Short-term physiological responses to flooding in *Quercus rubra*

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Introduction

Northern red oak (*Quercus rubra* L.) has been planted extensively for reforestation and afforestation purposes in the Central Hardwood Forest Region. Jacobs et al. (2004) reported 18.3% occurrence of northern red oak among all tree plantations in Indiana, with riparian bottomlands comprising 9% of these planting sites. Establishment success of hardwood plantations in the eastern United States is highly variable and many examples exist of failed plantation attempts. One of the most significant barriers to establishing vigorous plantations occurs immediately following planting, during the critical establishment period. One of the major environmental factors influencing seedling growth and survival during establishment is availability of moisture, which can affect growth and seedling mortality. However, an excess of soil moisture, such as saturated or flooded soil, can negatively influence survival and growth of newly planted seedlings. Riparian bottomlands are often prone to frequent flooding and species such as northern red oak may be subjected to flooding when planted in bottomlands. However, little is known with regard to the physiological responses of *Quercus rubra* to such post-transplant flooding.

Materials and methods

One-year-old containerized seedlings were transplanted into two-gallon pots maintained in a greenhouse and assigned to either a flooding treatment or a non-flooded control treatment. Treatments were initiated at the shoot linear phase of growth, as measured by the *Quercus* morphological index (QMI), and flooding treatment seedlings were inundated at this time; physiological measurements, including gas exchange, chlorophyll fluorescence, and current photosynthate translocation patterns, were assessed at one, four, and seven days after flooding (Hanson et al. 1986). Following physiological measurements, current photosynthate was labeled with ^{13}C in a gas-tight labeling chamber.

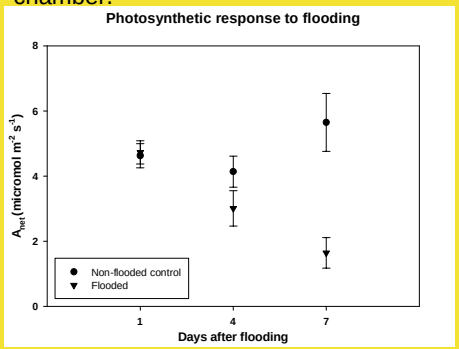

Figure 1. Net photosynthesis by flooding treatment

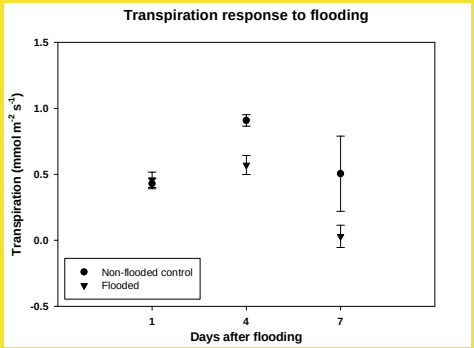

Figure 2. Transpiration by flooding treatment

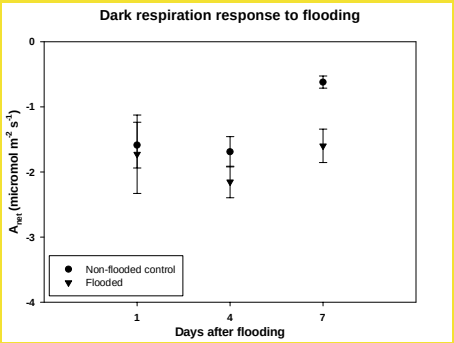

Figure 3. Dark respiration by flooding treatment

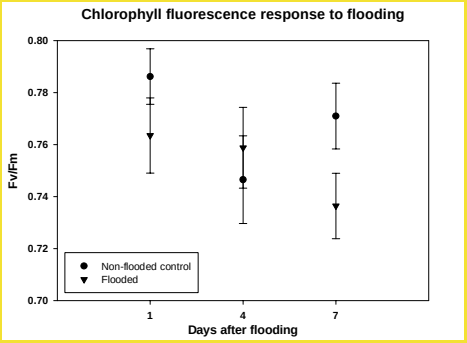

Figure 4. Chlorophyll fluorescence by flooding treatment

Results and Discussion

Short-term flooding was found to exert an negative influence on net photosynthesis (Fig. 1) and transpiration (Fig. 2) following seven days of flooding ($p = 0.0004$ and $p = 0.0166$, respectively). However, short-term flooding did not significantly affect dark respiration rates (Fig. 3) or Fv/Fm values (Fig. 4) ($p = 0.0593$ and $p = 0.1935$, respectively), suggesting flooding over seven days negatively affected gas exchange and assimilation without resulting in significant long-term damage to the seedlings. Results of ^{13}C labeling of sample trees so as to determine changes in translocation of current photosynthate will be forthcoming pending completion of isotopic ratio mass spectrometry analysis. Significant day effects suggest QMI developmental effects may play a role in post-transplant stress response and warrant further investigation.

These findings suggest that although brief periods of post-transplant flooding may adversely affect net productivity of northern red oak, the species exhibits a moderate tolerance to short-term flooding such as may often be experienced on low-lying plantation sites.

References

Hanson, P.J., Dickson, R.E., Isebrands, J.G., Crow, T.R., and Dixon, R.K. 1986. A morphological index of *Quercus* seedling ontogeny for use in studies of physiology and growth. Tree Physiol. 2: 273-281.

Jacobs D.F., Ross-Davis A.L. and Davis A.S. 2004. Establishment success of conservation tree plantations in relation to silvicultural practices in Indiana, USA. New Forests 28: 23–36.