

Effect of light emitting diodes (LEDs) on postharvest needle retention of balsam fir (*Abies balsamea* L.)

R. Scott Veitch, Rajasekaran R. Lada* and Mason T. MacDonald

Nova Scotia Agricultural College, Department of Environmental Science, P. O. Box 550, B2N5E3, Bible Hill, Nova Scotia, Canada. *E-mail: rlada@nsac.ca

Abstract

Two experiments were conducted to understand the effect of light emitting diodes on postharvest abscission in balsam fir (*Abies balsamea* L.) branches. In one experiment, branches were pre-exposed to the fluorescent light, LEDs, or darkness for 1, 4, 8, 12, 24, or 48 h. In a second experiment, branches were constantly exposed to fluorescent lights, LEDs, or darkness. The response variable was needle retention duration (NRD). A 48-hour exposure time to red, white, or blue LEDs significantly ($P < 0.001$) increased NRD by approximately 75, 118, or 127%, respectively, compared to a cool white fluorescent lighting or darkness. Constant exposure to any LED significantly ($P < 0.001$) improved NRD compared to fluorescent lights or darkness, though white and red LEDs were most effective. It is speculated that LED-promoted needle retention could possibly be due to changes in carbohydrate synthesis similar to those observed during cold acclimation.

Key words: Abscission, *Abies balsamea*, balsam fir, conifer, light emitting diode, needle retention, postharvest, senescence

Introduction

Balsam fir is the principal Christmas tree species and specialty horticultural product grown in Nova Scotia. Balsam fir are grown on over 10,000 ha (25,000 ac) and approximately 1.5 to 2.0 million trees are harvested each year. Overall, the industry generates 72 million dollars annually in the Atlantic region and employs several hundred people (CTCNS, 2010). Postharvest needle drop is a significant challenge faced by the Christmas tree industry of Atlantic Canada. In recent years, the severity of needle loss has escalated to an extent that threatens the survival of Christmas tree and greenery industry, where the number of annual sales is starting to decrease (Chastagner and Benson, 2000). While needle losses occur during harvesting, handling, transportation, and at display stands to a certain extent, extensive needle loss after consumers' purchase has become a matter of great concern for the industry (Mitcham-Butler *et al.*, 1988). The industry suffers huge economic losses due to the reduced marketability, as consumers no longer tolerate needle loss and there is an increasing trend towards purchasing artificial trees. While the exact reason for needle drop is yet to be determined, it is commonly believed that increased demand from foreign markets requires earlier harvesting. Harvesting balsam fir often begins in early October in Nova Scotia, which results in poor needle retention (MacDonald *et al.*, 2010a; MacDonald and Lada, 2008). In addition, warmer fall temperatures in late October have reduced the needle retention capabilities of Christmas trees worldwide (Chastagner and Riley, 2003).

The use of LEDs in horticulture was originally presented as a potential technology for space-based plant research chambers or bioregenerative life support systems (Bula *et al.*, 1991; Barta *et al.*, 1992). Certain advantages that LEDs provide, such as small size, durability, long operational life, wavelength specificity, and relatively cool emitting surface, could be useful during

transport and storage of Christmas trees (Li *et al.*, 2010). In addition, LEDs are considered eco-friendly due to their low electricity requirements and long operational lifespan. Light spectra quality, intensity and duration at different wavelengths, particularly those at red or blue, influence plants by triggering physiological reactions including dormancy, photoperiodism, flowering, senescence, and abscission (Li *et al.*, 2010, Okamoto *et al.*, 1996; Tennessen *et al.*, 1993; Yanagi *et al.*, 1996). For example, red light is important in the development of the photosynthetic apparatus and starch accumulation (Saebo *et al.*, 1995) while blue light is important in development of chlorophyll, chloroplast development, and enzyme synthesis (Senger, 1982). Light controls hypocotyls growth and activity of enzymes associated with nitrogen metabolism in Scots pine trees using a combination of phytochrome and blue/ultra-violet light. Other studies done on Scots pine trees showed that far red and red light invoke phytochrome system and induce cold hardening (Beck *et al.*, 2004).

Leaf senescence and abscission are affected by light. Leaves kept in the dark senesce faster compared to those exposed to light (van Lieburg *et al.*, 1990). In contrast, certain spectra of light can delay abscission. For example, abscission resistance in mung bean leaves is enhanced with red light (Curtis, 1978) while red LEDs delayed postharvest senescence and abscission in ornamental flowers such as hibiscus and lillies (van Lieburg *et al.*, 1990; van Meeteren and van Gelder, 2000). However, there is no information relating the role of LED's to postharvest abscission in balsam fir. The objective of this study was to understand the effect of certain spectrums (blue, red and white) of LED's on needle abscission in postharvest balsam fir.

Materials and methods

Sample collection: Balsam fir branches containing the two most recent years of growth were collected from mature grafted