Disease Management of Greenhouse Crops: The Role of Technology©

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An overview is presented of the role that technology plays in disease management in greenhouse crops. The fundamental principles of plant disease control as embodied in the disease triangle are being used as point of departure. The impact of technological advances in both the biological field and in the field of greenhouse equipment, including computer aided automation, on disease management is discussed.

INTRODUCTION

Plant disease control methods can be categorized as either preventative or curative. It is also helpful to view disease control in the context of the disease triangle which stipulates that, for any disease to develop, there must be a susceptible host and a virulent pathogen present, and the environmental conditions must be conducive for the disease. Any disease control measure should address one or more of these three components. Technological advances have provided the grower with many tools with which this can be achieved.

IMPORTANCE OF THE BIOLOGY, ECOLOGY, AND EPIDEMIOLOGY OF THE PATHOGEN

It is imperative to know the biology and epidemiology of pathogens in order to design an effective disease management strategy against it. The gray-mold pathogen, *Botrytis cinerea*, was used by Jarvis (1989) to illustrate how behavior of this fungus has profound implications in the design of preventative and therapeutic disease management strategies. The critical biological and epidemiological factors for fungal pathogens include the type of inoculum and the environmental requirements for sporulation, dispersal, spore germination, infection, and host colonization. *Botrytis cinerea*, for example, has sclerotia and conidia as inocula, produces conidia at temperatures above 12^{o}C in subsaturated atmospheres (optimum 15^{o}C), and infects plants from conidia and occasionally ascopores in a film of water at temperatures between 15 and 25^{o}C (Jarvis, 1989). It is obvious that each type of fungus or pathogen will have its own set of environmental requirements, necessitating different control measures. Bacteria and viruses will differ greatly from fungi in terms of inoculum, dispersal, and infection requirements.

CONTROL OF THE GREENHOUSE ENVIRONMENT

Modern technology is providing powerful tools enabling the grower to control the greenhouse environment, thereby managing both crop production and plant diseases more accurately. Temperature, humidity, radiation, carbon dioxide exchange, and nutrition are all important factors governing not only the processes of crop growth, but also pathogenesis. Accurate monitoring and control of these conditions as well as energy input and conservation, light, shade, air movement, ventilation, water vapour density, dew point, and irrigation can be achieved by microprocessors (Challa et. al., 1988; Jarvis, 1989; Ting et. al., 1989). Of these factors, Jarvis (1989) considered manipulating the interactions of temperature and water vapour density to be the most important in control of diseases of leaves, flowers, and fruit, whereas rhizosphere moisture and temperature were considered most important for root diseases. With adequate knowledge of the environmental requirements for infection and disease development, it is possible to design disease management strategies based on prevention, escape, or suppression. However, these strategies must be reconciled with requirements for optimum growth and productivity.

An example of the effect of environmental control on a plant disease is the development of cucumber gray mold in nonheated polyethylene greenhouses covered with various types of cladding repelling infrared irradiation compared with cladding which has no infrared repellency (Elad et. al., 1988). Cladding material has a profound influence on temperature and humidity in greenhouses, as well as quality of light.

EFFECT OF HIGH RELATIVE HUMIDITY AND FREE MOISTURE

Diseases which thrive under conditions of high humidity (low vapour pressure deficit) include gray mold (*Botrytis cinerea*), tomato late blight (*Phytophthora infestans*), downy mildew of lettuce (*Bremia lactucae*), downy mildew of cucurbits (*Pseudoperonospora cubensis)*, tomato leaf mold (*Fulvia fulva*), chrysanthemum white rust (*Puccinia horiana*), and bacterial diseases (Elad, 1999). Powdery mildew of cucurbits (*Sphaerotheca fusca*), on roses (*S. pannosa*), and in other crops is favoured by high humidity, but is negatively affected by leaf surface wetness (Jarvis, 1989). Diseases which are enhanced by wetness can be controlled by reduction of atmospheric humidity through environmental manipulation (Morgan, 1984; Winspear et. al., 1970). As was pointed out by Elad (1999), high humidity often leads to the condensation of moisture on aerial plant parts and, therefore, the effect of free water is often difficult to separate from that of high humidity. Furthermore, there is an interplay between relative humidity and temperature.

DISEASE ESCAPE

Disease escape in the context of greenhouse crop production implies elimination of inoculum as well as avoidance of conditions which favour infection and subsequent disease development.

The emphasis in this overview is on the role of technology in disease management. However, it is important to note that over many years a series of standard control measures has evolved which are routinely applied in nurseries and greenhouse production systems. Elimination of inoculum by soil or medium sterilization, use of pathogen-free seed and propagation material, insect vector control, and practicing strict hygiene are all important disease-escape mechanisms (Jarvis, 1992). However, even if inoculum is present, it is still possible to escape the disease by manipulating environmental conditions to prevent either infection or subsequent development of the disease. As an example of this, Jarvis (1992) refers to gray mold (*Botrytis cinerea*), pointing out that the fungus should be prevented from producing conidia and that the disease, following the processes of spore production, liberation, dispersal, and infection, is temperature-dependent. Also, low vapor-pressure deficits, with night or dawn deposition of dew, should be avoided. This can be achieved by heating and ventilation at sunset when the vapor pressure deficit is low (Morgan, 1983, as referred to by Jarvis, 1992). Examples of other diseases which are controlled by air circulation and the outward ventilation of humid air from the greenhouse include leaf mold of tomato (caused by *Fulvia fulva*); Septoria leaf spot of tomato (Stair et. al, 1928); gray mold (*Botrytis cinerea*) of tomato (Bravenboer and Strijbosch, 1975), geranium (Melchers, 1926), and *Saintpaulia* (Beck and Vaughn, 1949) as referred to by Jarvis (1992).

Other measures facilitating disease escape are management of soil water potential and light, grafting of vegetable scions onto disease-resistant rootstocks, optimal fertilization, irrigation, and avoidance of any conditions or cultural practices which can induce stress in the plant (Jarvis, 1992). Growing of plants in hydroponic systems in soilless substrates or water solution can also be a method of disease escape.

LIMITING DISEASE SPREAD

Disease control by means of limiting spread is strongly linked to the principles of epidemiology. The key issues are limiting inoculum production and dispersal. If the requirements for inoculum production and dispersal of a pathogen is known, the greenhouse environment can be manipulated to inhibit these processes.

Wind speed, for example is an important factor in the dispersal of conidia of the Hyphomycetes and Erysiphales and can be regulated by changing the fan speed of the ventilation system (Jarvis, 1992). Other measures of limiting disease spread include control of insect vectors and sanitation practices which reduce the amount of inoculum.

Biological Control. Technological advances in the biological field include biological control of both foliar and soilborne pathogens. Although the use of biocontrol against plant diseases in greenhouses is not yet common practice for diseases of roots, foliage, flowers, and fruit, glasshouse crops offer more attractive possibilities for biocontrol than field crops, because the population level of antagonists is easier to maintain under glasshouse conditions (Elad and Chet, 1995).

Examples of effective biocontrol in greenhouse crops are presented in Table 1.

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