Comparison of Seeding Versus Planting Loblolly Pine in Rips

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Forest managers often rip planting sites in the Ouachita Mountains to ameliorate adverse soil conditions before planting. Direct seeding in spots was compared to normal planting of loblolly pine (Pinus taeda L.) seedlings on a site prepared by ripping. At the end of the first growing season, bareroot seedling survival averaged 47% and spot stocking was 15%. Analysis of variance indicated that shade created by woody competition and coarse-textured soil contributed to significantly higher stocking rates, emphasizing the importance of microsite conditions to the success of direct seeding. Tree Planters' Notes 43(2):48-51; 1992.

Forest managers have used direct seeding as a regeneration tool for many years. The development of reliable bird and rodent repellents for coating seeds stimulated considerable interest in direct seeding southern pines during the 1960's (Jones 1985). Although direct seeding fell out of favor with many forest managers during the late 1970's and early 1980's, the method has attracted some renewed interest among those seeking to develop alternative, low-cost regeneration methods appropriate for small ownerships (Hazel *et al.* 1989).

A wide range of direct-seeding technologies has evolved, including hand planting in spots, hand-held "cyclone" broadcast seeders, modified tractor-pulled agricultural row seeders, and aircraft-mounted units. The particular situation in which direct seeding is to be used will determine which technique to employ. For example, landowners with small properties find direct seeding in spots to be especially appealing because it is cheaper, faster, and easier than hand planting nursery-grown seedlings (Lohrey 1970). Spot seeding, because it permits better control of stocking and spacing, requires only a third to a half of the seed required for broadcast sowing (Campbell 1981). In some situations, direct seeding can be more attractive than natural seeding because the mature stand can be harvested without waiting for a good seed year to occur.

Regenerating pine in the Ouachita Mountains of Oklahoma is often a difficult task. Most soils have developed from metamorphosed sandstone, shale, and stony colluvium. Typically, soil profiles in the region consist of clayey topsoils over sandy subsoils with abundant rock, making these sites droughty and difficult to plant. Ripping is a popular practice when planting bareroot seedlings in the region (Wittwer *et al.* 1986). Ripping-loosening and mixing the soil to permit free drainage and aeration, thereby providing channels to collect surface runoff-can alleviate these adverse soil conditions (Wilson 1969). For example, subsoiling the graded spoil of a reclaimed coal mine in Illinois significantly reduced soil bulk density and improved seedling root and shoot growth (Philo *et al.* 1983). Ripping can also provide some control of competing hardwood sprouts by disturbing rootstocks. However, the exposure of bare mineral soil may provide a more favorable seedbed for annual weeds and grasses.

The purpose of this study was to compare the survival of planted bareroot seedlings versus direct seeded loblolly pine in rips. Furthermore, various factors of the microsite environment that seeds are placed in (degree of shading, presence and type of vegetative competition, soil texture, and color) that could affect seeding survival rates when sown in rips were studied. There are no previous reports on the possible benefits of ripping for direct-seeded loblolly pine.

Study Site

The study site is located in southeastern Latimer County, Oklahoma, near the western edge of the southern pines' natural range. The soil is classified in the Bengal-Denman association (Brinlee and Wilson 1981). While it is typically well-drained and deep, the soil is low in natural fertility and organic matter content. Permeability is slow and available water capacity is average. The surface layer is brown stony loam, overlying yellowish-red clay loam. The original stand, composed of mixed hardwood and short-leaf pine *(Pinus echinata* Mill.), was clear-cut during the winter of 1988-89. A considerable amount of hard wood slash and large stones were present on the site. The site was ripped to a depth of 38 to 45 cm (15 to 18 inches) during the fall of 1989.

Methods

During March of 1990, 1 + 0 bareroot loblolly pine seedlings were commercially hand planted in the rips, except for four replicate plots of 0.04 ha (0.10 acre) each reserved for direct-seeding, distributed over the 5.3-ha (13-acre) site. The four plots to be seeded each consisted of eight 20-m (66-foot) long, ripped rows spaced about 2.4 m (8 feet) apart. Within each row, nine planting spots were located, between 2.1 and 2.7 m (7 and 9 feet) apart, spaced to avoid rocks and other unfavorable areas. The planting spots were created by scratching loose a space of mineral soil 15 to 25 cm (6 to 10 inches) long. Twelve seeds were scattered over the scarified area and covered with the loosened soil. Hence, each replicated seeding plot contained 72 seed spots and 864 seeds, equivalent to 1,800 seed spots and 21,600 seeds/ha (8,640 seeds/acre).

The loblolly pine seed source was a single open pollinated family harvested in the Oklahoma Forestry Division seed orchard 5 years before the beginning of this study. It was sown in April 1990 after being stratified for approximately 2 months. A post-stratification germination test indicated that 95% of the seeds were viable. Because the seeds were covered during the planting process, little predation was anticipated and the seeds were not treated with repellants.

Each planting spot was subjectively classified according to four criteria:

1. Presence or absence of shade from adjacent stumps, logging slash, or vegetation
2. Presence and type of any competing vegetation
3. Soil texture
4. Soil color

Stocking of seeded spots and survival of planted seedlings was evaluated in May and August 1990 and January 1991. Bareroot seedling survival and total height in January 1991 were estimated from observations on 20 to 40 seedling planting-spots adjacent to each of the four seeded plots. Seedling planting-spots were located in the rips extending beyond the ends of the plots reserved for seeding. The presence of living, green cotyledons or primary and secondary needles, depending on the stage of development, was used as an indicator of germination and survival. The data were analyzed using Statistical Analysis System's GLM procedure because the sample sizes were unequal and the data did not fit into a balanced design (SAS Institute 1988).

Results and Discussion

Seeding and seedling survival exhibited a declining trend during the study period (table 1). Given the 95% germination rate determined in the laboratory, the maximum expected number of seedlings per spot was 11. Had all 11 seeds per spot germinated and survived, they would have produced 19,800 seedlings/ha (7,920 seedlings/acre). However, at the first tally in May, only 600 seedlings/ha (960 seedlings/acre) were present, representing 12.1 % of the viable seeds sown.

The 12.1 % "field" germination obtained in this study is better than the 3.7% observed in May following natural seed-fall of 1,124,300 short-leaf pine seeds/ha (455,000/acre) in East Texas (Ferguson 1958). However, in that study the seeds lay exposed to predation over winter, unless they were naturally covered by precipitation, leaf litter, or other natural events. The seeds in the present study had the advantage of being immediately covered during the seeding process. Loblolly pine seeds spot-seeded by pressing into bare mineral soil in mid-March exhibited maximum field germination of 17% when mulched with forest floor debris from the site in a Georgia study (Dougherty 1990). Seeds not covered with mulch failed to germinate. Survival at the end of the growing season (2.9%) is slightly less than that reported for a disking site preparation treatment in a natural short-leaf pine stand (Dale 1958). In that study, survival was 6.2% on bulldozed plots, 4.2%0 on disked plots, and 1.4% on untreated plots one year after seed-fall in Kentucky.

Despite the low overall seeding survival, in May, 51.5% of the seed spots (table 1), equivalent to 930/ hectare (370/acre), were stocked with at least one live seedling. However, by the following January, only

Table 1—*Survival and stocking of direct-seeded and bare-root seedling loblolly pine during the first growing season*

Measurement date	Direct seeding: Survival[1] (%)	Direct seeding: Stocking[2] (%)	Bareroot seedlings survival (%)
May 1990	12.1	51.5	81.2
August 1990	3.6	18.0	61.7
January 1991	2.9	14.6	47.2

[1]Number of seeded trees as a percentage of all seeds planted.
[2]Number of stocked spots as a percentage of all planting spots.

about 15% of the spots remained stocked, equivalent to about 270/hectare (105/acre). The number of seedlings in the stocked spots ranged from 1 to 12. The stocking rate obtained at the end of the first growing season in. this study was comparable to the minimum reported in a North Carolina study (Hazel et al. 1989). They obtained milacre stocking (1 milacre = 4.05 m^2) ranging from 13.3 to 75.6% after one growing season on plots sown using hand-casting and broadcasting methods.

The initial drop in seeding survival and stocking may be attributed to the abnormal precipitation patterns observed from April through July. Unusually heavy rains during April and May washed a number of seeds more than a foot from their original location. In addition, approximately 4% of the seed spots were flooded during May. Other spots that failed to produce any germinates may have had seed either washed away or buried too deeply by water-borne sediment. During June, the site received less-than-normal rainfall. This low precipitation coincided with a 7 °C (13 °F) increase in the average monthly high temperature. Consequently, the remaining seedlings were subjected to unfavorable environmental conditions.

Some researchers have emphasized the importance of microsite conditions on seeding survival. Campbell (1964) argued that microsite conditions are perhaps more important than spot density when considering survival and height growth. More specifically, Dougherty (1990) demonstrated that mulching improved both seeding emergence and survival. In the present study, degree of shading from logging debris or vegetation, mostly hardwood sprout clumps, did not affect germination in May (table 2). However, at the end of the growing season a significantly higher proportion of shaded spots (especially those with woody vegetation nearby) were stocked than unshaded spots. Sufficient moisture in the uppermost soil layers is critical for germinating seeds and new seedlings. Shading may benefit the soil moisture regime for new seedlings by reducing direct evapotranspiration losses from the soil and seedlings. These hardwood sprouts will probably loose their beneficial influence and become true competitors as the pine seedlings develop and expand their rooting depth and volume. Significantly higher stocking levels were observed in August 1990 and January 1991 in spots with coarse-textured soil materials than in spots with medium or fine-textured soil. All microsite factors except soil color exhibited a significant effect on stocking for at least one of the observation dates.

Table 2—*The effect of shade, competition, soil texture, and soil color on the percent of spots stocked by direct seeding loblolly pine in Oklahoma*

Factor	Total spots 1990	% Stocking May 1990	August 1990	January 1991
Shade				
Shaded	42	64 a	31 a	26 a
Unshaded	246	49 a	16 b	13 b
Competition				
Woody	35	63 a	40 a	34 a
Herbaceous	212	47 a	15 b	11 b
None	41	63 a	17 b	15 b
Soil texture				
Coarse	54	59 a	30 a	26 a
Medium	130	55 a	21 ab	15 b
Fine	104	43 a	10 b	9 b
Soil color				
Red	83	52 a	24 a	22 a
Brown	80	51 a	18 a	14 a
Yellow	125	51 a	15 a	10 a

Means for a given factor and month followed by different letters differ significantly ($P < 0.05$).

In this study, as in other reports, planting bareroot seedlings resulted in higher stocking levels and is still recommended as the more reliable reforestation technique. At the end of the growing season, almost half the seedlings were still alive. This survival or stocking rate was over three times better than that for direct seeding. At the last measurement period, the bareroot seedlings had an average height of 25.4 cm (10.0 inches), with a standard deviation of 5.6 cm (2.2 inches). In contrast, direct-seeded trees had an average height of 9.6 cm (3.8 inches), with a standard deviation of 2.5 cm (1.0 inch). Direct seeding could be an attractive alternative to planting seedlings in some cases. Seeding in spots, while more labor intensive, might be especially suitable for small landowners from an economic viewpoint.

Full stocking is a high priority when attempting to regenerate a stand. There are two means of achieving full stocking by direct seeding: planting a sufficiently large number of seeds per spot to guarantee the survival of at least one live seedling per spot or planting a smaller number of seeds in enough closely spaced seed spots to insure full stocking. The results of this study indicate that specific characteristics of individual seed spots are very important in determining regeneration success. It appears that sowing a large number of seeds in a spot may not guarantee stocking if the microsite is unfavorable. Another approach may be to plant fewer seeds in more spots to increase the probability of encountering favorable microsites; however, this increases the labor required to seed a site.

The results of this study suggest that devoting attention to specific microsite conditions when selecting seed spots could improve seeding success. Shade created by logging slash or other vegetation was found to be beneficial in this 1-year study. However, the presence of vegetation may prove detrimental in subsequent years. Utilization of logging debris, stumps, rocks, and any available microtopographic features on the south and/or west side of spots selected for seeding to provide shade should be beneficial. In this study, coarse-textured soil materials, which are usually reddish and brown, were associated with improved seeding success. This guideline would need modification in other regions with different soils and parent materials of different geologic origin. The significance of soil texture for tree growth in various soil horizons is well recognized. However, for a germinating seed, only the material at and near the soil surface is of immediate importance. Taking some of these simple precautions to improve soil moisture and reduce soil surface temperatures near germinating seeds should improve the probability of successful regeneration with spot seeding techniques. More research is needed to develop seeding techniques that will result in stocking levels approaching reasonable success rates. The results of this study suggest some possible directions for future research.

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