Department of Primary Industries
and Regional Department

Primefact

Citrus huanglongbing

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Meena Thakur[1], Nerida Donovan[1], Jessica Lye[2], Jianhua Mo[1]

[1] NSW Department of Primary Industries and Regional Development (DPIRD)

[2] Citrus Australia Ltd (CAL)

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Huanglongbing (HLB), also known as citrus greening, is one of the most destructive bacterial plant diseases affecting citrus production globally, with significant effects in Asia, Brazil and the United States. Huanglongbing has resulted in the loss of millions of citrus trees worldwide. It has significantly increased production costs for citrus growers due to the need for regular pest scouting, psyllid sprays, and other management efforts. With no cure or reliable long-term strategy, growers face ongoing economic challenges and uncertainty.

Huanglongbing targets the vascular system of citrus trees, which restricts nutrient absorption and severely affects tree health. As the disease progresses, fruit will drop prematurely, be smaller and misshapen, leading to lower yields with reduced juice quality.

Huanglongbing is primarily spread by citrus psyllids, which transmit the bacteria to citrus trees. While no effective cure is available, various strategies have been proposed to mitigate its spread and manage the disease. These include using disease-free seedlings, removing infected trees, and integrated pest management (IPM) approaches that combine biological control, insecticides, and innovative techniques such as antimicrobial peptides and nanotechnology.

Huanglongbing has not been reported in Australia. This Primefact provides an overview of HLB, its causes, symptoms, and current management strategies, focusing on helping citrus growers protect Australia's citrus industry from this destructive disease.

What is huanglongbing?

Huanglongbing is a bacterial disease that severely affects citrus trees, eventually causing their death (Figure 1). It is spread by citrus psyllids, which are sap-sucking insects that are not present in Australia. Infection disrupts nutrient movement throughout the plant, hindering plant growth and causing premature fruit drop, reducing yields. Infected plants produce undersized, misshapen, green fruit with aborted seeds. HLB-infected fruit have lower sugar and higher acid content, giving it a bitter or sour flavour. The fruit do not develop colour properly, sometimes with colour inversion remaining green at the stylar end, as opposed to healthy fruit where the yellow–orange colour develops first at the stylar end (Bove 2006).

Over the past 2 decades, Florida's citrus production has dropped from nearly 300 million boxes (40.8 kg per box) in 2003–04 to fewer than 20 million in 2022–23 (Southern Ag Today 2024) due to a lack of effective control measures in production regions where HLB is endemic (Yuan et al. 2021; Singerman and Rogers 2020). According to the USDA's Animal and Plant Health Inspection Service (2022), HLB has caused a 75% drop in Florida's citrus production and has doubled production costs.

Figure 1. Huanglongbing-infected mandarin trees.

What are the economic effects of huanglongbing on commercial citrus production?

The economic effects of HLB on commercial citrus production are:

1. **Increased tree mortality**: HLB raises the mortality rate of citrus trees.
2. **Reduced marketable yield**: the disease affects the quantity, size, appearance, and flavour of the fruit, reducing the marketable yield per tree.
3. **Higher production costs**: growers face increased costs with increased insecticide and fertiliser use to mitigate the effects of HLB. Scouting labour may also contribute to the cost of production.

What causes huanglongbing?

Huanglongbing is associated with 3 phloem-restricting endophytic bacterial species from the genus Liberibacter:

- Asiatic species, *Candidatus* Liberibacter asiaticus (CLas).
- African species, *Ca*. L. africanus (CLaf).
- American species, *Ca*. L. americanus (CLam).

The predominant HLB pathogen globally is CLas, which originated in Asia (Bove 2006) and has spread to most citrus-producing countries except the Mediterranean basin and Australia (Wang 2020). CLas is a heat-tolerant bacterium that can thrive in temperatures up to 35 °C (Lopes et al. 2009).

The African species, CLaf, causes symptoms primarily in cooler climates and is common in Africa, while CLam is primarily found in South America.

What are the symptoms of huanglongbing?

Symptoms of HLB can vary and often resemble other disorders. Infected trees frequently develop yellow shoots and leaves (Figure 2), a hallmark of the disease that gives it its name. One characteristic symptom is the asymmetrical 'blotchy mottle' pattern of yellow and green on the leaves, crossing the leaf veins with no clear boundaries between the colours (Figure 3). Affected trees might also show signs of nutrient deficiency, especially zinc, with a symmetrical pattern on either side of the leaf midrib (Figure 4). As the disease progresses, leaves can thicken and develop enlarged, corky veins (Figure 5).

Infected trees are stunted, sparsely foliated (Figure 6), and might bloom off-season. Other symptoms that can appear over time include leaf drop, twig dieback, and misshapen hard fruit with colour inversion (Figure 7) and small, dark aborted seeds (Figure 8).

In well-managed orchards, the gradual yellowing that spreads slowly through the tree and across the orchard is easier to detect. However, this can be harder to spot in neglected backyard citrus trees in poor soil. Symptoms can take months or years to fully develop after infection, with a general decline in tree health and fruit becoming sour and bitter often being the most recognisable signs.

Figure 2. A huanglongbing-infected citrus tree displaying yellow shoot symptoms on new flush.

Figure 3. Asymmetric blotchy yellowing of leaves.

Figure 4. Zinc deficiency symptoms.

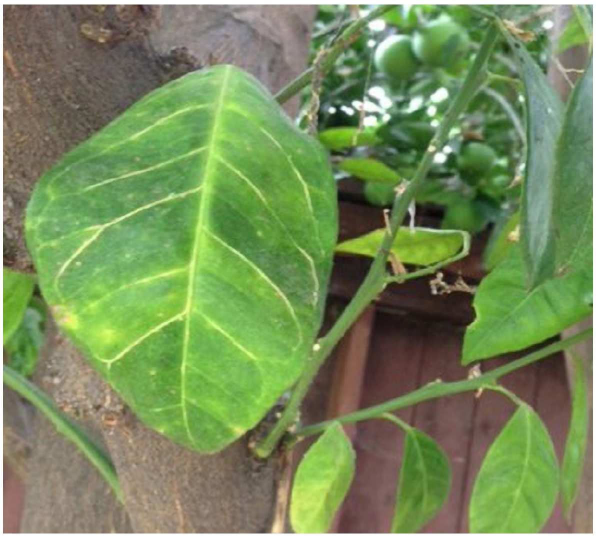

Figure 5. Corky leaf veins of huanglongbing-infected trees. Photo: California Citrus Pest and Disease Prevention Program.

Figure 6. Sparsely foliated infected trees.

Figure 7. Fruit with colour inversion.

Figure 8. Abnormal fruit with aborted seeds. Photo: Pat Bailey, University of California Citrus Pest and Disease Prevention Program.

What are the vectors of huanglongbing?

Huanglongbing is vectored by 2 psyllid species:

4. **Asiatic citrus psyllid (ACP)**: *Diaphorina citri*, which transmits CLas and CLam.
5. **African citrus psyllid (AfCP)**: *Trioza erytreae*, which transmits CLaf.

Asiatic citrus psyllids can acquire the pathogen as a nymph or adult, and once infected, remain infectious for life. Transmission efficiency is higher when the pathogen is acquired at the nymphal stage. Psyllids need 17–18 days to become infectious after acquiring the pathogen. Huanglongbing can also spread via grafting, but seed transmission is not considered high risk.

An important way to stop HLB from being introduced into Australia is to stop the spread of the Asiatic citrus psyllid. Also, budwood should only be imported into the country through legal channels and tested in post-entry quarantine before release. Orchards must be planted with healthy, disease-free trees.

What are the host plants of huanglongbing and Asiatic citrus psyllids?

Huanglongbing pathogens and their psyllid vectors target citrus and closely related species in the Rutaceae family, such as orange jasmine (*Murraya paniculata*) and curry leaf (*M. koenigii*). Over 25 plant species have been confirmed as ACP hosts (Hall and Hentz 2016). The psyllid has also been reported feeding on *Cordia myxa* in the Boraginaceae family, although the host status of this plant is yet to be confirmed (Guz et al. 2020).

Orange jasmine is a preferred host of ACP. However, infected plants do not develop typical HLB symptoms. Among citrus species, all commercial varieties are vulnerable to HLB (McCollum et al. 2016), but Valencia is more suitable than Hamlin for ACP development. 'Cleopatra' mandarin (*Citrus reshni*) is less suitable than sour orange (*C.* × *aurantium*) for ACP oviposition and survival (Tsagkarakis and Rogers 2010).

What damage does the Asiatic citrus psyllid cause to citrus trees?

Asiatic citrus psyllids extract significant quantities of sap from citrus plants as they feed, producing large amounts of honeydew. The honeydew coats the leaves, encouraging sooty mould growth. Furthermore, while feeding, the psyllids inject salivary toxins that inhibit terminal elongation and cause malformations in leaves and shoots (Michaud 2004). Notably, even a single psyllid feeding for less than 24 hours on a citrus leaf can permanently deform that leaf. However, direct damage caused by psyllid feeding is generally not a major concern compared with HLB transmission.

During the overwintering period, adult psyllids tend to aggregate on newly forming citrus leaf buds, where they feed and mate. Initial ACP infestations are often highly concentrated on individual trees within orchards. This aggregation and feeding behaviour lead to distortion of the leaf buds, which creates favourable conditions for oviposition. As a result, citrus flush is frequently damaged (Figure 9), leading to the abscission of leaves and shoots (Halbert and Manjunath 2004) or malformed mature leaves. While mature trees can generally withstand the loss of a few leaves or shoots as this is only a small fraction of the total canopy, nursery trees and newly planted citrus do not.

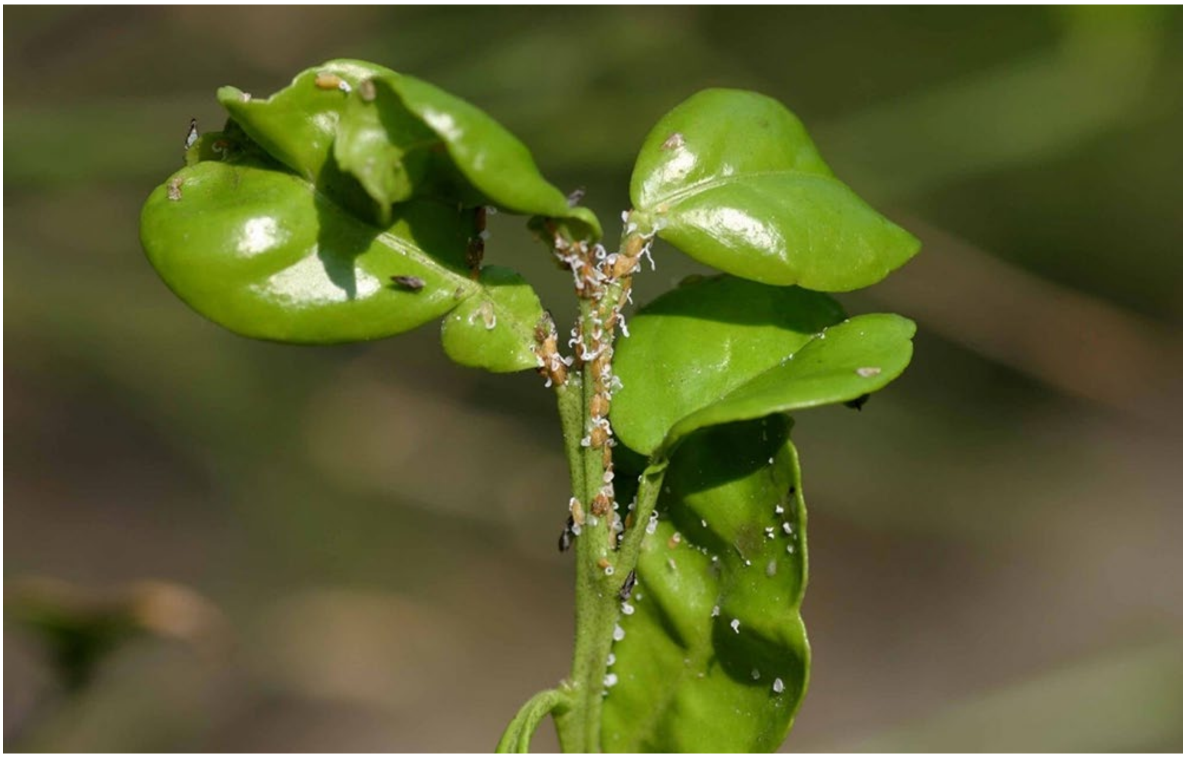

Figure 9. Asiatic citrus psyllid nymphs on young flush. Photo: California Citrus Pest and Disease Prevention Program.

How does huanglongbing spread?

Moving infected citrus plants or plant parts infested with HLB-infected citrus psyllids can spread HLB long distances.

How far do Asiatic citrus psyllids move?

Asiatic citrus psyllid adults can fly up to 2 km in 12 days and are known to fly further when young host plant flush is unavailable. Infected psyllids tend to disperse further than uninfected ones (Martini et al. 2015). Asiatic citrus psyllids can also be transported over long distances by wind. Severe weather, such as tropical storms and cyclones, can spread adult psyllids over vast areas.

What do Asiatic citrus psyllids look like?

Asiatic citrus psyllid adults are brownish, 3–4 mm long, with wings showing mottled brown patches. When feeding, the adult's body is raised at a 45° angle (Figure 10, left). The eggs are bright yellow-orange, almond-shaped, and deposited on the tips of growing shoots or in the crevices of newly unfolding flush leaves (Figure 10, right). The egg stage lasts 3–9 days, depending on temperature. Asiatic citrus psyllid nymphs are stationary, yellowish orange, with red eyes and prominent wing pads (Figure 11). They feed exclusively on new growth and produce white, string-like honeydew (Figure 12) that can melt to form droplets when the temperature is high, or be washed or blown away in wet or windy conditions. Both adults and nymphs have piercing-sucking mouthparts.

Figure 10. Asiatic citrus psyllid adult (left) and eggs (right).

Figure 11. Asiatic citrus psyllid nymphs.

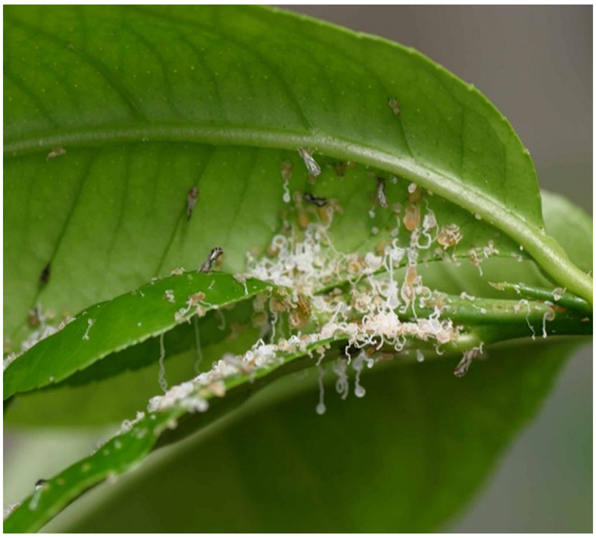

Figure 12. White stringy honeydew production by Asiatic citrus psyllid nymphs. Photo: California Citrus Pest and Disease Prevention Program.

How to monitor for huanglongbing

Monitoring for HLB involves testing leaves for the bacteria (*Candidatus* Liberibacter sp.) in a certified laboratory because visual symptoms can resemble other diseases.

Regular scouting for the ACP is essential. Observing psyllid populations and conducting molecular testing of plant material are vital steps to detect HLB early.

How to monitor for Asiatic citrus psyllids

Effective monitoring for ACP involves a combination of visual inspection and insect traps to identify all life stages. Yellow sticky traps are widely used to monitor adult ACP, as they are attracted to the bright colour. These traps are an effective passive surveillance method but can also capture other insect species. Active tap sampling can be used for more precise monitoring, where foliage is gently tapped onto a tray to collect adults and nymphs. Tap sampling provides immediate data on the presence and relative abundance of ACP in a single visit, unlike sticky traps, which require multiple visits.

Visual inspections are crucial for assessing all life stages of ACP, particularly on young tender flush leaves of citrus or *Murraya* species, where adults, eggs, and nymphs are often found. Adults can be collected using an aspirator, while eggs and small nymphs, which are hard to spot without a hand lens, are typically found within crevices and folds of leaves. Pay particular attention to signs of psyllid damage, such as twisted or curled shoot tips, sooty mould (Figure 13), and white waxy deposits on leaves (Figure 14), which indicate ACP activity. Special care should be taken to monitor for these signs, as they can often indicate the presence of ACP even when the insects themselves are not immediately visible (Halling et al. 2015).

Figure 13. Sooty mould on Asiatic citrus psyllid-infested citrus leaves Photo: California Citrus Pest and Disease Prevention Program.

Figure 14. Signs of Asiatic citrus psyllid activity. Photo: California Citrus Pest and Disease Prevention Program.

How is huanglongbing managed?

There are currently 3 essential management approaches for HLB, which include:

1. Removing HLB symptomatic trees to reduce the source of inoculum.
2. Using HLB-free nursery stock to establish or replant orchards.
3. Managing psyllid vectors.

Strategies 1 and 2 are essential for managing the spread of HLB because growers have no choice but to remove infected trees to prevent the disease from spreading. The entire orchard could be at risk if infected trees are left in place. However, these strategies can be expensive and difficult to carry out. This is often due to the limited scale or incomplete execution of the program (Yuan et al. 2021).

Strategy 3 involves a combination of biological, chemical, and repellent methods. A key biological control method is the parasitoid *Tamarixia radiata* (Figure 15), which targets all stages of ACP. *Tamarixia radiata* lays its eggs under the psyllid nymph, and the larvae feed on and kill the psyllid. Once the psyllid is dead, the parasitoid emerges through a hole it creates in the body. This parasitoid is commercially available in some countries and is a valuable tool for controlling ACP populations.

Figure 15. Asiatic citrus psyllid parasitic wasp *Tamarixia radiata*. Photo: Mike Lewis, Centre for Invasive Species Research, University of California, Riverside .

In addition to *T. radiata*, generalist predators, including spiders, lacewings, hoverflies, and tiny pirate bugs, feed on ACP. Among these, coccinellid predatory beetles are particularly effective at reducing psyllid numbers.

Chemical control via insecticides is also important but needs to be used cautiously due to the risk of insecticide resistance developing in the psyllid population. Integrated pest management (IPM), which involves using natural enemies, repellents, and insecticides, is recommended to manage psyllids. Repellents such as spray oils, kaolin, and certain plant-based essential oils, can also help deter ACP and limit their damage. Kaolin, in particular, forms a fine film on citrus plants, acting as a physical barrier that prevents ACP from settling and feeding while also reflecting light to make the plants less attractive to psyllids (Pierra et al. 2021).

Physical barriers, such as protective netting of the whole orchard (Figure 16), or individual protective covers (IPCs; Figure 17), are also increasingly used in regions where ACP poses a significant threat, especially in nurseries and high-value orchards. These barriers effectively prevent ACP from moving into citrus orchards, limiting the spread of HLB. Netting offers a sustainable and non-chemical option for ACP exclusion. Although IPCs are typically used for young trees while they are establishing in the orchard, once they are removed or if there are breaches in the netting, trees are exposed to ACP and quickly become infected with CLas.

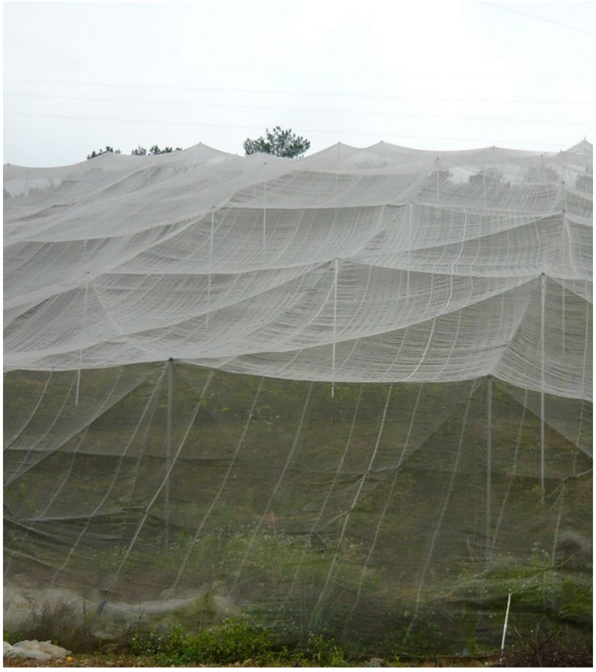

Figure 16. Protective netting in China to exclude Asiatic citrus psyllid and huanglongbing.

Figure 17. Individual protective covering in Florida. Photo: Citrus Industry (2022).

Other potential methods for managing HLB include:

- **Huanglongbing-tolerant varieties** are bred to tolerate or resist HLB infection, reducing the severity of symptoms, maintaining productivity and extending the lifespan of citrus trees. However, varietal choice is currently limited, and its use is best paired with other management strategies to reduce disease incidence.
- **High-density planting** involves planting citrus trees more closely together than in traditional orchards (Moreira et al. 2019). This method increases the number of trees per hectare, compensating for losses due to HLB. It allows growers to achieve higher yields per hectare in the early years of planting before HLB symptoms severely affect the trees. Additionally, high-density planting helps optimise land use and reduces the time needed to recover from yield losses. However, this method requires careful management of resources such as water and nutrients to effectively support the increased tree population.
- **Certain antibiotics**, particularly oxytetracycline (OTC) and streptomycin, have shown potential for managing HLB in citrus trees. While foliar applications have had inconsistent results and are often economically unfeasible for growers, trunk injections of OTC have demonstrated greater efficacy. These injections can reduce levels of CLas, leading to improved plant health, fruit quality, and yield.

  Despite these advantages, there are ongoing concerns regarding regulatory limitations and the effect of long-term antibiotic use, such as the risk of developing bacterial resistance. While antibiotics can temporarily relieve symptoms and slow disease progression, they are not considered a permanent solution for managing HLB.

- **Antimicrobial peptides** are small proteins that can inhibit or kill bacteria, including the Liberibacter species associated with HLB. Research is underway to explore the ability of antimicrobial peptides to reduce bacterial populations in infected trees and offer an alternative to traditional antibiotics.
- **Natural hormones and plant nutrition**: plant hormones, such as salicylic acid, can boost the tree's natural defence mechanisms, helping it resist or tolerate HLB infection. These hormones might reduce the severity of disease symptoms and improve tree health, making them a supportive tool in HLB management programs. Good nutritional management can also alleviate the severity of HLB symptoms in the early years of infection.

How can Australia safeguard against the entry of huanglongbing?

Preventing the introduction of HLB into Australia requires robust biosecurity measures to stop the introduction of the Asiatic citrus psyllid, the primary insect vector of the disease. Another significant pathway for HLB movement is infected grafted plant material. To minimise this risk, it is essential that budwood is imported only through legal channels and undergoes rigorous testing in post-entry quarantine before release. Additionally, orchards must be planted with healthy, disease-free trees to protect citrus production.

To further enhance biosecurity:

- Adopt strict hygiene practices, ensuring all equipment, vehicles, and materials are thoroughly cleaned before entering and leaving the orchard.
- Ensure all staff and visitors are trained in and follow your business's hygiene protocols.
- Source propagation material with a known high-health status from reputable suppliers.
- Continue surveillance for signs of psyllid activity or HLB, allowing for prompt action if the disease or psyllid is detected.
- Maintain detailed records to support traceability and biosecurity compliance.

More information on recognising and protecting your property from ACP and HLB is available from the NSW DPIRD website. A full list of notifiable plant pests and diseases can be found in Schedule 2 of the *NSW Biosecurity Act 2015.*

If you suspect you have found an Asiatic citrus psyllid or seen symptoms of HLB, call the Exotic Plant Pest Hotline 1800 084 881.

Further reading

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