Light Intensity and Air Movement Effects on Leaf Temperatures and Growth of Shade-requiring Greenhouse Crops

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Abstract. Five greenhouse-grown shade-requiring plants, Saintpaulia ionantha, Philodendron cordatum, Sanseveria trifasciata, Codiaeum variegatum cv. 'Aucubaeifolium' and Begonia semperflorens were grown in sunlight at wind velocities from 0 to 4.4 mph. Necrotic areas developed on Saintpaulia leaves in sunlight at all wind velocities, although injury decreased as air velocities increased. Codiaeum, Philodendron and Sanseveria were more compact at increased wind velocities than those at recommended leaf intensities. Leaves of those species also became smaller as air velocities declined. Abnormal variegation developed on newly formed Codiaeum leaves at lowest rates of air movement. Largest chlorophyll contents were found in plants receiving recommended light intensities. Chlorophyll contents of plants in sunlight generally increased as rates of air movement increased.

INTRODUCTION

Reductions in greenhouse light intensities are necessary for the best growth of shade-requiring florist crops. The lower light tolerance and saturation intensities for leaves needing shade is strongly influenced by leaf morphology. Boysen-Jensen (2) demonstrated that a leaf's adaptation to shade lowered the light saturation intensity and shortened the linear range of photosynthesis. Gates and Benedict (2) reported plants subjected to a heat load redistribute the absorbed heat in the form of reradiation, convection, conduction and transpiration. Greenhouse plants are deprived of the main part of radiant cooling, since glass and plastic greenhouse coverings reflect the energy radiated from leaves at the infrared lengths. Ansari (1), Leopold (5), Wolpert (8) and others have shown leaf temperatures in sunlight can be reduced by increasing the velocity of air movement. Ansari (1) found wind at 5 mph lowered the leaf temperature-to-air gradient to about half that measured without wind movement. Wolpert pointed out that leaf movement in wind can accentuate transpirational cooling.

Post (7) recommended maximum light intensities for some shade-requiring florist crops and suggested that higher intensities are not desirable and are seldom necessary for maximum plant growth. This research measured the response of representative florist shade-requiring plants to higher light intensities at several wind velocities.

MATERIALS AND METHODS

Five species of greenhouse-grown shade-requiring plants were selected for their varying tolerance to light. Those species and their maximum intensities as recommended by Post (7) or Graf (4) were Saintpaulia ionantha, Wendel, African-Violet (1500 ft-c), Philodendron cordatum, (2000 ft-c), Sanseveria trifasciata, Prain, Bowstring-Hemp (3000 ft-c), Codiaeum variegation, Blaume cv. 'Aucubaeifolium', (5000 ft-c), and Begonia semperflorens, Link & Otto (7000 ft-c). Scientific names are from Graf (4). Plants of each species were placed in 4-inch clay pots grown at recommended light intensities for 2 months prior to initiating the study. In mid-July, 15 plants of each type were double potted by placing a 4-inch pot into a 6-inch pot with peatmoss between. The moistened peatmoss prevented rapid evaporation from the clapot surface at higher rates of air movement.

A horizontal funnel-shaped wind tunnel 20 ft in length, facing east-west, was constructed in a greenhouse. The tunnel consisted of a vinyl film plastic covering supported by a wooden frame. A 24-inch exhaust fan was installed in the 4 ft² opening at the narrow end with a 61 ft² opening at the broad end. Plants were supported by a wooden shelf placed along the length of the chamber in its center. Wind velocities along the shelf, from air intake to exhaust, were measured with an omnidirectional air meter.
and found to range from 0.40 to 5 mph. Four locations were selected for placing 3 plants of each species. The rates of air movement at these locations were 0.45, 0.60, 3.2 and 4.4 mph. The increased air velocities in the wind chamber were begun daily at 6 AM and continued until 8 PM. No measurable air flow velocity was found for the plants in the greenhouse outside the chamber.

Temperatures of air and leaves were measured using copper-constantan thermocouples and a portable Rubrican potentiometer. A shielded thermocouple (24-gauge wire) was mounted in each of the locations where plants had been placed in the chamber. Additional thermocouples (36-gauge wire) were inserted into the mid-veins of sun-receiving leaves. Seventy-five thermocouples were used to determine leaf temperatures of the 5 plant species at 5 velocities of air movement.

Light intensities were measured in conjunction with air and leaf temperature readings, using a Weston 756 illumination meter. Serevar light intensities were studied in the wind chamber for short periods by placing cheesecloth or black polypropylene cloth overhead. The plants exposed to normal greenhouse air movement were placed outside the air chamber. The air movement in the greenhouse was very low and generally non-measurable. Similar light intensities by placing a piece of vinyl plastic, cheesecloth, or polypropylene cloth over them.

Leaf samples were collected for chlorophyll content determination from each species prior to beginning the study, and after 30 days for Saintpaulia and after 45 days for the remaining plants. All samples were prepared and analyzed according to the procedures of Mackinney (6). The degree of opening of stomates under the various treatments was observed hourly on several sunny days using a binocular microscope at 200 X.

RESULTS

Relationships between air and leaf temperatures at the various rates of air movement are shown in Table 1. Readings in maximum sunlight averaging 6685 ft-c and at 2270 ft-c are shown; intermediate intensities measured but not presented had corresponding results. As air velocities increased from non-measurable amounts to 4.4 mph the leaf-to-air temperature gradient in degrees F decreased. The largest decline occurred between the non-measurable velocity and 0.45 mph, which is in keeping with the results of Leopold (5). In all instances the leaf-to-air temperature gradient was significantly smaller at 0.6 mph than at 0.45 mph when the plants were exposed to maximum sunlight. This was not true at the lower light intensity where readings generally had non-significant differences at air velocities above 0.45 mph. In maximum sunlight the leaf-to-air gradients were similar at all wind velocities in excess of 0.60 mph.

Several visible differences in plant growth occurred during the 7-week duration of the study. Plants at the higher air velocities grew slightly faster than those at high light intensities in a greenhouse (Table 1). The exception was the B. semperflorens where the growth rate was reduced with increased air movement. The amount of variegation on the newly formed leaves of Croton increased as the air movement around the plants decreased. These leaves in the greenhouse at little to no air movement but under high light intensity appeared yellow from what apparently was abnormal variegation (Fig. 1).

Table 2. Chlorophyll contents (mg/100 g fresh weight) of shade-requiring plants at various wind velocities.

<table>
<thead>
<tr>
<th>Greenhouse</th>
<th>Chamber wind velocities</th>
<th>LSD 0.05</th>
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<tr>
<td></td>
<td>Recomended shade</td>
<td>Sunlight</td>
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<td>Begonia</td>
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Fig. 2. Typical leaves of Philodendron cordatum plants grown in sunlight at 0, 0.45 and 0.6 mph, upper left to right, and 3.2 and 4.4 mph wind velocities, lower left to right.
**Effect of Soil Moisture on the Recovery of Sandblasted Tomato Seedlings**

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**Abstract.** Increasing the length of time that 4-week-old tomato seedlings are exposed to a 13.4-m/sec (30 mph) windspeed and an abrasive flux of 0.2 ton/rod width/hr decreases the dry weight of tops, decreases height of the tops, delays first bloom, lowers potential yields, and increases the number of plants killed irrespective of the pre- or post-soil moisture level. Irrigation or rainfall immediately after exposure can reduce the damage.

**INTRODUCTION**

WIND and sandblast injury to vegetable crops is a serious problem where large acreages of vegetables are grown on sandy soils. Wind alone can cause damage and desiccation (10) but wind laden with sand and soil is much more destructive. Studies dealing with abrasive injury to cotton seedlings (1), grass and alfalfa seedlings (7), green bean seedlings (9), and to established wheat stands (11) have provided some information on soil abrasive injury to plants. No previous work on the effect of soil moisture on the recovery of sandblasted plants could be found but its importance is mentioned (1). This study was undertaken to determine the effect of soil moisture level before and after abrasive injury to tomato seedlings.

**MATERIALS AND METHODS**

Tomatoes, *Lycopersicon esculentum* L. var 'Homestead 24', were grown in the greenhouse in 61- by 15- by 23-cm flats filled with sandy loam soil. The plants were fertilized according to recommended cultural practices.

Treatment variables were pre-exposure soil moisture level (low—6 to 12 atm tension, medium—½ to 6 atm tension, and high < ¼ atm), post-exposure soil moisture level (low, medium, high), and length of exposure (0, 5, 10, and 15 minutes) to a 13.4-m/sec (30 mph) windspeed and 0.2-ton/rod width/hr abrasive flux. Treatments were arranged factorially and replicated 3 times.

Two-week-old plants were thinned to 4 plants per flat and the pre-exposure soil moisture levels imposed. Soil moisture levels were maintained by

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**LITERATURE CITED**


