A Precision Seed Sower for Longleaf Pine Bareroot Nursery Seedlings

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Commercial vacuum precision seed sowers were modified to obtain satisfactory density, row alignment, and spacing of longleaf pine (Pinus palustris Mill.) seed in two southern bareroot forest tree nurseries. Satisfactory seedling density and spacing for production of top-quality seedlings can be obtained with the modified sower if seed purity is at least 95 % and germination potential is at least 70%. Potential limiting factors encountered and suggestions for improvements are discussed. Tree Planters' Notes 41(4):33-38; 1990.

Longleaf pine (*Pinus palustris* Mill.) was previously the dominant tree species on approximately 60 million acres of virgin forests on the southern Coastal Plain and Sandhills of Georgia and North and South Carolina (3). The longleaf pine is well adapted to deep, sandy sites with good drainage. It is comparatively resistant to the fusiform rust fungus [*Cronartium quercuum* (Berk.) Miyabe ex Schirai f. sp. *fusiforme*], grows to a large size, and produces wood of excellent quality for a variety of forest products (8). However, there are only about 5 million acres presently forested in longleaf pine, and the species accounts for only about 2.5% (approximately 50 million seedlings) of the annual production of southern pine seedlings.

Outplanted longleaf pine seedlings have a recurrent history of failures, primarily resulting from inferior seedling quality, protracted slow growth in the characteristic "grass stage," and the extreme susceptibility of seedlings to the brown-spot foliage blight [caused by *Mycosphaerella dearnessii* Barr., synonym *Scirrhia acicola* (Dearness) Siggers] during the grass stage (1).

Recently, reforestation with longleaf pine has received considerable attention because many plantings of slash (*P. elliottii* Engelm.) and loblolly (*P. taeda* L.) pines on the deep sandy soils have either stagnated or succumbed to fusiform rust. More recently, key components of longleaf pine seedling quality have been identified and Wakeley's (9) seedling grading rules for this species have been expanded. Morphological characteristics of seedlings have been used in developing nursery management procedures for the consistent production of high-quality seedlings that show increased field survival, reduced disease hazard, and increased growth (2). Desirable characteristics associated with high-quality bareroot seedlings of longleaf pine include a root collar diameter of at least 10 mm (0.4 inch), at least 6 primary lateral roots that are 2 mm or more in diameter, a highly fibrous root system, and at least 25% of the feeder roots being ectomycorrhizal (2).

Close control of seedling and row spacing is needed to produce a high proportion of seedlings with the above characteristics (4). In addition to producing seedlings of uniform size, uniform spacing facilitates lateral root pruning, which significantly increases root fibrousness and ectomycorrhizal development. The standard bareroot nursery drill on row spacing of 15 cm (6 inches) permits scheduled root pruning to promote maximum development of roots and ectomycorrhizae. Controlled spacing between seedlings also promotes the development of larger root collar diameters and better quality seedlings (2, 6, 7, 10).

Precise sowing of longleaf pine seed has been a problem in southern nurseries because the seed shape is irregular and its accompanying wing is very difficult to separate completely from the seed. Longleaf seed has been sown by a variety of methods, including both hand and machine broadcasting. At the USDA Forest Service nursery, in Ashe, MS, a number of other methods were used to sow longleaf pine seed during the 1980's; these included custom-built and modified commercial seeders. However, none of these seeders or methods has provided the desired seedling density or spacing in nursery beds.

A cooperative project was established by the USDA Forest Service, Southern Region-the National Forests in Mississippi, Forest Pest Management, and the Savannah River Forest Station; the USDA Forest Service Missoula Technology Development Center; and the South Carolina Commission of Forestry to develop the system that was needed.

Methods

Only recently have precision seed sowers become available to forest tree nurseries in the United States. These machines pull a partial vacuum through specifically sized and spaced holes on a rotating drum or disc, which picks up and then drops individual seeds. A wide range of precise sowing rates can be obtained by adjusting the speed of the tractor, the rotation speed of the drum or disc, and the vacuum pressure. Very precise spacing and density are possible with small to medium-sized seeds of high purity and germination capability (5). However, irregular shapes caused by incomplete wing removal, low seed purity, and poor germination of longleaf pine seeds can complicate seed sowing with a standard Summit precision sower.

Consequently, the Summit seed sower was modified to accommodate the irregularities of longleaf pine seeds. The first requirement was to obtain high-quality seeds. Those used in seeding trials con-

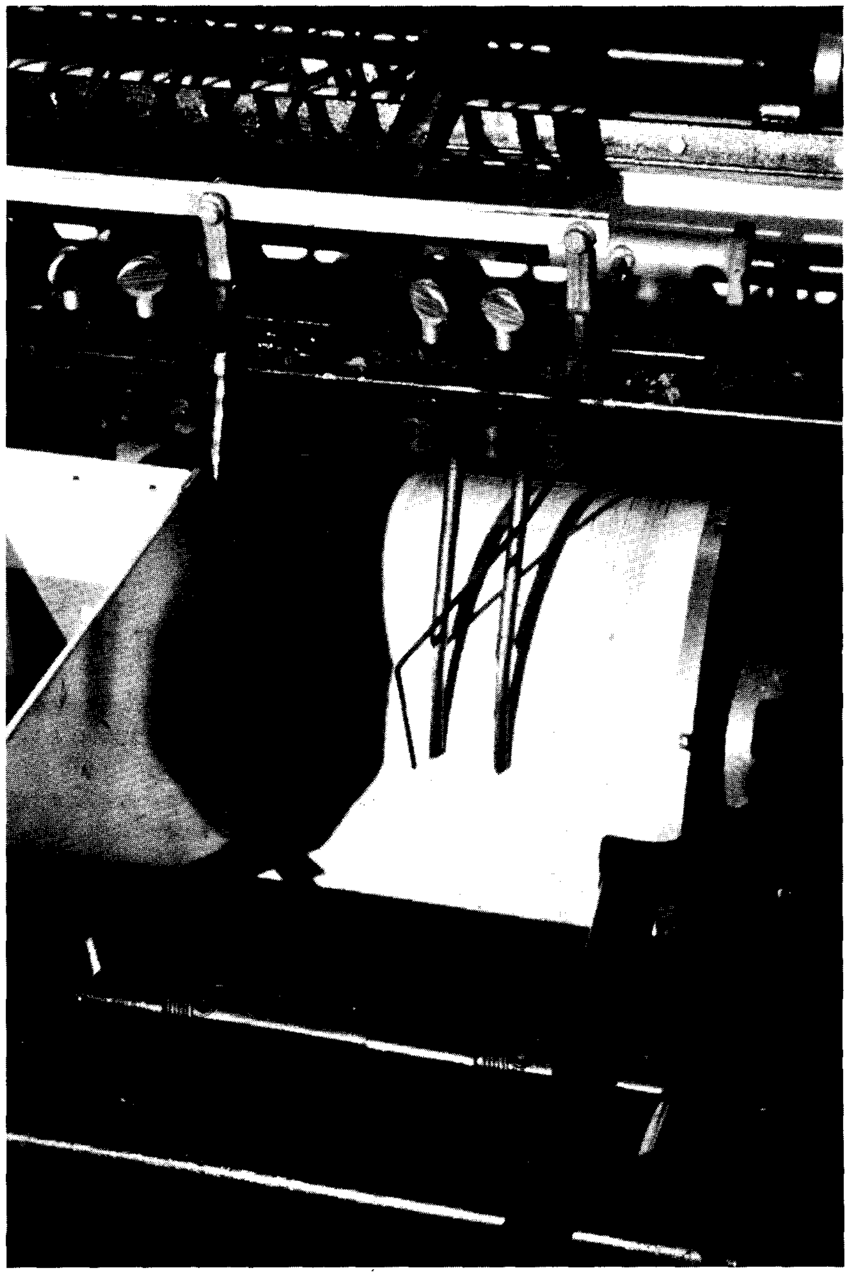
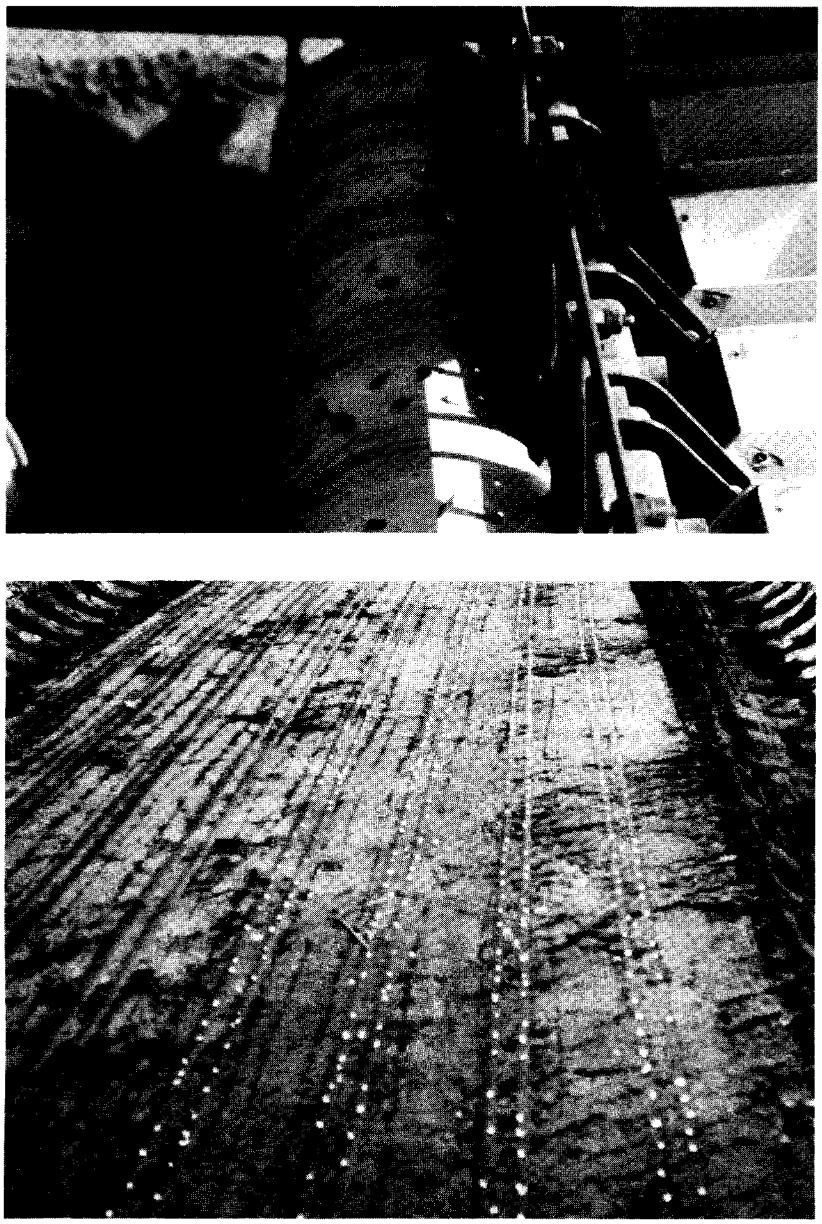


Figure 1—*Modified longleaf pine seeder showing added agitator in each seed hopper.*

A



B

Figure 2—*Longleaf pine seeder with custom-built vacuum seed drum (**A**) designed for precision sowing of 8 offset double rows per seedbed (**B**).*

ducted at the Taylor State Nursery in 1988 and 1989 had greater than 95% purity and greater than 70% germination potential. Modifications to the Summit machine included the addition of an agitator in each seed hopper to minimize the "bridging" effect of large, partially winged, and irregularly shaped longleaf seed (fig. 1). The agitator also minimized seed "doubles" by promoting the attachment of a single seed at each seed hole on the drum. A second modification involved custom-built seed drums to either sow 8 double offset rows per seedbed (fig. 2) at the Taylor Nursery or 15 single rows per seed bed (fig. 3) at the Ashe Nursery. A third modification at the Taylor Nursery involved the addition of a computer system for controlling seeding rates (fig. 4). This machine was purchased by the United States Department of Energy for the production of high-quality longleaf pine seedlings at the Taylor Nursery as part of a cooperative 5-year contract for forestation at the Savannah River Site, Aiken, SC. The supplemental modifications were made by the manufacturer in 1988.

Results

The modified Summit sowers provided acceptable seeding results for longleaf pine at two southern nurseries. At the Taylor Nursery, effective results were obtained in both 1988 and 1989. When seed

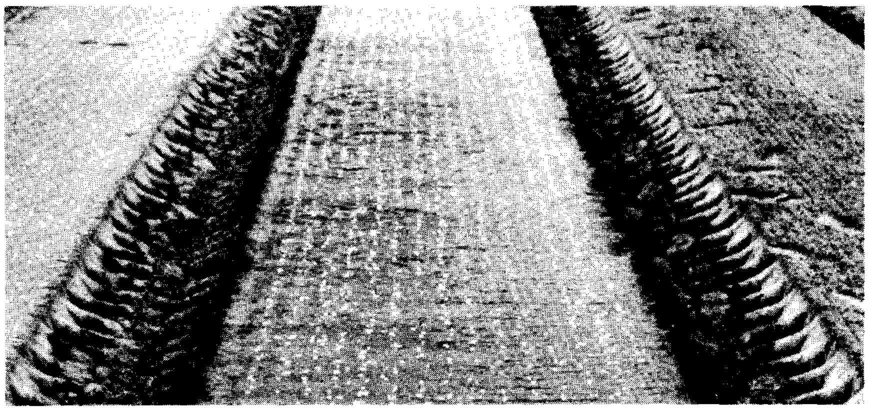


Figure 3—Precision sowing of 15 evenly spaced single rows per seedbed with longleaf pine seeder with custom-built vacuum seed drum.

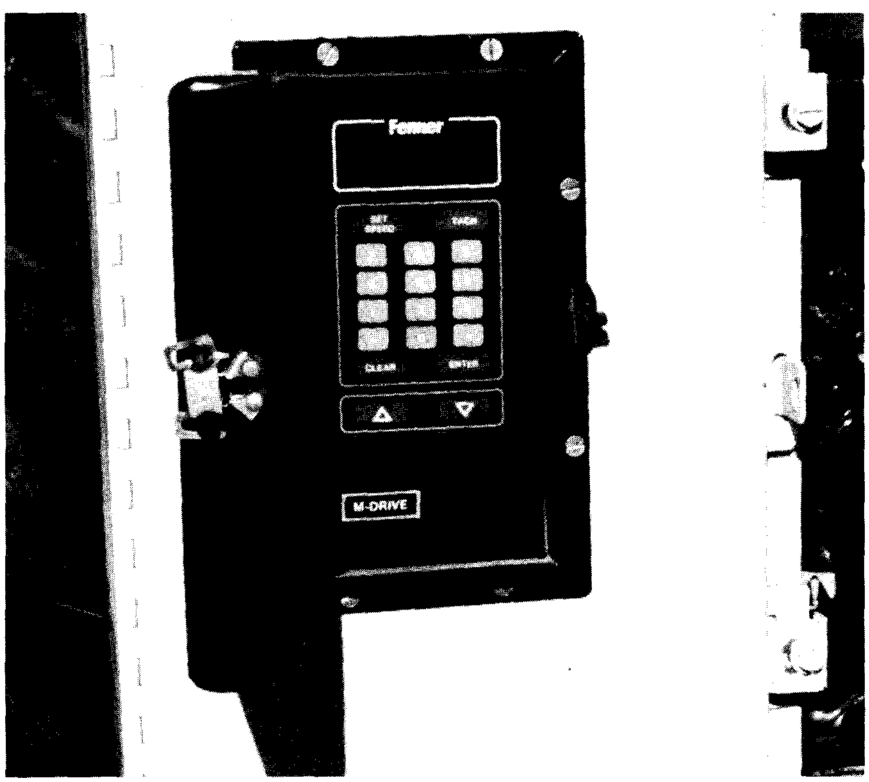


Figure 4—*Longleaf pine seeder showing synchronized computer system designed to maximize the effectiveness and flexibility of desired seed sowing densities.*

had a 70% germination potential, the actual seedbed density in 1988 and 1989 was 14 and 13 seedlings per square foot, respectively. Seed spacing within the offset double seed drill rows was also satisfactory. Single seeds were sown in >75% of the planting spots. At the Ashe Nursery, all 15 seed rows were equally spaced at 3 inches apart, and seed spacing within rows was sufficient to obtain the desired spacing within rows more than 75% of the time.

Using these two machines, seeds for approximately 10 million longleaf pine seedlings were sown operationally at these two nurseries during each of the 1988 and 1989 growing seasons.

Observations and detailed measurements showed that more than 90% of these custom-grown longleaf seedlings had root collar diameters greater than 10 mm (>.4 inch) at harvest time. In addition, the modified broadcast seeding at the Ashe Nursery eliminated the need for the expensive seedling thinning practices as routinely employed in previous years. Spring and fall sowing dates were utilized at the Taylor and Ashe Nurseries, respectively.

Discussion and Conclusions

Along with the observed improvements in longleaf pine seedling quality, improvements in seed efficiency were also observed in association with the vacuum sowers. Significantly less seed was used at both nurseries in 1988 and 1989 than in previous years, when other seeding equipment and procedures were used. This apparently resulted from the observed improvements in both between-row and within-row seed spacing that increased the available growing space for the developing seedlings.

Although the modified Summit vacuum seeders were considered successful in controlling the density and spacing of longleaf pine seedlings in two bareroot nurseries, several factors must be considered for their operational application in southern nurseries.

First, the sowing must be done at low speeds: best success has been achieved at speeds of 0.75 and 1.0 mile per hour. Speeds in excess of 1.0 mile per hour may cause seeds to be thrown forward off the seed drum and then bounce on the ground. Because the rotational speed of the vacuum seeding drum may be varied relative to the tractor's ground speed, the drum's rotational speed must be carefully calibrated and maintained, with the most effective seeding at 20 to 25 revolutions per minute. If the drum rotates too slowly, there is insufficient agitation in the hoppers and seeds often are not picked up by the vacuum drum. If the drum rotates too fast, seeds may be thrown over the drum onto the ground by momentum rather than being picked up singly by the holes in the drum. This is a highly significant factor when the seeder is moving down a slope greater than 1%. As with all vacuum precision seeders, the operator must concentrate on seed placement (quality) rather than sowing speed (quantity).

Second, seed agitation in the hoppers is required for precision sowing of longleaf pine with a vacuum seeder. Unlike loblolly and slash seeds, longleaf seed will not be picked up by the vacuum drum without agitation. Because of their odd shape and the partial wings, longleaf pine seeds tend to interlock and bridge in the hopper. Efforts to sow longleaf seeds precisely without agitation have always failed. Agitation in the seed hoppers has also been found to be the most effective when the vacuum drum is running between 20 and 25 revolutions per minute and with the oscillating agitators extended about 2.5 mm (1 inch) deep into the seeds.

Third, vacuum pressure must be adjusted and monitored to consistently pick up single longleaf seeds on the vacuum drum. If the pressure is too low, the seeds will not be picked up. If the pressure is too high, more than one seed will be picked up by each vacuum hole, and two or more seeds will fall at each seed location on the bed. Whenever the rotational speed of the seeding drum is changed, the vacuum must also be checked and adjusted as needed. The desired vacuum may also change with different seed lots with different seed sizes and shapes.

Fourth, the seeds must be as clean and have as high a germination rate as possible. Debris and trash are picked up by the vacuum seeder and sown just like the seeds. Because longleaf seeds cannot be totally dewinged, they should be rescalped just before sowing to remove any newly broken wings. Seed germination potential should be at least 70% to obtain satisfactory sowing results. Attempting to sow seeds at high rates to compensate for poor germination potential generally results in poor seedling spacing.

Although the longleaf pine seeding results were generally satisfactory, there are opportunities for additional improvements. A consistent supply of longleaf seed from the proper source and with high purity (>95%) and seed germination potential of >70% is urgently needed and may be the most limiting factor in future artificial forestation programs with this species. Without quality seeds, it is virtually impossible to obtain correct spacing of longleaf pine seedlings. Additional modifications are also needed to the vacuum seed drum, including attachments to improve the seed pickup and singulation on the holes.

Finally, a more effective and less destructive method of dewinging longleaf pine seeds would be highly beneficial in obtaining even more precise seed sowing results.

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