First-year performance of northern red oak on reclaimed mined lands in Indiana

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Project overview

The objectives of this research are to compare the effectiveness of four stocktypes and assess the contribution of controlled-release fertilizer and mycorrhizal inoculation on survival and performance of northern red oak on reclaimed mined lands.

Northern red oak (*Quercus rubra* L.) seedlings were planted in April 2003 on two former surface coal mine sites in Clay County, Indiana (Figure 1). Surface coal mining is an intensive process and reclamation is necessary to return the land to a semi-natural cover (Figure 2). Poor soil physical properties, low nutrient availability, and severe compaction characterize these sites. These characteristics can result in low seedling survival and poor performance, which may lead to conversion of the land to other uses. For reclamation to forestland to be effective, seedling establishment must be improved. Northern red oak was selected as the trial species as it is known to survive on a variety of sites and has a high commercial value.

The four stocktypes consisted of June-sown (2002) (Figures 3 and 4) and January-sown (2003) containerized seedlings (container volume of 650 cm^3), and standard-density (nursery density of 75 seedlings/m^2) and low-density (nursery density of 21 seedlings/m^2) 1+0 bareroot seedlings (sown in 2002). Three treatments were applied to each stocktype: mycorrhizal inoculation, addition of controlled-release fertilizer, and both mycorrhizal inoculation and addition of controlled-release fertilizer. A control, with neither mycorrhizal inoculation nor addition of controlled-release fertilizer, was established for each stocktype. Initial height and root-collar diameter were recorded immediately after outplanting. Competing vegetation was controlled by herbicide application and a 2.3 m fence was erected to minimize animal damage. In August 2003 leaf water potential was measured to determine seedling moisture stress, and in October 2003 survival was assessed and height and root collar diameter were measured for all surviving seedlings (Figure 5).

Figure 1. Tractor-hauled coulter with trencher and packing wheels for tree planting.

Figure 2. Coal mining in Clay County, Indiana.

Figure 3. June-sown containerized seedling showing fine-roots.

Figure 4. June-sown containerized seedling in July 2003.

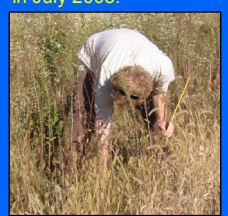

Figure 5. Measuring a seedling, October 2003.

Findings

There was a significant stocktype × controlled-release fertilizer interaction influencing seedling survival (Figure 6). Bareroot seedling survival was higher than containerized seedling survival, except in the case of June-sown containerized seedlings without controlled-release fertilizer which had equal survival.

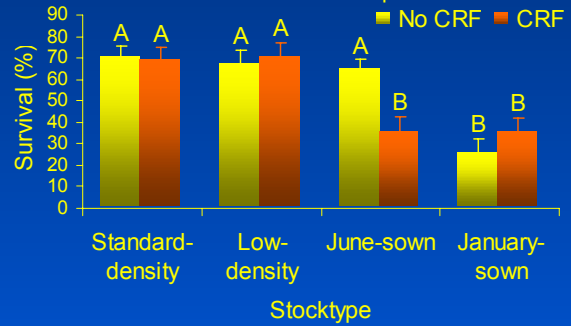

Figure 6. Seedling survival as influenced by a significant (p = 0.0215) stocktype × controlled-release fertilizer (CRF) interaction. Data points are means, error bars are SE. Treatments with the same letter did not differ significantly at α = .05.

Height growth was greater for low-density seedlings than containerized seedlings (Figure 7). For standard-density seedlings, height growth was greater than that of January-sown seedlings.

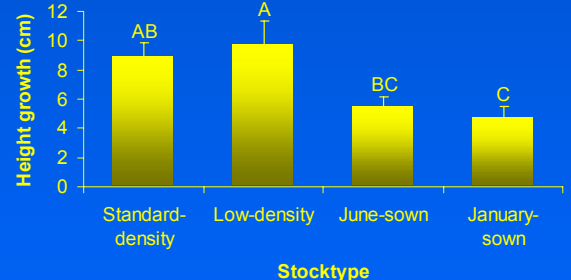

Figure 7. First-year seedling height growth. Data points are means, error bars are SE. Treatments with the same letter did not differ significantly at α = .05.

Conclusions

- Bareroot seedlings had a higher survival rate than containerized seedlings, except in the case of June-sown seedlings without fertilizer, which had equal survival
- Containerized seedlings tended to be less moisture stressed than bareroot seedlings, which could be partially attributed to containerized seedlings having entire root systems versus bareroot seedlings having modified root systems (lifting results in the loss of fine roots)
- Mycorrhizal inoculation and controlled-release fertilizer did not benefit first year survival or performance

Differences in root-collar diameter growth were not significant among treatments (data not shown). January-sown seedlings were less moisture stressed than all other stocktypes, and June-sown seedlings were less moisture stressed than low-density seedlings (Figure 8).

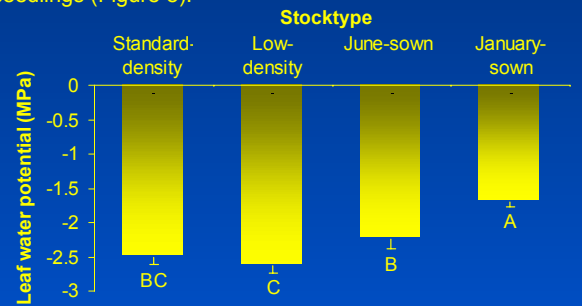

Figure 8. Influence of stocktype on leaf water potential. Data points are means, error bars are SE. Treatments with the same letter did not differ significantly at α = .05.

Seedlings that received controlled-release fertilizer were more moisture stressed than those that did not (Figure 9).

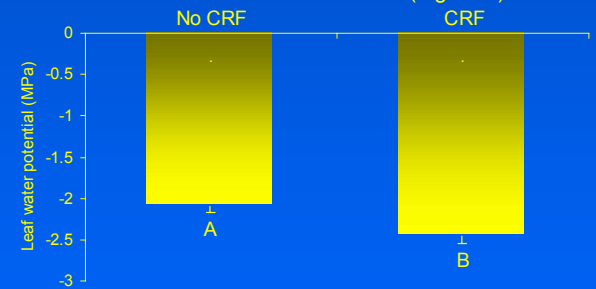

Figure 9. Influence of controlled-release fertilizer (CRF) on leaf water potential. Data points are means, error bars are SE. Treatments with the same letter did not differ significantly at α = .05.

Future directions

Developing stocktypes able to excel on former surface coal mines is needed to improve plantation establishment success. Identifying the influence of container size on seedling performance, increasing our understanding of seedling morphological and physiological requirements for successful establishment, and identifying the effect of specific nursery cultural practices on seedling performance will likely result in increasing successful reclamation of former surface coal mines through the development of nursery stock tailored to these unique site conditions.