PLANT DISEASE EVALUATION

The study of disease in plants; it is an integration of many biological disciplines and bridges the basic and applied sciences. As a science, plant pathology encompasses the theory and general concepts of the nature and cause of disease, and yet it also involves disease control strategies, with the ultimate goal being reduction of damage to the quantity and quality of food and fiber essential for human existence.

Plant disease - a disease that affects plants

Disease - an impairment of health or a condition of abnormal functioning

Throughout history, loss of crop yields from disease has had severe effects on the human race.

There are at least 50,000 diseases of crop plants. New diseases are discovered every year. About 15% of the total U.S. crop production is lost annually to infectious diseases despite improved cultivars and disease control techniques. Damage from disease has not been eliminated. Disease-causing organisms (pathogens) multiply and mutate rapidly. They develop genetic resistance to chemical controls and have the ability to infect new hybrids. Good gardening practices and an understanding of plant pathology are the first line of defense against disease.

DEFINITION OF PLANT PATHOLOGY

The study of plant diseases is known as plant pathology. Infectious diseases are caused by living organisms called pathogens. Noninfectious diseases caused by environmental stress and damage by weather and other environmental factors also will be covered.

Indirectly, environmental factors that cause a plant to be stressed may result in the plant's gradual decline. Decline results in the plant being more susceptible to disease organisms. Because of this, diagnosing plant diseases can be tricky. The real cause of a problem may be the stress factors, with the disease simply being a secondary factor.

DISEASE TRIANGLE FOR VIRUS INFECTION

Three critical factors or conditions must exist for virus disease to occur: a SUSCEPTIBLE HOST PLANT, a VIRULENT PATHOGEN, an active VECTOR and the right mix of ENVIRONMENTAL CONDITIONS. The relationship of these factors is called the disease triangle.

If only a part of the triangle exists, disease will not occur. Understanding the disease triangle helps us understand why most plants are not affected by the many thousands of diseases that exist.

VIRUS PATHOGEN

Viruses are very small (submicroscopic) infectious particles (virions) composed of a protein coat and a nucleic acid core. They carry genetic information encoded in their nucleic acid, which typically specifies two or more proteins. Translation of the genome (to produce proteins) or transcription and replication (to produce more nucleic acid) takes place within the host cell and uses some of the host's biochemical "machinery". Viruses do not capture or store free energy and are not functionally active outside their host. They are therefore parasites (and usually pathogens) but are not usually regarded as genuine microorganisms.

Most virus pathogens are host-specific to a particular plant species, genus or family. Viruses also cause many important plant diseases and are responsible for huge losses in crop production and quality in all parts of the world. Infected plants may show a range of symptoms depending on the disease but often there is leaf yellowing (either of the whole leaf or in a pattern of stripes or blotches), leaf distortion (e.g. curling) and/or other growth distortions (e.g. stunting of the whole plant, abnormalities in flower or fruit formation).

VECTOR

Some important animal and human viruses can be spread through aerosols. The viruses have the "machinery" to enter the animal cells directly by fusing with the cell membrane (e.g. in the nasal lining or gut).

By contrast, plant cells have a robust cell wall and viruses cannot penetrate them unaided. Most plant viruses are therefore transmitted by a vector organism that feeds

on the plant or (in some diseases) are introduced through wounds made, for example, during cultural operations (e.g. pruning). A small number of viruses can be transmitted through pollen to the seed (e.g. *Barley stripe mosaic virus*, genus *Hordeivirus*) while many that cause systemic infections accumulate in vegetatively-propagated crops.

SUSCEPTIBLE HOST

A susceptible host has a genetic makeup that permits the development of a particular disease. The genetic defense against a disease is called disease resistance. This resistance can be physical characteristics of the plant (fuzzy or waxy leaf surfaces), chemical characteristics (enzymes that kill pathogens and lack of enzymes) and growth patterns (ability to block off diseased tissue or outgrow damage).

Plants also may be disease-tolerant. Even though infected with a disease, they can grow and produce a good crop or maintain an acceptable appearance. The plant outgrows the disease and symptoms are not apparent or at a damaging level.

It is important to remember that plants labeled as disease-resistant are resistant only to a particular disease. They are not resistant to all diseases. Resistance does not mean immunity. Under extreme circumstances, resistant plants may be infected by the disease to which they have resistance.

For disease to occur, the host plant must be at a stage of development that allows it to be susceptible to infection. For example, damping-off only affects seedlings. Botrytis is primarily a disease of buds, although it also can occur on flowers and leaves. Also, it is important that the pathogen be in a proper stage of its development to infect host plants.

ENVIRONMENTAL CONDITIONS

Certain environmental conditions must exist for disease pathogens to cause infection. The specific conditions vary for different pathogens. High moisture and specific temperature ranges are necessary for many virus diseases. These conditions must continue for a critical period of time while the pathogen is in contact with the host for infection to occur.

Moisture, temperature, wind, sunlight, nutrition and soil quality affect plant growth. If one of these factors is out of balance for the culture of a specific plant, that plant may have a

greater tendency to become diseased. Environmental conditions also affect the growth and spread of disease pathogens. Very dry or wet weather will have an accompanying set of virus diseases that thrive under these conditions.

MOISTURE

Moisture in the plant environment can include humidity, dew, rainfall or water from irrigation. Moisture is critical to the spread of most plant virus diseases. Constantly wet foliage from overhead watering is a condition that promotes disease development.

TEMPERATURE

Each disease pathogen has a specific temperature range for growth and activity. There are warm-weather and cool-weather diseases. Temperature affects how rapidly pathogens multiply.

Soil temperature can also be critical for disease infection. Cool, wet soils promote virus diseases transmitted by nematodes in root diseases. Temperature extremes can cause stress in host plants, increasing susceptibility.

WIND AND SUN

The combination of wind and sun affects how quickly plant surfaces dry. Faster drying generally reduces the opportunity for infection. Wind can facilitate vector movement from one area to another, even many miles. Wind and rain together can be a deadly combination. Sunlight is very important to plant health. Plants that do not receive the right amount of sunlight to meet their cultural requirements become stressed. This may make them more susceptible to infection.

SOIL AND FERTILITY

Soil type can affect plant growth and also development of some pathogens. Light sandy soil low in organic matter favors growth of many types of nematodes. Soil pH affects pathogen development in some diseases. Fertility affects a plant's growth rate and ability to defend against disease. Excessive nitrogen fertilization can increase susceptibility to pathogen attack. It causes formation of SUCCULENT tissue and delays maturity. Nitrogen deficiency results in limited growth and plant stress which may cause greater disease susceptibility.

DISEASE CYCLE

There are five stages in disease development: inoculation, incubation, penetration, infection and symptoms.

INOCULATION

The viral pathogen must be introduced (inoculated) to the host plant. This is done by insects, birds, animals and people.

Working in the garden when plants are wet is a common way to spread disease. Disinfesting tools requires a 9-to-1 solution of water and bleach and takes a minimum of ten minutes. Smokers can transmit tobacco mosaic virus from a cigarette to tomato plants.

Seeds or cuttings from infected plants will also transmit disease. Certified seed guarantees that at the time of sale the seeds are free of all diseases.

Disease-free stock guarantees that the plant is not infected with disease. This is particularly important with perennial plants, such as roses, raspberries and other small fruits.

INCUBATION

The second stage of disease development is incubation. The pathogen changes or grows into a form that can enter the new host plant.

PENETRATION

The third stage is penetration or the point at which the pathogen actually enters the host plant. Wounding roots of bedding plants during transplanting provides entry for viral pathogen. The mouthparts of an insect also result in openings for penetration.

INFECTION

The fourth stage is infection. The pathogen multiplies within the plant using some of the host's biochemical "machinery" and begins damaging the plant tissue.

SYMPTOMS

As the pathogen consumes nutrients, the plant reacts by showing symptoms. Symptoms are evidence of the pathogens causing damage to the plant. Symptoms

include mottling, dwarfing, distortion, discoloration, wilting, and shriveling of any plant part.

PATHOGEN SURVIVAL

Many pathogens can survive without a susceptible host even under the most unfavorable conditions. Many plant diseases survive from one growing season to the next on plant debris, seeds, and alternate hosts or in soil.

Because of pathogen survival, it is important to remove and properly dispose of any infected plant materials. It is also important for the gardener to know about the diseases that affect each plant throughout the home landscape, as well as the conditions needed for proper culture.

Symptoms of plant virus diseases

Symptoms are expressions of pathological activity in plants. They are visible manifestations of changes in color, form, and structure: leaves may become spotted, turn yellow, and die; fruits may rot on the plants or in storage; cankers may form on stems; and plants may blight and wilt. Diagnosticians learn how to associate certain symptoms with specific diseases, and they use this knowledge in the identification and control of pathogens responsible for the diseases.

Those symptoms that are external and readily visible are considered morphological. Others are internal and primarily histological, for example, vascular discoloration of the xylem of wilting plants. Microscopic examination of diseased plants may reveal additional symptoms at the cytological level, such as the formation of tyloses (extrusion of living parenchyma cells of the xylem of wilted tissues into vessel elements).

It is important to make a distinction between the visible expression of the diseased condition in the plant, the symptom, and the visible manifestation of the agent which is responsible for that condition, the sign. The sign is the structure of the pathogen, and when present it is most helpful in diagnosis of the disease.

All symptoms may be conveniently classified into three major types because of the manner in which pathogens affect plants. Most pathogens produce dead and dying tissues, and the symptoms expressed are categorized as necroses. Early stages of necrosis are evident in such conditions as hydrosis, wilting, and yellowing. As cells and

tissues die, the appearance of the plant or plant part is changed, and is recognizable in such common conditions as blight, canker, rot, and spot.

Many pathogens do not cause necrosis, but interfere with cell growth or development. Plants thus affected may eventually become necrotic, but the activity of the pathogen is primarily inhibitory or stimulatory. If there is a decrease in cell number or size, the expressions of pathological activity are classified as hypoplases; if cell number or size is increased, the symptoms are grouped as hyperplases. These activities are very specific and most helpful in diagnosis. In the former group are such symptoms as mosaic, rosetting, and stunting, with obvious reduction in plant color, structure, and size. In the latter group are gall, scab, and witches'-broom, all visible evidence of stimulation of growth and development of plant tissues.

dieback - a disease of plants characterized by the gradual dying of the young shoots starting at the tips and progressing to the larger branches

mosaic - viral disease in solanaceous plants (tomatoes, potatoes, tobacco) resulting in mottling and often shriveling of the leaves

yellow dwarf - any of several virus diseases of plants characterized by stunting and yellowing of the leaves

yellow spot - viral diseases characterized by yellow spotting on the leaves

Kinds of plant diseases

MYCOPLASMAS

Mycoplasmas are disease agents that were not accurately identified until the 1960's. Previously many mycoplasma-caused diseases were thought to be caused by viruses. A group of diseases caused by mycoplasmas is called YELLOWS diseases. Yellows disease is usually spread from one host plant to another by an insect vector. Leafhoppers are common vectors for mycoplasmas.

Viruses and viroids

Viruses are organisms so small that they can only be seen under an electron microscope, magnified 2,000 to 3,000 times. Viruses multiply only within living cells of host plants. Viruses are spread by insects, nematodes and humans. Symptoms include vein banding, mosaic, flecking or spotting on foliage and abnormal growth, similar to

herbicide damage. Tobacco mosaic virus on tomatoes and leaf mosaic on dahlias are common viral diseases. Control is limited to removing and destroying infected plants.

Viruses and viroids are the simplest of the various causative agents of plant disease. The essential element of each of these two pathogens is an infective nucleic acid. The nucleic acid of viruses is covered by an exterior shell (coat) of protein, but that of viroids is not. *See also* Plant viruses and viroids.

Approximately 400 plant viruses and about 10 viroids are known. The nucleic acid of most plant viruses is a single-stranded RNA; a number of isometric viruses have a double-stranded RNA. A few viruses contain double-stranded DNA, and several containing single-stranded DNA have been reported. The nucleic acid of viroids is a single-stranded RNA, but its molecular weight is much lower than that of viruses.

Some viruses, such as tobacco mosaic virus (TMV) and cucumber mosaic virus, are found in many plant species; others, such as wheat streak mosaic virus, occur only in a few grasses. Viruses are transmitted from plant to plant in several ways. The majority are transmitted by vectors such as insects, mites, nematodes, and fungi which acquire viruses during feeding upon infected plants. Some viruses are transmitted to succeeding generations by infected seed. Viroids are spread mainly by contact between healthy and diseased plants or by the use of contaminated cutting tools.

The control or prevention of virus diseases involves breeding for resistance, propagation of virus-free plants, use of virus-free seed, practices designed to reduce the spread by vectors, and, in some cases, the deliberate inoculation of plants with mild strains of a virus to protect them from the deleterious effects of severe strains..

Noninfectious agents of disease

Plants with symptoms caused by noninfectious agents cannot serve as sources of further spread of the same disorder. Such noninfectious agents may be deficiencies or excesses of nutrients, anthropogenic pollutants, or biological effects by organisms external to the affected plants. On the farm, plant-damaging pollution may be caused by careless use of pesticides. Mishandled herbicides are by far the most damaging to plants. Off the farm, anthropogenic air pollutants are generated by industrial processes, and by any heating or transportation method that uses fossil fuels. The most common

air pollutants that damage plants are sulfur oxides and ozone. Sulfur oxides are produced when sulfur-containing fossil fuels are burned or metallic sulfides are refined. Human-generated ozone is produced by sunlight acting on clouds of nitrogen oxides and hydrocarbons that come primarily from automobile exhausts.

Epidemiology of plant disease

Knowledge of these components, the outbreak of disease may be forecast in advance, the speed at which the epidemic will intensify may be determined, control measures can be applied at critical periods, and any yield loss to disease can be projected. The maximum amount of disease occurs when the host plant is susceptible, the pathogen is aggressive, and the environment is favorable.

Epidemiologically, there are two main types of diseases: monocyclic, those that have but a single infection cycle (with the rare possibility of a second or even third cycle) per crop season; and polycyclic, those that have many, overlapping, concatenated cycles of infection per crop season. For both epidemiological types, the increase of disease slows as the proportion of disease approaches saturation or 100%.

Control of plant disease is defined as the maintenance of disease severity below a certain threshold, which is determined by economic losses. Diseases may be high in incidence but low in severity, or low in incidence but high in severity, and are kept in check by preventing the development of epidemics. The principles of plant disease control form the basis for preventing epidemics. However, the practicing agriculturist uses three approaches to the control of plant disease: cultural practices affecting the environmental requirement of the susceptible host -pathogen-environment triangle necessary for disease development, disease resistance, and chemical pesticides.