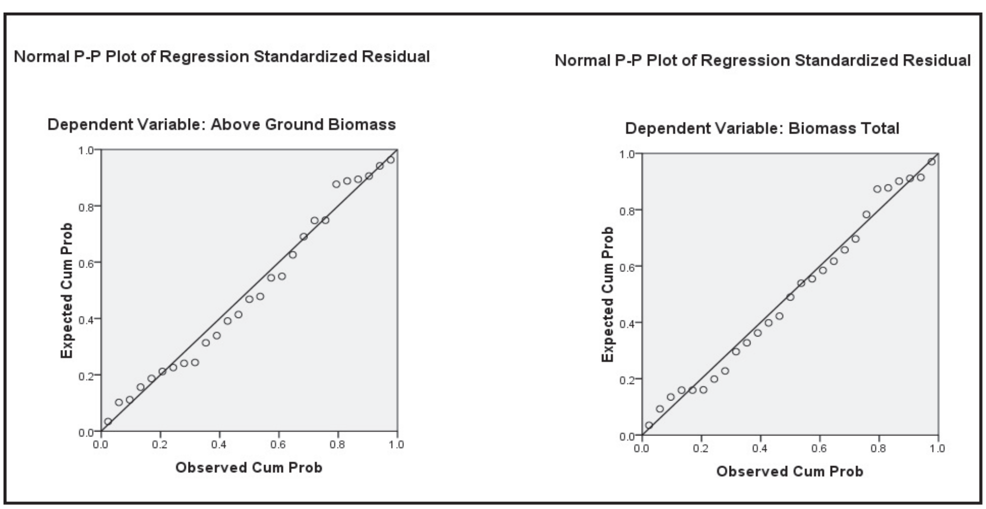

Fig 1. The Normal P-P Plot Regression Standardized Residual with dependent variable AGB and TB

Summary of R/S and BEFs calculation was presented in Table 12

CO_2) compared with root-zone resources (water and nutrients). Whole-plant growth rate and root: shoot ratio are thus an outcome of genotype × environment interaction, but source of control is ambiguous) (Atwell *et al*., 1999). Based on Table 1 and Table 12, R/S for rain tree varied from 0.09 to 1.09 with a mean of 0.548. The average R/S for rain tree found this study was larger that observed by some authors such as 0.17 for Pinus in Brazil (Sanquetta *et al*., 2011), 0.36 for Pinus in Great Britain (Levy *et al*., 2004), 0.24 for Lebombo Ironwood or *Androstachys johnsonii* in Mozambique (Magalhaes and Seifert, 2015), 0.52 for Norway spruce seedlings in northeast Italy (Pastorella and Paletto, 2014), varied from 0.157 to 0.190 for *Acacia mangium* in West Java, Indonesia (Miyakuni *et al*., 2004), varied from 0.09 to 0.67 with a mean 0.27 for the coniferous and broadleaf mixed forest in northeast China (Wang *et al*., 2008). This indicates that R/S will vary depending on the type and its habitat of vegetation growth and the influence of the environment such as water (quantity, quality and timing), nutrient, site index, sunlight, temperature and humidity, pest and diseases, tree density, etc. The R/S result of our study was larger and it was allegedly due to good maintenance such as watering, fertilizing and weeding regularly and there was no competition between tree roots and canopy from each others rain tree. According to Reid (2013), the standard error of the mean is the measure of how close your data points are to the true mean, and represent your precison. In this regards, based on Table 12 standard error of the mean was small (0.046) for R/S calculation and its mean that our data points closed to the true mean. In other word there was high precision of R/S measurement (8.44%). Therefore we can use R/S to measure root biomass or shoot biomass. Moreover, the biomass of root systems is difficult and expensive to measure accurately in forest trees. Root weight of individual trees can be estimated from stem diameter or from the root/ shoot ratio (Beets *et al*., 2007). Based on these considerations we can estimate the root biomass of young rain tree indirectly by using the total biomass through allometric equation based on diameter and height (Y = -10,310.50+1,820.89X1+10.89X2) and R /S (0.548) of young rain tree.

Based on Table 1 and Table 12, BEFs for rain tree varied from 1.17 to 3.41 with a mean of 1.896. The average BEFs for rain tree found this study was larger that observed by some authors such as 1.47 for Pinus in Brazil (Sanquetta *et al*., 2011), varied from 0.690 to 0.710 for Scot pine, varied from 0.777 to 0.862 for Norway spruce, varied from 0.544 to 0.556 for broad leaved in boreal forest of Finland (Lehtonen, 2004), varied from 0.02 to 1.31 for Lebombo Ironwood or *Androstachys johnsonii* in Mozambique (Magalhaes and Seifert, 2015) and varied from 1.180 to 1.332 for *Acacia mangium* in West Java, Indonesia (Miyakuni *et al*., 2004). Similar with R/S young rain tree, this indicates that BEFs will vary depending on the type and its habitat of vegetation growth and the influence of the environment such as water (quantity, quality and timing), nutrient, site index, sunlight, temperature and humidity, pest and diseases, tree density, etc. The BEFs result of our study was larger and it was allegedly due to good maintenance such as watering, fertilizing and weeding regularly and there was no competition between tree roots and canopy from each others rain tree. Based on Table 12 standard error of the mean was small (0.107) for BEFs calculation and its mean that our data points closed to the true mean. In other word there was high precision of BEFs measurement (5.67%). Therefore we can use BEFs to measure AGB or bole biomass content for young rain tree.

CONCLUSION

There were highly correlation among TB and tree diameter and tree height. We can use allometric equation: $Y = -10{,}310.50 + 1{,}820.89X_1 + 10.89X_2$ where X_1 = Diameter and X_2 = Height, R Square (adj) was 0.847 to estimate TB based on diameter and height of young rain tree. R/Svaried from 0.09 to 1.09 with a mean of 0.548, SE was small (0.046) and has high precision (8.44%). Due to the biomass of root systems is difficult and expensive to measure accurately in forest trees, we can estimate the root biomass of young rain tree indirectly by using the allometric equation and R / S (0.548) of young rain tree. Beside that, BEFs also varied from 1.17 to 3.41 with a mean of 1.896, SE was small (0.107) and has high precision (5.67%). Therefore we can use this BEFs to measure AGB or bole biomass content for young rain tree.

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REFERENCES

Allen, O.N. and Allen, E.K. 1981. The Leguminosae. *A Source Book of Characteristics, Uses and Nodulation*. London, UK: MacMillan Publishers Ltd.

Andale, 2015. Adjusted R^2 / Adjusted R-Squared: What is it used for? Statistics How To. Statistics for the rest of us! http://www.statisticshowto.com/adjusted-r2/ (Accessed 17 May 2016)

Atwell, B.J., Kriedemann, P.E. and Turnbull, C.G.N. 1999. *Biomass Distribution. Plants in Action: Adaptation in Nature, Performance in Cultivation*. Macmillan Education Australia Pty Ltd, Melbourne, Australia

Beets, P.N., Pearce, S.H., Oliver, G.R. and Clinton, P.W. 2007. Root/shoot ratios for deriving below-ground biomass of *Pinus radiata* stands. *New Zealand Journal of Forestry Science.* 37 (2): 267-288.

CABI. 2015. *Samanea saman* (rain tree). Invasive Species Compendium. http://www.cabi.org/isc/datasheet/4026, (Accessed 16 May 2016)

Delgado, D.C., Hera, R., Cairo, J. and Orta, Y. 2014. *Samanea saman*, a multi-purpose tree with potentialities as alternative feed for animals of productive interest. *Cuban Journal of Agricultural Science.* 48 (3): 205-212

IBM. 2012. IBM SPSS Statistics 21 Brief Guide. http://www.sussex.ac.uk/its/pdfs/SPSS_Brief_Guide_21.pdf (Accessed 9 August 2013)

IPCC. 2006. Guidelines for national greenhouse gas inventories. Intergovernmental Panel on Climate Change. http://www.ipcc.ch (Accessed 7 January 2013).

Jensen, M. 2001. *Trees Commonly Cultivated in Southeast Asia: An Illustrated Field Guide*. FAO Regional Office for Asia and the Pacific. Second edition. Craftsman Press Co., Ltd., Bangkok.

Lehtonen, A., Makipaa, R., Heikkinen, J., Sievanen, R. and Liski, J. 2004. Biomass expansion factors (BEFs) for Scot pine, Norway spruce and birch according to stand age for boreal forests. *Forest Ecology and Management.* 188 : 211-224.

Levy, P.E., Hale, S.E., and Nicoll, B.C.2004. Biomass expansion factors and root : shoot ratios for coniferous tree species in Great Britain. *Forestry*. 77 (5) : 421-430.

Magalhaes, T.M. and Seifert, T. 2015. Tree component brief and root-to-shoot ratio of Lebombo iron-wood: measurement uncertainty. *Carbon Balance and Management.* 10 (9) : 1-14.

McHugh, M.L. 2008. Standard error: meaning and interpretation. Lessons in biostatistics. *Biochemia Medica.* 18 (1) : 7-13.

Merrill, E.D. 1912. Notes on the flora of Manila with special reference to the introduced element. *Philippine Journal of Sciences*, *Botany.* 7 : 145-208.

Miyakuni, K., Heriansyah, I., Heriyanto, N.M. and Kiyono, Y. 2004. Allometric biomass equation, biomass expansion factors and root-to-shoot ratios of planted *Acacia mangium* Willd forest in West Java, Indonesia. *Japan Forest Planning.* 10 : 69-76.

Mokany, K., Raison, R.J., Prokushkin, A.S. 2006. Critical analysis of root: shoot ratios in terrestrial biomes. *Global Change Biology*. 12 : 84-96.

Ng, F.S.P. 2015. The rain tree-*Samanea saman*-and its yellow form. *Utar Agriculture Science Journal.* 1 (3) : 43-49.

Paguyuban Budiasi, 2014. BNI makes Kualanamu Shady by 5,000 tree seedlings. *http://www. paguyuban-budiasi.com/2014/04/1971.html*, (Accessed 26 July 2014).

Panin, 2013. Reforest Indonesia Program. *http://www.panin.co.id/pages/309/csr-program,* (Accessed 7 June 2014).

Pastorella, F. and Paletto, A. 2014. Biomass allocation in natural regeneration of *Fagus sylvatica* and *Picea abies* trees in Italian Alps. *Forestry Studies.* 61: 35-46.

Raintree, J.B. 1987. The multipurpose Raintree, *Samanea saman*. NFT Highlights, No. 87-06. Waimanalo, USA; Nitrogen Fixing Tree Association.

Reid, A. 2013. How to calculate precision. eHow Contributor. *http://www.ehow.com/ how_6186008_calculate-precision.html* (Accessed 26 May, 2016)

Sanquetta, C.R., Corte, A.P.D. and da Silva, F. 2011. Biomass expansion factor and root-to-shoot ratio for Pinus in Brazil. *Carbon Balance and Management.* 6 (6): 1-8.

Standley, P.C. and Steyermark, J.A. 1946. Flora of Guatemala. *Fieldiana (Botany).* 24 (5).

Soares, P. and Tome, M. 2012. Biomass expansion factores for *Eucalyptus globulus* stands in Portugal. *Forest System.* 21 (1) : 141-152

Tan, H.T.W. and Yeo,C.K. 2009. The potential of native woody plants for enchanching the urban waterways and water bodies environment in Singapore. Raffles Museum of Biodiversity Research and Singapor-Delf Water Alliance, National University of Singapore. Singapore.

Wang, X., Fang, J. and Zhu, B. 2008. Forest biomass and root-shoot allocation in northeast China. *Forest Ecology and Management*. 255 (12) : 4007-4020.

Widhanarto, G.O. 2009. Biomass equation for 1-7 years-old *Acacia mangium* Willd in West Kalimantan, Indonesia (Case Study in Plantation Forest PT. Finnantara Intiga). Pp 203-210. *Proceeding International Seminar Reseach on Plantation Forest Management: Challenges & Opportunities.* 5-6 Nov. 2009. Bogor.

Xie, S. and Zhao, D. 2014. Carbon storage dynamics of forest vegetation in Karst Mountain. A case study in Youyang Tujia and Miao Autonomous County. *Agricultural Science and Technology.* 15 (10): 1733-1737

Yuen, B. and Kong, L. 2009. Climate change and urban planning in Southeast Asia. SAPIENS. *Cities and Climate Change.* 2 (3): 14-22