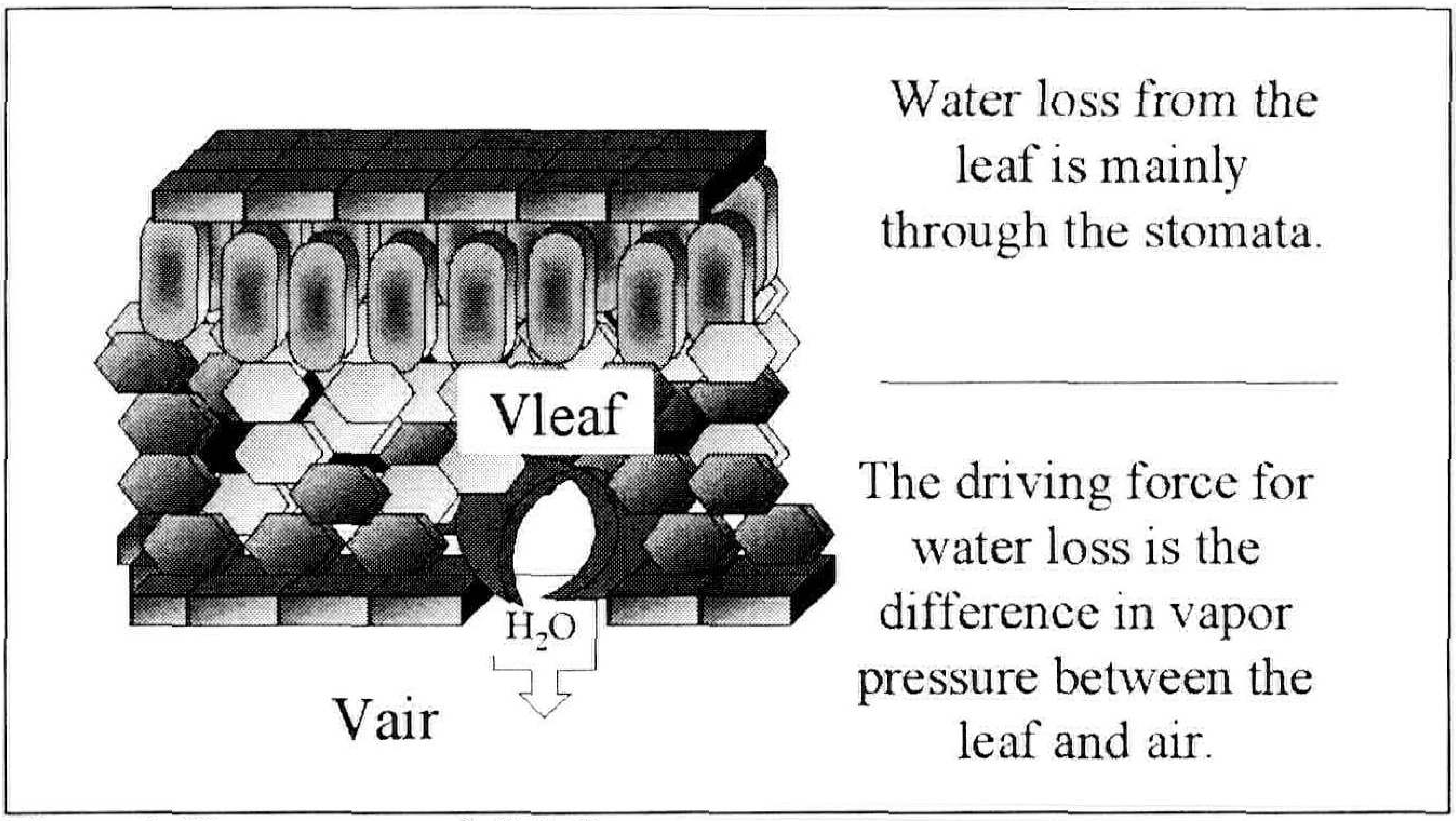
A Dynamic Control System for Scheduling Mist Propagation in Poinsettia Cuttings

Robert Geneve, Richard Gates, Sergio Zolnier, James Owen, and Sharon Kester
Department of Horticulture, Department of Biosystems and Agricultural Engineering.
University of Kentucky, Lexington, Kentucky 40546 U.S.A.

INTRODUCTION

Major greenhouse crops, (poinsettia, chrysanthemum, and geranium), as well as many woody nursery crops are propagated by softwood cuttings. The typical propagation system used to root cuttings is open bench misting. Although, cuttings from many species are remarkably tolerant of variable environments in the mist bench, mist propagation as currently employed can be an inefficient use of inputs such as water and electricity. This is the consequence of static control systems for controlling the interval between misting events. In some cases, inappropriate control of misting intervals can reduce or delay root formation by allowing cuttings to wilt, leaching nutrients from the leaf, or saturating the medium with water. In contrast, dynamic systems for controlling mist rely on plant or environmental signals to estimate the water status of cuttings. Several alternatives to static control have been developed including simulated mechanical or electronic leaves, light sensors, and humidistats (Hartmann et al., 1997). The objective of the current study was to evaluate an evapotranspiration model (Zolnier et al., 1998) for scheduling misting for poinsettia cuttings under summer greenhouse conditions.

Commercial poinsettia production starts with propagation of terminal cuttings taken from stock plants during midsummer in the United States. Summer season greenhouse environments are typically most severe because of high solar radiation, temperature, and air vapor pressure deficit (VPD). Because poinsettia terminal cuttings are initially unrooted, the propagation effort is focused on providing an optimal environment for the cuttings until they develop roots, typically 3 to 4 weeks. Water status of the cuttings must be maintained by maximizing water uptake and providing mechanisms to limit transpirational water loss (Mudge et al., 1995). Techniques such as intermittent mist, fogging systems, and shading control (Hartmann et al., 1997) that control VPD (Gates et al., 1998) can be used. VPD is the difference between the vapor pressure in the leaf (V_{leaf}) and the vapor pressure of water in the air (V_{air}) (Fig. 1). Vapor pressure deficit is the driving force for water loss from leaves. Because cuttings are initially unrooted, the propagator must limit transpiration. Fogging systems, humidity tents, and enclosed misting increase V_{air}, while open bench misting impacts V_{leaf} by water evaporating from the leaf surface, thereby reducing V_{air} and increasing V_{leaf}. Note that VPD of air is commonly used as a substitute for VPD leaf – air. This is acceptable so long as leaf temperature does not vary from air temperature by more than a few degrees.



Water loss from the leaf is mainly through the stomata.

The driving force for water loss is the difference in vapor pressure between the leaf and air.

Figure 1. Vapor pressure deficit diagram.

Recently, we have devised a dynamic misting control strategy for poinsettia propagation (Zolnier et al., 1998). Evaporation from cuttings is estimated from an energy balance (the Penman-Monteith equation) using parameters obtained from carefully controlled growth chamber experiments and online measurements of canopy temperature, air temperature and relative humidity, and light intensity (Zolnier et al., 1998). Mist is only activated when predicted evaporation reduces stored water in the canopy to below a threshold quantity.

MATERIALS AND METHODS

Stockplants and Cuttings. Poinsettia (*Euphorbia pulcherrima* 'Freedom') stock plants were maintained under standard greenhouse conditions and prevented from flowering by daylength control. Terminal cuttings (9 cm long) were treated with IBA (1000 ppm quick dip) and stuck in peat and perlite (1 : 1, v/v) medium.

Mist Chambers. Cutting were misted by four Netafilm nozzles suspended above the bench adjusted for uniform coverage (Fig. 2). Four individual mist chambers (1.5 m × 3 m) were independently controlled by computer. Two chambers were statically controlled for mist at 5 sec every 5 min. The remaining two chambers were dynamically controlled using the evapotranspiration model (Zolnier et al., 1998). The computer recorded temperatures, misting times and calculated V_{air} every minute. Root number and length was recorded after 21 days.

RESULTS AND DISCUSSION

The major difference between the two systems of mist control was the amount of water used. There was a 38% reduction in misting using the dynamic control system. This reduction in water usage should have resulted in a less wet propagation medium and could account for the differences seen in root length and diameter for the dynamically controlled cuttings. In general, the dynamic system of control misted more frequently during sunny conditions, and less frequently during

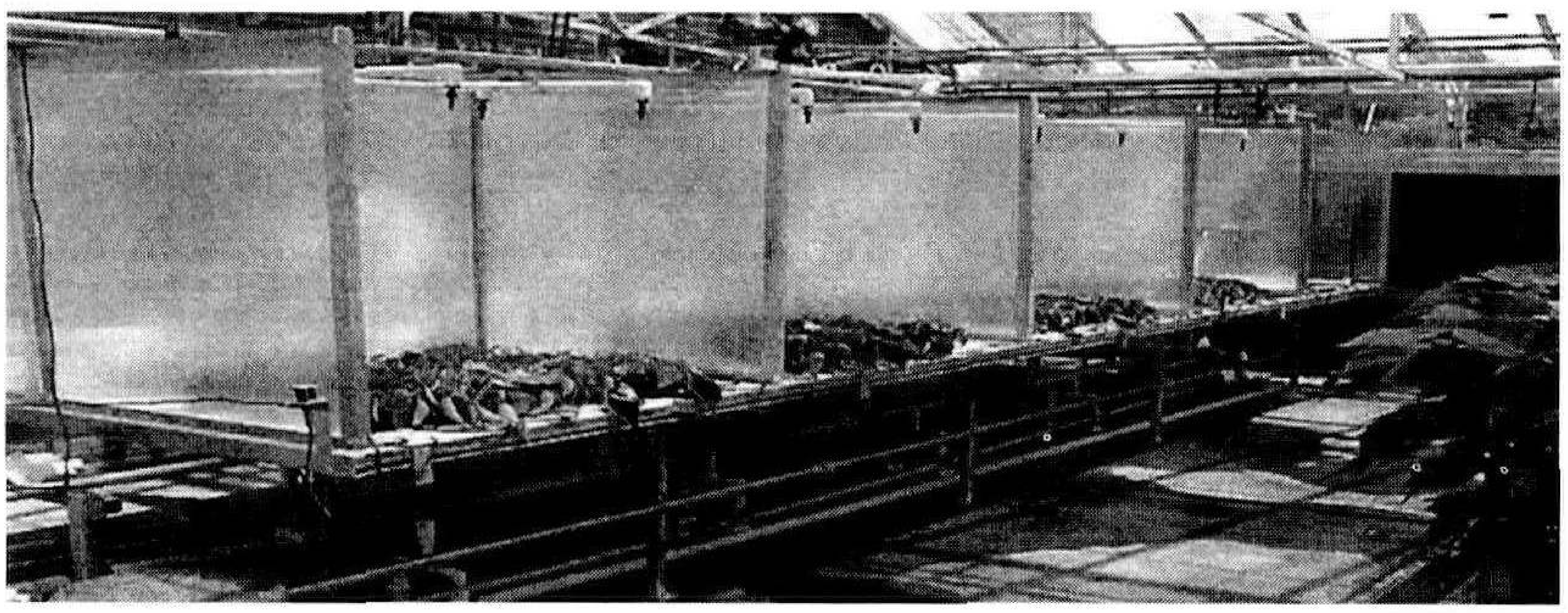


Figure 2. Mist chamber layout.

morning,evening, and cloudy times. This is illustrated by the number of times mist was activated during a typical sunny or partly cloudy day.

The number of roots per cutting did not vary between systems of mist control (static = 47.0; dynamic = 47.3 roots per cutting). There was also no difference in relative water content of the cuttings (a measure of water stress). Differences were seen in overall root length (static = 209; dynamic = 249 cm per cutting) and root dry weight (static = 89.0; dynamic = 101 mg per cutting). The percentage of fine roots (<0.8mm) was 24.5% greater in the cuttings controlled by the dynamic system. Poinsettias are the highest value pot crop in the United States. Propagation is from softwood cuttings that are usually rooted under mist using static time control of fixed or traveling nozzles. While some growers may adjust this mist interval manually as water status in the cuttings warrant, timely adjustment is certainly not prevalent. Indeed, no clear criteria exist for assessing what constitutes proper misting adjustment, other than observing wilted cuttings. Thus, the on/off interval is selected to satisfy extreme midday conditions, and consequently excess water consumption occurs during cloudy days, mornings, evenings and in some cases during night time. Excess water also reduces O_2 availability in the roots of newly propagated cuttings. Growers are hesitant to make adjustments toward water conservation, because forgetting to re-adjust for high radiant conditions can quickly result in a lost crop. The mean wholesale value of poinsettias sold in 1997 was about $3.70 per potted plant (USDA, 1998); it is common for propagators to have tens of thousands of terminal cuttings under propagation at one time. Mistakes during propagation can have serious economic impact. The model tested in this paper is one approach to dynamic mist control. It has proven to be a good predictor of misting frequency for poinsettia propagation. Additional testing will be required to optimize this system for poinsettia and to extend it to the general propagation of other crops.

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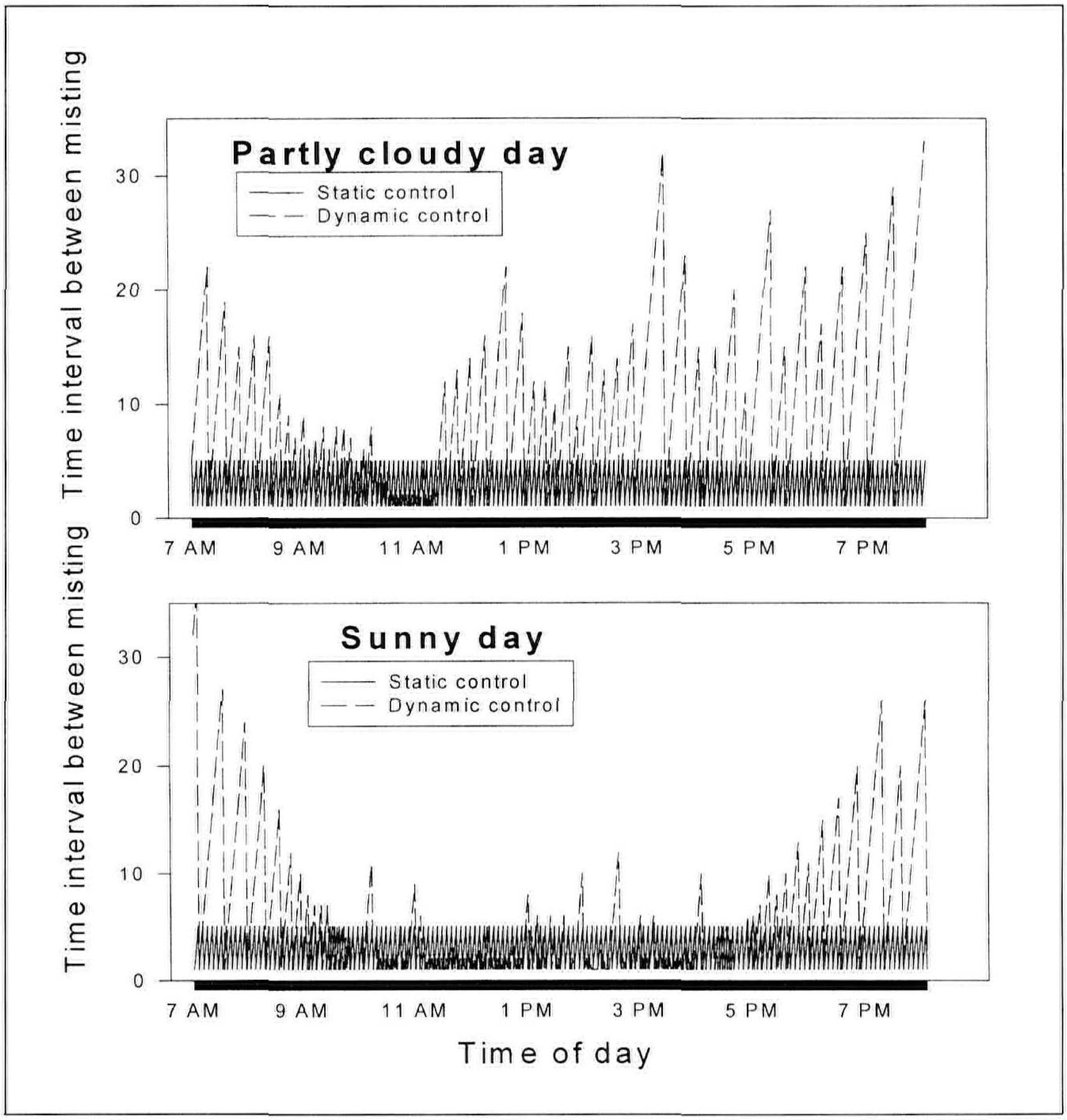

Figure 3. Frequency of misting during a sunny day and shady day under dynamic control.

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