Fall Nutrients Status & Needle Loss

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Usually, you can't shake needles off of a dormant Fraser fir Christmas tree whether it is standing in the field or recently cut. Time and again, people have overheated, frozen, or dried the tree in full sun and the needles still held tight. The tree's ability to hold up in retail lots from Chicago to South Florida and beyond reflects the often harsh and unpredictable conditions of its native Southern Appalachian mountain range.

The Problem:

When a North Carolina-grown Fraser fir tree does lose needles, it is unusual and a point of concern for the grower. In certain years, some Fraser fir Christmas trees shed more than the normal amount of needles in late September or early October. Losing older needles that have been on the tree for 5 to 7 years is normal. However, trees in some problem fields lose current year needles at this time. Trees in other fields may lose multiple years of needles all at once. The top, middle, or entire tree may be affected. Some trees that were tagged in summer can become unsalable.

Needle loss problems seldom show up before trees are of a marketable age and size. Trees greatly increase the amount of foliage with each progressive year. This creates an increasing demand for water and nutrients. Factors which may have been adequate or marginal for a smaller tree become limiting as the tree grows. The failure of symptoms to be expressed in younger trees has often lulled growers into complacency only to be surprised by needle loss in trees already tagged for market.

Growers easily identify needle loss as it occurs in the field, but the same factors that caused needle loss in trees in the field can contribute to needle loss after harvest when the trees are out of a grower's hands. A problem that only showed up in a few standing trees could involve more cut trees. As trees are stressed during shipping and display, some problems that were marginal in the field can be aggravated to the point where needle loss occurs.

Physiology of Needle Loss

Needle loss occurs when a series of chemical reactions result in a weakening of plant tissue along an abscission or separation zone at the base of the leaf. As cells in the abscission zone break down, the needle can shake or fall off. The balance of three plant hormones as influenced by light, temperature, moisture content, and other environmental factors is thought to control the formation of the abscission zone.

Abscisic acid (ABA) has been correlated with leaf fall in many plant species. ABA stimulates the production of ethylene in the plant, high levels of which are associated with the deterioration of leaf abscission cells. Increased ABA production has been associated with high salts in plant tissue and excessively dry or wet growing conditions.

Ethylene production is counter-balanced and limited by auxin production in buds and plant growing points. High auxin levels minimize the influence that ethylene levels have on the progression of leaf abscission. As auxin production drops in the fall with the advent of lower temperatures and shorter days, ethylene concentrations increase proportionally. If the normal fall shift in the auxin / ethylene balance is aggravated by those factors that favor ABA production such as excessive salinity or drought, then excessive needle loss can be expected.

Dormancy is a separate physiological process that becomes critical in needle retention of harvested Christmas trees later in the season. Dormancy of Fraser firs and other Christmas trees only occurs with the seasonal accumulation of cold temperatures uninterrupted by extended warm spells. During a mild autumn, many woody plants fail to undergo the physiological changes that induce dormancy. Without full dormancy, foliage respires more quickly and trees are under greater moisture stress. Judging by the history of poor needle retention in trees harvested too early in the fall, the stress of rapid foliage respiration in non-dormant cut trees may induce the hormonal shifts that lead to needle loss the same as drought stress in the field.

Contributing Factors:

The factors that contribute to changes in the hormonal balances related to premature needle loss vary from field to field and season to season. Climate, soil type, plant nutrition, and individual tree genetics all can influence a tree's ability to hold needles. However, once trees are planted, the only factor that growers can readily alter is plant nutrition. Climate and soil are most important from the management standpoint in the ways that they effect root function and nutrient status. It still comes down to what nutrients are high or low on the soil and tissue reports.

Over the years, a number of different nutrient problems have been linked to needle loss in Fraser fir. Only careful soil and tissue sampling and some knowledge of field history can determine which fertility problem underlies needle loss. Consider the following nutrient problems in relation to your own fertility management situation:

Salt Injury: Excessive fertilization can induce trees to shed needles at any time of year when high salt concentrations develop in

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plant tissues. Symptoms of salt injury have developed soon after fertilizer application or even months later during a fall drought when plants underwent moisture stress and the subsequent salt concentration in tissue. High salts can develop after excessively high per acre applications or when a proper amount of fertilizer is improperly applied over too small an area near each tree. Salt injury is most likely when fertilizers with higher salt indexes are used such as murate of potash (0-0-60), ammonium nitrate (33-0-0) or calcium nitrate (15-0-0).

Symptoms of salt injury in the field can include wilting of new growth, freckling of needles with narrow brown bands, needle loss of current season needles or of all needles in parts of the tree, branch tip dieback, to total death of the tree. Inner bark and the surface of the wood is often discolored to a gray-brown color or even a sticky black tar. This discoloration has been observed in roots, trunk, and branches. Sometimes these symptoms occur in a spiral of branches linked to the roots subjected to the excessive salt load. In cut trees, high salts are most likely to induce a general shedding of needles as salts become concentrated in the tissue.

Needle loss induced by high soluble salts.

Calcium and Manganese: Severe calcium deficiency has long been associated with fall needle loss in Fraser fir. In fields of mature trees with low pH and low calcium levels, a few trees often shed needles in the middle or top of the tree in late summer or early fall. Sometimes, only current season needles drop, but in more severe deficiencies, all the needles drop from effected branches. While calcium deficiency generally only effects a small percentage of trees in the field, the concern is that more trees may be at risk of losing needles after they are cut. In a study that followed tissue calcium levels from growth to harvest and display, Jim Shelton and Eric Hinesley observed a pattern of needle loss in more cut trees with less severe calcium deficiencies (Table 1). Some trees that had marginal calcium on the stump shed needles only after they were harvested. Calcium deficiency has always been a difficult problem to address because tree response has varied greatly.

In fact, a number of trees in the post harvest quality study that had adequate tissue calcium levels also shed needles. The pattern of needle loss made more sense in further analysis when calcium levels were paired with manganese levels. When a ratio of the two nutrients was calculated, an inverse relationship was suggested. The greatest needle loss in cut trees tended to occur when calcium was low and manganese was high. Trees that had adequate calcium levels also tended to shed more needles if manganese was excessive. The least needle loss occurred when calcium levels were normal to high and manganese levels were normal to

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Table 1

Calcium Deficiency and Needle loss		
Calcium Tissue Level	Field Symptoms	Cut Tree Symptoms
0.60	None	None
0.50	None	None
0.40	Localized Color Problems	Needle loss
0.30 and below	Needle loss	Needle loss

Fall needle loss resulting from calcium deficiency.

moderately low. Thus, high (toxic) levels of manganese may be as much a concern with needle loss as calcium deficiency.

While not a needle loss condition, trees grown under the high calcium, low manganese end of the spectrum just discussed often exhibit their own set of symptoms. Field experience and foundational research by Dr. Shelton and others have linked "lime pile" symptoms of stunted yellow growth in the middle of the tree to manganese deficiency created by excess calcium in the soil. The importance of monitoring and adjusting calcium and manganese to optimum levels before trees approach market size can not be overemphasized.

Other Nutrient Problems: While salt injury and calcium / manganese relationships have been key suspects in fall needle loss, other nutrient problems have also been diagnosed by soil and tissue sampling fields with needle loss. Phosphorus is often marginal or deficient in problem fields (as well as many fields with no needle loss). Excessive potash levels have frequently been identified in fields where a grower relied too heavily on balanced fertilizer blends. Levels of sulfur have been found that induced severe needle loss in a greenhouse study of Dr. Shelton's, but are not always associated with tree problems in the field. In scattered fields in some years, high levels of copper were linked to a marginal tip burn that resulted in some current year needle loss. The occurrence of needle loss in association with these other nutrient deficiencies and toxicities may not be prevalent enough to point to a consistent trend, but it does raise needle loss concerns when any nutrient strays too far from optimum soil and tissue levels.

Avoid needle loss with preventive soil amendments based on regular soil and tissue analysis.

Often multiple nutrients are out of balance when soil and tissue samples have been analyzed to diagnose needle loss problems. Multiple nutrient deficiencies may indicate nutrient uptake problems involving diminished root function. A root rot disease or a root feeding insect could have compromised the root system. All too often, drought or excessively wet weather has created soil conditions that limit root function or tie up specific nutrients. Excessive salts could have damaged feeder roots as well as foliage. Where roots are damaged, the stresses that shift plant hormonal levels toward leaf abscission and needle loss will be aggravated. While many sources of root function and tree stress are beyond a farmer's control, those activities which can be controlled should be.

Preventive Strategies:

Once a field is set in trees, many of the environmental stresses that can contribute to needle loss such as rainfall, site aspect, or soil texture are locked in. With drought or excess moisture both potentially contributing to the process of needle loss, middle ground can be hard to find and even the best sites could experience bad weather prior to harvest. Yet, much is still in the hands of an effective farm manager. The following are key points to minimizing some of the stresses that underlie leaf abscission and needle loss:

- Soil & Tissue Sampling: Don't go into harvest season blind. Take samples in fields of marketable trees the year before sale. Particularly watch for low calcium or excessive manganese and potash. Most problems can be corrected in a growing season, but few can be changed in a month or two.
- Indicator Trees: Pay attention to small areas or scattered individual trees that exhibit color or needle loss problems. They could represent a problem that will expand or possibly effect a larger number of cut trees. Monitor problem areas by taking samples from representative "good" and "bad" trees.
- Lower the Salt Load: Consider the salt index of fertilizer materials that you choose to apply and select less salty alternatives. Consider split applications that divide salt loads into separate time frames. Supervise fertilizer application to minimize piling, plopping, or dumping. Broadcast applications minimize salt concentrations as compared to banding. Consider calibrating by weight the amount of fertilizer that either machinery or workers apply.
- Change Your Plans: In a drought, change your plans. If you are already experiencing a dry autumn or regularly undergo a dry spell prior to harvest adjust your management accordingly. Pay extra attention to salt loading. Applying nothing could be better than adding more salt.
- Prevention: Work on problems before the symptoms are expressed. By working with soil and tissue analysis, fertility management can be optimized before trees express most problems. Do as much during site preparation as possible. Fine-tune soil fertility well before harvest.