ROW SEEDING OF FOREST TREE SPECIES ON LIGNITE SPOILS IN EAST TEXAS[1]

by

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Abstract. Freshly graded lignite spoil was row seeded to shumard oak, green ash, loblolly pine, shortleaf pine, sweetgum, and autumn olive. Half of the field plots were mulched with hay. Autumn olive did not germinate. Field plots exhibited serious erosional washing. Most of the loblolly pine, shortleaf pine and sweetgum were washed from the study area in heavy spring rains. Emergence of green ash was adequate but herbaceous competition introduced in the hay mulch adversely affected survival and growth. Shumard oak emerged and survived well despite vegetative competition. Foliar deficiency symptoms occurred with all species. Nitrogen and potassium were identified as contributing most to foliar chlorosis. These results indicate that noncompetitive erosion control together with heavy seeded species offer the most promise for direct seeding.

Additional Key Words: Direct seeding, spoil erosion, nutrient deficiencies.

Introduction

In 1890 there were approximately 150 lignite mines in 35 East Texas counties. These were underground mines that were abandoned when inexpensive natural gas and oil became practical for fueling electric generating plants. In 1975, the Texas Railroad Commission ordered a 25% reduction in the use of natural gas by 1985. Power companies began surface mining of lignite to make up the difference.

In 1978 Texas was producing approximately 20 million tons of lignite, making it the largest ignite producer in the nation. At present, nine East Texas counties have existing or proposed lignite strip mines. An estimated 400,000 hectares will eventually be disturbed by lignite mining. Past reclamation of these lands has emphasized improved pastures. Due to the role of the wood products industry in East Texas, reforestation of surface mined areas has become a desirable alternative.

The purpose of this study was to examine row seeding for forest tree species as a method of reclamation for surface mine spoils. Objectives were to identify tree species suitable for direct seeding on mine spoils and determine the effect of ground cover on tree seed germination, seedling survival, and growth.

Artificial reforestation is most often achieved by planting seedlings by broadcast seed application, or by row seeding (direct seeding). Seedling planting is often expensive and is most successful while plants are dormant (limited planting season). Broadcast seeding success can be sporadic due to bird and rodent predation and drought. Wittwer, Grave, and Carpenter (1979) stated that regeneration of oaks is often difficult using conventional bare-rooted seedling because of their tap roots and suggests that direct seeding would be especially useful in regenerating these species. Row seeding can be accomplished during an expanded seasonal "window" (Williston and Balmer 1977) and the soil covering offers protection from erosion, dessication, and animal predation (Russell and Mignery 1968). Sluder (1965) found that seed depth was a factor in germination and that deep planting seemed to conceal the acorns of scarlet oak and protect them from animal predation. The protective layer of soil is especially important on mine spoils because erosion is often so severe that mulch used as spoil cover is washed from the seeded areas (Banfield 1982). Many of these disadvantages are eliminated with furrow seeding (Russell and Mignery 1968). Furrow seeding places the seed in rows at defined spacing. The layer of soil placed over

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the seed offers protection from erosion, desiccation, and animal predation.

Direct seeding requires site preparation to expose mineral soil and to control competing vegetation (Williston and Balmer 1977). Ten-year old loblolly pines sown in prepared strips were taller, larger in diameter, and survived better than similar trees sown in grass rough (Lohrey 1974). Bengston, Mays, and Allen (1973) found that pine seedling establishment was higher on freshly graded spoil than on older spoil.

Plass (1974) concluded that predominantly fine textured spoils interfered with plant emergence due to soil surface crusting. Coarse textured soils with a pH of 4.1 to 5.0 were found to offer the best chance of seeding success.

Study Area

The study area was located in Panola County, Texas which typically receives 114-127 centimeters (45-50 inches) of rainfall per year. Principal tree species of the county include loblolly, shortleaf and slash pine as well as sweetgum, eastern cottonwood, sycamore, and water oak.

This research was conducted on land leased by Texas Utilities Generating Company in Panola County, Texas. The natural soils are described as loamy to clayey (Dolezel 1975). The spoil material throughout the study sites is generally clay loam. Surface drainage was good and spoil material was free of rocky material. Two recently mined areas were selected. Spoil was contoured to slopes less than eight percent.

Soil samples were analyzed by the SFASU Soil Testing Laboratory and it was determined that the spoil material was generally low in nitrogen, phosphorus, and potassium. Micronutrient levels were relatively higher. Soil pH ranged from 5.0 to 6.2.

Methods and Procedures

Species Selection

Shumard oak, green ash, loblolly pine, shortleaf pine, sweetgum, and autumn olive were selected for seeding principally on the basis of their tolerance to poor site conditions and potential for rapid growth. Desirability of the species for forest products, wildlife habitat, aesthetic and recreational value were also considered.

Site Preparation

Two sites were chosen the latter part of February 1982. The spoil was graded during the first week of March 1982. One week later, the plots were delineated on the site. Soil samples were collected from each of the eight cells within the block and mixed to obtain composite samples for analysis. Three samples from each site were analyzed for plant nutrient levels. Spoil was disked just prior to seeding. One half of the study area was mulched with hay which was mechanically tacked to the spoil material.

Originally, it was proposed that a ground cover of rye and subterranean clover would be planted on one-half of the site to achieve soil stabilization. This became impossible when heavy rainfall kept the environmental staff of Texas Utilities Generating Company from grading and disking until the middle of March. At this late date, it was not feasible to plant a cool season cover crop. Since a warm season cover-crop would compete with the tree seedlings for moisture during the dry summer months, the area was mulched with hay instead. The mulch was mechanically tacked to the spoil material. This operation was intended to simulate the ground cover that would have been achieved after the cool season cover-crop had died and its stubble was left.

Seed Preparation

All seeds were obtained from commercial sources, and cutting tests were performed since viability was not guaranteed. The seeds appeared to be in satisfactory condition. Seeds were mixed in clean builder's sand and kept in cold, damp storage at recommended times (USFS, 1974). Just prior to planting, the stratified seeds were inoculated with microorganisms, especially mycorrhizae. To do this native forest soils were removed from beneath stands of mature trees for each of the six species. Seeds were then stored in this soil prior to planting.

Planting

In the field, each species was randomly assigned a position in each of four replications and each species was planted in unmulched and mulched plots on both study sites. All planting was done by hand. Seeds of all species except Shumard oak were planted at two-foot intervals. Shumard oak was planted at three-foot intervals because only a limited number of acorns could be obtained. Planting was done at the deepest of the range of seeding depths recommended by the Handbook of Seeds of Woody Plants in the U.S. (USFS, 1974). The greatest seeding depth for each species was chosen to protect the seeds from sheet erosion.

Growth Data

Data related to growth was collected as follows: Emergence was counted the last week of June and expressed as the percentage of seeds planted in the replication. Survival was inventoried in October and the survival rate was expressed as the percentage of emerged seedlings in the replication. Height measurements were taken with the survival count and expressed as total height in centimeters.

A scale of one to five was devised to estimate the vigor of the seedlings, based on deficiency symptoms:

1. healthy, no sign of nutrient deficiencies,
2. relatively healthy, beginning to exhibit deficiencies,
3. increased chlorosis, firing of leaf margins, stunted growth,
4. extreme chlorosis, necrotic leaf margins, stunted growth,
5. severe chlorosis, necrotic spots, severely stunted growth, near death.

Each seedling was rated with this scale when height measurements were taken.

Random samples were taken within each cell to estimate percent ground cover and invading vegetation.

Foliage Analysis

Foliage was collected from each seedling in a cell and dried, milled and analyzed for nitrogen, phosphorus and potassium contents. Digestion of samples was done by a modified Kjeldahl method (Isaac and Johnson 1976). Nitrogen content was determined after distilling 5 ml of the extract by the micro Kjeldahl procedure (Bromner, 1965). Phosphorus was done with 5 ml of extract and 25 ml of ammonium solution mixed in a test tube and shaken twice within a 2-hour period. Samples were read on a colorimeter and percentages were determined on a line graph on which known standards had been plotted. Percent potassium was determined by mixing 1 ml of the extract with 100 ml of distilled water and analyzing on the atomic absorption spectrophotometer.

Statistical Analysis

All data were analyzed with Biomedical Computer Programs (BMDP 2V) at the SFASU Computer Center. The experimental design was a split-split plot design. Analysis of variance and covariance with repeated measures was used to test emergence, survival, height growth, deficiency symptoms and foliar nitrogen, phosphorus and potassium. Analysis of variance failed to show any significant difference between the two planting sites. Therefore, the measurements and observations were combined for further analysis.

Results and Discussion

Emergence

Emergence was nil for sweetgum and autumn olive and poor for loblolly pine and shortleaf pine. For this reason, only percent emergence could be analyzed for all six species. Shumard oak and green ash had the greatest emergence (see Table 1). Shumard oak and green ash were the largest seeds planted, were planted at the greatest depths, and were the least affected by erosion.

Table 1. Percent seedling emergence in field plots.

Species	Unmulched*	Mulched*
	|------------Percentage	------------|
Shumard Oak	85.94 a	67.19 a
Green Ash	29.06 b	36.16 b
Loblolly Pine	2.20 c	1.86 c
Shortleaf Pine	0.34 c	0.85 c
Sweetgum	0.00 c	0.00 c
Autumn Olive	0.00 c	0.00 c

*Means with different letter subscripts are significantly different at the 95% confidence level, within like treatment. The mulch effect was significant at the 95% confidence level for Shumard oak and green ash, based on a one-way analysis of variance. (Not reflected in Table 1.)

Survival

Shumard oak had the greatest survival with 95.09% in unmulched plots and 93.88% in mulched plots. Mulching did not have a significant effect on the survival of Shumard oak. Green ash survival was significantly lower than Shumard oak for both treatments. Survival was 80.89% in unmulched plots and 62.90% in mulched plots. The mulch effect was significant on survival of green ash. This was probably due in part to the competition introduced by seeds in the hay mulch. This competition seemed to have negatively affected the growth and development of green ash throughout the study.

Little or no emergence of loblolly pine, shortleaf pine, sweetgum, and autumn olive prevents further analysis for those species.

Height Growth

Height growth for Shumard oak was 10.91 cm and 10.80 cm in unmulched and mulched plots, respectively. Height growth of Shumard oak was not significantly affected by the mulch effect. Height growth for green ash was 12.35 cm and 7.91 cm in unmulched and mulched plots, respectively. No significant difference existed between species at the 95% confidence level. The mulch did, however, have a negative effect on green ash with the introduction of grasses which competed for moisture. Moisture appeared to be a limiting factor for growth.

Deficiency Symptoms

Deficiency symptoms were exhibited by all species (see Table 2). The symptoms were typical of nitrogen and potassium deficiencies as described by Walker and Beacher (1963) and Baule and Fricker (1970). The most predominant symptoms included chlorosis, stunted growth and firing of leaf margins.

Table 2. Seedling deficiency symptoms in field plots.

Species	Unmulched	Mulched*
	Rating	
Shumard Oak	3.25	3.05
Green Ash	2.76	3.15

1 = Healthy, 5 = Severe Deficiency Symptoms

*No significant difference was detected between species at the 95% confidence level. The mulch effect was significant at the 95% confidence level for Shumard oak and green ash, based on a one-way analysis of variance.

Foliage Analysis

Green ash was significantly higher than Shumard oak in foliar nitrogen, phosphorus and potassium levels (see Table 3). This is due mainly to the physiological differences in the two species. Green ash foliage is naturally high in nutritional value and for this reason is identified as excellent wildlife browse (Vines, 1976).

Table 3. Seedling foliar element content in field plots versus normal forest trees.

Species	Unmulched*	Mulched	Normal Forest Tree
	Foliar Nitrogen Percentage		
Green Ash	1.41 a	1.27 a	1.15
Shumard Oak	1.20 b	0.78 b	1.57
	Foliar Phosphorus Percentage		
Green Ash	0.22 a	0.24 a	0.10
Shumard Oak	0.06 b	0.04 b	0.09
	Foliar Potassium Percentage		
Green Ash	0.78 a	0.64 a	0.96
Shumard Oak	0.34 b	0.55 a	0.71

*Means with different letter subscripts are significantly different at the 95% confidence level.

The mulch effect was significant at the 95% confidence level for foliar nitrogen of Shumard Oak only, based on a one-way analysis of variance. (Not reflected in Table 3.) Addition of organic material will generally limit the amount of nitrogen available to the plant. Green ash appeared to have adequate nitrogen while Shumard oak appeared to be deficient. Species differences were noted for all elements due to mulch effect. It did appear that both Shumard oak and green ash were very deficient in potassium content.

Deficiency symptoms described earlier were identified as nitrogen and potassium deficiencies. Foliar analysis indicated that Shumard oak was probably very nitrogen deficient. Tissue analysis also indicated that both Shumard oak and green ash were very deficient in potassium content. The deficiency symptoms exhibited by the seedlings appear to be good indicators of the low foliar nutrient levels.

Conclusions

Results from this study indicate that Shumard oak and green ash are suitable for row seeding on lignite spoils. Few problems were encountered with

Shumard oak. The summer drought did not have noticeable effects on seedling survival. Initial growth was rapid and roots developed quickly. Green ash performed well where there was little competition. Soil stabilization is not often achieved by a grass cover. Therefore, green ash does not appear to be a suitable species for mine spoil reclamation in conjunction with such competiton. It would perhaps be feasible to plant green ash with a cool season cover crop since this crop would die before moisture became critical for the seedling. Planting in scalped strips or spots could be considered although this would not offer the cost efficiency of seeding concurrently.

Loblolly pine, shortleaf pine, sweetgum, and autumn olive did not have significant emergence prior to heavy seasonal rains. As a result, these rains washed many of the seeds from the site, despite respective planting depths.

Seed size and sowing depth were identified as critical elements due to site instability. Larger seeds were planted at deeper depths and were less susceptible to disturbance by water and soil movement. In addition, the mulch was beneficial in reducing erosion, thereby protecting the site and the seeds.

Nutritional deficiencies were noted by the end of the growing season. However, prior research in mine spoil fertilization indicated possible detrimental effects to seed germination and emergence (Bengston, Mays and Alle, 1973).

Future research suggested by this study includes refinement of small seed sowing depths, evaluation of tree seed planting in combination with a cool season cover crop, and evaluation of optimum timing for fertilizer applications.

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