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DROUGHT, ITS AFTER-EFFECTS, AND MANAGEMENT STRATEGIES FOR WOODY ORNAMENTALS

Drought can impact many types of woody plants in landscapes, natural woodlots, and forests (Figure 1). It is a meteorological and environmental event defined as the absence of rainfall for a period of time long enough to deplete the soil of moisture and cause damage to plants. Under drought conditions, the water content of the soil is reduced to the extent that plants can no longer extract sufficient water to maintain life processes.

In defining what comprises a "drought year," the pattern and frequency of precipitation is more important than the total amount of precipitation recorded for the year. Total precipitation levels can be deceiving when interpreted solely on the basis of yearly amounts rather than on a month-by-month basis. This is because one or two significant precipitation events or storms in a year could account for much of the total precipitation recorded for that year. Therefore, it is the amount and frequency of precipitation rather than yearly totals that are important to the long-term health, growth, and vigor of woody plants. This is especially true during the growing season, when water demands are the greatest. Up-to-date information on precipitation levels recorded at the Experiment Station's Lockwood Farm is posted on the Station web site (http://www.ct.gov/caes).

Figure 1. Trees growing in thin soils along the top of a ridge show symptoms of drought in contrast to trees growing in deeper, organic soils.

To understand the impact of drought on woody plants, we need to understand the water relations in the plant. Without water, there is no plant life. Water is necessary for nearly all biological and biochemical processes within plant cells. For example, water is necessary for uptake and transport of mineral nutrients and transpiration drives the movement of water in the plant from the soil, to the roots, to the xylem, to the leaves, and to the air.

Drought causes primary and secondary physical damage as well as physiological changes in woody plants. The primary physical effect of drought or dry soil conditions is direct damage to the roots and root death. The root system of a woody plant has four types of roots: 1) framework roots consisting of primary and secondary woody roots, 2) transport and storage roots, 3) non-woody feeder roots, and 4) root hairs. The fine, multiple-branching, non-woody roots constitute the major proportion of the surface of the root system. Their primary function is to absorb water and minerals. Almost 99% of this root mass is in the top 12-18 inches of the soil. Unfortunately, non-woody roots and root hairs are the first parts of the root system to be affected by drought, since they are very sensitive to drying. When feeder roots and root hairs become nonfunctional, a water deficit develops in the plant because these roots can no longer provide sufficient water to the top of the plant.

In addition to direct physical damage to the root system, a significant secondary physical effect of drought is that it weakens plants and predisposes them to secondary invaders and opportunistic pests.

Drought also has physiological effects on plants. It triggers a cascade of metabolic changes in the physiology of the plant. A major drought effect is the reduction of photosynthesis. In part, this is associated with a decline in leaf expansion, impaired photosynthetic "machinery," and premature leaf senescence. Other effects are slowed or completely stopped growth, reduced ability to respond to wounds and compartmentalize, changed hormone levels associated with stomate function, and many others (e.g., factors that influence the number of leaves that are set and will emerge the next year).

SYMPTOMS:

Symptoms of drought are manifest in many different ways, depending on the plant species. These are also influenced by the severity and length of the drought, by the site, and by the vigor and vitality of the species. One important characteristic of drought is the fact that the symptoms are often not evident in the above-ground portion of the tree or shrub during or shortly after the drought, but may develop as much as one to two years later.

Drought symptoms include loss of turgor in needles and leaves, drooping, wilting, yellowing, and premature leaf or needle drop—symptoms that are often associated with moisture stress. Some atypical symptoms include bark cracks, and twig and branch dieback. Leaves on deciduous trees can develop a marginal scorch (Figure 2), interveinal necrosis, or a general browning (Figure 3). Needled evergreens can become chlorotic (Figures 4 and 5). Trees and shrubs can also exhibit general thinning of the canopy (Figure 6), poor growth, and stunting. In extreme cases, drought can result in plant death.

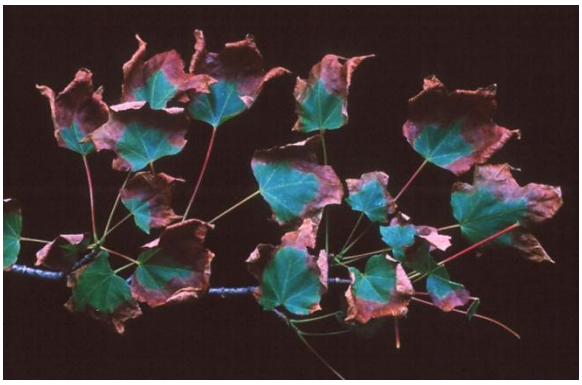

Figure 2. Typical marginal necrosis (scorch) of maple leaves associated with drought stress.

Figure 3. Browning of dogwood leaves associated with drought.

Figure 4. Hemlock with yellow (chlorotic) needles and tip dieback associated with drought.

Native plants growing naturally in woodlots or forested areas are usually adapted to regional and seasonal fluctuations in precipitation and only *unusually* severe drought conditions cause problems for them. However, planted landscape trees and shrubs often show symptoms of drought and severe water stress. Planting practices are frequently key sources of this problem, since trees and shrubs are often planted in unfavorable sites and the rootballs aren't properly prepared. They are also planted too deep or too shallow, or are mulched so

Figure 5. Spruce with chlorotic one-year needles (arrows) associated with loss of feeder roots from drought conditions the previous season.

thickly ("volcano mulched") that water cannot penetrate into the soil (Figure 6).

Symptoms of drought can develop on a wide range of deciduous and evergreen trees and shrubs and are particularly severe on seedlings and new transplants (Figure 8). This is because their roots occupy the uppermost layers of soil where the most rapid drying occurs. In addition, recent transplants typically lose important functional roots during the transplant process. For example, balled and burlapped trees are estimated to contain only 5% of their original root mass after digging.

For container-grown ornamentals, the medium in which the transplant is growing can be a key factor—many of the soilless mixes used for container stock are highly

porous, dry out very quickly, and are very difficult to re-wet.

Figure 6. Thinning of the canopy of an established tree.

Figure 7. "Volcano" mulching of trees in a landscape.

This situation creates moisture stress in the root ball, regardless of the availability of water in the surrounding soil. This problem often continues until the roots grow beyond the root ball into the native soil. Contrary to popular opinion, it often takes woody transplants several years to become completely established in a new site. A rule of thumb is one year of recovery for each inch of trunk diameter. Thus, larger specimens require more time to recover from transplanting than smaller ones, so these plants should be given extra care and attention during periods of drought.

Figure 8. Death of a Christmas tree transplant (arrow) because of drought. Note that the established trees surrounding it have no symptoms.

Established trees and shrubs can also be affected by drought, especially those planted in marginal sites such as those with pavement over their roots, street trees, and those in pockets of soil on ledges or in sandy soils. Problems have also been observed on apparently established trees and shrubs that have survived despite improper planting and have root defects that haven't been addressed such as girdling or circling roots. Once stressed by drought, these trees quickly decline and often die.

Since drought also weakens and predisposes plants to secondary invaders and opportunistic pests, a variety of diseases can be identified on these compromised plants. These include tip blights, vascular wilts, root

rots, and needlecasts. Among the key secondary problems are:

Winter Injury: Drought-stressed woody ornamentals are not as winter-hardy as their healthy counterparts.

Root Problems: Injured or weakened root systems are more susceptible to root rots.
Example:

- Armillaria Root Rot
  - Causal Agent: *Armillaria* species complex
  - Hosts: many species including pine, fir, oak, maple

Cankers: Weakened woody ornamentals have slowed "defenses" and wound healing is inhibited.
Examples:

- Bleeding Canker
  - Causal Agent: *Phytophthora* spp.
  - Hosts: many species, esp. beech
- Botryosphaeria Canker
  - Causal Agent: *Botryosphaeria* spp.
  - Hosts: many species, oak, maple, crabapple, rhododendron
- Cytospora Canker
  - Causal Agent: *Leucostoma kunzei*
  - Hosts: spruce, esp. blue spruce
- Hypoxylon Canker
  - Causal Agent: *Hypoxylon* spp.
  - Hosts: many species, oak
- Nectria Canker
  - Causal Agent: *Nectria* spp.
  - Hosts: many species, maple, birch

Wood Rots: Associated with slowed defenses because of limited ability to compartmentalize and react to invasion by wood-rotting fungi.
Examples:

- Fomitopsis on red spruce
- Ganoderma on oak, maple, and most hardwoods

Sensitivity to Pesticides: Weakened woody ornamentals are more sensitive to pesticides, including compounds that normally do not cause problems for healthy plants. Phytotoxicity of drought-stressed plants results from increased sensitivity to many herbicides, insecticides, and fungicides.

Sensitivity to De-icing Salts: Weakened woody ornamentals are more sensitive to de-icing salts, especially sodium chloride.

Miscellaneous Diseases: An increase in the frequency and severity of several diseases has been associated with drought stress.
Examples:

- Ash Yellows
  - Causal Agent: Phytoplasma
  - Hosts: ash, especially white and green ash
- Diplodia Blight
  - Causal Agent: *Diplodia pinea*
  - Hosts: many conifers include Douglas-fir, spruce and pine, esp. two- and three-needled pine
- Dutch Elm Disease
  - Causal Agent: *Ophiostoma novo-ulmi*
  - Hosts: elm
- Elm Yellows
  - Causal Agent: Phytoplasma
  - Hosts: elm
- Rhizosphaera Needlecast
  - Causal Agent: *Rhizosphaera kalkhoffii*
  - Hosts: spruce, esp. blue spruce
- Verticillium Wilt
  - Causal Agent: *Verticillium* spp.
  - Hosts: many woody plants, esp. Japanese maple, redbud, and smoke tree

STRATEGIES FOR MANAGING DROUGHT:

While there is no "cure" for this problem, the effects of drought can be minimized by following some preventative measures:

1. Water in periods of low soil moisture--
Trees and shrubs require approximately one inch of water per week. Special attention to young trees is important. For most soil types, water is best applied at one time as a slow, deep soaking of the entire root zone to a depth of approximately 12-18 inches. The length of time required to "deep-water" will vary depending on soil type and water pressure; clay soils usually require more time than sandy soils. Frequent, light, surface watering will ***not*** help the tree and can actually cause harm by promoting growth of non-woody surface roots. A deep soaking just before the ground freezes in the fall will also help the winter hardiness of drought-stressed plants.

2. Select the appropriate site and follow good planting practices--
Drought stress can magnify even the most subtle improper planting practices (e.g., planting too deep or too shallow, failure to remove or cut the burlap and/or the wire basket). When planting a tree, try to anticipate the soil volume and water needs of the tree at maturity.

3. Select native plants or match plant species to site conditions--
Drought-sensitive (e.g., dogwood, some oaks, ash, birch) *vs.* drought-tolerant (e.g., most pines, junipers, many *Prunus*, larch).

4. Mulch to maintain soil moisture--
Properly applied organic mulches can be very helpful for retention of soil moisture. Mulches are usually applied 1-3 inches thick and spread evenly out to the drip line of the tree. It is also important to keep the mulch 6-12 inches away from the trunk. Mulches that are applied too thickly ("volcano" or "pyramid" mulches) or too close to the base of the tree can be harmful.

5. Prune any dead or weakened tissues to avoid secondary problems--
Removal of weak or damaged branches can eliminate entry points for secondary insects and diseases. Pruning of diseased branches also prevents infections from spreading to other parts of the tree and to the main trunk.

6. Maintain plant vigor by following good cultural practices--
It is generally accepted that trees under stress should not be fertilized. However, applications of biostimulants, mycorrhizae, or similar compounds have occasionally been reported to stimulating root growth and regeneration.

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