Survey of Root and Shoot Cultural Practices for Hardwood Seedlings

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Abstract: A telephone survey of selected forest seedling nursery managers was conducted in early 2004. About 2 dozen managers were contacted and asked to respond during a brief (15 to 30 minute) conversation about the current practices they employ to manage root and shoot growth of hardwood seedlings. The participants involved were evenly split between public agencies (government) and private agencies (forest industry or other corporate entities). To receive open and honest responses to all questions, individual nursery names, locations, and managers were kept confidential.

Keywords: root pruning, undercutting, top clipping, shoot pruning, root wrenching, shoot-to-root ratio

Introduction

The efficient production and culturing of forest tree seedlings for reforestation, or even afforestation, of land in the United States has attracted broader interest in recent years, with a stronger emphasis on the benefits these trees bring to wildlife, watersheds, and the esthetic values of the landscape. Large-scale efforts are ongoing for most of the major conifer species, which are usually managed for forest products uses, including lumber and paper production. In contrast, hardwood species are now being grown to meet different objectives. These are often smaller-sized planting sites with specifically intended outcomes, such as wildlife habitat improvement for hunting, viewing, or, in some cases, replenishing threatened or endangered species. This emerging interest in hardwood seedling production has stimulated the need to compile the current state of knowledge and practices for producing the wide variety of hardwoods grown in a more effective and efficient manner.

The objective of this survey was to determine what types of activities nursery managers use to manipulate the growth and development of plant roots and shoots. Other investigators at this conference gathered information on the current state of knowledge and practices for hardwood seedlings in the areas of soil fertility and plant nutrition, crop rotation, cover cropping, and weed management.

Methodology

In May 2004, a list of forest seedling nurseries was reviewed to find those that currently grow hardwood seedlings. An effort was made to contact a sampling of those nurseries across the southeastern and northeastern areas of the United States. Approximately 24 nursery managers from these regions were eventually contacted. Roughly half of these managers worked for public agencies (state nurseries), and half were employed by private sector enterprises. These private nurseries were again split between large forest industry corporate nurseries, small nursery companies, and family-operated businesses. Ultimately, nurseries in Alabama, Arkansas, Florida, Georgia, Indiana, Louisiana, Maryland, Missouri, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and Wisconsin were contacted.

After initial contact with these nurseries, it was determined that participants in the survey would speak most freely and frankly if their actual employer affiliation remained confidential.

Survey Questions and Discussions

The survey questions and discussions were categorized into these topic areas:

1. Why do you culture your hardwood seedlings?

2. Do you use any special equipment to accomplish the culturing procedures?

3. Are there any special considerations for culturing hardwood seedlings?

4. What pitfalls have you learned to avoid when culturing hardwoods?

Culturing Hardwood Seedlings

The most common response was "to meet customer specifications." An alternative response was "to have more uniform seedlings." Further questioning on this topic revealed that proper shoot-to-root ratio was deemed important. The need to facilitate seedling harvesting and packaging was also mentioned by several nursery managers as a reason to manipulate the shoots and roots of seedlings.

Figure 1—Stationary blade used to undercut root systems in bareroot seedling beds.

Special Equipment Used to Culture Hardwoods

The equipment question naturally divided between root culture and shoot culture. For root culturing, 3 types of devices were most often mentioned by nursery managers. A stationary, sharp blade that is drawn behind a tractor is commonly used to undercut root systems in the nursery seedbeds (Figure 1). Some nurseries like to use a more intricate and costly reciprocating undercutting blade implement (Figure 2). Each of these types of undercutters can accomplish acceptable manipulation of the depth of root development.

For managing the lateral roots of hardwood seedlings, either a series of rolling coulter blades positioned to run between the drills of growing seedlings (Figure 3), or a set of stationary knife-like blades drawn between the seedling drills is used. However, it should be stated that nursery managers did not universally do lateral root pruning of hardwoods. The reason for this was divided: (1) any disturbance to, or reduction in, the mass of lateral roots is detrimental to survival and growth of hardwood seedlings; and (2) some nurseries do not own lateral root pruning implements.

Management of seedling shoots requires a totally separate assortment of equipment. Most commonly employed for this purpose is a rotary mower or brush hog (Figure 4). Several of the nurseries contacted use sickle-bar clippers (Figure 5) to limit the height growth of hardwood seedlings. They cited the more surgical cutting action and better visibility as the reasons for choosing this tool. Finally, a few nurseries that only occasionally do top pruning of hardwoods said they tried gasoline powered hedge trimmers.

Special Considerations for Culturing Hardwood Seedlings

The nursery location and climate conditions were often mentioned as factors that determine when seedling cultural

Figure 2—Reciprocating blade used to undercut root systems in bareroot seedling beds.

Figure 3—Rolling coulter blades used to manage lateral roots in bareroot seedling beds.

Figure 4—Rotary mower used to manage seedling shoot growth in bareroot seedling beds.

activities can be performed. Soil and weather conditions are always part of the decisionmaking process around a seedling nursery. This seems to be where experience and knowledge of local conditions become very important in managing a seedling crop. Possibly this is when the science and art of nursery production part ways?

The next most frequently referenced consideration was the customer type—whether they are buying trees for reforestation use or liner stock for ornamental nursery production. The size and shape of seedlings going to the horticultural trade is far more demanding in terms of seedling height, caliper, and quality of the root systems. Generally, these plants are larger than reforestation grade plants. Of course, the pricing for seedlings entering this part of the market tends to be considerably higher than those sold for reforestation.

Figure 5—Sickle-bar clippers used to manage shoot growth in bareroot seedling beds.

Pitfalls to Avoid When Culturing Hardwoods

Pitfalls or practices to avoid in the culturing of hardwood seedlings probably came to light from a big problem that a nursery manager encountered in the past. The range of responses to this particular discussion question ran the gamut from “we never top-prune or root-prune” all the way to “we top-prune early and often.” Again, the customer usually determines which of these extremes is practiced. A few items that were mentioned by several survey contacts included: (1) don’t top-prune seedlings of opposite budded species, such as maple, ash, and dogwood; (2) top clip tender, green growth and avoid cutting into hardened, woody stems; and (3) produce a plant that does not require any additional field pruning of either shoots or roots.

Summary

Hardwood seedlings vary a great deal. Different species, different customer expectations, different soils, varying climate conditions, various availability of special nursery equipment, and the range of experiences and personalities of nursery managers make generalizations on the subjects of root and shoot pruning very difficult. The topics deserve a more thorough treatment in terms of fact-finding on the currently observed methods and scientifically based investigation. With the growing interest in producing hardwood seedlings, a forum should be convened to advance the accumulated knowledge and understanding on these important topics. This information could then become a basis for better plant production and education for the future generations of nursery practitioners.

Panel Discussion: Using Shielded Sprayers to Control Weeds in Nursery Beds

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Abstract: Shielded sprayers have proven to be more effective than mechanical-type machines at controlling weeds in hardwood crops. Hand weeding times are reduced significantly, lowering costs and saving time for nursery personnel to do other jobs.

Keywords: Roundup™, Egedal, MTDC, Goal™, herbicides, bareroot seedlings

Controlling weeds in hardwood nursery crops has always been a major problem for nursery managers due to the lack of effective herbicides that will kill the weeds without damaging the crop. With the realization that the potential loss of methyl bromide could make the problem even worse, the Virginia Department of Forestry (VDOF) began looking at alternative methods of weed control in the late 1990s.

Mechanical cultivators, such as the brush hoe and triple share cultivators that would physically remove the weeds between drill rows, were purchased and tested. Although these pieces of equipment were helpful in removing weeds, they had drawbacks. Some weeds that were disturbed managed to live, and we felt that damage was occurring to fine feeder roots of crop plants. The violent spinning action of the brush hoe created dust and visibility problems for the operators and any small error in alignment would result in damaged seedlings.

As a result of our less than complete satisfaction with these units, we decided to purchase a shielded sprayer that could be used to apply Roundup™ directly to the weeds between drill rows. At the time, the only shielded sprayer (Figure 1) known to us was made by Egedal, a company based in Denmark. We purchased the unit and began testing it, tentatively at first, until we were comfortable that we would not kill the seedlings as well as the weeds. Roundup™ is a non-volatile chemical that does not produce vapors that can drift around and damage susceptible vegetation nearby. The shields prevent the spray from escaping and damaging seedlings. A row marker is suspended directly over the outside drill row to allow the tractor operator to keep the sprayer running properly between rows. The unit also has an operator seat and steering bar to help keep the unit lined up in the rows. An added benefit to using shielded sprayers over mechanical weed removal is that weeds growing in the drill row that extend some foliage into the inter-row spaces receive enough spray to eliminate them.

The VDOF has also cooperated in the testing and development of a shielded sprayer (Figure 2) designed and constructed by Keith Windell of the USDA Forest Service Missoula Technology Development Center (MTDC) (see also Vachowski, this proceedings). Mr. Windell and VDOF personnel tested his sprayer at the New Kent Forestry Center. After a few changes, the unit is now located at the VDOF Augusta Forestry Center where it is working fine. The sprayer has specially constructed shields that can be adjusted to varying widths, allowing the sprayer to be used in seedbeds having 4 to 8 drill rows. As part of the MTDC effort at technology transfer, this sprayer is available for others to try. Contact the author for more information. Design specifications and drawings will soon be available on the MTDC Web site allowing others to build their own sprayer if they desire.

The VDOF currently uses the shielded sprayer to assist in weed control in hardwoods in the following manner. In any seedbeds where our initial spray schedule of other herbicides has failed to adequately control the weeds, which occurs all too frequently, Roundup™ is applied to all inter-row areas and to the tractor paths using the shielded sprayer. An application of Vantage® or other grass control herbicide is applied to the beds to remove grasses from the drill rows where Roundup™ is not effectively applied. After these 2 applications are allowed to work, the beds are hand weeded until the beds are free of weeds. To prevent weeds from returning, Goal™ is applied to the beds of oak and other large-seeded species using the shielded sprayer at the monthly rate for Goal™ use. This method will take care of severe weed problems and usually allows the seedbed canopies to close in, preventing more weeds from getting started.

Figure 1—Egedal shielded sprayer used to spray Roundup™ directly to weeds between drill rows.

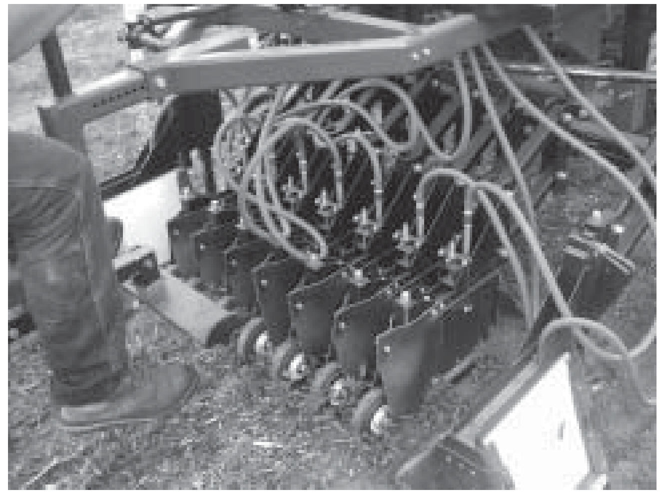

Figure 2—Shielded sprayer designed by USDA Forest Service Missoula Technology Development Center.

VDOF has found the use of shielded sprayers to be a highly effective tool in the constant battle to keep hardwood seedbeds free of weeds. Our hand weeding time has been significantly reduced, which has lowered our costs. If methyl bromide is lost, tools of this type will be absolutely necessary to control weeds in both hardwood and conifer seedbeds.

Container Hardwood Seedling Production

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Abstract: Container production of hardwood seedlings requires larger cavities, more space, and the ability to easily sort seedlings (as compared to conifers) very early during the germination phase of production. This presentation demonstrates the most productive system, based upon past experience, to commercially produce container hardwoods. The container system of choice is called "Old Native Tube" or "Vic Pots" and was developed and manufactured in Australia. Seedling target sizes are 18 to 24 in (45 to 60 cm) in height and 5 to 7 mm root collar diameter (RCD).

Keywords: Vic Pots, sorting, seed quality

Introduction

International Forest Company introduced commercially produced container hardwood seedlings to the Southeastern United States market in the early 1990s (McRae 1999). Details of production techniques and costs compared to bareroot seedlings have already been reported (McRae and Starkey 2002). This presentation focuses on container and media revisions since the 1990s.

Container Production

Container Types

Early production of container hardwood seedlings occurred in Hiko V-93 containers. Although the seedlings grew very well, usually in excess of 18 in (45 cm), the root-to-shoot ratio was often out of proportion. Outplanting survival was not affected by this ratio imbalance, which was likely due to the excellent quality root establishment as a result of our growing techniques. However, height growth after outplanting was often less than desired. To create a better ratio, production was changed to the Ray Leach™ system, using 115 cc (7 in^3) tubes. These were easily sorted to accommodate noticeable germination and subsequent growth rate variability that was traced to seed size. Better yield (more quality seedling production) resulted, as well as increased height growth after outplanting. However, the system was expensive to use, primarily during the media filling operation. Also, we still desired a larger cavity. A Styroblock™ product (Superblock 60/220 ml [13 in^3]) was used to facilitate media filling. A better root-to-shoot ratio was obtained, but the seedlings were very difficult to extract and sort by size during the germination phase. This operation (sorting by size) is crucial to our success of increasing the yield of our shippable products.

Seed Size and Quality

Seed size and quality, especially among oak species, have a tremendous influence on speed of germination as well as subsequent growth rates. Proper moisture content is, of course, crucial to uniform germination. Assuming filled live seeds are sown also plays a large role in container production. Inevitable significant germination and growth rate variation make it difficult to obtain uniform stands that are critical to efficient production required for container seedling success. Seed quality remains a significant issue that all growers must understand; adjustments in growing techniques are employed to maximize yields within individualized restraints. The effects of seed size are evident within 19 days of sowing, resulting in seedlings as tall as 9 in (23 cm) adjacent to many acorns from the same species and seedlot that have yet to initiate hypocotyl growth (Figure 1).

After observing successful production of rooted cuttings in "Vic Pots" by Boise Cascade personnel in Los Angeles, CA, we surmised that this system would best suit our needs as well. This container system, also referred to as "Old Native Tube," is manufactured in Australia. The tray system is composed of 3 parts: (1) the tray, (2) tube inserts, and (3) a bottom drip

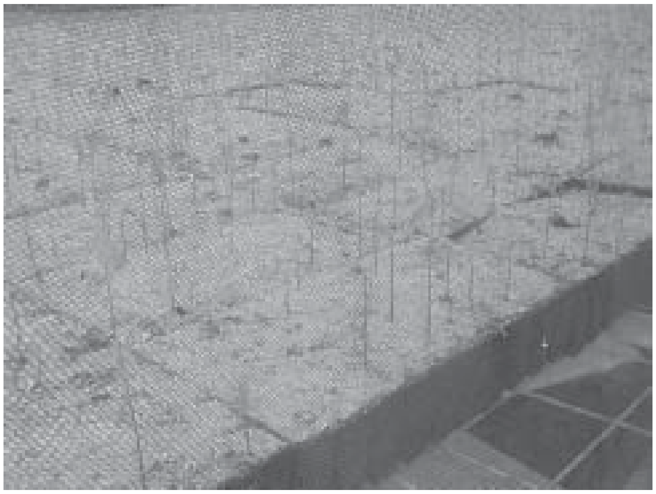

Figure 1—Oak seedlings showing variations in height growth initiation 19 days after sowing.

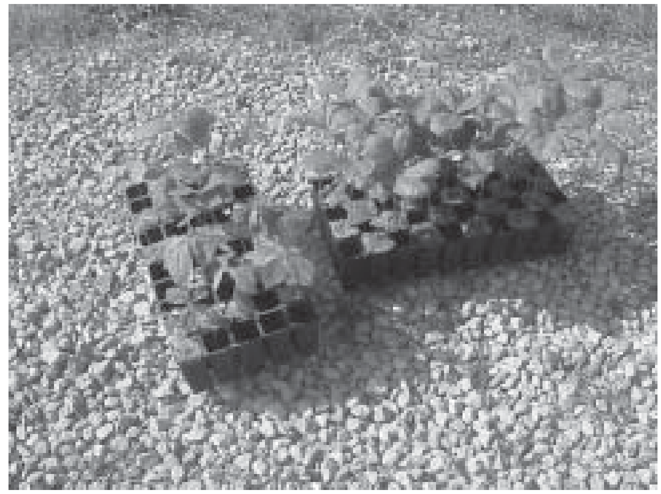

Figure 3—Oak seedlings grown in "Vic Pots" and sorted by size 30 days after germination.

rail that snaps on the tray bottom to aid air pruning and media drainage (Figure 2). The tray holds 50 cavities that are flush mounted, which facilitates mechanized media filling very well. They are square tapered tubes containing ribs that perfectly guide root growth downward. The cavity is 15 in^3 (240 cc), 5 in (13 cm) deep, 2.5 in (6 cm) across the top that tapers to 2 in (5 cm) at the bottom containing a double "cross hair" to help media retention. The cavity density is 22 cavities/ft^2 (244 cavities/m^2) (as compared to the HikoV-93 tray of 49 cavities/ft^2 [544 cavities/m^2] and typical bareroot production of 10 to 12 seedlings/ft^2 [111 to 133 seedlings/m^2]).

This large cavity allowed us to change our media mixture to include hammered peat moss and fine vermiculite to enhance moisture retention which, in turn, provided greater flexibility in our watering regimes. Also, as a standard practice, we add Banrot 8G and a Polyon 4-month controlled release fertilizer to the media.

Figure 2—"Vic Pot" 50 cavity tray with drip rail.

This system allowed seedling sorting very early in the germination phase without disturbing the roots, thereby increasing our seedling yield and quality. Seedlings 8 to 12 in (20 to 30 cm) in height after 30 days were removed from the trays and transferred to alternating cavities in new trays (Figure 3). The consolidated shorter seedlings had more space to grow vigorously into shippable products. Based on results thus far, we expect a 50% greater yield of quality seedlings, resulting in vigorous growth after outplanting as compared to production in Hiko V-93 trays. Seedling target sizes remain 18 to 24 in (45 to 60 cm) in height and 5 to 7 mm root collar diameter.

Summary

Based upon the results of 2 seasons, International Forest Company will continue to employ the "Vic Pot" growing system to produce hardwood container seedlings. Hardwood seed quality will always remain a critical issue. Hence, nearly any physical improvement that can be made that results in greater uniformity will certainly be researched and then employed where success is evident.

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Use of Cover Crops in Hardwood Production

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Keywords: bareroot seedlings, organic content, weed control

Cover crops are as essential a practice in hardwood production as in pine production or any other nursery operation. Without proper cover crop rotation in a nursery plan, we open ourselves up to an array of problems: more diseases, wrong pH, more weeds, reduced fertility, and less downward percolation of soil moisture due, in part, to compaction.

Proper cover cropping is probably the single most important thing we can do to enhance seedling health and vigor. Without reasonable organic matter content in the soil, we spend more on fertilization, disease control, and irrigation. Soil tilth, cation exchange capacity (CEC), and moisture retention begin to be problems. This in turn leads to pH, fertility, and disease problems, which in turn lead to poor root systems and poor seedling quality. Organic material in the soil is in a constant state of decay. This means it must be renewed constantly by the addition of plant residue. It is the main source of soil microorganisms, thus keeping biochemical activity constant in the soil. We keep organic material renewed in 2 ways: (1) by the addition of plant and animal residue, and (2) by the growing and maintenance of cover crops.

The program we use in cover crops is quite simple. On a 2:2 rotation (2 seedling crops, then 2 cover crops), we start with corn in the first spring following seedling lifting. This is followed by winter wheat and then by sudex, which is cut under with 2 in (5 cm) of cotton gin trash in August and September in preparation for fumigation in the fall. Sunflowers can also be a very good cover crop, but can also become weeds if we aren't careful. Many cover crops can be harvested and sold. They can also provide a continuous source of seed for the next crop.

The soil at Columbia Nursery (Columbia, LA) and Monroe Nursery (Monroe, LA) are both silt loams. Monroe Nursery has soil that is a little tighter, with shallower topsoil and heavy clay subsoil. The high lignin content and deep root systems of the mix of cover crops work very well in these soils. These help in the granulation and maintenance of the soil, not only chemically and biologically, but physically as well.

Cover crops, and thus organic material, are possibly even more important in sandy soils due to its lack of capacity to absorb and hold sufficient moisture and nutrients. The only way to improve the soil structure is with the addition of organic matter. Organic material increases the ability of the soil to retain nutrients, acts as a binding agent, and increases its water holding capacity.

Cover crops act as weed control in 2 primary fashions. Cover crops shade out any potential weeds; it is best to over-seed all crops to assure an adequate stand and full coverage to prevent any possibility of a weed problem. In addition, a wider range of chemicals can be used on cover crops to control a wider variety of weeds. This helps prevent a particular weed from becoming resistant to a chemical and allows better control of historically hard-to-handle nursery weeds, such as yellow and purple nutsedge, spurge, primrose, and morning glory. This is especially true in a hardwood nursery where our chemical controls are somewhat limited. Also, with a 2:2 rotation, chemicals that may have a little residual can be used in the first year after seedlings without having an effect on the next seedling crop. If at any point there is a weed problem in the cover crop, it should be cut under, treated, and replanted. It is very important that a weed control program be utilized along with all cover crop rotations.

Everyone knows the advantages of high organic matter content in the soil. Low organic matter creates a myriad of problems. It is just so much easier to grow a crop with an acceptable organic matter content. It takes less irrigation, less fungicide, less fertilization, less fumigation, less tillage and can, when done properly, take less herbicide and manpower. With proper rotation of cover crops, high organic matter content can be obtained and sustained. A 2:2 rotation is preferred because it allows 3 different crops before every seedling crop: corn and sunflower for high lignin; wheat for deep penetrating roots; and sudex for lignin and mass. This rotation also allows us to work on any field with problem areas for 2 years before going back in with seedlings.

If for any reason a cover crop is not taken just as seriously as a seedling crop at a nursery, it would be wise to readjust the thought process and consider the advantages of a good, well maintained program.

Panel Discussion: Application of Living Mulch for Spring-Sown Loblolly Pine

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Keywords: bareroot seedling, cover crops, herbicides

Those who grow hardwood seedlings are familiar with fall sowing seeds and using rye, wheat, or oats to over-winter the crop. Throughout this paper, reference to rye is GRAIN, NOT GRASS (do not use rye grass). The rye stabilizes and insulates the beds while retarding predation and weeds. Normally sown at 2 bushels/ac (5 bushels/ha), the rye is killed with Roundup before the seeds germinate (around mid-February), allowing the seeds to germinate and emerge unimpeded. Light-seeded, fall-sown hardwoods often necessitate only 1 bushel/ac (2.5 bushels/ha).

As an outgrowth of this, we experimented in 1999 on 9 beds using an application rate of 2 bushels rye/ac (5 bushels rye/ha) for spring-sown loblolly pine (*Pinus taeda*). The results were so favorable that we expanded to 0.5 ac (0.2 ha) in 2000. Finding no problems, we expanded this application to half our loblolly pine crop in 2001.

The use of pine bark mini-nuggets on our whole loblolly pine crop in 2001 would have cost us approximately U.S. $30,000. The same area using the rye would have cost us U.S. $400. An equally important savings is the application time. A broadcast seeder can cover 5 beds with 1 pass; the more conventional bark application requires 1 pass per bed with a manure spreader that must return to the bark pile to be loaded between applications.

There were several unanticipated findings:

1. There seemed to be some positive partial shading of seedlings in early days.
2. No mulch floated off.
3. There were no introduced weeds (as would have occurred with mulch).
4. The weeds were shaded out by the rye.
5. Rye can stand Goal pre-emergent to a degree. We generally did not use Goal when using rye.
6. The dead thatch lasted until crown closure.
7. The seedlings achieved the same density as those grown without the living mulch.
8. The seedlings were the same quality at lifting as those grown without the living mulch.
9. As a cover crop, rye was better than oats, which was better than wheat.

A negative finding was that the seedlings were about 2 weeks behind in reaching crown closure. We attributed that to nitrogen deficiency caused by microbial action on decaying rye root systems.

Other uses of living mulch include stabilization of the sawdust applied over sown pine seed and the over-wintering of white pine (*Pinus strobus*) between the 1+0 and 2+0 years. (**When killing the rye before the spring growth of the white pine it is important to mow the rye at Tree Top level approximately days after herbicide application but before it falls over This will prevent a thatch from forming over the top of the seedlings The winter rye will be tall and present an impenetrable thatch if this is not done**)

The steps for using living mulch on spring-sown loblolly pine are:

1. Level the ground.
2. Broadcast the rye at an application rate of 2 bushels/ac (5 bushels/ha).
3. Build the seedbeds.
4. Sow the pine seeds.
5. Kill the rye with Poast . Although it may appear that the rye is too abundant when viewed from ground level, an overhead view would show that this is not so. It is all right if the rye is taller than the seedlings as long as the dead rye does not form a thatch over the seedlings when it falls over.
6. The pine seeds must be covered with soil or at least pressed in.

Some alternatives to consider:

1. Wait 2 to 3 days after building beds to sow pine seeds to give the rye a head start in germination and growth.
2. If you decide to use Goal pre-emergent, increase the rye to 3 bushels/ac (7.5 bushels/ha) and/or sow the rye after the bed is formed instead of before. The rye germinates very poorly if it is not covered or pressed in.