
1A


1B


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BY DR. DAVID L. ROBERTS
THE PLANT DOCTOR, LLC

Dr. Roberts retired from Michigan State University in 2018 after committing four decades to advancing MSU's Land Grant Mission, originally signed into law by President Abraham Lincoln during the midst of the American Civil War. He has published hundreds of articles and has taught hundreds of lectures and workshops.

Dr. Roberts has researched many issues in Michigan's plant industry, including Oak Wilt, Dutch Elm Disease, Diplodia Tip Blight of Pines, along with variety of cultural problems such as plant nutrition and herbicide toxicity. During his career, he has discovered a variety of new diseases and pests such as Phomopsis Canker of Spruce and the first bacterial wilt disease of turfgrasses in North America.

In the early 2000s, his research on Ash Decline in Southeast Michigan led to the discovery of the invasive Emerald Ash Borer in North America.

In his retirement, Dr. Roberts intends to remain active with the Arboriculture/Landscape/Nursery industries. Dr. Roberts is President, CEO and CBW (Chief Bottle Washer) of The Plant Doctor, LLC…aka The Tree Doctor. His contact information remains the same: Phone (248) 320-7124; Email robertsd@msu.edu

DIAGNOSING HERBICIDE INJURY ON TREES AND LANDSCAPE PLANTS

Introduction:

Herbicides are used for managing unwanted plants (weeds) in a variety of locations: landscapes, golf courses, athletic fields, crop production, and right of ways. In the landscape, trees represent the most valuable commodity potentially affected by herbicides (Photos 1A & 1B). Can you identify the tree in Photos 1A & 1B? The answer is given in Photos 1C and 1D at the end of this article.

Because herbicides are designed to kill plants, damage to non-target plants is not an uncommon occurrence (Photos 2, 3 & Inset, & 4). Herbicides can affect non-target plants for a variety of reasons. Spray drift, volatility (Photo 5), persistence (long residual), movement or translocation in water (Photo 3), movement on tools or equipment (Photo 6), contaminated soil (Photo 7), and other media such as mulch. Obviously, misapplication and/or applicators' failure to follow label directions or understand the herbicides attributes are rather common contributors to herbicide toxicity to trees or other desirable plants (Photo 8 & Inset). Occasional mistakes also occur with herbicide labeling or imprecise directions from manufacturers/marketers/suppliers (Photos 9, 10 & 11). I sometimes suspect that vague labeling is done for marketing purposes.


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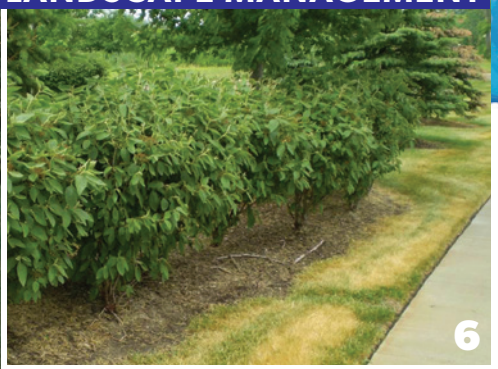

1A & 1B Trees usually represent the most valuable living commodity in landscapes. It is not unusual for herbicide (mis)applications to severely damage or kill large trees. Can you identify the tree from these photographs by its structure and foliage? The answer is provided in Photos 1C & 1D at the end of this article.

2 The application of herbicides may result in damage to non-target or desirable plants. In many instances, the damage is minimal and plants will return to normal health with discontinuance of the herbicide applications and with enough passage of time, as was the case with this growth regulator herbicide distortion of the foliage on wisteria. (Photo credit: Denise Schroeder, University of Michigan)

3 In some situations, unintended consequences of herbicide applications can be lethal or near lethal. At this award-winning landscape site, imazapyr was applied to mulch rings for "long term" weed control the year before…according to a low bid contract. The affected trees and shrubs on-site had extreme difficulty recovering over the next couple of years…. and many didn't recover. Note the sparse foliage on the shrub (left & Inset). Movement of the herbicide not only occurred downward into the shrubs' root zones but also translocated laterally in water, killing the turf (left).

4 This photo shows herbicide injury on maple due to contaminated "fill dirt" (see Photo 7). Apparently, herbicides had been previously applied to the fill dirt piles in the storage yards for weed suppression.

5 A novice plant aficionado might identify this as a White pine or White spruce. In reality, this Colorado Blue spruce tree was affected by Command herbicide, which volatilized from a nearby soybean field after application.

6 A landscape maintenance company applied Roundup (glyphosate) to the mulch area near these shrubs to prevent the encroachment of the turf into the shrub bed. Before allowing the herbicide to dry with the morning dew, mowing crews transferred the herbicide to large areas of lawn, resulting in the discoloration and death of large patches of the lawn.

7 "Fill dirt" was distributed in this landscape to help alter the topography, which was prone to flooding. Unfortunately, the fill had been treated with an unknown herbicide in the storage yard. The fill killed many trees and shrubs in this landscape at a property in southeast Michigan. Due to the contaminated soil, turf was difficult to establish.

8 This crabapple tree will likely die due to a heavy dose of glyphosate (Roundup, etc.) to "suckers" (Inset) growing from the tree's lower trunk and roots. The applicator apparently didn't comprehend that a systemic herbicide such as glyphosate would translocate throughout the tree, whereas a contact herbicide would not.

9 A supplier recommended that a commercial applicator apply Milestone herbicide to the cracks in the pavement for long-term weed suppression at this strip mall. Even though Milestone was only applied to the pavement cracks and not to landscape areas, all honeylocust trees near the treated cracks died. Upon careful examination of the label for this herbicide, originally developed for pastureland, there were no warnings about damage to trees. Further investigation of Dow's website, however, disclosed that leguminous plants (redbud, honeylocust, black locust, alfalfa) may be severely harmed by this herbicide, much like Imprelis was lethal to honeylocust trees.

10 DuPont had not apparently thoroughly tested its new Imprelis herbicide before releasing it to turf and ornamental markets in 2010. Severe toxicity to many landscape plants, especially conifers and legumes, ensued as the herbicide was readily translocated to the meristematic tissues in the shoots. Due to inhibition of growth by the herbicide, many trees died or their growth was severely depressed…some recovered with time.

11 Many herbicides such as Imprelis exhibit differential toxicity to species of plants. At this location near Wyandotte, MI, many honeylocusts (left) died while maples and oaks were largely unaffected.

Damage to non-target plants by herbicides seems to be an increasing phenomenon. Hence, I thought it might be useful to relate some examples of various herbicide problems I have encountered over the past 35+ years. As professionals, it is important that we understand the general groups of herbicides as well as learn to recognize the types of symptoms they may produce on plants. Recognizing symptoms of herbicide toxicity can lead to an accurate diagnosis of herbicide injury, which can be mistaken for other causal factors such as diseases, pests or plant malnutrition and soil problems. Obviously, herbicide injury to plants is a humongous issue that could occupy volumes of books. This article is nothing but a very brief summary.

Types of Herbicide Injury Symptoms:

Depending on sensitivity of the plant and the exposure dose, herbicide symptoms on plants may range from mild (Photo 12) to wild to deadly (Photo 13). Herbicides may be categorized according to a variety of attributes. One of the most general characteristics of an herbicide is whether it is a systemic or contact. Another general characteristic is whether the herbicide exhibits pre- vs. post-emergent activity. Other classifications are more distinct and may include "mode of action" (examples: photosynthetic inhibitor, amino acid synthesis inhibitor, growth regulator, germination inhibitor or root inhibition). Partly in conjunction with their mode of action, we can also classify herbicides based on their symptomatic effects on plants. Following is a brief description of various classes of herbicides arranged according to their symptoms and impacts on plants.

Growth Regulators: Some of the more common symptoms of this group include tip and/or leaf chlorosis (yellowing), shoot dieback, leaf/shoot growth distortions such as twisting and curling, epinasty (outward and/or downward bending), and abnormal leaf development/appearance (Photos 2, 3, 6 & 10). Some of the more common members in the group are the widely used herbicides: 2,4-D, 2,4-DP (dicloprop), MCPP (mecoprop), dicamba, triclopyr (example Garlon), picloram (Tordon), imazapyr (examples: Sahara, Arsenal, Chopper, Polaris, Stalker, etc.), and glyphosate (examples: Roundup, Kleenup, Accord, Rodeo, Touchdown, etc). Some of these herbicides (examples: glyphosate, imazapyr, triclopyr) are marketed as total vegetation control, but in sublethal doses may cause various other symptoms described for this class. Some chemical formulations of these herbicides can be more volatile (example: ester form of 2,4-D) than other formulations of the same active ingredient (example: amine form of 2,4-D). Some products contain two or more herbicides and are sold under various trade names (examples: Monsanto's Roundup Extended Control and Roundup 365, Ortho's Ground Clear, etc.). This large class of herbicides is used extensively and undoubtedly contributes to most of the herbicide problems we encounter with trees and other plants in landscapes and nurseries.

Leaf Bleaching: A few herbicides cause leaf bleaching (usually whitening) in plants and hence are called "bleachers". They "bleach" because they inhibit the synthesis of pigments in plants; pigments (red, yellow, etc.) are produced to protect chlorophyll from oxidation or breakdown. Examples of herbicides in this class include amitrole (Amitrole, Amizine) and clomazone (Command). The author has occasionally seen leaf whitening from herbicides external to this group such as glyphosate. As with chemicals in other classes of herbicides, some formulations tend to be more volatile after application (Photo 5).

Leaf Spotting: This group includes the preemergence herbicides: examples include oxyfluorfen (trade names Rout & Ornamental Herbicide 2 (OH2)) and oxadiazon (trade name example, Ronstar). This group also consists of some post-emergent herbicides: paraquat, diquat, fluazifop (trade name example, Fusilade) and sethoxydim (trade name example, Poast). Direct application (high exposure) of these herbicides may lead to death of plants but

12 Mild symptoms of herbicide injury to this oak tree include leaf cupping and distortion, plus darker green coloration. Such symptoms are typical on my woody plants in the vicinity of applications of 2,4-D and dicamba for broadleaf weed control in lawns.

13 These two red oaks appear dead; initially, the suspected cause was the lethal disease, Oak Wilt. However, further investigation revealed that the culprit was the application of Imazapyr herbicide to the gravel drive for long term weed control. Red oaks seem particularly sensitive to this herbicide while white oaks (center, background) do not.

14 Contact herbicides in sufficient doses usually kill plants, as they were designed to do. With drift, however, contact herbicides may cause leaf or stem spotting, similar in appearance to many plant diseases or certain insect galls.

15 "Leaf seal" can be a symptom of some classes of herbicides (note rosetted needles). In this situation, Imprelis herbicide, a carboxylic acid growth regulator, impacts spruce near the herbicide's application to the lawn.

16 The symptoms on this plant resemble herbicide damage after the plant had put on early season growth (note normal foliage, left). This issue is actually aphid damage on imported honeysuckle. However, depending on the timing of herbicide application, similar damage may only appear on foliage not yet emerged.

spray drift and other unintended avenues of exposure will often lead to the most commonly observed symptoms of spotting on stems or leaves (Photo 14).

Root Inhibitors: The dinitroaniline family inhibits the meristematic development of root tissue; examples include triflualin (Treflan, etc.), benefin (Balan), oryzalin (Surflan), pendimethalin (Prowl, etc.), prodiamine (Blockade, etc.), among others. The dinitroanilines are often combined with other members of the group or other groups (oxyfluorfen) for enhanced preemergence results (examples: oryzalin + oxyfluorfen = Rout, pendimethalin + oxyfluorfen = OH2, oryzalin+benefin = XL). Herbicides in this group are commonly used in nursery production and landscape maintenance for controlling annual grasses and broadleaf plants. Symptoms on affected plants often include root swelling and/or stunting. Shoot development may also be inhibited as a direct consequence of root inhibition. Because these herbicides do not typically move through soil from the application target area, larger woody plants such as trees or shrubs are generally not affected….at least from what is generally believed by most experts. Small herbaceous weeds, annuals and perennials are the most likely affected plants.

Root & Shoot Inhibitors: Some herbicides can inhibit shoot development and may also inhibit root development. Hence, this group may occasionally be confused with the root inhibitor herbicides. The herbicides in this group essentially affect meristematic (cell division) tissues in the apical regions. This group includes: the Amides, such as diphenamid (trade name example, Enide) and napropamide (trade name example, Devrinol); the Anilides, such as alachlor (trade name example, Lasso) and metolachlor (trade name examples, Dual and Pennant); and the Thiocarbamates, such as Eptam, Sutan, etc. The Amide group causes general stunting of roots and shoots. The Anilide group causes stunting and shoot twisting in herbaceous plants. The thiocarbamate group may cause stunting and, in some cases, "leaf seal", where leaf edges are connected (Photo 15). Established woody plants are usually not severely affected by this group of herbicides.

Tips for Diagnosing Herbicide Injury:

There are several steps to take when diagnosing herbicide injury. It is also important to keep in mind that in order to increase the efficacy or provide for a broader spectrum of activity, weed control products may contain two or more herbicides, possibly confounding our ability to accurately diagnose specific herbicide damage. Complicating herbicide injury to plants is the fact that certain diseases, pests, nutritional deficiencies and other causal factors can imitate herbicide injury.

Following the steps below might assist us in making a more accurate diagnosis of herbicide issues.

1) Carefully examine the symptoms on plants suspected of being affected by herbicide injury; perform a thorough diagnosis by checking for signs of pests, diseases, nutritional deficiencies (soil pH) and causes other than herbicide activity…at least initially. Herbicide symptoms will most likely, but not always, show up in the shoots and/or foliage.

2) Scrutinize other species of plants in the vicinity; herbicide drift or misapplication will usually affect multiple species of nearby plants (herbaceous plants, shrubs, trees, weeds, etc.) while diseases and pests usually do not (Photos 14 & 16).

3) Determine through questions and other investigative methods (trickery, torture and skullduggery, if necessary) whether any herbicides were applied at the impacted site. Don't be surprised if applicators, whether private homeowner or commercial, are sometimes reluctant to admit the use of herbicides or specific types.

4) If an herbicide was applied, ascertain whether the observed plant symptoms could be caused by the class(es) or type(s) of

herbicide(s) utilized. Remember, the applicator may not always disclose what was applied for fear of retribution by a property owner or even (gulp) a spouse!

5) If all else fails, herbicides can often be detected by residue analysis of the affected plant or surrounding soil/media. The costs of performing such analyses used to approach $300-500 per herbicide per sample. Today, extensive screens of various suspected herbicides can be run for much less than the previous costs. Please consult the author for information on the various testing options and facilities.

Ameliorating Herbicide Injury:

There are several options that might help us address potential issues with herbicide injury to non-target, desirable plants.

Avoidance: Obviously, the primary option is to ***avoid any potential*** for herbicide injury to desirable plants. In some cases, it may be advisable to NOT use an herbicide unless absolutely needed. Herbicides, like many chemicals, are often overutilized in lawns, gardens and landscapes. If an herbicide is planned to be applied, be sure to follow label directions, paying particular attention to precautions, rates, application techniques, weather conditions and so forth. If the applicator does not have experience with the proposed herbicide, it might be best to seek additional advice before a serious error is made (Photos 1A-D, Photos 3 & 9).

Soil Amendments: If a problem is encountered with a ground-applied herbicide, the application of activated charcoal and other compounds to the soil can sometimes help absorb unwanted herbicides and/or reduce their residuals or decrease their persistence.

Leaching: Some herbicides, such as those in the carboxylic acid/growth regulator group, are soluble in water. This solubility doesn't only lead to problems (Photos 3, 9 & 10), it can also enable us to minimize their impact to some extent by leaching the herbicide beyond the root zone of affected plants. This can be accomplished by heavy doses of irrigation if caught early after an application of an herbicide.

Watching & Waiting: Depending on sensitivity, many unintended herbicide problems may not be lethal to plants. Plants sometimes recover with time as the herbicide dissipates or is processed by the plant's own physiology… and/or by other avenues (example-microbial) of decomposition in the environment. If there is live cambial and bud tissue, there is potential hope of recovery (Photo 17).

1C & 1D A highly toxic "right of way" herbicide was given to a property owner by a "friend" for use on this walkway (1C), leading to a patio in the yard; the herbicide severely distorted the foliage of this tree (Photo 1A and 1B). After discontinuing the use of the herbicide, luckily before the tree was killed, the normal growth of the tree eventually resumed (Photo 1D). This is not some exotic corkscrew tree (Photo 1B); it is an ash tree, being successfully treated for the Emerald Ash Borer, overlooking the shores of Elk Lake in northern MI.

17 Viable cambial (green) and bud tissues indicate "life" in this denuded (leafless) oak tree the year after Imazapyr application. Survival may be possible with time. Note the stunted leaves and shoots that are trying to emerge-a good sign. Watching and waiting might be a recommended practice for some high value plants.

Dr. David Roberts is a speaker at GLTE 2019 on Monday, January 28th and Tuesday, January 29th.