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Effect of Postharvest Moisture Stress on the Keeping Qualities of Douglas-fir Christmas Trees

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Abstract. **On placement of their freshly cut bases in water, cut douglas-fir Christmas trees, which had dried to −2.0 or −3.0 MPa, rehydrated to about −1.0 MPa within 24 hr, and limited needle loss occurred as their water potential gradually decreased to −6.0 MPa during display. Only 90% and 75% of the trees, dried to water potentials of −4.0 or −5.0 MPa, respectively, rehydrated when placed in water, and water potentials of these trees increased to −1.9 and −2.8 MPa, respectively. About 40% of the trees dried to −4.0 or −5.0 MPa exhibited severe needle loss, characterized by complete abscission of fresh-appearing needles from the stem within a few days of rehydration. These data indicate that douglas-fir has a threshold water potential between −3.0 and −4.0 MPa. When trees were allowed to dry to or below this threshold, tree quality was significantly reduced.**

Western Washington and Oregon produced about 6 million sheared, plantation-grown Christmas trees and 1.2 million natural-cultured Christmas trees during 1983. This represented 20% of the total U.S. production. Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] accounted for 72% of the plantation-grown trees and almost all of the natural-cultured trees harvested (5). Only 20% of the Northwest production in purchased within the Northwest, the majority of trees being shipped to markets in California and the Southwest. Harvesting begins in late October and early November and continues through early December. Trees are usually baled individually or in bundles and stored out-of-doors at shipping yards until shipment to wholesalers and retailers.

Postharvest quality (keepability) of trees is an important concern of growers, wholesalers, retailers, and consumers (2, 12). Most research on the keeping quality of trees has been concerned with freshness, which usually is taken to mean moisture content and needle retention. Fire safety is another important concern (11).

Studies of the effects of Swiss needle cast disease on the keeping quality of douglas-fir Christmas trees (3) indicated that severe needle loss occurred on trees that had dried to xylem water potentials of about −3.5 MPa prior to rehydration.

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This paper reports the results of experiments to determine the effects of postharvest moisture stress on subsequent rehydration by douglas-fir Christmas trees and their subsequent keeping quality during display.

Forty sheared, plantation-grown douglas-fir Christmas trees were harvested and transported to Puyallup, Wash. Harvested trees were about 2.5 m in height. Branches were removed from the lower 20–40 cm of the trunk. Wooden stands were nailed to the bases of the trees, which were then maintained dry (20°C, 40–60% RH, continuous light was provided by cool-white fluorescent lamps) to induce moisture stress (3). Trees were divided randomly into 4 groups and arranged as a randomized complete block designed with 10 blocks. The development of moisture stress was determined by measuring xylem water potentials at intervals with a pressure chamber (3). Trees were dried to water potentials of −2.0, −3.0, −4.0, and −5.0 MPa. On reaching the desired water potential, wooden stands were removed and about 10 cm from the base of the trunk was trimmed prior to placing in a plastic bucket containing water. The pH of the water, its electrical conductivity at 25°, and hardness measured as $CaCO_3$ were 7.6, 183 $dS \cdot m^{-1}$, and 87 $mg \cdot liter^{-1}$, respectively. Water was replenished so that the bases of the trees always remained immersed.

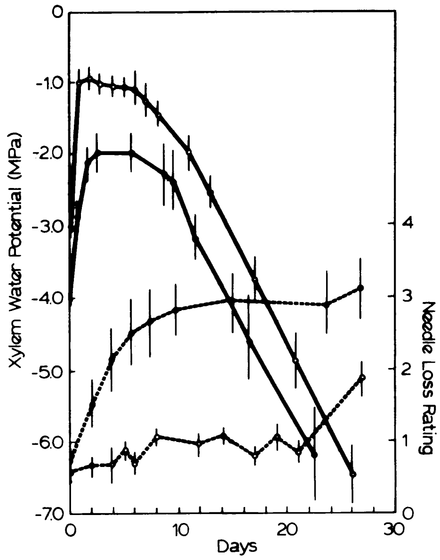

Fig. 1. Changes in xylem water potentials and needle loss after rehydrating douglas-fir trees in water and holding them in water at 20°C and 40–60% RH. Trees were dried to water potentials of −3.0 (○) and −4.0 (●) MPa prior to rehydration. Needle loss rating was 0 = no needle loss, 1 = 1–25%, 2 = 26–50%, 3 = 51–75%, and 4 = 76–100% needle loss. Data points represent the average of 20 (○) and 18 (●) trees. Solid lines represent water potentials and dashed lines represent needle loss. Vertical lines are ± SE.

The effects of initial moisture stress on tree rehydration and subsequent keeping quality were determined during a 4-week period after placing each tree in water. Changes in water potentials and needle loss were determined during the display period. Needle loss data were obtained by harvesting a single shoot of current season needles and rating needle loss on a 0–4 scale after needles on the sample were gently rubbed between 2 fingers. A rating of zero was given for samples with no needle loss, one for samples with 1–25% needle loss, 2 for samples with 26–50% needle loss, 3 for samples with 51–75% needle loss, and 4 for samples with 76–100% needle loss.

The experiment was done twice using trees harvested during November and January.

Since trees harvested in November or Jan-

Table 1. Effect of moisture stress on the rehydration of cut douglas-fir Christmas trees when placed in water and needle loss during display at 20°C.

Water potential prior to rehydration (−MPa)	Percentage of trees that rehydrated[z]	Maximum water potential[y] (−MPa)	Needle loss rating after 7 days[x]	Number of trees with severe needle loss
2.0	100	0.9 ± 0.1	0.7 ± 0.1	0/20
3.0	100	0.8 ± 0.1	0.6 ± 0.1	0/20
4.0	90	1.9 ± 0.2	2.7 ± 0.4	8/18
5.0	75	2.8 ± 0.3	2.6 ± 0.4	8/15

[z]Based on 20 trees per water potential.
[y]Means ± SE for trees which rehydrated.
[x]Means ± SE. Needle loss rating was 0 = no needle loss, 1 = 1–25%, 2 = 26–50%, 3 = 51–75%, and 4 = 76–100% needle loss.

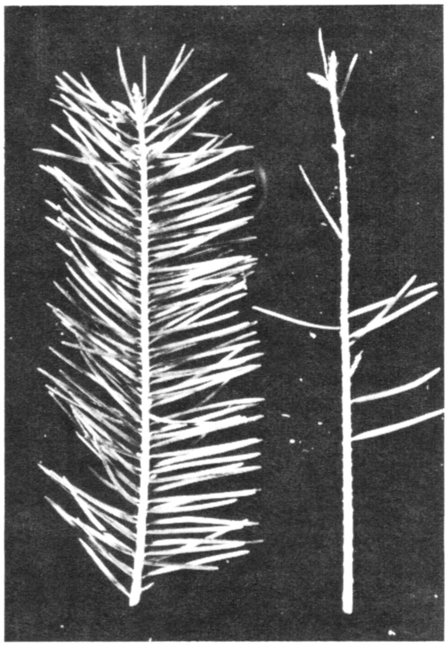

Fig. 2. Abscission of needles 6 days after rehydration of douglas-fir Christmas trees allowed to dry to predisplay water potentials of −3.0 (**left**) or −4.0 (**right**) MPa.

uary gave similar results, the data have been combined for presentation in this paper.

Water potentials of the trees displayed on wooden stands decreased to −2.0, −3.0, −4.0, and −5.0 MPa in 1, 2.3, 6.6, and 7.5 days, respectively. There were only slight changes in the appearance of trees as their water potentials decreased to −5.0 MPa. Needles became more pliable and twisted slightly at the point of attachment to the stem.

The level of predisplay moisture stress affected rehydration capacity of trees, the extent of rehydration, and needle loss during display (Table 1). All trees dried to −2.0 or −3.0 MPa rehydrated when placed in water, and water potentials increased to about −1.0 MPa within 24 hr then gradually decreased to −6.0 MPa after 26 days. Limited needle loss occurred until the water potentials of these trees decreased below −6.0 MPa. At water potentials below −6.0 MPa, needle loss was characterized by a breaking of brittle needles when samples were passed between fingers.

Although there was no apparent reduction in the keeping quality of trees dried to predisplay water potentials of −3.0 MPa, drying trees to water potentials of −4.0 MPa or lower impaired rehydration and increased needle loss during display (Table 1 and Fig. 1).

The increased rate of needle loss observed in trees dried to predisplay water potentials of −4.0 or −5.0 MPa was due to complete abscission of fresh-appearing needles from some of the trees shortly after rehydration (Fig. 2 and Table 1).

The development of moisture stress is known to affect many physiological processes within plants (1, 4, 7, 8). Stress-induced abscission of plant parts is common, and some plants shed leaves gradually as stress develops, while others (such as cotton) shed leaves upon relief of the stress (9, 10, 13). The data presented in this paper suggest that abscission of douglas-fir needles occurs upon relief of moisture stress, if trees have dried below a critical threshold water potential between −3.0 and −4.0 MPa. Although the effects observed appear to be due to the level of moisture stress that developed prior to rehydration, the importance of the additional display time on the wooden stands required to decrease water potentials from −3.0 MPa to −4.0 MPa or lower is unclear.

The identification of a critical threshold water potential for douglas-fir Christmas trees provides a method that can be used to evaluate the quality of trees during storage, after shipment, and on retail lots. Changes in needle pliability have been used with other species of Christmas trees as an indicator of freshness (6) and can be used with douglas-fir to identify trees that have dried below −3.0 MPa (unpublished data). Although this study indicates that water potential measurements can be used to predict the quality of trees, they were not effective in identifying which of the trees that had been dried to −4.0 or −5.0 MPa would not rehydrate when placed in water or which of the trees would exhibit severe needle loss on rehydration.

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