Eco. Env. & Cons. 26 (November Suppl. Issue) : 2020; pp. (S415-S422)
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ISSN 0971–765X

The rate of absorption of carbon dioxide and moisture content in Linggua (*Pterocarpus Indicus* Willd.) for climate change management

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(Received 4 August, 2020; accepted 25 September, 2020)

ABSTRACT

The Linggua (*P. indicus*) is a multipurpose tree with a considerable distribution; nevertheless, the IUCN has classified it as an endangered species. The tree species has great potential to be included in the REDD + mitigation program in handling climate change. REDD + has made it possible to implement carbon trading. Thus, countries that can manage forest properly, and implement reforestation, are able to partake in carbon trading with the rest of the world. Therefore, research was conducted to determine the level of absorption of carbon dioxide (CO_2) and water content (H_2O), as this is a preliminary step in determining the allometric equation for the Linggua tree type. The sampling of tree species through damage (destructive sampling) was carried out by cutting down 3 young trees. The methods used include field observation and laboratory analysis for the determination of water content and biomass in the treatment, which involved the use of a spectrophotometer. The results of the water content *P. indicus* starting from the roots, base of stem, middle, tip and successive leaves: 79.99%; 72.40%; 82.44%; 80.34% and 83.45%. The Total biomass content on 3 tree samples is: the chest diameter of 15 cm, 15.5 cm and 16 cm respectively, 34.9589, 43.7536 and 52.4008 tons. If only the biomass on the ground alone is 34.9552, 43.7484 and 52.3998 tons. Total Carbon stock on trees with diameter at breast height of 15 cm, 15.5 cm and 16 cm are 12.7040; 19.3348 and 24.5020 tons respectively and CO_2 Carbon sinks: 46.6239589, 43.7536 and 52.4008 tons respectively.

Key words : *Carbon absorption, Carbondioxide, Water content, REDD +, Climate change.*

Introduction

It is widely known that forests are beneficial to humans. The direct benefits include the presence of wood, bamboo, rattan, enau, honey, medicines, essential oils etc, while the indirect include erosion prevention, consciousness or natural beauty for tourism attractions, absorption of carbon elements (CO_2), arrangement of water circulation (H_2O), hydrological functions, flood prevention and other environmental services. In general, forests play an important role in carbon renewal globally including in the storage of plant biomass, dead plants and in the soil. Tropical rainforests form a steady ecosystem by adding CO_2 to the atmosphere (through respiration and decomposition). However, when forests are cut or burned, the carbon stored in biomass and on the ground which eventually migrate from the biosphere into the atmosphere.

According to Sutaryo (2009), in forest carbon inventory activities, the carbon pools are four in number, namely: surface biomass, subsurface biomass, dead organic matter and soil organic carbon. Forage degradation and deforestation has led to the emission of CO_2 gases that trigger climate change throughout the world due to global harvests. The solution that is achieved through mitigation is the implementation of the REDD + program (reducing emissions from deforestation and forest degradation). REDD + has made carbon trading possible, hence, any country that manages it properly, by protecting it or conducting reforestation has the opportunity to become a global carbon seller.

In drafting GhG emission reduction strategies, deforestation, degradation and increase in carbon stocks are important data and information for ascertaining both spatial and biomass changes. In this case, the National Carbon Calculation system is comprehensive, credible and verifiable. The first step in the implementation of this system is to conduct an inventory and study of the allometric models of biomass and tree numbers according to specific conditions especially in Indonesia, which constitute the main framework of monographs (FORDA, 2012). In the monograph, biomass allometric and the number of tress are unavailable for *P. indicus*. The aim of this research is to determine the level of absorption of CO_2 and H_2O and the density value of the *P. indicus* tree. The results of this research will complement the available information on carbon stocks in the most privileged forest biomass regions as well as the development of allometric equations in handling the climate change.

The linggua tree (*P. indicus*) grows very fast and adapts to the tropical rainforest environment. It is distributed from southern Burma, Southeast Asia (Indonesia, West Pacific, Southern China) to Salomon and Ryukyu Islands. Its species are characteristic of high-quality timber trees, which, in wood trading, is classified as Narra or rosewood. The plant is internationally known as the Red Sandalwood Amboyna. Furthermore, the tree has excellent potential to form soil organic matter and provide surface mulch due to its nitrogen-binding capacity and annual autumn leaves. *P. Indicus* is a nitrogen-binding species that has the ability to change the input of nutrients and thus suppress native vegetation. Generally, the size of the canopy is rather dense, which enhances the habitat by replacing or surpassing natural canopies. Additionally, its large size and heavy shade inhibit the formation of native underplant species (Thomson, 2006; Orwa *et al.*, 2009; T and T Biodiversity; 2017; PIER, 2017). Its biological population has decreased and the main causes are illegal or excessive timber exploitation and increased habitat loss for more agricultural land expansion. Its subpopulations in Vietnam are considered extinct based on the results of an extensive forest survey in the Philippines and Indonesia, as its species are highly threatened. Some of the exaggerated reexploitation in the Malaysian peninsular may have caused extinction in the region and what is presently believed to be the largest remaining subpopulation in Papua being exploited massively (Barstow, 2018).

P. indicus has many benefits, due to its several compounds: Loliolide and Paniculata in the leaves, Lupeol and Phytol ester in its flowers, and Formononetin, IsoLiquiritigenin on its stem, timber for building construction and furniture manufacturing. The tree is used for natural dyes and its skin and fiber are mainly used for handicraft products. Many studies have been conducted on the use of *P. indicus* for alternative renewable energy such as waste utilization of leaves, through which *P. indicus* becomes a biomass briquette for new and renewable energy. Most of these trees are grown in major cities in Indonesia including the city of Surabaya. In general, the fast leaf growth during the fall contributes to the beauty of the city, and therefore, it is necessary to make it an alternative source of energy (Anggono *et al*., 2017; Suprianto *et al.,* 2020). Additionally, Martin, *et al*. (2010) compiled allometric equations based on a fractal branching model for estimating the above-ground biomass of 4 native tree species (including *P. indicus*) in the Philippines. The allometric equation for *P. indicus* was $Y = 0.063 D^{2.54}$ where Y = above-ground biomass and D = diameter. Given that the allometric equation of a tree type is locally specific (Krisnawati *et al*., 2012) it is necessary to ascertain the feasibility of this equation in the area of Tobelo (eastern Indonesia) where this research was conducted. *P.indicus* is currently an endangered species, and since 1998, the IUCN World Conservation Agency (International Union for Conservation of Nature) has incorporated *P. indicus* into VU or vulnerable status (RimbaKita, 2019). Whenever the IUCN issues a red list for a species of flora or fauna close to extinction, the institution cooperates with the government where the specie habitat is located. Its main goal is to find a solution to prevent the extinction of such species. Thus, to carry out the rehabilitation of forest land or restoration with the plant *P. indicus*, the information of the level of absorption of CO_2 and H_2O is indispensable for the implementation of the REDD + program oriented towards carbon trading.

Methodology

In the early stages of field observation for sample determination of young Linggua (*P. indicus*) tree which was followed by laboratory analysis, 3 sample trees with a diameter at breast height: 15 cm, 15.5 cm and 16 cm with consecutive branch-free rods: 3 m, 3.5 m and 3.5 m were taken respectively. The sampling was carried out with these three trees obtained from Tobelo City, which were cut down. The moisture content and biomass was determined by taking the root components, stems, twigs and leaves as samples, and measuring the wet weight. Hereafter, it was inserted into the oven dry kiln at a temperature of 100 ± 3 ° C until it reached a constant weight before obtaining the dry weight.

Formula of calculating biomass is as follows:

1. Stem:

$$\text{Wood density} = \frac{\text{Dry disc weight}}{\text{Disc Volume}}$$

Stem biomass (stem weight/Ws) = Wood density × Stem volume

2. Branches biomass (branch weight/WB):

$$\frac{\text{Dry weight of branch sample}}{\text{Wet weight of branch samples}} \times \text{Total of wet branch weight}$$

3. Leaf biomass (leaf weight/Wl):

$$\frac{\text{Dry weight of leaves sample}}{\text{Wet weight of leaves sample}} \times \text{Total of wet leaves weight}$$

4. Root biomass (root weight/Wt):

$$\frac{\text{Dry weight of root sample}}{\text{Wet weight of root samples}} \times \text{Total of wet roots weight}$$

5. Total Tree Biomass

Total of tree biomass includes stems, branches, leaves and roots biomass

Total biomass (total weight) = Wv + Wb + Wl + Wt

Determination of carbon content with Spectrophotometer

Carbon content is measured using the Walkly and Black methods in the spectrophotometer with the following stages of carbon analysis activities:

1. Moisture content measurements: Weight of dry disc; Placement of plant organ sample powder of 1 g (BBSS) into the disc; weight of disc and wet weight of powdered sample (BC + Bbss); Importation of disc and plant organ powder (BC + Bbss) into the oven with temperature $103^0 \pm 2^0$ C; Weighing and recording every weight decrease until it is constant. Weighing and recording of the disc and powder sample (BC + Bkss) was carried out. Calculation of water weight was performed using the formula:

   BA (g) = (BC + Bbss) – (BC + Bkss)

2. Carbon analysis was done with the following stages of the experiment: the balance of air dried organ powder samples is about 0.025 g (qualified 40 mesh). Weighing was performed in a clean and dry from watch glass; Powder samples were placed in 50 ml volumetric flask, with an addition of 2.5 ml $K_2Cr_2O_7$ 1 N with pipette and then shaken; Consecutively, an addition of conc. 5 ml of H_2SO_4, was done, and the solution whisked in a flat and rotating motion (extraction process); the solution was cooled 30 minutes; Sample solution was added to ion-free water up to 50 ml (addition of ion-free water using water transmitter bottles in order to fit the size); The sample solution was left for 1 day after which a clear measurement of the absorption of the solution was carried out with a spectrophotometer at a wavelength of 561 nm. Comparisons were made with standard 0 and 250 ppm C. For the standard containing 250 ppm C, take 2.5 ml standard solution 5000 ppm C by using pipette into the volumetric flask 50 mL, added 2.5 ml solution of $K_2Cr_2O_7$ and 5 ml H_2SO_4 with workmanship as in the treatment of samples. Blanko was also used as a standard at 0 ppm C.

3. Carbon Stock Calculation

The Total results of chemical analysis above and below-ground i.e. stem, leaf, branch, and root are carried out using the Spectrophotometer method using formula:

C content % = ppm curve x ml extract/1000 ml x 100/mg sample x fk

Where: ppm curve = the sample content obtained from the relationship curve between the standard noise level and the reading after corrected blanko. 100 = Convert to %, fk = moisture content correction factor = 100/(100-% moisture)

Moisture content (%) = (((BC + BBSS) - (BC + BKSS))/((BC + BBSS)) x 100

Where:

BC = weight of disc

BBSS = wet weight of sample powder
BKSS = dry weight of sample powder

The amounts of carbon content above and below ground is measured by multiplying the biomass of each plant organ with the percentage of total carbon content of the chemical analysis calculation with the following formula:

Ct = Wt x % carbon content (% C)

Where:

Ct = weight of carbon content (g, kg)
Wt = weight of biomass (g, kg)
% (C) = total carbon content (C total%)

Results and Discussion

Moisture content test result of *P. indicus* tree

The results on the level of absorption of moisture content (H_2O) on different plant components are as follows: The leaves had the highest moisture content of 83.45% and the lowest was the stem base of 72.40%. The center of the stem has a high moisture content of 82.44% compared to the stem base of 72.40% and the stem tip 80.34%. The moisture absorption of *P. indicus* is presented in Table 1 and Fig. 1.

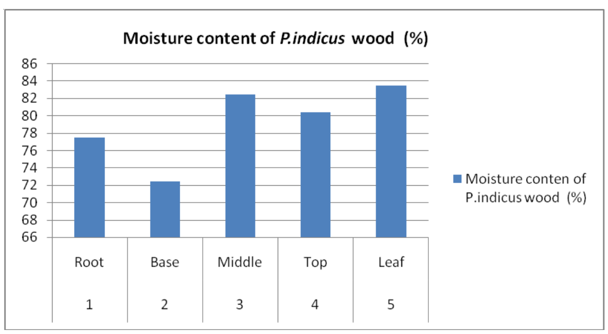

Fig. 1. Moisture content of *P. indicus*

According to Iswanto (2008) the average moisture content of *P. indicus* in the stem base, middle and tip was 95.81%, 102.14% and 91.06% respectively. The highest moisture content was found at the tips of roots, stems and branches, respectively 0.51, 0.43 and 0.35 as presented on Table 2.

Table 2. Average Specific gravity of *P. indicus*

Tree species	Section	Specific gravity (g/cm^3)
Linggua	Stem	0.43
	Branch	0.35
	Root	0.51

The specific gravity of *P. indicus* of the base, middle and tip is 0.39, 0.36 and 0.33 respectively.

Therefore the calculation of the moisture content and specific gravity, when compared with the results of Iswanto (2008), the moisture content is below moderate levels, and its weight is greater. The specific gravity from the stem part of *P. Indicus* is also found to be smaller than some of the other research results which are: 0.54 and 0.66 (The Wood-Database, 2008), 0.58 (ITTO, 2020) or 0.52 – 0.97 (Prosea, 2020). This suggests that the determination of the specific gravity of stem for similar trees vary, depending on the age, habitats and climate, growth speed, and also the position of timber in stem etc.

Carbon test result with spectophotometer

The first stage in ascertaining the carbon content is to calculate its concentration. Therefore, a solution containing different concentrations of carbon, glucose and absorbance was made. Their chemical link-

Table 3. Carbon concentration and absorbance in various Glucose concentrations.

Glucose concentration	Carbon concentration (ppm)	Absorbance
25	10	0.067
50	20	0.112
100	40	0.135
150	60	0.183
200	80	0.227
250	100	0.256
300	120	0.296

Table 1. Absorption of moisture in *P. indicus*

No	Sample	Wed weight(g)	Dry weight from oven (g)	Moisture content (%)
1	Root	59.503	30.811	79.99
2	Stem base	62.362	20.288	72.40
3	Stem middle	44.261	17.209	82.44
4	Stem tip	45.889	20.768	80.34
5	Leaf	26.000	4.300	83.45

age was then determined through a regression equation. The results of carbon concentration and Absorbance on various Glucosa concentration presented in Table 3.

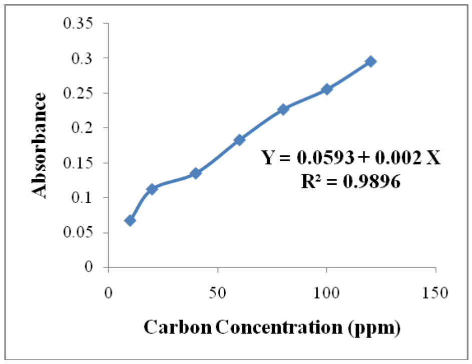

Fig. 2. The relationship between Carbon concentration and Absorbance on various Glucosa concentration.

The regression equation obtained from Table 3 and Figure 2 is: Y = 0.0593 + 0.002 X where Y absorbance and X carbon concentration with the coeffi-

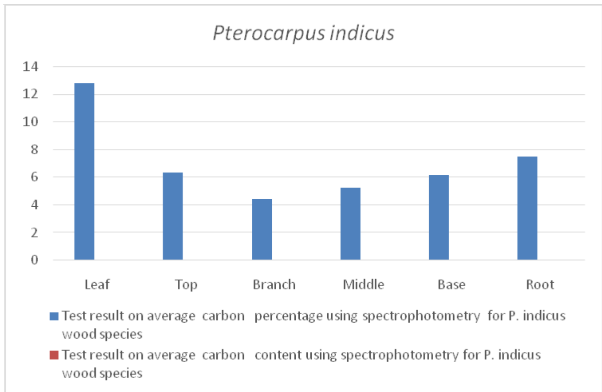

Fig. 3. Average test result spectrophotometry of the carbon content in *P. indicus*

Table 4. Carbon concentration and carbon stock of *P. indicus* based on laboratory sample tests with Spectrophotometry

Sample of Lingua	Code	Absorbance	Carbon concentration (ppm)	Sample weight (mg)	Carbon content (%)	Carbon Stock (g)
Leaf 1	DL1	0.193	66.85	25.6	13.06	0.0033
Leaf 2	DL2	0.182	61.35	25.4	12.08	0.0031
Leaf 3	DL3	0.192	66.35	25.2	13.16	0.0033
Branch 1	CL1	0.087	13.85	25.7	2.69	0.0007
Branch 2	CL2	0.116	28.35	25.5	5.56	0.0014
Branch 3	CL3	0.111	25.85	25.3	5.11	0.0012
Middle stem 1	TL1	0.128	34.35	25.5	6.73	0.0017
Middle stem 2	TL2	0.106	23.35	25.6	4.56	0.0012
Middle stem 3	TL3	0.104	22.35	25.1	4.45	0.0011
Tip stem 1	UL1	0.073	6.85	25.2	1.36	0.0003
Tip stem 2	UL2	0.108	24.35	25.3	4.81	0.0012
Tip stem 3	UL3	0.19	65.35	25.6	12.76	0.0032
Base stem 1	PL1	0.124	32.35	25.3	6.39	0.0016
Base stem 2	PL2	0.138	39.35	25.1	7.84	0.0020
Base stem 3	PL3	0.103	21.85	25.4	4.30	0.0011
Root 1	SAL1	0.121	30.85	25.3	6.10	0.0015
Root 2	SAL2	0.155	47.85	25.6	9.34	0.0024
Root 3	SAL3	0.129	34.85	25	6.97	0.0017
Total					**42.43**	**0.0323**

Table 5. Total carbon content through laboratory testing using Spectophotometry

	Carbon content (%)						
Tree	Leaf	Branch	Middle	Tip	Base	Root	**Total**
1	13.06	2.70	6.73	1.36	6.39	6.10	36.34
2	12.08	5.56	4.56	4.81	7.84	9.35	44.19
3	13.16	5.11	4.45	12.76	4.30	6.97	46.76
Total	38.30	13.36	15.75	18.93	18.53	22.41	127.29
Average	12.77	4.45	5.25	6.31	6.18	7.47	42.43

cient of determination $R^2 = 0.9896$. This indicates that there is a very close relationship between the absorbance and carbon concentration. This confirms that the higher the carbon concentration will cause a correspondingly higher absorbance. Therefore, this regression equation can be used in the calculation of carbon concentration sample fraction of *P. indicus* tree.

Each fraction sample of the *P. indicus* tree in the laboratory is calculated on its absorbance and with the use of such regression equations, the concentration of carbon was acquired as presented on Table 4.

The total amounts of carbon content of all fractions and the average carbon content of *P. Indicus*

Table 6. Average Carbon content at *P. indicus*

Sample	Absorbance	Weight(g)	Carbon concentration (ppm)	Carbon content (%)	Heavy carbon stock (g)
Leaf	0.1890	0.0254	64.85	12.77	0.0040
Branch	0.1046	0.0255	22.68	4.45	0.0011
Tip stem	0.1236	0.0253	32.18	6.31	0.0016
Middle stem batang	0.1127	0.0254	26.68	5.25	0.0013
Base stem	0.1217	0.0253	31.18	6.18	0.0016
Root	0.1350	0.0253	37.85	7.470	0.0019

Table 7. Biomass, carbon content and absorption of CO_2 per section of *P. Indicus* tree using the Spectrophotometry method

No	Section	Specific gravity	Weight (g)	Biomass content (g)	Carbon stock g	Carbon stock ton	Carbon sinks (CO_2) g	Carbon sinks (CO_2) ton
Tree of *P. indicus* 1, dbh: 15.0 cm								
1	Stem	0.44	79,403,000	34,937,320	12,696,222	12.6962	46,595,135	46.5951
2	Branch	0.35	50,000	17,500	6,359	0.0064	23,339	0.0233
3	Leaf	0.16	2,500	400	145	0.0001	533	0.0005
4	Root	0.52	7,000	3,640	1,323	0.0013	4,854	0.0048
Total 1 (g)					34,958,860	12,704,049		46,623,861
Total 1 (ton)				34.9589		12.7040		46.6237
Total without root 1 (ton)				34.9552		12.7027		46.6189
Tree of *P. indicus* 2, dbh: 15.5 cm								
1	Stem	0.43	101,736,000	43,746,480	19,331,569	19.3316	70,946,860	70.9469
2	Branch	0.34	4,500	1,530	676	0.0007	2,481	0.0025
3	Leaf	0.16	2,400	384	175	0.0002	642	0.0006
4	Root	0.52	10,000	5,200	2,298	0.0023	8,433	0.0084
Total 2 (g)					43,753,594	19,334,718		70,958,416
Total 2 (ton)				43.7536		19.3348		70.9584
Total without root 2 (ton)				43.7484		19.3302		70.9500
Tree of *P. indicus* 3, dbh: 16.0 cm								
1	Stem	0.43	121,856,000	52,398,080	24,501,342	24.5013	89,919,926	89.9199
2	Branch	0.35	4,000	1,400	655	0,0006	2,402	0.0024
3	Leaf	0.16	2,000	320	154	0,0001	566	0.0006
4	Root	0.52	1,900	988	462	0,0005	1,695	0.0017
Total 3 (g)					52,400,788	24,502,613		89,924,589
Total 3 (ton)				52.4008		24.5025		89.9246
Total without root 3 (ton)				52.3998		24,5020		89.9229

per tree are presented in Table 5, Table 6 and Figure 3.

The results of biomass calculation, carbon content and CO_2 absorption are shown in Table 7.

Martin *et al.* (2010) compiled allometric equations based on a fractal branching model for estimating above-ground biomass of 4 native tree species (including *P. indicus*) in the Philippines. Allometric equation for *P. indicus* was $Y = 0.063\ D^{2.54}$ where Y = above-ground biomass and D = diameter at breast height. Given that the allometric equation is inserted in the diameter at breast height of the 3 trees in Table 5, the consecutive biomass above ground will be 61.180 tons, 66.494 tons and 72.078 tons. This result is significantly greater than that of this research which was only 34.9552, 43.7484 and 52.3998 tons. This indicates that the allometric equation is specific for P. *indicus* originating from the Philippines, and cannot be applied to the same type that grows in eastern Indonesia. The difference is due to various habitat conditions ranging from sand densities, multifarious agro-climatic conditions including rainfall, humidity, illumination intensity and soil fertility which contribute to the growth of *P. indicus* tree. Its specific gravity differs between the stems, branches and roots.

Conclusion

The moisture content of *P. indicus* starting from the root, middle and tip of the stem and successive leaves are 79.99%; 72.40%; 82.44%; 80.34% and 83.45% respectively. The contents of above and below-ground biomass in the 3 tree samples are: the diameter at breast height of 15 cm, 15.5 cm and 16 cm in a row: 34.9589, 43.7536 and 52.4008 tons. The above-ground biomass is 34.9552, 43.7484 and 52.3998 tons. The value of this biomass is relatively smaller if it is used as the basis of the diameter at breast height *P. indicus* for measuring carbon stock based on above and below-ground the allometric equation in the results of study conducted in Philippines, carbon stock on above and below-ground on trees with a diameter of breast height of 15 cm, 15.5 cm and 16 cm in a row: 12.7040, 19.3348 and 24.5020 tons of CO_2 and Carbon sinks: 46.6239, 43.7536 and 52.4008 tons.

Acknowledgement

The authors are grateful to the Director General of Higher Education, the Ministry of Education and Culture Republic of Indonesia, for financially supporting this research through the PEKERTI Research scheme in 2019.

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