**Unit 3: Plant Diseases Epidemiology**

**Forecasting of plant diseases**

Being able to forecast plant disease epidemics is intellectually stimulating and also an indication of the success of modeling or computer simulation of particular diseases. Foremost, however, it is extremely useful to farmers in the practical management of crop disease.

Disease forecasting allows the prediction of probable outbreaks or increases in intensity of disease and, therefore, allows us to determine whether, when, and where a particular management practice should be applied. In managing the diseases of their crops, growers must always weigh the risks, costs, and benefits of each of numerous decisions. For example, they must decide whether or not to plant a certain crop in a particular field. Growers must also decide whether to buy more expensive propagating stock free of virus and other pathogens or whether they can “get by” with untested stock. Quite often, growers must decide whether to plant seed of a more expensive or less-yielding but resistant variety rather than seed of a high-yielding but susceptible variety that needs to be protected by chemical sprays. Most frequently, farmers need forecasts that will help them determine whether a plant infection is likely to occur so they can decide whether to spray a crop right away or to wait for several more days before they spray. If disease forecasting allows them to wait, they can reduce the amounts of chemicals and labor used without increasing the risk of losing their crop.

To develop a plant disease forecast, one must take into account several characteristics of the particular pathogen, host, and, of course, environment.

In general, for most monocyclic diseases (such as root rot of peas) and Stewart’s wilt of corn) and for a few polycyclic diseases that may have a large amount of initial inoculum (such as apple scab), disease development may be predicted by assessing the amount of the initial inoculum. For polycyclic diseases (such as late blight of potato) that have a small amount of initial inoculum but many infection cycles, disease development can best be predicted by assessing the rate of occurrence of the infection cycles. For diseases in which both the amount of initial inoculum and the number of disease cycles are large, e.g., beet yellows, both factors must be assessed for the accurate prediction of disease epidemics. Such assessments, however, are often difficult or impossible, and, despite considerable improvements in equipment and methods, assessments of initial inoculum or rapidity of infection cycles are seldom accurate.

**Disease Diagnosis: The Key to Forecasting of any Plant Disease Epidemic**

Plants in a field are rarely attacked by a single kind of pathogen. More often than not, leaf spots and blotches caused by abiotic factors or bacteria may be present along with spots and blotches caused by fungi. Such symptoms may be confused with those caused by the pathogen in question and may be difficult to diagnose accurately. Such difficulty is especially likely early in the development of a disease when accurate diagnosis is needed most for determining if a threshold for development of an epidemic has been reached and appropriate instructions for its management must be issued.

**Evaluation of Epidemic Thresholds**

It is always desirable for the grower to have flexibility in timing fungicide applications according to the progress of an epidemic.

In diseases characterized by numerous localized infections (foliar diseases), epidemics are generally characterized by three parameters: disease incidence in individual plants, disease incidence in individual organs (usually leaves), and disease severity (percentage infected leaf area) in leaves.

**These parameters mark different phases of disease development-**

* In the early stages of disease, disease incidence in plants may increase rapidly but disease severity on individual plants is low.
* In the second phase of the epidemic, i.e., disease incidence in leaves, there is a small increase in disease severity along with an increase in disease incidence in leaves. Depending on the specific disease, when a percentage (e.g., 1–50%) of plants and a percentage (e.g., 1–25%) of leaves show disease incidence, these are taken as the epidemic threshold in the first two phases of the epidemic for the application of fungicides to stop or slow the development of the epidemic. During the third phase of a disease, disease severity is likely to increase rapidly (up to 2–50% per week).
* During this phase, fungicides are applied according to disease severity assessment, the dictates of weather conditions (rainfall, relative humidity, temperature measured daily, and providing a daily infection value), and continue as long as there is healthy tissue on the plants that needs to be protected while the crop is not yet ready for harvest.

Therefore, in order to apply fungicides only when needed, one must evaluate the tolerance level of disease severity at harvest. This tolerance level, known as economic damage threshold, is the highest disease severity level that does not decrease economic profits. The economic damage threshold is obtained by studying a disease–loss relationship of disease severity at harvest and the final value of the produce and then determining the point beyond which disease severity at harvest decreases economic profits.

**Forecasts Based on Amount of Initial Inoculum**

In Stewart’s wilt of corn [caused by the bacterium Erwinia (Pantoea) stewartii], the pathogen survives the winter in the bodies of its vector, the corn flea beetle. Therefore, the amount of disease that will develop in a growing season can be predicted if the number of vectors that survived the previous winter is known, as that allows an estimation of the amount of inoculum that also survived the previous winter. Corn flea beetles are killed by prolonged low winter temperatures. Therefore, when the sum of the mean temperatures for the three winter months December, January, and February at a given location is less than -1°C, most of the beetle vectors are killed and so there is little or no bacterial wilt during the following growth season. Warmer winters allow greater survival of beetle vectors and proportionately more severe wilt outbreaks the following season.

In the downy mildew (blue mold) of tobacco (caused by the oomycete Peronospora tabacina), the disease in most years is primarily a threat to seedbeds in the tobacco-producing states. When January temperatures are above normal, blue mold can be expected to appear early in seedbeds in the following season and to cause severe losses. However, when January temperatures are below normal, blue mold can be expected to appear late in seedbeds and to cause little damage. If the disease is expected in seedbeds, control measures can be taken to prevent it from becoming established, and subsequent control in the field is made much easier. The warning system keeps the industry aware of locations and times of appearance and spread of blue mold and helps growers with the timing and intensity of controls.

In pea root rot (caused by the oomycete Aphanomyces euteiches) and in other diseases caused by soilborne fungi and some nematodes, the severity of the disease in a field during a growing season can be predicted by winter tests in the greenhouse. In these tests, susceptible plants are planted in the greenhouse in soil taken from the field in question. If the greenhouse tests show that severe root rot develops in a particular soil, the field from which the soil was obtained is not planted with the susceptible crop.

**Forecasts Based on Weather Conditions Favoring Development of Secondary Inoculum**

In late blight of potato and tomato (caused by the oomycete Phytophthora infestans), the initial inoculum is usually low and generally too small to detect and measure directly.

When constant cool temperatures between 10 and 24°C prevail and the relative humidity remains over 75% for at least 48 hours or is at least 90% for 10 hours each day for 8 days, infection will take place and a late blight outbreak can be expected from 2 to 3 weeks later. If, within that period and afterward, several hours of rainfall, dew, or relative humidity close to the saturation point occur, they will serve to increase the disease and will foretell the likelihood of a major late blight epidemic.

Computerized predictive systems have been developed for epidemics of late blight and several other diseases; in some such systems, e.g., BLITECAST for late blight; FAST (for forecasting Al. solani on tomatoes); TOMCAST (for tomato forecaster) for tomato early blight, Septoria leaf spot, and anthracnose; and PLAM for peanut leaf spot, moisture and temperature are monitored continuously. From this information weather severity values are calculated, infection and disease severity values are predicted, and recommendations are issued to growers as to when to begin spraying.

**Forecasts Based on Amounts of Initial and Secondary Inoculum**

In apple scab (caused by the fungus Venturia inaequalis), the amount of initial inoculum (ascospores) is usually large and is released over a period of 1 to 2 months following bud break.

After primary infections, however, secondary inoculum (conidia) is produced, which multiplies itself manyfold with each succeeding generation. The pathogen can infect wet leaf or fruit surfaces at a range of temperatures from 6 to 28°C. The length of time that leaves and fruit need to be wet, however, is much shorter at optimum temperatures than at either extreme (9 hours at 18–24°C versus 28 hours at 6 to 28°C).

By combining temperature and leaf wetness duration data, the apple scab forecast system can predict not only whether an infection period will occur, but also whether the infection periods will result in light, moderate, or severe disease. Such information, collected and analyzed by individuals or by weather-sensing microcomputers, is used to make recommendations to growers. The latter are advised of the need and timing of fungicide application and about the kind of fungicide (protective or eradicant) that should be used to control the disease.