*Colorado Master Gardener*sm *Program*
Colorado Gardener Certificate Training
Colorado State University Extension

GardenNotes #331

Plant Pathology

Outline:

Introduction

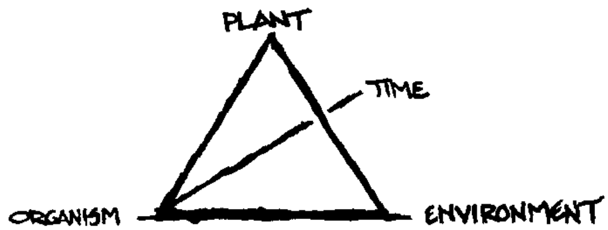
Definition

A plant disease is usually defined as abnormal growth and/or dysfunction of a plant. Diseases are the result of some disturbance in the normal life process of the plant.

Biotic vs. Abiotic – Diseases may be the result of living and/or non-living causes. **Biotic** diseases are caused by living organisms such as fungi, bacteria and viruses. **Abiotic** diseases are caused by environmental conditions.

Plant Disease Pyramid

Specific conditions must be present for biotic disease to develop. There must be a susceptible host, the causal organism, a time component and environmental conditions conducive to disease development. These conditions make up what is called the “Plant Disease Pyramid”. Biotic disease cannot occur if one of these pieces is missing.



Symptoms

Symptoms of disease are the plant’s reaction to the causal agent. Plant symptoms include:

- **Chlorosis –** loss of green color
- **Mosaic –** varying patterns of light and dark plant tissue
- **Necrosis –** dead plant tissue
- **Blight –** sudden death
- **Wilting–** limp, droopy appearance
- **Canker –** sunken, discolored areas on any plant part
- **Stunting –** lack of growth
- **Galls –** localized swellings of plant tissue
- **Distortion –** malformed plant tissue

Insect feeding injury is also a symptom used in diagnosis, but not a symptom of disease.

Even though a plant has symptoms on a specific part, it does not necessarily mean the damaged tissue contains the organism causing the symptoms. For example, a root rot can cause chlorosis and wilting of stems and leaves, BUT the disease causal organism is in the roots. It is imperative to examine as much of the plant as possible to determine exactly where the problem is originating.

Signs

Signs are the actual organisms causing the disease. Signs include:

- **Ooze –** slime like droplets.
- **Mycelium –** thread-like vegetative growth of fungi.
- **Spore masses –** masses of spores, the “seeds” of a fungus
- **Mildew–** whitish growth produced by fungi composed of mycelium
- **Mushrooms –** fleshy reproductive structures of fungi
- **Conks –** woody reproductive structures of fungi
- Insects and/or their frass (excrement) are also signs, although not signs of disease.

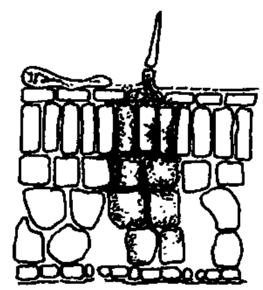
Biotic Disease

Biotic causes of disease include fungi, bacteria, viruses, phytoplasmas, nematodes and parasitic plants.

Fungi

Fungi are organisms that are classified in the Kingdom "Fungi". They lack chlorophyll and conductive tissue. Until a few years ago, fungi were considered lower forms of plants, but today are classified as a group by themselves. Because fungi cannot manufacture their own food (due to lack of chlorophyll), they must obtain it from another source as either a **saprophyte** or **parasite**. Most fungi encountered are saprophytic (feed on decaying organic matter). The parasitic fungi, those that derive their sustenance from living plants, are the group of interest in plant health. Of all the living causes of plant disease in Colorado, the fungi are the most frequently encountered.

A fungus "body" is a branched filamentous structure known as mycelium. One single thread is called a hypha (hyphae, plural). Most fungi reproduce by spores, reproductive structures that unlike seeds contain little stored food. Spores are the main dispersal mechanism of fungi and can remain dormant until germination conditions are appropriate. Many fungi over-winter as fruiting structures embedded in dead plant tissue.



When a spore comes into contact with a susceptible plant it will germinate and enter the host if the proper environmental conditions are present. Hyphae develop from the germinated spore and begin to extract nutrients from host plant cells. The hyphae secrete enzymes to aid in the breakdown of organic materials that are ultimately absorbed through their cell walls. Fungi damage plants by killing cells and/or causing plant stress.

Fungi are spread by wind, water, soil, animals, equipment and in plant material. They enter plants through natural openings such as stomata and lenticels and through wounds from pruning, hail and other mechanical damage. Fungi can also produce enzymes that break down the cuticle, the outer protective covering of plants. Fungi cause a variety of symptoms including leaf spots, leaf curling, galls, rots, wilts, cankers and stem and root rots. Fungi are responsible for "damping off" symptoms associated with seedlings.

Damping Off

Damping off is the fungal infection of seeds or seedlings that leads to death. When infected with damping off, seeds may fail to germinate. In other situations, seedlings develop but eventually fall over and die. An examination of stems at the soil line reveals a discolored, "pinched in" appearance. Most plants are susceptible to damping off because of the soft immature nature of seedling tissue which is more susceptible to infection.

The best method to manage damping off is to avoid it in the first place. Use pasteurized soil or planting mix and ensure that plants are receiving optimum light and water. In home situations, damping off frequently develops due to poor lighting and overwatering. These conditions stress plants and make conditions optimal for the development of the soil-borne organisms that cause damping off. In the garden, plant seeds at appropriate times for the crop and avoid overwatering for optimal germination and growth. A strong healthy plant is better equipped to fight off infection.

Scientists continue to study the role of hyperparasites (parasites of parasites) in disease management. Several biological pesticides have been developed from naturally occurring hyperparasitic fungi and bacteria. The organisms protect plant roots against invasion by harmful soil pathogens. These pesticides must be applied prior to the development of damping off so the beneficial organisms have time to grow and colonize roots. They cannot be used as "rescue" treatments.

Weather plays a large role in fungal disease development. Many fungi require free water or specific levels of humidity or moisture for prolonged periods of time to develop. Dry climates are not conducive to their survival. The Rocky Mountain region has many fewer fungal diseases than many other parts of the United States due to climatic differences. However, gardens and other microclimates may have conditions ideal for disease development due to poor air circulation, shade, high humidity and high moisture.

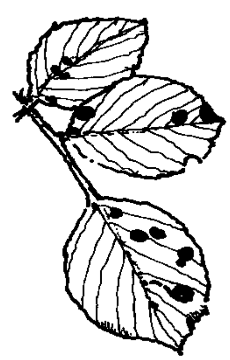
Leaf Spots

Extension Fact Sheets

- ***Aspen and Poplar Leaf Spots***, #2.920
- ***Powdery Mildew***, #2.902

One of the most common fungal plant symptoms is leaf spotting. Leaf spot symptoms are caused by many different fungi. Generally, fungal leaf spots possess a distinct dark brown or red margin between the interior (dead) and exterior (healthy green) tissue called a *border*.

Fungal fruiting structures (reproductive structures) are usually embedded in the dead interior. Frequently a "halo", a yellow or red colored area, develops around the border. A halo indicates recently killed tissue that will eventually die. Because of the cycle of killing tissue, creating a border, killing more tissue and creating another border, many fungal leaf spots take on a target-like appearance.

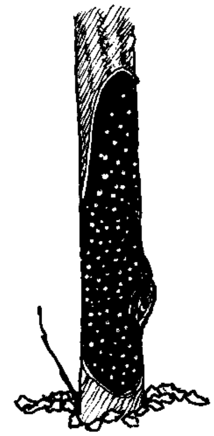


Fungal leaf spot

To confuse matters, a series of drought events can cause damage that exhibits alternating light and dark bands. Additionally, fruiting structures may not be obvious in Colorado's dry climate. To positively identify a fungal leaf spot, it is best to either culture tissue from the sample or look for spores under a compound microscope.

Cankers

<u>Extension Fact Sheets</u>
- ***Cytospora Canker,*** #2.937


Fungal canker

Cankers are discolored, sunken areas usually found on plant stems, branches, and trunks. They damage plants by killing the conductive tissue. Cankers may be caused by fungi, bacteria, virus and abiotics such as sunscald and hail.

Fungal cankers contain fruiting structures embedded in the discolored canker. Plants with cankers may exhibit branch dieback, leaf loss and/or poor growth above the damaged area.

Common Colorado canker diseases include *Cytospora sp.*, *Thyronectria sp.* (fungi) and fireblight (*Erwinia amylovora*), a bacterium.

Root Rots

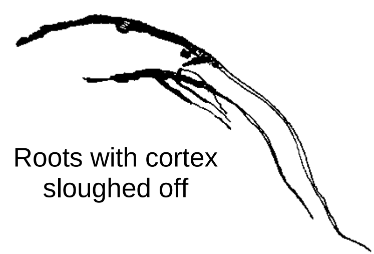
Root rots damage plants by stressing or killing root systems. Two common soil-inhabiting fungi that cause root rots include *Fusarium sp*. and *Rhizoctonia sp*.

Root symptoms of these (and other soil-borne) fungi include darkening, limpness and mushiness. Rotted roots may break off easily. The cortex (the outer protective covering) of roots sloughs off, leaving behind the thread-like root core.

Leaves, stems and entire plants may wilt, prompting one to think that the plant simply needs more water. (Unfortunately additional water often makes the problem worse.)

Generally, the lower, interior leaves turn yellow, then brown and drop off. In addition, plants may be stunted. If enough roots are damaged, the plant eventually dies.

There are no root-rot resistant plants. Management strategies include avoiding overwatering and improving soil drainage. Roots stressed from overwatering (or oxygen starvation) easily succumb to root rots, since the organisms move through moist soil and water.


Roots with cortex sloughed off

Sometimes a plant with root rot may be salvaged by cutting off damaged roots and replanting in well-drained soil. Biological pesticides containing hyperparasites may help protect against root rot. These products are not designed to “rescue” plants from ongoing damage, but act as preventives.

In the Green Industry, root rots can be managed with a combination of the cultural management strategies and through the use of fungicides. Because not all fungicides kill all root rot fungi, it is essential to determine which root rot organism is causing the problem through microscopic examination, so the correct product can be recommended.

Bacteria

Extension Fact Sheets

- ***Fireblight***, #2.907

Bacteria are single-celled microorganisms. They contain no nucleus and reproduce by dividing in two equal parts (fission). As a result they multiply and mutate rapidly. Bacteria function as either parasites or saprophytes.

Bacteria dividing

Bacteria can infect all plant parts. Unlike fungi, bacterial must find a natural opening for entry. Bacterial cells can move from one plant to another in water, soil and plant material, just as fungi do. However, bacterial pathogens are more dependent upon water. Conditions must be very wet and/or humid for them to cause significant and widespread damage.

Bacteria move between plant cells and secrete substances that degrade plant cell walls so the contents can be utilized. Some produce enzymes that break down plant tissue, creating soft rots or water-soaking.

Bacterial leaf spots appear different than fungal ones due to their intercellular movement. Veins often limit the development of a lesion, so they appear angular or irregular, not round.

Bacterial diseases are not common in the Rocky Mountain region due to lack of natural moisture. Like the fungi, bacteria cause symptoms such as leaf blights and spots, galls, cankers, wilts and stem rots.

It's difficult for beginners to tell fungal and bacterial plant symptoms apart. The following chart may be used to help distinguish symptoms caused by these pathogens.

Symptom Description	**Fungi**	**Bacteria**
Water-soaked appearance	No	Yes
Texture	Dry, papery	Slimy, sticky
Smell	No	Yes
Pattern	Circular, target-like	Irregular, angular
Disintegration	No	Yes
Color changes	Red, yellow, purple halos	No
Structures of pathogen	Mycelia, spores, fruiting structures	No

Viruses

Extension Fact Sheets

- ***Greenhouse Plant Viruses***,#2.947
- ***Recognizing Tomato Problems***, #2.949

Viruses are crystalline particles composed of nucleic acid (RNA or DNA) and protein. They are obligate parasites, meaning they are unable to survive outside of their host. Small virus particles can be found in all plant parts and they cannot be seen without an electron microscope.

To move from plant to plant, the particles must be transmitted by vectors and through a wound. The vector is typically an insect, nematode or human. Insects and nematodes spread viruses between plants as they feed on them. The feeding injury creates the necessary wound. Usually a plant virus is spread by only one kind of insect vector. Aphids, leafhoppers and thrips are examples of virus vectors, but not all aphids or all leafhoppers or all thrips spread virus.

Humans may spread plant viruses as they work in the garden. Mechanical abrasion from infected tools or touching and abrading plants with infected hands may be all that's needed.

Viruses overwinter in infected perennial plants or overwintering insects. A small portion of viruses can be transmitted through seeds. Some are transmitted through vegetative propagation.

Viruses cause mottling of leaves and fruits, spots and mosaic-like patterns on leaves and fruits, crinkling, malformation and stunting. Because viruses are systemic, infected plants must be rogued or discarded.

Viruses are named according to the first plant on which they were found and the type of symptom they cause (i.e., "Peony Ringspot Virus", "Rose Mosaic Virus").

Phytoplasmas

Phytoplasmas are classified as bacteria; however, they lack a cell wall and can take on a variety of shapes. They are obligate parasites, meaning they can only survive within their host. Phytoplasmas live in the phloem of plants and are vectored by certain phloem feeding-insects, such as leafhoppers. This pathogen causes distortion, yellowing, wilting and "***witches' brooms***" (a proliferation of growth). Immature leaf veins may appear clear (called "vein-clearing"). Flower parts may become vegetative and flowers that do develop produce sterile seeds.

Aster Yellows

Aster yellows damages over 300 species of broad-leafed herbaceous plants nationwide. Commonly affected flowering plants include *Echinacea sp*. (purple coneflower), cosmos, marigolds, asters, chrysanthemums, delphiniums, daisies, coreopsis and zinnias. Vegetables affected include carrots, lettuce and potatoes. Weeds such as dandelion, ragweed, plantain, wild lettuce and thistles may also be infected.

Aster Yellows is spread by the aster (or six-spotted) leafhopper. These insects are small (1/8 inch long), gray-green and wedge shaped. They are called leafhoppers because they move or fly away quickly when plants are disturbed. They feed only on plant sap (phloem tissue) and generally on leaf undersides.

Aster leafhoppers do not over-winter due to the cold climate, but are blown locally from the Gulf of Mexico in late spring or early summer. Once a leafhopper feeds on an infected plant, about 10 days to 3 weeks must elapse for the insect to become infective. Plant symptoms appear 10-40 days after infection. Dry weather can cause increased disease in the home garden as leafhoppers move from plants in prairies and pastures to irrigated yards. Generally, aster yellows symptoms appear in mid to late summer.

Although aster leafhoppers spread the disease, placing infected plants in the yard spreads it, too. Management strategies for aster yellows include planting healthy plants, controlling weeds that may harbor the insects and removal of infected plants. Even though only one part of a plant appears infected, one must assume the phytoplasma is throughout the entire plant.

The pathogen can over-winter in plant crowns and roots. Leaves and stems that develop from this tissue will always be infected and provide a source of inoculum for other susceptible plants. Insecticidal control of aster leafhoppers is very difficult as they are constantly moving in and out of the garden, so is not recommended.

Parasitic Plants

Extension Fact Sheets

- ***Mistletoe In Colorado Conifers***, #2.925

More than 2500 species of higher plants are known to live parasitically on other plants. Parasitic plants produce flowers and reproduce by seeds like other plants. The main difference is they cannot produce their own chlorophyll or produce only a small amount of chlorophyll. They must obtain sustenance from a chlorophyll-producing plant to survive. Parasitic plants are spread in various ways including animals, wind and forcible ejection of their seeds.

Dwarf mistletoe and dodder are two examples of parasitic plants encountered in Colorado. Dwarf mistletoe has chlorophyll but no roots and depends on its host for water and minerals although it can produce carbohydrates in its green stems and leaves. Dodder cannot produce its own chlorophyll and completely depends on its host for sustenance.


Dwarf mistletoe on branch

Plants damaged by parasitic plants appear wilted, stunted, distorted and chlorotic. Some plants, particularly conifers, develop witches' broom symptoms.

Nematodes

Nematode

Nematodes are microscopic roundworms that live in soil, water and plant material. They have a spear-like stylet mouthpart, require free water to move about and reproduce by eggs. They spread in water, infected plant material, soil and in some cases, insects.

Nematodes cause a variety of symptoms including stunting, yellowing and wilting of plant tissue. Some infected plants simply appear unthrifty. Some develop strange, knot-like growths on their roots. Many saprophytic and parasitic species exist. Nematodes as plant pathogens are uncommon problems in Colorado landscape plantings.

Pinewood nematode (*Bursaphelenchus xylophilus*) is a North American native nematode that invades exotic pines such as Austrian, black, and Scots pines.

Pinewood nematode causes pine wilt disease. The symptoms include needle necrosis, branch flagging, and eventual tree death. Trees may decline rapidly; whole tree death can occur in two weeks.

Pinewood nematodes are vectored two ways. The primary transmission is by maturation feeding of adult pine sawyer beetles (*Monochamus sp.*) on susceptible trees. Secondary transmission occurs when adult female pine sawyer beetles oviposit, or lay eggs, into phloem of susceptible trees. If this disease is suspected as the cause of pine tree death, samples must be sent to a diagnostic laboratory to accurately diagnose pine wilt disease.

Foliar nematodes are found occasionally in irrigated Colorado landscapes. They have a broad host range and can infect many plant species but especially anemome and chrysanthemum.

General Management of Biotic Plant Disease

Plant disease is best managed through an integrated approach which includes a combination of cultural, mechanical, biological and chemical practices.

Cultural management includes appropriate plant selection**.** Utilize plants that perform well in the local climate. Use disease resistant varieties when possible. Plant certified seed or seed pieces.

Place plants in the appropriate environment for optimum growth. For example, grow shade loving plants in the shade, not hot sun. Prepare soil before planting to improve root growth, reduce compaction in clay soils and improve water holding of sandy soils. Apply fertilizer and water according to plant needs. Prune correctly, as needed and at the correct time of year.

Mechanical management techniques include rototilling in the fall, which exposes pathogens, insect eggs and weed seeds to cold winter temperatures. This action also speeds the decomposition of crop residues, improving soil organic matter.

Clean up or prune out infested plant materials to reduce the source of inoculum on the property.

Rotate crops when possible to starve pathogens. For example, avoid planting solonaceous crops in the same area as pathogens specific to this group may build up in soil and infect new crops.

Apply mulch in gardens. Not only does this keep soil moister and cooler (helping roots thrive), it also creates a splash barrier against soil pathogens or pathogens on plant debris in the soil. Use soil solarization to reduce soil pathogens and weed seeds. Pull weeds and volunteer seedlings that hog precious water but also serve as a reservoir for pathogens and insects. Core-aerate turf once or twice yearly.

Biological controls include the use of compost, compost teas and hyperparasite products which may reduce pathogens by introducing beneficial microbes. Encourage beneficial insects by planting flowering plants attractive to all stages of development. Avoid blanket applications of pesticides which may kill beneficials in addition to harmful insects. Spot treat pest problems instead.

Chemical control refers to the use of chemical fungicides, insecticides and herbicides to manage a problem. Always first identify the cause of a plant problem. Then select and use a product appropriate for the problem and follow label directions. Apply it at the correct time using the recommended method. Always spot treat.

Abiotic Disorders

Extension Fact Sheets

- ***Healthy Roots and Healthy Trees***, #2.926
- ***Environmental Disorders of Woody Plants***, #2.932

Abiotic agents of disease are non-living factors and do not have signs associated with the disease. In diagnosis, the first question to answer is, “are the symptoms associated with signs?” If the answer is “no,” then explore abiotic causal agents. Abiotic agents are noninfectious and non-transmissible. Plant diseases deriving from these agents have been referred to as physiological diseases, or environmental diseases.

After analyzing the plant sample and not finding any signs of disease or insect, refer to examine the possibility of abiotic causes.

Water Management

One of the major causes of abiotic plant disorders is improper water application. Too much water can be just as damaging as not enough, since both kill roots. Examples of abiotic disorders related to water are leaf scorch, winter desiccation and oxygen starvation.

Leaf Scorch

Symptoms of leaf scorch include necrosis (browning) of leaf edges and/or between the veins. These are naturally the least hydrated areas of a deciduous leaf, so when moisture is lost, symptoms appear there first. Needled evergreens scorch symptoms appear as necrosis from the needle tips downward in a uniform pattern. The initial reaction to these symptoms is to provide more water, but that may only exacerbate the situation depending on what is causing scorch in the first place.


Leaf scorch

There are several causes of leaf scorch. There may not be enough water in the soil for root absorption. This occurs during drought periods as Colorado experienced in the early 2000's and during winter when soil water is frozen.

Water may be lost faster than it can be replaced. Warm, windy and sunny weather during winter months causes rapid transpiration at a time when soil moisture may be frozen. During summer, sunny, hot and windy weather causes such rapid transpiration that roots cannot physically keep up with the water loss.

Soil water may be available, but roots may not be functioning properly to absorb it. What causes roots to function poorly? Soil may be so compacted that roots cannot adequately explore soil for nutrients and moisture. Roots may be severed or otherwise damaged from construction activities. Planting too deep limits oxygen availability for roots and stresses or kills them. A thick layer of mulch or black plastic covering root systems also injures them due to oxygen deprivation.

Mechanical damage on lower stems or trunks from mowing equipment, improper planting, improper staking, animal chewing or boring insects may also prevent or slow water uptake. ***The bottom line is that more water is lost than can easily be replaced.***

Oxygen Starvation

Oxygen starvation occurs when excess water in the soil drives out oxygen, in effect "suffocating" roots. Plants respond by dropping the lower leaves that are usually yellowed or necrotic. Leaf loss is most noticeable from the inside of the plant out and the bottom up. In addition, leaves may be smaller than normal, growth increments may be small and the plant may have an overall unthrifty appearance. While oxygen starvation causes root damage, the first clue that something is wrong appears on the canopy, stems and branches. These parts are the furthest from the water source, so the symptoms appear there first.

To control problems caused by water management issues, identify the likely causes and correct them if possible. This will require some detective work to determine which factor or (usually) combination of factors is causing the problem.

Management strategies are based on good horticultural practices. For example, add organic matter to vegetable and flower gardens before planting to improve drainage as well as water holding capacity. Cut back on water applications or the quantity of the water applied. Apply more water or increase the amount of water applied. Core aerate turf, which will also benefit tree roots growing in it. Apply and maintain mulch at levels appropriate for the material used. Pull much away from tree and shrub trunks a couple of inches. Remove any black plastic in the landscape.

Weather

Winter desiccation is not related to hot temperatures but by dry winter winds which encourage leaf water loss. Water cannot be replaced in the plant because the soil is too cold and roots can't absorb it. Symptoms of winter desiccation include necrotic leaf or needle tissue (typically from the tips inward), discoloration of needle or leaf tissue, and patchy damage distribution on individual plants in windy locations. Plants may not exhibit symptoms until the following summer when droughty summer conditions ensue.

To deter winter desiccation, apply water monthly from November 1 to March 1 in the absence of snow cover or sufficient snowmelt or rainfall. Research shows that the water most important to good plant health is applied in the fall months. Roots are still active and can absorb water until soil temperatures drop below 40^{o} F.

Temperature

Temperatures below optimal plant growth cause plant damage. The amount and type of damage depends on how quickly temperatures drop, the lowest temperature reached, and how long cold temperatures are sustained. Freeze injury may be caused by frost crystals that form in the freezing water outside of plant tissues or by freezing water inside plant cells. Damage from the latter is much more severe and resembles herbicide phytotoxicity, bacterial blight, and branch flagging due to insect borer activity.

Spring freezes damage exterior buds first, as these are the first to deharden. Fall freezes affect interior buds first as these are the last to harden. Damage of tissues is uniform. For example, newly developing conifer needles may be killed completely or from the tips inward.

Temperatures above optimal growth cause plant damage as well. The severest injury occurs on leaves that are exposed to the sun and tissue that is furthest away from water such as outer branch tips, leaf margins and in between leaf veins.

Chemical Injury

Chemical injury is plant damage caused by pesticides, fertilizers, de-icing salts and other products.

> Example 1. The client says, "Why has my spruce tree has turned a different color after the Certified Arborist sprayed horticultural oil to control the Douglas Fir tussock moth?

Herbicides

Herbicides damage plant tissues by causing symptoms such as chlorosis, necrosis, distortion and elongated growth. Glyphosate, dicamba, and 2,4-D are examples of common herbicides that cause chemical injury to desirable plants when not used correctly.

Herbicides that behave like plant growth regulators (PGRs) such as **dicamba** and **2,4-D** translocate through both the xylem and phloem. They stimulate growth such as cell division, elongation and fruit and flower production.

Excessive concentrations of these chemicals cause twisting and curling of stems, stem swelling, weakened cell walls, rapid cell growth, cellular and vascular damage and death. Grasses are not affected by PGRs apparently due to a different arrangement of vascular bundles (xylem and phloem).

Glyphosate is an amino acid inhibitor that interferes with synthesis of certain amino acids needed to build proteins. Glyphosate moves through the phloem to the new growth of shoots and roots. Injury symptoms include chlorosis, shortened internodes (compact growth or stunting), stem proliferation, and mimics damage caused by 2, 4-D, and other PGRs, viruses, phytoplasmas, eriophyid mites and environmental factors.

Fertilizers

An excess or shortage of the seventeen essential elements required for plant growth and development may cause plant damage. Excess amounts of fertilizers can "burn" plants due to the level of salts in fertilizers.

Symptoms of fertilizer damage include leaf margin necrosis (similar to drought stress in appearance), leaf discoloration, soft rapid growth and vegetative growth at the expense of flower and fruit production.

Nutrient deficiencies include chlorosis, interveinal chlorosis, blossom-end rot, stunting and purpling. Symptoms of nutrient excesses and deficiencies may be confused with disease, insect, mite or environmental problems. If a soil nutritional problem or salt injury is suspected, have the soil tested.

When excess fertilizer has been applied, apply water in an effort to leach salts from the root zone. Quick release fertilizers are more prone to "burn" plants. Follow label directions when applying fertilizers to avoid plant damage.

De-Icing Salts

It is common practice in Colorado to use de-icing salts to remove snow and ice from roadways and sidewalks. Salts injure plants either from 1) root absorption of direct salt spray or 2) soil build-up which deteriorates soil structure, interfering with drainage and root growth. Symptoms include stem and leaf deformities, witches' brooms and twig dieback of deciduous plants. Conifers exhibit needle browning at the tips of branches. Salt spray damage is only noticeable on the plant side adjacent to a road.

Symptoms of salt accumulation in soils are different than salt spray and include marginal leaf scorch, stunting and twig dieback. Leaf scorch may not appear until later in the season or in following seasons.

To reduce salt burn, avoid de-icing salts or use alternatives such as calcium chloride, add organic matter and charcoal to the soil and leach with water, or protect plants using a barrier that will keep salt-laden snow away from plant material.

Plant Disease Diagnosis

Generic steps in the diagnostic process include the following:

1. Identify the plant.
2. Identify the problem(s).
   a. LOOK – Define the problem by describing the signs and symptoms.
      1) Identify "normal" characteristics of the plant
      2) A systematic evaluation of the plant helps organize questions in a methodical process.
   b. READ – Distinguish between possible causes by comparing signs and symptoms with details in reference materials.
   c. COMPARE – Determine probable cause(s) through comparison and elimination.
3. Evaluate significance of the problem/disorder.
   a. What type of damage/stress does this disorder/pest cause?
   b. Under what situations would management efforts be warranted?
   c. Are management efforts warranted for this situation?
4. Evaluate management options effective for this disorder/pest and when they are applied.

Determining the causal agent of plant damage can be a tumultuous endeavor, so let us expand on content around step 2, Identify the problem(s). Taking a systematic approach when diagnosing plant damage and determination will become easier (see Chart 1). The probability of correctly diagnosing plant damage based on one or two symptoms is low. In contrast, probability of correctly diagnosing plant damage based on many symptoms and factors is high. Therefore, using investigative skills and asking many questions is imperative to arriving at a correct diagnosis.

Sample Questions

Accurate diagnosis is absolutely dependent on accurate observation. When making observations we must ask the following questions:

1. What symptoms is the plant expressing?
2. How many plants are affected?
3. Is there a pattern associated with the problem? (i.e. is the problem located in one area; such as a low area, on the north side, south side, etc.)
4. Are there any differences in susceptibility of varieties or species? (i.e. is it just the tomatoes or are other plants affected too?)
5. Ask about obvious causes first, such as animals, frost, flooding, or mechanical damage.
6. Determine which part of the plant is actually damaged. Wilts, for instance, frequently are only a response to some damage to the roots. Dieback of branches is sometimes caused by cankers or mechanical damage further down the stem.
7. Are the roots healthy appearing (not black or mushy) and moist? NOTE: You may not be able to diagnose the problem without roots.
8. What about the texture and wetness of the soil? Is it too heavy, sandy or compacted? Is salt crusting evident?
9. What is the weed population? (They may indicate a particular soil problem.)

10. Find out as much as possible about the previous history: fertilizer, pesticides, land leveling, cultivation methods, irrigation schedules and climatic conditions.
11. There are many other questions that you may think to ask based on the specific sample in question. REMEMBER, WE CAN NEVER ASK ENOUGH QUESTIONS. THE MORE THOUROUGH YOU ARE, THE BETTER THE DIAGNOSIS.

Identify Plant and Its Normal Characteristics

Determine what the “normal” plant would look like during that time of year. Describe the damage using terms like “gall”, “witches broom”, “chlorotic.” Establish the location on the plant where initial damage occurred. For example, there are leaf spots with fruiting structures on the underside of leaves, but these symptoms are not what caused tree death. Cankers along the branches and trunk are what killed the tree.

Example 1. The spruce sample is exhibiting interior needle loss in the fall. What is the diagnosis?

Distinguishing the factor that caused plant death from other symptoms and signs can be tricky. In turfgrass, many times sclerotia, fruiting bodies, and conidia are spotted in necrotic and problematic areas. But these disease-causing structures may not be related to turfgrass death.

Identify Pattern of Plant Damage

Uniform damage patterns on individual plants and on many different plants in a specific area are typically characteristic of nonliving or abiotic factors. Abiotic factors include mechanical, physical, or chemical factors.

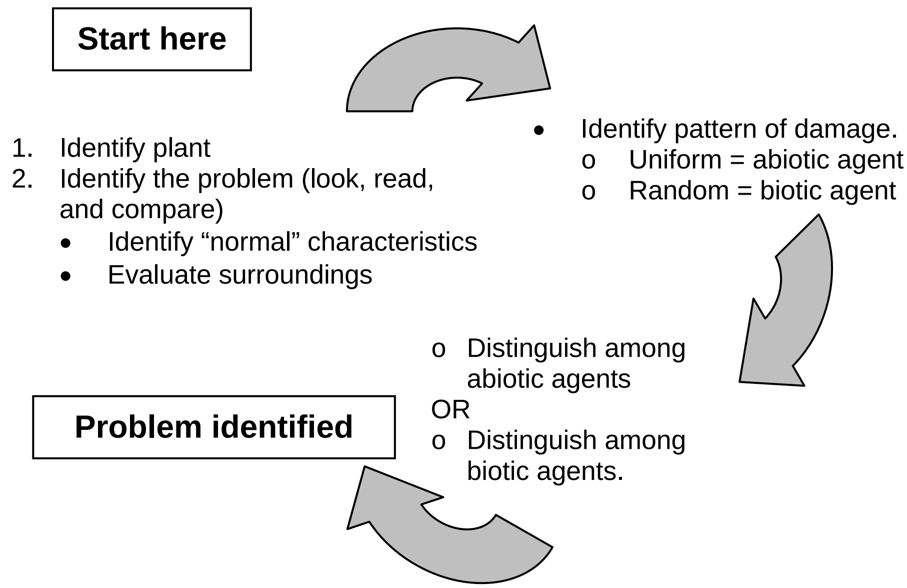
Random damage patterns on individual plants or on a specific family or genus of plants typically indicates a living or biotic agent of disease. Biotic factors include fungi, bacteria, or nematodes.


Random pattern of damage


Uniform pattern of damage

Important Note: You may come to a diagnosis based on the answers a client provided, but when double checking the diagnosis, you may realize the diagnosis doesn’t seem quite right. Keep an open mind, go back through your questions, and take a different diagnostic avenue.

Chart 1. A flow chart displaying the systematic approach to determining causal agents of plant damage.



<u>Distinguish Between Biotic and Abiotic Factors</u>

Signs of biotic pathogen activity will always be present. It is a matter of whether the sign is observed. First, closely study plant damage. Mentally identify possible causal agents. Then look for signs that would accompany such damage. Signs of disease include fruiting structures, overwintering structures, mycelium, insect frass or carcasses, and ooze. Because some diseases are vectored by insects, signs that the vectors are present are equally as important as finding signs of the disease. Also, some types of disease symptoms mimic symptoms of insect or vertebrate damage. It is critical, therefore, to distinguish between insect and pathogen damage using observed or unobserved signs of both insects and pathogens.

If no signs are observed, abiotic activity should be considered. Ask questions regarding mechanical, physical, and chemical factors affecting the damaged plant. Mechanical factors include string trimmer damage to tree trunks, improper pruning cuts, injury during transportation of plant material and guy wire damage. Physical factors include temperature extremes, light differentials and extreme changes in oxygen and moisture levels. Chemical factors include pesticide damage, fertilizer damage, nutritional disorders and pollutants.

Author: Mary Small, Colorado State University Extension.

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