Eco-Physiological Study on Two Urban Forestry Species  
(Azadirachta indica and Milletia thonningii) in Ghana

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Abstract: Eco-physiological study was conducted on A. indica and Milletia thonningii, two species often used in urban forestry. The study was conducted in the field to determine the pattern of transpiration, stomatal movement, relative humidity and anatomical features of leaves during the dry season in the Accra plains. The pattern of transpiration in Milletia thonningii during the period showed low rates in the morning, high rates at noon and low in the afternoon. Azadirachta indica on the other hand showed high rate in the morning, low rate at noon and low rate in the afternoon. The two behavioral patterns shown could be their response to drought. M. thonningii escape drought by shedding its leaves whereas A. indica is evergreen. Leaf Relative Water Content (RWC) for the two species was above 50%. Leaf anatomical study revealed the presence of thick cuticles. The stomatal frequency of A. indica was very high whereas that of M. thonningii was relatively low.

Key words: Azadirachta indica, Milletia thonningii, eco-physiology, transpiration

Introduction

Environmental stress (drought, heat, high or low temperature and relative humidity) normally results in the development of features that help plants to withstand stress conditions. Urban environment is normally stressful to plants species however, some plants are able to survive. Trees in urban environment suffer from poor management, pollution from exhaust fumes, erosion, cutlass wounds and others. In spite of all these plant species in urban environments contribute significantly to the clearing of the environment. They absorb the carbon dioxide in the atmosphere, absorb other chemicals and dispose off them through the peeling of the bark and dead branches.

Morphological features (both external and internal) and physiological responses are adaptive characteristics of plants in stressed environments. Some of the morphological features used include leaf angle (Schulze et al., 1987), leaf pubescence (Ehleringer and Mooney, 1978), polish upper leaf surface (Bazzaz et al., 1987), wax and resin coating (Mulroy, 1979), thick cuticle, (Trushow, 1970; Moomy and Gulmon, 1979), presence of mucilage (Green et al., 1986).

Studies to correlate transpiration behaviour with either the leaf anatomy or the ecological status failed to reveal any underlying patterns (Bannister, 1964). However the velocity of stomatal response depends to some extent on the rate of drying that is dictated by the external evaporating conditions (Chapin et al., 1987; Schulze, 1986). Most of the water taken up by the roots is lost through transpiration with little of it being used directly for plant growth (Schulze et al., 1987).

The internal water balance is known to affect nearly all-important physiological processes of plants (Hewlett and Kramer, 1963). Relative water content under stress could be used as a measure of tolerance to water stress (Srinivas Rao, 1986). However, Bannister (1978) indicated that whereas high water content may be indicative of high potential in one species or at a particular time of year, the same water content may be associated with a lower potential in a different species or at another time of year.

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Azadirachta indica and Millettia thorningii are two species commonly used in urban forestry. These species are able to thrive well in almost all drought stress environments. A. indica is an evergreen species whereas M. thorningii is a deciduous species. Eco-physiological study was conducted to determine the survival ability of these species in the urban environment.

**Materials and Methods**

The research was done in Accra in the coastal Savanna zone of Ghana from mid October to mid February 2000.

Three replicate twigs of approximately uniform sizes and physiological ages of *A. indica* and *M. thorningii* were used for transpiration rate determination. The transpiration rates were measured by the porometer method (Canong, 1908 as modified by Grobbellaar, 1960).

The total leaf area of each twig was calculated using the graph sheet method. The outlines of the various leaves were traced on the graph sheet and the area determined by collating the sizes. The air temperature and Relative Humidity (RH) were also measured using Ogawa Seiki thermohygrometer at 1 m above ground.

The Relative Water Content (RWC) of leaf was determined using the method of Weatherley (1950) as modified by Slattery and Barrs (1965).

Measurements were taken at specific times of the day viz., morning (8.00-9.00), noon (11.30-12.30), afternoon (3.00-4.00 pm). Only morning and noon measurements were recorded for RWC. Leaf epidermal peels were taken and mounted in glycerine to determine stomatal frequency. Five replicated field views were recorded.

Thin Transverse Sections (TS) at 3 μm thickness of leaf initially stored in Formal Acetic Acid (FAA) were made with a microtome. A camera lucida drawing of the epidermal peels and TS were produced.

![Graphs showing transpiration rate and relative humidity](image)

**Fig. 1:** Effects of prevailing diurnal ambient environmental conditions of temperature (°C) and Relative Humidity (% RH) on transpiration rates
Results and Discussion

The patterns of transpiration rates at high and low relative humidity are shown in Fig. 1. *M. thomningii* showed low rates in the morning, high rate at noon and low rate in the afternoon. *A. indica* on the other hand showed high rates in the morning, low rates at, noon and lower rates in the afternoon. The camera lucida drawing of the lower epidermis of *A. indica* (Fig. 2) showed approximately isodiametric cells. No stoma was observed in the upper epidermis. The lower epidermis contained numerous stomata (Table 1). The leaf T.S. of *A. indica* showed double-layered elongated palisade mesophyll (Fig. 3). The spongy mesophyll was made up of loosely packed isodiametric cells. *M. thomningii* showed elongated epidermal cells (Fig. 4). The stomatal frequency was relatively low (Table 1). No stoma was observed in the upper epidermis. The T.S. of *M. thomningii* showed relatively large elongated closely packed double-layered palisade mesophyll (Fig. 4). The diurnal stomatal dimension of both *A. indica* and *M. thomningii* was constant for both morning and afternoon (Table 1).

The pattern of transpiration rates observed in the study were peculiar in the sense that whereas *M. thomningii* showed a trend which was theoretically expected. *A indica* on the other hand showed the opposite. *A. indica* with its numerous stomata showed relatively low rate of transpiration showing that it may be depending on other factors to withstand the stress. The leaf RWC was low in the morning with very high turgor at noon (Fig. 1). The species may be depending on the anatomical features as well as the root system for adaptation to drought stress. The high stomatal frequency, coupled with open stomata may also be contributing to the efficiency of the species as these features may influence diffusion conductance (Mooney and Gulmon, 1979; Bannister, 1978).

The high transpiration rate of *M. thomningii* from morning to noon may be a characteristic of it deciduous nature. The species is able to escape drought by shedding the leaves. The species may be

<table>
<thead>
<tr>
<th>Species</th>
<th>Stomatal frequency (LP)</th>
<th>Stomatal length (μm)</th>
<th>Stomatal width (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Morning</td>
<td>Afternoon</td>
</tr>
<tr>
<td><em>A. indica</em></td>
<td>1737±27</td>
<td>0.028</td>
<td>0.028</td>
</tr>
<tr>
<td><em>M. thomningii</em></td>
<td>512±0</td>
<td>0.014</td>
<td>0.014</td>
</tr>
</tbody>
</table>
Fig. 3: TS of leaf lamina of *Azadirachta indica*

Fig. 4: TS of leaf lamina of *Milletia thonningii*

on the water supply from the sapwood of branches and twigs rather than the soil. The water storage in the branches and twigs may allow recharging of water in the sapwood after transpiration has decline in the afternoon (Schulze et al., 1985).

**Conclusion**

The results showed that *A. indica* was a good potential in plant-water economy. *M. thonningii* on the other hand is drought-resistant deciduous. The study could not explicitly correlate transpiration behaviour with the leaf anatomy. However, leaf anatomy, stomatal behaviour coupled with external morphological features may be contributing to the efficiency of the species.

**References**