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Study on Leaf Epidermis Structure and Dust-Retention Ability of Five *Machilus* Species

Xinru HE[1], Yumu ZHANG[2], Bing SUN[1], Pujie WEI[1], Die HU[1*]

[1]*Germplasm Resources Evaluation and Innovation Center of Phoebe Yangtze University, Jingzhou 434025, Hubei, China;* *hexinru10@163.com*; *690593440@qq.com*; *1902113155@qq.com*; *1293446583@qq.com (*corresponding author)*
[2]*Shaoguan Agricultural Bureau, Guangdong, China; zhangyumu05@163.com*

Abstract

Taking the leaves of five *Machilus* species as a research object, they are *Machilus oreophila*, *Machilus chinensis*, *Machilus microcarpa*, *Machilus lichuanensis* and *Machilus suaveolens*. By measuring leaf surface area, cell length and width , the total dust retention, pH value of retention fluid and the content of Pb, Cr, Fe, Cu and Cd of metallic elements were measured, and compare the dust retention of five plant seedling leaves ability. The results showed that: the leaves of different kinds of *Machilus* have different dust abilities. Comprehensive analysis can be obtained from five kinds of *M*achilus dust ability in descending order of *M. suaveolens* > *M. lichuanensis* > *M. chinensis* > *M. microcarpa* > *M. oreophila.*

Keywords: dust-retention; epidermal cell; leaf morphology; *Machilus*; metal element

Introduction

There are about 100 species of *Machilus* in Lauraceae family in the world and more than 70 species in China, mainly distributed in southwest, south central to Taiwan, north to Shandong, Hubei and southwest Shanxi (Wu and Raven, 2000). Most of the *Machilus* plants were trees or shrubs, which were the most important economic forests in southern China, most of which were characterized by tropical and subtropical forests. The species has a high utilization value. The whole plant can extract aromatic oil, the seed oil can be used as a lubricant, the leaves and bark can be used as a purifying agent for dyes and drinking water, and a blending agent for various incense (Guo *et al*., 2017). And it has a strong ecological function, can effectively conserve water and soil, water conservation; plant leaves can absorb harmful substances in the air, purify the air, so as to achieve the effect of dust control and dust retention.

As early as last century, The dust retention effect of birch forest near open pit mine was studied by Spitsyna *et al.* (1991), the dust-retaining effect of urban forest land was studied by Beckett *et al.* (1998), and the dust-retaining ability of the Mexican road greening plant Oleander was studied by Dongarra *et al.* (2003), which proved that individual plants of all life types in nature have dust retention. Scholars began to study the dust retention ability of plants. High-end technologies such as micro-analysis (Bogo *et al*., 2003) have been successfully applied to the analysis of various elements in dust adsorbed by leaves, and have begun to study the toxicity of these fine particles. The combination of micro-analysis and surface analysis has made the analysis depth often less than 1 micron. Tomasevic (2005) showed that there was a great correlation between the composition of foliar dust and the contaminated elements in leaves. At present, the research on plant dust suppression has become a hot spot in China, and its ecological application potential is enormous. It is not only suitable for street trees and shade trees, but also has good wind and sand-fixing ability. It can be widely used in urban greening.

In this study, the dust-retaining ability of the *Machilus* plants and its influencing factors were compared, and the dust-retaining ability of the same species was compared. It can be intuitively found that the adsorption capacity of various heavy metal elements was strong and weak, and the best use of the materials, to maximize its ecological benefits, to tap the greater ecological potential of the *Machilus* plants. In the future practical application, it can be used as a reference to explore the feasibility of *Machilus* plants in garden application, provide scientific guidance for the selection of plants, and obtain the optimal plant application program to give full play to the ecological benefits of plants. Improve air quality and create a comfortable and healthy living environment.

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Materials and Methods

Plant materials and treatments

The experimental materials were leaves of *M. oreophila*, *M. chinensis*, *M. microcarpa*, *M. lichuanensis* and *M. suaveolens*. The mother plants were all three years old.

In April 2018, the leaves of five *Machilus* species plants were collected in the bonsai Garden of Yangtze University. Choose healthy genus of genus, each plant in the same growing environment; select the same position of the same part of the leaves when collecting samples. Each plant was randomly selected from 180 leaves. After being taken down, it was sealed in a sealed bag and taken back to the laboratory for treatment. Each plant leaf was divided into three groups of 60 pieces each, and three replicates were set in the experiment.

Determination of various indicators of leaves

Leaf morphology observation: five leaf samples of the seedlings of *Machilus* were placed in a DFC550 stereo microscope to observe the leaf shape, tip, veins and surface attachments of the leaves. The epidermis cells of the leaves of five *Machilus* species were observed by light microscopy, and their dimensions were measured by microscopic micrometer.

Leaf area determination: each of the leaves of the *Machilus* was 30 pieces, and the leaves were scanned with a scanner (resolution 300 dpi), and then the length, width and area of the leaves were measured by computer software. Calculated as follows:

Actual blade length (cm) = measured length pixel points × (2.54 / scanner resolution)

Actual blade width (cm) = measured width pixel number × (2.54 / scanner resolution)

Actual blade area (cm^2) = (2.54 / scanner resolution) 2 × measured number of pixels

Determination of total dust retention, pH value of heavy dust and heavy metal elements: (1) the collected leaves of five kinds of *Machilus* were weighed and recorded separately. After the leaves were washed and dried, they were weighed again. The difference between the two weighing weights was the total dust retention of the leaves. (2) Five sets of leaf samples were placed in five large beakers, each of which was poured into 200 mL of distilled water. After soaking the leaves for 2 h, the leaves were pinched out with tweezers, and the remaining dipping solution was the dust-retaining test solution. First adjust the pHS-3e type acidity meter with pH 6.86 and pH 9.18 standard solution. The two values were repeated until the value was stable and will not be changed arbitrarily. Then the composite glass electrode was inserted into the test solution to determine its pH. (3) The contents of heavy metal elements Fe, Cu, Pb, Cr and Cd in the dust-removing liquids of five *Machilus* species were determined by atomic absorption spectrophotometry (Abdel-Halim, 2003).

Statistical analysis

Data were presented as mean value of each treatment. The results represent the means ± standard error with each experiment performed in triplicate. Data were analyzed using SPSS 24.0 for Windows and differences in the treatment means were compared with Duncan's multiple range test at the $P \leq 0.05$ level.

Results

Leaf morphology observation

The leaves of five *Machilus* species plants were observed by stereo microscope, and were compared from leaf shape, tip, vein and surface attachment. The leaf shape was mainly lanceolate and elliptical, the leaf tip was acuminate, the leaf texture was leathery, and the veins were different. The surface of *M. chinensis* and *M. microcarpa*, was hairless, while the other three surfaces were hairy (Table 1).

Comparison of leaf area and size

The leaf area and size of five *Machilus* species were measured and calculated (Fig. 1). The leaf area of five *Machilus* species was found: *M. lichuanensis* was the largest, with an average of 14.77 cm^2, and *M. suaveolens* was the smallest, with an average of 10.698 cm^2. There was no significant difference in the leaf area between *M. oreophila*, *M. microcarpa* and *M. lichuanensis*, which was significantly different from that of *M. chinensis*. There was a significant difference between the leaf area and the leaf area of *M. suaveolens*. The leaf length of five *Machilus* species: the longest of *M. oreophila*, the average was 12.486 cm, the shortest of *M. chinensis*, the average was 7.49 cm, and the leaf length of *M. oreophila* was significantly different from that of *M. chinensis*, *M. microcarpa*, *M. lichuanensis* and *M. suaveolens.* The leaf width of five *Machilus* species: the widest of *M. lichuanensis*, the average was 2.556 cm, the narrowest of *M. suaveolens*, the average is 1.461 cm, and there were significant differences in leaf widths between *M. suaveolens* and *M. chinensis*, *M. microcarpa*, *M. oreophila* and *M. lichuanensis*.

Observation and comparison of leaf epidermal cells

The epidermal cells on the leaves of five *Machilus* species were observed by electron microscopy. Thirty cells in the field of view were randomly selected, and the length and width of the epidermis cells were measured (Fig. 2). The upper epithelial cells of *M. lichuanensis* were the longest and the widest, and there were significant differences in the length of upper epidermal cells among *M. chinensis*, *M. suaveolens*, *M. oreophila* and *M. microcarpa*; There was no significant difference in the width of upper epithelial cells between *M. microcarpa* and *M. lichuanensis*, but there was significant difference in the width of upper epithelial cells among *M. oreophila*, *M. chinensis* and *M. suaveolens*. The lower epidermal cells of *M. microcarpa* were the longest. There were significant differences in the length and width of the lower epidermal cells of *M. oreophila*, *M. chinensis*, *M. lichuanensis* and *M. suaveolens*.

Comparison of total dust retention and pH value of dust-retaining liquid

The total dust retention and the pH value of the dust-retaining liquids of five *Machilus* species were determined (Fig. 3). The total dust retention of *M. suaveolens* was the largest, with an average of 120 mg. *M. oreophila* was the smallest with an average of 77 mg. Under similar growth conditions, there were significant differences in the total dust retention of the five species of the *Machilus*. The pH values of the five species of *Machilus* were neutral. *M. microcarpa* was the highest with an average of 7.85. The lowest was *M. oreophila* and the average was 7.57.

Comparison of heavy metal elements in leaf dust per unit area

The heavy metal elements Pb, Cr, Fe, Cu, and Cd in the leaf dust area of the five species of the *Machilus* were compared (Fig. 4).

Pb content: the highest value of *M. suaveolens* was 0.13 mg/cm^2, the lowest of *M. oreophila* was 0.06 mg/cm^2. There was a significant difference in the content of heavy metal Pb in the leaf area of *M. suaveolens*, *M. oreophila*, *M. chinensis*, *M. microcarpa* and *M. lichuanensis*. However, the difference in Pb content per unit leaf area among *M. chinensis*, *M. microcarpa* and *M. lichuanensis* was not significant.

Cr content: The highest content of *M. suaveolens*, the average was 0.047 mg/cm^2, the lowest in *M. oreophila*, the average was 0.009 mg/cm^2. Under the similar growth environment, there was a significant difference in the content of heavy metal Cr in the leaf area among *M. suaveolens*, *M. oreophila*, *M. chinensis*, *M. microcarpa* and *M. lichuanensis*.

Fe content: the highest in *M. lichuanensis* was 0.128 mg/cm^2, the lowest in *M. microcarpa* was 0.067 mg/cm^2. There was no significant difference in the content of Fe in the leaf area of *M. chinensis* and *M. lichuanensis*, *M. oreophila* and *M. suaveolens*. But there was a significant difference in the leaf area per unit area among *M. chinensis*, *M. lichuanensis*, *M. oreophila*, *M. microcarpa* and *M. suaveolens.*

Cu content: The highest content of *M. suaveolens* was 0.023 mg/cm^2, the lowest was *M. oreophila*, the average was 0.012 mg/cm^2. There was no significant difference in the content of heavy metal Cu in the leaf area of *M. chinensis* and *M. lichuanensis*. There were significant differences in Cu content per unit leaf area among *M. suaveolens, M. oreophila*, *M. microcarpa*, *M. chinensis* and *M. lichuanensis*

Cd content: *M. suaveolens* was the highest with an average of 0.015 mg/cm^2, and *M. oreophila* was the lowest with an average of 0.011 mg/cm^2. There was no significant difference in the Cd content of the heavy metal elements in the leaf area of *M. oreophila* and *M. lichuanensis*, *M. chinensis* and *M. suaveolens*. But there was a significant difference in the Cd content per unit area among *M. chinensis*, *M. suaveolens, M. microcarpa*, *M. oreophila* and *M. lichuanensis*.

Table 1. Comparison of leaf morphology of five *Machilus* species

Species name	Leaf shape	Leaf apex	Leaf texture	Epidermal appendages	Leaf vein
M. oreophila	long lanceolate	apex acuminate	thin leathery	a little pubescent	fine honeycomb shape
M. chinensis	long ellipse or lanceolate	a blunt or short acuminate apex	leathery	glabrous	honeycomb shallow fossa points
M. microcarpa	oval or rectangular round lanceolate	apex caudate acuminate	leathery	glabrous	the veins are densely reticulated on both sides
M. lichuanensis	oval or narrow oval	apex short acuminate to acute	leathery	dense villi	the reticular vein is visible on the ventral side
M. suaveolens	oval or elliptical inverted lanceolate	a blunt sharp point	leathery	dense villi	honeycomb-like pits

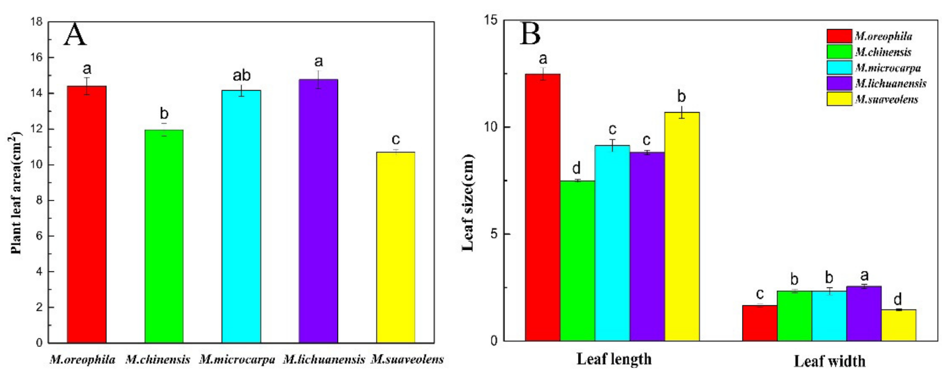

Fig. 1. Comparison of the leaf area and leaf size of 5 species of *Machilus*. A and B represent leaf area, leaf length and width, respectively. Each value represents the mean of three replicates of each plant, and the different normal letters in the same columns indicate significant differences at $P < 0.05$

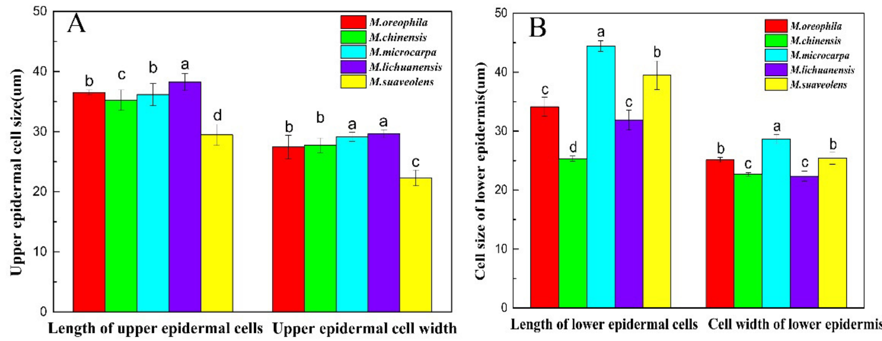

Fig. 2. Composition of epidermis cell in leaves of five *Machilus* species. A and B represent the length and width of upper epidermal cells and lower epidermal cells, respectively. Each value represents the mean of three replicates of each plant, and the different normal letters in the same columns indicate significant differences at P< 0.05

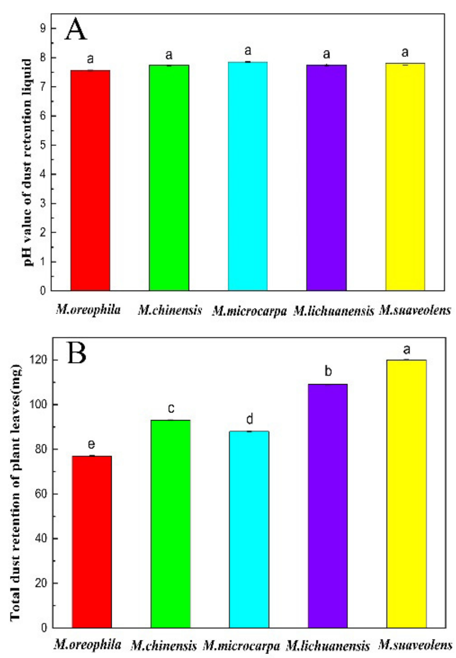

Fig. 3. Comparison of total dedusting amount and pH value of dedusting liquid in leaves of five *Machilus* species. A and B represent the pH value of dedusting liquid and total dust retention, respectively. Each value represents the mean of three replicates of each plant, and the different normal letters in the same columns indicate significant differences at P< 0.05

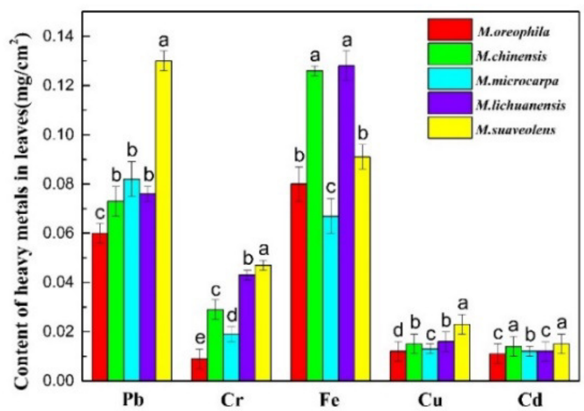

Fig. 4. Comparison of heavy metal contents in leaves of five *Machilus* species. Each value represents the mean of three replicates of each plant, and the different normal letters in the same columns indicate significant differences at P< 0.05.

Discussion

Different plants have different dust retention capacities and the same tree species have different leaf structure and different dust retention capacity due to differences in varieties (Tallis *et al*., 2011; Liu *et al*., 2013). The leaves of plants are the main carriers of dust in the air, and each plant leaf epidermis has its own unique characteristics and plant leaves have obvious barrier, filtration and adsorption effects on particulate dust in the atmosphere, which reduces the dust content in the atmosphere (Brack, 2002; Prusty *et al*., 2005; Qiu *et al*., 2009). However, there are significant differences in the dust-retaining ability of garden plants. A large number of studies have shown that the leaf surface roughness of plants, will affect its sedimentation effect on dust in the atmosphere (Liu *et al*., 2012). The leaf surface has gully structure, and the dense fluffy plants have strong dust-retaining ability. The plants with smooth and lint-free leaves have weaker dust-retaining ability, and some plant leaves are exposed to fluff or secrete oil and juice to absorb dust in the air (Sternberg *et al*., 2010; Fujiwara *et al*., 2011).

Powe, Willis (2004) and Beckett *et al*. (1998) studied that the relationship between leaf epidermis morphology and dust retention of some garden tree species. And they discussed the relationship between leaf structure and dust retention capacity of plants. It was found that the leaf structure with neat cell arrangement and smooth leaf surface had weak dust retention capacity, rough leaf surface, and obvious wrinkles or covered with dense epidermal hair, and the leaf with dense structure had strong dust retention capacity. The results of this study showed that the dust-retaining ability of *M. suaveolens* and *M. lichuanensis* was relatively strong. When observing the leaf morphology of five plants, it was found that the epidermis of *M. suaveolens* and *M. lichuanensis* was dense, while the dust-retaining ability was higher. The weak of *M. microcarpa* and *M. chinensis* have no epidermis, and the leaves are smooth, which is not conducive to the retention of dust. This is consistent with the previous research conclusions, but the dust retention ability of *M. oreophila* with the same leaf epidermis is not high. In other plants, it may be due to other external factors, but it cannot be denied the ability to retain dust, because plant leaf surface morphology is one of the important factors affecting plant dust retention, but it is not the only factor, there are many factors affecting plant dust retention capacity.

The amount of dust retention can intuitively reflect the strength of the dust-retaining ability (Kretinin and Selyanina, 2006).

Some scholars (Paulbeckett *et al*., 2006; Schaubroeck *et al*., 2014) have shown that the dust retention capacity of plants can be directly reflected, and the dust retention capacity of plants is positively correlated with its dust retention capacity. Schabel (1980) considered that there were great differences in dust retention ability among different plant individuals, whether broad-leaved or coniferous trees, shrubs or herbs. In this study, the total dust retention of the leaves of five *Machilus* species was: *M. suaveolens* > *M. lichuanensis* > *M. chinensis* > *M. microcarpa* > *M. oreophila*, this indicates that the dust retention capacity of plants can be directly affected by the dust retention capacity, which is consistent with previous conclusions, and further verifies that different plants have different dust retention capacity.

The content of heavy metals in plant leaves is closely related to the content of heavy metals in air pollution (Sloof, 1995; Wlau and Luk, 2001; Yin *et al*., 2013; Gajbhiye *et al*., 2016).

Fernandez and Oliva (2006), Norouzi *et al*. (2015) showed that the contents of heavy metals in plant leaves were significantly correlated with the concentrations of heavy metals in the atmosphere. Lehndorff and Schwark (2010) suggested that heavy elements in pine needles growing in Cologne City preferentially reflected atmospheric pollutant loads. Similarly, Simon *et al*. (2011) showed that the effects of air pollution in urban areas could be assessed based on elemental concentrations in foliage dust and leaf tissues of *Acer pseudoplatanus*. Our results are similar to theirs. The results show that different plants have different absorption and resistance to different heavy metal elements, and the same plants have different absorption capacities for different heavy metal elements, which may be due to different leaf surface morphology, which causes different reactions to different heavy metal elements. The quantitative analysis of heavy metal elements in the leaf area per unit area was found to be the strongest indicator of the retention of heavy metal elements in the leaves of *M. suaveolens* and *M. lichuanensis*, followed by *M. chinensis* and *M. microcarpa*, *M. oreophila* was the weakest. This result is consistent with the results of comprehensive evaluation of dust retention ability of leaves of five *Machilus* species. The higher the content of heavy metals in dust retention liquid, the stronger the dust retention ability.

Conclusions

This study has carried out related research on the dust-retaining ability of five *Machilus* species. The results showed that there were significant differences in the leaf size and appearance of the five plants. These differences affect the dust-retaining ability more or less. From the characteristics of leaf epidermis, the epidermal cells of the *Machilus* were mainly irregular and polygonal. From the point of dust retention and heavy metal elements, the adsorption capacity of each plant in the *Machilus* was different. The dust-retaining ability of five *Machilus* species was comprehensively evaluated. The order was: *M. suaveolens* > *M. lichuanensis* > *M. chinensis* > *M. microcarpa* > *M. oreophila*. Therefore, when selecting a dust-reducing tree species, it is possible to select the most suitable tree species according to the characteristics of the tree species, and to maximize the dust-retaining ability of the tree species.

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Conflict of Interest

The authors declare that there are no conflicts of interest related to this article.

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