# CHAPTER 6—SOWING AND MULCHING

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## ESSENTIAL FACTORS

Each of the Southern pines has different but exacting requirements for seed germination and seedling establishment. To successfully produce millions of pine seedlings annually, it is essential for the nursery manager to:

A. Choose the proper sowing date for each species.
B. Determine the correct sowing rate for each species and seed lot.
C. Prepare the seedbed properly to receive the seed.
D. Sow the seed at the proper depth.
E. Pack or roll the seed into the surface soil.
F. Cover the seed with a mulch during the germination period.
G. Promptly start on an irrigation schedule that will provide optimum moisture during seed germination.

## SEASON OF SOWING

The correct timing of sowing is one of the most important parts of the seedbed technique. If sowing is too early in the spring, germination may be slow, resulting in nonuniform seedlings and a low yield of plantable seedlings. If sown late, germination is often variable and seedlings are affected by heat and soil pathogens, resulting in an unpredictable crop. In years with wet springs, yields are low because of excessive soil moisture. In years with dry springs, yields may be low because of lack of moisture for seed germination.

In the lower South from the 1920's through the 1940's, most of the sowing was done in February or March (Wakeley 1954). As nurseries moved toward a 2:1 rotation (2 years in seedlings and 1 year in a cover crop) and began to control soil and weed pests with chemicals, the sowing dates were extended to April or even to early May in the northern part of the region (Vande Linde 1968).

Most lifting operations are not complete until about March 1 or later. Then several weeks are needed to fertilize and prepare the land for another crop of seedlings. Many soil fumigants can be applied only when the soil temperature is about 60 °F or higher and the soil moisture is 25 to 50 percent of field capacity. An aeration period of 3 to 4 weeks between treatment and sowing of seed may be required. Thus, the later planting dates are unavoidable unless fall fumigation is possible.

When the period of aeration is short, a simple bioassay will confirm the presence of toxic fumigants in the soil (appendix 6-2).

### Fall Sowing

Early field planting of seedlings, i.e., beginning in July and extending through September, is practiced on a limited scale in those parts of the region where the rainfall is highest during July, August and September. Fall sowing will provide seedlings suitable for planting during these months.

Seed of some species may be sown in the fall or spring. Fall sowing is best for longleaf pine seed, good for Virginia and sand pine seed and is used occasionally for loblolly, slash and eastern white pine seed.

Slow-growing species such as longleaf, white, shortleaf and Virginia pines are adversely affected by high summer temperatures. These species may benefit from fall sowing because the longer growing season will produce larger seedlings.

Fall sowing dates are usually between October 15 and November 30th. In southern Alabama the optimum time for fall sowing of longleaf pine is usually October 20-30[1]. Longleaf pine seeds sown in October and early November germinate immediately after sowing, allowing young

[1]Personal communication: Carl Muller, Hammermill Paper Company, Selma, AL.

plants to establish a deep taproot. When longleaf seeds are sown in late November to early January, many young seedlings may die when their roots are exposed by frost heaving. The succulent foliage may also be killed by low temperatures. Fall-sown seed of most southern pines need not be stratified as the over-winter contact with the moist soil serves the same purpose. When the soil warms in the spring, the seeds usually germinate promptly and uniformly, resulting in a long growing season for the seedlings.

## Spring Sowing

In this season, optimum results are usually obtained in April. Seeds sown earlier germinate over too long a period, which results in nonuniform seedlings. Late spring sowing results in rapid, but inconsistent, i.e., unpredictable or spotty, germination because of heat and pathogens. The two extreme periods are distinctly different and neither is desirable.

Longleaf pine should usually be sown before other species. Longleaf pine seeds germinate better at lower temperatures than do seeds of the other southern pines. Moreover, longleaf seeds spoil rapidly at high temperatures.

Shortleaf and Virginia pine seeds should be sown earlier than loblolly and slash pine seeds, because the seedlings of the former two species take longer to reach plantable size. The growth of shortleaf and Virginia pine seedlings is normally slow and practically ceases during hot summer weather. Early sowing is needed to allow these seedlings to become as large and heat resistant as possible before the onset of high temperatures.

Germination of loblolly pine seeds can be very erratic, especially with old seeds. The germination period of some unstratified lots of seed may extend over a period of several months, especially when sown in the spring. Fall-sown seeds undergo stratification in the seed beds and germinate when temperatures become favorable. Other lots of seed germinate as well or better when nonstratified as when stratified. These seeds can be sown during either the fall or spring. In general, stratification produces more uniform germination and a shorter germination period. Sow seeds between March 15 and April 15 to produce a high percentage of plantable seedlings—and maintain optimum seedling density, soil moisture and fertility. Low soil fertility may require fall or early spring sowing to produce seedlings of plantable size by lifting time.

Slash pine may be sown later than the other southern pines because of its usual prompt germination, rapid growth and early attainment of some heat resistance.

Seed sizing will usually produce a more uniform seedling crop because of the different germination rates associated with seed size (see chapter 5). A rule of thumb is that small seeds should be planted first. Then 1 week later plant medium seeds, and after another week plant the large seeds. All seeds will germinate at about the same time. This schedule leads both to uniform seedlings within each sub-lot and a higher percentage of seeds producing plantable seedlings (Bland 1964).

Seed orchard seeds from a single clone tend to be relatively uniform in size. When these seeds are planted by clone, sizing of the seed is unnecessary.

Heavy spring rainstorms of 1 to 5 inches within a few hours can wash mulch and seed from the seedbeds. Many seeds may be buried, seedbed shoulders eroded, and the soil saturated, resulting in death of germinating seeds.

Fall or early-spring sowing may result in a longer exposure of young seedlings to the risk of fusiform rust infection than would late spring sowing.

Late-spring sowing may be feasible with soils of high fertility. Late sowing has five advantages: (1) less injury from freezing and frost heaving, (2) less bird damage, (3) lower costs of weeding, (4) less fusiform rust infection, and (5) less spraying to control this rust. On the other hand, late-spring sowing is likely to increase damping-off, some root-rot pathogens, and heat and drought injury.

## Factors Influencing Time of Sowing

1. Season of lifting: late summer vs. winter.
2. Desired size and quality of planting stock.
3. Temperature requirements for germination.
4. Precipitation and temperature patterns at the nursery site.
5. Germination and growth pattern of the species.
6. Soil texture.
7. Rotation scheme
8. Fumigation schedule.
   (See Table 6-1).

The workability of the nursery soil is a function of the soil texture as affected by soil moisture and temperature. Fine-textured soils may remain wet and cold much longer than coarse-textured soils.

When using a 1:1 or 1:2 rotation (1 year in seedlings and 1 or 2 years in cover crops) some phases of seedbed preparation can be handled in the fall preceeding the seedling crop. When seedlings follow seedlings, the entire operation of seedbed preparation and sowing must be completed within about 30 to 60 days. Most nurseries operate with a limited amount of equipment and a fixed staff, which requires some flexibility in scheduling of nursery operations.

# SEED TREATMENTS

Delayed germination resulting from various types of seed dormancy can be a serious problem in nurseries. Treatments designed to counter the effects of internal dormancy and promote rapid seed germination are discussed in chapter 5.

Even with stratification most seeds are exposed to the hazards of the environment for 10 days to 2 weeks before germination. During this time birds, rodents, and pathogens are a constant threat. Seeds can be treated to repel birds and rodents. Fungicides and insecticides may be applied for control of damping-off fungi and insect pests.

## Treatments for Bird and Rodent Control

Birds are one of the greatest hazards in all southern pine nurseries (Wakeley 1954). Mourning doves, meadowlarks, bobolinks (ricebirds or reedbirds), various blackbirds, crows, cardinals, quail, pigeons, and sparrows are the most troublesome species. They eat not only the seed but kill or severely injury newly germinated seedlings by clipping off the cotyledons when the seedcoats are still attached. They may even tunnel under a heavy pine straw or similar mulch. Damage rises to a peak when germination is about complete and often continues until the seedcoats have dropped from the cotyledons. Control efforts described by Wakeley (1954) include the use of bird patrols, automatic exploders and seedbed covers.

Thiram and related chemicals are used as bird repellents in nurseries. Gustafson 42-S has replaced Arasan 42-S and is currently available. The status of pesticide use including repellents is continually changing. For information on the current status of chemicals contact the Forest Pest Management Staff, Pesticide Specialist, Southern Region, USDA Forest Service, Atlanta, Ga. See Chapter 18, section on "Pesticide Safety" before using pesticides.

The amount of material that is used to treat seed varies by species and by nurseries. Dry seed and moist stratified seed are treated alike. Thiram is used at rates of 1 to 2 quarts for each 50 pounds of seed.

Other chemicals are used to help the repellents work more effectively. A latex or asphalt emulsion binds the repellent to the seed. Aluminum powder keeps the seeds from sticking together and enhances the free flow of seeds through the seeder. Dow latex No. 202 or 237 is used at a rate of 1 part latex to 9 parts of water. Asphalt emulsion Flintcote C-13 HPC has been used, in lieu of latex, at rates of 1 or 1½ parts of emulsion to 2 parts of water. Aluminum powder is used at a rate of 6 or more tablespoons for each 50 pounds of seed.

The following procedures are suggested (adapted from Derr and Mann 1971).

1. Wear a respirator, rubber gloves, and protective clothing when using repellents.
2. Pour the seed into a small concrete mixer.
3. Add enough sticker to coat the seed as the mixer turns.
4. Add enough repellent to coat the seed as the mixer turns.
5. Add enough aluminum powder to coat the seed.
6. Spread the seed on a clean surface to air-dry.

Seeds can be dried in the sun or by a fan within 2 to 3 hours if the seeds are stirred. Drying in the shade may require 12 to 24 hours. This drying has no adverse effects on the germination of stratified seeds if the seeds are handled carefully. Careless handling of the seeds may crack the seed coats, e.g., carelessly raking the seed to hasten drying.

Thiram is very irritating to the eyes, nose, throat, and skin, and may retard germination. A respirator and rubber gloves must be worn when working with thiram. Latex is cleaner to handle than asphalt and is a better adhesive. Latex does not cause the seed to stick together after drying (Vande Linde 1968).

## Storage of Treated Seed

Occasionally, seeds that have been stratified or treated with a bird repellent are not sown. These seeds must be stored or discarded. Treated seeds can be redried to about 8 percent moisture content and stored at 20 °F. The quality of the seeds after storage depends on the species, vigor of the seeds before treatment, effects of the treatment on the seeds and the moisture content of the seeds at the time of storage. Treated seeds, after 6 to 12 months of storage, may become dormant or lose viability and the speed of germination may be reduced (McLemore and Barnett 1966, Cayford and Waldron 1966, Jones 1963, Barnett 1972). It is essential to retest any stored seed before sowing. Restratification is usually not necessary, but when needed, moisture should be added gradually. The seed should *not* be soaked in water (Belcher 1968).

## Treatments to Prevent Damping-off

Damping-off is always a potential problem in seedbeds. Damping-off pathogens may be in the soil or introduced on infected seed coats. Tests of fungicides over many years and in many nurseries have given very inconclusive results. Many of the fungicides used either did not control damping-off or they became phytotoxic to germinating seeds even at low rates. Thiram and captan are usually the least toxic of the available fungicides and have been effective in reducing damping-off (Kahler 1955, Morris 1955, Neel and Belcher 1968, Lamontagne 1974, Pawuk 1979). Thiram is the only seed treatment currently recommended.

# FINAL PREPARATION OF SEEDBEDS

Seedbed preparation is discussed in chapter 4. Seedbeds prepared several days or weeks before sowing, or seedbeds that have dried in the sun or become crusted by rain and sun should be tilled lightly, immediately before sowing. This step will permit better placement of the seed.

Tractor-mounted equipment that is attached to a three-point hitch provides the most rapid and efficient final preparation of seedbeds. Spiked leveling boards are

*Table 6-1. — A comparison of fall, early spring and late spring sowing.*

| Factor | Sowing Time: Fall | Sowing Time: Early Spring | Sowing Time: Late Spring |
|---|---|---|---|
| Seedlings needed for summer planting | X | | |
| Seed stratification not needed | X | | |
| Longer growing season needed to produce larger seedlings of: | X | X | |
| longleaf pine | X | X | |
| Virginia pine | X | X | |
| sand pine | X | X | |
| shortleaf pine | X | X | |
| white pine | X | X | |
| Shorter growing season desirable (seedlings tend to be too large): | | | |
| loblolly pine | | | X |
| slash pine | | | X |
| Reduced cost of fusiform rust control | | | X |
| Low soil fertility | X | X | |
| High soil fertility | | | X |
| Mycorrhizal inoculation | | | X |
| Reduced risk of damage from: | | | |
| freezing | | | X |
| frost heaving | | | X |
| birds | | | X |
| Increased risk of damage from: | | | |
| damping-off | | | X |
| root rot | | | X |
| heat and drought | | | X |
| fusiform rust | X | X | |
| poor germination | | | X |

usually sufficient for this operation. Other equipment that can be used are the Whitfield bed builder, the Larchmont bed former, the Lely Rotera, and other types of levelers with a blade or blade-rake combination.

## DENSITY OF SEEDLING STANDS

In most southern pine nurseries, the average density of living seedlings ranges from 24 to 30 per square foot throughout the growing season. This standard applies to all southern pines except longleaf. However, the biological optimum appears to be about 19 square foot (Mexal 1981). Stem diameters, oven-dry weight of stems and roots and root:top ratios decrease with an increase in stand densities over 15 per square foot (May 1933, Burns and Brendemuehl 1971). Studies of field survival show that Grade 1 seedlings produced in seedbeds containing fewer than 30 per square foot, survive better on poor sites and under adverse conditions than do smaller seedlings from denser stands (Shoulders 1961; Shipmen 1960, 1966)

At densities below 19 per square foot the seedlings may not fully utilize the capacity of the soil (Mexal 1981). Stem height of seedlings may be influenced by competition for light with tall, spindly seedlings in the denser stands and short seedlings in sparse stands. Increasing the fertility of the soil may increase the number of plantable seedlings of a given size that can be grown in a given area (Switzer and Nelson 1963).

Grade 1 longleaf pine seedlings have a root collar diameter larger than ½ inch. Seedlings of this size are grown at a density of about 15 per square foot.

Sowing in drills instead of broadcast does not change the optimum number per square foot if the drills are spaced about 6 inches apart. A unit area of a given nursery soil tends to produce a constant weight of seedling tissue in the form of many small seedlings or fewer large seedlings (Wakeley 1954).

Emphasis should be on living or total seedlings in a seedbed. All seedlings, even if unplantable, compete with, and therefore affect the development of adjacent seedlings. Under good nursery management 90 to 95 percent of all living seedlings should be plantable. Inherent genetic characteristics, injury caused by weeding, drought, heat, wind, water, hail, and infestation or infection by insects and pathogens may reduce the number of plantable seedlings by 5 to 50 percent.

The optimum seedling density for each nursery or segment of a nursery must be determined by local experience and frequent tests.

## SOWING RATES[1]

Seedling stand density depends primarily upon the rate at which the seeds are sown. Sowing at a correct rate for each seed lot is the best assurance of obtaining the desired number of seedlings per square foot or per linear foot at lifting time. The sowing rate can be calculated in terms of pounds of seed to be sown per bed or per 100 linear feet of seedbeds, or on the number of seeds to be sown per running foot of drill.

### Calculation of Sowing Rates

The following information is needed to calculate sowing rates:

1. Desired seedbed density, calculated at the nursery.
2. Area of seedbed, calculated at the nursery. (For 4-foot-wide beds, the bed area will be 400 square feet.
3. Number of seeds per pound; available from laboratory data. (These calculations are listed in English units. See the appendix for metric conversion.)
4. Expected germination rate; available from the National Tree Seed Laboratory's reports or from local germination test data.
5. Expected survival rate: This is the average percentage of planted seeds that are expected to produce plantable seedlings. *Tree Percent* is another term for this figure. The percentage used may be determined from nursery records or from history plots (Belcher 1964). For most of the South, this figure will range from 50 to 80 percent.
6. Purity; available from laboratory data.

### Nursery Survival or Expected Survival Percent

The expected survival rate is also called the "finagle factor" because it is sometimes a guess or rough estimate. Empirical studies at many nurseries indicate that nursery survival varies greatly among seed lots and years and is strongly affected by soil properties and climatic conditions. Actual nursery survival has varied from about 20 to 95 percent. A value of from 70 to 85 percent is frequently used in lieu of more accurate survival percents (Eide 1962).

Wilson (1969) described a technique for a better estimate of nursery survival used in the sowing formula. Wilson's technique is useful if accurate records are available and the actual nursery survival is known for several years. The nursery survival for individual seed lots can be calculated by the formula:

$$N = \frac{D}{(T)\ (S)\ (P)\ (G)}$$

where:
N = Percent nursery survival
D = The actual number of plantable seedlings lifted and packed from that lot
T = Total pounds of seed sown
S = Number of seeds per pound
P = Purity percent
G = Germination percent

[1]For a more complete discussion of seed quality, seed testing and associated definitions see Chapter 5.

When sowing by weight the following formula is used:

$$\text{Pounds of seed/100 linear ft. of bed} = \frac{(\text{desired density}) \times (\text{area of bed})}{(\text{seeds/lb.})\ (\text{germination})\ (\text{survival})\ (\text{purity})}$$

With more precise planting machinery, sowing may be based on the number of seeds per unit area. Calculate the sowing rate with this formula:

$$\text{Number of seeds/sq. ft.} = \frac{\text{desired density}}{(\text{germination})\ (\text{survival})}$$

The seeds must be very clean to sow by seed count, as trash particles will create variations in density.

Nursery Survival can be correlated with several seed and nursery characteristics including:

1. Seed age
2. Seed collection year
3. Seed source
4. Seed weight
5. Seed germination
6. Year of sowing
7. Season of sowing
8. Seedbed density
9. Seedbed location in the nursery
10. Effectiveness of chemical treatments to seed and soil
11. Rainfall pattern during germination
12. Temperature pattern during germination.

## Other Considerations Used in Determining Sowing Rates

Rates calculated by weight can be applied directly only to seed sown at about the same moisture content at which the number of seeds per pound was determined. For a specific seed lot, the number of seeds per pound will be different for fresh seed, air-dried or oven-dried seed, or seed moistened by stratification or soaking.

Seed lots should be weighed before stratification and again after stratification and seed treatment. From these weights, a factor can be computed to use when calibrating the seeder and using the weight of stratified and treated seed.

Rates calculated by numbers of full seeds apply directly to both dry and to stratified or soaked seed. They do not involve the purity percent or the number of seeds per pound. They do, however, require determination of effective germination percents in terms of all sound seeds, and cutting tests at the end of the germination tests.

The germination of a seed lot in the nursery is seldom the same as that of the corresponding test sample from a seed testing laboratory. Germination energy may be a more valid and reliable value to use than germination percentage for some seed lots. Cumulative germination curves (chapter 5) show daily cumulative germination percent over the test period. Germination reports from the National Tree Seed Laboratory show approximately the peak period of germination for the specific seed lot. Seeds that germinate 10 to 30 days later than the peak germination usually do not produce plantable seedlings. Late germinating seedlings are subject to heat injury and extreme competition and may not survive until lifting.

Examples of other variables that affect nursery seed germination, seedling survival and the calculated sowing rate are:

**Seed quality.**—Seed collected during years of poor seed crops is often of lower quality than seed collected during years of bumper or good seed crops. Seeds of some lots and species will decline as the seeds age. Seeds of low quality have generally lower germination and seedling establishment rates in the nursery than in the laboratory tests. Seed quality, as determined by germinative ability and storage potential, often is affected by the time of collection. Seeds collected early may have excellent germination if planted promptly, but may not store well. Artificial ripening techniques can be useful in such situations (see chapter 5). Seeds from the same source collected as little as 2 or 3 weeks later (when seeds are fully mature) can maintain high germination for many years if kept dry in cold storage, i.e., 6 to 8 percent moisture content and at a temperature of $\pm 20\,°F$.

**Moisture content of the soil.**—Either saturation or extreme dryness of the surface soil during the germination period may reduce germination and seedling establishment (Belcher 1975). Excessive moisture may cause the seed to die from lack of oxygen. The radicle may die before penetrating mineral soil in cases of excessive dryness. Thus, frequent light watering is required during the germination period.

**Depth of seedling.**—This variable is influenced by several factors:

1. Southern pines have a definite light requirement for germination.
2. The type of mulch affects the optimum depth of sowing. Rowan (1980) found that surface sowing of slash pine is a better practice when sawdust and pine straw are used as the mulch, whereas a depth of ¼ inch is best with hydromulch.
3. The type of seeder affects the depth at which the seed is placed.
4. The texture of the soil affects the amount of settling and washing of the soil after sowing.

Seeds can be placed on the surface of the soil or in shallow grooves and pressed into the soil surface by a roller. The seedbed can be covered with a mulch after sowing.

Seeds that are covered more than ¼ to ½ inch with soil will germinate slowly and may not have the energy to push through the soil cover. The embryonic plant may be killed by soil pathogens.

### Catastrophic Losses

Uncontrollable losses, particularly those caused by flooding, wind, hail, freezing, mass infestations of birds and rodents, and epidemics of insects and diseases, may occur on concentrated areas in the nursery or may be scattered throughout the nursery. Some loss can be expected to occur in any year. Increasing the sowing rate per unit area of seedbed will not reduce the losses from these causes, but may result in overly dense stands of seedlings. The best way to keep nursery production up to the planned yield despite catastrophic losses is to sow extra seedbeds at the regularly calculated rate. In southern pine nurseries, the number of seedbeds should be increased from 10 to 20 percent to allow for catastrophic losses.

### Aids for Determining Sowing Rates

Determination of the amount of seed of each lot needed and the amount of seed to sow per bed or per linear foot of drill can be computed with a calculator or by longhand. Swofford (1968) developed a circular cardboard slide rule for computing the sowing rate of slash and loblolly pine seed. This rule was prepared as a joint effort by the Eastern Tree Seed Laboratory and the Georgia Forestry Commission. Multiple slide rules comparable to an engineer's slide rule are described by Mugford (1962) and Wilson (1964). The Wilson rule has the most flexibility and can be assembled in a workshop.

## MIXING SEED BEFORE SOWING

Before seed is sown, it must be thoroughly mixed. This is especially important for seed that has not been sized, when seed has been transported some distance from the treatment facilities to the nursery, and when one seed lot is stored in several containers. If the seed is not thoroughly mixed before sowing, inevitable variations in germinability in different parts of the seed lot and in seedling densities may nullify all the care taken in sampling and testing the seed, in calculating the sowing rate and in adjusting the seeder. Despite calculations of correct average rates of sowing, failure to mix the seed has resulted in dense stands in some sections of the beds and thin stands in other sections.

Seeds from either small or large sowing lots can be easily mixed by pouring seed on a large tarpaulin or on a smooth floor and then turning the seed over several times with a shovel. When lots are in two or more containers, spread the seed from successive containers on top of the other and then thoroughly mix the layers with shovels. Extreme care is needed to avoid damaging the seed.

## METHOD OF SOWING

In all sowing the objective is to distribute seeds as evenly as possible over the area or in the drill so that each seedling has equal space in which to grow. Whether seed should be sown broadcast or in drills is a matter of local option. Drill sowing is preferred where machinery is available to cultivate between the drills and where seedlings are lifted by the belt-type lifters. Drill sowing must be done if lateral root pruning is practiced.

### Seeding Equipment

A seeder must be reasonably accurate over a wide range of sowing densities and with many species. It must be easy to clean, adjust and calibrate for small seed lots. There is a need for accurate and easily adjustable depth control. Depth is usually controlled by using small metal runners or shoes which open a shallow furrow. The furrow is closed by sweeps or other attachments and firmed by packing wheels directly behind the seed furrow. Seed damage during sowing must be minimal.

Lowman and McLaren (1976) and Lott and Lowman (1976) described the major seeders currently in use. A good description of early seeders is given by Toumey and Korstian (1942) which includes the Hazard Seeder, the Williamson modification of the Hazard Seeder for longleaf pine and the Planet Jr seed drill. The use of several other seeders, including the Gandy Nursery Special Fertilizer Spreader and seeder, is described by Arnold (1956, 1958), Mony (1956), Stoeckeler and Jones (1957), and Muller (1968).

Broadcast seeding is still used in a few nurseries. The Gandy seeder or a similar type of broadcast seeder costs little to operate and gives reasonably good distribution of seed (figure 6-1). A front and back roller or only a back roller is a major component of most seeders.

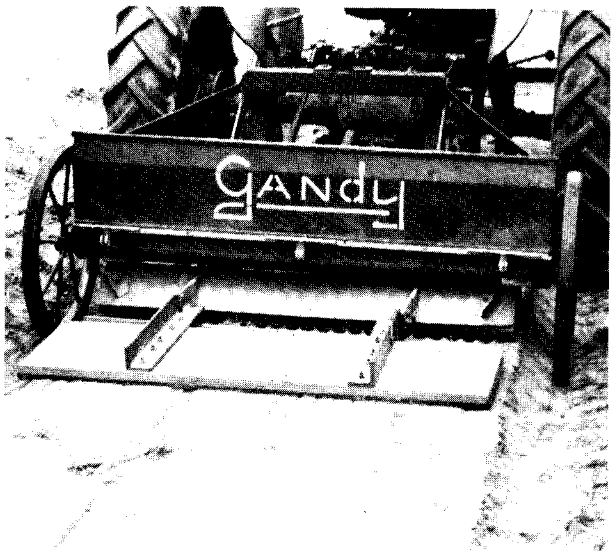


**Figure 6-1. — Gandy seeder.**

The Hazard drill seeder was one of the first seeders developed exclusively for seeding forest tree nurseries (figure 6-2). It consists of three segments: (1) a front roller to provide a smooth bed surface; (2) a grain drill with a depth-gauge hoe in front of a drill hoe, and a horseshoe-like device back of the drill hoe to move soil back into the furrow; and (3) a 42-inch diameter back roller to drive the seeding apparatus, firm the seedbed, and press the seed into contact with the soil.

The Whitfield seeder (figure 6-3) replaced the Hazard seeder in the late 1940's and early 1950's and is widely used in the South. It consists of a seeder box, a seed-metering device, drop tubes and a ground-penetrating apparatus with rollers for pressing seed into the soil. A shortcoming of this seeder is that the metering gear drive is not well adapted to small seed. The Whitfield seeder does a reasonably acceptable job with medium and large seeds (10,000 to 30,000 per pound) that are completely clean (Muller 1968).

The Stanhay seeder has individual seeder units for each row (figure 6-4). Each unit has a rubber belt with holes that meter seed into double rows on the seedbed. The seeding rates can be adjusted by gear changes and by using belts with different size holes and spacings and by using different plates under the belts. A drawback of this seeder is that skilled operators, and considerable calibration data, are needed for optimum performance from the machine (Black 1974).

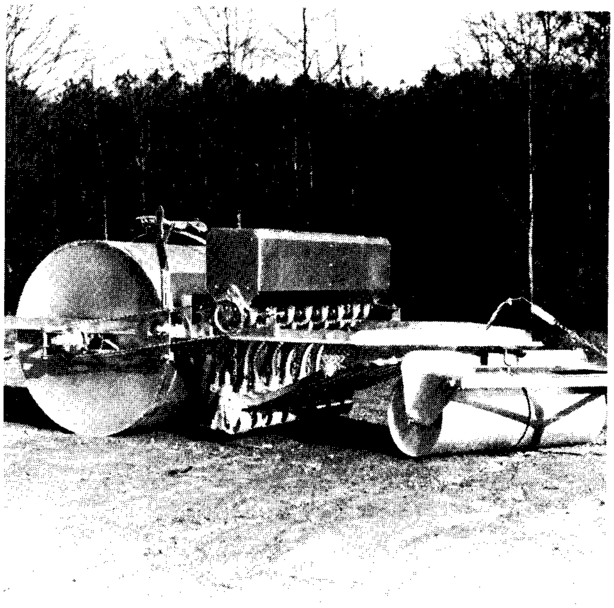

**Figure 6-2. — Hazard drill.**

The Oyjord seeder looks like the Whitfield seeder except for the seed hopper and metering device (figure 6-5). Seeds from the hopper go into a spinner that divides them equally into the desired number of rows. This is one of the most accurate machines currently available and is easy to adjust, calibrate and clean, especially for small seed lots (Schowater and Martin 1977).

**Figure 6-3. — Whitfield seeder.**

None of the seeders described in this chapter achieve the level of accuracy normally desired, i.e., a ±10-percent variation in seed density per square foot. However, seeders operating on a vacuum principle can potentially place seed with the desired precision. One such machine developed in New Zealand is commercially available (figure 6-6). A rotating vacuum drum with holes

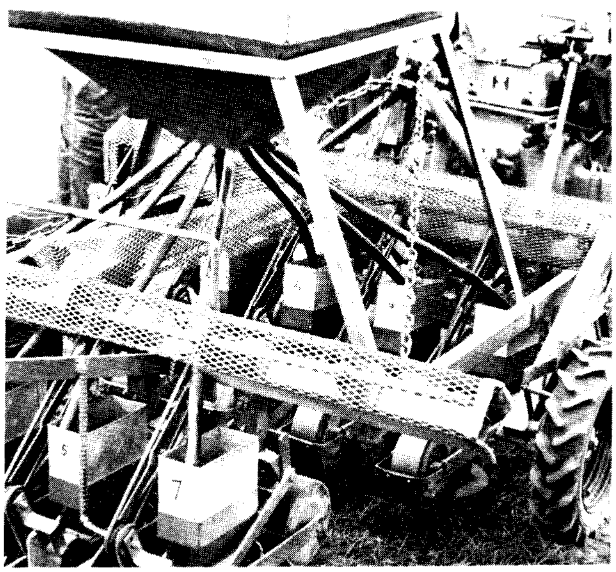

**Figure 6-4. — Stanhay seeder.**

picks up seeds from a hopper and spaces them one per hole. As the drum rotates, the vacuum to the row of seeds closest to the ground is cut off, and these seeds are discharged onto the bed. Similar machines are under development in this country.

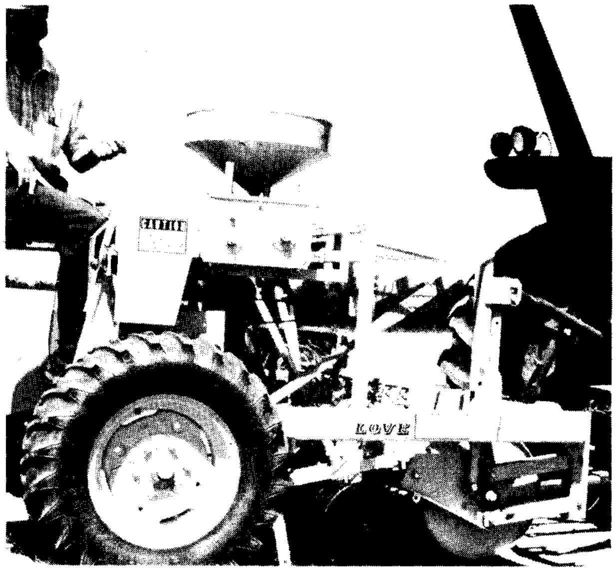

Figure 6-5. — Oyjord seeder.

## Sowing

Calibration of seeders is an exacting job requiring skill and patience. Test areas should provide 30 to 40 foot runs and sampling by drills at 10, 20 and 30 feet. Some seeders can be calibrated by blocking the unit up, turning the drive wheel and counting the seeds from one or all drills. When the circumference of the drive wheel is known, the seeds per linear foot can be calculated. Travel speed on test runs or with a blocked-up unit usually differs from actual sowing speeds, thus causing some variation in the amount of seed deposited in any 1-foot area.

Seeds may be sown on the surface and rolled or packed to provide contact with mineral soil. They may also be sown in shallow concave drills with a light covering of soil pressed on the sides or over the seeds. It is important that the seeds remain in place when dropped onto the soil, and that the seed be firmly pressed into the mineral soil.

Either intentionally or accidentally covering seed with less than 1/8 inch of soil will not adversely affect germination. Seed buried to a depth of 1/4 inch or more may not have the energy to push the hypocotyl through the soil, especially if a crust has formed at the soil surface (Chan, et al, 1969).

Actual sowing rates should be checked on the beds by making frequent random counts of the number of seedlings per square foot for broadcast sowing, and the number of seedlings per linear foot for each drill row when drilling seeds.

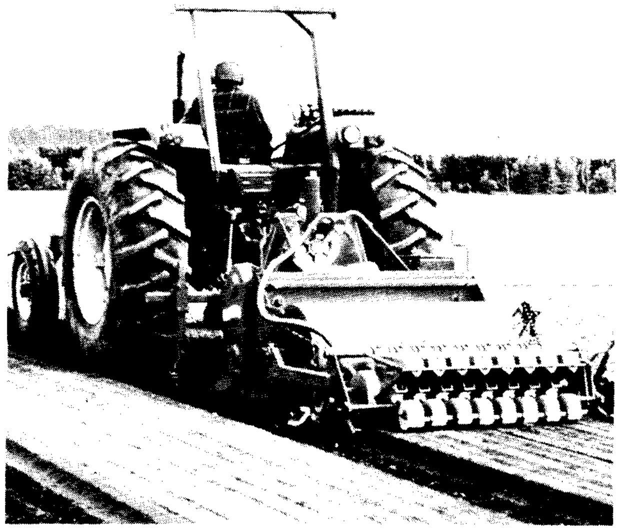

Figure 6-6. — Vacuum seeder.

## SEEDBED MULCH

Seedbeds must be covered to protect the seeds from displacement by rain, wind and irrigation water. Mulch does this and also helps to keep seeds and soil moist during germination. The covering or mulch must be light and let water, air and some light reach the seed. Mulch should be nontoxic, inexpensive, quick and easy to apply. Other desirable characteristics of a good mulch are to:

1. Permit good water absorption, infiltration, and retention in the soil
2. Control erosion.
   a. Prevent rapid runoff of water
   b. Stabilize bed shoulders and edges
   c. Prevent movement of seed
3. Prevent sand splash
4. Prevent crusting of surface soil
5. Maintain ground temperature favorable for germination
6. Prevent wind and rain damage
7. Add to the organic matter content of the soil

### Mulch Material

Materials used or tested as a mulch include:

1. Jute burlap
2. Cotton fabric
3. Sawdust
4. Pine bark, both fine and coarse
5. Shredded hardwood bark

6. Piling and post peelings, shredded
7. Chipped veneer
8. Shavings
9. Wood chips
10. Shredded pine cones
11. Wood pulp
12. Grain straw
13. Peanut hulls
14. Soil guard green latex
15. Sand
16. Plastic-polyethylene films
17. Recycled paper

Mulching materials that have been most effective, other than cloth and pine straw, are sawdust, bark, chipped veneer, grain straw and wood pulp fiber mulch (Clifford 1965; Dansbury et al 1965; Nichols 1968; Bland 1974; Gehron 1974; Vande Linde 1974).

## Burlap and Cloth

During the 1930's and 1940's cloth seedbed covers of jute burlap or porous cotton were used extensively. The materials were priced out of the market during the 1940's (Wakeley 1954).

## Pine Straw

Pine straw is an effective mulch and has been used extensively. The straw can be scattered evenly over the beds with a manure spreader that has been modified to maintain an even flow and prevent side scattering. The optimum straw depth is from 3/8 to 3/4 inch before settling and from 1/4 to less than 1/2 inch after settling. This is enough to conceal the seed from the drying effects of intense sunlight. The pine straw requirements for a 4 × 400 foot bed are from 2.5 to 3.65 cubic yards or from 13 to 19 standard bales (14 × 18 × 36 inches); 5.25 cubic feet or 70 pounds. An acre of 4-foot beds with 2-foot alleys requires from 45 to 67 cubic yards of straw. Assuming a minimum of 3 cubic yards per bed and 54 cubic yards per acre (1,458 cubic feet or 278 bales), pine straw at 2 cents per pound would cost about $400 per acre.

Loblolly pine straw is most satisfactory, with slash pine straw the second choice. Shortleaf pine needles are shorter but can be used. Longleaf pine straw is long and coarse and should be chopped before use. Seedlings of southern pines easily come up through a properly applied layer of pine straw. If applied too thick, part of the pine straw can be removed during or after germination. Pine straw may float away if rains flood the beds. Some straw also may be moved by strong winds. A thin layer of straw can be left on beds all summer as a mulch, which can provide excellent site protection, help improve the quality of the nursery stock and add some organic matter. (Wakely 1954, Delong and Nolder 1957, Nichols 1968).

A disadvantage of pine straw is that it may introduce weed seeds or diseases in the nursery seedbeds. Hand-weeding time may be increased by as much as 100 hours per worker per week (South 1976a, b). Methyl bromide applied to plastic tarp-covered pine straw piles at a rate of 1 pound to 20 to 25 cubic feet of straw will drastically reduce weed problems in seedbeds mulched with pine straw. Use a tarp with a minimum thickness of 1½ mils, and cover the straw for 48 to 72 hours. See appendix 6-1. Refer to Chapter 18-section on Pesticide Safety for the safe handling of pesticides.

## Sawdust

Sawdust was used as a mulch beginning in the early 1950's (Posey and May 1954). Germination of loblolly and slash pine seed was as good or better under a sawdust mulch as that obtained under a pine straw or cloth cover. The optimum depth for sawdust mulch is about 1/4 inch. Two difficulties are encountered in the use of sawdust: (1) If beds are not level, it is difficult to apply sawdust to a uniform depth. (2) Heavy rains or strong winds may wash or blow some of the sawdust from the beds, particularly the outside drills. For these reasons fast-germinating seeds such as slash and longleaf pine are better adapted to a sawdust mulch than are the slower-germinating loblolly pine seeds. These difficulties may be partly eliminated by making the beds level, covering the seeds, keeping the sawdust moist, and using windbreaks. Sawdust mulch can be about 3/4 inch thick if seeds are sown in the furrows of corrugated surface beds. Wind will blow the sawdust from the top of the bed; but it settles in the furrows. If kept moist, the sawdust will remain in the furrows even in strong winds (Clifford 1955, Darby 1956, Farnsworth et al 1956, Knight 1958, Hamner 1972). Sawdust must not be applied "green" because it may injure seeds or seedlings.

Rowan (1980) found that slash pine seeds germinated faster when sown on the surface of the soil and then covered with sawdust instead of soil.

## Bark and Shredded Materials

Pine or hardwood bark, wood chips, chipped veneer, shredded pole and piling peelings and shredded pine cones were used as a mulch by about one-fifth of the nurseries in the early 1970's (Vande Linde 1974). These materials give fair to good results, but are usually less satisfactory than pine straw and sawdust. Very fine material will wash away or blow off the seedbed. Coarse material tends to restrict seed germination and seedling establishment and should be screened before use. Peelings are useful when flooding of the seedbeds is likely. These materials can be applied with a manure spreader or a shredder-blower.

## Wood Fiber

Wood fiber prepared from hardwood or conifer chips or recycled paper and paper board is used in many nurseries (Watt 1960). Wood fiber is clean, uniform in size, nontoxic, free of grass and weed seed, fungi and other plant pathogens often found in pine straw and sometimes in sawdust or shredded pine cones. Wood fiber is applied with a hydroseeder equipped with a nursery mulcher attachment consisting of a discharge pipe, spreader board and a deflector. The discharge pipe sprays the wood fiber, suspended in water, under pressure against the spreader board. As the mixture bounces and disperses from the spreader board, the deflector controls the fall of the mulch and allows the mulch to fall at the exact velocity needed to cover the entire bed evenly and without disturbing the seed (figure 6-7). Hydromulch machines can be equipped with spray booms that will mulch from one to four beds simultaneously (Terrell 1968).

**Figure 6-7. — Hydromulcher.**

Wood fiber is applied at a rate of 1,500 to 2,000 pounds per bed acre. Seeds germinate as fast and as evenly under a uniform, moist wood fiber as under pine straw or a sawdust mulch. The effectiveness of fiber alone depends to a great extent on weather conditions. Heavy rains shortly after sowing will dissolve and remove the fiber from the seedbeds. If washed from the bed, seed may be moved with the fiber, leaving bare areas on the seedbed. The fiber may splash up on the seedlings and lodge in the cotolydons or primary needles or form a cast around the seedling stem. When attached to the needle or stem, the fiber smothers the seedling resulting in slow growth and some mortality. Rowan (1980) found that when hydromulch is used, slash pine seeds germinated best at a 1/4-inch soil depth.

During a dry spring season, wood fiber mulch requires more initial irrigation (about 1/2 inch of water) to wet the surface soil beneath the mulch. Dried-out mulch creates a light crust on the surface. Thus, results with wood fiber mulch have varied. If the mulch can cure on the seedbeds for 48 to 72 hours before a heavy rain, it stays in place better than on those beds receiving a heavy rain shortly after mulching (Plyler 1979).

Approximately 20 gallons of a binder added to 300 pounds of fiber mulch in an 800-gallon mix has been effective in holding the mulch on the beds and in increasing the number of seedlings per bed foot. Binding agents such as Petroset, Soil Guard Green Latex, emulsion type Asphalt AE-5 grade and XFS 4163 Dow Mulch Binder have been used.

The entire hydromulching system, including tank, pump, hose, valves and nozzles must be cleaned out by flushing with fresh water immediately after the tank is empty. Otherwise, fiber will clog the system. The type and rates of mulches and binders that are optimum for each nursery will vary and must be determined by trial and error.

Shredded newspapers and magazines are being tested as a substitute for wood pulp fiber mulches. Some forms of this material clog the pump and hoses of the hydromulcher. If properly spread over the seedbed, the shredded paper material is not as adversely affected by rain and wind as the wood pulp fiber, nor does it splash up on the stems, or form a crusty surface.

## Grain Straw

The scarcity of pine straw, sawdust and similar mulches has forced some nurseries to use a grain straw mulch. Rye, wheat and oats have been grown in the nursery and cut before seed maturity. The straw is allowed to cure on the ground or in loose piles before it is baled and stored. The straw can be applied to the seedbeds with a shredder-blower or with a manure spreader. Although coarser than pine straw, grain straw is a fair-to-good mulch when chopped before use. As the cost of other materials continues upwards, grain straw may be used more (Lantz 1969).

## Binding Materials

Results with binding materials have varied, with about as many successes as failures. Spraying a liquid binder on a previously-deposited mulch such as pine straw, sawdust, shredded bark, wood chips or grain straw has resulted in early and uniform germination of seed in some nurseries. The binder also reduced the erosion of seedbed shoulders during heavy rains. However, the use of liquid spray binders over wood fiber mulches has resulted in poor germination (Bland 1974).

A tank-mixed binding agent and mulch is often as effective as a natural mulch. The effectiveness of a binder in a tank-mix is probably associated with the technique of application. Good agitation is critical to the optimum formulation of mulch-binder in a tank-mix. The mixing procedure differs for each type of binder and the manufacturer's instructions should be followed carefully.

Some mulch binders should be applied in dry weather because water evaporation is necessary for effective binding. Drying may take from 1 to 6 hours, depending on weather conditions.

Binders can be sprayed onto the mulch with several types of conventional equipment, including hydroseeders, mulch spreaders equipped with asphalt spraying attachments, and recirculating tankers equipped with pumps and nozzles. Additional field testing is required to determine the proper binder and the optimum amount of binder to use for a particular mulch.

## SUMMARY

Seed sowing and the associated processes constitute the most important phase in the production of a crop of seedlings. Most seeds need presowing treatments to stimulate germination and to protect them and young seedlings from birds and some rodents. Stratification and treatment of seeds with repellents such as thiram or anthraquinone are standard operational procedures. The time of sowing is critical for a uniform stand of seedling as it affects germination, incidence of disease and possible losses from bad weather. Sowing of the right number of seeds per unit area of seedbeds requires precise information on seed quality and some knowledge of the site, i.e., nursery seedbeds, including soil, pests and climatic variables. Seeding equipment must meter the seeds to the bed within acceptable limits and put the seeds into firm contact with mineral soil. Seedbeds must be mulched with a material that will protect the seeds and the seedbeds, allow the young seedlings to push through the mulch, and which is not phytotoxic. The entire operation must be so well planned and executed that all phases of the operation will mesh together and be completed within about 5 working days.

## REFERENCES


Arnold, Ingersoll. Drill versus broadcast sowing. Tree Planters' Notes. 26:5-6; 1956.

Arnold, C. Ingersoll. Nursery seeding machine. Tree Planters' Notes. 31:3-5; 1958.

Barnett, James P. Drying and storing stratified loblolly pine seeds reintroduces dormancy. Tree Planters' Notes, 23(3):10-11; 1972.

Belcher, Earl W., Jr. Influence of substrate moisture level on the germination of seed of selected *Pinus* species. Seed Science & Technology 3:597-604; 1975.

Belcher, E.W. Jr. The use of history plots in the nursery. Tree Planters' Notes, 64:27-31; 1964.

Belcher, E.W. Repellent-coated seed of loblolly pine can be stratified. Tree Planters' Notes, 19(2):1-3; 1968.

Black, Gerald. Precision planting of seeds. In: Proceedings, southeastern nurserymen's conferences, eastern session, Gainesville, Florida, August 6-8; western session, Nacogdoches, Texas, July 17-18. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area; 1974: 128.

Bland, William A. Nursery production, cost reduction, quality stock production. In: proceedings, Region 8 forest nurserymen's conference, Morganton, NC, Aug. 19-20, 1964, and Oklahoma City, OK, Sept. 16-17, 1964. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region; 1964: 84-85.

Bland, William A. Study to evaluate the effects and costs of mulching materials in loblolly pine seedbeds. In: Proceedings, 1974 southeastern nurserymen's conferences, eastern session, Gainesville, Florida, August 1968; western session, Nacogdoches, Texas, July 17-18. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area; 1974: 150-156.

Burns, Russell M.; Brendemuehl, Ray H. Nursery bed density affects slash pine seedling grade and grade indicates field performance. Res. Pap. SE-77. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1971. 7 p.

Cayford, J.H.; Waldron, R.M. Storage of white pine, jack pine and red pine seed treated with Arasan, Endrin and aluminum flakes. Tree Planters' Notes. 77: 12-16; 1966.

Chan, F.J.; Harris, R.W.; Leiser, A.T.; Paul, J.L. Factors influencing depth of seeding. Tree Planters' Notes. 20(2): 1-5; 1969.

Clifford, Edward D. The use of sawdust as a mulch on red, white and jack pine seed beds. Tree Planters' Notes. 21: 24-25; 1955.

Clifford, Edward D.; Massello, James W. Mulching materials for nursery seedbeds. Tree Planters' Notes. 72: 18-22; 1965.

Dansbury, C.A., et al. Mulching (Advance and cost). In: Proceedings, Region 7 nurserymen's conference. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area; 1965: 22-27.

Darby, S.P. Agitator type sawdust spreader for use on a dump truck. Tree Planters' Notes. 25:8-10; 1956.

Delong, Thomas; Nolder, Charles R. Pine needles for seedbed covering. Tree Planters' Notes. 29:10-11. 1957.

Derr, Harold J.; Mann, William F. Direct seeding pines in the South. Agric. Handb. 391. Washington, D.C.: U.S. Department of Agriculture; 1971. 68 p.

Eide, Rex. Sowing factors. Col. W.B. Greeley Forest Nursery, Nisqually, Washington. In: Proceedings of the eighth biennial western forest nurserymen's meeting, Cowichan Lake Experiment Station, Mesachie Lake, B.C., Canada. 1962: 80-96.

Farnsworth, C.E., Lea, R.V.; Engelken, John. Mulching coniferous transplant bed with sawdust. Tree Planters' Notes. 25:4-7; 1956.

Gehron, Clyde. Mulch. In: Proceedings, southeastern nurserymen's conferences, eastern session, Gainesville, Fla., August 6-8; western session, Nacogoches, Texas, July 17-18. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area; 1974: 108-110.

Hamner, John G. Producing the most plantable seedlings per pound of seed. In: Proceedings, southeastern area forest tree nurserymen's conference. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area; 1972: 205-208.

Jones, LeRoy. Germination of repellent treated southern pine seed before and after storage. Res. Note SE-15. Ashville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1963. 4 p.

Kahler, L.H. Pelleting conifer seeds for control of damping-off. Tree Planters' Notes. 21:3-6; 1955.

Knight, H. A testing to determine acceptability of sawdust as a seedbed cover. Tree Planters' Notes. 31:10-14; 1958.

Lamontagne, Yves M. Germination retarded but protection enchanced in conifer seed after coating. Tree Planters' Notes. 25(1):14-16; 1974.

Lantz, Patrick M. Uniformity in seedbed mulching using chemical mulch. Tree Planters' Notes. 20(2):8-9; 1969.

Mann, W.F., Jr.; Derr, H.J. Not for the birds. Tree Planters' Notes. 20:3-6; 1955.

May, Jack T. Effect of density of stocking on the growth and development of longleaf, loblolly and slash pine seedlings. Athens, GA: University of Georgia; 1933. 55 p. M.S. thesis.

McLemore, B.F.; Barnett, J.P. Storing repellent coated southern pine seed. Journal of Forestry. 64(9): 619-621; 1966.

Mexal, John G. Seedling bed density influences seedling yield and performance. In: Lantz, Clark W., Comp., Proceedings, 1980 southern nursery conference. Technical Publication SA-TP 17. Atlanta, GA: U.S. Department of Agriculture, Forest Service Southeastern Area; 1981: 89-95.

Mony, Charles C. Forced feed seed hopper. Tree Planters' Notes 26: 7-10; 1956.

Morris, Caleb L. Treatment of forest tree seed with chemical protectants. Tree Planters' Notes. 21:9-10; 1955.

Mugford, Delbert G. Slide rule computer for sowing rates in nursery seedbeds. Tree Planters' Notes. 51: 21-22; 1962.

Muller, Carl A. Seeders: conifers, hardwood, band and broadcast. In: Proceedings, southeastern area forest nurserymen's conferences. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area; 1968: 31-38.

Neel, William W.; Belcher, Earl W. Jr. Effects of systemic insecticides on the germination of unstratified eastern white pine, Virginia pine and loblolly pine seed vary greatly. Tree Planters' Notes. 19(3): 3-5; 1968.

Nichols, C.R. Seedbed mulch material. In: Proceedings, southeastern area forest nurserymen's conferences. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area; 1968: 28-30.

Pawuk, William H. Fungicide coverings affect the germination of southern pine seeds. Tree Planters' Notes. 30(1): 3-4; 1979.

Plyler, R.P. Hydromulching operations at Weyerhaeuser's Magnolia Nursery. In: Proceedings, 1978 southern nursery conferences. Technical Publications SA-TP 6. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area; 1979: 104-105.

Posey, H.G.; May, Jack, T. Some effects of sawdust mulching of pine seedlings. Leaflet No. 42. Auburn, AL: Alabama Polytechnic Institute, Agricultural Experiment Station; 1954. 4 p.

Rowan, S.J. Planting depth and seedbed mulch affect germination of slash pine seeds. Res. Note SE-292. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1980. 3 p.

Schowater, W.; Martin, C. Evaluation of the Oyjord Seeder. Pollen Grain. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area; 1977; 11(1) 13-14.

Shipman, R.D. Survival and growth of graded longleaf pine nursery stock. Journal of Forestry. 58:(1) 38-39, 42; 1960.

Shipman, R.D. Low seedbed densities can improve early height growth of planted slash and lobolly pine seedlings. Tree Planters' Notes. 76: 24-29; 1966.

Shoulders, Eugene. Effect of nursery bed density on loblolly and slash pine seedlings. Journal of Forestry. 59(8):576-579; 1961.

South, David. Weed prevention in forest nurseries. In: Proceedings, 1976 southeastern area nurserymen's conferences. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area; 1976a: 88-94.

South, David. Pine straw mulch increases weeds in forest tree nurseries. Highlights of Agricultural Research. Auburn, AL: Auburn University, Agricultural Experiment Station; 1976b; 23(4):15.

Stoeckeler, J.H.; Jones, G.W. Forest nursery practice in the lake States. Agric. Handb. No. 110. Washington DC: U.S. Department of Agriculture; 1957.

Switzer, G.L.; Nelson, L.E. Effects of nursery fertility and density on seedling characteristics, yield, and field performance of loblolly pine (*Pinus taeda* L.). In: Soil Science Society of America Proceedings. 27: 461-464; 1963.

Swofford, Thomas. Sowing rate computer [cardboard circular slide rule] Macon, GA: U.S. Department of Agriculture, Forest Service, Eastern Forest Tree Seed Laboratory; 1968.

Terrell, E.G., Jr. Hydromulching. In: Proceedings, northeastern area nurserymen's conference. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area; 1968: 57-61.

Toumey, James W.; Korstian, Clarence F. Seeding and planting in the practice of forestry. 3rd ed. New York: John Wiley & Sons; 1942. 520 p.

Vande Linde, Frank. Topics relating to forest nursery practices. In: Proceedings, southeastern nurserymen conferences. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area; 1968: 39-41.

Vande Linde, Frank. The new era—shortages—mulch. In: 1974 proceedings, southeastern nurserymen's conferences. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area; 1974: 146-149.

Wakeley, Philip C. Planting the southern pines. Agric. Monograph No. 18. Washington, DC: U.S. Department of Agriculture; 1954. 233 p.

Watt, Richard F. A test of wood fiber pads as a seedbed mulch. Tree Planters' Notes. 41: 5-7; 1960.

Wilson, Boyd C. A slide rule for computing seed needs and sowing rates in forest nurseries. Tree Planters' Notes. 66: 17-19; 1964.

Wilson, Boyd C. A better estimation of nursery survival used in the sowing formula. Tree Planters' Notes. 20(3): 21-24.

# APPENDIX 6-1.—FOREST SERVICE LETTER TO SOUTHEASTERN FOREST TREE NURSERYMEN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
SA

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REPLY TO: 3400 Forest Insect & Disease Management February 29, 1980

SUBJECT: Disease Hazard by Pine Straw Mulches in Forest Tree Nurseries and Mulch Fumigation with Methyl Bromide

TO: Southeastern Forest Tree Nurserymen

Pine straw or needles is used as a readily available mulch in several forest tree nurseries. However, this material may serve as a highly effective substrate for pathogenic fungi that cause damping-off, root rots, stem disease, and foliage disease in the nursery. The fungi may be carried on the pine needles to the nursery where, under favorable environmental conditions, they produce spores that infect susceptible seedling hosts. These conditions have been observed in southern nurseries with several damping-off and root rot fungi (ie., Fusarium and charcoal root rot), foliage diseases such as brown spot and lophodermium needle cast; and more recently, the pitch canker fungus. Pitch canker has just recently been found in several Florida slash pine nurseries.

The most effective method of controlling or reducing this pine straw mulch disease hazard is by fumigating the mulch material with a recommended methly bromide - chloropicrin fumigation formulation. The control effectiveness can be increased by using the following guidelines:

1. Fumigate all pine straw or needle mulch with a methyl bromide - chloropicrin fumigant formulation consisting of either methyl bromide - 98%; chloropicrin - 2% or methyl bromide - 67%; chloropicrin - 33%.

2. Dosage rate should be 1lb. of fumigant per cu.yd. of mulch material.

3. Tightly compacted or baled material should be a maximum of 18 in. deep. Loose pine needles, straw, etc. may piled 3-4 feet deep for fumigation. Enclose the material completely with a polyethylene tarp (at least 1½ mil. thickness).

4. Fumigant exposure period should be a minimum of 48-72 hours.

5. Fumigant aeration period should be a minimum of 48-72 hrs. A check for detectible chloropicrin odors may suggest additional aeration of the material in some cases.

6. Material should be fumigated in the early spring to coincide as close as possible with the proposed use time for maximum control and reduction of potential disease hazards.

7. All physical, chemical, biological, and environmental factors and guidelines by Seymour and Cordell for the control of charcoal root rot with methyl bromide soil fumigation in forest tree nurseries, Southern Journal Applied Forestry, August 1979, pp. 104 - 108, should also be utilized for the mulch fumigation. The utilization of these practices will significantly reduce the hazard of introducing damaging disease problems into your nurseries on pine straw or needle mulch materials.

Let us know if you have additional questions, comments, or if we can be of further assistance on this matter.

Charles E. Cordell

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Forest Insect & Disease Management

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Forestation & Management

Enclosure (See Appendix 13-1)

## APPENDIX 6-2.—BIOASSAY FOR FUMIGANTS IN NURSERY SOIL[1]

If toxic material (fumigants) is suspected:

1. Collect soil from the surface 6 inches.
2. Mix the soil thoroughly and place it in petri dishes or trays.
3. Sow leaf lettuce seed on moist soil. Maintain at room temperature in the laboratory office.
4. Germination within 24 hours indicates that the soil is sufficiently aerated for sowing pine seed.

[1]Source: S.J. Rowan, USDA Forest Service, Athens, Ga.