Christmas Trees

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Introduction

Approximately 33 million natural Christmas trees were used in the U.S. in 1998. Given a conservative wholesale value of $10.00 per tree, the value of the trees alone approaches $330 million. When associated products are added to the picture, total value is well above $500 million. The National Christmas Tree Association estimated the average retail price for Christmas trees in 1998 at $3.45 to $6.30 per ft. Based on a standard 6- to 7-ft tall (2 m) tree, the retail value of natural Christmas trees approaches $1.5 billion.

About 25% of the live Christmas trees consumed in the U.S. are sold on choose-and-cut farms. This means that 75% of the trees experience some form of storage and shipment after harvest. Storage and shipment times can be several weeks for trees shipped between countries or less than one day for trees sold in local markets.

Natural Christmas trees quickly lose quality if handled improperly. People who grow, sell, handle or use Christmas trees should know something about tree keepability. This is true of the consumer who may use only one tree each year, as well as brokers or growers who handle thousands of trees.

Many publications have been written concerning postharvest physiology, handling, and keepability of Christmas trees. Despite this, there is often ignorance of the subject, resulting in wasted trees, reduced tree quality, erroneous information, or dissatisfied consumers. In this chapter, we provide a summary of information concerning Christmas tree keepability.

Moisture Status of Cut Trees

A Christmas tree is a perishable product that contains a finite amount of water when cut. Postharvest quality and fire safety are closely tied to moisture status. When a tree is cut, it begins to dry. Rate of drying is affected by species as well as environmental conditions (vapor pressure deficit, temperature, wind) and cold hardiness.

The two most common methods for determining moisture status are twig moisture content (MC) and water potential (ψ). The second method uses a pressurized chamber to extrude water from the cut end of a twig encased in a heavy-walled metal chamber. The drier the twig, the greater the pressure required to force water out of the end of the twig. Freshly harvested trees normally have ψ = -0.2 to -0.8 MPa. (1 MPa = 10 atmospheres or about 10 bars.)

The temporal change in moisture content has several inflection points. Initially, the tree dries quickly to an inflection point, V_1, which varies considerably by species. For example, V_1 is about

-1.8 MPa (-18 bar) in eastern red cedar, -2.2 MPa (-22 bar) in eastern white pine, and -2.8 MPa (-28 bar) in Fraser fir. At that point, the rate of drying slows noticeably, presumably because stomata close to reduce water loss under increasing stress. Eventually, another value is reached, V_2, at which the drying rate accelerates again, presumably when increasing drying stress exceeds the capacity of guard cells to limit water loss. V_2 probably corresponds to the "damage threshold," a term first used by Montano and Proebsting (1986). Further drying results in irreversible damage (needle abscission, discoloration, failure to rehydrate when placed in water) to the tree. The damage threshold for Douglas-fir and Fraser fir is between -3.5 and -4.0 MPa (-35 to -40 bar), compared to -3.0 to -3.2 MPa (-30 to -32 bar) for eastern white pine. Spruces typically experience very heavy needle loss when they dry to a certain MC, making it important to handle these species in a way that minimizes moisture loss after harvest and to display them in water before they reach that threshold.

The values of V_1 and V_2 vary by species. In addition, a pressure potential of -3.0 MPa (-30 bar) does not correspond to the same value of MC in various species. The time required to reach a particular MC also varies by species. For example, eastern red cedar and Atlantic white cedar dry very fast when displayed under room conditions, whereas Fraser fir and noble fir dry much slower. The latter species are regarded as long-lasting trees, whereas the former have a short shelf-life.

The moisture status of the tree determines its ability to rehydrate when recut and displayed in water. Fresh-cut trees typically have an MC in excess of 100%. When a fresh tree is recut and displayed in water, it typically gains weight, reaching a MC 5 to 10% above the initial value.

Trees without water gradually lose moisture and can readily rehydrate at moisture levels approaching V_2. Beyond that, the degree of rehydration may decrease; or if rehydration occurs, there may be adverse changes in quality (needle abscission, discoloration). For example, eastern red cedar rehydrates when V_2 = -4.5 to -5.0 MPa (-45 to -50 bar), but not without subsequent abscission of foliage.

The moisture status during display also varies among species. Species that endure for a long time during the display period, such as noble fir and Fraser fir, tend to maintain MC and ψ close to the initial value for at least 4 weeks. Species that have a short shelf-life, such as eastern red cedar and Atlantic white cedar, maintain a high water level for about 1 wk and then begin to slowly dry even while displayed in water. This process is reflected by a decrease in ψ (more negative), a decrease in twig MC, and a reduction in water consumption.

Water Use

When supplied with water, cut Christmas trees generally consume about 1 qt (about 1 L) of water per day per inch (2.54 cm) of stem diameter. Thus, a tree with a 4-in diameter trunk would use about 4 qt (about 4 L) of water per day. The biggest mistake by consumers is using a stand with too little capacity, resulting in trees drying up between waterings. If this happens, the tree might not rehydrate when rewatered.

Water use changes during the display period and also varies among species. Compared to other species, true firs tend to use large quantities of water over extended display periods. For example, a 6-ft (about 2 m) Fraser fir can easily use 4 qt of water per day during the first 5 to 7 days and 2 to 3 qt (about 2 to 3 L) per day thereafter for the next 3 to 4 weeks. In contrast, water use by an eastern red cedar might decrease noticeably after a week. In general, if the tree continues to use a relatively constant amount of water, it indicates that the tree is maintaining its initial water status. On the other hand, if there is a marked reduction in water consumption, it probably indicates that the tree is beginning to dry.

Additives

Many chemicals and home concoctions have been tested in hopes of prolonging the life of cut Christmas trees. Additives are of little benefit and sometimes produce adverse effects. Additives can undesirably increase water consumption by displayed trees. Because people often use stands that are too small, increased water consumption would increase the likelihood of a tree "going dry" in the stand. Some additives can induce heavy needle loss. The best tree preservative is plain water, without additives.

Cold Hardiness

Cold-hardened Christmas trees keep better after harvest and better withstand exposure to low temperatures. Induction of cold hardiness requires photosynthesis, reduced temperatures, and shorter days. In this context, it will not occur in darkness, as in a refrigerator. When trees are harvested too early, heavy needle loss is possible, even with proper care. It is not known why cold-hardened trees keep better than nonhardened trees. Foliar raffinose increases during fall, although the absolute amount is small compared to sucrose. The increase in raffinose is mostly a response to lower temperatures. The role of raffinose is not clear, although in other plants it can reduce the ice crystallization temperature in cell sap. Nonhardened trees also transpire more and thus dry faster than hardened trees.

Tree species and seed sources also differ in their ability to tolerate exposure to cold temperatures. Coastal types of Douglas-fir are genetically not as cold-hardy as intermountain types. If coastal types of Douglas-fir are shipped into cold-weather market areas and not protected from exposure to cold temperatures, they can exhibit severe needle loss due to cold injury. The level of damage depends on the level of cold hardiness of the trees, the rate of temperature drop, and the lowest temperatures the trees are exposed to. People should be aware that tree species, the environmental conditions prior to harvest, and the environmental conditions that trees are exposed to during transit and on retail lots can have a bearing on postharvest quality.

Diseases and Pests

Christmas trees can be damaged by a variety of diseases and pests. Although trees and branches can be killed, most of the damage results in cosmetic needle discoloration or loss of needles prior to harvest. Little information is available concerning the direst impact of various diseases and pests on the postharvest keepability of trees. Swiss needle cast on Douglas-fir Christmas trees can accelerate moisture loss and needle loss when trees are displayed indoors.

Quarantine Issues

Live Christmas trees sometimes harbor plant pathogens, insects, and other arthropods. Most are only an annoyance; but some, if exported to places that have no natural enemies, could potentially cause serious problems. States and countries impose various quarantines in an effort to prevent the introduction or further spread of potentially harmful pests. For example, trees grown in areas infested with the gypsy moth, European pine shoot moth, or pine shoot beetle are frequently prevented from being shipped out of these areas unless they have been certified to be free of these pests. Many quarantine problems can be avoided by appropriate scouting, trapping, management practices, and certification programs. Mechanical shakers can be used to remove old dead needles and certain types of insects. The failure to meet quarantine requirements can result in entire shipments being rejected, causing great loss and inconvenience to producers and importers.

Fumigation. In some instances trees are required to be treated prior to entry, especially in some foreign countries. Fumigation is a common method used to meet quarantine requirements for a number of horticultural products. Although methyl bromide is one of the most common materials used to fumigate horticultural products, information on the tolerance of various types of Christmas trees to methyl bromide is limited. Chastagner (1990) fumigated several species typically grown in the Pacific Northwest with methyl bromide at rates up to 6 lb per 1,000 ft^3 for 2 h at 10 °C (50 °F). Douglas-fir and noble fir were not damaged, Fraser fir and grand fir experienced only slight damage, Scotch pine showed moderate damage, and Shasta fir was severely damaged. Use of methyl bromide will likely diminish in the future, and alternatives are needed. Increasing development of international markets will increase the demand for procedures to ensure that exported trees are pest-free.

Irradiation. Gamma radiation can be used to sterilize or kill insects in all stages of the life cycle, including larvae and pupae within the wood. Little information is available for Christmas trees, but balsam fir is sensitive to chronic, low-level doses of gamma radiation. The cumulative lethal dose (LD_{50}) is about 0.1 kGy over a period of years. Dormant branches of Fraser fir, when subjected to single doses of gamma radiation, experienced significant needle loss at 0.10 kGy. Massive needle loss occurred within 2 days for branches that receive higher doses of radiation. In addition, there was great intertree variation; for example, for the 0.1 kGy treatment, needle loss ranged from 5 to 100% for branches displayed for 2 weeks in water (average 42%). Irradiation discolored foliage and accelerated drying.

If Fraser fir is representative of other Christmas tree species, irradiation does not appear to be a viable way to meet insect quarantine requirements. Sterilizing insect pests would probably require irradiation doses of 0.5 to 1.0 kGy, and levels needed to outright kill insects would be higher. These levels of radiation would result in virtually complete defoliation of Fraser fir within a few days after exposure.

Controlled Atmosphere (CA) and Modified Atmosphere (MA) Storage

Information is limited, but short-term CA or MA storage at low temperature (5 °C, 41 °F) appears to be of little benefit with Fraser fir. CO_2 >5%, as well as O_2 <3%, can lead to increased needle loss. The respiration rate at 21 °C (70 °F) is about four times that at 5 °C (41 °F).

Fire Safety

Fresh Christmas trees, if properly watered and maintained, are not a fire hazard and are very difficult to ignite with a point source of flame. But problems can arise when trees become too dry. Several factors are important in assessment of fire risk, including ignition time, peak heat release rate (PHRR), total heat released, peak smoke release rate, and total smoke released**.** Dry trees produce extremely high PHRR in short periods. A PHRR of 500 kW is enough to cause flashover. Although limited PHRR data is limited, very dry Douglas-fir can produce PHRR up to 3,000 kW within 1 min of exposure to an open flame.

Recent experiments (Chastagner 2002, unpublished) tested 21 conifer species to determine the MC at which branches initially begin to fail an ignition test and the MC for consistent failure. Branches were exposed to a flame from a small alcohol lamp for 5 sec. If the sample failed to burn or self-extinguished without any additional spread when removed from the flame, it passed the test. If there was any spread of the flame after the sample was removed from the flame, it failed the test. There is considerable interspecific variation in the MC for ignition. In addition, there is often a large transition zone of MC from the point of initially failing the flammability test to the point of flash ignition. For example, Douglas-fir begins to fail the flammability test at about 68% MC, but is totally consumed only when dried to about 30% MC.

There is a close relationship between twig MC and water potential (ψ), which also varies among species. With noble fir, twig MC must reach about 37% before it begins to fail the flammability test. This corresponds to a pressure potential below -6 MPa (-60 bars), well beyond its damage threshold. Based on this and other postharvest display data, one can estimate how long it would take for trees to dry to moisture levels at which they would fail the test. With proper care, winter-hardened noble fir and Fraser fir can easily be displayed in water for 6 to 8 wk without becoming a fire hazard.

The use of flame retardants on trees is not recommended unless required by law. Flame retardants can damage needles and increase moisture loss from trees. The best way to minimize any potential fire hazard associated with cut Christmas trees is to display them in water-holding stands.

Colorants, Stickers, and Antitranspirants

Many conifers naturally fade to a yellow-green color in fall. Colorants, similar to latex paint, mask this effect if applied prior to the change, increasing consumer acceptability. Needle stickers, which dry to a clear, shiny film on the surface of foliage, supposedly cause better needle retention, but this has not been confirmed by research.

Antitranspirants form a thin film on the surface of foliage. Although it would seem that such products should greatly reduce the drying process, this is usually not the case. Under moderate to strong drying conditions, they do little to retard drying unless applied at levels sufficiently high to render trees qualitatively less acceptable to consumers by making them sticky. However, minor differences sometimes occur. For example, drying of eastern red cedar was slowed by latex colorant, but the overall drying rate of trees was so fast that the difference was of little practical significance.

Species Comparisons

Some Christmas tree species maintain postharvest quality better than others. Based on various experiments and observations by the authors, a rating of the postharvest quality of 30 species of Christmas trees is given in table 1. Ratings in this table should be used as a guide, given that the postharvest quality of cut Chrismas trees can be affected by preharvest and postharvest environmental factors and can vary between different seed sources within a species.

The postharvest period has two phases: the period between cutting and placement back in water and the period after placement in water. Some trees endure well in both phases, such as noble fir and Fraser fir. Others do poorly when displayed dry but endure well in water, such as white spruce and grand fir. Some species have a short shelf-life whether displayed wet or dry, such as eastern red cedar, and are not suited for wholesale marketing or long-term display in the home. Many of the true firs have excellent quality when displayed in water but tend to shed needles when displayed dry, such as Nordmann fir.

Tree Handling Recommendation for Growers and Retailers

Cut Christmas trees can deteriorate under the effects of heat, wind, sunlight, and extreme changes in temperature. Thus, reducing exposure to these elements should be the goal of every grower and retailer. Below is a series of recommendations that should ensure consumers get the freshest tree possible:

- In warm climates, harvest trees as late in the season as possible to allow for cold hardening, which will improve keepability after harvest.
- Bale trees soon after cutting, especially if the weather is sunny and warm. Drying can be very rapid in the first 24 h.
- Temporarily store trees in areas that are shaded and cool. Trees can be stored either vertically (standing on the end of the trunk) or horizontally (piles or pallets). It is not clear if one method is better than the other; however, under some conditions horizontal stacking can lead to increased mold problems and damage to foliage and branches. Limiting the height of storage piles and thus reducing the compaction of trees helps minimize these problems.
- Avoid baling wet trees under warm temperatures because doing so can lead to premature needle loss.
- Ship or sell trees on a “first in, first out” basis.
- Avoid piling baled trees on hot parking lots or against south-facing brick or concrete walls.
- The best storage condition is low temperature of 33 °F to 50 °F (1 °C to 10 °C), high RH of 85 to 95%, and darkness.
- Use refrigerated trucks, if possible, especially on hauls exceeding 400 miles or when

moving trees into warm regions. For long-distance shipment and storage in refrigerated trucks and containers, trees should be loaded and baffled to allow for air circulation on top, bottom and sides and refrigeration systems should be run on wet cycles so they do not dehydrate the trees.

- Never allow closed vans or flatbeds to sit idle in the sun for extended periods because it quickly leads to overheating.
- In warm marketing areas, trees should be displayed under shade, protected from the wind, and standing in water.
- On retail lots, store trees upright or in shallow piles in a shady, cool place out of high traffic areas. If permanent shade is unavailable, use a tarp or shade cloth suspended above the trees and down the sides with at least a 2-ft (61 cm) air-space for ventilation.
- Minimize or eliminate walking on baled trees because it breaks limbs and leaders and crushes foliage. Be especially careful handling frozen trees: They are very brittle.
- Trees on display in retail lots in warm market areas can be misted or sprayed with water at night to reduce the moisture lost during daylight hours. Misting trees on the surface of storage piles may also be beneficial, but soaking trees can result in severe mold and deterioration problems.
- Trees hauled long distances on open trucks should be smoke-tarped on the front and covered with shade cloth on the top and sides to prevent windburn and damage from diesel smoke.
- Avoid temperatures above 10 °C (50 °F) in closed storage.
- In cold-weather market areas, protect trees from drying winds. Do not attempt to sell trees such as coastal Douglas-fir in these types of markets unless they can be protected

from exposure to potentially damaging temperatures.

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Table 1. Postharvest quality ratings for Christmas trees, displayed dry or in water

[Trees are assumed to be cold-hardened.]

		Rating	
Species	**Scientific name**	**Displayed—**	
		Dry[†]	**Wet**
Arizona corkbark fir	*Abies lasciocarpa* (Hook.) Nutt. ssp. *arizonica* (Merriam) E. Murray	F	E
Arizona cypress	*Cupressus arizonica* Green var. *glabra* (Sudw.) Little 'Carolina sapphire'	P/F	F/G
Atlantic white cedar	*Chamaecyparis thyoides* (L.) BSP.	P	P/F
Balsam fir	*Abies balsamea* L.	F	G/E
California red fir	*Abies magnifica* A. Murray	G	E
Canaan fir	*Abies balsamea* (L.) Mill. var. *phanerolepis* Fern.	F	G/E
Colorado blue spruce	*Picea pungens* Engelm.	F	G/E
Concolor fir	*Abies concolor* (Gordon & Glend.) Lindl. ex Hildebr.	P/G*	P/E*
Douglas-fir (coastal)	*Pseudotsuga menziesii* ssp. *glauca* (Beissn.) E. Murray	P/F	G
Douglas-fir (intermountain)	*Pseudotsuga menziesii* (Mirb.) Franco ssp. *menziesii*	F/G*	G/E
Eastern red cedar	*Juniperus virginiana* L.	P	F
Eastern white pine	*Pinus strobus* L.	G	G/E
European silver fir	*Abies alba* Mill.	P	G/E
Fraser fir	*Abies fraseri* (Pursh) Poir.	G	E
Grand fir	*Abies grandis* (Douglas ex D. Don) Lindl.	P	G/E
Greek fir	*Abies cephalonica* Loud.	P	G/E
Korean fir	*Abies koreana* Wils.	G	G/E
Leyland cypress	× *Cupressocyparis leylandii* (Dallim. & A. B. Jackson) Dallim.	F	G/E
Monterey pine	*Pinus radiata*	F	G
Noble fir	*Abies procera* Rehd.	G	E
Nordmann fir	*Abies nordmanniana* (Steven) Spach.	P/G*	E
Norway spruce	*Picea abies* (L.) Karst.	P	G
Pacific silver fir	*Abies amabilis* Douglas ex Forbes	F	G/E
Scotch pine	*Pinus sylvestris* L.	F/G	G
Shasta fir	*Abies magnifica* A. Murray var. *shastensis* Lemmon	P/F	F/G

Turkish fir	*Abies nordmanniana* ssp. *equitrojani* (Asch. & Sint. Ex Boiss.) Coode & Cullen (syn. *Abies x bornmuelleriana* Mattf.)	P/G*	E
Veitch fir	*Abies veitchii* Lindl.	G	E
Virginia pine	*Pinus virginiana* Mill.	F	F
Western white pine	*Pinus monticola* Douglas ex D. Don	G	G/E
White spruce	*Picea glauca* (Moench) Voss	P	G

Scientific names from Griffiths (1994).

Ratings: Excellent (E), has potential to last 4 to 6 wk under typical household conditions. Good (G) can last 3 to 4 wk. Fair (F) can last 10 d to 3 wk. Poor (P) lasts only 7 to 10 d.

* Results vary greatly among seed sources.

† It is never a good practice to display Christmas trees dry.

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