ESTABLISHMENT TRIAL OF AN OAK-PINE/SOYBEAN-CORN-WHEAT ALLEY-CROPPING SYSTEM IN THE UPPER COASTAL PLAIN OF NORTH CAROLINA

H.D. Stevenson, D.J. Robison, F.W. Cubbage, J.P. Mueller, M.G. Burton, and M.H. Gocke[1]

Abstract—Alley cropping may prove useful in the Southeast United States, providing multiple products and income streams, as well as affording sustainable land use alternatives to conventional farming. An alley-cropping system may be a good alternative in agriculture because of the benefits provided by trees to crops and soils, as well as the income generated from wood products and timber. In the current study triple row single-species strips of cherrybark oak (*Quercus pagoda* Raf.), loblolly pine (*Pinus taeda* L.), or longleaf pine (*P. palustris* Mill.) were planted separated by 12- or 24-m wide areas of agricultural crops. Survival, seedling height, and diameter growth were measured in the first and second year of the study. Cherrybark oak, loblolly pine, and longleaf pine seedlings all had over 80 percent survival rates and showed positive height and diameter growth over the first two growing seasons.

INTRODUCTION

Agroforestry has been practiced for centuries around the World, and new agroforestry systems and strategies are currently under research, with an emphasis on improving practices and preserving the quality of the environment (Jama and others 2006, Nair 2007, Sanchez 2005, Williams and others 1997). In recent years, agroforestry research has focused on developing techniques and improving efficiency in various systems (Erdmann 2005, Sanchez 1995, Young 2004). One type of agroforestry that has been gaining interest in the Southeastern United States is alley cropping (Stamps and Linit 1997). Alley cropping is a system of trees and crops that are managed on the same parcel of land at the same time, and generally consists of tree rows running in narrow strips along the length of an agricultural field planted in annual crops. The current study was designed as an alley-cropping system that incorporated cherrybark oak (*Quercus pagoda* Raf.), loblolly pine (*Pinus taeda* L.), and longleaf pine (*P. palustris* Mill.) into an agricultural crop rotation.

In alley-cropping systems, trees can provide a diverse and extensive range of ecological benefits (Huxley 1983). Land managed for both trees and agriculture can host and support a wider range of arthropods and members of the soil community, which has been shown to increase aboveground productivity (Crutsinger and others 2006). Trees affect soil nutrition by helping to stabilize soil structure, which can also determine the ability of root growth and nutrient accessibility of annual crops (Leakey 1999). Trees can access and recycle nutrients that would otherwise be unattainable for annual crops (Sanchez 1987, Young 1989) and pump water out of soils (Erdmann 2005, Ledgard 2001, Wood and Burley 1991) which can reduce salinity and enhance soil fertility (Jose and others 2008). Trees can provide extra ground cover for better protection of waterways (Bernstein 1975, Prinsley 1992), create an improved microclimate for crops (Long and Nair 1999), minimize weed competition (Basavaraju and Gururaja Rao 2000), and contribute to economic diversity (Jose and others 2008), including the potential for landowners growing trees to earn carbon credits (Rizvi and others 1999).

METHODS

The study consisted of cherrybark oak, loblolly pine, and longleaf pine in an alley-cropping management scheme with annual crops that included soybean [*Glycine max* (L.) Merr.], corn (*Zea mays* L.), and wheat (*Triticum aestivum* L.) in a 3-year rotation. It was deployed in Goldsboro, NC, in January 2007. The field site is located at the North Carolina Department of Agriculture & Consumer Services, Cherry Research Farm on the Coastal Plain in the eastern-central part of North Carolina. The Cherry Research Farm hosts the Center for Environmental Farming Systems (CEFS), established in 1994, and is one of the largest centers for the study of environmentally sustainable farming practices in the Nation (www.cefs.ncsu.edu).

The site is a 10-ha (25-acre) agriculture field that had been in corn and soybean production for several years prior to the current study. The southern edge of the field borders the Neuse River, and the eastern edge borders a tree-lined ditch for drainage. According to the U.S. Department of Agriculture soil survey (http://soils.usda.gov/survey), the field site includes four soil types: Lakeville sand (49.7 percent of total field ha), Coxville loam (37.7 percent of total field ha), Chewacla loam (9.3 percent of total field ha), and Leaf loam (3.3 percent of total field ha).

The three tree species planted were selected for their regional relevance and market value. The agriculture production was set up in a 3-year annual crop rotation with long-term plans

[1] Graduate Student, Professor, and Professor, North Carolina State University, Department of Forestry and Environmental Resources, Raleigh, NC; Professor, North Carolina State University, Department of Crop Science, Raleigh, NC; Professor, Missouri State University, Department of Agriculture, Springfield MO; and Greenhouse and Nursery Manager, University of North Carolina, Chapel Hill, NC, respectively.

for establishing perennial forage, with a possibility for grazing, as the trees mature. The field was blocked into five replicates from north to south to account for the gradient of soil variation and slope. Each block was 165 m (540 feet) wide and 128 m (140 feet) long with 1.5-m (5-foot) buffers (fig. 1).

Each block was then divided into annual agricultural crop plots and tree plots. The annual crop sections were 12 m (40 feet) wide by 128 m long, or 24 m (80 feet) wide by 128 m long. Each block contained two of each of 12-m width, and 24-m width areas, and included five tree plots, 6 m (20 feet) wide by 128 m long. The tree plots (triple-row wide strips) were laid out in between the annual crop areas (fig. 1). They were divided into thirds lengthwise, each species randomly assigned to each section, measuring 6 m wide by 43 m long (20 by 140 feet). Trees were planted in plots, three rows wide, at 1.5- by 2-m (5- by 7-foot) spacing. The total number of seedlings planted, including all species, was 5,000. Equipment access roads were delineated between blocks, as 4.5 m (15 feet) of unplanted areas, running across the width of the field.

The entire field had been conservation tillage planted to corn in 2006 and harvested before the end of that year. In that year it was not cultivated before the start of the current study. Trees were planted by block in January 2007. All the seedlings came from the North Carolina Division of Forest Resources, F.H. Claridge Nursery in Goldsboro. The loblolly pine seedlings were 1-0 bare root from genetically improved seed. The longleaf pine was planted as 1-0 container seedlings grown from seed that originated from Bladen County, NC. The cherrybark oak was planted as 1-0 bare-root seedlings with seed that came from Pee Dee River Basin in upper South Carolina.

In March 2007, before the trees had broken bud, the preemergent herbicide, Oust® (Du Pont, Wilmington, DE; sulfometuron methyl) was sprayed overtop at 219 ml/ha (3 ounces per acre) using a 6.5-m (20-foot) spray boom so that the three rows of trees, each row 1.5 m apart, were covered with herbicide. Between the triple-row plots of trees, in the agricultural areas either 12 or 24 m wide, the field was disk harrowed in April, and again in May 2007, but not closer than 1.5 m from the outer tree row in each plot. Potash [potassium oxide (K2O)] was then broadcast applied to the entire field, including trees and agriculture areas, at 224 kg/ha (200 pounds per acre). The field areas between the trees were again disked twice in May, the area was then soil-surface conditioned with a Lorenz device (Lorenz Mfg. Co., Watertown, SD). The Asgrow 5905 (Asgrow Seed Company LLC, St. Louis, MO) variety of glyphosate-resistant soybeans were planted on May 21 on 76-cm (30-inch) row spacing at 49 398 seeds/ha (123,493 seeds per acre). The soybeans were sprayed in June with glyphosate at 210 g/ha (40 ounces per acre) with a hooded sprayer, and again in July with glyphosate at the same rate along with the herbicide FirstRate™ (Dow AgroSciences, Minneapolis, MN, cloransulam-methyl) at 21.9 ml/ha (0.3 ounce per acre), with

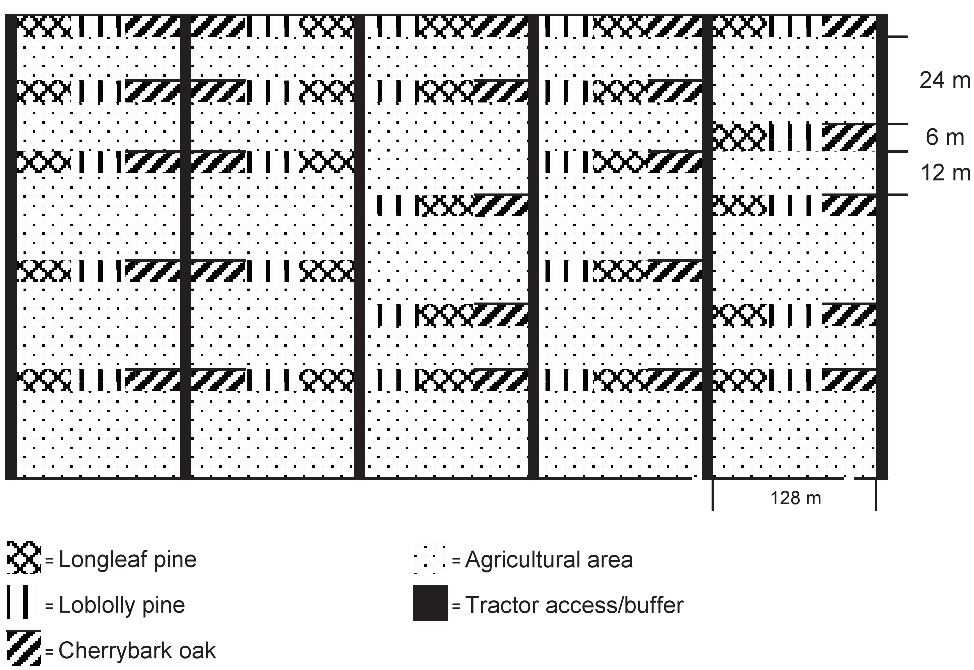

Figure 1—Layout and dimensions of agroforestry field trials, including tree species, of longleaf pine (*Pinus palustris*), loblolly pine (*P. taeda*), and cherrybark oak (*Quercus pagoda*) planted in early 2007 in triple-row strips between agricultural areas (two different widths) which were planted to soybean (*Glycine max*) in 2007 and corn (*Zea mays*) in 2008 near Goldsboro, NC.

a hooded sprayer. The soybean harvest yielded 670 kg/ha (10 bushels per acre).

Tree height (±1 cm) and diameter (±0.1 cm) measurements were taken from a subsample of 450 trees to represent the size of trees at the time of planting, and again after their first and second growing seasons, in November 2007 and December 2008. Cherrybark oak and loblolly pine height were determined by measuring from the soil surface to the tallest resting bud. For longleaf pine seedlings, height was measured from the soil surface to the top of the grass bunch. Diameters were measured with a dial caliper 2 cm above the root collar. Longleaf pine diameter was not recorded. Annual height and diameter growth was calculated. Seedling survival was recorded in November 2007 at the end of the growing season, and confirmed in spring 2008.

RESULTS AND DISCUSSION

The mean first year (2007) height growth of cherrybark oak seedlings was 10.7 cm, and diameter growth was 3.0 mm (table 1). In the second year, cherrybark oak seedling height growth increased by 218 percent, and the diameter growth increased 263 percent over the previous year's growth, with an average of 35 cm height growth and 10.9 mm diameter growth during the 2008 season. The total height growth over the two growing seasons was 45 cm, and diameter growth was 13.9 mm. Cherrybark oak survival was 93 percent. These results are within range of growth statistics reported in other studies of cherrybark oak seedlings in the Southeast (Dubois and others 2000, Stanturf 1995).

Loblolly pine seedlings averaged 7.5 cm height growth and 4.9 mm diameter growth for the 2007 growing season (table 1). In 2008, the loblolly pine seedlings' height growth increased by 380 percent, and diameter growth by 263 percent, over the previous year's growth. For the 2 years of the study, the total height growth was 85 cm, and diameter 28.6 mm. Loblolly pine seedling survival was 89 percent. The loblolly pine seedlings suffered Nantucket tip moth [*Rhyacionia frustana* (Comst.)] attack in the first 2 years, damaging the apical stems, and affecting height growth and possibly diameter growth, and introducing variability into the growth estimates.

Longleaf pine seedlings had an average needle height growth of 16 cm for the 2007 growing season, but in 2008 height growth slowed, averaging only 10 cm (table 1). The total 2 year-needle height growth was 27 cm. Longleaf pine seedlings survival was 86 percent. By the end of the 2008 season, some of the longleaf pine were emerging from the grass stage and beginning to show stem elongation.

This alley-cropping trial will be maintained and monitored for several decades. It will be used as an integral part of the demonstration and education goals of the research farm, and as a template for continued research. Studies will include tree and agronomic productivity, financial implications, soil system attributes, insect-disease-weed interactions between the crop and tree areas, compatibility of weed control systems between the closely associated crop and tree plantings, and agroforest-ecosystem changes as the trees mature and provide more above- and belowground competition to the crop/forage zones. In 2007 an additional study, by the current authors, was superimposed on the tree strip to evaluate the impacts of on-farm wastes (discarded hay, hog manure-corn stover mix, black plastic) used as mulches around the newly planted seedlings. Other studies addressing management techniques and efficiency will follow.

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Table 1—Two-year height and diameter growth of 1-0 seedlings planted in early 2007 in an agroforestry trial near Goldsboro, NC

	Height growth	Diameter growth	Height growth	Diameter growth	Total height growth	Total diameter growth
Species	2007	2007	2008	2008	2007–08	2007–08
	cm	*mm*	*cm*	*mm*	*cm*	*mm*
Cherrybark oak	10.7	3.00	34.5	10.90	45.2	13.89
Loblolly pine	7.5	4.94	77.4	23.72	84.9	28.66
Longleaf pine	16.1	—	9.7	—	26.7	—

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