RAMA UNIVERSITY

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FACULTY OF AGRICULTURAL SCIENCES & ALLIED INDUSTRIES

Lecture 5

ENVIRONMENTAL EFFECTS ON THE DEVELOPMENT OF INFECTIOUS PLANT DISEASE

EFFECT OF HOST–PLANT NUTRITION ON DISEASE DEVELOPMENT

Nutrition affects the rate of growth and the state of readiness of plants to defend themselves against pathogenic attack.

Nitrogen abundance results in the production of young, succulent growth, a prolonged vegetative period, and delayed maturity of the plant. These effects make the plant more susceptible to pathogens that normally attack such tissues and for longer periods. Conversely, plants suffering from a lack of nitrogen are weaker, slower growing, and faster aging. Such plants, therefore, are susceptible to pathogens that are best able to attack weak, slow-growing plants. It is known, for example, that fertilization with large amounts of nitrogen increases the susceptibility of pear to fire blight (*Erwinia amylovora*) and of wheat to rust (*Puccinia*) and powdery mildew (*Erysiphe*). It has also been shown that Cercospora diseases of cereals, such as corn gray leaf spot, rice brown leaf spot, and the Sigatoka disease of banana, increase in severity with increasing nitrogen fertilization. The reduced availability of nitrogen may increase the susceptibility of tomato to Fusarium wilt, of many solanaceous plants to *Alternaria solani* early blight and *Ralstonia solanacearum* wilt, of sugar beets to *Sclerotium rolfsii*, and of most seedlings to Pythium damping off.

It is possible, however, that it is not the amount of nitrogen but the form of nitrogen (ammonium or nitrate) that is available to the host or pathogen that affects disease severity or resistance. Of numerous root rots, wilts, foliar diseases, and so on treated with either form of nitrogen, almost as many decreased or increased in severity when treated with a source of ammonium nitrogen as did when treated with a source of nitrate nitrogen. Each form of nitrogen, however, had exactly the opposite effect on a disease (i.e., decrease or increase in severity) than the other form of nitrogen. For example, *Fusarium* spp., *P. brassicae*, *S. rolfsii*, *Pyrenochaeta lycopersici*, and the diseases they cause (root rots and wilts, clubroot of crucifers, damping off and stem rots, and corky root rot, respectively) increase in severity when an ammonium fertilizer is applied.

Phosphorus has been shown to reduce the severity of take-all disease of barley (caused by *G. graminis*) and potato scab (caused by *S. scabies*) but to increase the severity of cucumber mosaic virus on spinach and of leaf and glume blotch of wheat caused by *Septoria*. Phosphorus seems to increase resistance either by improving the balance of nutrients in the plant or by accelerating the maturity of the crop and allowing it to escape infection by pathogens that prefer younger tissues.

Potassium has also been shown to reduce the severity of numerous diseases, including stem rust of wheat, early blight of tomato, and gray leaf spot and stalk rot of corn, although high amounts of potassium seem to increase the severity of rice blast (caused by *Magnaporthe grisea*), corn gray leaf spot (caused by *Cercospora zeae-maydis*), and root knot (caused by the nematode *Meloidogyne incognita*). Potassium seems to have a direct effect on the various stages of pathogen establishment and development in the host and an indirect effect on infection by promoting wound healing. Potassium also increases resistance to frost injury and thereby reduces infection that commonly begins in frost killed tissues. In addition, potassium delays maturity and senescence in some crops and during these periods infection by certain facultative parasites can be severely damaging.

Calcium reduces the severity of several diseases caused by root and stem pathogens, such as the fungi *Rhizoctonia*, *Sclerotium*, and *Botrytis*, the wilt fungus *Fusarium oxysporum*, and the nematode *Ditylenclus dipsaci*, but it increases the black shank disease of tobacco (caused by *Phytophthora parasitica* var. *nicotianae*) and the common scab of potato (caused by *S. scabies*). The effect of calcium on disease resistance seems to result from its effect on the composition of cell walls and their resistance to penetration by pathogens.

A reduction in disease levels was also observed when levels of certain micronutrients were increased. For example, application of iron to the soil reduced Verticillium wilts of mango and of peanuts. Foliar applications of iron compounds reduced the severity of silver leaf of deciduous fruit trees (caused by *Chondrostereum purpureum*).

Copper applications to the soil significantly reduced take-all and ergot diseases (caused by the fungi *G. graminis* and *Claviceps purpurea*, respectively), as well as stem melanosis (caused by the bacterium *Pseudomonas chicorii*) in wheat and barley. Similarly, applications of **manganese** reduced potato scab and late blight of potato and stem rot (caused by *Sclerotinia sclerotiorum*) of pumpkin seedlings, but the addition of magnesium increased the severity of corn leaf blight caused by *Cochliobolus heterostrofus*, whereas applications of **molybdenum** reduced late blight of potato and Ascochyta blight of beans and peas. The severity of other diseases, however, was raised by the presence of higher levels of these micronutrients, e.g., Fusarium wilt of tomato by increased iron or manganese and tobacco mosaic of tomatoes by increased manganese.

Addition of **silicon** to the soil or to the nutrient solution supplied to greenhouse plants has been shown to reduce diseases. Field applications of various grades of silicon increased the amount of silicon taken up by the plants and reduced the amount of disease in rice such as brown spot of rice caused by *Cochliobolus miyabeanus*, of rice blast caused by the fungus *M. grisea*, and of rice sheath blight caused by *Rhizoctonia solani*. The addition of silicon to the soil reduced brown spot more than application of a fungicide, reduced rice blast comparable to that of a fungicide application, and reduced rice sheath blight by at least 50% not only in susceptible but also in the resistant varieties. In greenhouse applications, silicon reduced disease levels, for example, of cucumber powdery mildew and cucumber root rot caused by the fungus *Sphaerotheca fuligena* and the oomycete *Pythium ultimum*, respectively, and of wheat powdery mildew caused by *Blumeria graminis* f. sp. *tritici*.

ENVIRONMENTAL EFFECTS ON THE DISEASE DEVELOPMENT

EFFECT OF TEMPERATURE

Plants, as well as pathogens, require certain minimum temperatures to grow and carry out their activities. In temperate regions, the low temperatures of late fall, winter, and early spring are below the minimum required by most pathogens. Therefore, diseases are not, as a rule, initiated during that time, and those in progress generally come to a halt. With the advent of higher temperatures, however, pathogens become active and, when other conditions are favorable, they can infect plants and cause disease.

For example, in many canker diseases of perennial plants caused by fungi such as *Nectria*, *Leucostoma* (Cytospora), the oomycete *Phytophthora* or by bacteria such as *Pseudomonas,* infections begin and develop primarily in early spring or in the fall. The reason is that during these periods the temperatures are high enough for these fungi to grow well but are too low to allow optimum host development. Development of the same diseases stops during the winter when temperatures are too low for both host and pathogen, and it is quite reduced during the summer months when host growth and host defenses are at their optimum. Pathogens differ in their preference for higher or lower temperatures.

Some fungi grow much faster at lower temperatures than others, and there may be significant differences among races of the same fungus. Temperature affects the number of spores formed in a unit plant area and the number of spores released in a given time period. As a result, many diseases develop best in areas, seasons, or years with cooler temperatures, whereas others develop best where and when relatively high temperatures prevail. Thus, some species of the fungi *Typhula* and *Fusarium*, which cause snow mold of cereals and turf grasses, thrive only in cool seasons or cold regions. Also, the late blight pathogen *Phytophthora infestans* is most serious in the northern latitudes; in the subtropics it is serious only during the winter. Many diseases, such as the brown rot of stone fruits caused by *Monilinia fructicola*, are favored by relatively high temperatures and are limited in range to areas and seasons in which such temperatures are prevalent.

The effect of temperature on the development of a particular disease after infection depends on the specific host–pathogen combination. The most rapid disease development, i.e., the shortest time required for the completion of an infection cycle, usually occurs when the temperature is optimum for the development of the pathogen but is above or below the optimum for the development of the host. At temperatures much below or above the optimum for the pathogen, or near the optimum for the host, disease development is slower. Thus, for stem rust of wheat, caused by *Puccinia graminis tritici*, the time required for an infection cycle (from inoculation with uredospores to the formation of new uredospores) is 22 days at 5°C, 15 days at 10°C, and 5 to 6 days at 23°C. Similar time periods for the completion of an infection cycle are required in many other diseases caused by fungi, bacteria, and nematodes. Because the duration of an infection cycle determines the number of infection cycles and, therefore, the number of new infections in one season, it is clear that the effect of temperature on the prevalence of a disease in a given season may be very great.

EFFECT OF MOISTURE

Moisture influences the initiation and development of infectious plant diseases in many interrelated ways.

- ✓ It may exist as rain or irrigation water on plant surface or around the roots, as relative humidity in the air and as dew.
- ✓ Moisture is indispensable for the germination of fungal spores and penetration of the host by germ tube.
- ✓ It is also indispensable for the activation of bacterial, fungal and nematode pathogens before they can infect the plant.
- ✓ Moisture in the form of splashing rain and running water also plats an important role in the distribution and spread of many of the pathogens on the same plant and on other plants.
- ✓ Moisture also increases the succulence of host plants and thus their susceptibility to certain pathogens, which affects the extent and severity of disease.

EFFECT OF RAINFALL

- ✓ The occurrence of many diseases in a particular region is closely correlated with the amount and distribution of rainfall within year.
- ✓ Late blight of potato, apple scab, downy mildew of grapes and fire blight are found or are severe only in areas with high rainfall or high relative humidity during the growing season.
- ✓ In apple scab, continuous wetting of the leaves, fruits etc. for at least 9 hours is required for primary infection to take place even at optimum range (18 to 23°C) of temperature.
- ✓ At lower temperature the minimum wetting period required is higher.
- ✓ In powdery mildews, spore germination and infection are actually lower in the presence of free moisture on the plant surface than they are in its absence.

EFFECT OF RELATIVE HUMIDITY

- ✓ Relative humidity is very critical in fungal spore germination and the development of storage rots.
- ✓ Rhizopus soft rot of sweet potato (Rhizopus stolonifer) is an example of storage disease that does not develop if relative humidity is maintained at 85-90 %, even if the storage temperature is optimum for the growth of the pathogen. Under these conditions, the sweet potato root produces corky tissues that wall off the Rhizopus fungus.
- ✓ Moisture is generally needed for fungal spore germination, the multiplication and penetration of bacteria and the initiation of infection e.g., germination of powdery mildew spores occurs at 90-95 % relative humidity.

EFFECT OF SOIL MOISTURE

- ✓ Soil moisture influences the initiation and development of infectious plant diseases.
- ✓ High or low soil moisture may be a limiting factor in the development of certain root rot diseases.

- ✓ High soil moisture levels favours development of destructive water mould fungi, such as species of Aphanomyces, Pythium and Phytophthora.

Overwintering by decreasing oxygen and raising carbon-dioxide levels in the soil makes roots more susceptible to root rotting organisms. Diseases such as take all of cereals (*Gaeumannomyces graminis*), charcoal rot of corn, sorghum and soyabean (*Macrophomina phaseolina*), common scab of potato (*Streptomyces scabies*) and onion white rot (*Sclerotium cepivorum*) are most severe under low moisture levels.

EFFECT OF WIND

- ✓ Most plant diseases that occurs in epidemic portions and spread in large areas are caused by fungi, bacteria and viruses that are spread either directly by wind or indirectly by insects which can travel long distances with the wind.
- ✓ Uredospores and many conidia are transported to many kilometers by wind.
- ✓ Wind becomes more important when it is accompanied by rain.
- ✓ Wind blown rain splashes can help in spread of bacteria from the infected tissues.

EFFECT OF LIGHT

- ✓ Light intensity and duration may either increase or decrease the susceptibility of plants to infection and also the severity of disease.
- ✓ Light mainly cause production of etiolated plants due to reduced light intensity which in turn increases the susceptibility of plants to non-obligate parasites but decreases the susceptibility of plants to obligate parasites.
- ✓ It also enhances the plants' susceptibility to viral infections.

EFFECT OF SOIL PH

- ✓ Soil pH is a measure of acidity or alkalinity and it markedly influences occurrence of soil borne pathogens.
- ✓ Growth of potato scab (Streptomyces scabies) pathogen is suppressed at a pH of 5.2 or slightly below but is more severe at a pH 5.2 to 8.0 or above.

- ✓ Club root of crucifers caused by Plasmodiophora brassicae is most severe at a pH of 5.7, whereas its development drops sharply between 5.7 and 6.2 and is completely checked at pH 7.8.

EFFECT OF SOIL TYPE

- ✓ Certain pathogens are favored by loam soils and others by clay soils.
- ✓ Fusarium wilt disease which attacks a wide range of cultivated plants causes more damage in lighter and higher soils.
- ✓ Nematodes are also most damaging in lighter soils that warm up quickly.