International Journal on Advanced Science Engineering Information Technology

Vol.13 (2023) No. 4
ISSN: 2088-5334

The Effects Morpho-Anatomical Characters Leaves *Tectona grandis* and *Gmelina arborea* as Carbon Dioxide Absorption in Unhas Urban Forest

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Abstract*—Urban forests play an important role in reducing the impact of pollutants in the air, such as carbon dioxide (CO_2). Plants can absorb several kinds of pollutants, so they can play a role in cleaning the air from air pollution. Air pollution can also affect the morphology and anatomy of the leaves, such as chlorosis and necrosis. Thus, this study was conducted to characterize the morphology, stomata anatomy, and physiology of the *Tectona grandis* and *Gmelina arborea* tree species in their potential as CO_2 pollutant absorbers in the Urban Forest of Hasanuddin University Tamalanrea Makassar. The method used was an analysis of leaves morphology characterization, longitudinal leaves stomata characterization using nail polish containing acetone, analysis of leaves chlorophyll content, and CO_2 absorption; the data were analyzed descriptively. The results showed that the characteristics of leaves morphology leaves, stomata, and leaves chlorophyll content affected the absorption of CO_2 pollutants in each type of tree. *Tectona grandis* has thick leaves morphology characteristics, roughly hairy leaves surface, leaves size 298.42 cm per leaves blade, abaxial stomata number 80.000 stomata/mm^2, stomata size 80.390 µm, chlorophyll a 0.016 mg/g, chlorophyll b 0.104 mg/g, and ability of CO_2 absorption of leaves was 0.0138x10^{-4} g/cm^2. *Gmelina arborea* has thin leaves morphological characteristics, smooth leaves surface, leaves the size of 165.726 cm per leaves blade, several abaxial stomata of 488.667 stomata/mm^2, stomata size of 77.537 µm, chlorophyll a 0.015 mg/g, chlorophyll b 0.083 mg/g, and ability of CO_2 absorption of leaves were 0.0441x10-4 g/cm^2.

***Keywords*—Chlorophyll; *Gmelina arborea*; pollutant; *Tectona grandis*; urban forest.**

Manuscript received 31 Aug. 2022; revised 18 May 2023; accepted 26 Jun. 2023. Date of publication 31 Aug. 2023.
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I. INTRODUCTION

Urban development has an impact on increasing population, transportation, and industry. An increase in various population activities, motorized vehicles, and industries increases the amount of pollutants in the form of gases and particles in the air [1], [2]. Bio-indicators of urban air pollution can be used by various types of plants that are resistant to air pollution [3], [4], [5]. Leaves are one of the plant organs most exposed to air pollution [6], [7]. Plant growth and development were influenced by external environmental factors such as light, pH, temperature, and humidity [7], [8], [9], [10]. Internal factors include morphological structure, stomata anatomy, and leaves chlorophyll content [3], [11], [12], [13], [75]. Plants can absorb several kinds of pollutants, so they can play a role in cleaning the air from air pollution. The ability of plants to absorb air pollution together when the absorption of CO_2 is used for photosynthesis [14]. The entry mechanism of pollutants into the leaves' tissue occurs simultaneously during the day when the leaves release moisture and absorb CO_2 along with pollutants on the leaves' surface [15], [16]. Pollutants that were absorbed into the leaves tissue through stomata can gradually cause damage to the leaves blade, and chlorophyll content decreases so that inhibited rate of phosphorus eventually dies in the leaves—plant damage from air pollution, such as high CO_2 contents [2], [17]. Air pollution can also affect morphology and leaves anatomy, which eventually shows damage symptoms such as chlorosis and necrosis in the leaves and physiologically and biochemically cause damage to chlorophyll [18]. Planting various types of trees in urban areas to reduce air pollution and selecting plant species should have specific

characteristics and resist pollution. Based on the above problems, this study was conducted on the morphological characterization, stomata anatomy, and physiology of the *Tectona grandis* and *Gmelina arborea* tree species as CO_2 pollutant absorbers in the Urban Forest of Hasanuddin University Tamalanrea Makassar**.**

II. Materials and Methods

A. Materials

Plant materials used in this study were *Tectona grandis* and *Gmelina arborea* trees planted at the Hasanuddin University Campus Urban Forest Research location in Tamalanrea.

B. Method

Data were analyzed descriptively. The results of data analysis to determine differences in morphological characteristics, stomata anatomy, chlorophyll content, and CO_2 absorption from the *Tectona grandis* and *Gmelina arborea* tree species, then the data was presented in the form of tables, image designs, and histograms.

1) Morphological characteristics: Identification of canopy structure and morphology of *Tectona grandis* and *Gmelina arborea* leaves aims to determine the traits (leaves shape, leaves tip, leaves base, leaves recurrence, leaves edge, and leaves traits such as hairy leaves surface, rough, smooth, shiny, and leaves color).

2) Stomata anatomy: Stomata analysis of *Tectona grandis* and *Gmelina arborea* leaves [11] in a longitudinal manner as follows: the surface of the upper and lower leaves smeared with nail polish containing acetone when the leaves were still in the research tree. Observed samples were then photographed with a Bino microscope & DS model photos. IFi Nikon ECLIPSE 80i with 400x magnification. Stomata Index (IS) was calculated based on the formula [12] as follows:

$$IS = \frac{S/L}{(S+E)/L} \times 100\% \quad (1)$$

Whereby:
S= number of stomata
E = number of epidermal cells
L = unit leaves the area.
Stomata Size (SS) can be measured by the Franco formula [19] as follows:

$$SS = L \times B \times K \quad (2)$$

Whereby:
L= Length
B= width
K= constant Franco's (0.79).

3) Chlorophyll content: Content analysis of *chlorophyll a, chlorophyll b,* and *chlorophyll a + b of Tectona grandis* and *Gmelina arborea* leaves [19]. Leaves samples were weighed 0.1 g and extracted with 80% acetone solvent $\pm$ 10 ml—measurement of chlorophyll content with UV-2900 PC spectrophotometer with a wavelength of 663 μm and 645 μm.

4) CO_2 absorption from the Tectona grandis and Gmelina arborea tree species: Mass analysis of *carbohydrates*, the mass of CO_2, and absorption of CO_2 on the leaves of *Tectona grandis* and *Gmelina arborea,* in each type of tree, 30 g of leaves were taken. Leaves samples from trees were put into plastic bags, poured as much as 200 ml of 70% alcohol, and soaked for 15 minutes. The leaves are dried in the oven at a temperature of 70^0C for two days. Analysis of carbohydrates (glucose) in leaves that have been dried, mashed, hydrolyzed, and added 25 ml of 4% HCl. Determination of carbohydrates (glucose) was used spectrophotometry, the Nelson-Somogy method [20]. The determination of reduction carbohydrates enters in optical density (OD), then the determination of carbohydrate mass in fresh leaves [21], [22]. Carbohydrate mass was the percentage of wet carbohydrates from the wet weight of the sample leaves; for the calculation, the formula was used:

- $C_6H_{12}O_6$ mass = % wet KH x wet weight of leaves (30 g)
  % KH wet = (100% - KA) / 100 x Dry KH
  % KA= (Wet weight of the leaves-dry weight of leaves)/ (Wet weight of leaves) x 100%
  Description: KA = Moisture content from the type of leaves
- Determination of CO_2 mass, namely:
  CO_2 mass = mass $C_6H_{12}O_6$ x1,467
- Determination of CO_2 absorption ability per leaves sample area (D)
  Absorption of CO_2 leaves was affected by the leaves' area. Calculation of CO_2 absorption per leaves sample area (D) was used formula, namely:
  D = (CO_2 mass)/ (leaves area (from 30 g of leaves sample)

III. Result and Discussion

A. Morphological Characterization of Tectona grandis and Gmelina arborea

1) Tectona grandis: Tree habitus, tap root system, average tree height of 11.67 m, round and grooved stems, blackish brown peeled leaves, young branches in rectangle, average stem diameter of 31.00 cm, and average canopy cover area of 11.12 m. Sympodial branching system, irregular canopy shape. Single leaves face inter-sect, elongated round leaves, tapered leaves tips, pointed leaves base, pinnate leaves reinforcement, smooth serrated leaves edges, upper leaves surface rough green hair, tapered bottom surface, and light green color. The length of the leaves was 55.90-38.90 cm, the leaves' width was 27.00-32.20 cm, and the length petiole was 3.00-3.90 cm.

2) Gmelina arborea: Tree habitus, tap root system, average tree height of 23.67 m, round stem, whitish brown color, monopodial branching system, average stem diameter of 78.77 cm, average canopy cover area of 14.78 m, horizontal crown shape (spread). Single leaves facing interspersed, oval leaves shape, tapered leaves tip, rounded leaves base, pinnate leaves ascending, flat leaves edge, thin leaves like paper, upper leaves surface green feathered, lower leaves surface visible and light green. At the base of the leaves, two small green dots connected the end of the leaves' stalk and blade. Leaves length 19.90-27.20 cm, leaves width 17.60-22.60 cm, and petiole length 6.20-14.30 cm.

The study tree species above included woody plants from the Classis *Dicotyledoneae* group [23], [24]. *Tectona grandis* and *Gmelina arborea* tree species can grow as greening trees at the study site. The research results have been conducted at the location of UNHAS Urban Forest found ± 102 species of trees.

B. Characterization of Leaves Stomata Anatomy of Tectona grandis and Gmelina arborea

The results of the characterization of the leaves stomata anatomy of *Tectona grandis* and *Gmelina arborea* are shown in Figure 1 and Table 1.

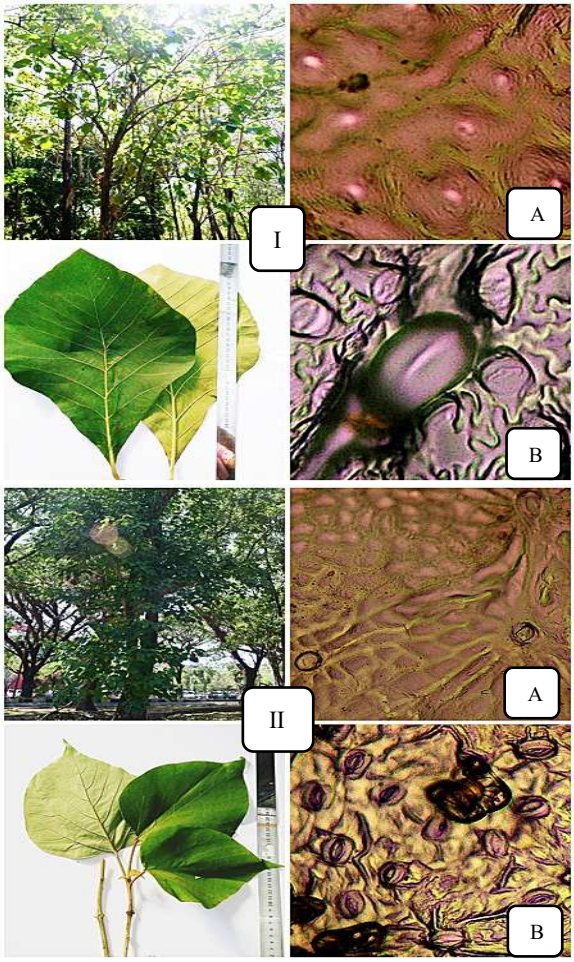

Fig. 1 Characterization of Stomata Anatomy Based Longitudinal Section (I) *Tectona grandis* and (II) *Gmelina arborea*, (A) Adaxial Stomata, (B) *Abaxia*l Stomata, 400x Stomata Magnification

TABLE I
ANALYSIS RESULTS OF ANATOMICAL CHARACTERIZATION OF STOMATA AND EPIDERMIS AVERAGE *TECTONA GRANDIS* AND *GMELINA ARBOREA* TREES

No.	Parameter		*Tectona grandis*	*Gmelina arborea*
1	Area of Leaves Per blade (cm^2)		298.424	165.726
2	Stomata Type		Paracytic	Paracytic
3	The Spread of Stomata		Apple	Potato
4	Number of Stomata (mm^2)	Adaxial	0	34.667
		Abaxial	80	488.667
5	Number of Epidermis (mm^2)	Adaxial	4747	2934.667
		Abaxial	4640	2240
6	Stomata Index (%)	Adaxial	0	1.214
		Abaxial	1.748	18.838
7	Long Stomata (µm)	Adaxial	0	16.8
		Abaxial	12.8	12.8
8	Width Stomata (µm)	Adaxial	0	12
		Abaxial	8	7.2
9	Size of Stomata (µm)	Adaxial	0	165.331
		Abaxial	80.39	77.537
10	Epidermal Cell Type	Adaxial	Irregular	Irregular
		Abaxial	Irregular	Irregular
11	Epidermal Cell Wall	Adaxial	Deep Grooves	Straight–Grooves
		Abaxial	Deep Grooves	Straight–Grooves

The results of the leaves stomata anatomy characterization of *Tectona grandis* and *Gmelina arborea* trees showed that both stomata cover cells were surrounded by one or more neighboring cells and the long axis of neighboring cells paralleled to the closing cell axis and gap [25], [26]. Based on the neighboring cell structure that was next to the cover cell, it includes the paracytic type [27].

Characterization on *Tectona grandis* leaves irregular epidermal cell type of adaxial and abaxial leaves, while the epidermal cell wall adaxial and abaxial leaves deep grooves. *Gmelina arborea* tree plants have irregular *adaxia*l and abaxial leaves' epidermis cells, whereas the adaxial and abaxial leaves' epidermal cell walls were straight grooves. The spread of stomata on the leaves of the *Tectona grandis* tree was not found in the adaxial because the leaves' surface was protected by a lot of coarse leaves' hair. Stomata were only found on abaxial leaves [19]. The spread of the stomata includes the type of *apple* [28]. In the leaves of the *Gmelina arborea* tree, the spread of stomata on both the leaves surfaces was adaxial and abaxial. The spread of stomata on both leaves' surfaces includes the type of *potato* [29]. The spread of stomata on the surface of the abaxial leaves was more than the adaxial leaves on plants that grow in terrestrial environments. This was an adaptation mechanism to reduce transpiration in leaves [13], [30], [31], [32].

The results of the research analysis on the number of stomata in both research trees are shown in Table 1. The highest number of stomata was found in *Gmelina arborea* abaxial leaves, 488,667 stomata/$mm^{2,}$ and the lowest at *Tectona grandis,* 80,000 stomata/mm^2. The highest number of the epidermis in the adaxial leaves of *Tectona grandis* tree 4,747,667 epidermis/mm^2, while *Gmelina arborea* 2,934,667 epidermis/mm^2. The highest stomata index on leaves of *Gmelina arborea*, abaxial leaves was 18.838%, and the lowest in *Tectona grandis* was 1.748%. The number of leaves stomata in each type of plant was different. This was influenced by the size and spread of stomata on the leaves' surface. The largest stomata size was found on the leaves of *Tectona grandis* at 80,390 µm, and the smallest stomata on leaves of *Gmelina arborea at* 77,537µm. Several previous studies supported this study that the size of the leave stomata was large, and the stomata amount was small, so if the stomata was large, the size of the stomata was small [33], [34], [35]. The plant's response to environmental changes can be seen in changes in the size and number of stomata [36], [37]. The number of epidermal cells was more on the adaxial surface

[34]. Leaves epidermal cells function to protect leaves tissue in plants against influences from transpiration and air pollution [38], [39], [40].

C. Leaves Chlorophyll Content

The analysis results of chlorophyll content, chlorophyll b, and chlorophyll a + b in the leaves of *Tectona grandis* and *Gmelina arborea* are shown in Figure 2.

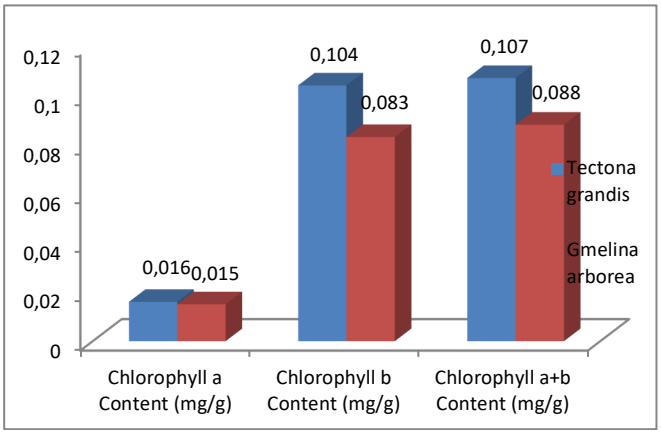

Fig. 2 Histogram of Average Chlorophyll a Content, Chlorophyll b and Chlorophyll a + b for 0.1 g of *Tectona grandis* Leaves and *Gmelina arborea*.

1) Chlorophyll a: Content of chlorophyll a in *Tectona grandis* leaves was 0.016 mg/g higher, while *Gmelina arborea* was 0.015 mg/g lower. The leaves of the *Tectona grandis* are dark green, and *Gmelina arborea* leaves are slightly yellowish green. In each leaves plant containing chlorophyll a ($C_{55}H_{72}O_5N_4Mg$), dark green and light green leaves containing chlorophyll b ($C_{55}H_{70}O_6N_4Mg$), chlorophyll plays an important role in photosynthesis [41], [42], [43]. Leaves exposed to air pollution, such as dust, can be absorbed into the leave stomata, then go to mesophyll tissue, dust that accumulates on mesophyll tissue causes damage to cells that contain chlorophyll, thus affecting photosynthesis [44], [45], [46], [47].

2) Chlorophyll b: The chlorophyll content of *Tectona grandis* leaves was 0.104 mg/g and *Gmelina arborea* 0.083 mg/g. The measurement results of chlorophyll contents b in the study location were higher than chlorophyll a. It was related to the presence of trees planted with close spacing so that the leaves were shaded. Shaded tree leaves have higher chlorophyll b than non-shaded leaves [48], [49], [50].

3) Chlorophyll a+b: Chlorophyll a + b contents on *Tectona grandis* leaves were 0.107 mg/g higher and *Gmelina arborea* 0.088 mg/g. Chlorophyll contents of a + b were found in many shaded leaves. *Tectona grandis* leaves size was 298.424 cm larger than *Gmelina arborea* leaves size of 165.726 cm. Chlorophyll contents can also be influenced by leaves size, leaves anatomy, and habitat [30], [51], [52], [53], [54]. Chlorophyll content can be used to measure canopy health [55]. The results of carbohydrate mass, CO_2 mass, and CO_2 /g/cm^2 absorption are shown in Figure 3.

D. Carbohydrate Mass, Carbon Dioxide Mass, and Carbon Dioxide Absorption Ability

The results of carbohydrate mass, CO_2 mass, and CO_2/g/cm^2 absorption are shown in Figure 3.

1) Carbohydrate Mass: The results of mass carbohydrate analysis from photosynthesis on the leaves of *Gmelina arborea* 0.0049/30 g and *Tectona grandis* 0.0013/30 g. *Gmelina arborea* tree plants have stomata spread on both leaves' surfaces; more stomal than *Tectona grandis* stomata were only found on the abaxial surface with fewer stomal (Table 1.). *Gmelina arborea* plants were able to absorb CO_2 higher than *Tectona grandis*. *Gmelina arborea* tree species include the Fast Growing Species (FGS) group, a plant that can absorb CO_2 faster than air, thus accelerating the increase in tree biomass. *Tectona grandis* plants belong to the Slow Growing Species (SGS) group, which is a type of tree whose growth is slow to absorb CO_2, thus prolonging the carbon stock content during its lifetime [56], [57].

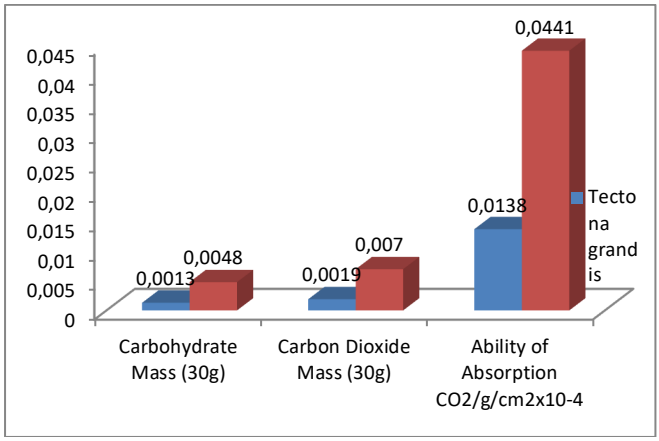

Fig. 3 Histogram of A Carbohydrate Mass (30 g Leaves), CO_2 Mass (30 g Leaves), and CO_2 /cm^2 Absorption of *Tectona grandis* and *Gmelina arborea*.

2) Carbon Dioxide Mass: The analysis results on the mass of CO_2 absorbed by the leaves of the *Gmelina arborea* tree species was 0.0070/30 g higher, while *Tectona grandis* was 0.0019/30 g. The results of measurements of environmental factors at the Urban Forest Research site at Hasanuddin Tamalanrea University Makassar were: temperature 32.6-34.2 ℃, air humidity 37.3-37.7 RH%, soil pH 6.0, soil moisture 35.0-36, 7%, and light intensity 71667-67233 lux. The highest type of *Gmelina arborea* CO_2 absorption was supported by the morphological and physiological characteristics of *Gmelina arborea* leaves, such as thin leaves, small leaves size, many stomata, and the surface of downy leaves. *Tectona grandis* leaves were thick, large leaves, few stomata, and coarse hair. The amount of carbon dioxide that can be absorbed depends heavily on the size of the leaf sample; the smaller the leaf area, the more carbon dioxide can be absorbed [58], [59]. To aid CO2 diffusion during photosynthesis, stomata open during the day and close at night to lessen transpiration [60], [61], [62]. Plant production can be measured precisely for the CO_2 used in photosynthesis [63], [64], [65]. The percentage of carbohydrates produced during photosynthesis can be used to determine the mass of CO_2 absorbed by plants [66]. Leaves exposed to sunlight speed of CO_2 absorption in the

photosynthesis process was higher than shaded leaves [59], [62], [67].

3) The ability of Carbon Dioxide Absorption: The results of analysis of CO_2/cm^2 absorption of leaves samples at *Gmelina arborea* were $0.0441x10^{-4}$ g/cm^2 and *Tectona grandis* $0.0138x10^{-4}$ g/cm^2. Both types of trees have the potential to absorb CO_2 and are suitable for use as greening trees. The result of high carbohydrate mass and CO_2 mass does not always produce high CO_2 absorption because it is influenced by environmental factors [5]. Plant type, structure, and canopy closure [41], [57], number of stomata [42], number of epidermis, stomata index [33] stomata size [38]. Leaves size and chlorophyll content of leaves [58], as well as leaves area per strand as a divider, were not the same in each type of plant [68], [69].

IV. Conclusion

The results showed that the characteristics of leaves morphology, leaves stomata, and leaves chlorophyll content affected the absorption of CO_2 pollutants in each type of tree. *Tectona grandis* tree has thick leaves morphological characteristics, roughly hairy leaves surface, leaves size 298.42 cm per leaves blade, abaxial stomata number 80.000 stomata/mm^2, stomata size 80.390 µm, chlorophyll a 0.016 mg/g, chlorophyll b 0.104 mg/g, and ability of CO_2 absorption of leaves was $0.0138x10^{-4}$ g/cm^2. *Gmelina arborea* tree has thin leaves morphological characteristics, smooth leaves surface, leaves size 165.726 cm per leaves blade, number of abaxial stomata 488.667 stomata/mm^2, stomata size 77.537 µm, chlorophyll a 0.015 mg/g, chlorophyll b 0.083 mg/g, and ability of CO_2 absorption of leaves was $0.0441x10^{-4}$ g/cm^2.

Acknowledgment

This research was funded by Specific Indonesian Maritime Continent Research Internal Grant through LP2M Hasanuddin University, No. 12287/UN4.21/PL.00.00/2018.

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