Establishing trees in an Appalachian silvopasture: response to shelters, grass control, mulch, and fertilization

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ABSTRACT

In the spring of 1995, approximately 350 bare-root seedlings each of black walnut (*Juglans nigra*) and honeylocust (*Gleditsia triacanthos*) were planted in six randomized paddocks within a silvopastoral study area at the Agroforestry Research and Demonstration Site in Blacksburg, VA. Three seedling establishment studies were tested, including; 1) a tree protection study, 2) a water retention study, and 3) a fertilization study. Seedlings were planted using two different tree shelters (60cm-tall poultry wire cage and 1.2m-tall plastic Tubex), two water retention treatments (mulch and herbicide spray), and one fertilizer treatment. Controls were tested along with each study. Tree survival, damage, and stem volume were compared for each species. Tree survival was comparable between all studies over three growing seasons. Tree establishment using poultry wire and Tubex shelters resulted in significant reduction of deer damage and significant increase in stem volume from 1996 to 1998. Tubex shelters had a pronounced positive impact on tree height and also on stem form (height of both black walnut and honeylocust was twice the height of control seedlings). Mulch and herbicide treatments for moisture control resulted in significant stem volume increases over control from 1997 to 1998. However, mulching was less effective than herbicide treatment. There was no significant tree growth resulting from fertilization during this same period.

INTRODUCTION

Efficient resource management is integral to any productive and economically viable land use system. If a landowner is to invest the time and energy planting trees into an existing pasture, he or she needs some assurance that the tree/pasture system will develop productively with a viable economic return. With that goal in mind, in 1994, a 10-ha site was identified as an agroforestry research and demonstration site (Figure 1) on Virginia Tech's 600-ha Kentland Agricultural Research Farm. The site is located at 37°11' N latitude and 80°35' W longitude approximately 16km southwest of Virginia Tech's campus in Blacksburg, Virginia in the Southern Appalachian Ridge and Valley Physiographic Province. Elevation of the site is approximately 540m (1760 feet) above MSL, with annual temperature ranging from -20°C (-4°F) in the winter to 33°C (92°F) in the summer. Mean annual temperature is 10°C (50°F) and average annual precipitation is 1500 mm (60 in). Soils at the site are Typic Hapludults, which are generally older, deep well-drained soils with gently sloping to steeply sloped topography (25-65% slope). Depth to water table is generally greater than 2m.

[insert Figure 1]

Honeylocust (*Gleditsia triacanthos*) and black walnut (*Juglans nigra*) were planted early in 1995 within the silvopastoral study area. The silvopastoral study consists of nine one-acre paddocks, with three replications of treatments consisting of (i) pasture only; (ii) pasture under honeylocust; and (iii) pasture under black walnut. The paddocks were arranged to accommodate future animal grazing (Figure 1). The trees are planted on 2.5m x 12.5m spacing with the expectation that eventual leave trees will be on 12.5m x 12.5m spacing (Garrett, Jones, Kurtz and Slusher 1991.)

Black walnut and the Millwood variety of honeylocust were selected because both tree species have sparse canopies, are relatively fast-growing, and they provide a number of desirable products and services (i.e., edible nuts and pods, shade for grazing animals, and marketable timber and veneer). The Millwood honeylocust cultivar produces a high-

energy fall fodder crop (Wilson 1991; Gold and Hanover 1993). The pulpy pods can contain up to 35% sugar and have yields similar to an equivalent area of oats (Smith 1950). The grass component of the silvopasture is predominantly native tall fescue (*Festuca arundinaceae*) overseeded with orchardgrass (*Dactylis glomerata*). Both species are cool-season grasses suitable for livestock grazing. Several researchers have reported higher forage production under black walnut trees than in adjacent, open fields (Smith 1942; Neel 1939; Garrett and Kurtz 1983). Several researchers (Akbar et al. 1990; McClaran and Bartolome 1989; Ratliff et al. 1991) have observed increased cereal crop and pasture yields under hardwood trees.

During initial planting of trees in the silvopastoral paddocks, three studies were installed to test the effectiveness of tree shelters, grass control, mulch, and fertilizers on bare-root seedling establishment. Two tree protection techniques were installed to prevent damage from deer browsing and rubbing, and girdling by groundhogs and rabbits. In addition to tree protection effects, previous work at the University of Tennessee has shown that use of plastic tree shelters results in an initial growth advantage in several hardwood species (W. Clatterbuck, pers. comm., 1999). Because pasture grasses compete intensely with tree seedlings for moisture (C. Feldhake, pers. comm., 1999), a water retention study was also devised to test two grass suppression techniques. A concurrent fertilization study tested whether individual tree fertilization was effective for seedling establishment.

MATERIALS AND METHODS

Tree Protection Study

In the tree protection study, tree seedlings were placed under three treatments for three years. The first treatment was a control with no protection. The second treatment was to encircle the seedling with a 60cm-high poultry wire cage at a distance of 15cm from the tree stem. The third treatment was a 1.2m-tall plastic Tubex tree shelter. All trees in the tree protection study received uniform weed control and fertilization. Measured response to treatment included seedling survival rate, winter die-back, insect and disease problems, tree height and diameter, and physiological development.

Water Retention Study

The water retention study tested the effects of herbaceous control treatments on soil water retention and tree growth response for two years. The water retention study was installed on one of the experimental blocks in the silvopastoral study. The experimental unit consisted of 3 trees (two control treatments and a control). The experimental unit was randomized and replicated on a continuum following slope and landscape position on the black walnut and honeylocust paddocks. All trees in the experimental unit were fertilized with 66g (2.33 oz) of diammonium phosphate in early summer and received an early spring application of glyphosate and simizine at a rate of 40ml/gal. The two herbaceous control treatments were 5- to 7.5-cm hardwood mulch and herbicide (glyphosate (20ml/gal)) applied within a 1m radius around the tree.

Volumetric moisture content of the soil in the water retention study was measured in summer 1997 and 1998 via permanently installed TDR (time domain reflectometry) instrumentation. Wave guide rods were permanently installed to a depth of 30cm (12 in) on all trees under treatment. Bendfeldt et. al (1998) previously determined that volumetric soil water content at this site declined uniformly with elevation across all paddocks. In the winter/spring of 1998/99 all trees were measured for basal diameter and total height.

Fertilization Study

The fertilization study tested the effect of fertilization on early tree growth between 1997 and 1998. All trees in the experimental unit received an early spring application of glyphosate and simizine at a rate of 40ml/gal. Trees receiving fertilization treatment were fertilized with 66g (2.33 oz) of diammonium phosphate in early summer. Controls received no fertilization.

Statistical Analysis

Tree growth data was collected in the fall of each year. Mean growth response and treatment effect for each study was tested for significant difference using a general linear model. All means were tabulated with differences among means separated using Duncan's Multiple Range Test ($p > 0.05$).

RESULTS

Table 1 presents the results of the tree protection study. Tree survival was not improved by tree shelters in this study because nearly 100% of all trees survived after three growing seasons. However, in black walnut and honeylocust seedlings, poultry wire and Tubex shelters significantly reduced deer damage compared to the control. Stem volume of black walnut seedlings was significantly greater than control under both tree protection methods. In honeylocust seedlings, only the Tubex shelters resulted in a significant increase in stem volume.

[insert Table 1]

Table 2 presents the results of the water retention study. Volumetric soil water content of mulched black locust was significantly higher than either herbicide or control. Soil temperature was significantly lower. In the honeylocust paddocks, neither herbicide nor mulch treatments had significantly higher soil water content. However, herbicide treatment resulted in significantly higher temperature than either mulch or control.

Diameter and height of both species under herbicide treatment were significantly greater than control. Mulch treatments resulted in greater diameters in only the honeylocust paddocks. Resulting stem volume for both species were significantly higher using both herbicide and mulch treatments.

[insert Table 2]

Table 3 presents the results of the fertilization study. From 1997 to 1998, there was not a significant increase in base diameter, height, or stem volume due to fertilization.

[insert Table 3]

DISCUSSION AND CONCLUSIONS

In the tree protection study, mechanical damage due to deer browsing and rubbing was significantly higher in control trees than in protected treatments. In honeylocust paddocks, deer selectively browsed the foliage including bark of the unprotected Millwood cultivars. For this reason, the 60cm poultry wire cage was less effective than the 1.2m fully enclosed Tubex shelter in preventing deer damage. The poultry cage was effective, however, in preventing damage from girdling by groundhogs. In the black walnut paddocks, damage was curtailed by both protection treatments, due to the tendency of deer to rub, rather than browse the black walnut seedlings. The Tubex shelter, however, provided more complete protection from deer rub.

In addition to providing protection from deer, the 1.2m-tall Tubex shelters had a pronounced positive impact on tree height and stem form. Height of both black walnut and honeylocust was twice the height of control seedlings. Work by other researchers suggests that an etiological (light reaching) response was triggered by the opaque Tubex shelters. In addition, a warmer, more moist micro-environment inside the shelter (similar to a miniature greenhouse) may have accelerated stem growth. Future studies with these same trees will test the wind-worthiness of these elongated stems.

In the water retention study, both herbicide spray treatments increased stem volume 100% over control in both species, while mulching increased stem volume 50% over control. Although mulch treatments were able to retain more soil water in black walnut paddocks, trees were not significantly taller. In honeylocust paddocks, mulching did not effectively increase volumetric water content, but did have a positive effect on stem diameter. Overall, results of this study showed that herbicide treatment of black walnut and honeylocust was more effective than mulching in establishing trees in a pasture.

The results of this fertilization study were inconclusive in determining the need for seedling fertilization.

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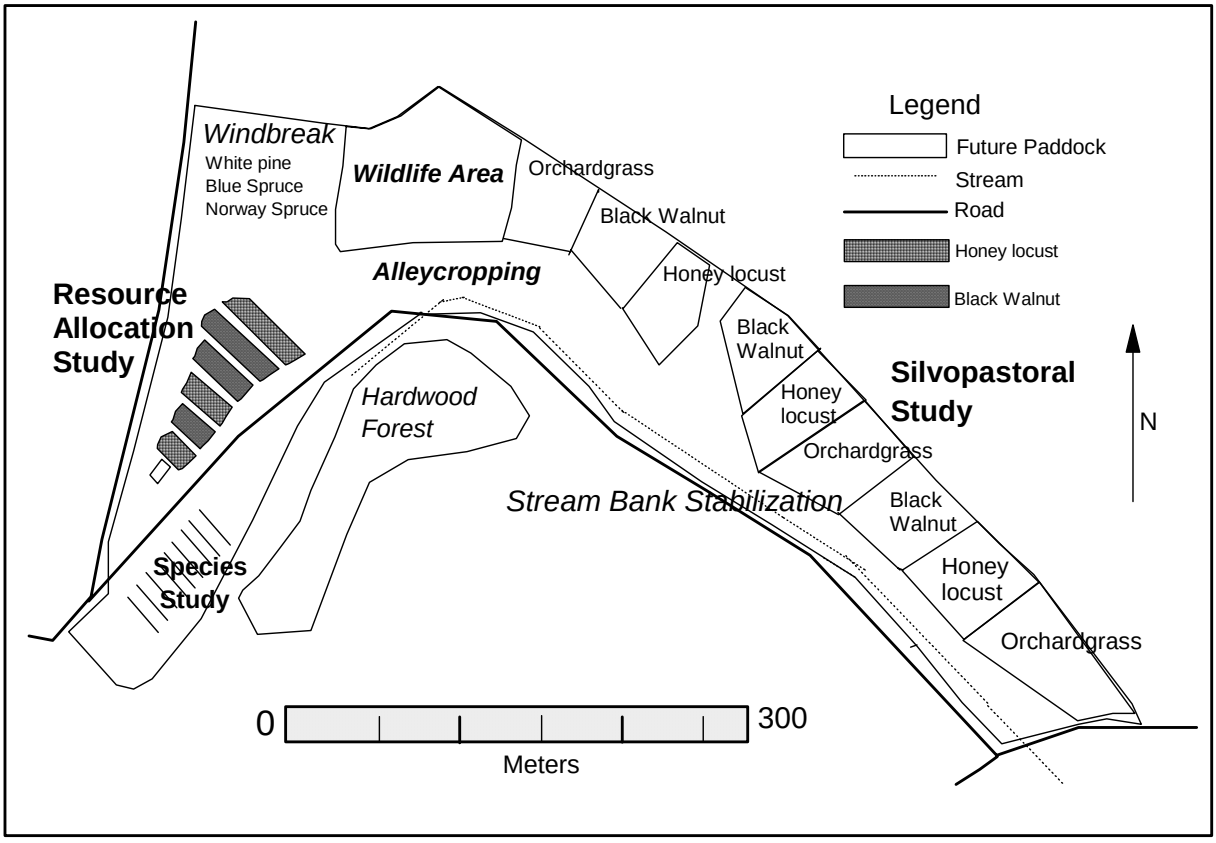
Legend
Future Paddock
Stream
Road
Honey locust
Black Walnut
Windbreak
White pine
Blue Spruce
Norway Spruce
Wildlife Area
Orchardgrass
Black Walnut
Alleycropping
Honey locust
Resource Allocation Study
Black Walnut
Honey locust
Orchardgrass
Silvopastoral Study
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Stream Bank Stabilization
Black Walnut
Honey locust
Orchardgrass
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