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REVIEW ARTICLE

Huanglongbing: Pathogen detection system for integrated disease management – A review

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Abstract Huanglongbing (HLB) is a major threat to citrus sustainable yield and production. Therefore, various strategies are discussed in this review to provide solutions for the control of the disease. These include phyto-sanitory techniques to reduce pathogen inoculum in the field which are based on several approaches such as the presence of a reliable pathogen detection system, control over vector populations, cultural practices, chemotherapy and finally the production of disease-free propagating material. In addition to phytosanitory techniques, efforts to introduce resistant genes into cultivatable germplasm are also needed and are thus also discussed in this review.

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1. Introduction

Diseases caused by different pathogens like fungi, prokaryotes, nematodes, viroids, viruses and probable viruses, are one of the most potential factors to shrink the yield from citrus groves. Among them citrus greening, a prokaryotic disease, is one of the devastating diseases prevailing in citrus orchards all over the world (Batool et al., 2007). This disease has been extensively reviewed by many scientists (Batool et al., 2007; Bove, 2006; Graca, 1991). Gottwald (2010) reviewed the epidemiological understanding of huanglongbing and showed that pathogen co-evolved as insect endo-symbiont which later on also moved to the plants. It was also showed that disease vector can transmit it to a very long distance. On average, the disease can cause 30–100% in yield losses depending upon the severity of the disease. It takes 2–5 years for a tree to become unproductive from the first appearance of the symptoms and the total life span of the tree is reduced to 7–10 years, although significant quantitative data on fruit yield and quality reduction due to this disease are absent.

HLB has been established itself in more than 40 countries (Brlansky, 2007). Disease is caused by the fastidious Gram-negative uncultivable bacterium belonging to the α-subdivision of the phylum Proteobacteria (Garnier et al., 1984; Jagoueix et al., 1994). Three major strains of this bacterium, Asiaticus, Africanus and Americanus have been differentiated on the basis of environmental conditions and insect vector (Coletta et al., 2004; Garnier et al., 2000). Symptomology of the disease has been elaborated by many scientists (Graca, 1991; Bove, 2006 and Batool et al., 2007). Typical disease symptoms include small and upright leaves and chlorotic mottling, Zn deficiency symptoms, severe vein yellowing and greening of mature fruits (Das, 2004). The pathogen has not restricted itself to *Citrus* species. Several other hosts have also been identified (Table 1).

2. Disease vector: population dynamics

HLB is transmitted through different means; infected branches, cascuta and insect vector in nature. Citrus psylla has been identified the most potent insect vector for the transmission of the disease. Two species, *Diaphorina citri* and *Trioza erytreae*, are known as vectors of specific strains such as Asiaticus, Americanus and Africanus of bacterial inoculum, respectively. These species can be differentiated on the basis of their sensitivity to temperature. Transmission of the pathogen has been described and reviewed in detail by Manjunath et al. (2008). Pathogen population inside the host tree releases specific volatile chemical methyl salicylate which attracts the vector population to feed on the infected tree and thus pathogen is also injected in the vector (Mann et al., 2012). Methyl salicylate based attractant for vector has been formulated for commercial exploitation (Stelinski et al., 2013, US patent 13/774,112).

The pathogen was found in both nymph and adult stages but was absent in the eggs or in offspring produced by infected females. The insect vector may carry the pathogen for 12 weeks (Hung et al., 2004). On the other hand, Das et al. (2002) noted the presence of an abundant vector population during February through April, being lower during October–January. Factors like temperature and humidity, weeds and cultural practices also affect the vector population. Higher temperature and saturation are negatively related to the growth of the African psyllid population (Tamesse and Messi, 2004). They also observed that adult psyllids showed variable infection on three hosts i.e. 100% in lime, 97% in lemon and 76% in mandarin. Vector population control was considered key in the management of disease. Grafton-Cardwell et al. (2013) reviewed the management strategies for the control of pest and showed the chemical control as primary management strategy of insect. However it was shown that chemical control induced the resistance against the insecticides. Therefore integrated strategies for the management of disease were recommended.

Host and environmental factors effects the spatial distribution of the vector, therefore DNA based diversity and seasonal abundance in the various populations of vector has been summarized in Table 2.

3. Pathogen detection systems

Traditionally, HLB is scored on the basis of variable disease symptoms. However, HLB is a fastidious organism that can

Table 1 List of alternative host of *Candidatus* Liberibacter.

Pathogen	Alternative hosts	Location	References
Candidatus Liberibacter asiaticus'	*Cleome rutidosperma*, *Pisonia aculeate*, *Trichostigma octandrum*	Jamica	Brown et al. (2011)
Candidatus Liberibacter asiaticus'	*Murraya paniculata*	Florida	Damsteegt et al. (2010)
'*Candidatus* Liberibacter solanacearum'	Tomato and Pepper	New Zealand	Liefting et al. (2009)
Candidatus Liberibacter psyllaurous	Tomato and Potato	California	Hansen et al. (2008)
Candidatus Liberibacter asiaticus	Wampee (Clausena lansium Skeels)	China	Deng et al. (2007)