Influence of canopy microclimate on incidence and severity of dogwood anthracnose¹

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Incidence and severity of dogwood anthracnose within the interior and exterior canopies of exposed dogwood (Cornus florida L.) trees and canopies of understory trees were recorded over a 53-day period during the summer of 1990. Concurrent measurements of vapor pressure deficit, air temperature, evaporative potential, and photosynthetically active radiation within the canopies were also recorded. Disease incidence was significantly lower in the exterior canopy of exposed trees than in other canopy locations. Disease severity was significantly different among all three canopy locations, with the lowest severity in exterior canopies of exposed trees and the greatest severity in canopies of understory trees. Of the climatic variables measured, evaporative potential provided the most consistent contrast among microclimates at the various canopy locations. Mean evaporative potentials averaged over 6- to 10-day intervals ranged from 0.00 g H₂O h⁻¹ in understory and exposed, interior canopies to 0.40 g H₂O h⁻¹ in exposed, exterior canopies. Disease incidence and severity were greater in canopies associated with low levels of evaporative potential.

Key words: Cornus florida L., dogwood anthracnose, canopy microclimate, evaporative potential.


Au cours d'une période de 53 j à l'été 1990, les auteurs ont enregistré l'incidence et la sévérité de l'anthracnose du cornouiller dans les canopies intérieures et extérieures de cornouillers arborecents (Cornus florida L.) exposés ainsi que les canopies d'arbres en sous-étage. Des mesures simultanées du déficit de la pression de vapeur, la température de l'air, le potentiel d'évaporation et la radiation active sur la photosynthèse ont été mesurées dans les canopies. L'incidence de la maladie est significativement plus faible dans la canope extérieure des arbres exposés qu'aux autres points des canopies. La sévérité de la maladie est significativement différente entre les trois localisations dans les canopies, la sévérité la plus faible se retrouvant dans les canopies extérieures et la plus forte dans les canopies en sous-étage. Parmi les variables climatiques mesurées, le potentiel d'évaporation est celui qui varie le plus entre les divers sites des canopies. Les potentiels d'évaporation moyens à intervalles de 6 à 10 j fluctuent de 0,00 g H₂O h⁻¹ en sous-étage et en position exposée, dans les canopies intérieures, à 0,40 g H₂O h⁻¹ dans les canopies extérieures exposées. L'incidence de la maladie et sa sévérité sont plus élevées dans les canopies où le potentiel d'évaporation est faible.

Mots clés : Cornus florida L., anthracnose du cornouiller, microclimat de la canopee, potentiel d'évaporation.

Introduction

Dogwood anthracnose is a newly described disease affecting dogwood trees (Cornus sp.) in North America (Hibben and Daughtrey 1988). The disease is caused by Discula destructiva Redlin, a fungus recently described as a new species of Discula (Redlin 1991). Where the disease has become established, it has caused high rates of tree mortality. For example, in 1984 one-third of the Cornus florida trees in Catoctin Mountain National Park had been killed by dogwood anthracnose (Mielke and Langdon 1986). Four years later, tree mortality in the same area had increased to 89% (Schneeberger and Jackson 1989). Cornus florida is an important resource, both in deciduous forests of the eastern United States and in urban landscaping programs, and the possibility that the species will decline severely or become extinct has caused much concern.

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RESULTS AND DISCUSSION

Disease incidence increased over time in all canopies (Fig. 1). The largest increase occurred between 26 July and 1 August. At the final measurement, mean incidence ranged from 0.35 clear days between 11:00 and 13:00 solar time. PAR levels were expressed as ratio of canopy PAR to ambient PAR. Ambient PAR was obtained from the average of readings taken in the open before and after each tree was sampled. This was done to minimize differences in total incoming PAR over the course of the season. PAR measurements were taken on five separate days during the months of July and August. Analysis of variance procedures were used to compare PAR levels of the three canopy locations (SAS Institute Inc. 1988).

Evaporative potential was measured with Livingston atmometers (Livingston 1935). Atmometers consisted of white porcelain spherical bulbs attached to water reservoirs by glass tubes (C&M Meteorological Supply, Riverside, Calif.). Reservoirs were wrapped in foil to minimize differences in water temperature among treatments. Replicate atmometers were placed in the canopies of two understory trees and in the interior and exterior canopies of two exposed trees. Replicate atmometers were also placed in open areas adjacent to each tree. Reservoirs were replaced at 6- to 10-day intervals. The adjusted water loss for intervals was determined by multiplying the difference in reservoir weight before and after placement in the field by a correction coefficient for standardization of each bulb obtained from the manufacturer. Evaporative potential was determined from the ratio of water loss to exposure time and expressed in g H$_2$O h$^{-1}$. Analysis of variance procedures and mean separation procedures were used to compare the mean differences between values (SAS Institute Inc. 1988).

Disease assessments were made at 6- to 10-day intervals from 18 July to 8 September 1990. Disease incidence is reported as the ratio of leaves with anthracnose symptoms to total leaves. Disease severity is reported as the percentage of leaf area with anthracnose lesions. A logarithmic rating scale developed by Horsfall and Barratt (1945) was used to assess the level of disease severity. Previously developed tables (Redman et al. 1969) were used to convert field ratings to percentages of diseased tissue.

Time was used as the covariate in analysis of covariance procedures applied to the data on disease incidence and severity (SAS Institute Inc. 1988). Standardized t-tests were performed to determine the significance of differences between adjusted means.

FIG. 1. Temporal changes in incidence and severity of dogwood anthracnose at a study site in the southern Appalachian Mountains of North Carolina.

Annual temperature is 12.6°C, and seasonal averages range from 6.7°C in the dormant season to 18.5°C in the growing season (Swank and Crossley 1988). Average annual precipitation is 1796 mm.

Seventy-five branches from three different canopy locations, namely understory, exposed interior, and exposed exterior, were monitored for changes in disease over time. Five branches were selected in each of five mature understory C. florida trees. All trees were within 25 m of each other, and the site was level. Because understory C. florida trees form a single layered canopy, all branches of these trees were considered to be in the exterior canopy. Five interior and five exterior branches within each of five exposed mature C. florida trees were also monitored for changes in disease. Exposed trees were within 0.5 km of the understory trees and were selected to ensure that the southern half of each tree received full sunlight.

Air temperature was monitored with thermocouple sensors (Electronically Monitored Ecosystems, Berkeley, Calif.). Relative humidity was monitored with thin-film polymer capacitor sensors (Omega Engineering Inc., Stamford, Conn.). Sensors were placed in the canopy of one understory tree and in the interior and exterior canopy of one exposed tree. Hourly measurements were taken throughout the course of the study. An electronic data logger automatically processed and recorded analog signals from the sensors (Electronically Monitored Ecosystems, Berkeley, Calif.). The rain computer network (Pickering et al. 1990) was used to collect and store all data.

Photosynthetically active radiation (PAR, 400–700 nm) was measured with the Sunfleck Ceptometer (Decagon Devices, Pullman, Wash.). This device is a portable integrating radiometer that measures PAR on 80 sensors located at 1-cm intervals along a narrow probe and automatically calculates and displays the arithmetic average of the sensor measurements. PAR was measured for every branch on which disease ratings were taken. Measurements were taken on}

<p>| TABLE 1. Analysis of covariance for effect of canopy location on incidence and severity of dogwood anthracnose |
|--------------------------------|-----------------|--------------|</p>
<table>
<thead>
<tr>
<th>Location</th>
<th>Incidence</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed tree, exterior canopy</td>
<td>0.29**</td>
<td>3.10**</td>
</tr>
<tr>
<td>Exposed tree, interior canopy</td>
<td>0.46</td>
<td>11.03***</td>
</tr>
<tr>
<td>Understory tree canopy</td>
<td>0.52</td>
<td>16.27**</td>
</tr>
</tbody>
</table>

*Ratio of infected to total leaves. **Percentage of leaf area with anthracnose lesions. **Adjusted means are significantly different from all other means at P < 0.01.

| TABLE 2. Comparison of PAR incidence in various canopy locations |
|-------------------|-----------------|
| Location          | Mean |
| Exposed tree, exterior canopy | 0.43** |
| Exposed tree, interior canopy  | 0.02  |
| Understory tree canopy       | 0.01  |

*Ratio of canopy PAR transmittance to total incoming PAR. **, significantly different at P < 0.01.
in the exposed exterior canopy to 0.70 in the understory canopy. Disease incidence was significantly lower in the exposed exterior canopy (Table 1).

Over time, disease severity changed substantially in the understory and exposed interior canopies (Fig. 1). Little change in disease severity occurred in the exposed exterior canopy. At the final measurement, disease severity ranged from 4% in the exposed canopy to 26% in the understory canopy. Disease severity varied significantly (at P < 0.01) among the different canopies (Table 1). There were diurnal fluctuations in temperature and vapor pressure deficit (VPD) in all three canopies. The largest changes occurred in the exposed exterior canopy (Figs. 2, 3). Differences between temperatures in the interior canopy of exposed trees and the canopy of understory trees varied. For example, in the 72-h period from August 18 to 20, differences greater than 1°C were observed three times, whereas in the 72-h period between August 8 and 10, differences greater than 1°C were observed seven times. All of the differences were observed over a 2- to 5-h period at midday (Fig. 2). VPD followed similar patterns (Fig. 3).

Significantly more PAR reached the exterior canopy of exposed trees than reached the other canopy locations (Table 2). No difference between the amount of PAR reaching the interior canopy of exposed trees and the amount reaching the canopy of understory trees was observed. In both canopies less than 2% of the available PAR reached the leaves.

Evaporative potential was lowest between July 18 and 25 (Fig. 4). During the same period precipitation was recorded on 6 of the 7 days. Evaporative potential was greatest in the period between July 25 and 31. Evaporative potential was greatest in atmometers placed in the open near exposed trees. Evaporative potentials in open areas on the forest floor did not differ significantly from the evaporative potential in the canopy of understory trees (Table 3). Within the three canopies, evaporative potential differed significantly in all sample periods except the period from July 18 to 25 (Table 3).

Although disease severity was significantly different in all
three canopy locations, air temperature, VPD, and PAR were clearly differentiated in only one of the tree canopy microclimates. Evaporative potential, an index of the drying potential and an integrated measurement of air temperature, VPD, air movement, and impinging solar radiation consistently distinguished all three canopy locations. The combined effect of subtle changes in climatic variables such as wind speed and solar radiation significantly impacts atmospheric evaporation rates. More fundamental approaches to measuring evaporation rates involve the use of meteorological instrumentation and mathematical formulation (e.g., Penman’s equation). The Livingston atmometer has several advantages in that it is inexpensive and easy to use and continuously integrates the combined effect of individual climatic variables without the need for sensitive electronic equipment.

The canopy with the most disease (understory canopy) was associated with the lowest evaporative potential measurements over the course of the season. The interior canopy of exposed trees had significantly higher evaporative potentials and lower disease severity than the canopy of understory trees, whereas the exterior canopy of exposed trees had the greatest evaporative potentials and lowest disease incidence and severity ratings. Thus, it appears that an inverse relationship exists between evaporative potential and severity of dogwood anthracnose in C. florida. Although prevalence of the disease has been associated with cool, moist environments (Anderson 1991), this is the first quantitative evidence for a relationship between microclimate and dogwood anthracnose.


