Plant Disorders and Disease

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Plant Disorder/Disease Defined

A plant disorder is defined as any abnormal growth and development of a plant. The growth and development of the plant does not live up to the normal expectations, it is incapable of carrying out its normal physiological functions to the best of its genetic potential. Plant disease is a disorder specifically caused by an infectious microorganism.

Basic Concepts In Plant Pathology

Many different living and nonliving entities can have a negative affect on plants.

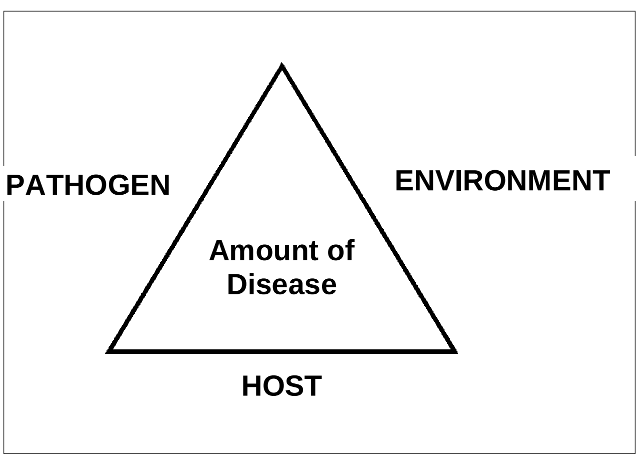
Infectious Diseases

(caused by biotic organisms): Fungi, Prokaryotes: Bacteria, Phytoplasmas, Viruses and viroids, Nematodes, Parasitic Higher Plants

Non-Infectious

(caused by abiotic factors): Examples: Temperature extremes, Moisture extremes, Light extremes, Nutrient extremes, Soil acidity or alkalinity (salt problems), Pesticide toxicity, Air conditions: pollution, strong winds, etc., Improper cultural practices

A disease episode requires the interaction of three components: the host, the pathogen and the environment. This interaction is known as The Disease Triangle.



The host must be susceptible to disease. That is, the plant must be at the proper age and in a certain physiological state for infection and development of disease to occur. Strong growing, vigorous, non-stressed plants are less susceptible to disease than plants under stress.

The pathogen must be virulent (aggressive and able to cause disease), not in a state of dormancy. While one fungal spore or bacterial cell can cause disease, reality is that the pathogen must be present in a certain minimum population level for disease to occur.

The environment must be conducive (favorable) for the development of disease: Temperature, moisture, nutrients, wind, etc. must all favor the pathogen.

Some diseases (notably those caused by viruses) require a vector (transmitting agent) for infection. In these cases, the vector is an additional component of this interaction.

The degree to which these three components interact, relates to the severity of the disease episode (e.g., if the host is highly susceptible, the pathogen highly virulent and the environment highly conducive, then the disease will be very severe). The longer the environment remains favorable for disease development, the greater the severity of the disease.

Successful disease control depends on the integrated use of available control methods.
Symptoms and Signs
Symptoms are the visual response of the plant to attack by a disease-causing agent.
Examples: leaf spots, wilting, stunting, chlorosis, necrosis, etc.
Symptoms are non-specific.
Symptoms change over time.
Symptoms often develop away from the site of the infection. For example, above ground symptoms of water and nutrient stress occur when roots are damaged.

Signs are the visual presence of some structure formed by the pathogen on the host.
Examples: mycelium, spores, fruiting bodies, bacterial ooze, etc.

Organisms Associated with Diseased Tissue

Primary organism - the organism is directly responsible for the disease.

Secondary organism(s) - the organism(s) is taking advantage of weakened tissue.

Multiple infections, disease complexes and organism succession.

Multiple infections occur when a plant is infected by more than one pathogen at a time. These pathogens are operating independently from one another.

Disease complex refers to the situation where the disease is caused by more than one organism. In this case, each of the pathogens in the complex must be present for disease to occur. Disease complexes are especially common in turf.

Organism succession refers to the fact that plants are colonized over time-by many different organisms. For example, when plants are healthy, they are colonized by nonpathogenic symbionts. These saprophytes are in constant association with healthy plants. When the plants become diseased, they are first colonized by primary pathogens, then by secondary organisms, and eventually by other saprophytes. The primary disease-causing agent is only operating by itself for a short period of time. Secondary organisms (weak-pathogens or pathogens) quickly invade the weakened tissue. Weak pathogens are organisms that are not aggressive and (typically) do not cause disease by themselves.

Multiple infections and disease complexes add to difficulty in disease management as identification and control of one organism may accelerate activity of another organism in the complex.

Organism succession makes primary pathogen identification difficult. Diseased plant specimens must be examined relatively quickly after symptoms begin; otherwise, secondary pathogens or saprophytes are all that can be found. Accurate diagnosis of the causal agent is required for effective use of management strategies in general and specifically for effective chemical control. Use of an inappropriate chemical will not only be ineffective against the disease agent, but can also lead to additional disease problems by killing beneficial microorganisms in the environment.

Diagnosing Plant Diseases

Diagnosis is the process of determining the cause of a plant disorder. The process requires a blending of science, experience, observation and art. Diagnosis is a cooperative effort between the grower and the plant expert. Accurate diagnosis depends on routine observation of plants and early detection of problems, examination of good plant specimens, and obtaining accurate information. Factors such as non-specific symptoms, biotic and abiotic problems occurring simultaneously, and multiple infections complicate the diagnostic process. Additionally, it is important to keep an open mind in evaluating plant problems. Getting a mindset is one of the biggest obstacles to an accurate diagnosis.

Elements of Diagnosis
Identify the plant species affected: genus, species, and cultivar (whenever possible).
In a mixed turf stand, identify the species and which are diseased or not diseased.
In the landscape, note if (and what) other types of plants are affected.
Observe and describe the symptoms. Be as specific and detailed as possible. If possible, take photographs of the plant and it's environment.
What plant parts are affected?
How long has the plant been showing symptoms?
Did the symptoms appear suddenly, or have they developed gradually over time?
Is the disease spreading or localized? Consider whether or not the disease is spreading on the plant or to other plants.

Determine the environmental conditions prior to and during symptom development.
Temperature - day and night.
Moisture - air (humidity) and soil.
Wind, dust, blowing sand, etc.
Hail.

Determine the growing conditions:
Determine soil type - sand, silt, clay, drainage, etc.
Where is plant growing? Lawn, home garden, organic garden, landscape, courtyard, greenhouse, golf course, commercial nursery, indoors, etc.
What is the exposure - sun, shade, etc?
What is the proximity of the plant to structures such as, other plants, buildings, sidewalks, roads, walls, etc?
What is the irrigation history? How is the water applied, how much is applied, how often, time of day applied, etc.

What is the fertilization history? What type of fertilizer is applied, how is the fertilizer applied, how much, how often, etc.
What is the history of chemical use? What chemicals have been used, how are they applied, how much, how often, etc.

Additional Questions for;

Home gardens: Size of garden, Crop rotation, Proximity to structures.

Lawns: Presence of other plants in or nearby the turf area, Terrain (slope), Age of turf and how it was established (seed, sod, plug), Maintenance practices: mowing, aeration, de-thatching, raking, etc.

Commercial fields: Acreage, Crop Rotation, Past problems in the field, Percent of plants affected and distribution of diseased plants in the field (scattered, one side, in one area, etc.), Proximity to structures, Crops growing nearby.

Microscopic examination of the tissue - dissecting, light and electron microscopy.
Isolation and identification of associated microorganisms.
Plate sample on culture media.
General - water agar, PDA, nutrient media, etc.
Organism specific - bacteria, actinomycetes, fungi, etc.
Selective - type (e.g., group of fungi, such as oomycetes, etc.), genus, etc.
Moist chambers (culture the organism in the host).
Diagnostic kits:
Detection of fungi.
Identification of bacteria.
ELISA for virus detection and identification.

Determine possible causes of the problem. Use diagnostic resources:
APS compendium
UC IPM guides
Extension publications
Host indexes
Reference books: identification of fungi, bacteria, nematodes; plant disease handbooks; textbooks; etc.
Past experience

After diagnosis - what next?

Determine the major contributing factors for disease development.
Identify the means by which the organism -operates and survives (overwinters).
Ask yourself…
Can anything be done now?
Is damage significant to warrant action?
What action should be taken now? Later?
What management practices can the grower/home owner reasonably do? Cost? Equipment? Labor?
Can the problem be avoided in the future? How?
Make recommendations:
Cultural practices
Variety selection
Chemicals

Principles of Plant Disease Control

Avoidance - Avoiding disease by planting at a time when, or in areas where the pathogen is ineffective, rare or absent.
Exclusion - Reducing, inactivating, eliminating or destroying the pathogen at the source.
Protection - Preventing infection by use of a toxicant or other barrier between the host and the pathogen.
Disease Resistance - Use of plant genetic resistance or tolerance.
Therapy - reducing the effect of the pathogen in an already infected plant.
Trap Crop - Establish plants attractive -to insect vectors on the borders or the main crop, then destroy the trap crop and the vector.

Major Plant Disease Control Methods

The following are examples of management tactics used to control plant diseases. These tactics can be used to try to prevent disease or manage disease within plants, however ultimately the key to disease management is prevention.

Cultural Control

Species and cultivar selection.
Sanitation - pruning, removal of debris, removal of diseased plants, sterilizing tools, washing hands, etc.
Use of disease-free planting material.
Choice of planting location.
Time of planting and proper planting techniques.
Choice of irrigation method and schedule.
Choice of fertilizer: type, timing, application method, schedule.
Insect and weed management.
Crop rotation (for vegetables and annuals).

Biological Control

Management of pathogens by other microorganisms.
Occurs naturally, but often not at levels significant to manage serious disease outbreaks.
Beneficial microorganisms may be manipulated by: Stimulating beneficial organisms in the environment with soil amendments or other cultural practices. Adding beneficial organisms to the soil or plant environment.
Fungicides can deplete the population of naturally occurring beneficial fungi and bacteria.
Resistance or Tolerance - host plant genetic control.
Generally the most effective means of control when available.
Must be continually monitored, as pathogens will develop virulence to tolerant plant material.
Tolerance is limited by strain or race specificity in some pathogens.

Chemical Control

Act to eliminate, reduce or remove the pathogen at the source (eradication), to prevent disease (protection), or to cure disease (therapy).
Examples: fungicides, bactericides, nematicides, soil fumigants.
Chemical used must be less toxic to the plant than to the organism(s) they are designed to control.
Most fungicides are actually fungistats, which means that the chemical limits the activity of the fungus, but doesn't kill it. The disease will return when the chemical is no longer active an environment favorable for disease development reoccurs. Thus, management of diseases with fungicides often requires repeat applications.
Effective chemical use depends on: Choosing the right chemical. Applying the chemical in the right way, at the right time, and in the right concentration. Reading and following the label directions very carefully.

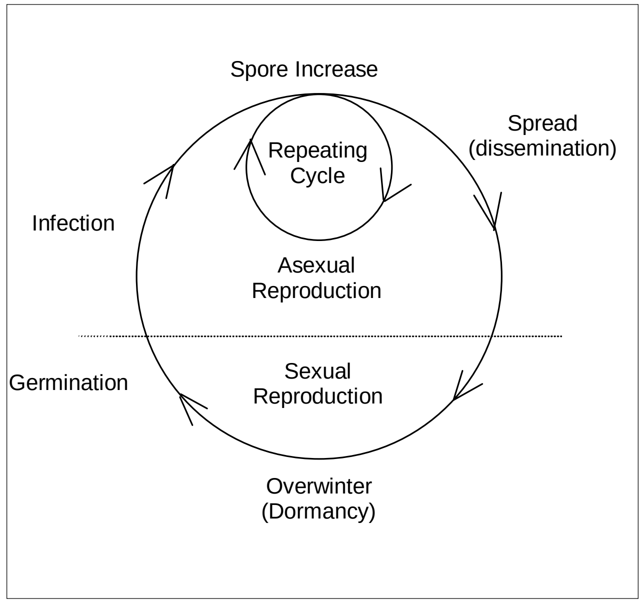
Effective Disease Management

Effective disease management requires knowledge of: The pathogen, it's life cycle, and the environmental conditions needed for disease development. Where pathogens come from. How diseases are spread. How pathogens survive between crops.

This information helps in applying the best management method at the most effective time.

Living organisms go through a life cycle in which part of the time they are dormant. Most organisms are dormant in winter and this time in the life cycle is called "overwintering" (a few organisms "oversummer"). The following is a general fungal life cycle indicating which management principles are most effective at different times.

General Life Cycle



Where do pathogens come from?
Infected planting material:
Contaminated seed – exterior.
Infected seed – interior.
Infected cuttings, graft pieces, buds, and transplants.
Soil.
Water.
Air.

How do diseases spread?
Wind-blown propagules – short and long distances, depending on the type of propagule and the environmental conditions.
Water – rain, irrigation, movement of water through soil (drainage).
Vectors – insects, man (equipment), other animals, fungi, nematodes, mites, parasitic plants.
Self-propelled (typically limited distance).
Fungal hyphae growing between plants.
Motile spores.
Forced discharge of spores into air currents.
Self-propelled movement of nematodes in soil.

How do pathogens survive?

Plant debris.
Soil (as dormant spores and other resting structures).
Living hosts (infected perennial hosts and in annual alternate hosts – weeds).
Vectors (internal).

Infectious Microorganisms

FUNGI

Fungi are the largest group of plant pathogens. They can be thought of as plants that lack chlorophyll; but they are not plants, they are organisms in their own kingdom. Fungi obtain food from other living organisms or from decaying organic matter. Most produce microscopic spores, which can be compared to seeds of higher plants. The spores develop into threads called hyphae, which grow and branch into mycelium or other specialized structures (fruiting bodies).

Fungi enter plants through wounds, natural openings, or by direct penetration through the surface of the plant. The fungal mycelium grows through the plant and eventually produces more spores. These spores can then spread the disease to other susceptible plants. Some fungi have complicated life cycles which require more than one type of spore and/or more than one type of host plant to complete the life cycle.

Fungi are disseminated (spread) by airborne spores (wind currents), soil, water (move in irrigation water or rain splashes), seed, or by vectors. Vectors are agents that transmit diseases from one plant to another. Examples of vectors are: man, other animals, insects, tools, other microorganisms (fungi, nematodes, etc.), etc.

Ornamental Diseases Caused By Fungi (examples):

Powdery Mildew

Powdery mildew is the common name for the disease caused by several different fungi that produce a whitish, powdery growth on the surface of infected plants. Powdery mildews are some of the most common disease worldwide. Almost all plants can be affected by powdery mildew, however each individual fungal species has a somewhat limited host range.

Powdery mildew affects only the above ground parts of the plants; roots are unaffected. Plants severely infected with powdery mildew, particularly year after year, become weakened over time. These plants are more susceptible to adverse environmental conditions, such as winter injury, and other pathogens.

In general, powdery mildew fungi are favored by high humidity in the plant canopy (but are inhibited by water on the leaf surface) and warm temperatures. Cultural practices that increase airflow around plants, thus reducing the humidity in the plant canopy, can help control powdery mildew. Additionally, protective fungicides are available for most plants, however timing of application is important in effective control.

Powdery Mildew of Rose

Powdery mildew of rose, caused by *Sphaerotheca pannosa*, is extremely common worldwide. The fungus attacks young, succulent foliage. The symptoms begin as slightly raised, blister-like, red areas on leaves. Eventually all infected above ground plant parts will develop a white powdery fungal growth.

S. pannosa overwinters in infected canes or buds and in fallen leaves. In spring, new shoots become infected from old mycelium, from conidia (asexual spores) or from ascospores (sexual spores). Conidia and ascospores are disseminated to other susceptible hosts by air currents. The conidia and ascospores germinate and directly penetrate the plant.

Night temperatures between 58-62°F and day temperatures between 65-78°F favor the disease. The fungal spores cannot germinate in free water, but germinate readily when the relative humidity in the plant canopy is high (97-99% at night and 40-70% during the day).

Powdery mildew is managed with good sanitation practices including, pruning out all infected canes, removing fallen leaves, and destroying all infected plant material. Protective fungicide sprays can be used when weather conditions favor disease development. Plants already infected with the fungus can be treated with systemic fungicides, which should help to reduce the spread and activity of the fungus. Be sure to check for registered materials and read and follow the label directions very carefully. In areas where powdery mildew is known to be a severe problem, it is best to plant tolerant varieties.

Other common hosts of powdery mildew fungi include; Euonymus, Photinia, Lilac, Pecan, Verbena, Crepe-Myrtle, Sunflower, Catalpa, Cotoneaster, Holly, Locust, Mesquite, Mulberry, Privet, Mexican Elder, Mexican Evening Primrose, Mexican Bird-of-paradise, Apple, Pear, Phlox, Zinnia, Stone Fruits, tomato, chile, cucurbits and many other vegetables.

Rust Diseases

Rust is the common name for the disease caused by several different fungi that produce dark-colored spore pustules on the surface of infected plants. A wide range of plants can be infected by rust fungi, but most individual rust fungi have a very limited host range. Rust fungi may have up to five different spore stages in their life cycle. Rusts may be autoecious (having only one host) or heteroecious (having two hosts). Heteroecious rusts need both hosts to complete its sexual life cycle, although inoculum can build on one host through asexual reproduction. When two hosts are required to complete the life cycle, one is often considered the "economic host" (the desirable plant) and one is called the "alternate host". In some cases, such as apple-cedar rust, both hosts are "economic hosts".

Like powdery mildews, rust fungi infect only the above ground parts of the plant, and while rust fungi generally do not directly kill their host plants, severe infections may ultimately lead to death by other factors (winter-kill or other diseases).

The presence of spore pustules is a tell-tale sign of rust infection. Spores produced in rust pustules can be carried by wind currents up to several hundred miles. Spores are also moved short distances by wind, insects, rain, and animals. Additional symptoms of rust diseases include, leaf and stem cankers, stunting, yellowing, galls, and a general unsightly appearance of the infected plant.

Rust fungi may be controlled by the integrated use of several different management practices. Removing infected bedding plants or other annuals will help to reduce spread in the garden. Depending on the host, tolerant varieties may be available. Contact and systemic fungicides may help to reduce or prevent disease. Check product labels for appropriate use of these materials.

Black Spot of Rose

Black spot of rose, is a fungal disease caused by *Diplocarpon rosea*. The disease develops in moderate temperatures when moisture is present on the leaf surface. General leaf chlorosis and circular, well defined, black spots on leaves are the most common symptoms. The disease is similar to powdery mildew in that it overwinters in canes and in fallen leaf debris. The fungus germinates in favorable conditions and is spread to susceptible hosts by splashing water or airborne spores.

Sanitation is important in the control of black spot. Rake and destroy fallen leaves and prune out infected canes. Look for tolerant varieties if black spot is a common problem in your area. Also some fungicides are registered for control of this disease. Check fungicide labels for complete instructions before using any chemicals.

Verticillium and Fusarium Wilt Diseases

Verticillium and some *Fusarium* spp. are common soilborne fungi that cause wilt diseases in a wide variety of plants. While they are two distinctly different fungi, the types of diseases they cause and the plants they infect are similar. Plants infected with these fungi become chlorotic and eventually wilt. In the case of Verticillium wilt, the plants may exhibit wilt or chlorosis on only one side of the plant. Infected plants also may have root rot. A helpful diagnostic symptom of these vascular wilt diseases is the presence of vascular discoloration (brown streaks in the xylem tissue).

These fungi survive in soil and crop debris. They are spread by soil, water, wind-blown dust, seed, and infected plant material. *Verticillium* spp. are generally more active at cooler temperatures than *Fusarium* spp.

Both of the fungi exist in many different genetic strains (called races) that vary in their aggressiveness and host range. Thus, a plant can be infected with a mild strain and exhibit chronic, mild to moderate symptoms over a long period. Or, a plant can be infected with a severe strain and be killed within one growing season. Additionally, plants know to be tolerant of the fungus may be tolerant of only one race. When these cultivars are planted where a different race of the pathogen occurs, the tolerance doesn't hold up.

If the plant is infected with a severe strain, there is little that can be done to save the plant. If infected with a mild strain, good water and fertilizer management can help to slow disease development and reduce symptoms. However, the plant is still diseased and will eventually become weakened and should be removed and destroyed.

When replanting an area where a plant has died from this disease, it is best to choose plants that are either non-hosts, or are known to be tolerant to the disease.

Always replant using disease-free seed and planting material. After planting, avoid injury to roots and crown and maintain good strong growth through proper water and fertilizer management.

Fusarium Wilt of Mimosa

Fusarium is a soil-borne fungus that invades trees through the roots. The fungus typically enters through wounds, but may also enter through direct penetration of the roots or plants weakened by abiotic stress. In addition to the typical symptoms listed above, this fungus causes infected Mimosa trees to ooze a frothy liquid from cracks and growth sprouts on trunks. Fungal spores produced on the exterior of the tree are easily washed off by rain or irrigation and can be moved long distance in surface water runoff. Control is dependent on sound cultural practices that help to maintain strong healthy trees. Mimosa trees should not be planted where trees have died from this disease. Some trees tolerant of this fungus include redbud, honey locust, and New Mexico locust.

Phymatotrichum Root Rot

(*only occurs in southern counties in New Mexico: Hidalgo, Luna, Dona Ana, Sierra, Chaves, Eddy and Lea*)
Phymatotrichum root rot (also known as Texas root rot or cotton root rot) is caused by the soil-borne fungus *Phymatotrichopsis omnivorum* (PO). The fungus has an extremely wide host range affecting over 2,300 species of dicotyledonous plants (monocots are not affected, although the fungus has been found to grow and reproduce on some monocots without causing any disease). PO is limited geographically to parts of the United States (parts of Arizona, New Mexico, and Texas) and Mexico. Even within its geographical boundaries, the fungus is spotty in occurrence. The fungus is found in soils that are high in alkalinity and low in organic matter. Spread of the fungus is limited as it does not produce any viable spores, but spreads instead through root grafts between nearby plants.

Symptoms first appear during the summer when air and soil temperatures are high. The first evidence of the disease is a slight yellowing of the leaves. Quickly the leaves turn to a bronze color and begin to wilt. Permanent wilting can occur very rapidly; as little as two weeks from the first expression of disease. Plants infected with PO die rapidly with the leaves remaining firmly attached. In some cases, the tree wilts so quickly that there is little color change, though the leaves become dry and brittle. A reddish lesion develops around the crown of trees killed by this fungus.
The fungus also produces signs on or near infected plants. Strands of fungal hyphae are produced on the surface of infected roots. These strands are usually visible with a good hand lens. When strands are viewed under a light microscope, cruciform (cross-shaped) hyphae unique to this fungus can be seen. Another sign is the formation of a white to tan colored spore mat on the surface of the soil around infected plants. Spore mats develop during periods of high moisture and are not always produced in New Mexico. Spores produced in spore mats have never been germinated, and are considered to have no function in survival or infection by this pathogen. Therefore, spore mats do not spread disease, but are merely evidence of the presence of the fungus.

This disease is very difficult, if not impossible, to control. The fungus survives over 12 feet deep in the soil reducing the effectiveness of soil treatments, such as solarization and fumigation. The fungus can be kept inactive by altering the soil environment (reducing alkalinity and increasing organic matter). The following treatment must be applied very quickly after the first sign of disease.

Steps to manage PO:
Heavily prune back infected trees or shrubs.
Loosen soil underneath the plant out to the drip line.
Cover ground with 2" of composted manure.
Cover manure with ammonium sulfate (1 lb to 10 sq. ft.).
Cover ammonium sulfate with soil sulfur (l lb to 10 sq. ft.).
Soak area with water till water penetrates the soil to a depth of 3-4 ft.
Also treat any adjacent susceptible trees or shrubs even if there are no symptoms.

Keep in mind that soil is a dynamic medium that will revert to its natural properties. As such, the treatment must be repeated each year in order to prevent a reoccurrence of the disease. This treatment is no guarantee of control and is expensive and labor intensive. Avoiding areas known to be infested with the pathogen is the best control measure.

Fungal Leaf Spots

All plants are susceptible to one or more leaf spotting fungi. *Alternaria*, *Phoma*, *Phomopsis*, *Phyllosticta*, *Colletotrichum* and *Septoria* are common leaf spotting fungi that can occur in New Mexico. Leaf spots are characterized by brown or black spots randomly scattered on leaves. The spots may develop in concentric rings, may be surrounded by a yellow halo, or appear darker in the center (due to the presence of fungal fruiting bodies). Leaf spots are favored by high humidity and/or leaf wetness. Spores are spread by rain and wind. Severe infections may cause premature leaf drop, however the fungi do not become systemic inside the host and do not cause progressive disease. Long-term damage to trees and shrubs is typically minimal, unless severe infections occur for several years in a row.

Leaf spots are managed with good sanitation practices – raking and destroying fallen leaves and pruning out over thick growth. Good pruning practices increase air circulation and decrease humidity in the plant canopy, thus reducing the factors that favor the development of the disease. Fungicides can be used, but the damage resulting from these fungi typically doesn't warrant their use. The use of chemicals to manage these diseases is not cost effective.

Sooty Mold

Sooty mold is a term used to describe the black sooty fungal growth on many trees and shrubs. Several different fungi can cause sooty mold. These fungi are not parasitic to the plants they grow on, but are growing on honeydew produced by insects (aphids, scale, and mealy bugs). Sooty mold is common in warm, humid weather. The fungi appear on leaves, stems or fruits as a superficial, black growth. The fungi do not penetrate the host tissue and can be wiped off with a damp cloth. Although sooty mold fungi are not pathogenic, they do create a problem when the growth of the fungi becomes dense reducing the amount of light that reaches the green leaves. This reduced light limits carbohydrate production by the plant and weakens the growth of plant. The most effective means of controlling sooty mold is managing the honeydew-producing insects.

Foliar Turfgrass Diseases Caused by Fungi (examples):

Powdery Mildew

(caused by: *Erysiphe graminis*)
The most common turf species affected by powdery mildew are bluegrass and fescue. The disease results in large areas of the turf appearing as if they were dusted with powder. The individual plants are infected with isolated colonies of whitish fungal growth, which rapidly enlarges to cover the entire leaf surface. Infected leaves eventually turn yellow then tan to brown as they die. Older leaves are more susceptible to attack than the young succulent growth. Dark fungal fruiting bodies called cleistothecia may form in mycelial mats on the surface of leaves.

The fungus survives as mycelium in living, infected plants or as cleistothecia embedded in plants or plant debris. The fungus is spread by airborne spores that can move great distances in air currents.

The disease generally occurs in the spring and fall and is favored by temperatures between 60 and 72° F, high humidity, and cloudy periods. The disease is most severe in shaded areas with poor air circulation.

Rust

(caused by several species of rust fungi)
All turfgrass species are susceptible to rust fungi. Turfgrass patches infected with rust are thin and weak, and are tinted red, brown or yellow in color. The individual plants exhibits light yellow flecks on infected leaf blades and stems. The yellowish flecks enlarge and become elongate, parallel with the leaf or stem axis. Rust pustules on the surface of infected plants expose colored spores.

Rust fungi survive as mycelium and spores in infected plants or plant debris. The fungi are spread by airborne spores that move short and long distances in air currents.

The disease occurs from spring through fall on grass that is growing slowly under stressed conditions. Disease development is favored by warm (68-86° F) temperatures, low light intensity, and moist leaf surfaces. After infection, disease spreads rapidly with high light intensity, dry leaf surfaces and high temperatures (above 85° F).

Snow Molds

Caused by several different fungi)
All turfgrass species are susceptible to at least one type of snow mold. The symptoms vary somewhat depending on the grass species and the fungus, but typical symptoms include; spots to large patches which are yellow, white, gray, brown, or pink in color.

Snow mold fungi survive as mycelium or fruiting bodies in infected plants or plant debris. They are spread by leaf-to-leaf contact, and usually require wet leaf surfaces for infection.

The disease occurs from winter to early spring. Snow molds are associated with low temperatures, frozen soil, snow cover or several freeze/thaw cycles during the winter. Snow molds are also favored by moisture from snow, frost, rain, and dew.

Snow molds are usually managed by application of fungicides (labeled for the disease) before the first lasting snow and during periods of snow melt.

Foliar and/or Root Turfgrass Diseases Caused by Fungi (examples):

Anthracnose

(caused by: *Colletotrichum graminicola*)
All grass species are susceptible to anthracnose, however the disease is most severe on bluegrass and bentgrass. Symptom development is highly dependant on the environment, but scattered chlorosis or irregularly shaped chlorotic patches ranging from a few centimeters to a few meters in size, is characteristic of infected turf. Individual plants have water-soaked lesions on the leaves or stems. The lesion eventually turns reddish brown and the entire leaf turns yellow, then tan to brown as the leaf dies. Tiny black fruiting bodies may appear on infected stems and leaves.

The fungus survives as mycelium in plant debris. It spreads by movement of spores by equipment, people, animals, water, and wind.

The disease occurs any time of the year, but is most severe during the summer months. Disease development is favored by high humidity and leaf wetness. Grass that is under stress, particularly from high temperatures and drought, is particularly susceptible to this disease.

Helminthosporium-like Diseases

(melting out diseases)
Melting-out diseases, caused by several different species in the genera, *Bipolaris*, *Curvularia*, *Drechslera*, and *Exserohilum*, are among the most common turf diseases that occur in New Mexico. All turfgrass species are susceptible to one or more of these pathogens. Symptoms of this disease are variable depending on the fungal species causing the disease, however, some general symptoms include overall thinning or decline of turf followed by irregular patches 5 centimeters to 1 meter in size. It is common for these patches to have many bare spots with exposed soil. The appearance on individual plants can be in the form of brownish-green to black lesions, dappled yellow and green patterns on the leaves, or elongated water-soaked lesions with a yellow halo.

The fungi survive in infected plants or plant debris and are spread by the movement of spores by equipment, people, animals, water, and wind.

The disease occurs from spring through fall. Diseases caused by *Bipolaris* are favored by either wet or dry conditions and temperatures between 68-86° F. *Curvularia* diseases are favored by wet conditions and high temperatures (above 86° F). *Drechslera* diseases are favored by wet conditions and cool temperatures between 55-65° F.

Fusarium diseases

(caused by: *Fusarium* spp.)
All turfgrass species are susceptible to disease caused by *Fusarium* spp. Diseased turf develops sunken, circular to irregular shaped patches between 2 and 30 centimeters in size. Patches may develop a “frog’s eye” symptom - dead circles with live grass in the center. Individual plants will have black to brown “dry rot”; of the roots, crowns, rhizomes, and stolens. Infected leaves start out light green in color and rapidly fade to tan. White to pink mycelium develops on infected grass during periods of high temperature and moisture.

The fungi survive as mycelium in infected plants or plant debris. They are spread by movement of spores by equipment, people, animals, water and wind.

The disease occurs from late spring through summer and is favored by high temperatures and drought stress. Susceptibility increases in grass with excessive nitrogen or unbalanced fertilizer applications.

Pythium Diseases

(caused by: *Pythium* spp.)
All turfgrass species are susceptible to Pythium diseases. While the symptoms are somewhat variable, the disease is typified by an overall decline in the turf area. This decline may be gradual or rapid, depending on the environmental conditions. Small areas of declining turf may coalesce to cover large areas. Individual plants have dark, water-soaked lesions. The leaves turn yellow, then tan. Roots of infected plants rot. In the early

morning when dew is present, a white, cottony growth may appear on the grass surface.

The fungi survive as oospores in infected plants or plant debris. They are spread by movement of infected plant material by equipment, people, animals, and water. Swimming spores move short distances in water and contribute to the enlargement of individual areas.

The disease occurs anytime during the growing season. Disease development is favored by hot (86-95° F), wet weather with night temperature above 68° F. Susceptibility increases in dense turf and in turf growing in alkaline conditions.

Brown Patch

(caused by: *Rhizoctonia solani*)
This is one of the most common turf diseases in New Mexico. All turfgrass species are susceptible to brown patch. Although the symptoms are highly variable, the disease is characterized by small to large rings or patches of dead grass. Individual plants have small to large, irregularly shaped lesions with a distinct dark brown margin. Infected leaves become chlorotic, then brown with age. Dark brown sclerotia, (masses of mycelium with a hard shell) may develop at the base of infected plants.

The fungus, *R. solani*, survives in soil and in infected plants and plant debris. It is spread by leaf-to-leaf contact, and by movement of infected plant material by equipment, people, animals, water and wind.

The disease occurs from spring through fall and is favored-by warm (70-90° F), wet conditions. Dense, highly fertilized, frequently watered grass is more susceptible to the disease.

Root Turfgrass Diseases Caused by Fungi (example):

Summer Patch

(caused by *Magnaporthe poae*)
Summer patch is common on bluegrass and fescue, but also has been found on ryegrass and bentgrass. It is a common disease on golf greens and is often identified when bluegrass is killed and seemingly unaffected bentgrass grows into diseased patches. Before the causal agent, *M. poae*, was identified, the disease was thought to be part of the Fusarium blight complex.

The symptoms first appear as small (3-8 cm), circular patches of slow-growing, thinned, or wilted turf. The diseased area may increase in size to 30-60 cm in diameter. Affected leaves rapidly fade from grayish green to a light straw color during sustained host weather. Infected roots, rhizomes, and crowns turn dark brown as they are killed. Microscopic examination of these tissues reveals a network of sparse, dark brown to black hyphae.

The fungus survives as mycelium in plant debris or perennial host tissue and is spread by aerification and dethatching equipment as well as by transport of infected sod.

Infection occurs in the spring when soil temperatures stabilize between 65 and 68° F. Symptoms develop during hot (86-95° F) rainy, weather or when high temperatures follow periods of heavy rainfall. The disease is more severe when turfgrass is maintained under conditions of low mowing height and frequent, light irrigation.

Fairy Rings and Slime Molds:

Fairy Rings

(caused by: several species of basidiomycetes)
Fairy rings are characterized by circles, rings or arcs of by dark green, faster growing turf areas. In many cases., the diseased areas die-out as the disease progresses leaving dead area surrounded by dark green growth. Rings can vary in size during the year and can appear or disappear throughout the growing season. The dark green areas may be surrounded by mushrooms, toadstools, or puffballs that are fruiting bodies of the fungi that cause the disease. These fruiting bodies are excellent signs of the fungi and can be very diagnostic.

The fungi that cause fairy rings live in the soil and decomposing thatch layer. They are spread from one area to another by the movement of infected plant material or infested soil by equipment and wind blown spores.

The disease occurs from spring to early summer, and the fruiting bodies generally appear in the late summer (during the summer rainy period). The fungi are favored by light textured soils, low fertility, and drought.

Fairy rings are difficult to control. Fungicides are rarely effective. The affected turf must often be removed including a significant amount of soil. The area must then be prepared and re-sodded.

Slime Molds

(caused by slime mold fungi)
Slime molds are not disease causing agents as they do not penetrate and infect plants. However, they do cause harm to plants by covering the leaf surface and reducing the amount of light reaching the plant surface. Slime molds are pinhead-sized white, gray, or purplish-brown fungi, which are slimy in appearance and texture. They appear in patches 2 to 60 cm in diameter) during periods of warm, wet weather. They usually disappear within 2 weeks after the favorable conditions are gone. Turf with a thick thatch layer is more susceptible to disease. Slime molds can be washed off of plants with a hard stream of water, or swept off with a broom.

BACTERIA

Bacteria are single cell microorganisms that lack chlorophyll. They obtain food from living or dead organic matter. The average size of a bacterium is less than 5 microns. Bacteria reproduce by division of the cell into two equal parts. Bacteria can divide very rapidly: Under the proper environmental conditions one bacterium can produce over 1 million identical cells in less than 1 hour.

Bacteria enter plants only through wounds or natural openings on the plant surface. Once inside the plant, bacteria multiply rapidly and break down the plant tissue creating a watery mass. Bacteria are only apparent to the naked eye if clumped together to form a colony (bacterial ooze).

Bacteria are spread by splashing rain (waterborne), in soil, in wind-blown dust, by vectors (man, tools, equipment, insects, etc.), and infected planting materials (seed, transplants, cuttings, etc.). Diseases caused by bacteria are generally favored by high air and soil moisture. Because of this, bacterial diseases are few and somewhat rare in arid regions.

Diseases of Ornamentals and Vegetables Caused by Bacteria (examples):

Bacterial Spots and Blights

Bacterial spot and blight diseases affect all above ground parts of plants: leaves, stems, blossoms, and fruit. A wide variety of ornamentals and vegetables are susceptible to spot and blight diseases. Necrotic, circular or angular shaped spots characterize spot diseases. In some diseases, the spots are surrounded by a yellow halo and/or dead leaf tissue may fall out of spot leaving holes in the leaf (known as a “shot hole”). Bacterial blights are characterized by a continuous, rapidly advancing death of infected organs.

The bacteria overwinter in infected and healthy tissue, in or on seeds, in plant debris, and in soil. The organism is spread by rain, leaf-to-leaf contact, insects, cultivation, and tools. Water soaking of tissue caused by heavy rains predisposes plants to infection.

Bacterial spots and blights are managed with good sanitation practices; removing and destroying infected plant parts and frequent cleaning of tools and other equipment. Copper fungicides and antibiotics can be useful for high value crops, such as in orchard or nurseries. In vegetable crops, look for tolerant varieties, and rotate crops around the garden.

Fire Blight

Fire blight is a bacterial disease caused by *Erwinia amylovora*. It affects plants in the rosaceae family, most notably apple, pear, rose, pryracantha, Photinia and cotoneaster. Infected plants exhibit blighted branch tips that are black and look like they have been scorched by fire. Another symptom is the development of a shepherd’s-crook on young, vegetative shoots. The bacterium overwinters in cankers and as symptomless infections in leaf and flower buds. In the spring, the bacterium oozes from infected cankers and is spread by water, pruning tools and insects (primarily bees) to nearby blossoms. Ideal conditions for infection and development of disease are rain (or high humidity) and temperatures between 75-85° F.

Cultural practices can be highly effective in the management of fire blight. Infected plant parts should be pruned, cutting at least 6” below the disease margin (margin between healthy and diseased tissue), and destroyed. When pruning infected plants, it is advisable to dip pruning shears in a 10% bleach solution, in 70% alcohol, or use fire to sterilize tools in between cuts. Succulent, lush growth is more susceptible to infection, thus it is best to avoid over fertilization (especially with nitrogen) and provide adequate, but not excessive water. Copper fungicides and antibiotics can be effective sprays, however timing is critical and improper use can lead to phytotoxicity (from the copper chemicals) or development of resistance in the bacterial population.

Bacterial Canker

Bacterial canker (also referred to as "gummosis") is caused by several different species of bacteria. It affects stems, branches, twigs, leaves, buds, flowers, and fruit. The disease occurs on a wide range of hosts, including stone fruits, apple, pear, lilac, rose, tomatoes and small grains. Symptoms include: splits in trunks or stems, necrotic areas in the woody tissue, and sunken cankers that may be soft, leathery, or scabby in appearance. Some cankers exude a slimy or gummy substance. The bacteria overwinter in perennial cankers, in buds, plant debris and in or on seed. The disease is spread by rain, runoff water, cultivation, tools and infected plant material.

Bacterial canker is best controlled by good sanitation practices. This includes pruning and destroying infected plant parts and maintaining strong, but not excessively vigorous growth. Avoid planting any material that is suspicious in appearance. Copper fungicides or antibiotics may help in reducing spread when many similar plants are in close proximity (e.g. home orchards). Caution should be taken in using copper fungicides as improper use may lead to plant injury and effective use is dependent on proper timing of applications.

Crown Gall

Crown gall, caused by the soil-borne bacterium *Agrobacterium tumefaciens*, has a wide host range among woody and herbaceous plants. The bacterium enters roots or stems near ground through wounds created by cultural practices, insects, etc. The bacterium can also infect plants above the crown by pruning with infested cutting shears.

Once inside susceptible hosts, the bacterium stimulates host cells to enlarge causing tumor-like galls to develop. The galls impede the movement of water and nutrients in the plant. Reduced transport of water and nutrients causes chlorosis, stunting, slow growth, and a general decline in the health of the plant. Some plants infected with crown gall will continue to grow seemingly unaffected while others decline over time until they have to be removed.

Once infected, there is little that can be done to help the plant other than providing adequate water and nutrients. Well managed trees are less likely to go into a rapid decline. When planting susceptible hosts, use disease-free nursery stock. Avoid injury to roots and crown at planting and during cultivation of turf or other plants nearby.

Slime Flux
(bacterial wetwood)
Slime flux is a disease that can be caused by several different species of bacteria. The bacterium enters the plant through wounds or natural growth cracks. Fast growing trees, like willow, elm and cottonwood, are particularly susceptible to the disease. Once inside the tree, the bacteria raise the internal gas pressure in the tree. As a result of increased pressure, the bacteria is forced back out of the tree in the form of an ooze. The ooze flows down the trunk or affected limbs. It first causes the bark to appear moist (thus the name wetwood), and eventually dries to a whitish color. The slime is toxic to the bark and to plants growing under the tree.

Once trees are infected, there is no cure. Proper water and fertilizer will help to reduce the affect of the bacteria and help to minimize the amount of slime that is produced. The slime can be washed off the tree, reducing the toxic effects, however care must be taken to avoid washing the slime onto other plants. These management tactics may slow the activity of the disease, however infected trees become progressively weaker over time and will eventually become hazard trees.

VIRUSES AND VIROIDS

Viruses consist of nucleic acid (RNA or DNA) surrounded by protein (coat protein). Viroids consist only of nucleic acid (RNA only). Both are so tiny they can only be seen with an electron microscope. They do not carry out respiration, digestion, or other metabolic functions, therefore, they are not living organisms. Viruses and viroids cannot grow or multiply outside the host cell, but cause the plant to transform host plant components into more virus or viroid particles.

Viruses and viroids are transmitted from one plant to another by vectors (so they are biotic disease agents). Common vectors include man, insects, budding, grafting, nematodes, fungi, seed and/or pollen. The virus or viroid particles enter plants through wounds created by the vector.

Symptoms of these types of diseases are nonspecific and can look like symptoms caused by many other disease agents. General symptoms include stunting, yellowing, curling or twisting of leaves and stems, distorted leaves and fruit, mosaics, mottles, and ring spots.

Diseases of Ornamentals and Vegetables Caused by Viruses (examples):

Rose Mosaic Virus

Rose mosaic virus occurs worldwide. The symptoms are highly variable depending on the variety and the environment, however chlorotic bands or rings, vein clearing, and general mosaics are common. Symptom development on only a portion of a plant is common. Infected plants have decreased vigor, poor flower production, and are more susceptible to winterkill. The virus is transmitted through vegetative propagation and pollen. There is no control for a plant infected with the virus. Infected plants should be removed and destroyed.

Beet Curly Top Virus

Beet curly top virus (BCTV) is common in arid and semi-arid regions on a wide host range (affects over 300 plant species). The virus is transmitted (vectored) by the beet leafhopper (*Circulifer tenellus*). Some of the more common hosts include tomatoes, peppers, cucurbits, potatoes, beans, spinach, geranium, nasturtium, petunia, stock, and zinnia. Weeds are important survival hosts for the virus and the vector. Weed hosts include; Russian thistle, sow thistle, London rocket, pigweed, purslane, knotweed, and lamb's-quarter.

Symptoms vary somewhat depending on virus strain and host plant, yet there are some common characteristics among infected plants: Overall chlorosis, curling of leaves, thickening of leaves and stems, stunting, deformed fruit, and reduced fruit production. On some hosts, such as tomato and pepper, leaf veins on the underside of the leaves may turn purple. Although viruses usually do not kill their host plants, young seedlings attacked by BCTV may die.

The only means of disease transmission is by leafhoppers. Leafhoppers feeding on infected plants will rapidly (1 minute) acquire the virus. The virus then circulates through the insect and can be transmitted to a susceptible plant after as little as 4 hours. The leafhopper then remains infective for the rest of its life, although the effectiveness of transmission is decreased when the insects do not continually feed on infected plants. The virus is not passed on to progeny, however, young leafhoppers that develop on infected hosts will quickly become carriers of the virus. As far as is known, the virus has no negative or positive affect on the insect. Leafhoppers overwinter in winter weeds. Mild winters (which allow for significant leafhopper survival) and large populations of winter weeds are two important factors in BCTV epidemics.

There are no chemicals available for the control of viruses, but several cultural practices can help to reduce or eliminate infections. Good sanitation practices, including weed and insect control and removing infected or suspect plants, are essential in limiting the occurrence of the disease. Home gardeners may also consider planting susceptible hosts, such as tomatoes and peppers, in a slightly shaded part of the garden, as leafhoppers prefer to feed in sunny locations. However even shaded plants will become infected when leafhopper populations are high. Placing netted cages over susceptible hosts (particularly when young) may help to prevent infection. The netted material should be small enough to prevent leafhoppers from getting through the material. It is also important that the cages be large enough that the plants do not touch the netting. When plants mature, the cages should be removed. At this stage, the plants are less susceptible to the virus. Although there is little tolerance known to BCTV in commercial varieties, this is an active area of research and new varieties may soon be released which possess a level of resistance to the virus or the leafhopper.

Tomato Spotted Wilt Virus

Tomato spotted wilt virus (TSWV) is an important disease of many vegetables and ornamentals in temperate and subtropical regions of the world. In New Mexico, it is particularly troublesome in greenhouses, but can easily move to gardens on infected plant material or carried by its vector (thrips). The virus has a tremendously wide host range including tomatoes, peppers, celery, lettuce, spinach, potatoes, peanuts, begonias, geranium, nasturtium, impatiens, petunia, snapdragons, verbena, stock, and statice. Like beet curly top virus, TSWV has many weed hosts that help it survive from one season to the next. Common weed hosts include curly dock, field bindweed, lamb's-quarters, pigweed, morning glory, jimsonweed, and nightshade.

Symptoms of TSWV are numerous and varied. Some fairly characteristic traits of infected plants are bronzing and yellowing of leaves, leaf spots, leaves become distorted, and petioles curl downward creating a wilt-like symptom although the plants retains its turgor pressure. Other symptoms include dieback of the growing tips and dark streaking of the terminal stems. Infected plants may develop a one-sided growth habit or may be completely stunted. Infected plants produce little or no fruit. Fruit that is produced exhibits symptoms, such as necrotic streaking, raised bumps, chlorotic spots or ring spots, uneven ripening, and deformation.

TSWV is transmitted from infected to healthy plants by at least 9 species of thrips. Thrips transmit the virus in a persistent manner, which means that once the insect acquires the virus it can transmit the virus for the remainder of its life. The virus is not passed from adult to egg; however, progeny that develop on infected plants will quickly pick up the virus and become effective disease vectors.

Controlling the disease is difficult. The wide host range, which includes perennial ornamentals and weeds, enables the virus to successfully overwinter from year to year. In landscape situations, controlling thrips does not translate into reduced disease. This is probably due to the fact that large populations of thrips may fly or be blown into treated areas from non-treated area nearby. Controlling thrips, is somewhat more effective as a disease control measure in greenhouses. Control of thrips may be obtained with pyrethroids, carbamates, chlorinated hydrocarbons, organophosphates, and insecticidal soaps. However great care should be taken to avoid repeated use of any one type of chemical as thrips in the treated population may rapidly build resistance to the material. Rotating the insecticide class is the best approach to insect control. Pesticide registrations are constantly changing so it is important to read the label for legal uses and follow all label instructions carefully. In greenhouses, thrips populations may be reduced by covering all openings (doors, vents, etc.) with a fine mesh (400 mesh) screen.

While elimination of disease may not be possible, the incidence and severity of the disease may be reduced by several cultural practices. It is .important to start with virus-free plants. Do not purchase or plant any plant that exhibits symptoms such as described above. Remove any infected or suspect plants from the greenhouse, garden and landscape. Control weeds. Efforts are underway to breed cultivars with good horticultural characteristics that also exhibit tolerance to the virus.

NEMATODES

Nematodes are microscopic, non-segmented worms. They are filamentous in shape, however, females in some species may become swollen at maturity and exhibit round or pear shaped bodies. Plant parasitic nematodes have a hollow stylet that penetrates plants cells. This stylet is visible under a light microscope and sometimes under a dissecting scope. Nematodes have well developed digestive and reproductive systems.

Nematodes are placed into different classification based on how they live their lives. For example, ectoparasitic nematodes live freely in soil, do not enter plant tissue and feed superficially on roots. Migratory endoparasitic nematodes live freely in soil, enter plants and move through plant tissue feeding internally. And sedentary endoparasitic nematodes have a free-living juvenile stage, but as adults they attach to the root and feed in one location.

All nematodes live at least part of their life cycle in soil. Nematodes can move slowly in moisture film surrounding roots and soil particles, but long distance spread is achieved by the movement of soil. Thus, soil in irrigation water, on animals, on equipment, and plant material can spread nematodes from one location to another.

Diseases of Ornamentals, Vegetables and Turfgrass Caused by Nematodes (examples):

Root-Knot Nematode

Root-knot nematodes (*Meloidogyne incognita*) can be a serious pest in home gardens and field grown crops. The pest is most serious in warm, light soils. Root-knot nematodes have an extremely wide host range (over 2,000 species) that includes most vegetables, many cereals and field crops, some trees, and weeds.

The severity of symptoms depends on the host, the nematode and the age at which the plant was infected. Younger plants are more severely damaged than mature plants. Above ground symptoms are not unique, and in fact may be reminiscent of diseases caused by many other pathogens and abiotic disorders. Common above ground symptoms include stunting, chlorosis, wilting (particularly during the heat of the day), and reduced yield. Roots of infected plants exhibit characteristic galls, and may be distorted. These galls are usually visible with the unaided eye, and can clearly be seen with a hand lens or dissecting microscope. The size and number of galls is dependent on the type of host, the age of infection and the nematode population. Because nematodes are sensitive to soil type, damage may be “spotty” rather than uniform across a field or garden.

Root-knot nematodes live in soil as eggs and juveniles, and in plants as adults. Juvenile nematodes invade roots of susceptible hosts. Once inside the host root, the nematodes swell and become pear-shaped, disrupting the developing root tissue. As the nematodes feed on root cells, the cells enlarge creating what is called “giant cells." It is the formation of giant cells and the presence of the nematodes in the roots that creates the characteristic root galls. Female nematodes lay their eggs (200-500 per female) in a gelatinous matrix on the outside of the root. Eggs hatch in the soils and new juvenile nematodes invade other roots. During favorable conditions, the life cycle of this pest is completed in about one month, so there may be up to four or five generations per season. Therefore, populations can build up in soils very rapidly.

Several management practices can be used to reduce nematode populations. Never plant transplants which exhibit nematode galling (remember that legumes form root nodules for nitrogen fixations which may look similar to small nematode galls). Avoid areas known to be heavily infested with nematodes. Crop rotation may be helpful, but the wide host range of the pest limits its effectiveness. There are chemicals registered with can be used to control nematodes, however most are soil fumigants that can only be used prior to planting and they are "Registered Use Materials" which means that they need to be purchased and applied by a licensed pesticide applicator. Some success controlling nematodes has been had in relatively small areas with the incorporation of soil amendments containing crushed seashells. The seashells are made of chitin, which is the same protein that makes up the nematodes exoskeleton. The addition of chitin to the soil stimulates beneficial soil microbes that degrade chitin. This increase in beneficial organisms will help to reduce the nematode population by destroying the nematodes cell wall. Additionally, one year of weed-free fallow may significantly reduce nematode populations. The key is that the ground must be kept weed-free as many weeds are important alternate hosts for the nematode.

Turfgrass Nematodes

Plant parasitic and saprophytic nematodes are components of every turfgrass ecosystem. The importance of these microscopic worms in the overall health of the turf varies depending on the type of nematode, the nematode population, and the environment. While some nematodes can be beneficial in controlling some pests, others can cause serious diseases in turf. Nematodes are more likely to cause disease in warm temperate or subtropical regions, although disease can occur in cooler regions as well.

All turfgrass species are susceptible to nematodes. Several different species of nematodes can cause damage in turf. Some of the common species in warm climate species are:
Meloidogyne spp. - root-knot nematode
Trichodorus spp. and Paratrichodorus spp. - stubby root nematode
Belonolaimus spp. - sting nematode
Dolichodorus spp. - awl nematode
Helicotylewhus spp. - spiral nematode
Hoplolaimus spp. - lance nematode

Some of the common species in cool climates are:
Xiphinema spp. - dagger nematode
Pratylenchus spp. - lesion nematode
Macroposthonia spp. - ring nematode
Tylenchorhynchus spp. - stylet nematode
From species above; a, b, e and f.

Nematode injury might appear as areas of low fertility, even when adequate fertilizers have been applied. Symptoms will be slight to severe chlorosis, declining growth, gradual thinning, wilting, and in severe cases, death. Turf that is under stress, particularly from high heat, drought, low fertility, or excessive thatch, is more susceptible to nematode injury.

Chemical treatment with a nematicide is available to professional sod growers, nursery operators, and professional pesticide applicators. Retail nematicides are not available to homeowners.

PARASITIC HIGHER PLANTS

Parasitic higher plants are flowering plants that live off other plants. True and dwarf mistletoes and dodder are examples of parasitic plants.

Mistletoes have chlorophyll, but no roots and thus, rely on host plants for water and nutrients. True mistletoes parasitize hardwood trees, such as cottonwoods, elms, oaks, and locusts. This pathogen is disseminated by birds, which feed on the seed-baring mistletoe berries. Dwarf mistletoes attack conifers and are an important pathogen in conifer forests. This pathogen forcibly discharges its seeds and is disseminated by wind currents.

Dodder has no chlorophyll and no true roots. It depends on its host for water, nutrients and carbohydrates. Dodder is a soil-borne vine-like plant that twines around its host. It is mostly a problem in agricultural fields, but can be troublesome in home gardens and landscapes, particularly in newly developed areas that were once used for agriculture.

Non-infectious disease causing agents (abiotics):

NUTRIENT DEFICIENCIES

Nutrient deficiencies occur when essential elements are not available in the required amount. The effect on plants is dependent on the host plant and element(s) that is deficient. Some general symptoms include, stunting, chlorosis, small leaves, malformed leaves, poor root growth, weak plant growth, poor turfgrass stand establishment, etc.

Common nutrient deficiency descriptions:
Nitrogen: slow growth, stunted plants, and chlorosis (particularly older leaves).

Phosphorus: slow growth, stunted plants, purplish coloration of foliage on some plants, dark green coloration with tips of leaves, delayed maturity, poor fruit or seed development.

Potassium: leaf tips and margins “burn” starting with the older leaves, weak stalks, small fruit, and slow growth.

Iron: interveinal chlorosis of young leaves (veins remain green except in severe cases), twig dieback.

Zinc: decrease in stem length, rosetteing of terminal leaves, reduced bud formation, interveinal chlorosis, dieback of twigs (if deficiency lasts more than one year).

Magnesium: interveinal chlorosis in older leaves, curling of leaves upward along margins, marginal yellowing with green “Christmas tree” area along midrib of leaf.

Calcium: death of growing points (terminal buds and root tips), abnormal dark green, premature shedding of blossoms and buds, and weak stems.

Sulfur: light green color of (mostly) young leaves, small and spindly plants, slow growth, delayed maturity.

Manganese: interveinal chlorosis of young leaves - gradation of pale green coloration with darker color next to veins. No sharp distinction between veins and interveinal areas as with iron deficiency.

Boron: death to terminal buds, thickened, curled, wilted and chlorotic leaves, reduced flowering and improper fertilization.

Soil availability of nutrients is influenced by soil characteristics. The pH of the soil has a profound effect on nutrient availability. For example, iron, though plentiful in the soil, is mostly unavailable to plants in alkaline soils (pH above 7.5). Likewise, phosphorus, manganese, copper and zinc are also less available in alkaline soils. Boron, which is needed by plants in very small amounts is almost completely unavailable at pH between 7.5 and 8.5. A soil pH between 6.5 and 7.5 gives a maximum availability of the primary nutrients (nitrogen, phosphorus and potassium), and a relatively high degree of availability of the other essential elements. Unfortunately, much of the soil in the southwest is alkaline.

Some elements such as nitrogen are readily leached through the soil and therefore need more frequent application to provide the plants with an adequate amount of the element. Additionally, the relative amounts of different elements effect nutrient availability. The excesses of certain nutrients may result in the plants inability to take up another essential element.

Soil tests are needed to determine the base nutrient content and other important soil characteristics. The results of soil test will help to determine the type and amount of fertilizers needed for different plants. Nutrient toxicities can occur with over fertilization or with improper application of fertilizers. In most cases, application of a balanced fertilizer with essential micronutrients is beneficial to plant growth. In some areas, additional foliar applications of some microelements such as iron might be needed to keep plants green.

PESTICIDE INJURY

All pesticides, if used inappropriately, can be toxic to plants. In most cases, damage results from improper application or from pesticide drift. Failure to thoroughly clean spray equipment can also result in injury to non-target plants.

Common symptoms of pesticide injury include: leaf burn, leaf distortion, chlorosis, flattened or enlarged stems and roots, plant death, etc. Symptom type and severity are dependent on the type of pesticide and the concentration of the chemical. In turf situations, damage appears in patterns associated with application of the chemical.

When any pesticide is used, it is imperative that the material be applied carefully and in accordance with the pesticide Label. It is also important to avoid spraying on windy and/or hot days.

TEMPERATURE EXTREMES

Temperature extremes, both high and low, can cause injury to plants. High temperature Results in excess transpiration, wilting, heat stress and sunscald. The plants are unable to cool themselves by evapotranspiration. In turf, heat stress is intensified by objects covering blades, high humidity, dry soil, and lightning strikes.

Low temperature injury causes leaf epidermal cells to separate from underlying tissue giving the affected tissue a silvery appearance. The affected herbaceous tissue will wilt and turn black. On trees, frost or freeze damage results in splits and cracks in trunks branches and twigs, eventually causing cankers to develop. These cankers become entry sites for secondary organisms such as fungi and bacteria.

SALT INJURY

Salt injury occurs when the plant takes up excessive salts from either the soil or the irrigation water. damage results from a loss of feeder roots. Symptoms include marginal necrosis and leaf, stem and twig necrosis. Salt injury is often seen in association with heat and water stress.

LIGHT EXTREMES

Light affects germination, growth and shape of plants. Lack of light causes etiolation (elongation) between nodes and results in poor color. Excess light can result in sunburned foliage or fruit.

WATER EXCESS

Excess soil moisture results from excess irrigation, rainfall or poor soil drainage. These soils have reduced oxygen levels, which inhibits plant growth. Plants may be chlorotic, have small or thin foliage, and have numerous dead or dying roots. Roots may die from a lack of oxygen or from soil-borne fungi that favored by high soil moisture. The final result may be plant death. Chronically wet soils may become black in appearance and have a foul odor.

Water soaked above ground plant parts are predisposed to many diseases. Additionally, excessive moisture on the foliage favors many foliar diseases that require either free water or high humidity for germination and infection.

DROUGHT INJURY

Drought injury results from a chronic lack of water. Affected grasses turn bluish in color and the leaves curl before turning brown. Shrubs and trees wilt in the afternoon and recover at night until they wilt permanently. New foliage is small and pale in color. Plant growth is restricted and plants are more susceptible to heat stress.

WIND AND SAND INJURY

Wind Injury results from excess air movement. Damage is more severe if temperatures are high. Plants become desiccated, and may become radically altered in shape due to directional force of wind. Leaves become tattered either from the force of the wind whipping the foliage around, or from wind blown sand. Wind may lead to problems associated with wind blown pathogens.

HAIL DAMAGE

Hail causes necrotic spots on foliage and fruit. Severe hail may cause holes in leaves or leaves to become tattered. Hail striking the crown of young plants can cause plants to fall over and die.

AIR POLLUTION

Air pollution, which results from a lack of sufficient air currents, can cause problems on many different types of plants. Combustion of fuels, auto exhaust, coal burning, interaction of sunlight and nitrogen oxides make up different air pollutants. The common major pollutants are: nitrogen oxides, ozone, hydrocarbons,. peroxyacetyl-nitrate (PAN), and sulfur dioxide.

Symptoms of air pollution vary somewhat depending on the type of pollutant, however common symptoms include, flecking of upper leaf surface, bronzing of the lower leaf surface, interveinal bleaching, or damage may be invisible.

IMPROPER CULTURAL PRACTICES:

Management Practices that Impact the Health of Ornamentals
Planting: Choice of location, Soil preparation, Root preparation, Planting depth

Irrigation: Timing, Amount applied, Frequency of irrigation, Application method (coverage)

Fertilization: Selection: Macronutrient ratio, addition of micronutrients, Timing, Frequency of application, Application method: water-soluble, slow release, foliar sprays, injection

Cultural Practices: Pruning; timing and method, Sanitation; removal of debris, clean tools, weed and insect control, Staking, Mulching/Cultivation

Management of Turfgrass

Turf diseases are best controlled with good management of the turfgrass. For maximum disease control, turfgrass should be maintained at moderate rate of growth. Turf that is very lush or under stress is more susceptible to disease than turf that is grown at a moderate pace. Management, practices include, irrigation, fertilization, mowing, and de-thatching (aeration).

Water

Turfgrass is best watered in the early morning. This allows for efficient use of the water and for the grass blades to dry before nightfall. Water thoroughly so that water penetrates several inches into the soil. It is better to water less frequently and for longer periods than to water frequently for short periods of time.

The amount of water needed will vary depending on the time of year and the weather conditions. You can determine the amount of water you are applying with each irrigation by placing a few empty food cans in various locations on the lawn. Turn on the sprinklers for a designated amount of time. After irrigation, measure the amount of water that has accumulated in the cans. This will tell you how much water in inches that you are applying in that specified amount of time. You can then adjust the duration of irrigation to provide the desired amount of water.

Fertilizer

The use of slow release nitrogen fertilizers can help to reduce the rapid flush of lush growth after fertilization. Slow release fertilizers releases nitrogen slowly over a long period of time. This avoids disease problems that may by associated with large amounts of nitrogen available all at one time. Fertilization is best applied in split applications during the growing season.

Mowing

The practice of mowing creates problems with diseases by damaging the turf (the cut) and by altering the carbon/nitrogen ratio in the plant. However, mowing is an import practice in turf maintenance. Thus, efforts should be made to lessen the impact of mowing on the grass. Grass should be mowed as high as is practical for the use of the turf. Low mowed or scalped grass plants are more susceptible to diseases. Be sure that your mower blades are sharp and that they are making nice clean cuts of the grass blades. Dull mowers tear or shred leaf blades, leaving jagged tips of injured leaves straw colored. Overall appearance of turf is ragged and grayish in color. In addition to poor appearance, the jagged cuts made by dull blades are more attractive to many disease organisms. Scalping injury (mowing grass so short that yellow or brown stem tissue is exposed) is caused by infrequent mowing, weedy grass areas, and uneven areas. Scalping weakens turf plants making them more susceptible to diseases.

When grass is mowed properly, the clippings can be left on the surface of the lawn. This will help with the overall balance of nutrients and microorganisms in the thatch and soil. If grass is mowed infrequently, clippings should be removed because the large amount of clippings will mat on the surface of the lawn reducing the amount of water and air penetration to the soil, and causing heat stress to the grass immediately under the clippings.

Dethatching and Aerification

Thatch is the layer just below the grass blades and above the soil. It is made up of decomposing grass plants - leaves, shoots, rhizomes and roots. A small amount of thatch is desirable, however if thatch accumulates over 2 cm it impedes water penetration and can cause detrimental affects to the grass. Roots tend to grow in the thatch layer instead of the soil, increasing risk of drought or high temperature damage. Excessive thatch is caused by keeping turf too wet or too dry, high soil acidity or alkalinity, high nitrogen fertilization, and repeated pesticide applications.

Thatch accumulation is controlled with periodic aeration of the grass. Aeration is achieved by poking holes in the lawn, by vertical mulching, slicing or power raking. Lawns should be aerated at least once a year, twice a year for turf exposed to heavy traffic.

Benefits of aeration include; improved exchange of air and water, reduced water runoff, water penetration/retention into soil, increased root/shoot growth, improved drainage, reduced thatch and disease and insect control.

Fungicides for Turf Disease Control

Several broad spectrum and disease specific fungicides are available to help manage turf diseases. It is important that the disease be identified as best possible to help in selecting the proper chemical. Only use registered fungicides and use them only when absolutely necessary as repeated fungicide application will reduce the effectiveness of the chemical due to the development of resistance in the fungal population. Keep in mind that fungicides typically do not kill the fungus, they stop the activity of the fungus and allow for the turf to get a head start on filling in the diseased areas. However, if conditions that initiated the disease problem reoccur, repeat treatment may be necessary.

SUMMARY

Many living and non-living factors cause abnormalities in plants.

The host, the pathogen and the environment must all work together to cause disease.

Strong, vigorous, well-managed plants are less susceptible to disease than plants under stress.

Effective control programs disrupt the interactions between at least two of the interacting components.

The best disease management programs utilize an integrated approach to control.