

Epidemiology and control of citrus tristeza and huanglungbin (greening) diseases in Réunion island

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Epidemiology and control of citrus tristeza and huanglungbin (greening) diseases in Réunion island.

ABSTRACT

INTRODUCTION. Citrus tristeza virus (CTV) and huanglungbin bacteria are the two major graft transmissible pathogens affecting citrus in Réunion island. **CONTROL OF CITRUS HUANGLUNGBIN.** In the 1970's, an epidemiological study showed that, 7 years after plantation of healthy trees, the rate of huanglungbin contamination amounted to 65% of individuals. A control strategy was therefore developed, based on the careful disease-free management of foundation blocks and nurseries, combined with biological control of the vectors. Ten years after the release of exotic parasitoids of psyllids, the two huanglungbin vector populations were consistently reduced thus enabling the development of a profitable citrus industry. This was confirmed by a recent survey of the orchard established with this new strategy. **EPIDEMIOLOGY OF CTV.** To set up an adapted control strategy, the spread of CTV was studied in various ecological conditions of the island. The kinetics of tree contamination by CTV showed a high rate of virus infection. In 1994, a survey was aimed to assess the population dynamics of aphids on citrus in relation with tree phenology and orchard management. The large predominance of *Toxoptera citricidus* (*Tc*) as compared to other aphid vectors was confirmed. Although seasonal variations occurred in *Tc* populations in relation to tree flushing and the presence of natural enemies, colonies of *Tc* could be observed all year round. **CONCLUSION.** Considering the presence of severe stem-pitting isolates disseminated in numerous small orchards and backyards trees, the high rate of virus spread prohibits the plantation of CTV-free susceptible material. Alternatively, the plantation of pre-immunized trees enables the establishment of sustainable *Citrus hystrix* orchards.

KEYWORDS

Réunion, *Citrus*, viroses, epidemiology, disease control.

Épidémiologie et contrôle des maladies de la tristeza des agrumes et du huanglungbin (greening) à l'île de la Réunion.

RÉSUMÉ

INTRODUCTION. Le virus de la tristeza des agrumes (CTV) et la bactérie du huanglungbin sont les pathogènes majeurs des agrumes à l'île de la Réunion. **CONTRÔLE DU HUANGLUNGBIN.** Une étude épidémiologique ayant montré que, 7 ans après la plantation d'arbres sains, 65 % d'entre eux étaient atteints de huanglungbin, une stratégie de lutte contre la maladie était alors conçue, fondée sur la production de masse de plants sains combinée au contrôle biologique des vecteurs. Dix ans après l'introduction de parasitoïdes des psylles, les deux vecteurs du huanglungbin se raréfiaient, permettant une exploitation rentable des agrumes. L'efficacité du contrôle de la maladie a été récemment confirmée. **ÉPIDÉMIOLOGIE DU CTV.** La distribution du CTV étudiée dans diverses conditions écologiques de l'île a montré une forte vitesse de contamination des arbres par le virus. En 1994, une enquête en vergers a étudié la dynamique des populations d'aphides sur agrumes, en relation avec la phénologie de l'arbre et la gestion des vergers. La forte prédominance de *Toxoptera citricidus* (*Tc*) sur les autres vecteurs a été confirmée. Malgré la variation saisonnière des populations de *Tc*, liée aux poussées végétatives des arbres et à la présence d'ennemis naturels, des colonies de *Tc* ont été observées tout au long de l'année. **CONCLUSION.** La présence d'isolats sévères disséminés dans les vergers et les jardins et le fort taux de dissémination du virus n'incitent pas à planter du matériel sensible indemne de virus. En revanche, la plantation d'arbres prémunis permet d'établir durablement des vergers productifs de combavas (*Citrus hystrix*).

Received 20 February 1997
Accepted 10 October 1997

Fruits, 1997, vol 52, p 409-413
© Elsevier, Paris

RESUMEN ESPAÑOL, p 413

MOTS CLÉS

Réunion, *Citrus*, virose, épidémiologie, contrôle de maladies.

● introduction

Citrus tristeza virus (CTV) and huanglungbin bacteria (*Candidatus Liberobacter* sp) are the two major vector-borne pathogens affecting citrus in Réunion island. Both diseases, as well as their respective insect vectors (*Toxoptera citricidus* Kirkaldy, *Diaphorina citri* Kuwayama and *Trioza erythrae* del Guercio), were widely spread when reported in the island in the first half of this century and prohibited the development of a profitable citrus industry.

The implementation of specific control strategies for these two graft-transmissible diseases is reported here. Their success was largely dependent on high standard nursery management for producing certified disease-free planting material.

● control of citrus huanglungbin

citrus huanglungbin spread in the 1970's

In the early 1970's, the huanglungbin bacteria and its two vectors were widely established, covering the entire citrus area of the island. An epidemiological study carried out on 2 740 healthy trees planted in seven locations showed that, within only 7 years, 65% of these certified trees were rendered unproductive due to huanglungbin contamination (AUBERT, 1985). A control strategy was therefore set up, based on: i) the establishment of disease-free foundation blocks and nurseries combined with ii) a vigorous programme of biological vector control.

present situation of the disease

Ten years after the release of exotic parasitoids of psyllids, *T. erythrae* was eradicated, and the populations of *D. citri* experienced a sharp decrease (AUBERT et QUILICI, 1984). In the mean time, a profitable citrus industry could be redeveloped thanks to the continuous production of healthy planting material in registered nurseries. An intensive survey was recently conducted in the district of Petite île, representative of the local citrus

industry (AUBERT et al, 1997). This area is growing some 80 ha of commercial citrus orchards established between the sea level and 1 000 m of elevation. More than 6 000 trees representing 50% of the orchards were checked visually for the presence of disease in September/October 1995. The results confirmed the effectiveness of huanglungbin control, since only 0.5% of mature bearing trees were found to be affected by huanglungbin symptoms. These data give further evidence of the importance of plant certification in the development of control strategies, particularly against pathogens of perennial crops, and in association with proper vector control.

The strategy resulted in a practical eradication of huanglungbin disease from commercial orchards thus enabling a continuous increase of orange and mandarin production in the island. It was therefore possible to focus more attention on tristeza virus that represents another constraint to the development of susceptible species.

● epidemiology of citrus tristeza virus

Citrus tristeza virus (CTV) was probably introduced accidentally in the late 1800's with contaminated material. Today, almost all citrus plants grown in the island are infected. Additionally, the seven aphid species known as potential vectors of the virus (including *T. citricidus*) were reported in the island. Quick decline of tristeza is efficiently controlled through the grafting onto tolerant rootstocks, ie, citrange Carrizo. Nevertheless the productivity of susceptible species such as combava (*Citrus hystrix*) or lime (*C. aurantifolia*) is badly affected by the severe stem pitting isolates prevailing in the island. To set up an adapted control strategy, the spread of CTV was studied in various ecological conditions of the island.

virus spread

In a first approach, the kinetics of CTV contamination of healthy trees were monitored by ELISA in nine citrus plots between 1991 and 1995. The results showed a high

rate of virus contamination (percentage of infected trees) since all the plots were totally infected within one to three years after plantation (figure 1). The disease progress curves fitted well with the pseudo-linear logistic model, with disease increase rates ranging from 0.18 to 0.76 month⁻¹. Spatial analyses of infection were performed using ICOR2, 2DCLASS and ordinary runs. The position of infected trees were generally in a random pattern, although aggregation or edge effect could be observed in a few occasions.

population dynamic of vectors

A survey of 17 orchards was initiated in 1994 to assess the population dynamic of aphids on citrus, in relation to tree phenology and orchard management (ROCHAT, 1995). Flushes and aphids colonies as well as predators and parasitoids were visually rated at weekly intervals between April 1994 and February 1995. The strong predominance of *T citricidus* was confirmed (figure 2). *Aphis spiraecola*, *A fabae*, *A gossypii*, *T aurantii* and *Macrosiphum euphorbiae* were also encountered but with much lower frequency.

A close correlation was observed between tree phenology and abundance of *T citricidus* colonies at the temporal and spatial levels (figure 2). However, with the variable flushing dates among the different types of citrus (due to individual, clonal or environmental factors), young shoots suitable for development of colonies of *T citricidus* are available all year round. *Aphelinus gossypii* (Aphelinidae) was the major parasitoid of *T citricidus*, 15–50% of aphids being parasitized. Aphidiidae were frequently observed on *Aphis gossypii* but very rarely on *T citricidus*.

Interestingly, a significant reduction in aphid infestations was observed in young trees planted on black plastic mulch compared with bare soil plantations. CTV infection was delayed by several months in such mulched trees (figures 1 and 3).

discussion

The data presented here show the high rate of dissemination of CTV in the conditions of Réunion island which may be related to

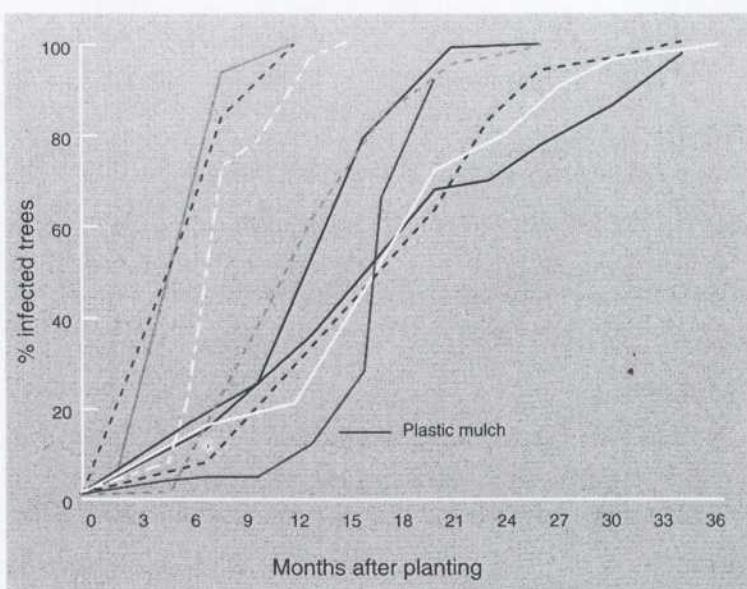
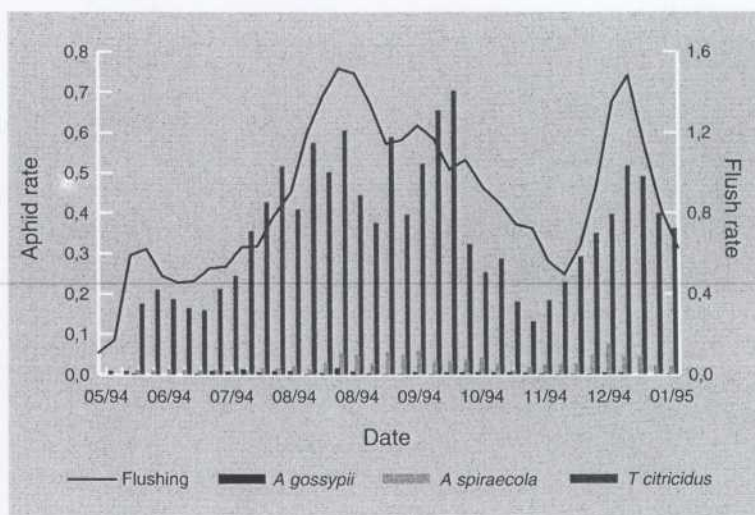


Figure 1
Evolution of percentage of Citrus Tristeza Virus contamination in nine citrus orchards.

the predominance of *T citricidus* as citrus colonizing aphid species. The major role played by this vector on tristeza spread was recently confirmed in several caribbean islands. Clearly severe CTV outbreaks recorded recently in this area correlate with the sudden ingress of *Tc* (GOTTWALD et al, 1995; BERTIN et al, 1997). In agreement with GOTTWALD et al (1995), a sigmoid-like infection process was observed that fitted well with the logistic and Gompertz models. However, in contrast with these authors, no clear aggregation could be evidenced concerning CTV infection or *T citricidus* infestations.

Figure 2
Average flushing rate and aphid infestations in 17 citrus orchards (from ROCHAT, 1995).



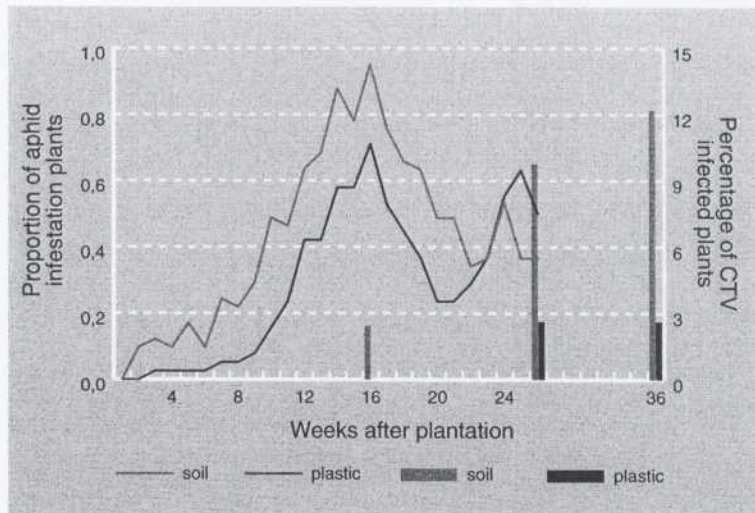
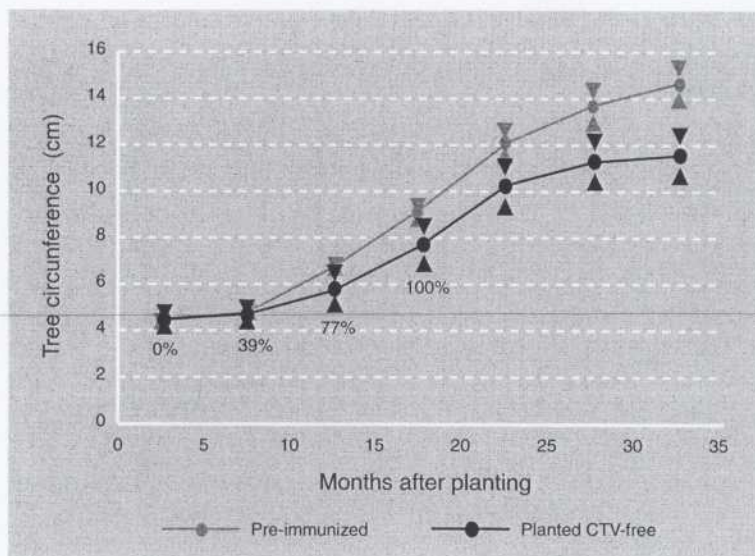


Figure 3
Effect of black plastic mulch on shoot infestations by *Toxoptera citricidus* and citrus tristeza virus infections.

Figure 4
Growth comparison between pre-immunized and healthy *Citrus hystrix* trees. Percentages indicate the rate of CTV contamination of disease-free planted trees.



The citrus industry in Réunion is based on commercial orchards of limited extension (0.5 to 1 ha) and numerous backyard trees. The latter generally lack management and represent an important reservoir of virus and vectors, densely distributed throughout the citrus area. From *T. citricidus* population dynamics and spatial analysis data, it is assumed that infectious aphids originating from neighbouring citrus contribute to new infections in the orchards all over the disease progress. In such a case, a monocyclic disease progress curve could be expected. However disease increase rate is likely to vary over time since tree size, number of

shoots and number of infectious aphids visiting the orchard are not constant. Alternative models that take into account these parameters are worth testing to improve our understanding of CTV epidemics in the conditions of the island.

● conclusion

Due to the prevalence of severe CTV isolates and the vectoring efficiency of citrus aphids, the planting of tristeza-free planting material cannot be recommended. The production of tolerant or resistant material is therefore required. At present, a satisfactory protection of combava against severe stem-pitting isolates is achieved through pre-immunization with a mild local strain (figure 4). This technique is being developed routinely in nurseries. On the other hand, the epidemics of huanglungbin, a lethal disease affecting all types of citrus irrespective of the scion combinations, were efficiently mastered, as a result of the success of biological control against the two psyllid vectors, combined with the release of certified huanglungbin-free material.

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Epidemiología y control de las enfermedades de la tristeza de los agríos y del huanglungbin (greening) en la isla de La Reunión.

RESUMEN

INTRODUCCIÓN. El virus de la tristeza de los agríos (CTV) y la bacteria del huanglungbin son los principales patógenos de los cítricos en la isla de La Reunión. **CONTROL DEL HUANGLUNGBIN.** A partir de un estudio epidemiológico, que demostraba que al cabo de siete años, un 65 % de los árboles sanos plantados tenían huanglungbin, se ideó una estrategia de lucha contra la enfermedad, basada en el cuidado de plántones saneados y el control biológico de los vectores. Diez años después de haber introducido parasitoides de psyllidae, los dos vectores de del huanglungbin se enrarecieron, permitiendo así, una explotación rentable de los cítricos. La eficacia del control de la enfermedad ha sido recientemente confirmada. **EPIDEMIOLOGÍA DEL CTV.** La distribución del CTV, estudiada en distintas condiciones ecológicas de la isla, ha mostrado una alta velocidad de contaminación de los árboles por el virus. En 1994, una investigación en las plantaciones estudió la dinámica de las poblaciones de áfidos en cítricos, ligada a la fenología de los árboles y a la gestión de las plantaciones. Se confirmó el importante predominio de *T citricidus* (*Tc*) respecto de los otros vectores. A pesar de la variación estacional de las poblaciones de *Tc*, ligadas al crecimiento vegetativo de los árboles y a la presencia de enemigos naturales, se han observado colonias de *Tc* durante todo el año. **CONCLUSIÓN.** La presencia de razas severas esparcidas entre los árboles de plantaciones y patios, y el importante índice de diseminación del virus, no favorecen la plantación de material sensible libre de virus. En cambio, la plantación de árboles ya inmunizados permite el establecimiento duradero de huertos productivos de *Citrus bystrix*.

PALABRAS CLAVES

Réunion, *Citrus*, virosis, epidemiología, control de enfermedades.