Undercutting in Loblolly Pine

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Abstract—Undercutting has been demonstrated in many species to be an effective method to control seedling height, manipulate root system morphology, and alter seedling physiology. Similar results have been demonstrated in loblolly pine undercutting research at Union Camp. Apparently, the moisture stress condition of the seedlings at the time of undercutting plays a very important role in the response achieved.

Keywords: Pinus taeda L., undercutting, nursery.

SUMMARY OF REPORTED UNDERCUTTING EFFECTS

Undercutting is defined as the physical manipulation of roots while the seedling is still in the nursery bed. This procedure has been used since the late nineteenth century (Racey and Racey 1988). Summer or early fall undercutting has become a standard procedure in southern pine *(Pinus* spp.) nurseries (SAF Tech. Comm. 1932, Hastings 1948, Johansen 1955, Shipman 1958, Shoulders 1959, 1965). The objectives and methods of undercutting vary somewhat with area regeneration concerns but generally undercutting is practiced to maintain a balance between shoot and root growth, and to modify the form and function of the root system.

Most cultural treatments which sever the roots of a seedling during the growing season will reduce shoot growth (Duryea 1984). Undercutting has been demonstrated to be an effective method to control the shoot growth of the southern pines (Darby 1962, Shoulders 1963, Tanaka et al. 1976, Dierauf and Olinger 1982). Similarly, intensive nursery bed root manipulation of radiata pine *(P. radiata* D. Don) in New Zealand has been shown to decrease height growth, increase root system fibrosity and root growth rates (Cameron 1969, Rook 1971, Sweet and Rook 1972, van Dorsser and Rook 1972, Benson and Shepard 1977, Bacon 1979, Escobar et al. 1977).

The effect of undercutting on diameter has been inconsistent in many species. In loblolly pine, some studies reported a decrease in diameter with undercutting (Tanaka et al. 1976, Dierauf and Olinger 1982) while others report undercutting has no effect (Shoulders 1963, Venator and Mexal 1981). Undercutting will reduce diameter depending on the severity and frequency of the treatment and the physiological status of the seedling at the time of undercutting (Racey and Racey 1988). Since undercutting will reduce height growth and may reduce diameter growth, seedlings must be given sufficient individual space to allow for maximum diameter growth (van Dorsser 1981) and Jakabffy (1969) indicates that to be

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successful root manipulation requires sowing to be sparse and uniform. For example, large and vigorous longleaf pine *(P. palustris* Mill.) seedlings were produced when undercutting at a seedbed density of 20/ft^2 compared to 40/ft^2 (Johansen 1955, Shipman 1958). In a review of 162 papers involving root manipulation, Racey and Racey (1988) conclude “there is no evidence that undercutting or wrenching are as effective at higher seedbed density”. Clearly, undercutting is only effective with lower seedbed densities.

Once undercut, the physiOlogical balance and form of the seedling is altered. Root wounding results in reduction of photosynthetic output, preferential transfer of assimilates from foliage to roots, increased water stress compensated by increased stomatal resistance, and massive root proliferation including lateral root development (Davey 1964, Rook 1971, Wardlaw 1976, Bacon and Bachelard 1978, Stupendick and Shepard 1980, van Dorsser 1981). The recovery period after root pruning in radiata pine seedlings was characterized by decreased stomatal resistance, increased photosynthetic output, and proliferation of new roots (Stupendick and Shepard 1980). Since shoot growth is reduced and root growth stimulated, the root:shoot ratio in undercut seedlings is increased, resulting in better seedling “balance” (Benson and Shepard 1977, Mexal 1982, van Dorsser 1981, Venator 1983, Mexal and Fisher 1984).

Properly done, undercutting has the potential to produce a seedling in “balance” with a nutrient-charged, fibrous root system and a shoot with enhanced stomatal resistance. Such a seedling will probably survive and recover more quickly from planting shock than an untreated seedling. Survival of undercut seedlings has been reported to be enhanced due to the relative large and active root system which allows rapid contact with soil moisture and nutrient reserves (Rook 1969, Bacon and Hawkins 1977, Benson and Shepard 1977). Undercut radiata pine seedlings were able to maintain active root growth during drought compared to intact seedlings (Rook 1969, van Dorsser 1981). Undercutting was credited with improving the survival of loblolly pine on droughty sites from 70 to 907, (Tanaka et al. 1976).

Undercutting has also been reported to enhance the early growth of seedlings in some species. Early growth of undercut seedlings was greater than non-treated controls in radiata pine (van Dorsser and Moberly 1969), white spruce *(Pica glauca* (Moench) Voss), and Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco). Presumably, the robust root system created by undercutting allows for a seedling to rapidly overcome planting shock and commence height growth. Current information is insufficient to support a similar claim for southern pine species.

UNDERCUTTING RESEARCH AT UNION CAMP

Since 1984, Union Camp Corporation has conducted a series of undercutting trials in loblolly pine to assess impact of undercutting timing, frequency, seedbed density, water stress, and equipment on seedling characteristics and 1st year field performance. Seedling characteristics typically examined include height, root collar diameter (RCD), and oven dry (O.D.) tap and lateral root weight . Undercutting research has been conducted at all three company nurseries located at Bellville, Ga., Capron, Va., and Union Springs, Ala. . Described below are the results from several studies which demonstrate the effect of undercutting timing, frequency, and seedbed density on loblolly pine seedling morphology and field planting performance .

In 1988, a factoral study consisting of all combinations of July, August, and September undercuttings was installed in two single-family loblolly seedlots at our Bellville, Ga. nursery to determine the optimum time of undercutting. The same nursery fertilization, irrigation, herbicide, and pesticide treatments were applied to both the undercut and control seedlings of each family. The July cutting was applied at a depth of 3 inches, the August cutting at a depth of 5 inches, followed by the last undercutting in September at 6 inches. Seedlings were lifted and graded in November 1988. Surviving seedbed density for both families was approximately 23/ft^2 . For each family, a subset of grade 1 (4.8-5.5mm RCD) seedlings from each treatment group were field planted on November 18, 1988. First year height and survival measurements were obtained in February 1989. When graded at the time of lifting, both families responded in similar fashion to undercutting. For all seedling variables studied, the undercutting-family interaction was not significant. Undercutting reduced seedling height (Table 1). Significant treatment effects occurred in July (P = 0.0005), August (P = 0.0001), and September (P = 0.0373). The greatest reduction in height occurred with more frequent undercutting treatments. Other treatment combinations were not significantly different. Diameter was smaller in all undercutting treatments compared to control trees but this difference was not significant. Similarly, tap root weight (O.D.) was lower in the undercut seedlings but this difference was not significantly different. Compared to control seedlings, lateral root weight (O.D.) was increased by undercutting for all treatments with the August treatment being significantly different (P =0.0019).

In 1989, a study was installed to determine the effect of seedbed density on undercutting effects. This study was installed at the Union Springs, Ala. nursery at seedbed densities of 15/ft^2 and 23/ft^2. Two undercutting treatments were applied, the first in July at a depth of 5 inches and the second in August at a depth of 6-7 inches. Undercutting reduced both seedling height and diameter compared to control seedlings. However, diameter was significantly (P = 0.0001) greater in the lower seedbed density. Tap root and lateral root weight (O.D.) were also significantly greater in the low seedbed density (P = 0.0001, P = 0.0004, respectively). Seedling height was not affected by seedbed density.

Seedling survival and growth in the field is the final and best test of undercutting success. In the 1988 study, control seedlings not undercut and seedlings undercut once in July, August, and September were field planted. All seedlings, both with and without undercutting, were grade one at the time of planting. Survival and height growth were assessed one year after planting. Time of undercutting was not significant for height and survival. Although not significant, undercut seedlings demonstrated greater height and survival one year after planting than control seedlings. Undercut seedlings averaged 54.4 cm tall with 91% survival compared to control seedlings which averaged 52.8 cm with 90% survival. Survival effects may have been more dramatic if the trees were planted on a droughty site or rainfall was insufficient.

Table 1. Seedling height (cm), root collar diameter (mm), and oven-dried tap and lateral root weight (g) for all combinations of July, August, and September undercuttings at time of lifting.

			Root Weight	
Date	Height	Diameter	Tap	Lateral
July (J)	40.2	4.8	.40	.50
Aug. (A)	39.8	4.8	.41	.51
Sep. (S)	40.9	4.8	.41	.52
J,A	39.0	4.8	.39	.54
J,S	39.1	4.8	.39	.53
A,S	38.6	4.7	.39	.56
J,A,S	38.6	4.7	.39	.56
Control	43.2	5.0	.44	.48

Perhaps more important than morphological changes are alterations in seedling physiology due to undercutting. The concentration of soluble sugars in the tap roots of undercut seedlings was found to be 43% higher than in control seedlings. Similarly, undercutting increased soluble sugar content of lateral roots by nearly 25%. Undercut loblolly pine seedlings have also demonstrated, at least temporary, osmotic adjustments that may help them better withstand drought stress compared to control seedlings.

Since drought conditions cannot be created in the field on demand, a greenhouse study was utilized to determine if undercut trees were physiologically prepared to meet drought conditions. Control and undercut seedlings were tagged and potted in sand. Seedlings were watered only when potted and again three weeks later. Three months later, 80% of the undercut seedlings were still alive compared to only 20% of the control seedlings.

Undercut and control seedlings were also placed in aerated hydroponic systems containing various amounts of polyethylene glycol (PEG) to induce moisture stress. Three PEG levels were tested, 0%, 10%, 17%, which correspond to osmotic potentials of approximately -3, -5, and -8.5 bars. PEG induced moisture stress substantially increased cell osmotic response to undercutting. Undercutting increased the tension required to remove water from cells by only 5% in 0% PEG but increased it by over 30% in PEG induced moisture stress compared to control seedlings.

UNION CAMP'S USE OF UNDERCUTTING IN LOBLOLLY PINE

Undercutting is used at all Union Camp nurseries in combination with root wrenching and lateral root pruning. The seedlings produced have root systems that have been manipulated to enhance survival and perhaps initial growth. The lack of a significant single family undercutting interaction permits one root management protocol for all loblolly pine single families. Control of seedbed density is critical for producing seedlings with the desired diameter. Undercutting will not be as effective with high seedbed densities . The results of Union Camp undercutting research are not entirely uniform. Variation exists in some studies repeated over a period of years. Although the conclusions achieved still indicate the value of undercutting, the strength of the response does vary. Apparently, the moisture stress condition of the seedlings at the time of undercutting plays a very important role in the response achieved. Research efforts are currently underway to help us better understand the relationship of water stress at the time of undercutting and seedling response. Ultimately, nursery irrigation regimes may be altered to produce the best physiologic response in undercut seedlings.

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