Living with Citrus Greening in South Africa

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ABSTRACT. Greening disease has had a devastating effect on commercial citrus production in a number of regions of the Transvaal and Natal provinces of South Africa since it was first observed in the late 1920s. In recent years, efforts to contain the impact of the disease and its spread have involved a three-pronged strategy; the provision of certified greening-free nursery trees to commercial growers, a reduction of the inoculum through an ongoing programme of removing plant parts showing greening symptoms and the implementation of effective measures to control the psylla vector *Trioza erytreae* (Del G.). This strategy has brought about a distinct reduction in the incidence of greening-infected trees in commercial plantings. New orchards, managed according to industry recommendations, are in many instances performing well, and commercial citrus production is even returning to some areas previously abandoned because of the effects of greening.

A disease known as yellow branch was first observed in the Western Transvaal province of South Africa in 1928/29 (17). Subsequently, in 1937, the disease was described, when it was presumed to be a mineral deficiency (27). According to Basson (2), greening in South Africa was particularly severe during the years 1932 to 1936, 1939 to 1946 and again after 1958. The disease was encountered most severely at altitudes exceeding 700m in the areas bounded by the latitudes 23°30′ and 30°00′. In such greening areas, humidity rarely falls below 25% and mean monthly maximum temperatures vary between 18 C and 30 C.

In 1965 McClean and Oberholzer (15) showed that the citrus psylla *Trioza erytreae* (Del G.) was responsible for the transmission of the disease. This important finding led to the realisation that psylla populations could no longer be tolerated in commercial citrus orchards (1), and provided citrus growers with some hope of curbing the incidence and spread of the disease. Nevertheless, during the late 1960s and early 1970s, production was virtually eliminated in three major citrus areas and by the mid 70s it was estimated that 4 million of the 11 million trees in South Africa were infected.

It was during this period that it was realised that drastic steps were required to save the South African citrus industry from greening. Consequently a co-ordinated approach to the control of the disease was adopted, involving relevant universities, citrus research organisations and producers. One aspect which attracted particular attention was the quest to isolate and culture the causal organism with a view to developing a reliable indexing method for the disease. This proved elusive and gave impetus for the industry to focus on practical methods for reducing the impact of greening in the major citrus production areas of the country.

This article discusses the development and outcome of a three pronged strategy which has succeeded in checking the advance of greening and made it possible for profitable citrus production to continue in areas seriously threatened by the disease.

PRACTICAL STEPS TAKEN TO CONTROL GREENING

Tree treatment with antibiotics. Da Graça (11) has traced the investigations made and conclusions drawn by the various researchers who studied the nature of the causal agent. Indications that the organism may be a mycoplasma (14) led to the proposal that tetracycline hydrochloride be evaluated as a tree injection to reduce the symptoms of greening (19). Subsequently the causal organism was shown to be a bacterium (3). Various methods of tree injection were subsequently developed and applied commercially with a certain degree of success. However, it was not sustained as a commercial treatment because the method proved expensive, remission was only temporary, treated trees were inclined to produce small fruit, phytotoxic effects at the injection site and the high levels of residues found in the fruit of treated trees.

Some of these problems were resolved through the application of N-pyrrolidinomethyl tetracycline (PMT), by means of trunk injections with microsyringes (5). However, the fact that only partial success was achieved even by such refined methods of antibiotic treatment caused attention to be focused on control of the vector. Consequently this, the reduction of the inoculum by removal of infected plant parts, and the use of greening free plant material became the backbone of the greening reduction strategy in South Africa.

Control of the vector, *Trioza erytreae* . *Historical developments*. The behaviour and characteristics of citrus psylla, *T. erytreae*, and its ability to transmit greening in commercial orchards has been well documented (11, 18, 20, 21, 22, 23, 24, 25, 26). Arising from these and other findings, the following key features of the vector, which need to be taken into account in the formulation of control strategies, are:

- While psylla are considered to have weak dispersal powers, they can move a distance of at least 1.5 km with wind (20). However, the insects are excellent invaders and can readily locate isolated areas of flush over several hundred meters (18).
- There is continuous movement of psylla between citrus and adjacent indigenous vegetation where this occurs. Indications are that by eradicating native host plants from the vicinity of citrus orchards, psylla populations can be reduced in those orchards (24).
- Adult citrus psylla are almost exclusively confined to young leaves and if new flush is present the vector will remain on the same tree for several hours, especially at night (22).
- The adult psylla cannot survive longer than 55 hr away from suitable foliage, and the maximum lifespan in the absence of their host plants is estimated to be 85 hr (22).
- Females prefer soft leaves for oviposition, this influencing the cultivar as well as time of year of greatest reproductive activity (25).
- There is evidence that females can transmit greening to the plant during oviposition. Psylla nymphs emerging from the eggs may be infected with greening. This suggests that adult psylla may already be infected with greening without any acquisition feeding (26).
- Adult citrus psylla are able to acquire the greening organism within 24 hr of feeding on infected foliage and can transmit the disease 24 hr after the acquisition feeding (26).
- Although contact and systemic insecticides may not prevent the spread of greening to an orchard they may serve to reduce the spread of the disease (22).

These and other findings have assisted in the process of developing effective psylla control programmes. Tree cover sprays specifically aimed at psylla control were proposed by various researchers (4, 10). It was realised that control should be aimed at keeping psylla populations low in all orchards, thereby limiting their dissemination and that of greening to a minimum.

However, it was found after the development of organophosphate resistant redscale (12), that multiple sprays aimed at maintaining low populations of psylla throughout the spring, summer and autumn periods were impractical and caused pest repercussions. It was then realised that systemic treatments targeted specifically at psylla and applied either to the stem or to the roots of the tree would be most effective.

In 1977 Milne and de Villiers (16) developed a method for controlling psylla through the application of dimethoate together with irrigation water to the basin of trees. For various reasons including high costs, the erratic uptake due to different soil types, root health factors, the incompatibility of certain rootstocks with dimethoate and the possibility of accelerated microbial degradation of the soil-applied chemical occurring, this method subsequently fell out of favour.

Control measures since 1985. Having recognised that the application of systemic insecticide treatments were required for effective psylla control, the trunk application of dicrotophos (6) and subsequent monocrotophos (Azodrin 40) (7) was investigated. Following its registration for psylla control in 1986 the use of monocrotophos increased rapidly. This was because its treatment costs were relatively low, minimal disruption of beneficial insects occurred and its application by means of semi-automatic trunk applicators was both easy and effective. Arising from the commercial experience gained, Buitendag (9) proposed a programme for psylla control in 1991. In this paper recommendations were presented for non-bearing trees, those coming into bearing and with a trunk circumference of less than 300 mm, trees with a trunk circumference of between 300 and 400 mm and for trees with a circumference of more than 450 mm. A table giving specific Azodrin 40 dosages required per tree trunk diameter was also referred to (8).

Buitendag (9) also mentioned two new trunk application products which were under investigation to provide an alternative to monocrotophos in the event of psylla developing resistance to this product. It was hoped that the 26 days of control given by monocrotophos could be extended by alternative products. One of these products, methamidophos (Citrimet) was found to be rapidly absorbed through the trunk but only effective against psyllids and aphids for 16 to 18 days. While this control period is relatively short, it is accompanied by a low residue level of the chemical in the tree and thus a short safety period between application and harvest. This product was also found to be effective against a range of mites and thrips.

A second product with the active ingredient imidacloprid was also investigated. It is not an organophosphate and thus reduces the likelihood of psylla developing resistance to the trunk-applied products. The residual effect of the product in the tree, after trunk application, is almost twice as long as that of methamidophos or monocrotophos. However, it is likely to require a lengthy safety period between application and harvest.

Good progress has also been made in the development of effective applicators for trunk treatments. Two patent applicators are presently commercially available and both deliver measured quantities of toxicant when a trigger mechanism is activated. This development has made trunk applications in large citrus orchards a commercial proposition.

The use of disease-free nursery trees. Most of the nursery trees planted by citrus producers in Southern Africa emanate from one of the 32 nurseries which participate in the South African Citrus Improvement Programme (28). One of the requirements of the programme is that trees produced in greening-endemic areas be grown in nursery areas which are enclosed with psylla-proof screening. The budwood used for all certified trees is derived from the Outspan Foundation Block which is located in a greening-free area. Consequently commercial citrus nursery trees from all participating nurseries reach the grower greening free. By pursuing effective psylla control programmes after planting, growers can raise greening-free trees even in areas where psylla and greening are endemic.

Reduction of inoculum (infected plant tissue). The removal of symptomatic plant tissue from infected trees will lead to a reduction of the inoculum and thus the level of psylla infected by the greening organism. This in turn will reduce the extent of greening transmission by the vector (13).

For the purpose of inoculum reduction citrus trees can be divided into two age groups (8):

(i) Trees up to 10 yr of age

The recommendation is that when trees up to 5 yr of age show symptoms of greening of the canopy, they should be removed. Trees from 6 to 10 yr old, which are 75% or more infected with greening should also be removed. Where the infection is lower than these thresholds, only the infected branches should be removed. Interplanting young trees in orchards older than 10 yr which have a history of greening is not recommended.

(ii) Trees older than 10 yr

Individual branches infected with greening do not bear healthy fruit and will not recover. In addition, they consume the nutritional reserves of the tree. In the cases of trees with up to 40% of the branches infected such branches should be marked and removed.

DISCUSSION AND CONCLUSIONS

Although greening disease remains one of the most important factors limiting citrus production in certain areas of South Africa, practical strategies have been developed to enable citrus producers to continue citrus exports successfully in such areas.

A good understanding of the behaviour of the greening vector, *T. erytreae* has enabled control programmes to be developed which are effective in keeping populations down to an absolute minimum. However, this alone is not sufficient. Active programmes to reduce the inoculum of the disease by removing infected tree parts has contributed to a decline in greening pressure in all areas. Further, the large majority of citrus nursery trees entering the South African citrus industry are considered to be free of citrus greening.

This combined approach has paid dividends and has given new hope to citrus growers in areas previously devastated by the disease.

However, the success of the practical measures taken to keep greening at bay should not be seen as a long-term solution to the problem. In effect it is only giving growers a breathing space until more effective control measures are found. In this regard the need for on-going research aimed at understanding the behaviour of the pathogen in the plant, the development of an effective indexing method and the eventual breeding of plants resistant to greening remain a high priority.

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