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Strategies for Diagnosing Abiotic and Biotic Problems

by Steve Tjosvold and Steve Koike

Diseases, disorders and other plant problems are critical concerns for the wholesale nursery. These include biotic problems — caused by living organisms such as pathogens, nematodes, and insects and other arthropods — as well as abiotic problems — caused by factors such as temperature and moisture extremes, mechanical damage, chemicals, nutrient deficiencies or excesses, salt damage and other environmental factors. Many plant problems, especially biotic problems, if not recognized and controlled early in their development, can result in significant economic damage for the producer. Therefore, timely and accurate diagnoses are required so that appropriate pest and disease management options and other corrective measures can be implemented.

Definition of Plant Diagnosis and Steps

Diagnosis is the science and art of identifying the agent or cause of the problem under investigation. When one renders a diagnosis, one has collected all available information, clues and observations and then arrives at an informed conclusion as to the causal factor(s). Hence, plant problem diagnosis is an investigative, problem-solving process that involves the following steps:

1. Ask and answer the appropriate questions to define the problem and obtain information that is relevant to the case under investigation.
2. Conduct a detailed, thorough examination of the plants and production areas.
3. Use appropriate field diagnostic kits and lab tests to obtain clinical information on possible causal agents and factors.
4. Compile all the collected information and consult additional

resources and references.

5. Finally, make an informed diagnosis.

Throughout this process compile all notes, observations, maps, laboratory results, photographs and other information. This compilation will be the information base for the present diagnosis and can also be a useful resource for future diagnostic cases. Keep an open mind as the information is analyzed and do not make unwarranted assumptions.

Distinguishing Abiotic and Biotic Problems

The first step is to determine whether the problem is caused by an infectious agent, and this can be difficult. Plant symptoms caused by biotic factors such as infectious diseases and arthropod pests are often similar to damage caused by other factors. Leaf spots, chlorosis, blights, deformities, defoliation, wilting, stunting and plant death can be common symptoms of both biotic and abiotic problems; therefore, the presence of these symptoms does not necessarily mean the problem is a disease. Some general guidelines for distinguishing abiotic and biotic problems follow and are summarized in table 1.

Table 1 DISTINGUISHING ABIOTIC AND BIOTIC PROBLEMS

Characteristics	Abiotic	Biotic
Hosts	often affects several species or plants of various ages	often affects one species or cultivar of the same age
Pattern of plant symptoms	often related to environmental or physical factors or cultural practices; may be regular or uniform	often initially observed in random or irregular locations
Rate of symptom development	relatively uniform, extent of damage appears similar among plants	relatively uneven, time of appearance and damage severity varies among affected plants
Signs	no evidence of the kinds of pests or pathogens known to cause the current symptoms	presence of insects, mites, fungal mycelium and spore clusters, bacterial ooze, mollusks; products produced by pests such as honeydew / sooty mold, cast skins, frass, or mollusk slime.

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Management of Downy and

Spread	**is not infectious, is not progressive, commonly caused by one incident and does not spread**	**infectious, spreads on host over time if environmental conditions are suitable**
Recurrence	**possibly previously associated with current or prior environmental conditions or cultural practices**	**possibly caused by pests that have affected this crop during previous growing seasons or are known to commonly affect this crop species or cultivar**
Adapted from Table 18, ANR Pub 3420		

Biotic problems. Identifying biotic problems is sometimes facilitated if signs of a pathogen, primarily the growth of a fungus, are present. The most obvious examples of such signs are the mycelium and spores produced by rusts and powdery and downy mildews. However, in other cases nonpathogenic fungi can grow on top of damaged plant tissues and appear to be signs of a pathogen, resulting in possible misdiagnoses.

Biotic problems often affect one species or cultivar of the same age and typically are initially observed in random or irregular locations; symptoms appear at varying times, and severity varies among affected plants. Biotic problems are infectious, spreading when environmental conditions are favorable, and may be associated with pests that have affected the crop. This infectious aspect is important, as biotic diseases will many times be progressive and continue to affect additional tissues and more plants.

Abiotic problems. In contrast to biotic factors, abiotic problems often affect several species or plants of various ages; typically, damage is relatively uniform, doesn't spread and is often not progressive. Abiotic problems are not associated with pests. They are often caused by a single incident and are related to environmental or physical factors or cultural practices. Once the responsible factor has dissipated and is no longer affecting the plant, the plant may grow out of the problem and develop new, normal appearing foliage.

Diagnosing Biotic Problems

Infectious diseases. To confirm if a problem is caused by a pathogenic fungus, bacterium, nematode, or virus, it is often necessary to have symptomatic tissues analyzed by a trained horticulturalist or plant pathologist. Such experts will attempt to microscopically observe the

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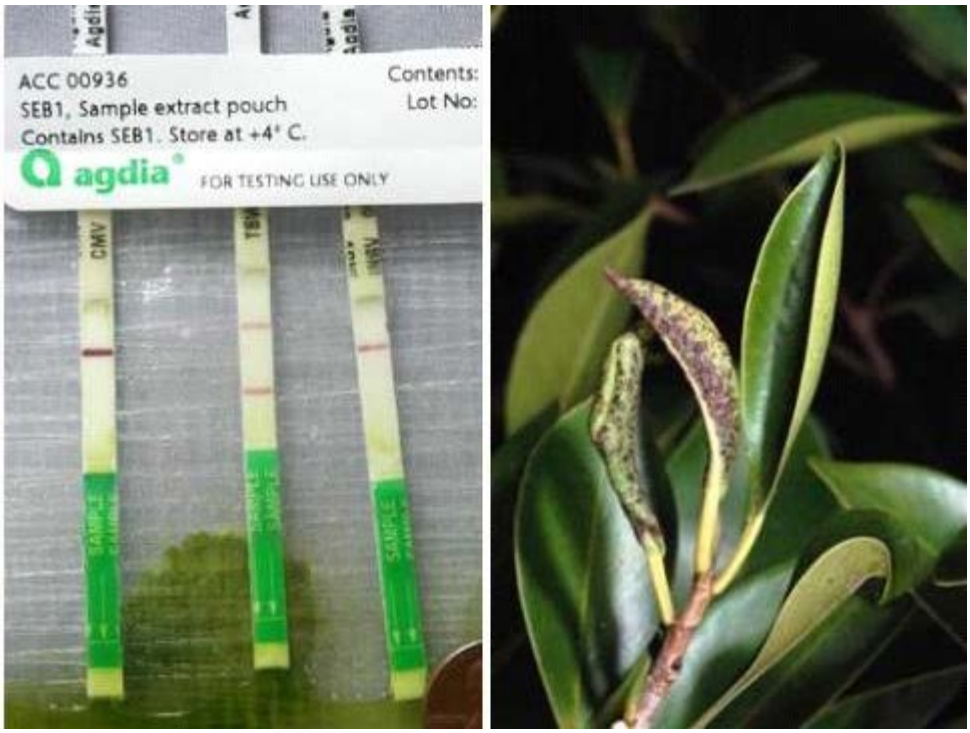
The use of controlled-release fertilizers (CRF) as

agent and recover it, if culturable, through isolation procedures. Lab analysis is particularly important to determine if multiple pathogens are infecting the plant. A downside is that obtaining a diagnosis from lab analysis is not a fast process. However, quick test kits (fig. 1A) are available that can be used to rapidly identify many common diseases in the field. (Editors' note: See Steve Tjosvold's regional report for more details.)



A B

Fig.1. Diagnosing biotic problems. Plant pathogens can sometimes be rapidly diagnosed using commercially available quick tests, such as these test strips for viruses (A). Arthropod pests such as Cuban laurel thrips (shown here on *Ficus*) cause feeding damage, which can help in pest identification (B). *Photos*: S.T. Koike (A), J. K. Clark (B).

It is worthwhile to emphasize that diagnosing plant diseases requires careful examination of the entire plant specimen. Symptoms on leaves, stems, or other above ground plant parts might lead one to suspect that a foliar pathogen is involved. However, these symptoms could also result if the roots are diseased. Therefore, it is important to conduct a complete examination of the symptomatic plant.

Because biotic diseases are caused by living microorganisms, the collecting and handling of samples is particularly critical. Samples that are stored for too long a time after collecting or that are allowed to dry out or become hot (if left inside a vehicle, for example) will sometimes cause the pathogen in the sample to die, making pathogen recovery and identification impossible. Plants that have been diseased for a long time and that are in the late stages of disease development will often be colonized by nonpathogenic saprophytic organisms. If these tissues are collected, it will be difficult to recover the primary

pathogen of concern because of the presence of these secondary decay organisms. Root samples should be collected carefully as diseased roots are sometimes difficult to dig out of the potting mix or soil, are usually colonized by the pathogen as well as secondary agents, and are very sensitive to high temperatures and drying conditions.

Arthropod and other invertebrate pests. Insects, mites, slugs and snails cause damage while feeding on the plant (fig. 1B). Feeding damage is usually associated by the type of feeding characteristics and mouthparts of the insect or pest. For example, mites and insects such as whiteflies, aphids and mealybugs have tubular sucking mouthparts that suck plant fluids, causing buds, leaves, or flowers to discolor, distort, wilt, or drop. Thrips have rasping mouthparts that result in dried out, bleached plant tissue. Caterpillars, weevils, snails and slugs have chewing mouthparts that make holes and cuts in foliage or flowers. They can also prune plant parts and sometimes consume entire plants.

If present, these pests are visible with the naked eye, a 10 X hand lens, or stereomicroscope, all depending upon their size. An assessment of whether the identified arthropod or invertebrate matches the plant damage it is associated with must be determined. Sometimes the identified arthropod or invertebrate may not be the sole problem or could, in fact, be a beneficial organism or insignificant pest.

Aphids, whiteflies, thrips, leafhoppers and some other insects that suck plant juices may vector pathogens such as viruses and phytoplasmas (and to a lesser extent fungi and bacteria). They can feed on infected plants, acquire the pathogen, feed on healthy host plants and transmit the pathogen to the new host. The insects do not necessarily have to be present in large numbers to cause a significant disease outbreak. The insect vectors are not always present at the same time the disease symptoms are being expressed.

The excrement and byproducts from these pests can also provide clues that the pests have been or are actively present. Caterpillars and other chewing pests produce dark excrement or droppings. Greenhouse thrips and plant bugs produce dark, watery, or varnish-like droppings on foliage. Aphids, whiteflies, soft scales, and some other sap-sucking insects excrete excess plant fluids as honeydew, a sticky sap, which provides a medium for the growth of sooty mold.

Diagnosing Abiotic Problems

Nutrient deficiencies and toxicities. Nutrient deficiencies and toxicities reduce shoot growth and leaf size, cause leaf chlorosis (fig.2A), necrosis and dieback of plant parts. However, nutrient deficiencies cannot be reliably diagnosed on the basis of symptoms alone because

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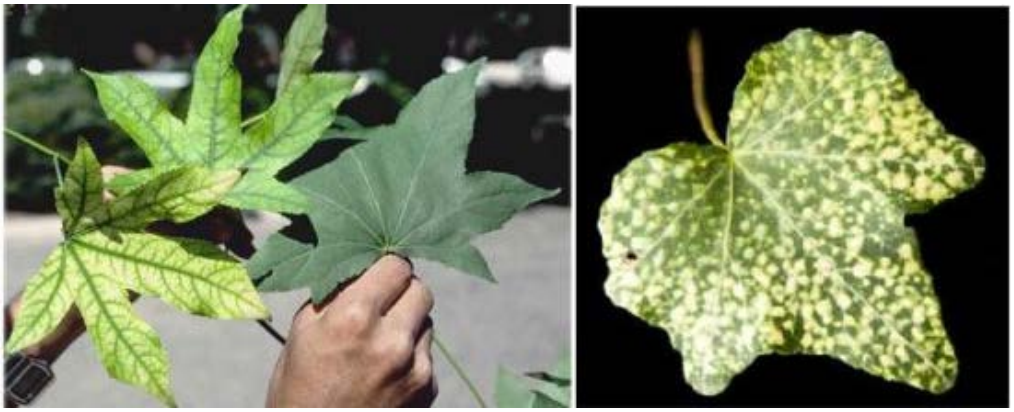
numerous other plant problems can produce similar symptoms. There are general symptoms that can be expressed by deficiencies of nutrients but usually leaf and/or soil samples are needed to confirm the problem.



A B

Fig. 2. Examples of abiotic problems. Iron deficiency on sweet gum (*Liquidambar styracifolia*) showing interveinal chlorosis (A). Chorotic spots on *Hedera* caused by a miticide application at a higher dosage rate than specified on the pesticide label (B). *Photos*: E. Martin (A), S. A. Tjosvold (B).

Herbicide, insecticide and fungicide phytotoxicity. Herbicides used to control weeds in crops or in non-cropped areas sometimes injure ornamental crops when they are not used in accordance with label instructions. Examples include when an herbicide is used in or around sensitive non-target crops, when an herbicide rate is increased above tolerable limits, or when an applicator makes a careless application. By understanding the mode of action of the herbicide, one can determine if the symptom fits an herbicide application. Herbicide detection in affected plants is possible with the help of a specialized laboratory but the analysis can be expensive. To minimize the cost of testing, the laboratory will need to know the suspected herbicide or its chemical group to narrow the analysis.

Insecticides and fungicides occasionally cause obvious plant damage. Symptoms can vary widely. Generally, flower petals are more susceptible to damage from pesticide applications than are leaves. The younger and more tender the leaves the more susceptible they are to pesticide applications. Hot weather can exacerbate the damage the chemicals cause. Pesticides that have systemic action can have a more profound effect. Some active ingredients can adversely affect the photosynthetic mechanism or other physiological processes and can result in a general leaf chlorosis, interveinal chlorosis, leaf curling and stunting. Emulsifiable concentrate (EC) formulations, soaps and

oils can adversely affect the waxy surface layer that protects the leaf from desiccation. Applications with these products can result in the loss of the shiny appearance of a leaf, leaf spotting and necrosis. Pesticides applied as soil drenches can cause poor germination, seedling death, or distorted plant growth.

Check label precautions against use on certain species. Make sure the pesticide is not applied more frequently or at a higher rate (fig. 2B) than recommended, or that the pesticide is not mixed with incompatible pesticides. When in doubt as to whether the plant species is sensitive to the pesticide, spray a few plants and observe them for several days to a week for any signs of damage before spraying any more of the plants.

Physiological and Genetic Disorders

There are numerous disorders that can occur because of environmental extremes — too much or too little of an environmental element such as light, temperature, water, or wind. Sunburn is damage to foliage and other herbaceous plant parts caused by a combination of too much light and heat and insufficient moisture. A yellow or brown area develops on foliage, which then dies beginning in areas between the veins. Sunscald is damage to bark caused by excessive light or heat. Damaged bark becomes cracked and sunken. Frost damage causes shoots, buds and flowers to curl, turn brown or black and die. Hailstones injure leaves, twigs, and in serious cases even the bark. Chilling damage in sensitive plants can cause wilting of foliage and flowers and development of dark water-soaked spots on leaves that can eventually turn light brown or bleached, and die. Physical and mechanical injury can occur when plants are mishandled during transport or routine cultural practices. Wounds might serve as entry sites for plant pathogens and can attract boring insects to woody stems.

In closed environments such as greenhouses and nursery storage areas, plants can be exposed to toxic levels of ethylene gas. Sources of ethylene include improperly functioning or unvented greenhouse heaters; exhaust from engines of forklifts and vehicles; cigarette smoke; damaged, decaying, or dying plants; and ripe or decaying fruit. Toxic levels of ethylene gas can cause premature abscission of flower buds, petals (fig. 3) and leaves. Other symptoms include wilted flowers, chlorosis, twisted growth or downward bending of stems and leaves and undersized or narrow leaves.

A B

Fig. 3. Poor air quality can lead to physiological disorders. Shattering (petal drop) on geranium was caused by plant exposure to low levels of ethylene in the greenhouse or during postharvest storage (A). Yellowish and brownish patches on Japanese maple leaves are damage caused by ozone (B), an outdoor air pollutant. *Photos*: J. K. Clark.

Outdoors, exposure of nursery plants to air pollutant gases such as ozone (fig. 3), carbon monoxide, nitrous oxides and sulfur dioxide can cause damage. Typical symptoms vary widely, but include slow growth and discolored, dying, or prematurely dropping foliage. Damage is often found where plants are located near sources of polluted air such as near freeways or industries or where weather and topography concentrate the pollutants.

Sometimes plants or plant shoots exhibit an unusual and sudden change of color producing discrete markings of variegation. For example, a plant with entirely green leaves suddenly produces a shoot that has leaves with edges lacking green pigment, stripes, or blotches. A new shoot such as this is probably a chimera (fig. 4). It is produced when a genetic mutation occurs in a specific region of the growing tip resulting in a section with genetically different cells. The ostensible result of the genetic change is dependent on the arrangement of the genetically different cells in the shoot tip and their expression. This can lead to sometimes bizarre variegation forms or sometimes forms that are quite desirable. Sometimes variegation can be caused by viruses. Viruses usually cause non-uniform chlorosis, such as mosaics, while chimeras usually produce patterned forms such as variegation of color on leaf margins, stripes, or complete loss of pigment. Some viroids may also cause bleaching of pigments in leaves; such symptoms, however, are generally produced throughout the plant and are not restricted to a single shoot. Some nutrient disorders can cause variegation but these disorders usually do not arise from a specific shoot as with chimeras.

Fig. 4. Genetic disorder. Growing points with variegated leaves can sometimes arise spontaneously from some species such as this *Origanum*. Genetic variants such as this are sometimes confused with plants with virus disease or nutrient deficiency symptoms. *Photo*: S. A. Tjosvold.

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This article was condensed from: Diagnosing Plant Problems, Chapter 11. In Newman, J. (ed) Container Nursery Production and Business Management. Univ. of Calif. Agric. and Nat. Resources. Publication 3540. Richmond, CA.

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Page Last Updated: May 22, 2015