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Differences in Anatomical Thickness of Leaves of Six Types of Monocot Ornamental Plants at Base and Top Position

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Abstract: The position of the leaves on each plant can affect the thickness of the leaf tissue. This study aims to determine the thickness of the leaf tissue at the base and shoot positions. The study used a nested design model (random nesting pattern design). This design uses two factors, the first factor is the leaves of six types of monocot ornamental plants, namely adam hawa (Rhoeo discolor), daffodils (Hymenocallis littoralis), hanjuang (Cordyline fructicosa), lilies of paris (Chlorophytum laxum), song india (Dracaena reflexa) and sri fortune (Aglaonema commutatum), while the second factor was leaf position (base and shoot) with three replications. The method of making leaf preserved preparations is paraffin which refers to Johansen. Parameters measured were total leaf thickness, upper epidermis, lower epidermis, mesophyll (palisade and sponge). Data were analyzed with ANOVA followed by LSD if the factor results were significant. The correlation was made between the total leaf thickness and the tissue which was significant on the leaf position factor. The results showed that the type of plant affected the total leaf thickness, upper and lower epidermis, mesophyll (palisade and sponge). However, leaf position has no effect on the thickness of the upper epidermis and sponge for differentiated mesophyll. The thickness of the leaf depends on the thickness of the lower epidermis, followed by the thickness of the mesophyll or palisade for differentiated mesophyll.

Keywords: Anatomical; Monocot; Ornamental plants; Thickness of leaves

Introduction

Ornamental plants are plants that have high aesthetic value, so they are often used to decorate yards or indoors (Hartutiningsih-M. Siregar et al., 2018). In addition to beauty, ornamental plants also function as environmental air fresheners (Surya et al., 2022). The function of this environmental air freshener is related to the function of leaves for photosynthesis. Leaves are usually flat flat so that it is easy to get sunlight and CO_2 gas. Leaves are diverse organs both in terms of morphology and anatomy (Mulyani, 2006).

Morphological and anatomical development of leaves can change according to age. These changes are related to the physiological processes of the plants themselves or adaptation efforts to their environment. Ornamental plants require better cultivation to sustain their life. Ornamental plants have varied characteristics in terms of anatomical changes related to adaptive abilities such as photosynthesis and transpiration. Starman et al. (1990) revealed that Helianthus annus L. 'Mammoth Russian' responded differently between mature leaves and young leaves. The use of 132 mg/liter of ancymidol inhibited the growth of young Helianthus annus leaves compared to mature leaves. Then in wheat plants (Triticum aestivum) young leaves have thinner cell thickness with larger inter-cell spaces compared to older leaves so that water conduction is faster in young leaves (Jahan et al., 2023). It has to do with anatomy.

The anatomy of a leaf consists of the epidermis, mesophyll (palisade and spongy), and vascular tissue (Azmin et al., 2021). To understand the character of ornamental plants, it is necessary to know the anatomical characteristics of the leaves. Anatomical data can be used to help characterize the type (Liu et al., 2020). Factors that affect the anatomical character of the leaves are shading, fertilization, differences in sun exposure, genes, position or location of the leaves on the

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stem (Nelza et al., 2018; Karyati et al., 2017; Coneva & Chitwood, 2018; Xie & Luo, 2003). Anatomical characters that can be observed include cuticle thickness, epidermal thickness, mesophyll thickness, stomata size, stomata and trichome density per 1 mm^2 of leaf epidermis. (Samiyarsih et al., 2019).

According to Coneva et al. (2018) leaf thickness is a quantitative property of leaves that can be measured. The quantitative property of leaf thickness is often associated with the ability to adapt to its environment. Ningsih et al. (2022) showed that leaf position had a significant effect on leaf thickness. The top leaves are thicker than the middle leaves, and the middle leaves are thicker than the base leaves. This means that the thickness of the leaves at the position of the stem from the top to the base is decreasing. Then Afzal et al. (2017) showed that the base leaves were thicker than the top leaves on corn and sorghum plants. Further research Xie et al. (2003) On the leaves of the Asian pear (Pyrus serotine Rehd. cv. culta rehd.) it was found that the anatomical structures (palisade tissue and sponges) varied according to the position of the nodes on the leaves, namely the palisade tissue on the top leaves was thicker than the palisade tissue on the base leaves. While the spongy tissue on the shoot leaves is thinner than the spongy tissue on the base leaves. Variations in anatomical structure are also found in ornamental plants.

Ningsih et al. (2022) showed that there were differences in the thickness of the leaves at the top and base of six types of monocot ornamental plants. However Ningsih et al. (2022) have not measured the thickness of each network. Six types of plants used were adam hawa (Rhoeo discolor), daffodils (Hymenocallis littoralis), hanjuang (Cordyline fructicosa), lilies paris (Chlorophytum laxum), song india (Dracaena reflexa) and sri fortune (Aglaonema commutatum Schott). Furthermore Daningsih et al. (2022) have observed the leaf anatomy of six types of dicot ornamental plants which are associated with transpiration. However Daningsih et al. (2022) have not observed the leaf anatomy of six types of monocot ornamental plants at the base and shoot positions. Therefore, further research is needed on the six types of monocot ornamental plants used by Ningsih et al. (2022) to measure the thickness of each tissue making up the leaf such as the thickness of the upper and lower epidermis, mesophyll (palisade and sponges on the shoots and base leaves. Knowing the differences in the thickness of the leaf tissue in ornamental plants can indicate the adaptability of these plants to their environment. This study aims to determine the anatomical differences of the shoots and base leaves within a species and between plant species.

Method

Location and Time

This research was conducted in February- October 2022. The samples were conditioned in the same environment, namely in a simple plant house. Sample preparation and observation was carried out at the Tanjungpura University Biology Education Laboratory.

Research Design

This study used a nested design model. This design uses two factors, namely the first factor is the leaves of six types of monocot ornamental plants, namely adam hawa (Rhoeo discolor (L'Her.) Hance ex Walp), daffodils (Hymenocallis littoralis (Jacq.) Saslisb), hanjuang (Cordyline fructicosa (L.). A.Chev.), paris lilies (Chlorophytum laxum R.Br.), song india (Dracaena reflexa Lam.) and sri fortune (Aglaonema commutatum Schott.), while the second factor is the position of the leaf base and shoot. Each sample had three replications taken from different plants for the same type of plant so that the total sample in this study was 36. The chart of the stages of the research method can be seen in Figure 1.

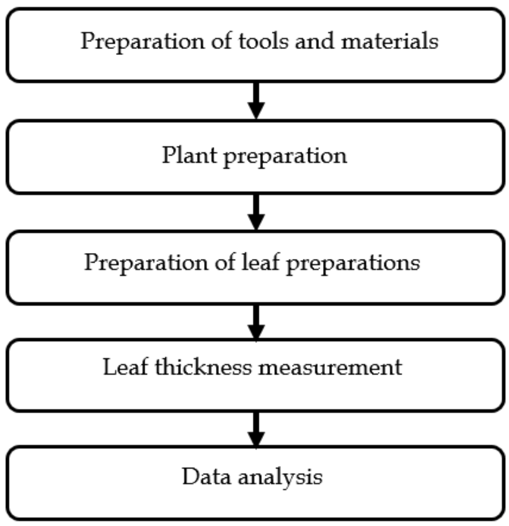

Figure 1. Chart of the stages of the research method

Tools and Materials

The tools used in this study were polybags measuring 30 x 35 cm, small shovel, scissors, slide, glass cover, tweezers, Olympus-CX 21 microscope, objective micrometer, Euromex rotary microtome, Memmert brand oven, Gunkol brand hot plate, staining jar, alcohol thermometer S-006, O'hauss balance brand A&D Company Limited, cutter, vials, film bottles, 50 ml beaker, ruler, measuring cup, petri dish, brush, razor blade, cardboard, label paper, tools wrote, Nikon D5200 DLSR camera, laptop, and OptiLab Advance SN: MTN004210791.

While the materials used are FAA solution (40% 5 ml formalin, 5 ml glacial acetic acid, 70% alcohol 90 ml), 30% alcohol, 50% alcohol, 70% alcohol, 80% alcohol, 90% alcohol, 96% alcohol , Alcohol 100%, safranin 2% (aqueous solvent), fast green 0.5% (96% alcohol solvent), tert-butyl alcohol (TBA), paraffin oil, xylol, paraffin, Haup't Adhesive (gelatin, sodium benzoate , and distilled water), 3% formalin, distilled water, Canada balsam, roasted soil, poor sand, pearl brand NPK fertilizer (16:16:16) and six types of monocot plants, namely: adam hawa (Rhoeo discolor), daffodils (Hymenocallis littoralis), hanjuang (Cordyline fructicosa), lilies of paris (Chlorophytum laxum), song india (Dracaena reflexa) and sri fortune (Aglaonema commutatum Schott).

Plant Preparation

The plants used have almost the same height and number of leaves for each type of plant. Plants were transferred to the same planting medium, namely burnt soil and poor sand with a ratio (2:1). Plants were conditioned for two weeks prior to sampling in open areas. Watering is done every day and fertilizer once every 2 weeks.

Preparation of Transverse Incision Leaf Preparations

Leaf samples were taken at the base and top of the leaf. The part of the leaf that is taken is on the lamina by avoiding the leaf veins. Preparation of preserved preparations of transverse incision leaves using the paraffin method refers to Johansen (1940) yang telah dimodifikasi. Modifikasi meliputi pada pelembutan dengan direndam dalam pelemput pakaian yang mengandung Diisopropylester Dimethyl Ammoniumethylsulfate 5%, Penyayatan menggunakan ketebalan 12-14 µm, pelekatan menggunakan Haupt'final adhesive (Berlyn & Miksche, 1976; Orchard et al., 2008).

Measurement of Leaf Tissue Thickness

Observation of preparations was observed under an Olympus C-X 21 microscope magnification 10 ocular x 10 objective and taking photos with optilab advance. Measurement of leaf tissue thickness using image raster software.

Data Analysis

Leaf tissue thickness measurement data were analyzed using the Anova test (Analysis of variance) using the SAS application version 6.12 of 1996 with a nested design model (random nested pattern design). However, before testing the analysis of variance, it is necessary to test for normality and homogeneity. If the treatment shows significant results then proceed with the Least Square Different (LSD) test α=0.05. Furthermore, Pearson correlation test was performed for significant tissue results on the position factor of the base and leaf tip. Category pearson correlation coefficient (Amruddin et al., 2022).

Results and Discussion

The leaf anatomy tissue observed included the total thickness of the leaf anatomy, upper and lower epidermis, and mesophyll (palisade and spongy).

Anatomy of Six Types of Monocot Ornamental Plants

Based on anatomical observations, the leaves of the adam hawa plant (Rhoeo discolor) (Figure 2) have upper and lower epidermal tissues and mesophyll which have differentiated into palisade tissue and spongy tissue. Adam has an upper epidermis that is thicker than the lower epidermis, because the upper epidermis has a hypodermis. Moreover, palisade tissue consists of vertically standing cells with a thinner thickness than the upper epidermis. Furthermore, adam hawa also has spongy tissue which is located between the palisade and the lower epidermis. Adam hawa base leaves have a total leaf thickness, palisade tissue, and upper epidermis which are thicker than the top leaves. While the upper epidermis and sponges are thicker on the top leaves than the base leaves.

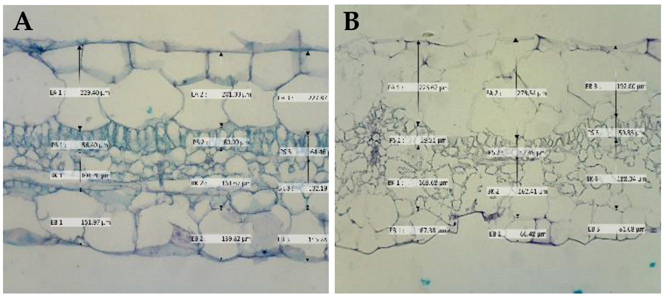

Figure 2. Adam hawa leaf anatomy (Rhoeo discolor) (A) base leaf anatomy, (B) top leaf anatomy, upper epidermis (EA), palisade (PS), sponge (BK) and lower epidermis (EB)

The results of measuring the thickness of the adam hawa leaf tissue (Rhoeo discolor) at the base had an average total thickness (483.65 µm), upper epidermis (190.15 µm), palisade (49.94 µm), sponge (113.65 µm), and lower epidermis (136.09 µm). While shoot leaves have an average total thickness (454.80 µm), upper epidermis (212.41 µm), palisade (44.22 µm), sponge (132.55 µm), and lower epidermis (65.61 µm).

Anatomy of a lily (Hymenocallis littoralis)

Based on anatomical observations, daffodils (Hymenocallis littoralis) (Figure 3) have upper, lower, and mesophyll tissues that have not differentiated into palisade and spongy tissue. Daffodils have a lower epidermis that is thicker than the upper epidermis. The mesophyll is located between the upper and lower epidermis. Daffodil base leaves have a thicker total leaf and mesophyll thickness than shoot leaves. While the upper epidermis and lower epidermis are thicker on shoot leaves.

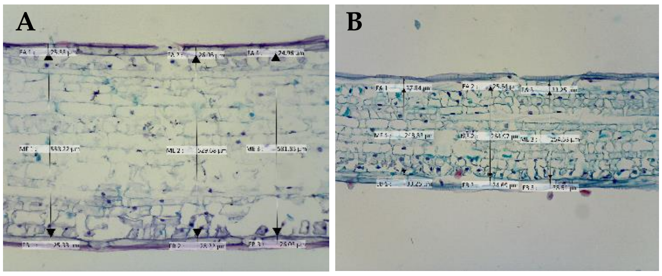

Figure 3. Anatomy of the leaf of the lily (Hymenocallis littoralis) (A) anatomy of the base leaf, (B) anatomy of the shoot leaf, upper epidermis (EA), mesophyll (ME) and lower epidermis (EB)

The results of measurements of the tissue thickness of daffodil leaves (Hymenocallis littoralis) at the base had an average total thickness (518.85 μm), upper epidermis (25.50 μm), mesophyll (467.77 μm), and lower epidermis (25.57 μm). While shoot leaves have an average total thickness (362.37 μm), upper epidermis (32.48 μm), mesophyll (295.63 μm), and lower epidermis (34.25 μm).

Anatomy of Hanjuang Leaves (Cordyline fruticosa)

Based on anatomical observations, hanjuang leaves (Cordyline fruticosa) (Figure 4) have upper epidermis, lower epidermis, and mesophyll that have not differentiated into palisade and spongy tissue. The leaves of the hanjuang shoots have a thicker total leaf thickness, upper epidermis, and mesophyll than the base leaves. While the lower epidermis is thicker on the base leaves.

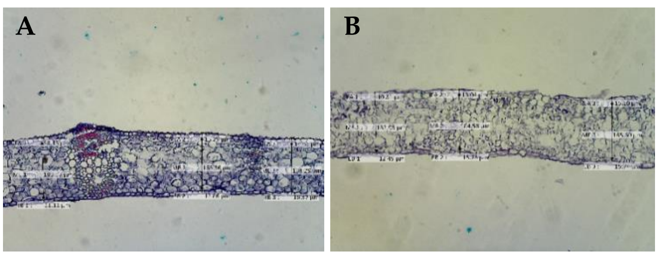

Figure 4. Anatomy of hanjuang leaves (Cordyline fruticosa) (A) base leaf anatomy, (B) top leaf anatomy, upper epidermis (EA), mesophyll (ME) and lower epidermis (EB)

The results of measuring the thickness of the leaf tissue at the base of the hanjuang (Cordyline fruticosa) base position had an average total thickness (180.24 μm), upper epidermis (12.20 μm), mesophyll (155.13 μm), and lower epidermis (12.91 μm). While shoot leaves have an average total thickness (193.06 μm), upper epidermis (13.54 μm), mesophyll (166.80 μm), and lower epidermis (12.72 μm).

Leaf Anatomy of the Paris Lily (Chlorophytum laxum)

Based on anatomical observations, the leaves of Paris lilies (Chlorophytum laxum) (Figure 5) have upper, lower, and mesophyll tissues which are differentiated into palisade and spongy tissues. Paris lilies have an upper epidermis which is thicker than the lower epidermis. In addition, Paris lilies have palisade tissue consisting of cells that stand vertically and are thinner in thickness than the upper epidermis. Spongy tissue is located between the palisade and the lower epidermis. Paris lily base leaves have a total leaf thickness, upper epidermis, palisade and sponge that are thicker than the top leaves. While the lower epidermis is thicker on the shoot leaves.

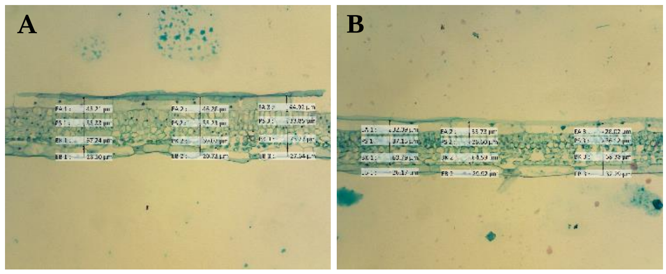

Figure 5. Anatomy of the leaves of the Paris lily (Chlorophytum laxum) (A) anatomy of the base leaf, (B) anatomy of the top leaf, upper epidermis (EA), palisade (PS), sponge (BK) and lower epidermis (EB)

The results of measurements of tissue thickness of Paris lily (Chlorophytum laxum) leaf base positions had an average total thickness (168.90 μm), upper epidermis (42.45 μm), palisade (32.95 μm), sponge (68.19 μm), and lower epidermis (25.31 μm). While shoot leaves have an average total thickness (144.85 μm), upper epidermis (32.53 μm), palisade (26.69 μm), sponge (59.38 μm), and lower epidermis (26.26 μm).

Anatomi Daun Song India (Dracaena reflexa)

Based on anatomical observations, the leaves of the Indian song (Dracaena reflexa) (Figure 6) have upper, lower, and mesophyll tissues that have differentiated into palisade and spongy tissues. Indian song has an upper epidermis that is thicker than the lower epidermis. In addition, song india has a layered palisade consisting of cells that stand vertically. Then the spongy tissue lies between the palisade and the lower epidermis. The leaf base of the Indian Song has a total leaf thickness, the upper epidermis, palisade and lower epidermis which are thicker than the shoot leaves. While sponges are thicker on the shoot leaves.

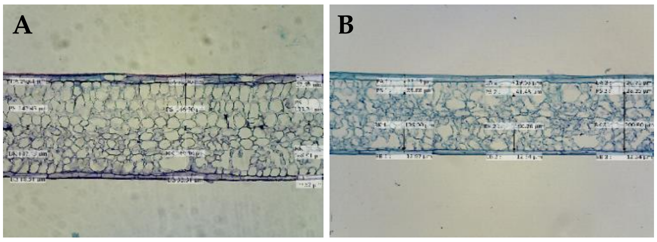

Figure 6. Anatomy of the leaf of the Indian song (Dracaena reflexa) (A) anatomy of the base leaf, (B) anatomy of the top leaf, upper epidermis (EA), palisade (PS), sponge (BK) and lower epidermis (EB)

The results of measuring the tissue thickness of the India Song leaf (Dracaena reflexa) at the base had an average total thickness (332.98 µm), upper epidermis (29.40 µm), palisade (126.76 µm), sponge (155.42 µm), and lower epidermis (21.42 µm). While shoot leaves have an average total thickness (293.61 µm), upper epidermis (21.63 µm), palisade (60.24 µm), sponge (195.47 µm), and lower epidermis (16.26 µm).

Anatomy of the Leaves of Sri Fortune (Aglaonema commutatum Schott.)

Based on anatomical observations, the leaves of Sri Fortune (Aglaonema commutatum Schott.) (Figure 7) have upper epidermis, lower epidermis and mesophyll which have differentiated into palisade and spongy tissue. Sri fortune has an upper epidermis that is thicker than the lower epidermis. In addition, sri fortune has a palisade network consisting of cells that stand vertically. Sponges are located between the palisade and the lower epidermis. The leaves of the base of the sri fortune have a total leaf thickness, the upper epidermis, palisade and lower epidermis which are thicker than the top leaves. While sponges are thicker on the shoot leaves.

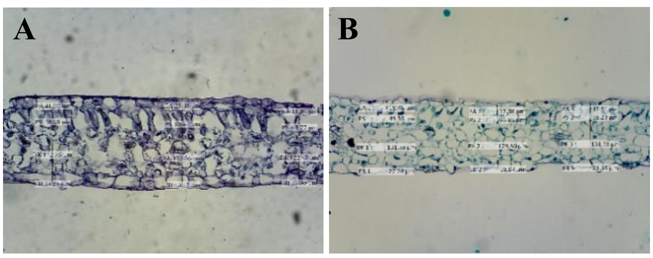

Figure 7. Anatomy of the leaf of Sri Fortune (Aglaonema commutatum Schott.) (A) anatomy of the base leaf, (B) anatomy of the top leaf, upper epidermis (EA), palisade (PS), sponge (BK) and lower epidermis (EB)

The results of measuring the tissue thickness of Sri Fortune (Aglaonema commutatum Schott.) leaf tissue had an average total thickness (270.76 µm), upper epidermis (29.59 µm), palisade (78.92 µm), sponge (133.94 µm), and lower epidermis (28.31 µm).). While shoot leaves have an average total thickness (233.27 µm), upper epidermis (22.71 µm), palisade (55.26 µm), sponge (135.18 µm), and lower epidermis (20.12 µm).

Based on observations of leaf tissue (Figure 1 to Figure 6) daffodils (Hymenocallis littoralis) and hanjuang (Cordyline fruticosa) have mesophyll tissue that has not differentiated into palisades and sponges, while the other four plant species, namely adam hawa (Rhoeo discolor), lilies paris (Chlorophytum laxum), song india (Dracaena reflexa), and sri fortune (Aglaonema commutatum Schott.) have mesophyll that has been differentiated into palisade and spongy tissue. According to Sumardi & Pudjoarianto (1993) In monocot leaves, the mesophyll is undifferentiated into palisade and spongy tissue. But the habitus of daffodils is herbs and hanjuang is shrubs. So that in monocotyledonous plants, not only the mesophyll grasses do not differentiate into palisades and sponges, but also occur in herbaceous and shrub habitus.

The six types of ornamental plants have a single layer of upper epidermis tissue, but in Adam Eve (Rhoeo discolor) it is equipped with a hypodermis. Tihurua et al. (2020) states that the hypodermis is a water-storing tissue that lies beneath the epidermis layer. The thicker the hypodermis of a plant indicates that the plant has a greater water storage capacity to prevent drought. The hypodermis can be found above and below the leaves, for example in the Piper acutilimbun plant (Tihurua et al., 2011). Thus Adam Eve has the potential to adapt to a rather dry environment.

Song india differs from the other five plants in terms of palisade tissue. Palisade tissue can consist of 1 to 3 layers that stand vertically. Klimko et al. (2018) reported that in several genera Dracaena there are palisade tissues that vary in number, namely 1-4 layers. The more layers of plant palisade tissue usually have the ability to photosynthesize more efficiently. Gotoh et al. (2018) stated that leaves with long palisade cells and high chloroplast content would be beneficial for plants exposed to high sunlight. The Indian song could have more efficient photosynthesis, but further measurements are needed.

The leaves of the six types of monocot ornamental plants have a thicker upper epidermis than the lower epidermis except for the daffodil (Hymenocallis littoralis). This is related to its function to prevent excessive transpiration and better protect the underlying tissue. Usually the upper epidermis has cells that are more rigid. According to Tihurua et al. (2020) thick epidermis is a form of adaptation to reduce the rate of transpiration.

Anatomical Thickness Analysis of Leaves of Six Types of Monocot Ornamental Plants at Base and Shoot Position

Normality and homogeneity were carried out before ANOVA (analysis of variance). The entire thickness of the leaf anatomical tissue was a sample that was normally distributed (p≤0.05), while the thickness of the upper epidermis was transformed to obtain normality. The results of the ANOVA can be seen in table 1. If the results are significant, then proceed with the LSD test α = 0.05.

Table 1. The Results of the ANOVA on the Anatomical Thickness of the Leaves of Six Types of Monocot Ornamental Plants at the Base and Top Position

Factor	The average thickness of the base leaves and shoots (μm)					
	KT	EA	EB	ME	PS	BK
Plant Type	*	*	*	*	*	*
Adam Eve (Rhoeo discolor)	472.50^{a}	199.35 (2.29^{a})	100.85^{a}	170.18^{cd}	47.08^{c}	123.10^{b}
Daffodil (Hymenocallis littoralis)	440.61^{a}	28.99 (1.46^{c})	29.91^{b}	381.70^{a}	-	-
Hanjuang (Cordyline fruticosa)	186.65^{d}	12.87 (1.11^{d})	12.82^{d}	160.96^{d}	-	-
Parisian lily (Chlorophytum laxum)	156.88^{d}	37.49 (1.57^{b})	25.78^{b}	93.60^{e}	29.82^{d}	63.79^{c}
Song india (Dracaena reflexa)	313.30^{b}	25.51 (1.40^{c})	18.84^{cd}	268.95^{b}	93.50^{a}	134.56^{a}
Sri Fortune (Aglaonema commutatum Schott.)	252.02^{c}	26.15 (1.41^{c})	24.22^{bc}	201.65^{c}	67.09^{b}	175.45^{b}
Position	*	Ns	*	*	*	ns
Base	326.99^{a}	54.88 (1.52^{a})	41.06^{a}	230.45^{a}	72.14^{a}	117.80^{a}
Shoots	280.33^{b}	55.88 (1.55^{a})	29.20^{b}	195.24^{b}	46.06^{b}	130.65^{a}
The position of the leaves nested into the plant	ns	Ns	*	*	*	ns
Base - Adam Eve (Rhoeo discolor)	490.19	186.29 (2.27)	136.09^{a}	163.59^{f}	49.94^{cd}	113.65
Shoots - Adam Eve (Rhoeo discolor)	454.80	212.41 (2.32)	65.61^{b}	176.78^{ef}	44.22^{d}	132.55
Base - Daffodil (Hymenocallis littoralis)	518.85	25.50 (1.41)	25.57^{d}	467.77^{a}	-	-
Shoots - Daffodils (Hymenocallis littoralis)	362.37	32.48 (1.51)	34.25^{c}	295.63^{b}	-	-
Base - Hanjuang (Cordyline fruticosa)	180.24	12.20 (1.08)	12.91^{f}	155.13^{f}	-	-
Shoots - Hanjuang (Cordyline fruticosa)	193.06	13.54 (1.13)	12.72^{f}	166.80^{f}	-	-
Base - Parisian lily (Chlorophytum laxum)	168.90	42.45 (1.63)	25.31^{de}	101.14^{g}	32.95^{de}	68.19
Shoots - Parisian lily (Chlorophytum laxum)	144.85	32.53 (1.51)	26.26^{d}	86.07^{g}	26.69^{e}	59.38
Base - Song india (Dracaena reflexa)	332.98	29.39 (1.46)	21.41^{e}	282.18^{b}	126.76^{a}	155.42
Shoots - Song india (Dracaena reflexa)	293.61	21.63 (1.33)	16.26^{f}	255.71^{c}	60.24^{b}	195.47
Base - Sri fortune (Aglaonema commutatum)	270.76	29.59 (1.47)	28.13^{d}	212.86^{d}	78.92^{b}	133.94
Shoots - Sri fortune (Aglaonema commutatum)	233.27	22.71 (1.35)	20.12^{ef}	190.44^{e}	55.26^{cd}	135.18

Table captions: total thickness (KT), upper epidermis (EA), lower epidermis (EB), mesophyll (ME), palisade (PS), sponge (BK), *=significant (α=0.05) and ns=nonsignificant. Different letters behind the mean in the same column show a significant difference when tested with LSD α=0.05.

Six types of monocot ornamental plants significantly influence all the thickness of the leaf anatomical tissue observed, namely the total leaf thickness, upper and lower epidermis and mesophyll (palisade and sponge). Adam hawa (Rhoeo discolor) and daffodils (Hymenocallis littoralis) had significantly higher total leaf thickness, followed by song india (Dracaena reflexa), sri fortune (Aglaonema commutatum Schott.), hanjuang (Cordyline fruticosa), and lilies paris (Chlorophytum laxum). Total thickness of adam hawa leaves (Rhoeo discolor) followed by upper and lower epidermis thickness was significantly the highest, while the total thickness of daffodil leaves (Hymenocallis littoralis) was followed by mesophyll thickness which was significantly highest. Then the total thickness of song india leaves (Dracaena reflexa) whose mesophyll has been differentiated into palisade and spongy followed by the highest thickness of palisade and spongy. This shows that the thickness of each tissue in the six types of monocot ornamental plants varies. Variations in leaf thickness are caused by genetics (Coneva & Chitwood, 2018). According to Metcalfe & Lime; Dickinson in Araújo et al. (2010) Anatomically, leaf organs vary the most based on hierarchical levels (species, genus, or even family) regardless of the influence of environmental factors. According to Palupi et al. (2021) The anatomical approach can show correlations between anatomical and other characters, so that it can be used for taxon restrictions, especially for taxonomic evidence such as dubious morphological characters. These tissue variations also indicate the potential of the species in responding to its environment such as adam hawa leaves have the ability to absorb more water in the presence of a hypodermis and can reduce high transpiration because it has thicker epidermal tissue. This can indicate that Adam and Eve can live better in areas that contain lots of water or have high humidity. Daffodils followed by song India had significantly higher mesophyll thickness than other plants (Table 1). Thickening of the mesophyll tissue indicates a higher content of chlorophyll and water vapor so that the process of photosynthesis can run efficiently. At the same time song india has two layers of palisade tissue which will adapt to different environmental conditions.

The total thickness of the leaf base is thicker than that of the top leaf because there is significant thickening of the lower epidermis, mesophyll and palisade (Table 1). The thickening of the total leaf thickness at the base is caused by an increase in the size and layer of cells. Afzal et al. (2017) showed that the base leaves of corn and sorghum were thicker than the top leaves. However Ningsih et al. (2022) indicates that the shoot leaves are thicker. The difference may be due to the different preparation methods. Then the lower epidermal tissue is significantly thicker on the leaf base. According to Juwarno et al. (2018) Increased thickness of the lower epidermis related to prevention of water loss.

The palisade tissue is thicker on the base leaves, this means that photosynthesis occurs more effectively on the base leaves. Palisade tissue has an important role in the process of photosynthesis because it contains many chloroplasts (Tobing et al., 2021). Tihurua et al. (2020) stated that a higher palisade ratio of spongy tissue showed the effectiveness of this tissue in the process of photosynthesis to obtain light and capture CO2. Then the palisade tissue is thinner on the shoot leaves, because the shoot leaves are still in the process of growth. According to Sarjani et al. (2017) growth and development of young leaves both morphological and anatomical structures are not fully developed.

The results of the study showing that the thickness of the palisade tissue was thicker on the base leaves were in line with the study Berghuijs (2016) on tomato leaves. However, contrary to what was obtained by Xie et al. (2003) in Asian pear plants (Pyrus serotina Rehd. cv. culta rehd), the palisade tissue on the leaf base is thinner Xie et al. (2003) also showed that photosynthesis in leaves aged 20 and 25 days had a maximum net photosynthesis. In most plants, the products of photosynthesis in the more mature leaves are transported to other parts, including the younger leaves. According to Azmin et al. (2021) the results of photosynthesis are distributed to all parts of the plant body that require the process of growth and development. In the studied monocotyledonous ornamental plants, the base leaves had a higher mesophyll or palisade than the leaves at the top. This may indicate that the root leaves in monocot plants have more efficient photosynthesis than the leaves at the top.

The thickness of the upper epidermis at the base of the leaves was not significantly different from the thickness of the upper epidermis at the shoots, which shows the function of the upper epidermis as a tissue that resists high transpiration and withstands exposure to light that is too high so as not to damage the underlying tissue from the base to the top of the leaf. This indicates that the upper epidermis is more rigid and is not affected by the position of the base and leaf tip. This is related to its function as a protector. Fahn (1991) states that the thickness of the epidermis is related to its function as a protector from UV and infra-red radiation.

The growth and development of leaves, both at the base and at the top, are in an area with the same temperature from 27°C-35°C. The optimal temperature range for the growth of most plants is 5 - 35°C, while the humidity is around 40%.(Prayugo, 2007). Plants can survive at certain temperatures to carry out photosynthesis.

Correlation between Total Leaf Thickness and UpperEepidermal Tissue, Mesophyll, Palisade

After that, a correlation test was performed for a significant network on the leaf position factor with the total leaf thickness. Significant tissues are the lower epidermis, mesophyll and palisade. The results of the correlation can be seen in Table 2.

The correlation between lower epidermal tissue and total leaf thickness showed a positive correlation except for the base leaves of the Parisian lily (Chlorophytum laxum), the base leaves and the shoots of Sri Rejeki (Aglaonema sp. var Siam Aurora). The positive correlation means the thicker the lower epidermis the thicker the total leaf thickness, while the negative correlation means the thinner the lower epidermis the thicker the total leaf thickness.

Then the correlation between mesophyll tissue and total leaf thickness shows a positive correlation, which means the thicker the mesophyll tissue, the thicker the total leaf thickness. According to Cambaba et al. (2016) Mesophyll tissue is the main part of the leaf blade so changes in mesophyll thickness greatly affect leaf thickness. According to Megia et al. (2016) The thicker the leaf, the thicker the mesophyll. Furthermore, the correlation between palisade tissue and total leaf thickness of four types of monocot ornamental plants, the position of the leaves at the base and the shoots showed a positive correlation, except for the shoots of Paris lilies (Chlorophytum laxum) which showed a negative correlation. The positive correlation means that the higher the palisade tissue, the higher the total leaf thickness. While the negative correlation means that the higher the palisade tissue, the lower the total leaf thickness. Gratani et al. (2006) stated that the increase in leaf thickness was mainly due to the thickness of the palisade tissue.

Correlation results showed that the total thickness of the leaves increased with increasing thickness of the lower epidermis, mesophyll and palisade tissue. This can be illustrated in the pattern written in table 3.

Table 2. Correlation Results between Lower Epidermis Tissue, Mesophyll, Palisade and Total Leaf Thickness

Plant Type	Position	Coefficient Correlation					
		EB		ME		PS	
		r	Category	r	Category	R	Category
Adam hawa (*Rhoeo discolor*)	Base	0.99	Very strong	0.99	Very strong	0.79	Strong
	Shoots	0.93	Very strong	0.94	Very strong	0.55	Strong enough
Bakung (*Hymenocallis littoralis*)	Base	0.95	Very strong	0.99	Very strong	-	-
	Shoots	0.76	Strong	0.96	Very strong	-	-
Hanjuang (*Cordyline fruticosa*)	Base	0.54	Strong enough	1	Very strong	-	-
	Shoots	0.86	Very strong	0.98	Very strong	-	-
Lili paris (*Chlorophytum laxum*)	Base	-0.09	Very weak	0.77	Strong	0.15	Very weak
	Shoots	0.99	Very strong	0.99	Very strong	-0.42	Strong enough
Song india (*Dracaena reflexa*)	Base	0.44	Strong enough	0.96	Very strong	0.36	Weak
	Shoots	0.33	Weak	0.99	Very strong	0.88	Very strong
Sri rejeki (*Aglaonema commutatum*)	Base	-0.13	Very weak	0.97	Very strong	0.91	Very strong
	Shoots	-0.49	Strong enough	0.97	Very strong	0.89	Very strong

Description: Lower Epidermis (EB), Mesophyll (ME), Palisade (PS)

Table 3. Pattern of Relationship between Total Leaf Thickness and Thickening of the Lower Epidermis, Mesophyll and Palisade on Six Types of Monocot Ornamental Plants

Species	Adam hawa		Bakung		Song india		Sri rejeki		Hanjuang		Lili paris	
Leaf thickness	Thick → Thin											
Position	PK	PC	PK	PC	PK	PC	PK	PC	PK	PC	PK	PC
Network												
EB	III	III	II	II	II	I	II	I	I	I	II	II
ME	I	I	III	III	III	II	II	II	I+	I+	I	I
PS	II	II	-	-	III	III	III	III	-	-	I	I

Note: PK=base, PC=top, EB=lower epidermis, ME=mesophyll, PS=palisade. I=thin thickness, II=medium thickness, III=thick thickness, I+ = thicker thickness than I, -= mesophyll not differentiated into palisade.

The increase in leaf thickness is due to having a thick lower epidermis such as in adam hawa (Rhoeo discolor) and paris lilies (Chlorophytum laxum) both at the base and shoot positions. If the thickness of the lower epidermis decreases, the total leaf thickness also decreases, seen in adam hawa (Rhoeo discolor) to paris lilies (Chlorophytum laxum). The thickness of the leaves is also affected by the thickness of the mesophyll as in the daffodil (Hymenocallis littoralis). If the mesophyll is thick, the leaves will also be thicker. Then seen from the palisade network, the thicker palisade also affects the thickness of the leaves. In plants where the mesophyll has differentiated into palisade and spongy, the palisade plays a more important role in leaf thickness.

Conclusion

In conclusion, the type of monocot ornamental plants significantly affects the total leaf tissue thickness, upper and lower epidermis, mesophyll in undifferentiated ornamental plants and palisade and spongy tissue in differentiated mesophyll. However, leaf position has no effect on the thickness of the upper epidermis and spongy tissue in differentiated plants. The thickness of the lower epidermis followed by the thickness of the mesophyll and palisade is related to the thickness of the total leaf thickness.

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Author Contribution

Conseptualization, M., E.D., and A.N.M.; methodology, M., E.D., and A.N.M.; software, M., and E.D.; formal analysis, M., and E.D.; data curation, M., and E.D.; writing-original draft, M., E.D., and A.N.M.; supervision, E.D., and A.N.M.

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Conflict of Interest

The author declare no conflict of interest in this research.

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