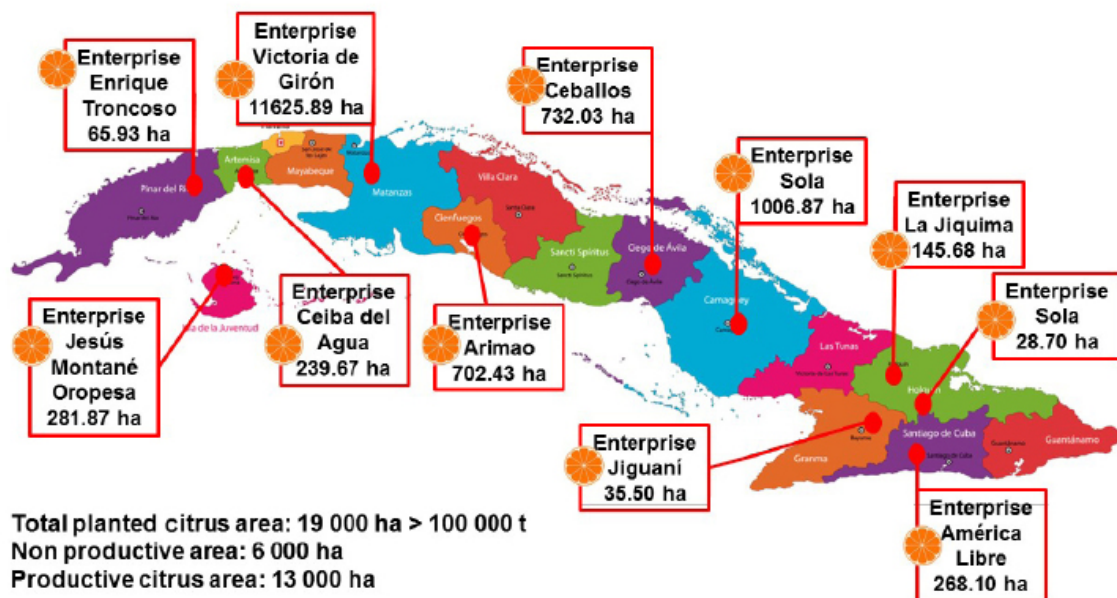




THE PROBLEM ADDRESSED

Sustainable “huanglongbing” management for the citrus industry in Cuba

“Huanglongbing” (HLB) was discovered in Cuba in late 2006 (Luis *et al.*, 2009), where the citrus production decreased from 500,000 tonnes in 2004 to 100,000 tonnes in 2017. There has been a marked acceleration in decline of total area planted to citrus since that time and 20,465 hectares have been replanted with alternative crops. A significant reduction in citrus consumer preference has occurred amongst Cuban people. National juice production for exportation has suffered a similar decline. Because no curative methods of HLB are available, a management of the disease is the main alternative to achieve sustainability of the Cuban citrus industry (Batista *et al.*, 2017).



- Geographic locations of citrus enterprises (citrus fruit icon) in provinces (color zones) of Cuba. Citrus areas planted in each one and data of general citrus production in 2017.



- Orchard of the sweet orange “Valencia 121” from Ceballos showing a low incidence of HLB-symptomatic plants and a high fruit production (photo by D. Lopez).



■ THE PRACTICE/INNOVATION PROPOSED BY TROPICSAFE

Alternative strategies for biological control of the disease in Cuba

One of the main aims of the TROPICSAFE project is to develop advanced pest integrated management strategies through the reduction of the environmental impact of plant protection strategies. Among these strategies, biological control such as the use of natural products is one of the most feasible and environmentally friendly strategies to manage many insect vectors.

Therefore, our aims are:

1-to evaluate the efficacy of **infected-tree eradication** to reduce temporal progress of the disease and to diminish the need for chemical applications;

2-to evaluate **two management practices** for control of *Diaphorina citri*, the entomopathogenic fungus *Hirsutella* sp. and kaolin applications.

■ HOW IS TROPICSAFE IMPLEMENTING IT?

Systematic surveys, application of treatments and observation

The **efficacy of eradication** on HLB management has been evaluated by comparison of the temporal progress of the disease in two areas in which different strategies are being applied. Six orchards of two citrus enterprises of Cuba were selected: Ceballos in Ciego de Ávila province and Victoria de Girón in Matanzas province. The TROPICSAFE activity has been developed in a block of 900 plants in each orchard. In Ceballos, the strategy includes the use of disease-free trees for replanting, the grove-wide chemical control of the insect vectors (only in the presence of the vector) and when plants are pre-sprouted (to protect new leaves); and removal of infected trees (eradication). In Victoria de Girón, the strategy is similar but without eradication.

The commercial varieties include the sweet orange "Valencia" [*Citrus sinensis* (L.) Osb.], grapefruit "Marsh" and "Ruby" (*Citrus paradisi* Macf.) grafted, and the rootstocks sour orange (*C. aurantium* L.), "Citranges carrizo" and "C-35" (*Poncirus trifoliata* x *Citrus sinensis*). Since March 2017, systematic surveys every two months have been carried out in each orchard for monitoring HLB-symptomatic plants. The main symptom used for visual diagnosis is foliar blotchy mottle.

The **entomopathogenic fungus *Hirsutella*** was applied in all the citrus enterprises in Cuba. Different isolates of entomopathogenic fungi were grown from infected adults of *D. citri*. The artificial medium used was Potato Dextrose Agar (PDA) and the fungus was identified by classical taxonomy. Three treatments are being applied and compared: (i) *Hirsutella* sp., (ii) systemic and contact insecticides and (iii) untreated (control). The presence of infected nymphs is being determined by visual sampling of 20 leaves per plant.

Finally, with regard to the evaluation of **efficacy of kaolin 5% application** against *D. citri*, the comparison will be between the insect presence on plants treated with this product and plants without treatment. The orchard selected ("Valencia" sweet orange) is from the citrus enterprise in the special municipality Isla de la Juventud. The applications of kaolin were in March, May and September 2018. The count of eggs, nymphs and adults of *D. citri* were recorded from March to November 2018. Four flushes/plant were selected according to the cardinal points. An arbitrary scale was used for the *D. citri* population: weak (w): 1- 2 individuals, medium (m): 3-5 and strong (s): more than 5.



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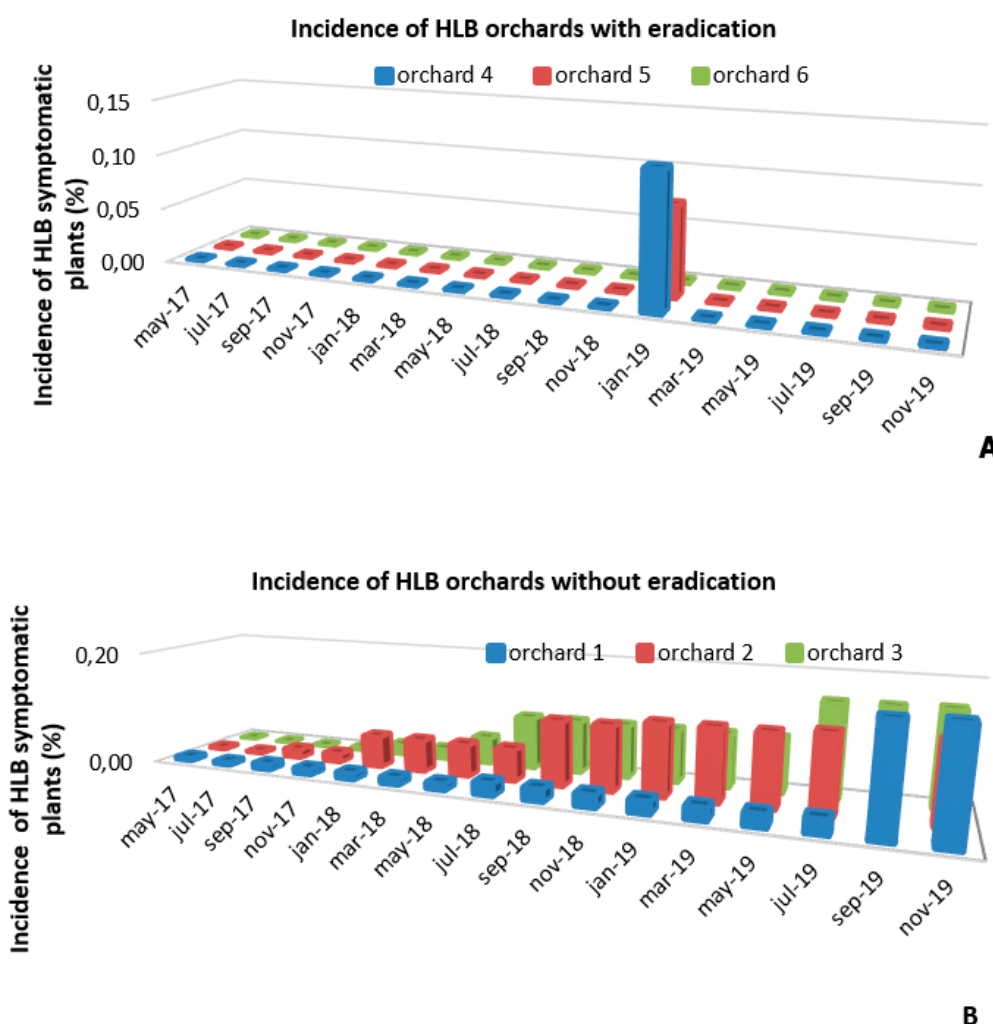


■ HOW IS IT WORKING?

Results: The eradication of diseased plants considerably reduces the incidence of the disease in plantations

The eradication results in Ceballos orchards obtained up to November 2019 showed that there was a low incidence of symptomatic plants. In January 2019, few trees with symptoms were detected (fig. 3 A). These small lights were located near the road. This result is mainly related to the efficient control of the insect vector (low population levels) avoiding secondary infections and the extensive spread of the infection. Furthermore, these orchards are far from the oldest. This allowed for less frequent applications of chemicals in a preventive manner only at the boundaries of the field. This result is a positive indicator of the effectiveness of the proven management strategy. In the orchards of Victoria de Girón, the incidence of the disease was higher than in those of Ceballos. Symptomatic plants were detected since March 2018 and ranged between 13 and 18% at the end of 2019 (Fig 3 B). This is possibly a consequence of the permanence of the source of primary inoculums from non-eradicated HLB infected plants.

The results demonstrate that the elimination of symptomatic trees at a regional scale should be implemented to manage HLB in commercial citrus orchards in Cuba, as it had been previously recommended in other areas (Gottwald, 2010). After two years, the percentage of trees with symptoms was 20% lower in the area where symptomatic trees had been eliminated.



• Fig. 3: Incidence of HLB in citrus orchards without (A) and with (B) eradication programs in Cuba from May 2017 to November 2019.



■ HOW IS IT WORKING? (continued from previous page)

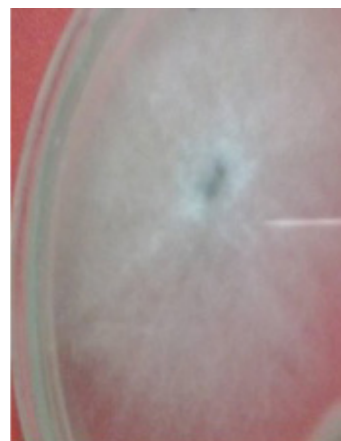
Regarding the **entomopathogenic fungus** practice developed in the citrus enterprises, adults of parasitized *D. citri* were collected in orchards located in Jiguani, Contramaestre and Sola from Granma, Santiago de Cuba and Camaguey provinces. The isolates obtained from these sampled insects included species of genus *Hirsutella*. The isolates were maintained on PDA medium under controlled conditions. The preliminary results suggest the potential use of this fungus for the biological control of the vector. Comparison of the efficacy of three treatments including (i) *Hirsutella* sp., (ii) systemic and contact insecticides and (iii) untreated (control) is under evaluation.

Some preliminary results for **kaolin application** showed its repellent capacity since it modified the behavior of *D. citri* and no individuals were detected after the applications. Any *D. citri* population was identified in the first months of the applications (March and May 2018). Only one plant with adults was detected in June and November 2018.

Potential HLB dispersion pathways include the presence of internal inoculum in the orchards (i.e. infectious symptomatic plants) and populations of the insect vector. The measures for its control are mainly focused on inoculum reduction by frequent removal of HLB-affected trees and control of psyllid vector populations by alternative treatments. These first results indicate that all the tested measures have had a positive effect, both by decreasing the spread of the disease and by decreasing the population levels of the vector.



• *D. citri* parasitized by entomopathogenic fungus on citrus leaf (photos by J.L. Rodríguez Tapia).



• Isolate of entomopathogenic fungus on potato dextrose agar medium (photos by M. Ramos).

KEY WORDS

Citrus, integrated pest management (IPM), biological control

FURTHER INFORMATION

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