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Optimizing Hardwood Reforestation in Old Fields: The Effects of Treeshelters and Environmental Factors on Tree Seedling Growth and Physiology

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Abstract

Strong competition for water is largely recognized as the main factor explaining the resistance of herbaceous old fields to tree invasion. Therefore, site preparation as well as chemical and mechanical vegetation control are recommended when establishing hardwood tree plantations on such sites, but those methods are sometimes socially or ecologically inappropriate. The main objective of this study was to analyze whether treeshelters could improve early tree growth in herbaceous old fields, when mulching alone is used to partially control herbaceous competition. Our results indicate that treeshelters can facilitate tree growth in those conditions but that this was not caused by an improvement of tree water relations. Rather, it appeared to be related to an optimization of light levels inside the shelter, where light intensity was low enough to lead to a photosynthetic system less costly to maintain due to a greater specific leaf area but high enough to have no adverse effects on photosynthetic rates. Although treeshelters increased tree growth when surrounding herbaceous vegetation was low (either height or standing biomass), allowing high light levels, they reduced growth when surrounding vegetation was high and blocked a substantial quantity of light. Therefore, environmental factors such as light availability need to be considered to optimize the success of hardwood plantations when treeshelters are used in recently abandoned agricultural fields.

Key words: ***Acer saccharinum*, facilitation, *Fraxinus pennsylvanica*, hardwood silviculture, microtopography, *Quercus macrocarpa*, water relations.**

Introduction

In eastern North America, marginal agricultural land is abandoned and allowed to follow secondary succession (Lepers et al. 2005). This socioeconomic phenomenon leads to the formation of "novel ecosystems" (Hobbs et al. 2006), which offer opportunities for forest restoration (Bouchard & Domon 1997), and a number of projects have already been established (e.g., Cogliastro et al. 1997*a*; King & Keeland 1999; Stanturf et al. 2000). In this region, low-growing plant communities that are resistant to tree invasion are frequently observed following agricultural abandonment (Pound & Egler 1953; Niering & Egler 1955; Benjamin et al. 2005). For this reason site preparation as well as chemical or mechanical vegetation control are recommended for the establishment of hardwood tree plantations on recently abandoned fields, whether for restoration or production purposes (e.g., Davies 1985; Cogliastro et al. 1990). However, those methods can sometime be socially or ecologically inappropriate, and in many regions of the world, such as the province of Québec (Canada), herbicide use has been banned for forestry (Gouvernement du Québec 1995). Therefore, there is a need to develop alternative strategies for the establishment of hardwood plantations in herbaceous fields.

Following recent theoretical work on the interplay of competition and facilitation in plant communities (Callaway & Walker 1997; Holmgren et al. 1997; Brooker & Callaghan 1998), restoration ecologists are now searching for novel ways to optimize tree establishment using pioneer vegetation instead of suppressing it, as to maximize facilitation and minimize competition (Castro et al. 2002; Gomez-Aparicio et al. 2004; Padilla & Pugnaire 2006). This is also the rationale behind techniques such as planting under shelterwoods (Paquette et al. 2006) or partial clearing in shrub thickets (Cogliastro et al. 2006). However, in recently abandoned fields, it is largely recognized that the interaction between tree seedlings and pioneer vegetation is strongly competitive (Berkowitz et al. 1995), mainly for soil water (Burton & Bazzaz 1995; Davis et al. 1998). On such sites, improvement of tree establishment through positive interactions with vegetation is thus difficult or even impossible. On the other hand, it might be possible to "artificially facilitate" tree establishment on such sites by improving their water relations, in order to counteract some of the competitive effects of herbaceous vegetation.

Such "artificial facilitation" of tree growth in abandoned fields has been obtained with mulching, which

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