

**BASIC PRINCIPLES OF PLANT  
PATHOLOGY**

**1 INTRODUCTION**

A plant is healthy or normal when it can carry out its physiological functions to the best of its genetic potential. Any departure, beyond a certain deviation, from the normal appearance, form or functioning thereof results in the plant being regarded as “diseased”.

Diseases are classified as either infectious (biotic) or non-infectious (abiotic). Biotic diseases are caused by various micro-organisms such as bacteria, fungi and viruses. Abiotic diseases are caused by adverse environmental conditions, nutritional deficiencies, genetic defects and incorrect cultural practices. These integrated disease management guidelines, deal only with the biotic diseases of practical significance to the citrus grower. Abiotic diseases are covered extensively in the other volumes in this series of Integrated production guidelines.

It should be appreciated by all growers that the status of any existing disease is ever-changing and that the potential always exists for a new disease to arise. Existing diseases can become tolerant to our methods of control; new diseases can and do suddenly appear. For example, the latter can happen through chance transmission by insect vector, of a disease present in a benign form in indigenous bush, into an adjacent citrus planting. In such a case the citrus host can provide an ideal substrate for the infecting organism with devastating results. Just such a case has occurred in Oman, where a new disease is presently destroying the entire lime industry of that country.

**An earnest appeal is therefore made to growers to be constantly on the lookout for unusual leaf or fruit symptoms in their orchards, and if observed, to report these to Citrus Research International.**

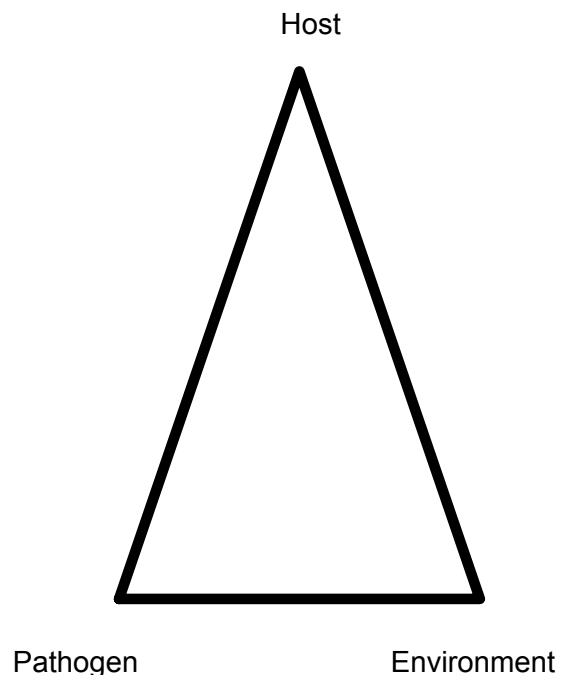
Only through such surveillance will we be in a position to take early action against a new disease.

The occurrence and status of biotic diseases are determined by the virulence of the pathogen, the susceptibility of the host plant

and the local environmental conditions. The relationship between these factors is discussed in the chapters which follow.

**2 THE RELATIONSHIP BETWEEN THE  
PATHOGEN, THE HOST AND THE  
ENVIRONMENT**

The mere presence of a plant pathogen does not necessarily mean that it will cause disease. Other factors or conditions are also necessary. These include the susceptibility of the plant to the pathogen and factors in the local environment such as climate, soil conditions and cultural practices. Since these factors are invariably related, they can be grouped into three basic components and illustrated in the form of a “disease triangle”. This relationship is illustrated in Figure 5.1.



**Figure 5.1.** The disease triangle

The relationship between three basic components is the same as that of the angles in a triangle in that a change in one of the angles of the triangle will bring about changes in the other angles. A change in the magnitude of influence of one factor in the disease triangle will bring about changes in the magnitude of influence of the other factors. Furthermore, in the same way that the removal of one or more of the corners of the triangle renders it incomplete, the elimination of one or more of

the components of the disease triangle results in a situation where disease cannot develop.

This principle is fundamental to the appreciation and management of diseases and should always be borne in mind. The practical relevance of this to the citrus industry is discussed in the chapters which follow.

## 2.1 The Pathogen

The old adage “prevention is better than cure” is of particular relevance in that the ideal situation is the complete absence of the pathogen. In this regard, control of the production and importation of plant material is very important in restricting diseases which may exist in other countries. Government regulations are in effect in practically all countries and the inspectors who enforce the regulations have wide powers. Where necessary, destruction of infected fruit or plant material may be ordered. Growers and nurserymen are therefore warned not to import plant material without going through the appropriate official channels *viz.* the Directorate of Plant Health and Quality .

A few of the diseases which are not currently present in southern Africa but which could pose a serious threat to our industry if they were introduced include the following:

- *Asian greening*: This disease is caused by *Liberibacter asiaticum* and transmitted by the Asian citrus psylla. If they both become established in the hotter citrus production areas of southern Africa, e.g., the Onderberg, Komatipoort, Pongola, Nkweleni, Mozambique and Swaziland, Asian greening could pose a larger threat to citrus production in these areas than African greening disease in the cooler areas.
- *Citrus canker*: This disease can be found in several of the major citrus producing countries of the world. It is caused by the bacteria *Xanthomonas campestris* pv. *citri*. The presence of leaf miner in South Africa makes the threat of citrus canker much larger than it was when it was eradicated in this country in 1927.
- *Citrus variegated chlorosis*: This disease can be found in Brazil where it kills 1 000 000 trees per year. It is caused by

the bacteria, *Xylella fastidiosa*, and is spread by a specific group of leafhoppers that have a wide host range. Controlling the vector is therefore difficult.

- *Colletotrichum post bloom fruit drop*: This disease is found in Brazil and Florida where it can cause crop losses of up to 90%. It is an airborne disease and the impact differs from year to year depending on the climate.
- *Fruta Bolita*: This disease has destroyed the entire citrus industry on trifoliolate orange in the Misiones Province of Northern Argentina. The cause is unknown.
- *Leprosis virus*: This virus can be found in Brazil. Its vector is the Brevipalpus mite which is present in South Africa.
- *Mal Secco*: This disease can be found in some of the Mediterranean countries. It is caused by *Phoma tracheiphila* and enters the branches through pruning wounds. If it originates as a root infection, tree collapse can be rapid. Mal Secco on lemon trees is extremely damaging and could eradicate the lemon industry if it establishes in the Western Cape.
- *Rubilose*: This disease occurs in South America and is caused by the fungus *Corticium salmonicolor*. Major limbs or entire trees are often girdled and killed.
- *Stubborn disease*: This disease is caused by the spiroplasm, *Spiroplasma citri*. The symptoms of stubborn are variable and can be confused with other diseases such as greening. The disease can be controlled by disease free budwood.
- *Witches Broom Disease of Lime*: This disease is caused by a mycoplasma. It had a devastating effect on the lime industry in the Sultanate of Oman.
- *Sudden death*: This is the most recent disease to strike Brazil. The cause is unknown but according to Bové it is Tristeza-related.

Within South Africa it is also important to prevent the spread of pathogens known to occur only in certain areas or plantings. The

pathogens that are of particular relevance in this regard are listed below.

**Soil-borne pathogens:** All the established citrus production areas in South Africa became infected with root pathogens through the planting of trees originating from open-ground nurseries which were infected. However, since the development of the Cultivar Improvement Programme (CIP) the prevalence of root pathogens in citrus nurseries has been drastically reduced. The citrus nematode, for example, has been totally eradicated from participating nurseries. For new plantings, growers should always insist on receiving trees that have been **certified** free from these pathogens in terms of CIP requirements.

**Greening disease:** This devastating disease occurs only in certain production areas. To prevent the spread of greening disease a law is in force, which governs the movement of citrus trees from one citrus-producing area to another.

**Bud-transmissible viruses:** Through the technique of shoot-tip grafting, it has been possible to eradicate all harmful diseases from the budwood that is used by nurseries participating in the CIP. These diseases include psorosis, exocortis, impietratura and severe strains of tristeza. To ensure freedom from these diseases only

In instances where plant pathogens are present, chemical treatments are applied on a wide scale to prevent infection. The accurate diagnosis and identification of the disease and the pathogen are necessary before control measures can be adopted. Effective disease control also depends on timely action against infection. Trees which appear healthy or are just beginning to show signs of infection or decline should be monitored. Furthermore, knowing whether the pathogen in question is resistant to the available treatments, provides valuable information as to the types of control measures that are likely to succeed. An example of this is the black spot fungus, *Guignardia citricarpa* which has developed resistance to the benzimidazole group of fungicides.

The Diagnostic Centre was established at CRI in Nelspruit to assist growers with the diagnosis and monitoring of diseases. For more information on the services available consult the

part on the Diagnostic Centre in this chapter.

When a disease is endemic and infection cannot be prevented, then it has to be managed. This applies in particular to the insect transmissible diseases such as greening and tristeza since no practical method is yet known for effectively treating these pathogens once they enter the plant. In the case of greening, control of the vector and removal of infected branches are the primary means of control. In the case of tristeza, use is made of the technique called cross protection whereby trees are inoculated with a mild form of the virus to protect them against the severe effects of more virulent aphid-transmitted forms.

## 2.2 The Host

When large numbers of identical plants are brought together and maintained under conditions ideal for growth and high yield, i.e., a monoculture, an opportunity exists for the spread of pathogens which may be of little account under natural conditions. A vigorous plant is also not necessarily more resistant to disease than a poorly developed one, and may in fact offer more opportunity to pathogens, such as *Alternaria* leaf and twig infection or *Phytophthora* in the case of root infection.

Large differences are also known to occur in the inherent tolerance of plants to disease. In citrus, disease tolerance is influenced by choice of both the scion and rootstock. However, the choice of a rootstock which is resistant to root pathogens may result in an increase in susceptibility to some other pathogen. For example, Trifoliate rootstock is very tolerant to nematodes and *Phytophthora* but induces susceptibility to greening disease in the scion, and is itself sensitive to exocortis.

The choice of scion and rootstock for a particular site should therefore take into account all the factors that are likely to influence susceptibility to disease. These aspects are discussed in the appropriate chapters in various volumes of these guidelines.

## 2.3 The Environment

By manipulating the environment through the choice of planting site and cultural practices, the grower should strive to create conditions which

are unfavourable for the transmission, infection or development of pathogens, yet ensure that the plant grows and produces optimally. Firstly, this can be achieved by ensuring that the climatic and soil conditions of the area to be planted are suitable for citrus production. The relevant sections in Volume 1 of this series should be consulted in this regard.

Secondly, the particular conditions of the planting concerned should be taken into account when selecting cultural practices. For example, *Alternaria*-sensitive cultivars such as Minneola tangelos should not be irrigated with overhead sprinklers since this creates a humid environment conducive to infection by the pathogen. Anaerobic soil conditions caused by over-irrigation or poor drainage favour *Phytophthora* which requires free-water in the soil profile for infection to take place. These conditions also lead to a decline in the plant's resistance to disease.

The increasing pressure to reduce the use of chemicals will in future result in greater emphasis being placed on cultural practices in the control and management of diseases. A sound knowledge of each of the primary disciplines involved in fruit production will therefore be required.