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Morphological and Stomata Characteristics of Trembesi (*Samanea saman* (Jacq.) Merr.) Leaves as Green Plants in Padang City, Indonesia

Vauzia[1*], Fadhila Mayandri[1], Nur Azizah[1], Rizka Putri Alti[1]

[1] Biology Department, Faculty of Mathematics and Natural Science, Universitas Negeri Padang, Indonesia.

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Corresponding Author:
Vauzia
vauzia.ivo@gmail.com

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Abstract: Greening along roads can be an alternative solution to overcome air pollution in urban areas. Direct contact of plants with pollutant particles in the air will affect the condition of plants, especially on leaves. Knowledge of morphological characteristics and stomata on leaves that have the potential to absorb pollutants is the basis for understanding plant responses to environmental changes. This research is descriptive research conducted in September-December 2021 with leaf samples taken in the area of PT Semen Padang, Padang State University, and Andalas University forests. Data were analyzed by t test level of 5%. The results showed that the morphological characteristics of trembesi leaves in the PT Semen Padang and Padang State University areas had significant differences in the aspects of the number of leaflets, leaf length, leaf width, not significantly different in the length of the mother petiole and the number of leaf branch bones and the characteristics of the stomata did not show any difference which is evident from the aspect of stomata length and stomata density. The morphological characteristics of trembesi leaves in the Padang State University and Andalas University forests showed significant differences in the length of the mother petiole, the number of leaflets, and the number of leaf veins, there was no significant difference in leaf length and leaf width and showed a significant difference in the aspect of stomata length, but did not show a significant difference in terms of stomata density. Morphological characteristics of trembesi leaves in the PT Semen Padang area and Andalas University forest showed significant differences in the length of the mother petiole, number of leaflets, leaf length, leaf width, and number of leaf veins and did not show significant differences in terms of stomata length and stomata density.

Keywords: Leaf Morphology; Stomata; Trembesi (*Samanea saman* (Jaqr.) Merr.)

Introduction

Air pollution is one of the environmental problems, namely the contamination of the air by pollutant materials (Rosyidah, 2016). Local topography, meteorological conditions, land use, land cover, and the amount and source of emissions affect air pollution (Ismiyati et al., 2014; Krupnova et al., 2020). The development of industry and means of transportation in the city of Padang, Indonesia affects air pollution. Pollutants such as carbon monoxide (CO), ozone (O_3), lead (Pb), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), fine particulate matter (PM2.5, particle size ≤ 2.5 µm), and particles that can inhale (PM10, particle size ≤ 10 µm) is strongly affected by traffic emissions (Nowak et al., 2014; Wu et al., 2020). Gas, steam, and smoke produced during the smelting, printing, drying, heating, and cooling processes that are released into the environment by industrial factories are also sources of air pollutants (Salih et al., 2020). These air pollutans can have a negative impact on the environment if not controlled (A'la et al., 2021).

One of the efforts to overcome the presence of air pollution is by planting shade trees and greening in every area that many motorized vehicle pass

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(Ariyansyah et al., 2023). Shade trees can play a role in reducing air pollution, especially carbon dioxide gas released by vehicles (Mansur et al., 2014). Studies describe greening plants as potential biomonitors of air quality contaminated with heavy metal pollution (Chaudhuri et al., 2022; Li et al., 2019; Sert et al., 2019). Street greening can be an efficient pollutant filter in reducing air pollution in urban areas (Pratama et al., 2022; Qin et al., 2019; Wu et al., 2020). Trees remove air pollution by absorption through leaf stomata (Nowak et al., 2014). Leaf surface, leaf type, and leaf area index affect the ability to capture pollutants. Species with rough leaf surfaces can capture more pollutants than species with smooth leaf surfaces (Liang et al., 2016).

Based on these criteria, there is a trembesi plant (*Samanea saman* (Jaqr.) Merr.) which is a type of shade and green plant (Zayadi et al., 2017). Trembesi plants have a very high absorption of carbon dioxide gas. One trembesi stem can absorb 28,5 tons of carbon dioxide gas annually and also has the potential to absorb Pb (Dahlan, 2010; Haruna, 2020; Indriani et al., 2021; Sofyan et al., 2014; Wirah Krisnawati et al., 2022). Trembesi leaves have a leaf structure that is hairy, and rough, especially on the lower leaf surface so they can bind and absorb pollutants through the stomata (Kusumo et al., 2017).

The increasing activity of motorized vehicles and industrial areas in the city of Padang, Indonesia has an impact on plants that grow in environments exposed to air pollution. Until now there is no information regarding the morphological and stomata characteristics of the leaves of the trembesi plant (*Samanea saman* (Jacq.) Merr.) to environmental changes. Knowledge of the morphological and stomata characteristics of plants is the basis for understanding plant responses to environmental changes. Based on this, research has been carried out on the morphological and stomatal characteristics of the leaves of the trembesi plant (*Samanea saman* (Jacq.) Merr.) as a greening plant at different locations in the city of Padang.

Method

This type of research is quantitative descriptive research. The tools used in the study included plant scissors, plant twig hooks, newsprint, raffia rope, object glass, cover glass, microscope, camera, plastic bag, label paper, stationery, oven, air thermometer, sling hygrometer, PH meter, and ruler. As for the material, namely samples of trembesi leaves (*Samanea saman* (Jaqr.) Merr). The research was carried out in September-December 2021 at the Botanical Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Padang State University. Data samples in the form of trembesi leaves were taken from several locations including the PT Semen Padang area, Padang State University, and Andalas University. Leaves were taken from 20 individuals at each location. Leaves are taken on the second branch above ground level. From this branch, the third leaf is taken from the end of the branch. Observations made in determining morphological characteristics include the length of the mother leaf stalk, the length of the leaflets, the width of the leaflets, the number of daughter leaves in one petiole, and the number of leaf veins. While observations were made on the characteristics of stomata on leaves including stomata density and stomata length.

Density of Stomata

Stomata density is calculated by the formula:

Stomata Density (cells/mm^2) = (Number of stomata (cells))/(Area of view (mm^2))

Information: Field of view magnification 400x = ¼ π d^2

Stomata Length

Stomata length was measured using a digital microscope, and stomata of trembesi leaves were measured with a magnification of 40x10. Research data were analyzed using the t test with a significant level of 5%.

Result and Discussion

Morphological Characteristics and Stomata of Trembesi Leaves (Samanea saman (Jacq.) Merr.) Found in the PT Semen Padang Area and the Padang State University Area

The results showed that the morphological characteristics from the aspect of the number of leaflets in one petiole, the length of the leaf, and the width of the leaf there were significant differences, but when viewed from the aspect of the length of the mother petiole and the number of leaf branch bones did not show any significant difference. Differences in morphological characteristics at these two locations are due to different environmental conditions. The morphological characteristics of the leaves are strongly influenced by the place of growth and environmental factors. Air pollution in the PT Semen Padang area is considered higher than in the Padang State University area. However, in terms of the length of the mother petiole and the number of veins of the leaf branches, there was no significant difference, this was because both locations received pollutant contributions that affected plant growth.

The PT Semen Padang area contributes SOx and NOx pollutants from the cement factory's industrial activities and is located side by side with a provincial highway with high transportation activity, while the Padang State University area is on the edge of a city highway and there is no factory area. This causes the condition of the plants, especially on the leaves, in terms of morphological aspects, in the Padang State University area to be better than the PT Semen Padang area. Satria (2006) stated that generally on large roads far from industrial areas, the contribution of Pb, Cu, CO pollutants mostly comes from the exhaust of vehicles that pass through these roads.

Table 1. Results of t-Test Analysis of Trembesi Leaves (*Samanea saman* (Jacq.) Merr.) in the PT Semen Padang Area and the Padang State University Area

Morphological Characteristics Locations	Long Mother Petiole (cm)	The Number of Leaflets on one Petiole (bh)	Leaf Length (cm)	Leaf Width (cm)	Number of Leaf Branches (bh)
PT Semen Padang	19.12[a]	10.15[a]	3.98[a]	2.17[a]	14.20[a]
Universitas Negeri Padang	20.90[a]	11.50[b]	4.56[b]	2.60[b]	15.30[a]

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% significance level.

Differences in morphological characteristics in the data of this study were influenced by temperature and humidity at both locations. Karamina et al. (2017) states that the condition of air temperature in an area or area is closely related to the altitude of the place. While plant growth is affected by temperature.

Table 2. The Density of Stomata of Trembesi Leaves (*Samanea saman* (Jacq.) Merr.) Found in PT Semen Padang Area and Padang State University Area

Locations	Stomata Density Average (mm^2)
Universitas Negeri Padang	83,057[a]
PT. Semen Padang	89,681[a]

Note: Numbers Followed by the Same Letter in the Same Column are not Significantly Different at the 5% Significance Level.

Based on the results of the research and analysis using the t test at a significant level of 5%, it was shown that the stomata density of trembesi leaves (*Samanea saman* (Jacq.) Merr.) found in the PT Semen Padang area and the Padang State University area showed no significant difference. Where the stomata density of trembesi leaves at Padang State University is 83.057 mm^2, while the stomata density of trembesi leaves in PT. Semen Padang is 89,681 mm^2.

Table 3. Stomata Length of Trembesi Leaves (*Samanea saman* (Jacq.) Merr.) Found in the PT Semen Padang Area and the Padang State University Area

Locations	Average Stomata Length (μm)
Universitas Negeri Padang	1,067[a]
PT. Semen Padang	1,608[a]

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% significance level.

Based on the results of the research and analysis using the t test at a significant level of 5%, it shows that the stomata length of trembesi leaves at Padang State University and PT. Semen Padang shows no real difference. Where the stomata length of trembesi leaves at Padang State University is 1.067 μm, while the stomata length of trembesi leaves at PT. Semen Padang is 1.608 μm.

The number of stomata found at Padang State University is less than the number of stomata found at PT. Semen Padang. This is due to a large number of motorized vehicles and industrial areas which affect the length and density of stomata. According to Haryanti et al. (2009), Stomata in plants are different due to differences in the location of the guard cells, their distribution, the shape and location of the thickening of the guard cell wall, and the direction of opening of the guard cells, the number and location of neighboring cells in dicot and monocot plants, the location of the cover cells to the surface of the epidermis, and its origins.

Morphological Characteristics and Stomata of Trembesi Leaves (Samanea saman (Jacq.) Merr.) Found in Padang State University and Andalas University Forest Areas

The results showed that the morphological characteristics from the aspect of the length of the mother petiole, the number of children in one petiole, and the number of leaf veins there were significant differences, but when viewed from the aspect of leaf length, leaf width did not show any significant difference. The difference in several morphological aspects is because transportation activity in the Padang State University area is higher than in Andalas University. Air pollution due to vehicle emissions is mostly caused by private vehicles such as cars, motorbikes, and public transportation. High air pollution can affect environmental temperature. Air temperature is closely related to the rate of evaporation from plant tissue into the air. The higher the air temperature, the higher the transpiration rate. If the temperature is outside the tolerance limit, the plant's

metabolic activities will be disrupted or stopped. This causes the length and width of the leaves in the highlands to be longer and wider than the length and width of the leaves in the lowlands. Narrow-leaf adaptations can reduce transpiration in plants (Xu et al., 2009). In line with the results of the study which showed some morphological characteristics. The length and width of the leaves in the Andalas University forest area are greater than the Padang State University area.

Table 4. Results of t-Test Analysis of Trembesi Leaves (*Samanea saman* (Jacq.) Merr.) in the Padang State University Area and Andalas University Forest Area

Morphological Characteristics Locations	Long mother petiole (cm)	The number of leaflets on one petiole (bh)	Leaf length (cm)	Leaf width (cm)	Number of leaf branches (bh)
Universitas Negeri Padang	20.90[a]	11.50[a]	4.56[a]	2.60[a]	15.30[a]
Universitas Andalas	32.32[b]	13.20[b]	4.62[a]	2.54[a]	17.15[b]

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% significance level.

Differences in morphological characteristics at these two locations can be caused by differences in soil pH. The Padang State University area has a higher pH than the Andalas University area. Rahmawati (2009) stated that soil pH greatly determines the growth and production of leaves, and even affects the green quality of the leaves. If the soil is alkaline (pH> 7.0), the soil usually contains high calcium, resulting in phosphate fixation and plants often experience P deficiency.

Table 5. The Density of Stomata of Trembesi Leaves (*Samanea saman* (Jacq.) Merr.) Found in Padang State University and Andalas University Forest Areas

Locations	Stomata Density Average ($mm^{2)}$
Universitas Andalas	90,955[a]
Universitas Negeri Padang	83,057[a]

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% significance level.

Based on the results of the research and analysis using the t test at a significant level of 5%, it was shown that the stomata density of trembesi leaves in the Andalas University and Padang State University forests showed no significant difference. Where the stomata density of trembesi leaves in the Andalas University forest is 90.955 mm^2, while the stomata density of trembesi leaves at Padang State University is 83.057 mm^2.

Table 6. The stomata length of *Samanea saman* (Jacq.) Merr.) leaves of Trembesi leaves in the Padang State University area and Andalas University forest area.

Locations	Average Stomata Length (μm)
Universitas Andalas	2,288[a]
Universitas Negeri Padang	1,067[b]

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% significance level.

Based on the results of the research and analysis using the t test at a significant level of 5%, it was shown that the length of the stomata of trembesi leaves in the forests of Andalas University and Padang State University showed a significant difference. Where the length of the stomata of trembesi leaves in the Andalas University forest is 2.288 μm, while the length of the stomata of trembesi leaves at Padang State University is 1.067 μm.

The length of stomata in the Andalas University forest was higher compared to the Padang State University area. This was because the leaves were protected and not exposed to direct sunlight when taking samples. Stomata will begin to open wide because the light intensity and temperature are not too high and sufficient moisture causes guard cell turgor to increase. Meanwhile, stomata close due to high light intensity and temperature to reduce excessive water evaporation (Taiz et al., 2002).

Morphological Characteristics and Stomata of Trembesi Leaves (Samanea saman (Jacq.) Merr.) Found in PT Semen Padang Area and Andalas University Forest Area

The results showed that the morphological characteristics in terms of the length of the mother petiole, the number of young leaves in one petiole, the length of the leaf, the width of the leaf, and the number of veins of the leaf branches showed significant differences. This is because the two locations have very different levels of pollutants from an industrial perspective and transportation density. The results of measuring the morphological characteristics of trembesi leaves in the Andalas University forest area were considered the best compared to the other two locations.

The difference in characteristics at the two locations is influenced by differences in environmental parameter factors between the two locations, the PT Semen Padang area was recorded as a location with a higher air temperature of 31°C and low humidity of 65%, inversely proportional to the Andalas University area with an air temperature of 27°C and 82% humidity. This is supported by the research results of Qin et al. (2019) which suggests that plant growth and development are

strongly influenced by plant intrinsic and extrinsic factors. Intrinsic factors are genetic and hormonal factors, while extrinsic factors are environmental factors, namely altitude, soil pH, light intensity, temperature, humidity, rainfall, soil texture, and others.

Table 7. Results of t Test Analysis of Trembesi Leaves (*Samanea saman* (Jacq.) Merr.) in PT Semen Padang Area and Andalas University Forest Area

Morphological Characteristics					
Locations	Long mother petiole (cm)	The number of leaflets on one petiole (bh)	Leaf length (cm)	Leaf width (cm)	Number of leaf branches (bh)
PT Semen Padang	19.12[a]	10.15[a]	3.98[a]	2.17[a]	14.20[a]
Universitas Andalas	32.32[b]	13.20[b]	4.62[b]	2.54[b]	17.15[b]

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% significance level.

The results showed that the trembesi plant is good as a greening plant because it can absorb pollutants in the air and acts as a shade plant along the road. This is supported by research conducted by Susilastri et al. (2018) which studied the uptake of several types of green plants in the city of Padang, suggesting that trembesi plants can absorb Pb, Cu, and CO with the highest values at high pollution levels. The arrangement of green plants at high-pollution locations can control air pollution optimally. Morphological data can determine the sensitivity of a species to its environment (Leghari et al., 2013).

Table 8. The Density of Stomata of Trembesi Leaves (*Samanea saman* (Jacq.) Merr.) Found in PT Semen Padang Area and Andalas University Forest Area

Locations	Stomata Density Average (mm^2)
Universitas Andalas	90,955[a]
PT Semen Padang	89,681[a]

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% significance level.

Table 9. Stomata Length of Trembesi Leaves (*Samanea saman* (Jacq.) Merr.) Found in PT Semen Padang Area and Andalas University Forest Area

Locations	Average Stomata Length (μm)
Universitas Andalas	2,288[a]
PT Semen Padang	1,608[a]

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% significance level.

Based on the results of the research and analysis using the t test at a significant level of 5%, it was shown that the stomata density of trembesi leaves in the Andalas University forest and PT Semen Padang area showed no significant difference. Where the stomata density of trembesi leaves in the Andalas University forest was 90.955 mm^2, while the stomata density at PT Semen Padang was 89.681 mm^2 (Table 8).

Based on the results of the research and analysis using the t test at a significant level of 5%, it was shown that the length of the stomata of trembesi leaves in the Andalas University forest and the PT Semen Padang area showed no significant difference. Where the length of the stomata of trembesi leaves in the Andalas University forest is 2.288 μm, while the length of the stomata in the PT Semen Padang area is 1.608 μm (Table 9).

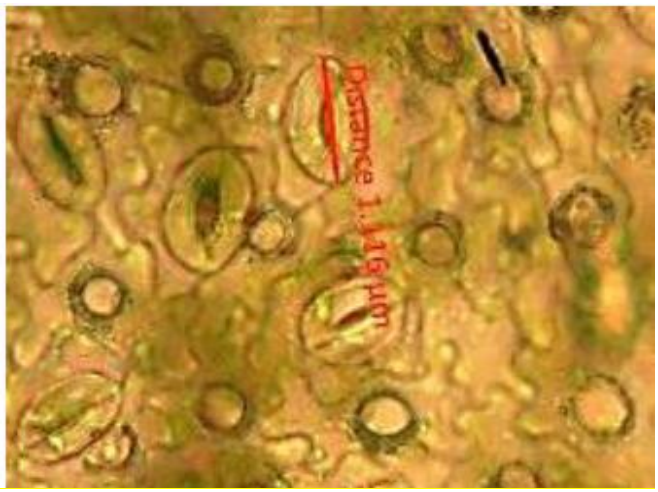

Figure 1. Stomata on *Samanea saman* leaves were Universitas Negeri Padang with a magnification of 40×10 and a stomata length of 1,116 μm

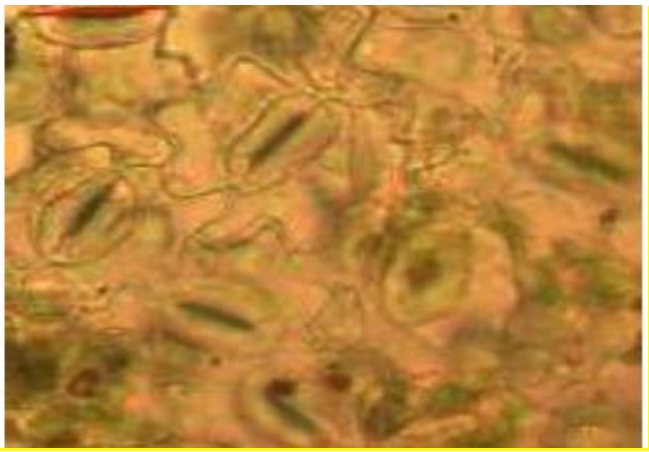

Figure 2. Stomata on *Samanea saman* leaves were Universitas Andalas with a magnification of 40×10 and a stomata length of 1,003 μm

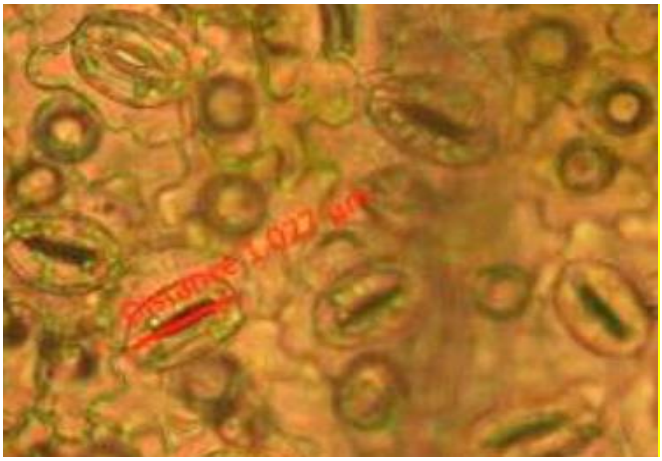

Figure 3. Stomata on *Samanea saman* leaves were PT. Semen Padang with a magnification of 40×10 and a stomata length of 1,027 µm

The number of stomata in the non-polluted area is higher than in the polluted area because there is a lot of factory smoke and motor vehicle exhaust in the PT Semen Padang area. This is following previous research conducted by Sembiring et al. (2006) on samples of S. macrophylla leaves, which showed that there was a decrease in the number of stomata on the leaves caused by motor vehicle exhaust gases and factory fumes. The following is an observation of the stomata of Trembesi leaves at various locations.

Conclusion

The morphological characters of trembesi leaves in the PT Semen Padang area and Padang State University showed significant differences in the aspects of the number of leaflets, leaf length, and leaf width, but not significantly different in the length of the mother petiole and the number of leaf veins and did not show significant differences from the aspect stomata length and stomata density. The morphological characters of trembesi leaves in the Padang State University area and Andalas University forest showed significant differences in the aspects of the length of the mother petiole, the number of leaflets, and the number of leaf veins, but not significantly different from the aspects of leaf length and leaf width and showed significant differences. significantly on the aspect of stomata length, but did not show a significant difference from the aspect of stomata density. The morphological characters of trembesi leaves in the PT Semen Padang area and Andalas University forest showed significant differences in the aspects of the length of the mother petiole, the number of leaflets, leaf length, leaf width, and some leaf veins and did not show significant differences from the aspect of stomata length and stomatal density.

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The contribution of the authors including vauzia doing conceptualization and supervision; fadhila mayandri and nur azizah doing methodology and data curation; rizka putri alti doing writing original draft and writing review.

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Conflicts of Interest
The authors declare no conflict of interest.

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