# ROOT AND SHOOT PRUNING

# AT SOUTHERN NURSERIES

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**Abstract** -Reforestation success in the South begins with the culturing of high quality forest tree seedlings. Nursery cultural practices such as shoot and root pruning alter seedling quality and field performance. This paper addresses four cultural practices: undercutting, root wrenching, lateral pruning, and top pruning and discusses 1) how these practices are employed by southern nurseries and 2) how they may affect seedling quality and field performance. Results of a nursery survey of 54 southern nurseries are discussed for each practice. Undercutting and root wrenching are practiced by 57% and 35% of the southern nurseries, to control height, promote a fibrous root system, and induce budset and hardening. Results of studies have shown that undercutting and root wrenching 1) decrease shoot height, weight, and diameter and shoot:root ratio, 2) have no effect on root weight, 3) may increase root fibrosity, 4) induce budset and hardening, and 5) may improve survival and growth. Seventy-three percent of southern nurseries lateral-prune their seedlings to facilitate lifting, control lateral root length, and promote a fibrous root system. The few studies that have investigated lateral pruning have shown that it 1) has no effect on shoot height or diameter, 2) may increase root fibrosity, and 3) prevents root entanglement. Not enough is known about lateral pruning's effects on survival and growth. Ninety-one percent of the southern nurseries responding to the survey top-prune their seedlings, mainly to control height and produce a uniform crop. Studies have shown that top pruning 1) decreases shoot height, weight, and shoot:root ratio, 2) may not effect shoot diameter or root weight, 3) may delay budset, 4) increases the number of multiple tops, 5) way increase survival, and 6) may have no effect on field growth. More knowledge about these pruning methods is needed so that the nursery manager can better integrate the variety of cultural practices available to yield high quality seedlings, that perform well in the field.

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## INTRODUCTION

Reforestation success in the South begins with the culturing of high quality forest tree seedlings. These seedlings are most often described by both their morphological and physiological characteristics. Nursery cultural practices such as shout and root pruning alter these seedling characteristics and, therefore, seedling quality and field performance after planting. Often a target seedling is defined, and the production of this seedling is the goal of a nursery. A hypothetical target seedling might have some of the following characteristics:

- Height - 25-30 cm
- Stem Diameter - >4 mm
- Roots - Fibrous, compact
- Bud - Set, hardened
- Nutrition - Adequate minerals and carbohydrates

Some of the practices employed in the nursery to arrive at a healthy seedling with these characteristics are:

- Undercutting and Root Wrenching
- Lateral Pruning
- Top Pruning
- Irrigation
- Fertilization
- Sowing Date

All these practices interact and the nursery manager incorporates these practices into the right regime to produce high quality seedlings. For example these seven practices may all be used in different ways to 1) promote or control height, stem diameter, and root growth; 2) promote or delay budset; or 3) alter nutritional levels.

This paper addresses four cultural practices, undercutting, root wrenching, lateral pruning, and top pruning and discusses 1) how these practices are employed by southern nurseries and 2) how they may affect seedling quality and field performance. Results of a nursery survey of southern nurseries are discussed for each practice.

## THE NURSERY SURVEY

Sixty-five southern U.S. nurseries received a nursery survey inquiring about their cultural practices; fifty-four (83%) responded. These 54 nurseries grew 1.24 billion seedlings in 1935 with the majority being loblolly [*Pinus taeda* L.) and slash [*Pinus*

elliottii Engelm.) pines (Table 1). This paper reports on the questions on top and root pruning; another paper in this proceedings by Jon Johnson reports on the irrigation questions.

TABLE 1. Seedling Production in 1985 by the 54 nurseries in the South that responded to the nursery survey.

| SPECIES | TOTAL NUMBER OF SEEDLINGS (MILLIONS) | % OF TOTAL |
|---|---|---|
| LOBLOLLY PINE | 919 | 74 |
| SLASH PINE | 232 | 19 |
| LONGLEAF PINE | 22 | 2 |
| EASTERN WHITE PINE | 16 | 1 |
| SAND PINE | 14 | 1 |
| SHORTLEAF PINE | 12 | 1 |
| VIRGINIA PINE | 11 | 1 |
| OTHERS | 14 | 1 |
| ALL SPECIES | 1240 | 100 |

## UNDERCUTTIONG AND ROOT WRENCHING

Undercutting is the drawing of a thin, sharp blade under the seedbed parallel to the surface. The blade severs the taproot and all other roots extending beyond the regulated depth of the undercut. Root wrenching which often follows undercutting is done with a thicker, broader blade tilted at an angle ($20^0$ to $30^0$) when drawn under the seedbed. Wrenching cuts off any newly penetrating roots and lifts seedlings, loosening and aerating the soil (Duryea 1934).

Undercutting is practiced by 57% of the southern nurseries, wrenching by 35%, and 21% both undercut and wrench (Figure 1). The main reasons given by survey respondents for undercutting and root wrenching in the South are to:

1. Control Height (34 responses)
2. Promote a fibrous root system (29)
3. Induce budset and hardening (18)
4. Control root length (12)
5. Facilitate lifting (8)
6. Loosen soil (5)
7. Avoid top pruning (3)

Seedlings are undercut one time (47%) usually sometime in

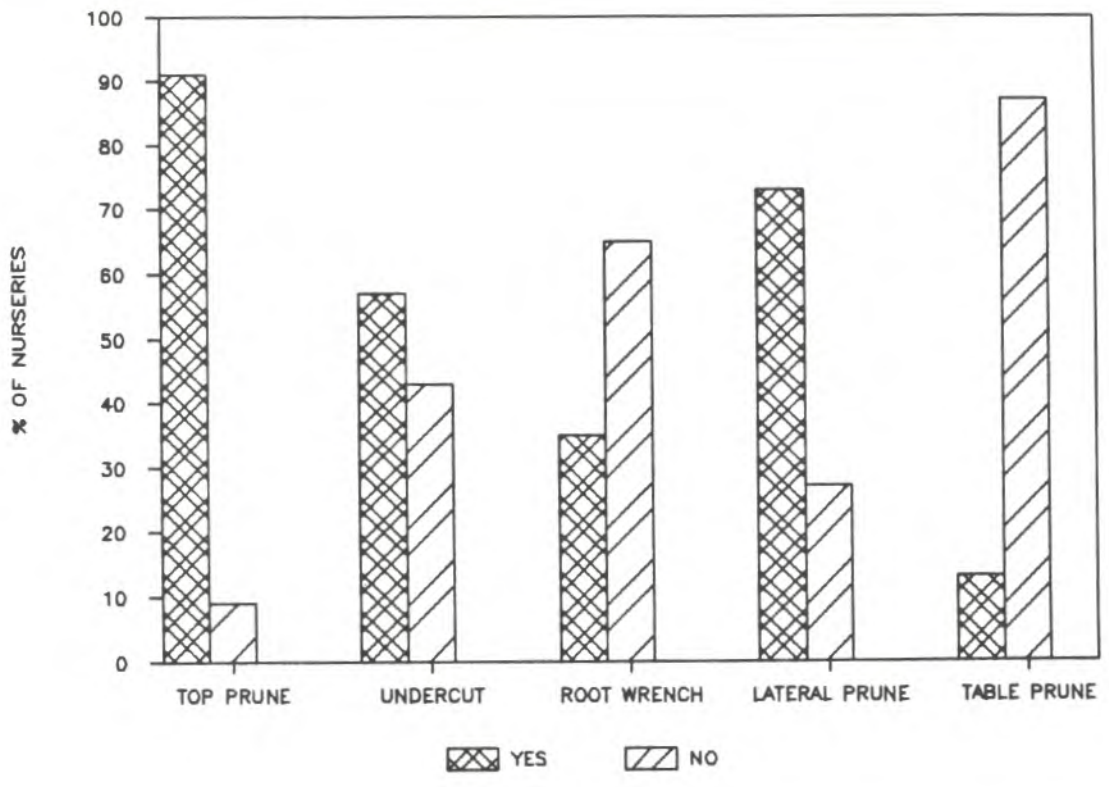


FIGURE 1. Use of five nursery practices by the 54 southern nurseries responding to the survey.

August to October, or more than once (53%), the first cut being in June to August and later cuts in August to October. The most comm on depth of undercutting is 15 cm (6") (Figure 2a). All nurseries (100%) use a fixed blade to undercut their seedlings although one nursery has both fixed and reciprocating undercutters.

Nurseries root-wrench usually one time (66%) in August or September; those that wrench more than once (34%), wrench first in June to August, and then again in August to October. The most co non wrenching depth is 15 cm (6") (Figure 2b). Again, all nurseries use a fixed blade, although one has both fixed and reciprocating wrencuers.

## Effects of Undercutting and Root Wrenching

**Shoot height.** If implemented at the correct time, undercutting or root wrenching will usually retard height growth and result in shorter seedlings. One recent study compared wrenching frequency and timing of loblolly pine using the following treatments: 1) no wrenching, 2) wrenching once in November, wrenching once a month in 3) October and November, 4) September, October, and November, and 5) August, September, October, and November. Although frequency

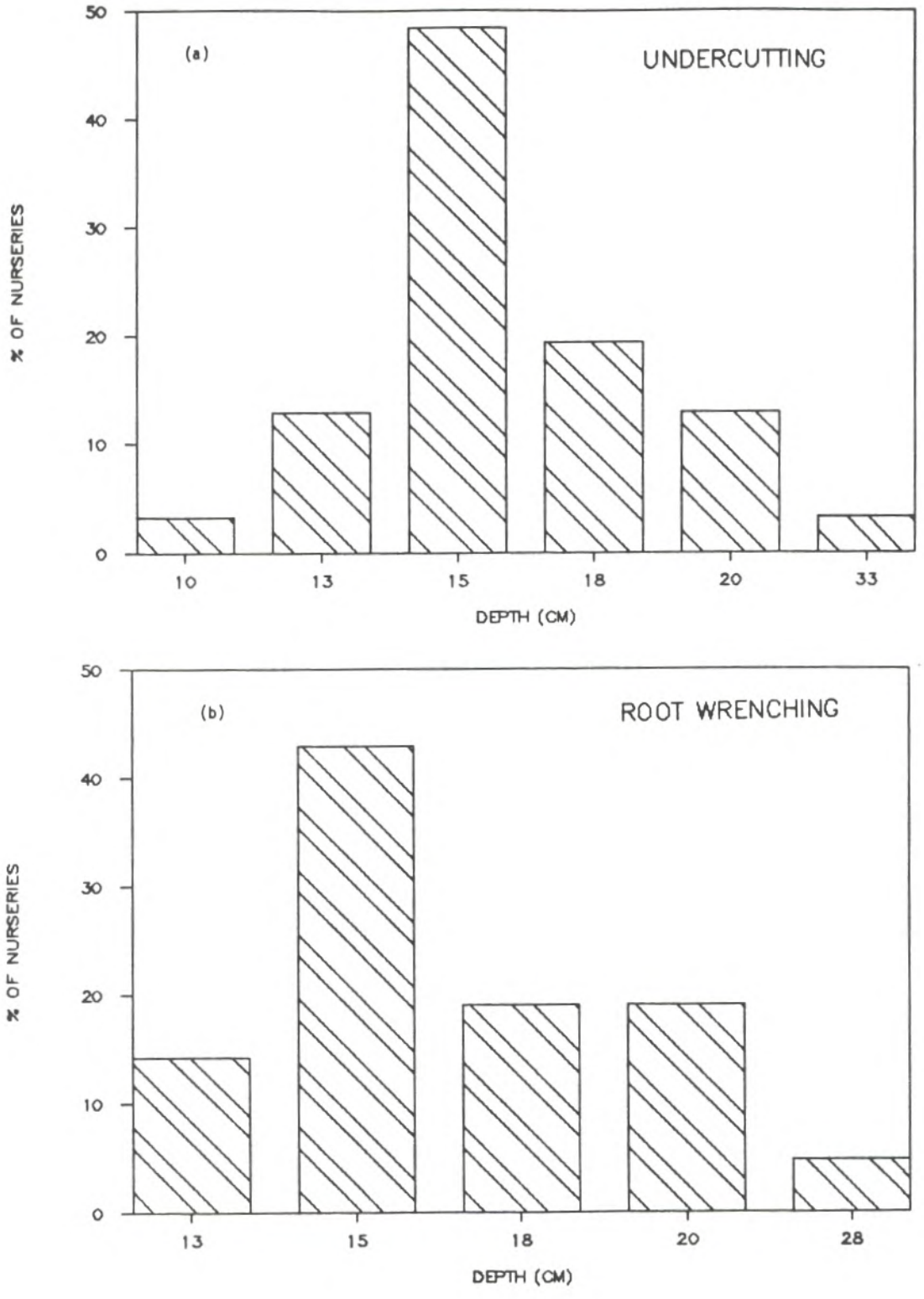


FIGURE 2. a) The depth of undercutting by nurseries in the South. b) The depth of root wrenching by nurseries in the South.

and timing were confounded in the study, the trends seem to show that the greater the frequency of wrenching and the earlier the treatment (first wrenching in August versus November), the shorter were loblolly pine seedlings Willer and others 1985). Another study, which investigated frequency and timing, showed that loblolly pine seedlings undercut early in August were shorter than those undercut in September, and both were shorter than those undercut in October. When comparing 1, 2, and 3 times undercutting, the greater the frequency, the shorter the seedlings (Dierauf and Olinger 1982). In another study, where undercutting was done in late August, and then wrenching 4 times beginning in late September, height of seedlings was not significantly affected although the trend was there (Tanaka and others 1973). Shoulders (1963) recaanended undercutting loblolly and slash pine in mid-August, and then cutting again 5 weeks later; single cuttings after August were usually ineffective at controlling height. Fran these studies, the best results for controlling height can be obtained by undercutting or wrenching the first time in August (or even earlier depending on the height of the crop), and then again in September and maybe October.

**Stem diameter.** Undercutting and wrenching most often result in a smaller stein diameter for the final crop for Douglas-fir [Pseudotsuga menziesii (mirb.) Franco] (Duryea and Lavender 1982), radiata pine [Pinus radiata D. Don) (Rook 1971), as well as the southern pines (Tanaka and others 1976, Walstad and others 1977). Dierauf and Olinger (1982) found that the timing of undercutting affected this reduction; seedlings that were undercut in August had smaller stem diameters *by* 13%, in September by 8%, and in October by 3%. Wrenching loblolly in another study reduced stein diameter from 5.0 to 4.2 mm (Tanaka and others 1973).

**Shoot weight and shoot:root ratio.** After undercutting, the smaller shoots are also lighter; this contributes to **e** decreased shoot: root ratio. In one study wrenched loblolly pine were lighter by 26% and the root weight was unaffected hut the shoot: root ratio was reduced with wrenching from 4.8 to 3.9 (Tanaka and others 1976). This reduction in shoot weight and shoot:root ratio is similar in other species such as Douglas-fir (Duryea and Lavender 1932, Stein 1984) and radiate pine (van Dorsser 1981).

**Root fibrosity and weight.** Root weight most often does not change after undercutting or wrenching, but the root fibrosity nay increase. Tanaka and others (1976) found no effect of root wrenching on loblolly root dry weight yet found a marked increase in the proportion of fibrous lateral roots; wrenched loblolly pine had 60% of its root weight in laterals compared to 43% for unwrenched controls. Most other studies with southern pines have riot measured root fibrosity. Observations, however, have been that both undercut and non-undercut seedlings appear to have equal numbers of secondary roots (Shoulders 1963), and that perhaps undercutting in August resulted in more secondary roots than September and October (Dierauf and Olinger 1982). Vith other species there have been mixed results on root fibrosity and weight.

Men the taproot of radiata pine is severed, root growth rates are similar for wrenched and unwrenched seedlings but the final root system is quite different in form; lateral root growth increases and many new tertiary roots grow, resulting in a more compact fibrous root system (van Dorsser and Rook 1972, Benson and Shepherd 1977). Undercutting and wrenching have produced variable results on the root system of Douglas-fir with most reports showing no effect on fibrosity (Tanaka and others 1976, Duryea and Lavender 1982, Stein 1984).

**Budset and hardening.** Undercutting and root wrenching when done properly, may induce budset; since this is the first step in cote. hardening and dormancy, this means that undercut or root-wrenched seedlings may become more dormant and cold hardy earlier than untreated seedlings (Duryea 1984, Duryea and M$^{c}$Clain 1984). The planting season was extended in one study where loblolly pine seedlings planted in November and April (two relatively harsh months for planting) survived better if they had been root-wrenched (Tanaka and others 1976); these seedlings were perhaps more hardy and resistant to the stresses of lifting, handling, and planting. The authors also noted that wrenching in the spring before lifting may delay flushing of seedlings in the spring, prolonging dormancy, and improving vigor and survival of spring-planted stock. In New Zealand, radiata pine do riot set bud in the first year in the nursery; root wrenching is used to stop growth and to condition or harden nursery stock (van Dorsser 1981). We need to further investigate the effects of undercutting and root wrenching on the induction of dormancy and cold hardening in southern pines.

**Root growth and water relations.** Wrenched radiata pine have more favorable water relations and active root growth when planted on droughty sites than do unwrenched seedlings (Rook 1969). Douglas-fir, on the other hand, grew fewer active roots during drought, and wrenching did not improve the seedlings' ability to endure drought (Duryea and Lavender 1982). One study measured root growth potential of three single-wrenching treatments; wrenching at different dates did not affect root growth potential (Miller and others 1985). The subject of root growth and water relations after planting needs further investigation; perhaps the successful survival of undercut or root-wrenched loblolly pine seedlings especially on droughty sites is also due to improved water relations after planting.

**Mineral nutrition.** Wrenching has been found to reduce the foliar concentrations of N, P, and K in radiata pine (Benson and Sheperd 1977) and Douglas-fir (Menzies 1980). This same response could most likely occur with souLhern pines; although we need more study, fertilizer should be applied when wrenching southern pines because nutrient-deficient pine seedlings may not grow as well in the field (Switzer and Nelson 1963, van Dorsser 1961, Fisher and 1984).

**Survival and Growth.** The effect of undercutting and wrenching on survival and growth has been variable:

Venator and Mexal (1960) compared loblolly pine which had been undercut-only in August with those which were both undercut and wrenched (at different intervals beginning in August). There were no differences in survival between those seedlings undercut and those both undercut and wrenched, even though with a droughty spring, survival ranged from 54 to 63%.

- Dierauf and Clinger's study (1982) of undercutting loblolly pine seedlings showed no effect on survival but after three seasons in the field, undercut seedlings were 12.2 cm (4.8") taller than the non-undercut control.

- Loblolly pine which had been undercut and root-wrenched beginning on August 30 had 93% survival compared to 70% for the non-undercut/non-wrenched control seedlings. The positive effect of undercutting and wrenching was greater on the droughty site (survival was improved by 30%) than on the moist site (survival was improved by 15%) (Tanaka and others 1970).

- Undercutting improved survival of longleaf pine in 5 out of 6 studies, of loblolly pine in 2 out of 5 studies and of slash in 1 out of 5 studies. Longleaf needs to be undercut at least 4 to u weeks before lifting and can be undercut as long as 18 weeks before lifting (Shoulders 1963). in 1963, Shoulders recommended that undercutting was not a reliable method for increasing survival of loblolly and slash but if it was necessary to undercut (once or twice) to control height, survival would not be reduced.

With other pines, undercutting and root wrenching have had mixed results. As mentioned before, radiata pine must be undercut and wrenched if consistently high survival rates are to be obtained; undercut and wrenched radiata pine seedlings also grow better in the field (van Dorsser and Rook 1972). Root wrenching of ponderosa pine [Pinus ponderosa Dougi. ex Laws) seem to have no effect on survival or growth (Tanaka and others 1170).

## LATERAL PRUNING

Lateral pruning, also called side pruning or side cutting, is the passing of cutting blades or colters between the drill rows on both sides of the seedlings to sever excessively long lateral roots. Seventy-three percent of southern nurseries lateral-prune their seedlings (Figure 1). Another 13% lateral-prune just before lifting to reduce root entanglement with use of mechanical lifters. The reasons for lateral pruning are to:

1. Facilitate lifting (17 responses)
2. Control lateral root length (16)

3. Promote a fibrous root system (12)
4. Facilitate planting (7)

Lateral pruning is done once (66%) or more than once (34%) at 13 to 15 au (5 to 6") depth. When lateral pruning once, nurseries usually prune in September or October; when pruning more than once, they prune first in July to September and again in September to October. To lateral-prune, nurseries most commonly use tractor-mounted rolling colters (60%); stationary blades are also used (20%).

**Effects of Lateral Pruning**

Few studies have investigated the effects of lateral pruning on southern pines. In one study, lateral pruning of loblolly had no effect on shoot height or stem diameter (Dierauf and Olinger 1932). In another study lateral pruning reduced the dry weight of lateral roots but did not reduce survival unless seedlings were stored for over two months (Walstad and others 1977). Lateral pruning of western hemlock [Tsuga heterophylla (Raf.) Sarg.], Douglas-fir, and Sitka spruce [Picea sitchensis (Bong.) Carr.] seedlings at different times from May to September did not reduce shoot height but did increase root fibrosity (Eis 1933, Eis and Long 1972).

Lateral pruning prevents the entanglement and intermeshing of roots of seedlings in adjacent drill rows; by cutting these roots it decreases the root stripping that occurs when seedlings are lifted and packed (Burdett and Simpson 1984). A more compact root system is also more easily planted avoiding problems associated with distorting the root system while placing it in the planting hole. Further research is Heeded to determine whether lateral pruning enhances fibrous root development in the nursery and whether this an effect on field performance.

**TABLE ROOT PRUNING**

When seedlings are laterally pruned, the pruning only severs roots growing perpendicular to the drill rows; roots which are growing parallel to the drill rows are not pruned (Burdett and Simpson 1984) and after lifting are much longer than the rest of the root system. Table root-pruning is the cutting of seedling root systems after lifting; seedlings are laid on a table and cut to a specified length, hence the name, table root-pruning. Some nurseries in the South (13%) (Figure 1) and many nurseries in the Pacific Northwest table root-prune their seedlings to make them easier to plant. Table root pruning in the South is done most often at 15 to 20 cm (6 to 3') although one nursery prunes its hardwoods at 7.6 on (3"). Roots are trinined with saws or other cutting tools. Little is known about the effects of table root-pruning on subsequent root growth and field performance.

## TOP PRUNING

Ninety-one percent (91%) of the southern nurseries responding to the survey top-prune their seedlings (Figure 1). The main reasons given by survey respondents for top pruning in the South are to:

1. Control height (37 responses)
2. Produce a uniform crop (19)
3. Improve the shoot:root ratio (5)
4. Release smaller seedlings (4)
5. Increase shoot diameter (3)

Most nurseries (65%) top-prune more than once, often depending on the development of their crop. Those nurseries that top-prune once usually prune in July or August; for those that prune more than once, the first cut may be as early as May to ju ly with most later cuts in August (and a few in September or October). The height of the cut varies, most often occurring between 13 and 31 cm (7 and 12 inches) (Figure 3). Most nurseries use a rotary/bush-hog mower (70%), although some use wire (20%), flail (8%), or sickle (2%) mowers.

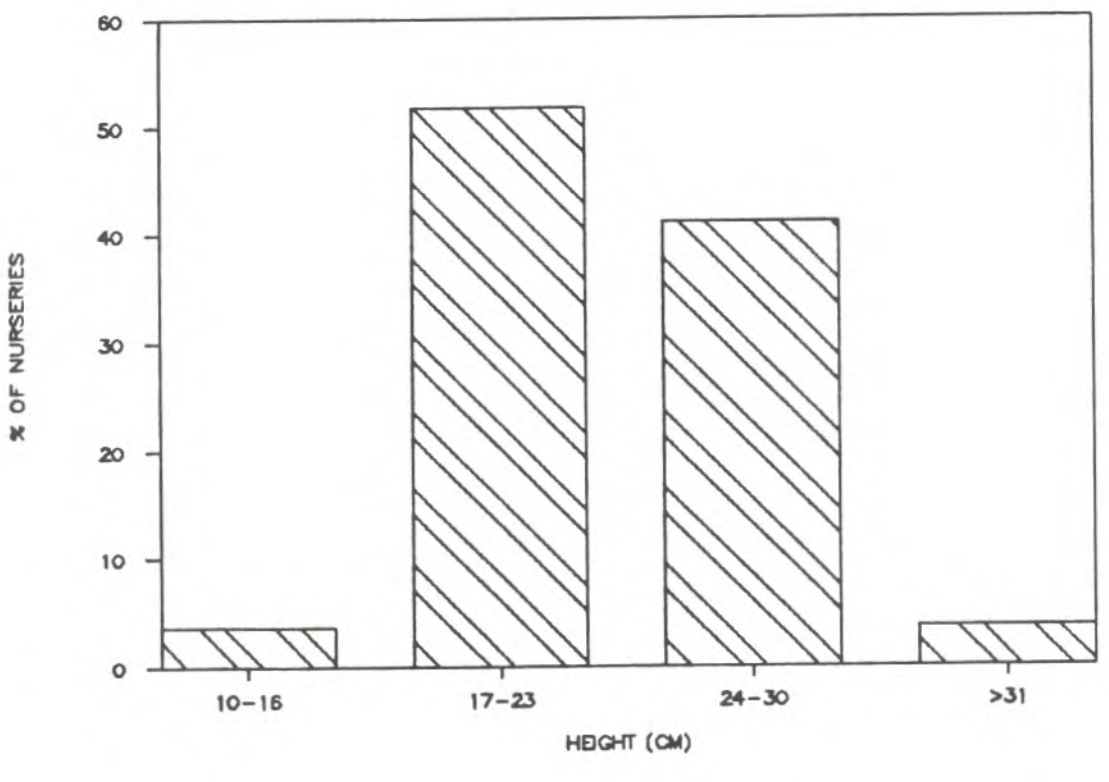


FIGURE 3. The height at which southern nurseries top prune their seedlings.

## Effects of Top Pruning

**Shoot Height.** The initial reason to investigate the use of top pruning in southern nurseries was to control top growth (Dierauf 1976). Excessively tall, loblolly pine seedlings which would other wise be culled need to be reduced in size for improved handling and field performance (Dierauf 1976, Mexal and Fisher 1984). Those nurseries that top-prune, cut the larger seedlings in the bed; the result is a crop which is shorter in size and also one which is more uniform in height. Studies to determine whether release of small seedlings occurs after top pruning have had mixed results (Dierauf 1976, Dierauf and Garner 1980, Mexal and Fisher 1984). Mexal and Fisher tagged seedlings to determine if release occurred and found that seedlings which were culls before pruning remained culls after pruning Mexal and Fisher (1984). In a similar study of Douglas-fir, Duryea and Qid (Unpubl. data) also did not find release of small, cull seedlings after top pruning.

**Stem Diameter.** Overall crop stem diameter is most often not affected by top pruning. Loblolly pine, top-pruned on September 1 did not have reduced diameters compared to the unpruned controls (Dierauf and Olinger 1982). Top pruning loblolly and slash containerized seedlings did riot affect the sten. diameter as compared to unpruned controls nor did the tinning of the pruning (10, 12, or 14 weeks after sowing) affect stem diameter (Barnett 1984). Timing of the top-prune (single prunings in August, September, or October) did not affect loblolly sten, diameter Willer and others 1985). One study reported the release of cull seedlings from top pruning resulting in fewer seedlings with small diameters and a more uniform stem diameter (Dierauf 1976). Another study which tagged seedlings which were pruned and unpruned within the bed reported no release of the smaller seedlings; those that were culls at the time of pruning remained culls with diameters (Mexal and Fisher 1334).

Maintaining the length of longleaf pine needles at 5 cm by constant pruning reduced stem diameter but clipping to 10 cm had no effect on stem diameter (Barnett 1984).

**Shoot Weight and Shoot:Root Ratio.** Because the shoot is cut, the shoot weight of pruned seedlings and usually the final crop is lighter. One study reported that although 20% of the height was removed this included much of the photosynthetic biomass because 45% of the secondary needles were removed (Mexal and Fisher 1384). The lighter shoot means a decrease in the shoot:root ratio. The timing of the top pruning (single prunings in either August, September, or October) did not affect the loblolly pine shoot:root ratio Willer and others 1935).

**Root System.** Although few studies have investigated top pruning's effects on roots, it has been observed in a series **of** studies that pruned and unpruned seedlings with the same stein diameter seem to have root systems of the same size (Dierauf 1976). In a study of Douglas-fir top pruning at six nurseries, root weight was

unaffected by top pruning (Duryea and Unpubl. data).

**Disease.** Because open wounds, in general, are potential sites for disease infection, pruning increases the chances of disease in a seedling crop. In a Mississippi nursery, longleaf pine seedlings after being top-pruned, became infected with brown-spot needle blight; spores were transported on the cutting blades and infected seedling tops, left in seedbeds and paths, contaminated water, which caused other parts of the nursery to become diseased (Kais 1978). Clean tools and equipment decrease the chance of carrying spores throughout the nursery. In addition, seedlings that are top-pruned during active growth and are adequately watered and fertilized, close wounds promptly, reducing the chance of infection (Duryea 1984).

**Multiple Tops.** The number of seedlings with multiple tops is increased with top pruning (Dierauf 1976). Perhaps, this number could be decreased by altering the pruning height and timing; earlier and taller pruning mean that the succulent shoot is being cut instead of lignified woody tissue. Cutting this succulent tissue ensures proper development of wound calluses and buds.

**Survival and Growth.** Top pruning, especially of larger pine seedlings, often increases survival but it usually does not affect growth of outplanted southern pines. In a series of studies from 1 71 to 1975 top pruning most often improved the field survival of loblolly pine seedlings; pruning of tall seedling lots improved survival more than pruning of shorter seedlings (Dieurauf 1976). In none of the studies did top pruning improve the field height growth of seedlings compared to the unpruned control. In another study, however, survival of lobiolly pine seedlings, which had been top-pruned on September 1 was not different after three years in the field from the unpruned control although the pruned seedlings were shorter at the time of planting (Dierauf and Olinger 1982).

## CONCLUSIONS AND RECOMENDATIONS

Looking at the target seedling and its characteristics, we can assess which of these practices might help and which might hinder the production of a good quality seedling (Table 2). For instance, if a short shoot and early budset are required, undercutting and wrenching might be more desirable than top pruning, or if a large diam eter is desired these three practices may have a negative effect. The timing of these practices also may enhance or decrease these effects.

Using the hypothetical target seedling as an example, how can nurseries arrive at their desired final product consistently year after year? First of all flexibility is needed because no two years seem to be alike -- so nurseries must be able to alter practices with the weather and crop development for an individual growing year. Next, it is important to keep track of crop development from year to year by establishing growth curves for a series of nursery crops. By using growth curves nurseries may be

TABLE 2. The effects of four practices on target seedling characteristics and field performance; + means a positive effect, 0 means no effect, and - means a negative effect.

| | PRACTICE | | |
|---|---|---|---|
| TARGET SEEDLING CHARACTERISTICS | UNDERCUT/ WRENCH | LATERAL-PRUNE | TOP-PRUNE |
| HEIGHT | | | |
| 10 to 12 cm | + | 0 | + |
| STEM DIAMETER | | | |
| >4 mm | - | 0 | -,0 |
| ROOTS | | | |
| Fibrous, compact | 0,+ | 0,+ | 0 |
| BUD | | | |
| Set, Hardened | + | 0 | -,0 |
| NUTRITION | | | |
| Adequate minerals | -,0 | 0 | 0 |
| Adequate carbohydrates | -,0,+ | 0 | -,0 |
| **FIELD PERFORMANCE** | | | |
| SURVIVAL | | | |
| Good site | -,0 | 0 | -,0 |
| Poor site | 0,+ | 0,+ | 0,+ |
| GROWTH | | | |
| Good site | -,0 | 0 | 0 |
| Poor site | 0,+ | 0,+ | 0 |

able to plan ahead and employ practices properly instead of employing thew too late -- for instance many nurseries arrive at September and then notice that their crop is too tall. Top pruning this late in the growing season often means cutting into woody tissue, causing late flushing, and causing problems with wound development and bud format ion. Root wrenching this late will not help in decreasing the height. Anticipating ahead of time may mean earlier top pruning or root wrenching or use of other cultural practices such as reduced irrigation or fertilization.

We need more information to help us make better decisions about these practices; establishing the optimal timing, frequency,

and height/depth for each practice would be most helpful. addition, what are the effects of these practices on the target seedling that a nursery wants to produce and also on its subsequent field performance. Calibration of these practices to specific nursery and field situations is necessary as well as knowledge about how these practices interact when used together. This knowledge would then aid the nursery manager in integrating the variety of cultural practices available to yield high quality seedlings that also perform well out in the field.

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