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E309

Bulletin

Landscape and Ornamental Plant Stress: Factors, Symptoms, Diagnosis, and Management

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Ornamental nursery and landscape plants, whether grown in field, container, lawn, or along a street, are subject to stresses that plants in native environment seldom encounter. Plants grow best within certain ranges of the various factors that make up their environment. Under environmental stress conditions plants show physiological changes that may result in diminished growth and vigor. In spring, trees, shrubs, and herbaceous perennials put a flush of new growth when temperature, light, and moisture are optimal. As the summer progresses, however, the environment may be less conducive to growth as rains become infrequent and temperatures and light intensities rise.

At least 90% of the problems on woody plants are caused by factors other than diseases caused by living organisms (or biotic agents) and insects. These abiotic (or nonliving), non-infectious agents include temperature and moisture extremes, compaction resulting in poorly drained soil, nutrient imbalances, unsuitable soil/media pH, air pollution, and inappropriate levels of light. Adverse environmental conditions predispose ornamental plants to attack by insects and organisms that cause disease. Common symptoms of abiotic plant disorders include wilt, marginal leaf scorch, needle burn, foliar chlorosis, root dysfunction, dwarfing, dieback, and death.

Factors that adversely impact plants over time (months, years, or decades) are considered chronic stresses. The cumulative effects of these stresses may result in visible symptoms and may cause plants to decline and die. Stresses linked to single event, such as drought, cold, wind, hail, flooding, or mechanical damage, are considered acute stresses. These stresses occur suddenly and the damage they cause is soon evident. With chronic stress there may be time to reverse the problem if it is recognized early; with acute stress, however, there is little time to prevent plant damage. In addition, improper cultural practices (e.g., improper pruning, poor plant placement or installation, and less than optimal irrigation or fertilization) weaken plants and adversely affect their growth.

This fact sheet describes problems associated with drought, flood, winter injury, heat/light extremes, and nutrient imbalances on ornamental plants grown in the landscape and in production. We also consider diagnosis and management tactics that can be implemented to avoid or reduce the effect of such stresses.

Drought

Water is essential for the movement of substances throughout the plant and serves as a medium for chemical reactions. Unless the roots have a continuous supply of water, the plant eventually will wilt and the leaves will curl, although exposing certain plants to moderate drought stress regularly can increase their ability to withstand drought. Wilting for short periods of time does not harm plants, but a prolonged drought or many smaller periods of drought in succession may cause serious damage. Non-woody feeder roots, usually located in the top 15 inches of soil, are particularly sensitive and are the first ones affected. When these roots dry, shrivel, and become non-functional, a water deficit develops within the plant.

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Changes in metabolic processes can cause leaf yellowing, scorch (Figure 1), browning, or drop (abscission), stunted growth, inhibition of flower formation, browning of flower buds, decreased viability of pollen, increased root/shoot ratio, and dormancy. In addition, plants affected by drought are more susceptible to organisms that cause canker diseases.

Figure 1. Drought injury: marginal scorch of weeping beech foliage. (Photo courtesy A. Gould)

Under drought stress, hormonal levels in the plant parts elevate and affect plant growth. For example, water stress triggers an increase of abscisic acid (ABA) levels in the foliage. This causes stomates to rapidly close, resulting in decreased photosynthesis, limited evaporative cooling potential of the leaf, and a decrease in auxin levels. These factors can reduce plant growth. Combined effects of drought and high temperature have additive and interactive effects on plant growth. Limited transpiration cooling rate in the leaf increases leaf temperature above air temperature, prohibiting photosynthesis.

Trees and shrubs differ in drought tolerance. Plants with high drought tolerance include elm (American, lacebark, Siberian), ginkgo, green ash, honey locust, juniper (Chinese, rocky mountain), maple (sycamore), oak (bur, scarlet, white), pine (Japanese black, mugo, Scotch), eastern red cedar, and Japanese zelkova. Plants with medium drought tolerance include American holly, arborvitae, bald cypress, blue spruce, crabapple, Japanese tree lilac, maple (Norway, rocky, sugar), oak (English, northern red, white), pine (Japanese red and white, lacebark), Turkish filbert, walnut, white ash, and white fir. Trees and shrubs with low drought tolerance include beech, dawn redwood, dogwood, Douglas fir, European white birch, magnolia, maple (Japanese, red, paperbark), and willow.

Excess Water/Flooding

Oxygen is among the 17 elements required for normal plant growth. Oxygen and water are required for the movement of nutrients from soil to plant roots. During the growing season, roots grow at a faster rate, thus actively growing tree roots use oxygen at higher rates than when they are dormant. A water-logged soil condition (either due to high clay content, soil compaction, or poor drainage of soilless container media) reduces oxygen availability in the root zone.

Woody roots are more tolerant than non-woody roots to flooding (due to prolonged periods of rain). These non-woody (or feeder) roots are particularly sensitive and are frequently the first ones to be damaged by excessive moisture (overwatering) and water-logged soil conditions. Plants such as azalea, camellia, and holly are susceptible to root dysfunction under conditions of poor drainage in landscape beds. Prolonged flooding or overwatering reduces oxygen levels in the soil, which can directly damage fine roots and thus reduce water and nutrient uptake. This further reduces stomatal aperture, inhibits photosynthesis and transport of carbohydrates, and inhibits root growth and development of mycorrhizae. Flooding or overwatering weakens ornamental plants and they become predisposed (due to restricted defense systems) to secondary pathogens and other opportunistic pests such as stem borers and fungal root rots caused by *Phytophthora* (Figure 2).

Figure 2. Wilt and dieback of rhododendron due to root rot caused by excessive moisture. (Photo courtesy G. Zinati)

There are several factors to take into account when considering the impact of flood stress on a particular ornamental and landscape plant. These include: 1) the age of the plant, 2) the tolerance of the plant species to flooding, 3) the season and duration of the flooding period, 4) over-all tree health, and 5) sediment accumulation around tree roots. Plants grown in poorly drained soils or those subject to over watering may show symptoms similar to plants under drought stress. Plants respond to excess moisture primarily by wilting. Other symptoms may include stem swelling, edema on the foliage, reduced or stunted growth, twig dieback, leaf yellowing and drop, or plant death (Figure 3).

Figure 3. Yew plants affected by excessive moisture. (Photo courtesy R. Buckley)

Compared to woody plants with little tolerance to excessive moisture, more tolerant species exhibit greater capacity to produce adventitious roots (roots that are produced from stem tissue due to increases in ethylene in the root tissues). Such plants also better facilitate oxygen up-take through stomata, form new lenticels, and exhibit better metabolic adjustment to stress.

Winter Injury

Winter injury is a result of many environmental factors. The causal factors are diverse and include late spring frost, a cool summer followed by a warm fall or a sudden drop in temperature, excessive or late season fertilization, excessive temperature fluctuations, abnormally cold temperatures during winter, drying winds, and lack of snow cover. Growing plants out of their hardiness zone reduces their ability to survive low temperatures during the winter.

Excessive drying (winter desiccation) is one type of winter injury. This is quite common in evergreens (Figure 4) and occurs when water evaporates from leaves or needles on windy or warm sunny days during the winter or early spring. Drying occurs because this water is not replaced since the roots cannot take up enough water from cold or frozen soil. Winter desiccation is prevalent on broadleaved evergreens such as rhododendron (Figure 5) and holly and on needled evergreens such as hemlock and pine. Rhododendron leaves affected by winter desiccation turn brown along the margins and roll longitudinally along the mid-vein. Desiccated needled evergreens exhibit browning of the tips of needles, needle drop, and twig dieback.

Figure 4. Winter injury on Douglas fir. (Photo courtesy R. Buckley)

Figure 5. Winter desiccation on rhododendron foliage. (Photo courtesy S. Davis)

Periods of fluctuating winter temperatures combined with sunny calm days can cause sunscald (or sunscorch). Sunscald becomes evident when bark splitting occurs on stems or branches, most often on the southwest side of the tree (Figure 6). Other symptoms include dried buds, scorching or shriveling and dying of newly emerged foliage, twig dieback, scalding of bark, stunted annual twig development, and reduced plant growth. Smooth, thin-barked deciduous trees and shrubs are most prone to sun scald injury. Examples include flowering cheery and almond, Japanese and red maple, and flowering plum and peach.

Figure 6. Winter injury: bark splitting of Japanese Zelkova trunk. (Photo courtesy A. Gould)

Keep in mind that, unfortunately, symptoms of winter injury are not often evident until the following spring or summer. Winter injury will predispose plants to secondary infections by insects and diseases caused by living organisms.

Heat/Light Extremes

It is difficult to separate the effects of extreme light and heat. High light intensity and temperatures can lead to a number of plant disorders. Plant leaves are the first plant parts to be affected by high temperatures. Symptoms begin as chlorosis (yellowing) at the leaf tip, and as the vascular system becomes unable to replace the water lost, chloroplasts break down and necrosis (tissue death) follows. Symptoms are more severe when strong sun is combined with dry soil conditions. High temperatures can also cause young leaves to be deformed. Hosta and rhododendron grow best in dappled shade and may exhibit leaf scorch or sunburn when they are planted in hot, sunny environments. In the Northeastern U.S., avoid planting broad-leaved evergreens at sites that face northwest (due to cold and dry winter winds), south, west, or southwest (due to afternoon sunshine). Northern and eastern sites are ideal locations for growing these plants.

Nutrient Imbalances and pH

Plants require macronutrients and many other micronutrients in sufficient quantities to grow. An excess of one element may cause the deficiency of other element, thus causing an imbalance. A balance among the available nutrients should be maintained for healthy plant growth.

In urban landscapes, woody ornamentals are often grown in soil that has been disturbed by construction or other human activities. Such sites have soil that does not contain the proper nutrients necessary for plant growth, or the pH of the soil does not provide an environment for nutrient availability for plant uptake. Most woody ornamentals thrive in soil/soilless media at a pH between 6.0 and 6.5. Acid-loving plants dwell better in soil/media with a pH of 4.5 to 5.0. Soil/soilless media pH plays a role in determining whether a given element is available or not for plant uptake.

For example, when soil/soilless media pH is too low or too high, certain elements will not be available for plant uptake while others may become available at toxic levels. At pH 6.0 to 6.5, certain nutrients (such as manganese, boron, zinc, and copper) may be considered available in a mineral soil, but they are not sufficiently available in organically-formulated (soilless) container media. Although nitrogen, potassium, and magnesium are quite available in a mineral soil of pH 6.0 to 6.5, magnesium levels are insufficient in organically-formulated media at same pH range. When there is an imbalance among certain elements (such as potassium/magnesium) the plant selectively takes up one element to the exclusion of the other, thus causing a deficiency in the plant if magnesium is not supplied. Ammonium toxicity is common in organically-formulated media, highly acidic media, or at low temperatures. Incorporation of nitrate nitrogen and potassium fertilizer to soilless media reduces the chances of increasing ammonium levels in soilless media during the fall/winter season.

Nutrient deficiency or toxicities can cause abnormally slow growth, deformity, reduced plant vigor, chlorosis, and necrosis. Such symptoms can mimic those caused by heat, moisture extremes, chemical injury, or damage by pests, so nutrient imbalances cannot be diagnosed reliably on the basis of the symptoms alone. For accurate diagnosis, chemical analysis for soil and leaf tissue taken from both symptomatic and non-symptomatic plants is recommended.

Diagnosing Plant Problems

Diagnosing problems is not always easy; most tree problems in the landscape or streetscape are combinations of multiple abiotic stresses or complexes with both biotic and abiotic agents. The most critical part of the diagnostic process is to determine the cause of the problem. The process for diagnosing plant problems includes: 1) gathering information on plant species, symptoms, site and weather conditions, maintenance practices, and recent activities in the area such as construction, 2) consulting references to determine which problems commonly occur in the growing area, and 3) contacting the Rutgers Plant Diagnostic Laboratory or your local County Rutgers Cooperative Research and Extension (RCRE) office for assistance with diagnosis and outlining strategies for minimizing the problem.

Management Strategies

Management strategies used to minimize environmental stresses may vary with the landscape or production site, soil conditions, climate, plant type, and maintenance. In the following sections, we suggest tactics that can be implemented to reduce plant stresses caused by abiotic factors:

Strategies to minimize drought effects include:

- Select native plants or match plants to site conditions. Native plants are usually adapted to seasonal fluctuations in the amounts of available water;
- Avoid planting new trees and shrubs in landscape sites during severe drought conditions and water restrictions. New plantings require more water than already established ones for root establishment;
- Mulch plants (no more than 3 inches) to reduce weeds and increase availability of soil moisture;
- Apply irrigation during drought conditions (1 inch per week for established trees and shrubs grown in landscape sites) and short, multiple irrigation cycles in production sites;
- Use plants that are indicators for water stress (such as azalea, dogwood, doublefile viburnum, redbud, hydrangea, and Japanese maple) to help determine the need for supplemental watering;
- Maintain plant vigor using proper cultural practices, including pruning of dead twigs and branches and proper fertilization and irrigation (refer to RCRE bulletins E302 and E303 for detailed information);
- Spray mature evergreen foliage with antidessicants (e.g., Wilt-Pruf®, Cloud Cover®, or Vapor Gard®). Antidessicants are latex-like materials. The spray forms an invisible, watertight film over the leaf surface which reduces moisture loss through stomata (microscopic openings in leaves for air exchange). This film does not harm plants and wears off after a few weeks.

Strategies to minimize wet soil problems include:

- Re-grade and install drain pipes in poorly drained soils;
- Select the appropriate plant species for soil and site conditions (e.g., water-tolerant species such as inkberry holly, red maple, and green ash instead of water-intolerant species such as yew and pine);
- Maintain plant vigor and growth using appropriate cultural practices;
- Install rainfall and soil moisture sensors. In New Jersey, it is mandatory to have rain sensors on all automatic irrigation systems in landscapes. These sensors prevent the system from irrigating in the rain, and soil moisture sensors permit watering only when the plant really needs it.

Strategies to minimize wind exposure, winter injury, and sunscald include:

- Install physical barriers such as canvas, burlap, or wood slats on the exposed sides to reduce winter desiccation (the screens should be placed 2 feet away from the tree or shrub and anchored securely);
- Select the appropriate plants (e.g. pine, spruce or juniper) as windbreaks in areas of high exposure to wind (northwest side);
- Apply sufficient moisture in the root zone before the soil freezes in the fall, and mulch the soil surface to retain moisture in the winter;
- Avoid late summer and early fall fertilization (this simulates and encourages plant growth late in the season which may not harden-off properly for the winter);
- Select ornamental plants that exhibit medium to high tolerance to low temperatures (refer to RCRE Fact Sheet FS528 for detailed information on winter hardy plants);
- Protect conifers and broadleaf evergreens from drying by spraying antidessicants in late fall and throughout the winter months when temperatures are above 45 ^{o}F.
- Prevent winter sunscald in newly planted, thin-barked trees (such as ash, crabapple, maple, and tuliptree) by wrapping the trunk with burlap or other tree wrapping materials (the wrap can be kept in place up to 2 years);
- Prune dead twigs and branches that serve as sites for secondary pests;

- If soil test results showed nutrient deficiency, fertilize with a complete fertilizer by spreading the fertilizer on the soil surface in early spring (refer to RCRE Fact Sheet FS031 for more details on placement of fertilizer).

Strategies to minimize heat/light problems include:

- Match plants to the site. For example, plant shade-loving landscape plants on eastern and northern sides of buildings or in the shade of trees or structures to reduce sun scald;
- Properly irrigate to reduce plant exposure to heat stress;
- Mulch to provide cooler temperatures around the roots during hot summer days.

Strategies to minimize nutrient imbalances include:

- Test the soil for nutrients and pH by sending soil samples to Rutgers Soil Testing Laboratory;
- Adjust soil pH to favor nutrient availability by using elemental sulfur to decrease soil pH or lime to increase soil pH;
- Apply a complete fertilizer in the spring to supply macronutrients as needed or as indicated by a soil test. Foliar application of certain micro-nutrients, such as iron, may be necessary in the spring to correct for iron deficiency in chlorotic plants.

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