THE PHYSIOLOGY OF TREE GROWTH REGULATORS[1]

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Abstract. Chemical regulation of tree growth has been evaluated for over a decade. There is increased confidence today in the use of chemical growth regulators due to the development of chemicals that regulate growth by inhibiting biosynthesis of gibberellins and to an improved understanding of application technology. These products are effective growth regulators when applied by either trunk injections or soil applications; bark banding treatments are presently under development.

Résumé. Le contrôle chimique de la croissance des arbres a été évalué pour les dix dernières années. Aujourd'hui, il y a une augmentation de la confiance dans l'utilisation des inhibiteurs de croissance, dû à l'amélioration des produits chimiques qui régularisent la croissance en inhibant la biosynthèse de gibberelline et à une plus grande compréhension des techniques d'utilisation. Ces produits sont d'efficaces inhibiteurs de croissance quand ils sont appliqués soit par injection dans le tronc ou appliqués sur le sol; le traitement par badigeonnage d'une bande d'écorce est présentement en développement.

Chemical regulation of tree growth has been evaluated as an alternative to mechanical trimming for over a decade. Two biological processes can be regulated by chemical applications to effectively control the rate trees grow: cell division and cell elongation. Recent research and development efforts have been focused on chemicals that inhibit cell elongation since they are highly effective growth regulators, producing more consistent responses and less toxic effects on trees. The physiology of growth regulation by these products is reviewed in this article.

Paclobutrazol (Clipper® 20 ul), uniconazol-P (Prunit®), and flurprimidol (Cutless® TP) are among the compounds that effectively regulate tree growth by reducing cell expansion. In plants treated with these compounds cells in leaves and shoots continue to divide, but do not fully expand or elongate as they differentiate. The reason that cell elongation does not occur is because these compounds disrupt the biosynthesis of gibberellins. Gibberellins regulate plant cell expansion, among other things, and the less gibberellin present the less cell expansion will occur. Growth reduction is proportional to the dosage of these compounds; treatment effects diminish after several years followed by the resumption of normal growth.

In general, all three compounds have similar properties when applied to trees and produce similar growth regulation effects. They move upward in the xylem but have little movement downward or in the phloem. The principal visual signs of growth regulation include shortened internodes on stems, smaller leaves that often have a darker green color and, in some species, enhanced flowering or increased epicormic bud development. Products that inhibit gibberellin production are active on many hardwood species, but to date have shown little or no activity on conifers when trunk injected.

Treatments using trunk injection, soil applications, bark banding and foliar sprays have been tested. To date, trunk injection and soil applications have produced comparable results. Bark banding has been effective on young trees or shoots with green bark but has not been efficacious on older trees with thick bark. Foliar applications are effective but are impractical for large trees or for sites where other desirable vegetation is present. Paclobutrazol and flurprimidol are now registered for trunk injection applications. Uniconazol-P has received an Experimental Use Permit.

Trunk injections are applied by drilling holes into the sapwood of the xylem and injecting the product directly into the tree trunk. The number of holes, hole depth and angle of entry into the trunk, and position of holes around the trunk determine the subsequent distribution of compound in the tree, thus affecting the uniformity of growth regulation. Tree species with a spiral or interlocking wood grain have a broader distribution of injected material across the sapwood than straight grained species.

During the trunk injection process the product initially forms a vertical column in the xylem. The greater the volume of product injected per hole, the broader the distribution of active ingredient in

1. Presented at the annual conference of the International Society of Arboriculture in St. Charles, Illinois in August 1989.

the sapwood. The low solubility active ingredients precipitate out in the xylem cells almost immediately following injection as the alcohol carrier is diluted into the water in the xylem. Since these products have low water solubilities (8 - 135 ppm), the active ingredient very slowly resolubilizes back into the water in the xylem and is carried upward into the tree crown. This process may continue over several years.

Injection probes must be completely sealed into the sapwood or there will be movement of product into the cambium. The alcohol carrier in the product will kill the cambial cells that it contacts. The resulting pattern of injury from a poor seal of an injection probe into the sapwood is a vertical streak of dead cambium above and below the injection hole with some lateral damage immediately around the hole. As the tree trunk continues to grow, the bark immediately outside of the dead cambium separates and exposes a vertical streak of xylem. Bark splits may heal over within a year in vigorously growing trees or may require several years on slower growing trees.

The potential for bark splits is greatly reduced by drilling a round hole of the recommended diameter. Holes drilled on a narrow angle place the injected product closer to the cambium, thus increasing the potential for lateral diffusion of the alcohol carrier into the cambium. Holes should be drilled at angles of 45 degrees or greater to reduce this potential. Furthermore, use of injector pressures below 100 psi will reduce the potential for lateral movement of product.

Fluid movement in the xylem almost totally ceases during periods of severe drought, after defoliation from insects or disease, or during dormant periods when leaves are absent. Cambium injury may occur following trunk injections during these periods because the alcohol carrier is not rapidly diluted by water moving in the xylem, thereby giving the alcohol time to move into the cambium. The potential for cambial injury may be reduced by avoiding injections when there are no leaves, when leaves are wilted or, in the northern states, during winter dormancy.

Bleeding of fluids from drill holes may also occur following trunk injections. Alcohol carriers leave a dry white residue or light colored area of bark if product bleeds back out of the drill hole following injection. Tree sap that bleeds from holes results in an area of darkened bark. Species differ in the amount of bleeding that occurs and trees within a species vary in response. Moreover, bleeding may occur seasonally or continually from some holes and not at all from others. Visual impact of bleeding is minimized by drilling injection holes as low on the tree trunk as possible.

There isn't a clear understanding of how compartment formation in the xylem following trunk injections affects trees. Doctors William Chaney and Harvey Holt of Purdue University are conducting studies under a Grant-in-Aid from Monsanto Company to determine the effects of trunk injections on tree function and integrity.

Various tree species require different treatment rates to accomplish comparable growth reduction. Within species, smaller trees require lower dosages for comparable regulation because they have less wood volume. Also, treatment rate may be reduced according to the amount of crown removed in the trimming process.

The earliest growth regulation effects may be observed within several months to a year. Full effects are normally observed the second season after injection. Hence, treatment timing and degree of trim are important factors to correlate. If treatment and trim occur at about the same time, the trim may need to be greater to ensure that adequate line clearance is maintained until regulation takes effect. If treatment occurs several months prior to trimming the amount of regrowth prior to regulation will be less, hence less trimming is required.

Soil applications involve placement of product in the soil around the trunk of the tree. Subsurface injections, surface drenches and surface band applications have all been effective in growth regulation. Soil texture and organic matter content affect product availability to the tree. However, field studies show adequate growth regulation following various dosages that have been applied to the more common soil types.

The full effects of soil treatments are normally evident 2 years following treatment. The degree of regulation is comparable to trunk injection treatments, although a higher dosage rate is needed when the products are applied by soil. Subsurface injections are the preferred application method in urban areas and sites where surface movement could produce undesirable effects on non-target vegetation since the potential for exposure and the risk of surface movement are reduced.

Bark banding applications to young trees or shoots with thin, green bark have been effective in reducing tree growth. However, applications to older trees with thick bark have not been as effective, and may point to bark penetration problems. Bark applications must penetrate to the xylem without injuring the cambium to be successful. Further development is needed to define the effectiveness of bark applications.

Products that regulate tree growth by inhibiting gibberellin production have been shown to effectively regulate the growth on many hardwood species. Rapid improvements in equipment and application techniques have taken place. Use of tree growth regulator products is expected to increase and provide the utility industry with a practical and effective tool that, when integrated with present trimming practices, will result in improved tree management.

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Abstracts

SHURTLEFF, M.C. 1989. **Spray calendar for evergreen trees.** Grounds Maintenance 24(4):106, 110, 112, 116, 118.

Protecting evergreens from disease means applying the right chemical, at the right concentration, at the right time and in the right way. The following spray calendar covers the disease-control chemicals currently labeled for commonly grown evergreen trees. Use the charts as a guide because the labels for pesticides may change without notice.

GULBRANDSON, R.R. 1989. **Laundering pesticide-contaminated clothing.** Grounds Maintenance 24(4):122, 124.

Drift, accidental spills or carelessness can cause pesticide contact with the user or his clothing. This clothing is then considered to be contaminated. If pesticides get on your clothing, change clothes as soon as possible. If you continue to wear pesticide-contaminated clothing, the pesticide residue could be absorbed through your skin into your bloodstream, where it could cause serious health problems. Also, thoroughly clean washers after laundering contaminated clothing. This means that after every load of pesticide-contaminated clothing, run the machine through a complete cycle with hot water and detergent only.