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Growth Medium Temperature in Containers as Influenced by Moisture Content[1]

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Abstract

In response to changes in ambient air temperature, temperatures within containers of a pine bark growth medium were slower to change and remained at 0 °C (32 °F) longer, as the moisture content of the medium increased. This suggests that timing of irrigation can reduce temperature extremes of short duration within containers.

Index words: Pine bark, media temperature

Introduction

Optimum growth medium temperature for root and shoot growth of many plants is between 20 °C (68 °F) and 30 °C (86 °F) (2). Beyond this temperature range, plant growth is reduced with plant injury or death often occurring below -5 °C (23 °F) (4) or above 40 °C (104 °F) (6). It is not uncommon for media temperatures in unprotected containers during the summer and winter months to exceed these extremes.

Cultural practices to reduce high temperatures have included the use of reflective containers, non-reflective bed mulches, overhead shade, and reduced pot spacing. To reduce cold injury to roots of container-grown plants and reduce temperature fluctuation within pots overwintering structures, insulation around or over pots, and reduced pot spacing are common management practices. Irrigation may also be an effective means of lessening temperature extremes in container. This study was initiated to determine what influence water had on container medium temperatures.

Materials and Methods

Pine bark milled through a Humboldt sample splitter (Humboldt Manufacturing Co., Chicago, IL 60656) was divided into 4 samples. One sample was air-dried at 20 °C (68 °F) for 1 week. A second sample was brought to container capacity by submerging in water under 525 mm (21 in) of mercury vacuum for 72 hours to insure saturation of the medium and then allowed to drain. The 2 remaining samples were syringed with water, mixed, and placed in sealed containers for 7 days. Moisture content on a vol/vol basis was 2.7% for the air-dried sample, 55.3% for the sample maintained at container capacity, and 23.2% and 35.2% for the moistened samples.

Three 11.4 cm (1 qt) black plastic pots were filled with 800 cm^3 (48.8 in^3) of pine bark medium of each moisture level, and individually sealed in plastic bags. A nichol-manganese oxide thermister (YSI 418 telethermometer probe, Yellow Springs Instrument, Yellow Springs, OH 45387) was inserted through the plastic bag and into the center of each pot to a 5 cm (2 in) depth. Pots were placed in a completely randomized design with 3 replications and frozen to -16 °C (3.2 °F), then removed to a 20 °C (68 °F) environment. Temperatures were monitored every 30 minutes until the container medium reached ambient air temperature. Pots were then placed in the freezer again and temperature monitored until the medium reached -12 °C (10.4 °F).

Results and Discussion

Temperature of the container medium increased rapidly and linearly from -16 °C (3.2 °F) to approximately 15 °C (59 °F) in the air-dried samples and to 0 °C (32 °F) in medium with the 3 higher moisture levels (Fig. 1). As moisture content increased, temperatures of the container medium remained at the freezing point longer, reflecting the high heat of fusion (80 cal/g) needed to change ice in the medium to water. Above 0 °C (32 °F), temperature of the medium rose slower in samples with higher moisture content due to the high specific heat of water (1 cal/g), buffering the container

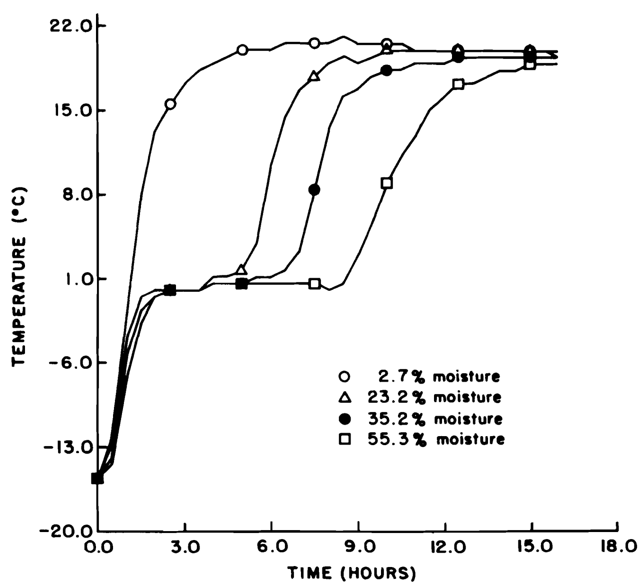

Fig. 1 **Influence of moisture content of a pine bark medium in a nursery container on rate of warming to 20 °C (68 °F).**

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medium against rapid temperature changes. It would require 5 times as much heat to raise the temperature of a unit volume of water 1 °C (1.8 °F) as is necessary to raise the temperature of a unit of soil (1). Because the growth medium samples studied were composed of different ratios of the growth medium to water, heat capacities would be between those for water and oven-dried medium. Differences among treatments may have been greater if samples had been unsealed, due to a more pronounced evaporative cooling effect at the higher moisture levels. As temperatures of the medium with different moisture levels approached environmental temperatures, the rate of change decreased because of smaller temperature differences.

The moderating influence of water in the growth medium on temperature is supported by Self and Ward (5) who reported that maximum summer temperatures were 4° to 7 °C (7.2°-12.6 °F) cooler in soils of optimum moisture content when compared to dry soils. Gouin and Link (3) also observed that irrigating container-grown plants during winter storage minimized fluctuating temperatures from 1° to 4 °C (1.8°-7.2 °F) during the coldest part of winter.

Similar trends were observed in temperature changes when the growth medium of different moisture contents was cooled from 20 °C (68 °F) to -12 °C (10.4 °F) (Fig. 2). Air-dried samples dropped rapidly to -6 °C (21.2 °F) due to the low moisture content of the medium, and slowly from -6 °C (21.2 °F) to -12 °C (10.4 °F) due to a small difference in medium and air temperatures. Samples with

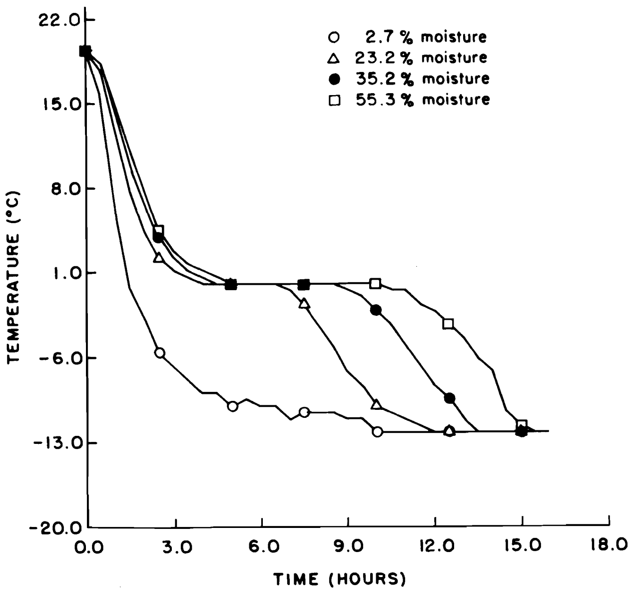

Fig. 2 Influence of moisture content of a pine bark medium in a nursery container on rate of cooling to -12 °C (10 °F).

higher moisture content decreased more slowly to 0 °C (32 °F), again due to the high specific heat of water. With increasing moisture content, container growth medium remained at the freezing point longer. Due to water's high heat of crystallization (80 cal/g) temperatures within the container did not fall below the freezing point as long as unfrozen liquid remained; neither did temperatures rise above the freezing point as long as the medium contained ice.

Water for irrigation, whether from ponds, wells, or municipal sources, is generally cooler than air and container growth medium temperatures during the summer months and warmer during the winter. Proper timing of irrigation can effectively reduce the maximum temperature of the growth medium in summer, raise minimum temperatures of the medium in winter, and reduce rapid temperature fluctuations.

Significance to the Nursery Industry

Knowledge of water's response to changes in ambient temperature is essential in utilizing water to effectively moderate growth medium temperatures during production of container-grown nursery crops. Due to water's unique properties, maintaining water content at or near container capacity during short periods of temperature extremes reduces temperature fluctuations in the growth medium and lessens temperature extremes, thus reducing the potential for root injury. Cultural practices may include irrigating near midday during summer and prior to expected low temperature extremes in winter. In areas where overwintering structures are used, plants should be watered well before enclosing structures and checked periodically during winter to insure that container growth medium does not dry.

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