EPIDEMIOLOGY IN RELATION TO TESTING FOR RESISTANCE TO DISEASES AND INSECTS

R F. Patton1/

Testing for resistance to diseases or insects makes indispensable a familiarity with the disease or insect under consideration. The manipulation of test plant and pathogenic organism in order to provide a useful rating or index of relative resistance or susceptibility is the aim of testing As a reminder of some points to be considered in the testing operation, let's look at a page or two from a plant pathologist's notebook.

HEALTH AND DISEASE

In any program concerned with testing for resistance to disease (or insects), it is important to have a clear understanding of the nature of health and disease° Health, which might be defined as soundness of body

1/ Assistant Professor, Department of Plant Pathology, University of Wisconsin, Madison 6, Wisconsin.

and vigor of normal activities, is dependent not merely on freedom from disease but primarily on physiological stability. Disease is the inhibition or other disturbance of one or more of the physiological activities of an organism, It is not a static "condition."

The occurrence, course, and severity of disease may be influenced by numerous factors other than the mere presence and contact of suscept and pathogen. The study of these various factors influencing disease development is the concern of epidemiology.

VARIATION IN THE NORMAL DISEASE CYCLE

Plant disease levels are variable. We recognize, for example, the existence of endemic and epidemic diseases, a classification based primarily upon the level or amount of the disease in an area. An endemic' disease represents a low level of pest incidence, usually present in a given area under normal conditions. If it suddenly flares into prominence, a plant disease is described as epidemic.

Similarly, there is variation in the course of disease in an individual suscept or, perhaps, group of suscepts. A disease may be severe in one plant, whereas in another the disturbance of physiological processes may be hardly noticeable. Moreover, it is possible that both of these "levels" of disease represent the "normal" course of events, depending upon the influence of all the various factors affecting disease development.

Thus, the range of variation to be expected in any normal disease cycle must be known in order to differentiate the normal suscept reaction from the reaction of a resistant suscept. And, too, just as there is a range of variation in normal disease development and normal suscept reactions to disease, so also are there often different degrees of resistance to disease. Therefore, an accurate knowledge of disease development is essential to the recognition of resistance when it does appear in the trees being tested.

THE SIGNIFICANCE OF PREDISPOSITION IN DISEASE DEVELOPMENT

We usually assume that activity of the "pathogen" is the direct cause of disease. However, we must not overlook the influence to varying degrees of numerous other factors in the development of disease. The activity of a pathogenic organism is only one factor and may be, in fact, only a relatively minor, if indispensable, one in disease development. The pathogens of many endemic diseases are always present, and other factors (e.g., age and vigor of suscept, weather, microclimate, etc.) actually determine whether disease development will occur. Heart rot of forest trees is such a case in point,

In working with disease resistance, then, we have developed the concept that disease resistance must be defined not alone in terms of organism-suscept relations, but also in terms that include the environmental conditions as they influence both suscept and pathogen.

THE PATHOLOGICAL SEQUENCE

A pathological sequence includes the series of successive stages in disease development produced in the intimate relation between a pathogenic organism and an individual suscept. After initial dispersal of the inoculum, there are generally three successive series of activities: (1) inoculation--the arrival of inoculum at the infection court; (2) incubation--the revival of activity of the inoculum at an infection court, entrance into the suscept, and initiation of disease; and (3) infection--the subsequent activities of the pathogen which cause progressive disease in the suscept and development of a characteristic symptom picture.

The course of this sequence is influenced at all of these various stages by numerous factors other than the mere presence and contact of suscept and pathogen. These factors may be internal (heritable) or external (environmental), and may influence disease development through effects on the suscept or pathogen or both.

FACTORS INFLUENCING DISEASE DEVELOPMENT

Internal (Heritable) Factors

Susceptibility and resistance to specific diseases in plants are inherited just as are characters of morphology. So also is virulence heritable in pathogenic organisms. Individuals or strains of the suscept may vary widely in relative susceptibility, and strains of the pathogen may also vary considerably in virulence. Both functional and structural factors affect the occurrence, course, and severity of disease.

Factors affecting resistance of the suscept include such things as structure of protective organs and tissues, "pitching-over" of wounds, self-pruning tendency of suscept, seasonal maturation of tissues, presence of substances toxic to the pathogen, and ability to block progress of the pathogen by the formation of gums, resins, or wound meristems.

Factors affecting the virulence of the pathogen may include such things as longevity of spores, period of spore release, abundance of inoculum reaching infection courts, ability to live saprophytically, the necessity for an alternate host for completion of the life cycle, and ability to penetrate normal and wound barriers of the suscept, to name only a few.

External (Environmental) Factors

Health and vigor of the suscept are dependent upon factors of the site and other external factors. These may also affect the pathogen in all stages of disease development, including dispersal of inoculum, inoculation, incubation, and infection.

The resistance of the suscept is influenced by climatic (including factors of the microclimate) components such as precipitation, temperature, light, weather injuries; by edaphic factors, including soil structure,

fertility, moisture, pH, etc.; and by biotic agents, limited almost entirely to the effects of man and other animals on the suscept, primarily in the form of injury. The latter are most important in providing infection courts, such as insect wounds or logging injuries.

Virulence of the pathogen may be affected at dispersal by such things as parasites and predators of the pathogen (affecting volume of inoculum), presence or absence of alternate hosts, and physical barriers. Inoculation may be affected by such things as winds and air currents, rainfall, running water, the presence of vectors, density and purity of stands of suscepts, and particularly temperature and humidity favorable to survival of inoculum. Incubation and infection are affected particularly by such factors as moisture, temperature and pH favorable to resumption and continuation of activity of the pathogen, and by the presence of antibiotic or antagonistic organisms in the substrate, especially in the soil. Factors of the microclimate play a very important role at this stage in many plant diseases.

CONCLUSIONS

In testing plants for resistance to disease, we must strive to effect a maximum disease development in the plants under test. Therefore, it is important to be aware of the factors influencing disease development. It must be recognized, too, that there is a range of variation in normal disease development, as well as that susceptibility of the suscept and virulence of the pathogen are also variable.

A program of breeding for resistance calls for providing a broad base for selection by using the widest array of genotypes of the suscept. But it is just as important to provide as broad a base of exposure as is practicable in the testing phase. This stage includes not only encompassing the wide range of virulence exhibited by different strains of the pathogen, but also providing favorable conditions for disease development to insure a severe and uniform exposure. Here are included such steps as learning how to create a localized epidemic in the experimental field, the location of test plots at such places where the environmental factors are conducive to an epidemic outbreak, the manipulation of cultural conditions to increase disease exposure, and other similar measures.