GREENING DISEASE

1 PATHOLOGICAL PROFILE

1.1 Distribution and status

Huanglongbing (Chinese for yellow shoot disease) or greening, as it is known in South Africa, is a devastating disease which has wiped out commercial production in several areas which were considered eminently suitable to citrus. Increased costs of production and reduced yield, cause heavy losses.

The areas in which greening occurs can be divided into three zones based on the severity of the disease. Zone A, where the highest incidence occurs, includes the areas Karino-White River, Hazyview, Brondal, Nelspruit, Tzaneen, Rustenburg, Potgietersrus, Zebediela and the Western Cape Province (Stellenbosch-Paarl areas). Zone B, where the incidence of greening is moderate, includes the areas Letsitele, Letaba Valley, Lydenburg-Ohrigstad, Muden-Pietermaritzburg-Richmond and the higher-lying areas of Swaziland. Zone C, where the incidence of greening disease is low, includes the areas Kaapmuiden-Malelane-Hectorspruit, Groblersdal-Marble Hall and large areas of northern KwaZulu-Natal including the Nkwaleni Valley.

In most cases greening disease was introduced to zone C areas by the planting of greening infected trees which originated from nurseries in greening disease areas.

1.2 Description

The organism associated with greening disease has been characterized as a bacterium and named *Candidatus Liberobacter*. This organism is phloem-restricted and has not yet been isolated in pure culture. For many years two forms of the disease have been recognized: an Asian form, relatively heat tolerant as symptoms of the disease occur at temperatures far above 30°C, and an African form, heat sensitive, with no symptoms occurring above 30°C. The African form is named *Candidatus L. africanum* and the Asian form *Candidatus L. asiaticum*.

1.3 Symptoms

All commercial scion and rootstock cultivars are susceptible to greening disease. However, differences in tolerance to the disease occur between cultivars. Sweet oranges, mandarins and tangelos, in particular, are very susceptible, with Minneola tangelo the most susceptible of all commercially grown citrus cultivars.

Grapefruit appears to be not as sensitive as sweet orange. Eureka lemons are fairly tolerant with Bears lime being most tolerant. Citrus trees on *Poncirus trifoliata* rootstock appear to produce a higher percentage of greened fruit than on other rootstock cultivars.

When trees become infected in the nursery or before reaching bearing age, all new growth tends to become systemically infected and the trees fail to come into production. Systemic spread in older trees is slow and the greening organism tends to remain localized in the branches infected initially. Spread from branch to branch in these trees is usually as a result of separate infections by the vector and not by systemic movement. When older trees as described above are pruned back they frequently respond with vigorous, symptomless new growth.

1.3.1 Leaves

Foliar symptoms are non-specific and can easily be confused with symptoms induced by root pathogens such as *Phytophthora* and *Fusarium* spp. or with symptoms of trace element deficiencies or those of citrus blight. Foliar symptoms vary from veinal chlorosis (“yellow vein”) to a “blotchy-mottle” of part or all of the leaf. Leaves showing this latter symptom are mostly the larger leaves on the lower parts of branches, those on short branches inside the canopy and those on more vigorous shoots that develop during the late summer flush. On chronically infected trees the mature leaves are small, upright and frequently exhibit signs of zinc and iron deficiency. These leaves may remain pale and turn green along the main and lateral veins. Green spots and blotches often develop. Leaves on affected branches often feel leathery as a result of starch accumulation in the tissues. Chlorotic leaves

usually abscise and the associated twigs die back. The blotchy-mottle symptoms arise as a result of damage to the chloroplasts caused indirectly by infection.

Infected trees may exhibit symptoms which are limited to occasional twigs on a single branch or a sector of the canopy, or symptoms may be observed throughout, depending on the age when the tree became infected. The presence of unthrifty branches is also indicative of the presence of greening disease in a tree.

Foliar symptoms are often absent during late spring and summer, but as winter approaches symptoms become more defined and are easier to detect. These symptoms can often be confused with so-called “winter-chlorosis”. Early and excessive blossoming is frequently observed on affected branches, but they usually bear poor crops.

1.3.2 Fruit

Symptoms on affected fruit are diagnostically more reliable than foliar symptoms. Fruits are affected in various ways. When they reach 10 to 20 mm in diameter they can become lopsided and mature only on one side, the immature side remaining green when the fruit ripens. Seed in this type of fruit is either absent or abortive in the green side of the fruit.

This type of fruit is found more frequently in the cool citrus producing areas. Other fruit, which may be normal in shape, attain full size but may fail to colour properly and remain lustreless, greenish yellow and fall off before harvest. The seed in this fruit is mostly sterile. Applying pressure with the thumb to an infected fruit on the green side usually leaves a silvery tinge to the depressed area. The juice of affected fruit is low in soluble solids, high in acid and has a bitter, salty taste.

1.4 Transmission

Greening disease is graft transmissible as well as being transmitted by the citrus psyllid *Trioza erytreae* (Del G.). Under ideal conditions the citrus psyllid can become infected (or become a carrier) with the organism after an acquisition feeding period of eight hours and then transmit it to healthy plant tissues within two days with an exposure time of less than one hour. This very rapid transmission rate, coupled with the ability of the insect vector to multiply extremely rapidly under favourable conditions, renders the effective control of the disease and the vector very difficult.

Citrus psylla is present in the majority of citrus production areas. The cool, high altitude production areas of the Limpopo Province are considered endemic and are particularly favourable for the development of this insect. In the hot, low-lying areas of the Limpopo Province, Mpumalanga and the Eastern Cape little or no spread occurs as a result of the sporadic presence of the vector. The incidence of the insect is also low in endemic areas following high temperatures accompanied by low relative humidity. These conditions cause high mortality in egg and young nymphal stages. The vector appears to be absent in the Citrusdal-Clanwilliam citrus areas but is present in high populations in the Paarl-Stellenbosch areas. (Consult citrus psylla in Chapter 3 of this volume of the production guidelines).

1.5 Seasonal occurrence

Once a tree has become infected it remains infected for its entire lifespan.

New growth in spring produces short twigs bearing narrow upright leaves which are completely chlorotic or with dark green spots. As the leaves mature they turn pale green with darker green veins. Summer growth flushes are weak, initially normal green in colour, but as the leaves mature they tend to become mottled. It is these symptomatic growth flushes that constitute the primary source of infection.

During early summer, affected trees appear to improve in condition but as autumn and winter approach, infected sectors or branches of the trees are easily identified.

2 MANAGEMENT ASPECTS

2.1 Disease assessment

Disease assessment should be carried out during winter when foliar and fruit symptoms are most pronounced.

Definite identification of infected branches can only be done when affected fruit is still on the trees.

Infected branches should be marked with strips of coloured plastic or old fertilizer bags. This will reduce the likelihood of healthy branches being inadvertently removed.

2.2 Control options

Control measures must include the following: Making use of disease-free plant material, eliminating the insect vector and eradication of infected material.

New plantings in greening areas should preferably be designed so that hedging and topping do not become necessary. Plantings which are to form hedgerows should be orientated in a north/south direction to minimize the creation of a habitat suitable for psylla breeding.

2.2.1 Cultural

Disease-free nursery trees. Only plant trees supplied by CIP-accredited nurseries in greening disease-free areas or by accredited nurseries which propagate trees from certified budwood under insect-free conditions.

Eradication of infected plant material. Inspect orchards during the winter months before harvest for signs of greening disease infection and mark the infected branches.

Trees up to five years of age which are infected to an extent of 50% or more should be removed. Infected branches should be removed in the remaining trees.

Trees 10 years and older which have 40% and less of the canopy showing symptoms should have the infected branches removed.

Pruning stimulates vegetative growth and this in turn, attracts psylla, particularly when growth occurs on the cooler, south side of the tree. This shady side also offers an ideal habitat for psylla breeding. Pruning should therefore be timed so that the regrowth coincides with a treatment that will control psylla.

When an entire main branch is infected it should be removed completely by sawing off at the point where it originated on the trunk. When a secondary branch is infected it should be removed by cutting it off flush with the main branch at its point of origin. To inhibit the regrowth of shoots from pruning wounds and thereby remove potential psylla breeding sites, the wounds can be treated with one part NAA (Planofix) plus six parts narrow range oil (Orchex, etc).

2.2.2 Biological

Indirectly, biological control of greening disease has been successful in Réunion by introducing the parasitoid wasps *Tetrastichus radiatus*, *T. dryi* and *Psyllaephagus pulvinatus*, which control the vector. *T. dryi* succeeded in eradicating *T. erytreae* within a period of six years after introduction in 1976. This parasitoid was collected in South Africa where it is the major parasitoid of *T. erytreae*. Unfortunately the activity of hyperparasitoids limits the efficacy of *T. dryi* and other parasitoids in South Africa. A survey of predators of psylla in South Africa showed that none of them reduced densities low enough to prevent the spread of greening.

2.2.3 Plant protection products

Psylla control is the most important facet of controlling greening disease. Without efficient psylla control the other measures become redundant. (Consult the section on psylla control in this volume of the production guidelines).