# Biotic or Abiotic Damage: Herbicide or Something Else

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Herbicide drift occurs when applications are made during suboptimal environmental conditions – generally this means too much wind. When herbicide injury does occur, diagnosis is often difficult since injury symptoms vary considerably in appearance for different herbicides, plant species, amount of drifted material, and application timing. Insects, disease, nematodes, nutrient stress, excess heat or cold, and chemicals other than herbicides can also cause symptoms that appear similar to those caused by herbicides. All too often when injury symptoms are observed, the first question is "What herbicide caused this?" Careful observation can often distinguish the cause of the symptoms and determine if herbicides are at fault. The purpose of this presentation is to describe symptoms of common herbicide and to show how other stresses can look similar. General symptoms of herbicide injury are given and may be of help in eliminating certain herbicides as the probable cause of injury.

**ACCase inhibitors**

Compounds in this group include fluazifop (Fusilade), fenoxaprop (Whip, Puma), diclofop (Hoelon), cyhalofop (Clincher), sethoxydim (Poast), and clethodim (Select, Prism). Symptoms are generally only observed on grasses since most broadleaf plants are tolerant. Injury has been observed on flowers (reduced petal size and spotting of petals) of broadleaf ornamentals. Cyhalofop has also been observed to spot peach leaves and fruit. The spotting can result in dead spots that form holes in the leaves (somewhat similar to shothole disease). Leaf spotting has also occurred on some azaleas and tip burn on Bar Harbor juniper with fluazifop. Symptoms are temporary and regrowth is normal.

In grasses, the first effect is a cessation of top growth, followed by yellowing (without pattern) in young leaves within 7-10 days. Later the older leaves become yellowish and may show some purple. Internodes just above the node (meristemmatic area) turn necrotic brown and appear to "rot". The young shoot can easily be separated from the remainder of the lower shoot.

**ALS inhibitors**

The herbicides in this class are used at very low rates and are extremely active in broadleaf plants. The principal ALS herbicides used in California are chlorsulfuron (Glean, Telar), sulfometuron (Oust), bensulfuron (Londax), nicosulfuron (Accent), halosulfuron (Sandea), Mesosulfuron-methyl (Osprey), rimsulfuron (Matrix), imazapyr (Arsenal), imazethapyr (Pursuit), imazamox (Raptor), pyrithiobac (Staple) and bispyribac-sodium (Regiment) and imazamethabenz (Assert). Foliar and root uptake can occur with these herbicides.

Symptoms are generally observed in new foliage. Growth generally slows and chlorosis and necrosis of the meristematic region occurs. In new growth, internode length is shortened and

small chlorotic leaves appear in small, sometimes distorted whorls. Purplish pigmentation also sometimes is observed in mature foliage. In new growth, symptoms may appear somewhat similar to glyphosate. When drift occurs on the mature leaves of trees, symptoms may appear the following spring, with new growth having shortened internodes.

Soil residual varies considerably between materials, with some lasting a year or more.

**Photosynthetic Inhibitors**

This broad group of chemicals blocks photosynthesis and includes materials applied primarily preemergence. However, some materials (metribuzin, linuron, diuron, propanil) have some postemergence activity when used with surfactants or oils. Herbicides in this group include metribuzin (Sencor), prometryn (Caparal), simazine (Caliber 90, etc), hexazinone (Velpar), diuron (Karmex), linuron (Lorox), propanil (Stam, etc.), tebuthiuron (Spike) and bromacil (Hyvar).

In perennial crops such as almonds, apples, walnuts, peaches, grapes, many woody ornamentals, etc., symptoms from low rates of the photosynthetic inhibitors start as a yellowing around the leaf margins on mature leaves. Young leaves do not show symptoms. As time elapses, interveinal areas of leaves also turn yellow. Progressive injury includes marginal leaf necrosis with more interveinal yellowing. Iron chlorosis also causes these symptoms. Symptoms are rate dependent with higher rates giving greater and more rapid symptoms. Perennial plants retain the leaves with symptoms until normal senescence. Excessive rates can be observed to reach new foliage before symptoms of chlorosis occurs in mature leaves. These symptoms appear as a rapid progression of chlorosis followed by necrosis, similar to drought. Another pesticide (metalaxyl – a fungicide) will also give similar symptoms.

Prometryn, Karmex, Hyvar, or Lorox drift results in the reverse of these symptoms. Veins become chlorotic with the intervein remaining green. .

Bromacil is used as preemergence, soil applied material. Since this herbicide is relatively soluble in water (815 ppm), there is a tendency to leach into the root zone of perennial plants. Annual horticultural plants do not tolerate bromacil. The more tolerant plants (citrus, apples, peaches, almonds) show symptoms on mature leaves as a striking veinal yellowing, and less commonly, the leaves will also have blotchy chlorosis. Sensitive trees such as walnuts or figs develop necrotic leaves. This necrosis frequently appears rapidly, with no veinal chlorosis. These leaves normally fall and new leaves are formed. Depending on rate of the material present in the soil these new leaves may be smaller and chlorotic at low rates or they may also drop if high rates are still present. If trees are healthy, they can drop a set of leaves and develop new leaves at least two times in a season. If the trees are not healthy, they may be killed by high rates of these herbicides.

If soil applied (drift or direct application) prior to seeding or seedling emergence, seedlings may germinate and appear to grow normally for a number of days (7-10) before the leaves turn chlorotic and necrotic and the seedlings collapse. In transplants, root uptake occurs until mature leaves show yellowing with some leaves showing a partial leaf chlorosis (blotchy appearance). Depending upon rate and susceptibility of the plant injury can range from crop death to mild chlorosis.

**PPO Inhibitors**

PPO inhibitors includes oxyfluorfen (Goal, GoalTender), carfentrazone (Shark, Aim), sulfentrazone (Zeus), oxadiazon (Ronstar), and flumioxazin (Chateau). Although these herbicides are used primarily as preemergence herbicides (except for Shark), they all can have some postemergence activity on exposed leaf tissue. Oxyfluorfen symptoms frequently appear on young leaves, apparently due to low wax content in the leaf cuticle. Oxyfluorfen causes tip dieback on new growth in conifer species, while older foliage is not generally affected, except at excessive rates. On a sensitive plant like petunia, silvery spotting and a glazing appearance occurs, somewhat like smog damage. When applied preemergence to crucifer crops such as broccoli the tips of the cotyledon leaves are frequently cupped, as if the leaves are burned, as they push through the treated soil, leaving the cotyledons distorted. Girdling of the shoots of annual plants, principally broadleaves, is common and appears almost as if there is insect feeding at the soil surface. This symptom is sometimes observed on seedlings after rainfall or irrigation moves treated soil in contact with stem tissue.

Chateau can cause foliar symptoms that often appear to look similar to oxyfluorfen or paraquat symptoms. Ronstar or Zeus can cause desiccation and necrosis if they contact foliar parts of the plant. Susceptible plants emerging from the soil turn necrotic and die after exposure to sunlight. Shark drift, at low concentrations, results in necrotic spots on leaves, with the spots dropping out of the leaf. Fruit of plums will show brown spots and gumming from the spots. If sprayed so coverage is uniform it acts as a contact burn on leaves. Shot hole disease looks similar, but does not affect the fruit.

Paraquat, considered a Photosystem I inhibitor, can cause foliar symptoms similar in appearance to the PPO inhibitors. Injury symptoms from paparquat is usually the result of drift, since it is a contact herbicide, and would not be intentionally applied to a desirable plant. Depending upon concentration, chlorotic or necrotic spots may appear on young or mature foliage. These spots normally don't "fall out" of tree foliage thus it should not be confused with "shot hole" disease. Symptoms progress more rapidly on bright, sunny days. Necrotic spots caused by hail or sand blasting may sometimes be confused with the symptoms seen following PPO Inhibitor or paraquat drift.

**Auxinic Acids**

Phenoxys include 2,4-D, 2,4-DB (Butyrac), MCPA, and mecoprop (MCPP). Dicamba (Banvel, Clarity) is the only benzoic acid in this group. The carboxylic acids currently in use include picloram (Tordon), triclopyr (Turflon, Garlon, Grandstand), and clopyralid (Stinger, Transline). These compounds can be grouped together because of similar symptoms. Though each may have a characteristic symptom on an individual plant and have a greatly different rate response, symptoms generally cannot be differentiated unless directly compared.

With phenoxys, symptoms appear in new growth of broadleaf plants (annual or perennial). The time interval can be 3-10 days after application before symptoms appear. Interval is generally temperature dependent with a faster response at increasing temperature. Leaves lose their planar angle, the petioles twist and there is general disorientation of growth in new foliage. Old leaves and stems in woody plants such as peaches, grapes, etc., do not appear affected. Leaves of broadleaf plants take on various changes in development patterns. Using grapes as an example, leaves become abbreviated at the tips where there are major veins. This may become so

extreme as to cause "fan-shape" or "strap" leaves. Veins become very prominent with the reduction or absence of the interveinal area. High rates kill the young tissue causing necrosis. Stems of immature woody plants may develop splits or "corky" zones.

In grape, symptoms of 2,4-D have often been confused with fan-leaf virus. In diagnosis there should be a different field pattern from 2,4-D drift or accidental application as compared to the sporadic occurrence of diseased plants.

Annual broadleaf plants exhibit similar leaf symptoms as perennials; leaf petioles and stems twist severely. In carrots, root growth appears as irregular thickening giving a "warty" appearance or in some cases splitting occurs because of the irregular growth. Splitting alone is not a characteristic symptom of phenoxy damage, because it can be caused by lack of proper water management. San Jose scale can also cause bark to split, which looks similar to phenoxy damage. Leaf bases are enlarged with a reduction of length of new leaves and some twisting of the leaves can be observed following drift from this group of herbicides.

**ESPS Inhibitor (Glyphosate)**

Symptoms from glyphosate are variable, depending on timing and method of exposure. Exposure must take place through leaves or young, thin or green bark. Soil exposure is minimal to nil if the soil has been tilled before planting or there is soil over roots. In perennial crops, symptoms from a spring to summer exposure (new to maturing growth) have varied from chlorosis with no specific pattern in new growth when sprayed on older leaves to interveinal chlorosis. Overall leaf chlorosis can occur and new growth following exposure to older foliage is commonly distorted, puckered, and glossy small leaves.

Exposure to mature foliage in the fall may not result in symptoms until the following spring when new growth initiates. Trees with glyphosate exposure can have delayed leaf emergence, reduced leaf size, loss of apical dominance and shortened internodes. Depending upon exposure it may appear on one branch or cane or the total plant may show the effect. As growth occurs, depending upon date and amount of exposure, new growth may be normal and even mask the early symptoms. High rates of exposure, however, cause symptoms to persist during much of the season. These symptoms may appear in new foliage each spring for 2 to 3 years without additional exposure. Unless exposure is very high on mature foliage normally a tree or vine survives. This also depends upon the original health of the plant. In grapes it does not appear to reduce fruiting greatly, even though foliage symptoms may be severe. In pines and firs, the new candles or growth tips become necrotic and die forcing secondary whorls.

After exposure to high glyphosate rates, annual plants leaves turn light green and chlorotic about 7 to 14 days after application, depending upon temperature and sunlight, and then the plant collapses. Plants may survive low rates of glyphosate, showing chlorosis in new growth, and possibly some stunting of subsequent growth. Young tomato leaves can show interveinal chlorosis, whereas the mature leaves may not show symptoms. Some glyphosate symptoms (chlorosis of young growth and shortened internodes) could resemble the sulfonylurea or imidazolinone herbicides.

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