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Adsorbative and Absorbent Properties of Andong (*Cordyline fruticosa* (L.) A. Chev.) Plant Morphology for Mitigating Motor Vehicle Lead Emissions

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ABSTRACT

Motorized vehicles contribute to air pollution containing lead. The ability of leaves to absorb pollutants is influenced by leaf characteristics. Stomata are one of the entry points for pollutants, especially from the air, such as lead. The research aims to: obtain information about morphological and anatomical characters and compare between cultivars. Using exploration and characterization methods. Leaf morphology, based on observations of color, shape and size, is different Winnie Gold cultivar has length, L/W, width, Miss Andrea cultivar has higher width, lower L/W. The H. Bonsai cultivar has lower length, width, leaf area than the other 5 cultivars.The anatomy of andong leaves is based on observations of stomata, the same, hypostomatic/abaxial and actinocytic types. The Fire Brand cultivar has a higher number, density, lower width, the H. Bonsai cultivar has a higher length, higher width, lower number, density, the Miss Andrea cultivar has a lower length than the other 5 cultivars.
Keywords : *Cordyline fruticose*, morphology, anatomy, lead

INTRODUCTION

Motorized vehicles contribute 85% of air pollution containing lead/lead, suspended particulate matter (SPM), nitrogen oxides (NOx), sulfur oxides (SO_2), hydrocarbons (HC), carbon monoxide (CO_2), photochemical oxides (Ox) (Ismiyati *et al.*, 2014). The average size of lead emitted from motor vehicles is 0.02 – 0.05 µm, amounting to 60 – 70% (Sulistiana and Setijorini, 2016). Lead is a heavy metal with a high level of distribution and availability in water, soil and air when compared with other types of heavy metals (Tangahu *et a*l., 2011).

Andong is used as an ornamental plant in city parks because it can absorb lead from the soil (Haryanti *et al*. 2013) and from the air (Putri and Ariffin, 2018), a medicinal plant (Wijaya and Cahyanto, 2023 and (Suliartini *et al*., 2023)., natural dyes, especially: batik (Rosita *et al*., 2014), leaves as food packaging (Metananda *et al*., 2023).

Macroscopically, plant leaves that are contaminated with lead above normal levels will experience chlorosis and necrosis, while microscopically plant leaves will experience changes in the size and number of leaf stomata. Chemical changes can be seen from the level of accumulation and element content in leaf tissue (Satolom *et al*., 2013). Stomata are one of the entry points for pollutants, especially pollutants that come from the air, such as lead.

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Andong has varied leaf colors and patterns. Leaves that have varying colors and patterns have different morphological and anatomical structures. (Rocca *et al*., 2011). Variations in color and pattern in leaves can be studied by analyzing the morphological and anatomical structure of the leaves.

This research aims to: obtain information about the morphological and anatomical characters of horse cart plants and compare the morphological and anatomical characters of horse cart plants between cultivars.

The morphology of andong leaves, based on observations of color, shape and size, is different. Morphology based on color and shape of the leaves, is presented in Figure 1. The leaves are shaped like swords or lanceolates, the tip is sharp, the base is pointed, the edges are flat, the arrangement of the bones is pinnate. Leaf color varies between cultivars. Cultivar White has green, green and white leaves, smooth leaf surfaces, pointed and sometimes curved leaf tips. The Drawft Pink cultivar has maroon, red, pink leaves, rough, wrinkled (rugose) leaf surfaces, slightly wider/blunt leaf tips and sometimes curved. The Fire Brand cultivar has maroon, red, pink leaves with red and pink leaf tips. smooth, thin and transparent leaf surface, pointed leaf tip. The H. Bonsai cultivar has dark brown leaves, smooth leaf surfaces, pointed and curved leaf tips. The Miss Andrea cultivar has green, brown and bone white to cream colored leaves, rough, wrinkled (rugose) leaf surfaces, pointed and sometimes curved leaf tips. The Winnie Gold cultivar has orange, yellow, green leaves, smooth, thin and transparent leaf surfaces, pointed leaf tips. Variations in leaf color are caused by the presence of chlorophyll, carotenoid and anthocyanin pigments in the leaf tissue. The biosynthetic ability of each plant to produce color pigments is not the same, thus affecting the color of plant organs (Mlodzinska, 2009). Chlorophyll is a pigment that gives plants their green color, a solitary, vital and most abundant photosynthetic pigment (Tripathi and Gautam, 2007). Air pollution causes the breakdown of chlorophyll a and b into phaeophytin due to the loss of magnesium ions (Giri et al., 2013). Carotenoids are pigments responsible for yellow, orange and some reddish colors (Jenson, 1978). Chlorophyll and carotene are very important and are responsible for the color modification from dark green to yellow (Nayek *et al.,* 2014). Carotenoids protect chlorophyll from photooxidative damage (Giri *et al.,* 2013). Anthocyanins are red, orange, purple or blue colored substances (Hidayat and Saati, 2006).

Table 1. Size of Andong plant leaves

Cultivar	Length (cm)	Width (cm)
White	24.33 ± 3.79 b	7.73 ± 0.64 b
Drawft Pink	24.40 ± 2.25 b	9.87 ± 0.90 cd
Fire Brand	27.23 ± 3.07 b	9.00 ± 0.00 bc
H. Bonsai	10.57 ± 1.40 a	4.50 ± 0.50 a
Miss Andrea	22.33 ± 1.35 b	10.87 ± 0.40 d
Winnie Gold	35.83 ± 5.35 c	9.90 ± 1.28 cd

Note : Numbers followed by different letters in the same column showed a significant difference in the DMRT test of 0.05

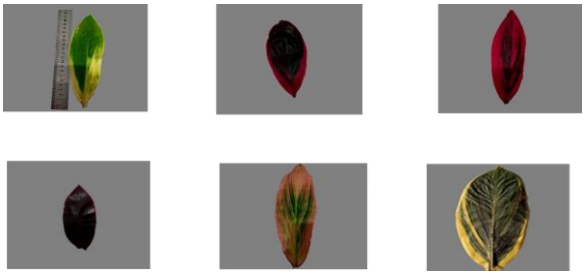

Figure 1. Leaf morphology based on color and shape of six Andong cultivars
(a) White, (b) Drawft Pink, (c) Fire Braand, (d) H.Bonsai, (e) Miss Andrea White, (f) Winnie Gold

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Character Anatomy

The anatomy of andong leaves, based on observations of the stomata, is the same. The anatomy of andong leaves, based on observations of the stomata, is presented in Figure 2. Based on the position on the leaf surface, the sixth cultivar has hypostomatic/abaxial type stomata, namely stomata that are only found on the lower surface of the leaf. This is in accordance with research conducted by Fathia *et al.* 2015. The sixth cultivar has actinocytic type stomata. This is in accordance with research conducted by Nurza, (2019). Stomata have guard cells accompanied by 2 guard cells. The actinocytic type of stomata is a variation of the diacytic type, the stomata are surrounded by guard cells that are regularly arranged in rows (Mulyani, 2006).

Stomata are one of the plant organs that are used to interact with their environment. Stomata are one of the entry points for pollutants, especially pollutants that come from the air, such as: lead.

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Table 2. Stomata size of Andong plants

No.	Cultivar	Number Stomata	Stomata Length (µm)	Width Stomata (µm)	Stomata Density (μm^2)
1.	White	13.94 ± 1.55 ab	18.48 ± 1.05 bc	10.52 ± 3.07c	39.84 ± 4.42 ab
2.	Drawft Pink	14.72 ± 1.36 b	16.79 ± 1.28 ab	8.76 ± 1.36 ab	40.06 ± 3.88 b
3.	Fire Brand	20.30 ± 2.75 d	17.89 ± 0.81 bc	8.09 ± 0.90 a	57.99 ± 7.86 d
4.	H. Bonsai	12.94 ± 1.78 a	19.18 ± 1,29 c	11.24 ± 1.65 d	36.98 ± 5.09 a
5.	Miss Andrea	17.43 ± 2.33 c	15.75 ± 2.99 a	9.02 ± 1.02 b	49.79 ± 6.66 c
6.	Winnie Gold	14,22 ± 1.38 b	17.60 ± 1.13 bc	9.37 ± 1.29 b	40.63 ± 3.82 b

Note : Numbers followed by different letters in the same column are significantly different in the DMRT 0.05 test.

(a) (b) (c)

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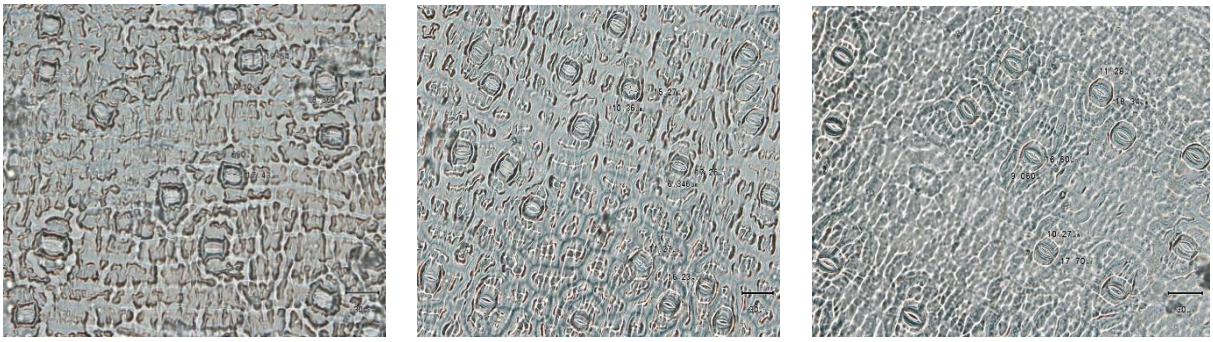

(d) (e) (f)

Figure 2. Stomata of leaves of six Andong cultivars
(a) White, (b) Drawft Pink, (c) Fire Braand, (d) H.Bonsai, (e) Miss Andrea White, (f) Winnie Gold

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Stomata are one of the plant organs that are used to interact with their environment. Stomata are one of the entry points for pollutants, especially pollutants that come from the air, such as: lead. Motorized vehicles produce 85% of air pollution containing lead/lead, suspended particulate matter (SPM), nitrogen oxides (NOx), sulfur oxides (SOx), hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO2), photochemical oxides (Ox) (Ismiyati *et al*., 2014). Lead is a heavy metal with a high level of distribution and availability in the air, soil and air when compared to other types of heavy metals (Tangahu *et al.*, 2011). In general, stomata are located on the bottom of the leaf. is a mechanism for plant adaptation to conditions that are detrimental to plants, such as air pollution, including reciprocal emissions from motor vehicles (Campbell, 2003). The reciprocal emissions from motor vehicles that fall on the upper surface of the carriage leaf only stick to it (get trapped) but cannot enter (absorb) because the upper surface of the carriage leaf does not have stomata.

Leaf anatomy based on stomata measurements is presented in Table 2. The Fire Brand cultivar has a higher number and density of stomata and is significantly different from the other 5 cultivars. The H. Bonsai cultivar has a stomata length that is higher than but not significantly different from the other 5 cultivars and the stomata width is higher and significantly different from the other 5 cultivars. The H. Bonsai cultivar has a lower number and density of stomata and is significantly different from the other 5 cultivars. The Miss Andrea cultivar has a lower stomata length and is significantly different from the other 5 cultivars. The Fire Brand cultivar has a lower stomata width and is significantly different from the other 4 cultivars, except Drawft Pink. Stomata length ranges from 15.75 – 19.18 µm and stomata width ranges from 8.09 -11.24 µm. The number of stomata ranges from 12 – 20. Stomata density ranges from 36.98 – 57.99 mm2. Stomata length categories according to Agustini *et al.*, 1999: not very long (< 20 µm), long (20 – 25 µm), very long (> 25 µm). Categories for the number of stomata, according to Haryanti 2010: few (1 - 50), quite a lot (51 - 100), many (101 - 200), very many (201 - 300), infinite (301 - 700). Stomata density categories according to

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Karubuy *et al*., 2018: low density (<300 /mm2), happy density (300 – 500 mm2) and high density (>500 mm2). The length of the stomata is related to the width of the stomata, that is, when the stomata are open, the guard cells only widen and the length of the stomata remains constant (Taluta *et al*., 2017). An internal factor that influences lead levels in plant leaves is the size of the leaf stomata (Siringgoringo, 2000). The results of the research showed that the six horse cart cultivars had less long stomata, a small number of stomata and a low stomatal density, however lead emissions from motor vehicles could enter through the stomata (absorb) because the size of the lead emitted from motor vehicles was smaller, measuring 0.02 on average. – 0.05 µm (Sulistiana and Setijorini, 2016), from stomata length which ranges between 15.49 - 20.28 µm and stomata width which ranges between 8.01 -12.61 µm. Thus, lead emissions from smaller motor vehicles can enter (absorb) through stomata that are larger in size (Ebadi *et.al*., 2005).

CONCLUSION

The morphology of andong leaves, based on observations of color, shape and size, is different. Differences in leaf color and pattern are related to pigment content. The anatomy of andong leaves, based on observations of the stomata, is the same. It has hypostomatic/abaxial type stomata, namely stomata that are only found on the lower surface of the leaf and stomata with guard cells accompanied by 2 guard cells. The actinocytic type of stomata is a variation of the diacytic type, the stomata are surrounded by guard cells that are regularly curved.

Based on morphological characters, the Winnie Gold cultivar has a higher length, L/W and leaf area than the other 5 cultivars. The Miss Andrea cultivar has higher leaf width and lower leaf L/W compared to the other 5 cultivars. The H. Bonsai cultivar has a lower length, width and area than the other 5 cultivars. Based on anatomical characters, the Fire Brand cultivar has a higher number, density of stomata and lower stomata width compared to the other 5 cultivars. The H. Bonsai cultivar has a higher length and width of stomata and a lower number and density of stomata than the other 5 cultivars. The Miss Andrea cultivar has a lower stomata length compared to the other 5 cultivars.

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