MOISTURE STRESS CONDITIONING OF CONTAINERIZED LOBLOLLY PINE

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Abstract.--Containerized loblolly pine seedlings were conditioned to three levels of water stress: no water stress, moderate water stress, and severe water stress. The water stress treatments resulted in the production of significantly smaller seedlings, with root growth being reduced more than shoot growth. Although initially much smaller, the severely-stressed seedlings had the best field performance, likely as a result of their improved physiological condition.

Additional keywords: Pinus taeda, water stress, field performance, physiological condition.

The survival and growth of newly planted tree seedlings depends directly on their physiological condition at the time of outplanting. However, the physiological condition of seedlings is generally not evaluated and seedling morphology used as an index for field performance. Although morphological attributes may correlate well with field performance (McGilvray and Barrett 1981), this relationship is generally due to the fact that morphologically poorer seedlings are also in poorer physiological condition. Improving seedling physiology, irrespective of morphology, is therefore likely to improve field performance. Since seedling physiology is affected by its environment, it can be modified prior to outplanting.

Containerized seedling production offers the advantage of being able to easily manipulate the seedling environment. With this advantage, numerous environmental parameters can be strictly controlled, enabling the regulation and manipulation of seedling physiology. One important environmental parameter is soil moisture availability. Tree seedlings grown in containers normally never experience water stress until outplanted. As a result, seedlings often develop severe water deficits, resulting in decreased survival and growth.

Exposure to sublethal water stress has been shown to modify numerous physiological parameters in loblolly pine (Pinus taeda L.) resulting in an improvement in drought tolerance (Seiler 1984). In a similar manner, short-term water stress, induced through root wrenching and pruning, are known to improve seedling field performance (Bacon and Bachelard 1978). With this in mind, the objective of this study was to determine if moisture stress conditioning could improve the field performance of containerized loblolly pine.

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METHODS

Loblolly pine seeds were germinated and grown in a greenhouse in Ray Leach SuperCells (160 cc) containing a 3:1 (V:V) mixture of sterilized nursery soil and peat. The nursery soil had a loamy-sand texture and was obtained at the New Kent Forestry Center (Virginia Division of Forestry, Providence Forge, Virginia). Seedlings were grown for an 18-week period under natural lighting, supplemented with fluorescent lights to maintain a 16-hour photoperiod. During the growth period seedlings were watered regularly and fertilized weekly with 20-20-20 water soluble fertilizer (Peters General Purpose, Fogelsville, PA), supplemented monthly with micronutrients (Peters Soluble Trace Element Mix, Fogelsville, PA).

After the initial growth period seedlings were subjected to one of the following moisture stress treatments:

1. No water stress; seedlings were watered to keep pre-dawn needle water potential above -0.5 MPa,[2]

2. moderate water stress (MWS); seedlings were watered only when pre-dawn needle water potential fell below -0.8 MPa,

3. severe water stress (SWS); seedlings were watered only when pre-dawn needle water potential fell below -1.4 MPa.

Needle water potential was measured on a single needle fascicle with a pressure chamber (Scholander et al. 1965). The treatment levels were monitored on a random subsample of seedlings from each treatment. Control seedlings were generally watered daily, while the MWS and SWS treatments were watered approximately every four and seven days, respectively.

After 14 weeks of the conditioning treatments, seedlings were outplanted on 16 April 1983 with planting bars at the Reynolds Homestead Research Center (Patrick County, VA). As part of a larger project (Fox 1984), the site was prepared by shearing all residual material using a KG-blade mounted on the front of a Caterpillar D7-G tractor. The area was then raked, and the residual material piled into windrows, followed by discing using a Rome, 16 disc offset harrow.

Prior to outplanting and at the end of the first growing season, height was measured on all seedlings, and shoot and root dry weight measured on a subsample of seedlings. Twenty-one seedlings per treatment were subsampled prior to outplanting and 18 subsampled after the first growing season in the field. The field design was a randomized complete block, with seedlings planted in 24-tree plots. Analysis of variance followed by Duncan's multiple range test was used to separate treatment differences.

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[2] MPa = megapascal, 1 megapascal = 10 bars.

RESULTS AND DISCUSSION

Seedling biomass was affected by moisture stress conditioning (Table 1). Root biomass was greatly reduced with the SWS seedlings having root weights 39% lower than the controls. Height growth was affected less, with both conditioning treatments averaging approximately 12.0 cm, only 16% less than the control average of 14.3 cm.

Decreased growth due to water stress is not surprising; however, shoot growth is generally decreased more by water stress than is root growth, resulting in an increase in root/shoot ratio (Kozlowski 1982, Kramer 1983, Seiler and Johnson 1984). Root growth in this study was decreased more than shoot growth, resulting in a decrease in root/shoot ratio (Table 1). This response could be the result of root tips being killed or becoming quiescent in response to the water stress and upon rewatering the roots failed to re-elongate. This conclusion is supported by the results of Kaufmann (1967) and Lesham (1970) where root tips were found to become quiescent in response to water stress.

Table 1. Container grown loblolly pine biomass before and after outplanting as affected by moisture stress conditioning.[1]

Treatment	Height	Shoot weight	Root weight	Root/shoot ratio
	(cm)	(g)	(g)	
		Prior to outplanting		
Control	14.3 A	1.60 A	0.38 A	0.244 A
Moderate stress (MWS)	12.0 B	1.24 B	0.27 B	0.222 AB
Severe stress (SWS)	11.9 B	1.07 C	0.23 B	0.218 B
		Following the first year in the field		
Control	30.2	11.9	4.2	0.372
Moderate stress (MWS)	28.8	11.9	4.1	0.363
Severe stress (SWS)	29.8	12.8	4.6	0.360

[1]Means followed by the same letter within a column do not differ significantly (alpha = 0.05); no means following the first year in the field differed significantly; n = 18.

After the first growing season in the field there were no significant differences in growth parameters due to moisture stress conditioning (Table 1).

Total height of SWS trees was only slightly less than controls, averaging 29.8 cm compared to 30.2 cm in controls. Although not statistically different, SWS trees had shoot and root weight approximately 8 and 9 percent larger, respectively, compared to controls or MWS trees.

First-year growth increment was significantly larger for SWS seedlings which averaged 17.9 cm of growth compared to 15.9 cm for control seedlings (Table 2). Shoot and root dry weight increase, although not statistically different, were also greater for SWS seedlings. Survival, although over 95% in all treatments, was roughly 2% higher in the SWS seedlings averaging 98.4%, compared to a low of 96.6% in the MWS treatment (Table 3).

These are important trends in growth and survival considering the SWS seedlings were much smaller at the time of outplanting. Small containerized seedlings generally show poor field performance both in growth and survival (McGilvray and Barrett 1981), probably as a result of poorer physiological condition often associated with smaller seedlings. However, based on numerous physiological parameters measured in other studies with conditioned loblolly pine (Seiler 1984), the SWS seedlings were in better physiological condition to survive outplanting and associated stresses. Physiological, as well as the morphological, condition of outplanted seedlings is known to be associated with their ability to survive (McGilvray and Barrett 1981). Therefore, the better growth and survival of SWS seedlings is likely due to their better physiological condition. Possibly the physiological condition of the MWS seedlings was not sufficiently improved to overcome the height advantage of controls, resulting in their relatively poor field performance.

Table 2. Container grown loblolly pine growth increment after one year in the field as affected by moisture stress conditioning.[1]

Treatment	First-year growth increment		
	Height	Shoot weight	Root weight
	(cm)	(g)	(g)
Control	15.9 A	10.0 A	3.8 A
Moderate stress (MWS)	16.9 AB	9.8 A	3.5 A
Severe stress (SWS)	17.9 B	11.4 A	4.2 A

[1]Means followed by the same letter within a column do not differ significantly (alpha = 0.05); n = 18.

Table 3. First-year field survival of containerized loblolly pine as affected by seed source.[1]

Treatment	% Survival
Control	96.8
Moderate stress (MWS)	96.6
Severe stress (SWS)	98.4

[1]No means differed significantly (alpha = 0.05); n = 18.

SUMMARY AND CONCLUSIONS

Conditioning containerized loblolly pine through sublethal water stress treatments resulted in an initial decrease in seedling size. Despite their initial smaller size, SWS seedlings showed the best first-year field performance. The results indicate the potential for moisture stress conditioning for improving field growth of containerized loblolly pine and with further field trials, moisture stress conditioning could become a practical tool for use in containerized seedling culture.

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