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LEAF TEMPERATURES OF *AGAVE VIRGINICA* L. DURING A CLOUDY AND A CLEAR DAY IN SUMMER[1]

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Abstract

Leaf temperatures of *Agave virginica* L. were measured with copper-constantan thermocouples and a null potentiometer. Measurements were made at 15-min intervals throughout a cloudy and a clear day in July 1970. When incoming solar radiation was high, leaf temperature was as much as 7.2 C above air temperature. When incoming solar radiation was low, leaf and air temperatures were nearly the same.

Introduction

Temperature is a very important physical factor of the plant's environment because the plant's biochemical functioning, thus growth and development, is either directly or indirectly influenced by temperature. Because of its importance in plant functioning and because it is relatively easy to measure, temperature is often measured in studies on plant-environmental relationships. In many studies on plant-temperature relationships, measurements have been made of air temperature only, and relatively few measurements have been made of temperatures inside the plant, especially under natural environmental conditions. Since ambient temperatures may be several degrees below plant temperatures under intense radiation (Ansari and Loomis, 1959; Gates, 1962; Mellor, Salisbury and Raschke, 1964; Salisbury and Spomer, 1964), measurement of temperatures inside of plants, especially those growing in environments where incoming radiation is high, is more meaningful than air temperature in interpreting plant-temperature relations. No plant temperature measurements have been made on plants growing under the extreme environmental conditions in the middle Tennessee cedar glades. The purpose of this study was to measure leaf temperatures of *Agave virginica* L., a characteristic species of the cedar glade community (Baskin, Quarterman and Caudle, 1968), during the summer when incoming radiation is high and temperatures at and near ground level may reach 40 C and above (Freeman, 1933; Baskin and Baskin, unpub. data). *A. virginica* was chosen as the plant for leaf temperature measurements because (1) it is one of the characteristic components of the cedar glade community that is actively growing and reproducing during the summer months and (2) its thick, succulent leaves allowed for easy insertion of the tiny thermocouples into the leaf mesophyll.

Methods

Measurements of leaf and air temperatures and incoming radiation were made in the natural cedar glade habitat of *A. virginica* on a cloudy day (8 July) and a clear day (27 July) during 1970. The *A. virginica* plants were growing in a small opening, about 35 feet in diameter, in a *Forestiera ligustrina* (Michx.) Poir. thicket. All readings of temperature and incoming radiation were taken at 15 min intervals. Leaf and air temperatures were measured using 40 gauge wire, copper-constantan thermocouples and a one-channel null potentiometer with a temperature and millivolt scale. The accuracy of the leaf and air temperatures measured with the potentiometer were within $\pm$ 1 C. A thermocouple was inserted into the mesophyll of the succulent *A. virginica* leaves so that the cooper-constantan wire junction was embedded completely in the tissue. Air temperatures were measured with a second thermocouple using the same potentiometer. The air-temperature thermocouple was shaded during readings; however, the temperature difference between the shaded and unshaded thermocouple was 1 C or less. The part of the leaf in which temperature measurements were made was about 8 cm above ground level; air temperature measurements were made at the same height and in close proximity to the leaf. In a typical measurement, leaf temperature was measured, the leaf thermocouple disconnected from the potentiometer, the air-temperature thermocouple connected to the potentiometer and air temperature read. The time elapsed between reading air and leaf temperatures was 30 to 45 seconds.

Incoming radiation was measured with a portable Yellow Springs Instrument model 68 direct reading pyranometer using a YSI model 6701 probe equipped with a silicon solar cell. The solar cell is responsive to wave lengths of 0.4 to 1.1 μ. The sensing element was mounted on a ring stand 1 meter above ground surface and was held in an exactly horizontal position.

Although not measured, wind speed in the *A. virginica* habitat during almost all of the measurements on both days was very low.

Results

On 8 July 1970, a relatively cloudy day, the sun remained almost totally obscured by clouds until about noon (Fig. 1a). Prior to 12:00 Noon the incoming radiation was low, usually less than 0.4 cal/cm^2/min. During this time the leaf and air temperatures were nearly the same. During mid day and early afternoon (12:00 Noon to 4:00 P.M.) when cloud cover in general was not as heavy as it was during the morning, the incoming radiation increased greatly (up to 1.18 cal/cm^2/min at 2:00 P.M.), causing an increase in temperature differences between leaf and air. When there was a difference in leaf and air temperatures, the temperature of the leaf was always higher. Differences between leaf and air temperatures fluctuated with cloud movements. With passage of a heavy cloud cover there was very little difference between leaf and air temperatures, but when the sun was relatively unobscured by clouds the difference between leaf and air temperatures increased. The greatest difference between leaf and air temperatures occurred at 1:15 P.M. when the in-

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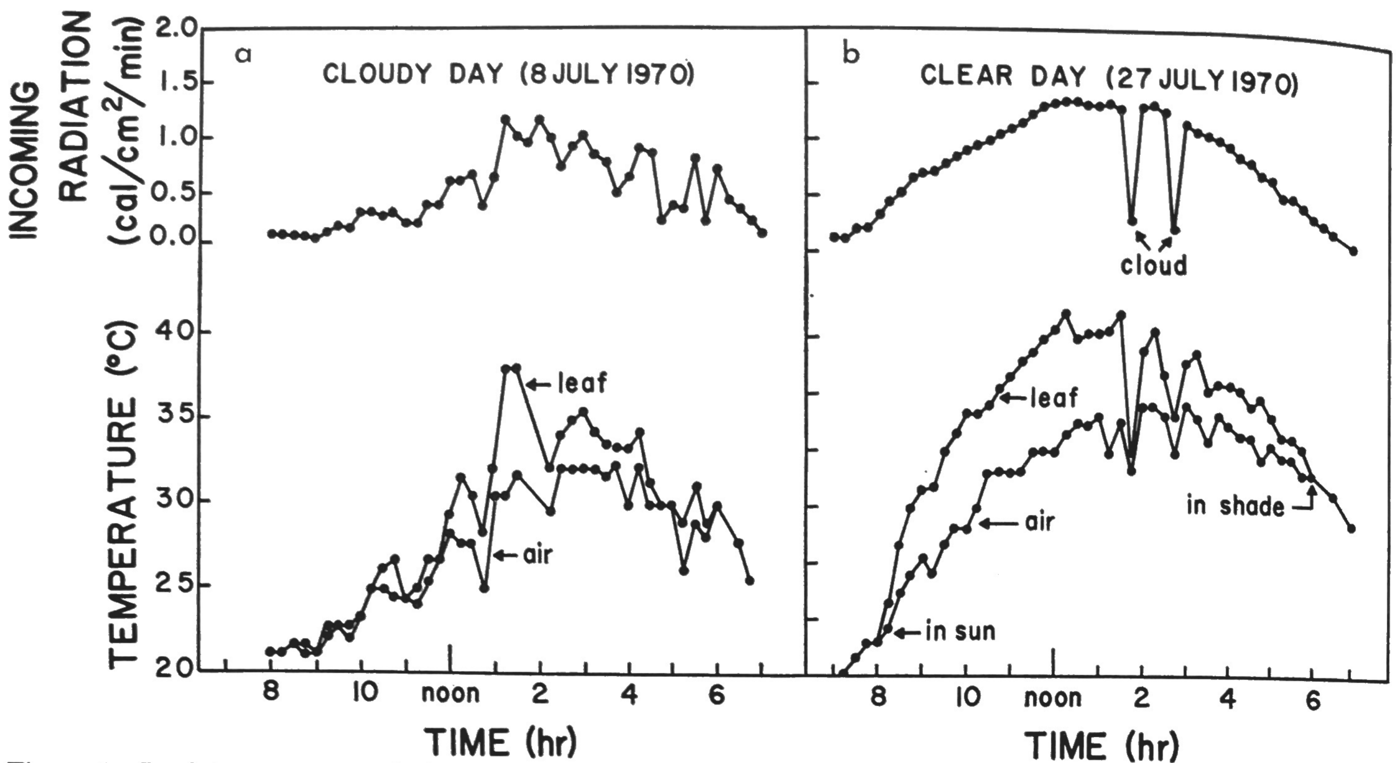

Figure 1. Leaf temperatures of *Agave virginica,* air temperatures and incoming solar radiation during a cloudy (a) and clear (b) day during July 1970.

coming radiation was at a peak (1.17 cal/cm²/min). At this time the air and leaf temperatures were 30.5 and 37.7 C, respectively. Toward late afternoon the incoming radiation decreased, and the difference between leaf and air temperatures in general decreased. At about 5:45 P.M. leaf and air temperatures were the same and remained the same until measurements were stopped at 6:45 P.M.

On 27 July 1970, a relatively clear day, measurements were started at 7:15 A.M. The *A. virginica* plants remained in the shadows of the surrounding *F. ligustrina* thicket until approximately 8:15 A.M. During the time that the leaves were shaded, leaf and air temperatures were the same; however, shortly after leaves were exposed to direct sunlight leaf temperature rose above air temperature. Leaf temperatures remained above air temperatures until about 6:00 P.M., when leaves again were shaded by the surrounding *F. ligustrina* thicket (Fig. 1b). In general, there was an increase in leaf and air temperatures and in the difference between leaf and air temperatures until about 12:15 P.M. The greatest difference (7.2 C) between leaf and air temperatures was recorded at 12:15 P.M. At this time the incoming radiation reached its peak for the day, 1.38 cal/cm²/min. During the afternoon there was a decrease in leaf and air temperatures and in the difference between leaf and air temperatures until about 6:00 P.M., at which time leaf and air temperatures were the same.

Early in the afternoon, the incoming radiation twice was drastically reduced by passage of clouds. During these brief intervals leaf and air temperatures dropped, and the differences between leaf and air temperatures were reduced greatly.

Conclusions

The following conclusions are drawn from this study: (1) under high insolation during summer, leaf temperatures of *A. virginica* may be as much as 7 to 8 C higher than temperatures of the surrounding air; (2) on summer days characterized by a heavy cloud cover leaf and air temperatures are nearly the same; (3) on clear summer days the leaf temperatures of *A. virginica* may remain above air temperatures throughout most of the daylight period unless shaded; (4) during intermittently cloudy summer days leaf temperatures are several degrees above air temperature during periods of high incoming radiation while during periods of low incoming radiation leaf and air temperatures are nearly the same and (5) accurate assessment of the plant-temperature relations of cedar glade plants should include measurements of temperatures inside the plants.

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