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Silverleaf whitefly in vegetables

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Whitefly

Whitefly are small sucking pests like aphids or leafhoppers. Whitefly are usually found on the undersides of leaves, often in large numbers. When leaves are disturbed in infested crops, clouds of white flying insects are seen.

In vegetables, two species can be pests, greenhouse whitefly (GHW) and silverleaf whitefly (SLW). Greenhouse whitefly *Trialeurodes vaporariorum* can occur in high numbers on vegetables and usually can be controlled with insecticides if necessary, although insecticide resistance can be induced. Silverleaf whitefly is one of a number of strains or 'biotypes' of *Bemisia tabaci*. These different strains can act almost as distinctly different species, primarily by having different host crops and responses to insecticides.

Figure 1. Adult greenhouse (R) and silverleaf (L) whitefly (image courtesy of P De Barro, CSIRO)

The native *Bemisia tabaci*, sometimes called cotton whitefly, is not known to be a pest of vegetables, is usually found on native vegetation, and is easily controlled with insecticides. Two distinct biotypes have been introduced to Australia, biotype B and recently biotype Q, both currently known as silverleaf whitefly. Other common names used are sweet potato, tobacco and poinsettia whitefly, and in the USA the scientific name *Bemisia argentifolii* is often used. SLW is a serious pest of many vegetables including cucurbits, tomatoes, eggplant, brassicas, lettuce and beans. Biotype B develops resistance to insecticides quite quickly but the newly identified biotype Q is 'super-resistant' to insecticides. SLW is also an efficient vector of gemini viruses. SLW biotype B, but not biotype Q, can cause serious crop physiological responses such as the silvering in cucurbits.

SLW biotype B first arrived in Australia in the early 1990s, and has largely been restricted to Northern Australia. By the mid 2000s vegetable growers in Queensland had experienced several outbreaks with significant damage to crops. SLW has established in Northern Territory. In Perth and Carnarvon areas of Western Australia, and in the North Coast and Sydney Basin of NSW, SLW is primarily causing problems in protected cropping systems. In the summer of 2008–09 SLW outbreaks were observed in the cotton regions around Narrabri and on some field cucurbit and greenhouse tomato crops in the Riverina.

Silverleaf whitefly description

Whitefly eggs are pear-shaped and not usually visible (0.2 mm) but deposited in circular groups on undersides of leaves, usually the youngest leaves. The eggs are anchored into a slit in the leaf surface and are initially white, changing to brown. Eggs hatch within 8–10 days. The 'crawler' or 1st instar nymph moves to a suitable feeding site and inserts its feeding mouthparts into the leaf and will then not move until it pupates into an adult.

Crawlers are flat, oval and scale-like in shape. Every 2–3 days they moult into the next instar. The 4th and final nymphal instar is termed the puparium, is dark yellow and is approximately 0.7 mm long. For approximately 2 days the 4th instar continues to feed and then for 2 days it does not feed before emerging as an adult. Whitefly adults are small

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(1 mm) insects with white, slightly waxy wings that depending on species are held tent-like (SLW) or flat over the body (GHW).

Figure 2. Silverleaf whitefly adult, 'crawler' (inset) and pupa.(Photo I&I NSW)

The time from egg to adult is 18–28 days in warm conditions but takes 30–48 days in cooler conditions. The number of eggs a female produces ranges from 50 to 300. SLW populations can build rapidly during warm conditions. The minimum temperature for development is about 10°C and the maximum is about 35°C. Optimal conditions for development are between 25° and 28°C.

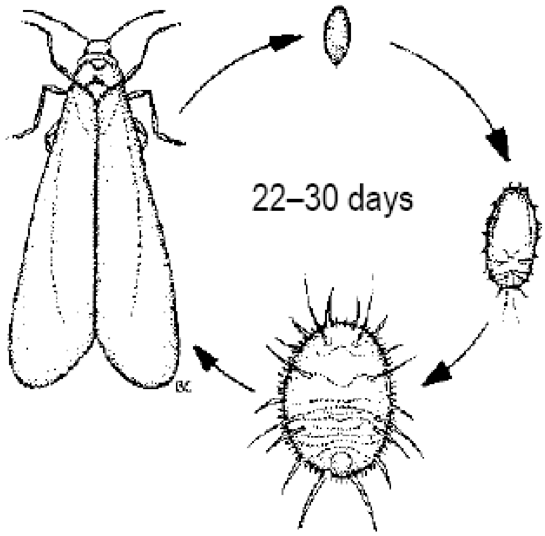

Figure 3. Whitefly lifecycle – greenhouse whitefly

Identification

Identification of SLW can be difficult for the inexperienced. SLW puparium taper onto the leaf surface without distinct side walls or a fringe of short waxed rods such as is seen with GHW. Both GHW and SLW have long waxed rods on the puparium. SLW adults hold their wings tent-like but not quite meeting at the apex so the body can be partially seen, whereas GHW hold their wings flat and almost parallel; they obscure the body when viewed from above. For this reason sticky traps and specimens in alcohol are very difficult to identify.

However, if you have large numbers of whitefly in your crop which have not reduced after a synthetic pyrethroid or organophosphate spray, then you most likely have SLW.

Hosts

SLW is primarily found on cucurbits, tomatoes and other solanacous crops, brassicas, legumes, lettuce and cotton. It is also found on a wide range of broadleaf weeds. The relative survival of SLW on the available broadleaf weeds and local host crops, and the temperature profile will drive SLW abundance. Sowthistle, turnip weed, mallow, wireweed and lucerne are common hosts.

Population abundance

Temperature is the key factor driving SLW abundance. SLW risk modelling suggests that those areas with an average of at least 9–10 generations per year and the shortest 'longest generation' (i.e. warmest winters) are predicted to have the highest risk of SLW outbreaks.

Griffith is predicted to have 7–8 generations, so outbreaks are not expected and only 5 are predicted for Wagga Wagga. However, greenhouse environments are optimal for outbreaks.

SLW nymphs are adapted to withstand frosts and adults shelter in the warmest part of the plant canopy. Frosts are most likely to reduce SLW numbers by killing the host plant. In cool conditions, however, SLW populations do not increase.

Damage – direct feeding

SLW adults and nymphs suck plant sap. Large numbers of whitefly feeding can cause stunting, reduced yields, leaf or fruit deformation, defoliation and even plant death.

Damage – physiological disorders

While feeding, SLW biotype B inject saliva into the plant which can cause physiological changes in crop tissue. In squash, zucchini and pumpkins it causes a characteristic 'silver-leaf' symptom and fruit discolouration. In tomatoes it causes uneven ripening of fruit.

Figure 4. 'Silver' leaf and normal leaf of a Japanese pumpkin (image courtesy of P De Barro)

Figure 5. Uneven ripening of pumpkin caused by SLW feeding (image courtesy of P De Barro)

Figure 6. White stalk of broccoli caused by SLW feeding (image courtesy of P De Barro)

In broccoli it causes pale stalks or 'white streaking disorder'. In lettuce some leaf yellowing can be caused by SLW feeding. Different varieties can vary in the extent of physiological responses, but work in cucurbits showed similar yield reduction under high SLW pressure in varieties that showed the leaf silvering and those that don't.

SLW Biotype Q feeding does not induce these physiological disorders.

Damage – sooty mould

Whitefly excrete most of the water and sugar in the plant sap as honey-dew, which falls onto plant and fruit surfaces below the whitefly feeding sites. This makes the fruit and foliage sticky to handle and in humid conditions can result in sooty moulds growing. The black mould discolours the leaves and fruit and, when severe, reduces photosynthesis in the plant.

Figure 7. Sooty mould on tomatoes and cucumber (image courtesy of P De Barro)

Damage – virus transmission

Virus transmission in Australia is mainly an issue for tomatoes, with two gemini viruses present in the country: ATLCV (Australian tomato leaf curl virus) and the recently introduced TYLCV (tomato yellow leaf curl virus).

Figure 8. Tomato yellow leaf curl virus TYLCV in tomatoes (image courtesy of D Persley, DEEDI)

TYLCV is of most concern. SLW need to feed on infected plants for at least 15 minutes to acquire TYLCV and then feed on another host plant for 15 to 30 minutes to transmit the virus. Transmission efficiency increases as the duration of feeding times increases. Although the transmission efficiency of individual insects may be low, where enormous populations of SLW are moving within and between crops, this can result in rapid spread and high disease levels.

Research results are inconclusive, but TYLCV is probably not carried from generation to generation through the SLW egg. Hosts of TYLCV include two symptomless crop hosts, capsicums and beans, plus various weed hosts. SLW is an efficient vector of gemini viruses. Neither gemini viruses are widespread in NSW but are potentially a serious problem.

BPYV (Beet pseudo yellows virus) is transmitted by GHW. Lettuce, endive and cucumber are hosts of this disease.

Insecticide resistance

SLW arrived in Australia with resistance to synthetic pyrethroids, organophosphates, carbamates and insect growth regulators. Since its arrival, SLW has developed measurable resistance to endosulfan, amitraz, bifenthrin and imidacloprid (R. Gunning pers. comm.). Overseas, biotype Q has developed high levels of resistance to insect growth regulators and neonicotinoids.

Management of SLW

Where possible, host-free periods need to be maintained to reduce the potential for outbreaks. Controlling weeds in and around fields or greenhouses is essential. Cropping breaks with non-host crops will break the population increase.

The four different modes of damage and insecticide resistance have important bearing on potential approaches to SLW control.

- In crops where the priority is to avoid direct feeding and honeydew issues, population management/suppression is the key – i.e. as long as high populations are avoided, damage will not result.
- In crops where SLW cause physiological reactions or transmit virus, low populations can cause economic damage. Approaches that focus on reducing the symptoms will have merit, including using less susceptible varieties or those that have virus resistance, and in strategies that delay time to virus infection (weed management and roguing infected plants).

Given that SLW biotype B readily develops resistance to insecticides, and biotype Q even more quickly, it is important to use strategies to prevent and manage resistance. These strategies maximise ‘cultural’ or ‘biological’ control and minimise chemical controls. When chemicals are used they must be rotated to avoid repeat chemical applications of the same group of chemicals.

Prevent infestation – sanitation

All possible efforts should be made to prevent seedlings being infested with whitefly. Ensure that seedling nurseries are well screened to prevent infestation.

Control weeds in existing crops and in neighbouring areas to reduce background populations of whitefly – do this all year but it is critical at least 3–4 weeks prior to new plantings.

Destroy old crops immediately (same day) after harvest or when abandoned.

Delaying SLW infestation or virus infection in tomato crops can have significant impact on levels of crop loss experienced. Using zucchini or squash as a trap crop in the vicinity of tomatoes was shown to reduce loss by virus in Queensland.

Monitoring

Crop monitoring should be the basis for deciding pest management interventions for all pests including SLW. Visual monitoring of whitefly adults and nymphs should be included in routine crop monitoring. Adults, eggs and young nymphs are found most commonly on young leaves, while older nymphs and puparium are found on older leaves. Adults will take flight easily when disturbed, so it is important to turn the leaves over gently to count numbers of adults. Eggs and young nymphs cannot easily be seen without magnification; using a 10x hand lens is recommended. Older nymphs and puparium can usually be seen by the unaided eye.

It is best to sample in the early morning in the coolest conditions. Inspect 30–40 plants per 3–4 ha block walking in a U-shaped or zig-zag pattern through the crop, randomly selecting plants every 8–10 m. During the warmer months when populations can increase rapidly it is recommended to check crops twice per week. When crops are in decline or past maturity, adult whitefly migrate to neighbouring crops.

Yellow sticky traps placed around the crop just at or slightly above crop height can act as an indicator to when foliage needs to be visually checked for adults or larvae. Rate recommended is 3–5 traps in a 2–3 ha planting. Change the traps each week when whitefly are present. In periods of high pressure, estimates of whitefly numbers can be made by selecting ten 1 cm^2 areas and multiplying the count by 15. Record the number of adult whitefly per trap per week. Check young crops when adult counts exceed 10 adults per trap per week.

Figure 9. Yellow sticky trap used to monitor whitefly numbers. (*Photo I&I NSW*)

Natural enemies

All organisms are attacked by natural enemies. Natural enemies of whitefly crawlers include the generalist predators: bigeyed bugs, lacewing larvae and ladybeetles.

Eretmocerus hayati, a parasitoid of SLW, was introduced into Australia from Pakistan and released in crop production areas of Queensland in early 2006. It has spread to Narrabri and the Sydney Basin but it is not known if it has reached the Riverina.

Figure 10. Whitefly parasitoid Eretmocerus hayati (male) (image courtesy of P De Barro)

Figure 11. Whitefly parasitoid Eretmocerus hayati (female) (image courtesy of P De Barro)

Encarsia spp. is another group of parasitoids that also attack whitefly more generally. *Encarsia formosa* is available from commercial insectaries and is used in IPM management of whitefly in protected cropping systems. It is not particularly effective in field cropping situations.

Yellow sticky traps can be used to monitor populations of these parasitoids. When visually monitoring, black pupa indicate parasitisation.

Figure 12. Parasitised pupa (image courtesy of University of California)

Varietal resistance

Some cucurbit varieties do not show the classic silvering of leaves which is a physiological response to SLW biotype B feeding although these varieties can still lose yields to high levels of SLW feeding.

At close range SLW prefer non-glossy-leaved over glossy-leaved brassicas which results in a partial resistance of the glossy-leaved varieties.

Lines of tomatoes that are gemini virus resistant have been bred from wild tomatoes and some Australian varieties may have some of this resistance already incorporated.

Chemical controls

Overseas populations of SLW have developed resistance to virtually all insecticides, biotype Q is particularly quick at developing resistance. Prophylactic use (seedling or pre-plant soil applications) of systemics such as the neonicotinoids can be quite effective on SLW biotype B. Remember that it is a legal requirement to use insecticides only on crops that are listed on the label or have a permit issued. Any foliar applications of insecticides need to target the undersides of leaves. Use well calibrated equipment, small droplets and high water rates. Test coverage under leaves with water-sensitive paper. After spray applications monitor the crop to assess the impact. If coverage is good, spray conditions are optimal and label rates are followed but control is poor, resistance may have developed.

Collection of specimens for identification

Whitefly and plants showing virus or physiological disorders can be sent to diagnostic labs for further identification. In all cases the information on the host plant, locality of origin, date and collectors contacts should be provided in permanent ink or pencil – avoid biro as it runs when wet.

For whitefly identification, collect infested leaves, preferably containing puparia, and package them in a container which will not squash the leaves and will protect them from extremes of heat, cold or humidity. Enclose information on the relevant host, locality and sender's contact details inside the package. Wrap it well, sealing it so that specimens cannot escape. Address it to the diagnostic lab, noting on the outside of the sealed container: *live whitefly contained inside*.

Resources

Silverleaf whitefly management in vegetable crops Subramaniam S., J. Lovatt, B. Nolan and P. Deuter, QDPI&F 2006

Silverleaf Whitefly Management. Subramaniam S. and P. De Barro, Vegenotes Autumn 2006

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