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Growth, gas exchange, and root respiration of *Quercus rubra* seedlings exposed to low root zone temperatures in solution culture

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Abstract

Spring planting is standard operational practice in the Central Hardwood Region, though little is known about potential impacts of low root temperature (RT) common during spring on establishment success of temperate deciduous forest tree species. The effects of low RT on growth, gas exchange, and root respiration following winter dormancy were studied in 1-year-old northern red oak *(Quercus rubra L.)* container seedlings grown in solution culture at uniform air temperatures, but exposed to three different root zone temperatures (10, 15, and 25 °C). After 14 days of treatment, net photosynthesis (A), stomatal conductance (g_s), and transpiration (E) were significantly affected by RT; however, these treatment effects did not persist for the remaining measurement period (days 21 and 28) despite growth reductions. After 28 days, new shoot length, leaf area, and number of new roots were reduced with decreasing RT. Shoot dry mass was higher in seedlings exposed to 25 °C compared with those in 10 °C, while an opposite trend occurred for root-to-shoot ratio. Leaf water potential (Ψ w) at day 28 and days to budbreak were not significantly altered by RT treatments. Root 02 uptake in seedlings exposed to 10 °C was 65% lower than for those seedlings at 25 °C. Low RT has a physiological role in the control of root growth and root respiration, which could potentially affect establishment success of northern red oak seedlings planted in spring when soil temperatures are still low.

Keywords: Hardwood seedlings; Northern red oak; Root growth; Root physiology; Transplanting stress

1. Introduction

Field establishment success of newly planted seedlings is largely dictated by the environmental factors to which they are exposed to at the time of planting. The ability of seedlings to produce new roots shortly after transplanting is critical to regeneration success (Grossnickle, 2005), as these new roots facilitate water and nutrient uptake (Häusling et al., 1988; Jacobs et al., 2004a). Low soil temperature has been shown to inhibit root growth of newly planted conifer seedlings (Lopushinsky and Kaufmann, 1984; Amponsah et al., 2004).. Although much research has been conducted on the effects of low root zone temperatures on seedling growth and physiology in conifers (Delucia, 1986; Grossnickle, 1988; Ryyppö et al., 1998; Amponsah et al., 2004), little is known about this phenomenon in temperate deciduous forest tree species. To our knowledge, there are no recent studies conducted on the effects of low root zone temperature with northern red oak *(Quercus rubra L.)* and oaks in general. Most studies conducted with oak species were restricted to examining shoot and root growth (Larson, 1970, 1971; Teskey and Hinckley, 1981) and therefore the transient physiological mechanisms by which low root temperatures inhibit seedling growth in northern red oak are not well understood.

In the Central Hardwood Region of the USA, temperate deciduous forest tree species such as northern red oak are usually planted in early spring (Pijut, 2004; Seifert et al., 2006) during late February to early April when root zone temperatures at planting sites are below favorable levels for root growth. At Wooster, Ohio, USA, for example, soil temperature at planting

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