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Pre- and post-production characteristics of *Coprosma* as influenced by temperature, irradiance, and nutrient treatments

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ABSTRACT

The genus *Coprosma* has the potential to be used as a house and garden plant throughout the world. *Coprosma* 'Coppershine' was selected to study the effect of nutrition and irradiance on *Coprosma* growth and development. Post-production characteristics were also evaluated by placing greenhouse grown plants in 12.5 cm pots directly into a simulated interior environment (SIE). The amount of leaf abscission was lowest in the SIE when plants received 2 g of controlled release fertilizer (CRF). Our data show that the tissue nitrogen (N) concentration should be higher than 4% to prevent leaf abscission of *C.* 'Coppershine'. Increased fresh and dry weights combined with no leaf abscission after 18 days under SIE using 2 g CRF demonstrates that a steady availability of nutrients is required. More leaves abscissed when plants were grown at high temperature (21 °C) and under the highest irradiance (316 μmol m^{-2} s^{-1}) as compared to plants grown at low temperature (15.5 °C) and mid level of irradiance (218 μmol m^{-2} s^{-1}). The tissue concentration of calcium (Ca) in the mid leaves may also be associated with the leaf abscission and reduced fructose was associated with low drop of leaves. This is the first report that post production leaf abscission in *C.* 'Coppershine' can be reduced by growing with an increased fertilizer level at high temperature. This response is correlated with high tissue N concentration responding to CRF treatment under a SIE.

1. Introduction

The genus *Coprosma*, Rubiaceae, comprises over 90 species and is endemic to New Zealand, Australia, and Polynesia (Wilson, 1979; Beuzenberg, 1983). Plants in the genus are shrubs or small trees with shiny or variegated leaves. *Coprosma* has been commercialized in Europe, however, it has not widely known to the public either as a landscape or house plant. Information on the culture of *Coprosma* as an outdoor ornamental plant or on the performance as an indoor plant is not available.

Extensive research has been carried out on *Ficus benjamina* L. to study foliage abscission or leaf loss when plants grown under full sun conditions were transferred directly to a SIE without acclimatization (Steinkamp et al., 1991). Acclimatization of plants when placed under interior light levels was also related to fertilization rates which affected leaf morphology structure, and abscission (Johnson et al., 1979). Leaf abscission was severe when plants grown under full sun and receiving high rates of nitrogen fertilization were transferred to interior conditions without acclimatization (Conover and Poole, 1975a,b; Turner et al., 1987). The level of irradiance for optimum growth may differ by crop. The ornamental value of *Pachira aquatica* Aubl. (Li et al., 2009) was significantly improved by growing plants under intermediate irradiance between 285 and 350 μmol m^{-2} s^{-1}. When *Chamaedorea elegans* Mart. plants were treated at different irradiance levels and fertilizer rates, total soluble carbohydrate in leaves was higher when grown at an intermediate irradiance (306 μmol m^{-2} s^{-1}) and the starch concentration was affected by irradiance and fertilizer level (Reyes et al., 1996). During the production of many foliage plants, high levels of nitrogen should not be applied before placement indoors (Conover et al., 1991).

Controlling mechanisms that are involved in leaf abscission when plants were transferred to a SIE has not been elucidated in detail; possible relationships may exist with the tissue concentration of calcium (Ca) which may inhibit ethylene induced abscission in bean petiole (Poovaiah and Leopold, 1973) and abscisic acid induced ethylene evolution of leaf abscission in *Radermachera sinica* L (Dunlap et al., 1991). Sun grown *F. benjamina* had more carbohydrates than those grown under shade and increased N lowered the carbohydrate reserves (Milkes et al., 1970). Carbohydrate reserves accumulated in plants at high irradiance provided energy for plants to adapt to a low-irradiance environment *Megaleranthis*

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saniculifolia (Reyes et al., 1996; Veneklaas and den Ouden, 2005), although there is no direct relationship between changes in carbohydrate in the leaf blade during defoliation with a chemical defoliant (Hall and Lane, 1952).

Cultural information for *C.* 'Coppershine' on the optimum levels of irradiance, temperature, and nutrition for successful greenhouse production and the post-production keeping quality in interior environments is currently unavailable. When grown outdoors *C.* 'Coppershine' should be grown in full sun to retain leaf color and avoid leaf abscission (Metcalf, 1987). Therefore, it is expected that *C.* 'Coppershine' plants grown under full sun may lose leaves when transferred to low light environments as reported for other foliage plants (Chen et al., 2005; Li et al., 2009; Turner et al., 1987). English ivy (*Hedera helix* L.) grown under low irradiance and low fertility produced good quality plants when placed under SIE which resulted in better acclimatization (Pennisi et al., 2005).

Research was initiated to investigate the effect of controlled release and liquid fertilizer, irradiance, and temperature treatments on growth during greenhouse forcing and subsequent keeping quality when plants were moved to SIE without pre-acclimatization treatment. Changes in carbohydrates and foliar mineral content on the keeping quality of *C.* 'Coppershine' were also evaluated.

2. Materials and methods

2.1. Plant material and greenhouse conditions

Five-cm long stem tip cuttings of *C.* 'Coppershine' were propagated in Metro Mix 200 in a mist bench (12 s mist every 15 min from 08:00 h for 16 h) in a greenhouse maintained at 24 °C with heat pads. One week after transplanting rooted cuttings into 12.5 cm pots filled with a growing medium composed of soil:perlite:peat moss (1:1:1, vol%), controlled release fertilizer (CRF) (Osmocote 14N–6P–8.2K, Marysville, OH, USA) was applied on the surface of growing medium. Additionally, plants were fed weekly with 200 mg/L N from a 20N–8.6P–11.7K (Peters 20-20-20 fertilizer, Marysville, OH, USA) water soluble fertilizer, and grown at 8/16 h day/night cycle at 21 °C/16 °C, respectively, under a natural day length and irradiance levels ranging from 240 to 490 $\mu mol\ m^{-2}\ s^{-1}$ using high irradiance discharge (HID) lamps from 08:00 to 20:00 h.

2.2. Effect of controlled fertilizer (CRF) and liquid fertilizer (LF) on plant growth and post-production quality in a simulated interior environment (SIE) (Expt. 1)

2.2.1. Plant growth

Plants received CRF at the rates of 0, 2, and 4 g per pot and also LF at 200 and 400 mg/L in a 3 CRF × 2 LF factorial design. The first LF was given one week after pinching. For fresh and dry weight collection, the entire shoots from 3 plants per treatment were sampled 50 days after the first LF treatment. Dry weight was determined following exposure at 75 °C under a forced air-dryer for 3 days. There were 10 plants per treatment and the number of shoots longer than 5 cm from the main shoot were counted.

2.2.2. Foliar macro- and micro-elements and carbohydrate analyses and assessment of leaf loss

To investigate foliar elements, soluble carbohydrate extracted with 80% ethanol and leaf abscission, we collected leaf samples at day zero (day 0) and from plants following a SIE 11 days later. The SIE conditions were maintained at constant 21 °C in the SIE at an irradiance of 20 $\mu mol\ m^{-2}\ s^{-1}$ using cool white florescent and incandescent light for 12 h. Humidity varied between 50 and 75%.

Fully developed leaves were collected from mid-way up the stem in duplicate for foliar analysis as described (Roh et al., 2012).

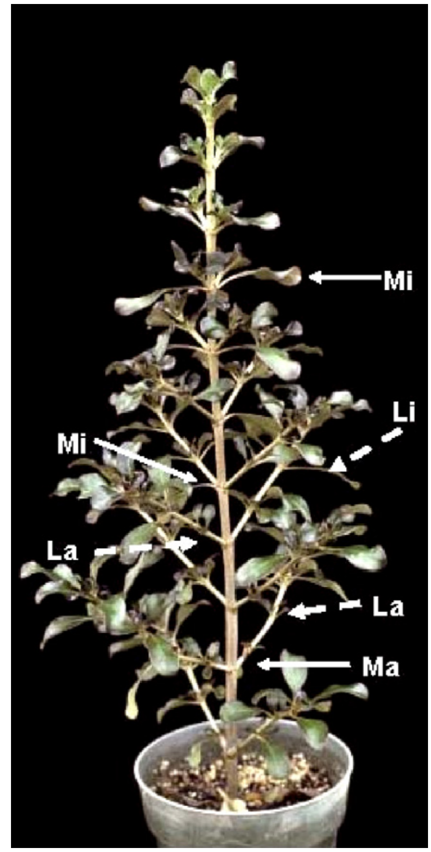

Fig. 1. *Coprosma*, 'Coppershine' in 12.5 cm pot. Leaf from the main shoot as indicated with solid arrow and from the lateral shoots as indicated with dotted arrow is indicated. Leaves intact from the main shoot (Mi) and the lateral shoot (Li) and abscised from the main shoot (Ma) and the lateral shoot (La) are indicated.

For soluble carbohydrate analysis extracted with 80% ethanol, samples of mature leaves were collected in triplicate and analyzed as described previously (Lee and Roh, 2011). The number of leaves dried from the main shoot and lateral shoots were recorded on day 11 and on day 18 during evaluation under SIE. Leaves from the main shoot were larger than those from the lateral shoots, and absence of the abscised leaf scars from the node on the main shoots were examined to confirm the leaves dropped from the main shoot (Fig. 1).

2.2.3. Temperature, irradiance, and controlled release fertilizer treatment on growth and post-harvest physiology (Expt. 2)

To investigate the effect of temperature, irradiance and fertilizer on plant growth, 5 cm long cuttings were collected from the stock plants as described above. We placed 15 rooted stem-tip cuttings planted into 12.5 cm pots per treatment were placed into two greenhouse sections maintained at 23 °C/21 °C and 21 °C/15.5 °C, day/night. Experimental treatments was carried out in a factorial design; 3 CRF (0, 2, or 4 g of CRF applied on the surface of the growing medium at planting) × 2 greenhouse temperatures × 3 supplementary light irradiance (no supplementary irradiance and at 218 and 316 $\mu mol\ m^{-2}\ s^{-1}$ from HID lamps as indicated above). Plants were fed weekly with 200 mg/L N from a 20N–8.6P–11.7K water soluble fertilizer.

Plant height, plant width at one-half of the plant's height, and the number of nodes were recorded 65 days after the initiation of treatments. From three median plants in height, leaves and shoots that were formed during treatments were collected for fresh and dry weight measurement following the sample drying method previously described. Six uniform plants representing the treatment